Alexis Bazin

MIA Fuel Cell H2

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Cogito 44

Introduction

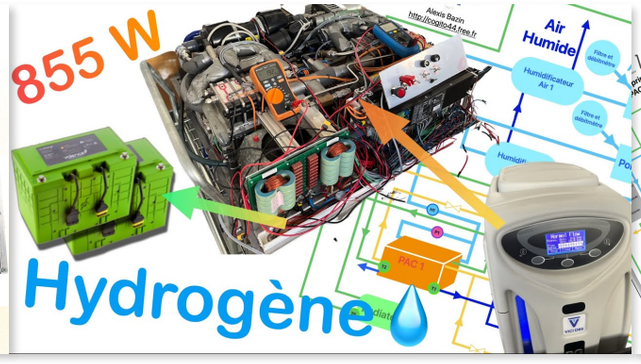
Proton Exchange Membrane Fuel Cells

The Mia's fuel cell represents a remarkable step forward in the field of ecological propulsion. Operating according to the principle of the proton exchange membrane, this ingenious technology converts the gaseous dihydrogen and oxygen of the air into a source of electricity. Thanks to this innovative process, it not only directly feeds the vehicle's propulsion while driving, but it also offers the possibility to recharge the Mia's battery.

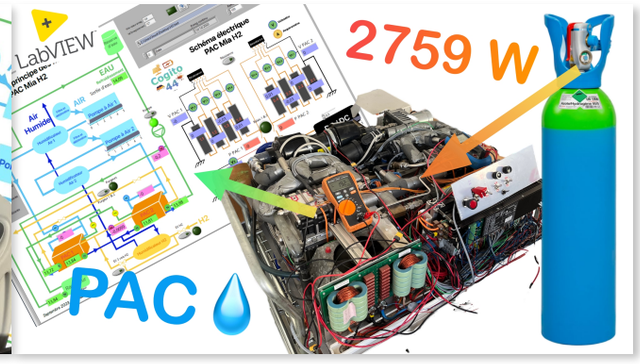
The architecture of this fuel cell is designed with 2 fuel cells mounted in parallel, delivering a nominal power of 2880 W. This configuration gives the Mia a range of 270 km with a 50-liter tank*.

Vidéos

Removal of the CAP and the battery



First test of the CAP, with a dihydrogen generator



Fuel cell test, with a dihydrogen bottle

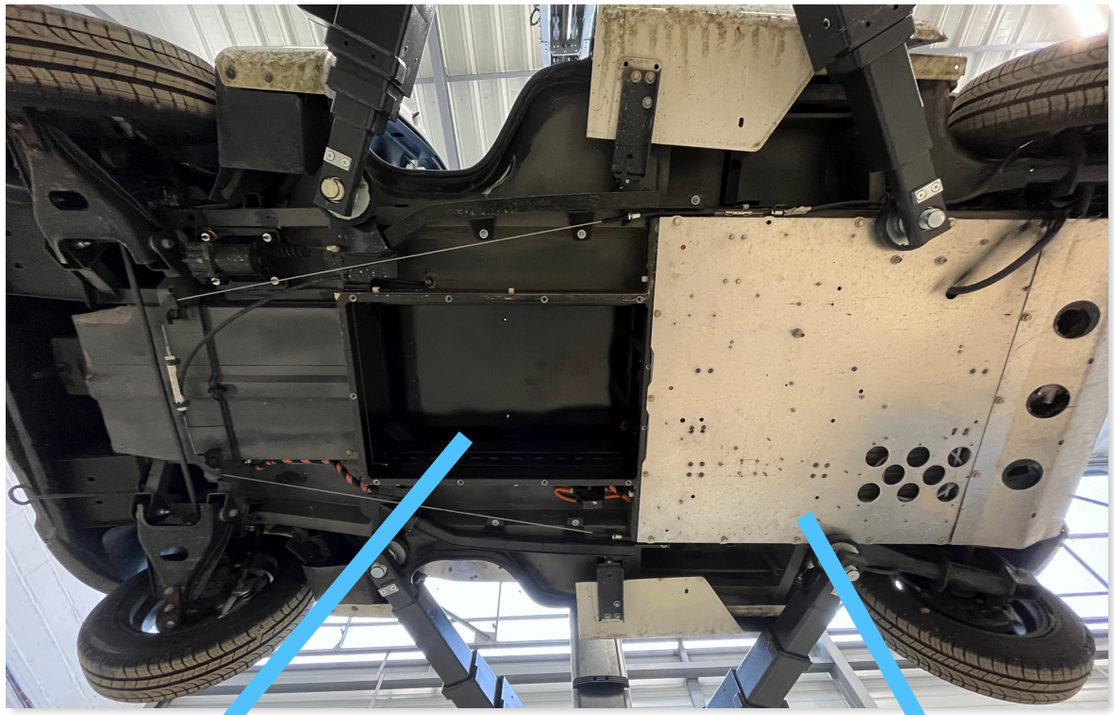
Mia road test with functional fuel cell

* See page 9

Deposit of the fuel cell

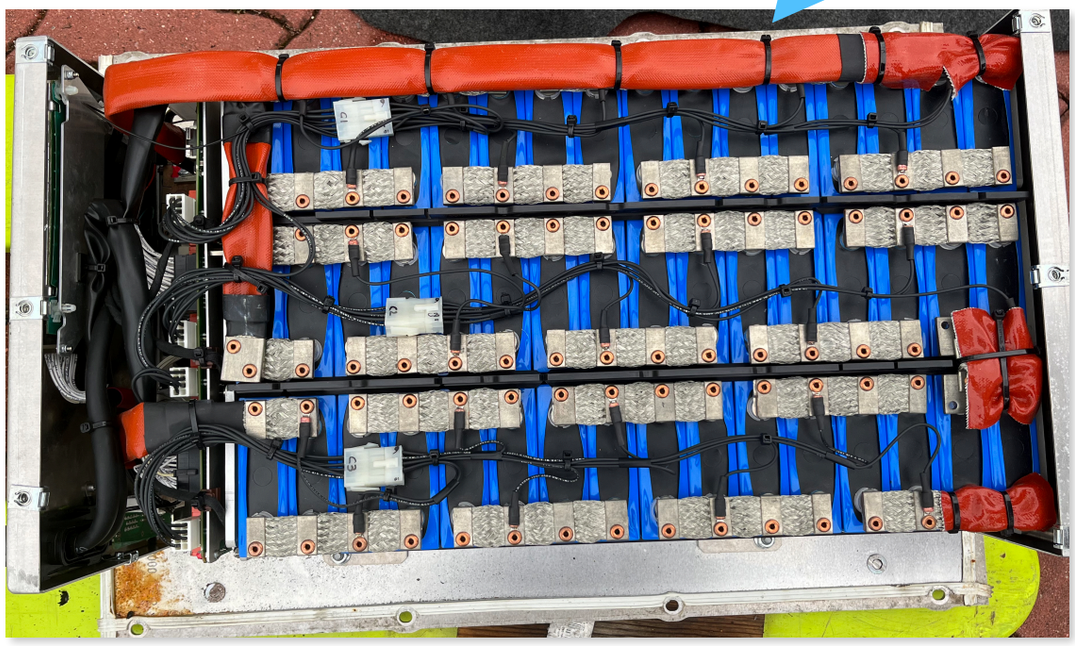
Battery

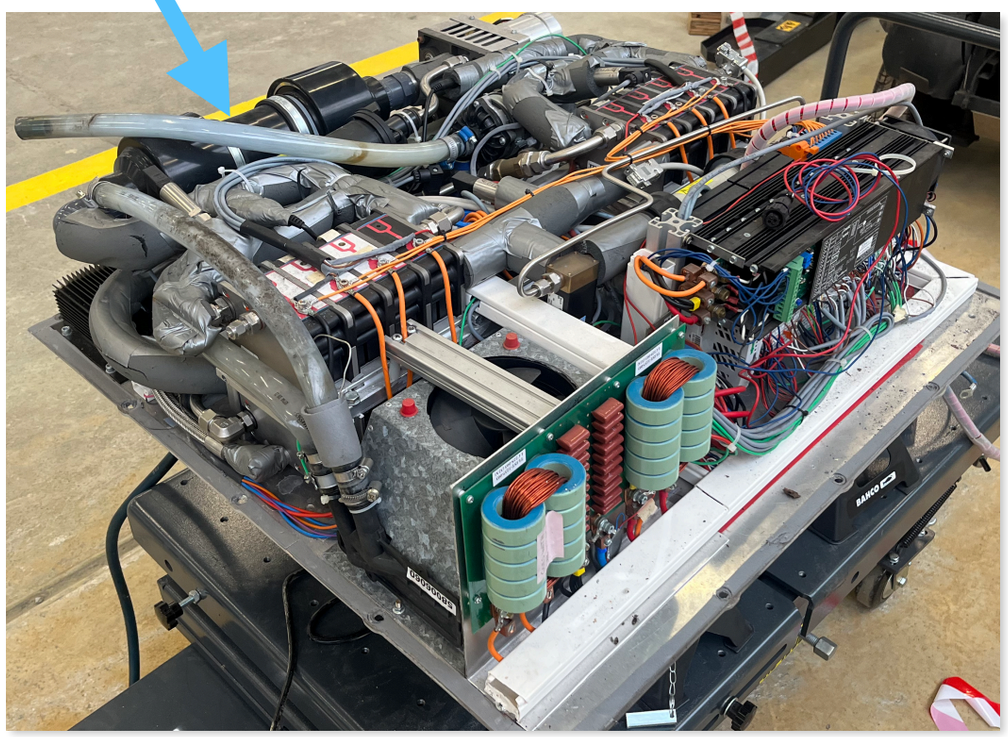
The E4V brand battery has a capacity of 6.14 kWh mount with 2 parallel modules of 40 Ah and a nominal voltage of 76.8 V. Either 2P 24S, 80 Ah x 76.8 V = 6.14 kWh



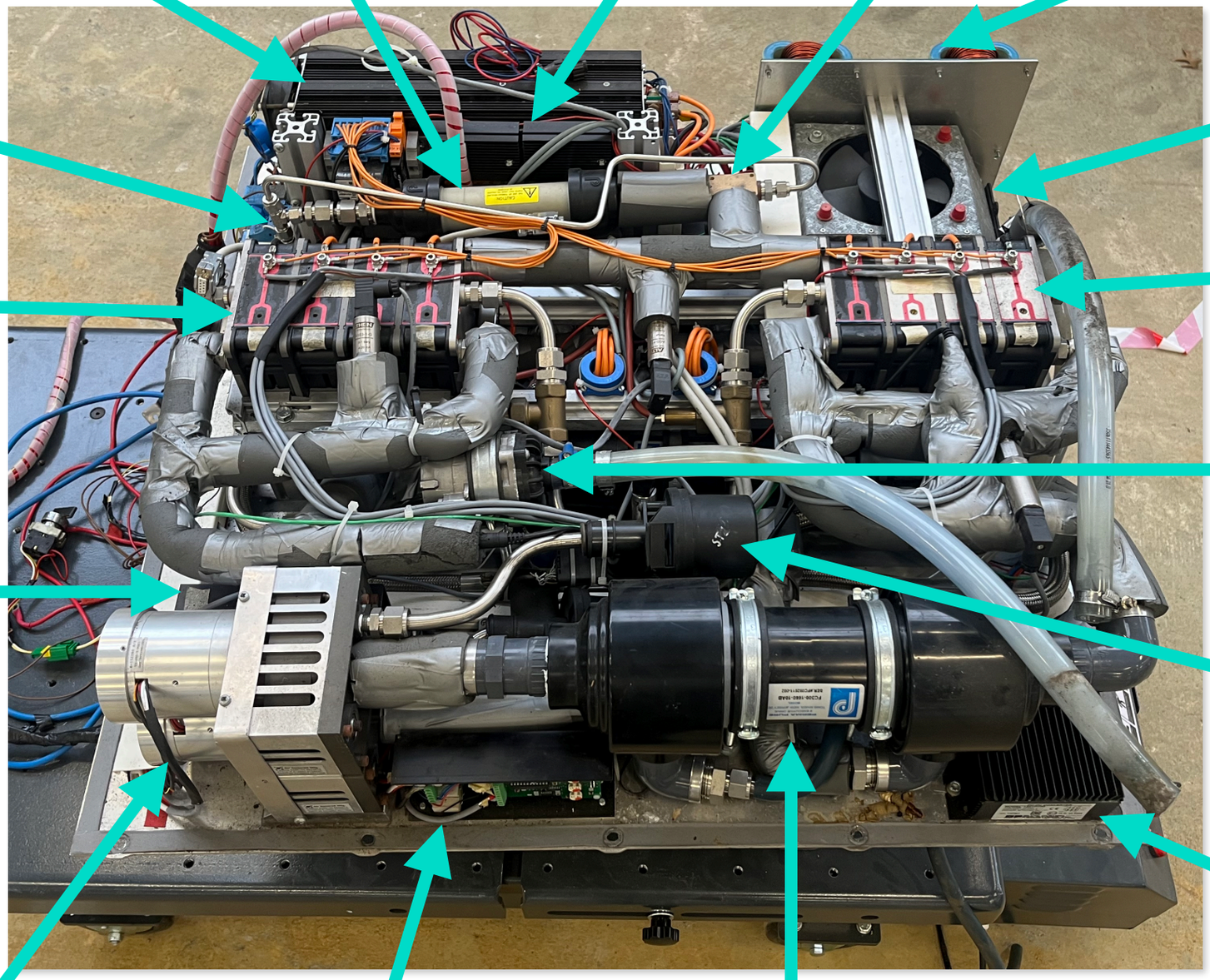
FuelCell

The fuel cell occupies the entire place of the back plate of a long Mia. It is connected to the car via its 12 V power supply and its connection to the E4V battery. The charger and DC DCs had to be moved on the right side step.





Composants fonctionnel



Fluids principle diagram

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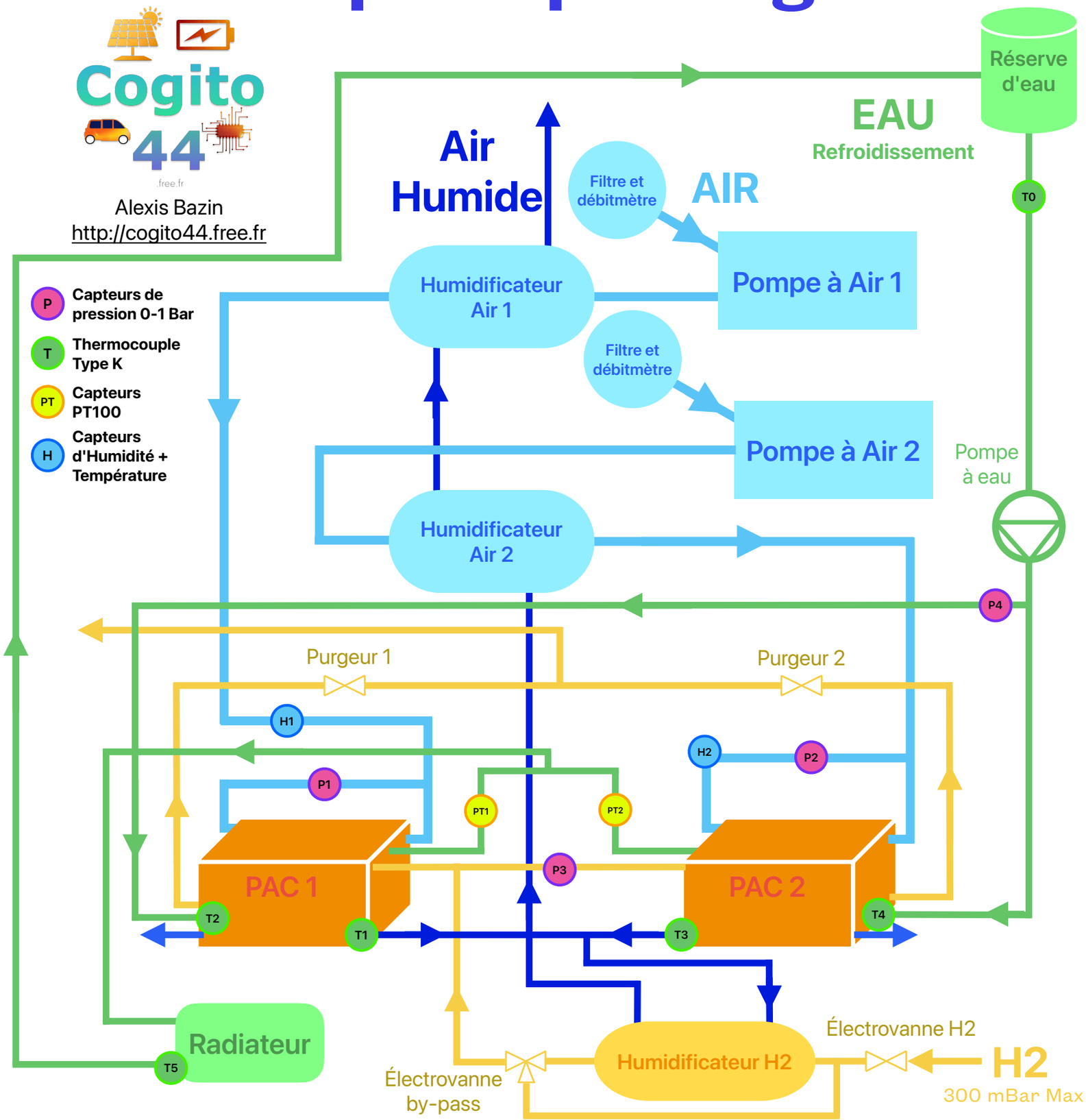
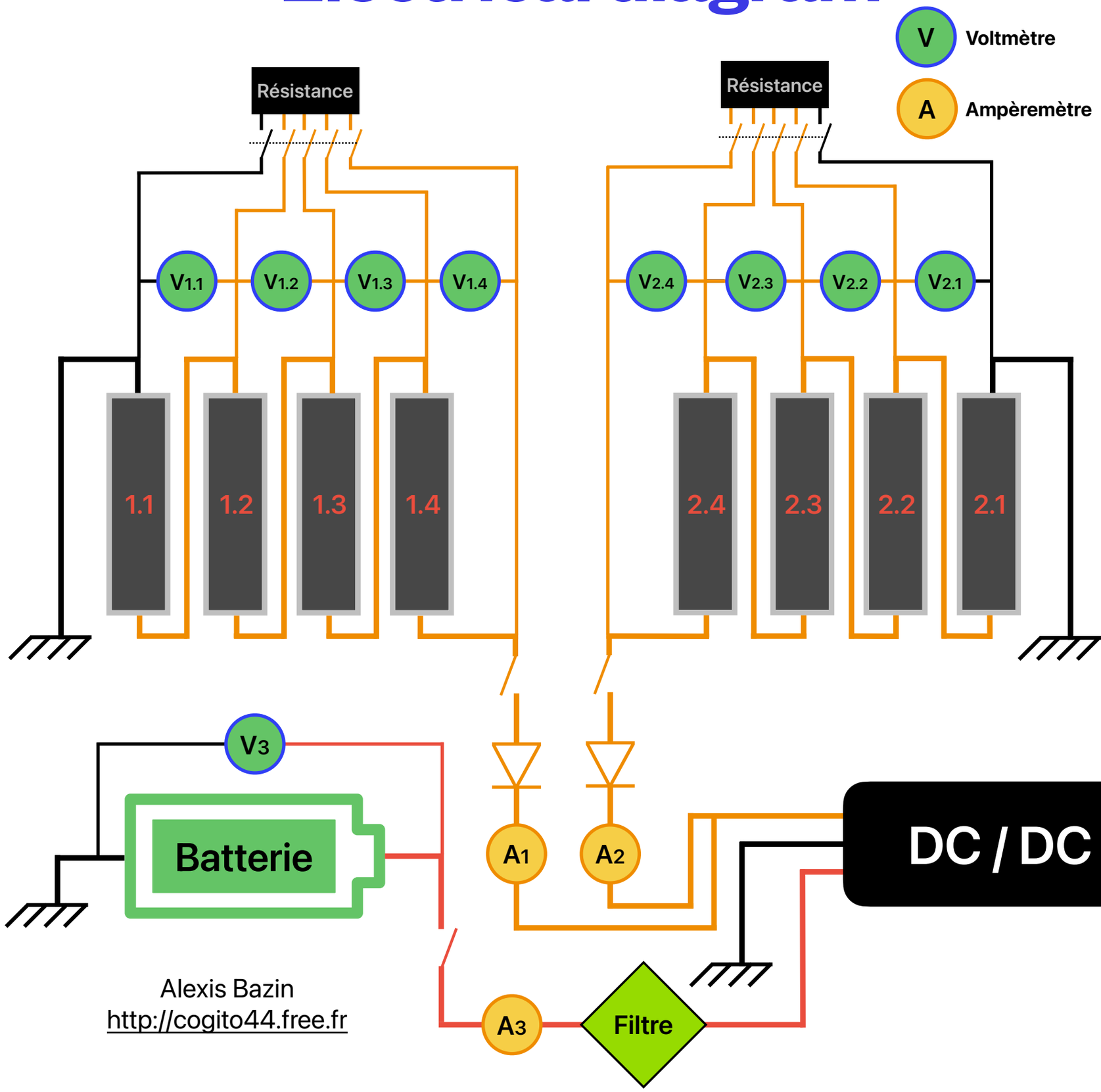


Electrical diagram



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Components & Features

Components	Mark	Reference	Observation
DC/DC of power	Zahn Electronics Inc.	CH 25045F-S, 2 LC225s	The DC/DC allows you to convert and regulate the voltage of the Fuel cell to charge the Mia's battery. It can be controlled by running, via a 0-5Vdc. Max power 4050W or 45 A in 90V. Input voltage 80 V to 200 V and output voltage from 0 V to 199 V.
DC/DC 12V/24V	Sure Power Industries, Inc.	12010C00	This DC/DC, makes it possible to convert the 12 V from the Mia's easement battery into 24 V to operate the organs that work in 24 V like solenoid valves. Output current Max 10 A.
Fuel cell PEM	Schunk	FC - 42	The 2 Proton Exchange Membrane fuel cells. Characteristics for a fuel cell : • Nominal power of 1.44kW • 42 cells X 4 = 168 cells in series • 8 kg • 130 x 202 x 190 mm • Dihydrogen consumption: 20 l/min at full load • Air consumption: 120 l/min barely charged • Nominal voltage 96 V • Nominal current 15 A
Air humidifiers	Perma Pure	FC300-1660-10AB	Air humidifiers make it possible to bring air into the Fuel cell with the right humidity level.
Air humidifiers	Perma Pure		The dihydrogen humidifier makes it possible to make a moisture exchange between the air coming out of the fuel cell and the dihydrogen entering the fuel cell, it can be bypassed with a 3-way solenoid valve.
Air pumps	Air Squared Mifg.	P16H34N2.3	Both pumps can be controlled via a 0-5 Vdc. It makes it possible to supply fuel cell with air, they are regulated via air flow meters.
Flowmeters	PIERBURG		The air flow meter makes it possible to measure the air flow that enters the CAP, this is one of the data used by the algorithm for regulating the amount of air that enters the fuel cell.
Humidity and temperature sensors	BB Sensors	FF-IND-20MA-EXT-TE1	The data of this sensor is used in the power and air flow regulation algorithm. It works in 24 Vdc and returns data in 4-20 mA on humidity and temperature.
Pressure sensors	BAMO MESURES	TP 805	Measuring range of 0-1 bar with a 4-20 mA output, measures the pressure of dihydrogen, fuel cell inlet air and water circuit.
Current sensor	Sensilec	SHo10V12	DC current sensor with Hall effect, 0-60 Adc with a 0-10 Vdc output. It measures the current of each fuel cell individually and the output current from the DC/DC to the Mia's battery.
Automaton	National instruments	NI cRIO 9063	This automaton consisting of a chassis and several modules makes it possible to acquire the data of all the sensors and to regulate the shareholders according to the state of the CAP and the power demand. (More details below)

Fuel cell

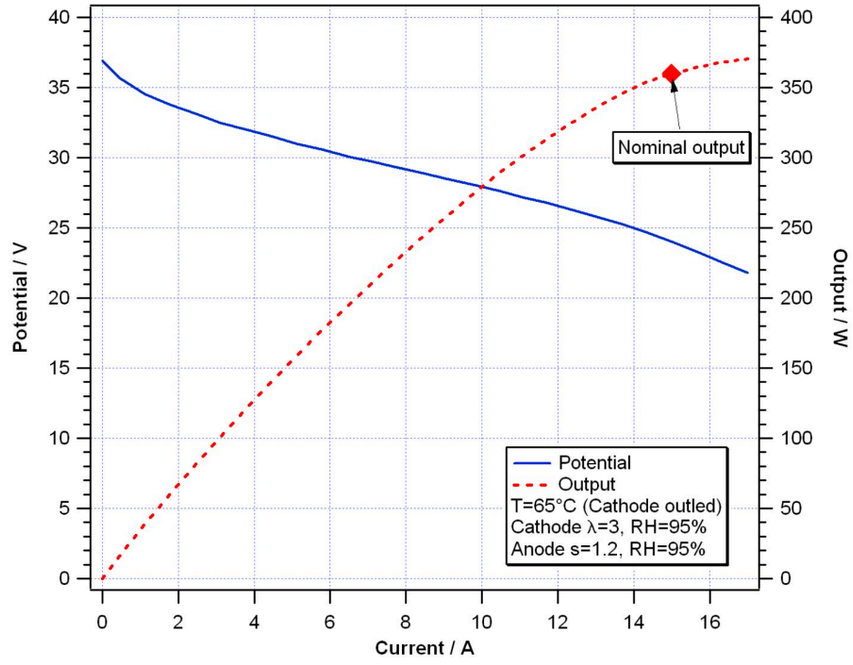
FC - 42

Schunk's FC-42 modules are designed in a modular way and can be assembled up to 4 elements in series with a unit power of 360 W. They have a nominal voltage of 24 V and can deliver 15 A for a mass of 2.1 kg.

For the life of the fuel cell, the conditioning of gases, temperature and energy must be controlled and adapted to remain within the optimal operating characteristics of the CAP.

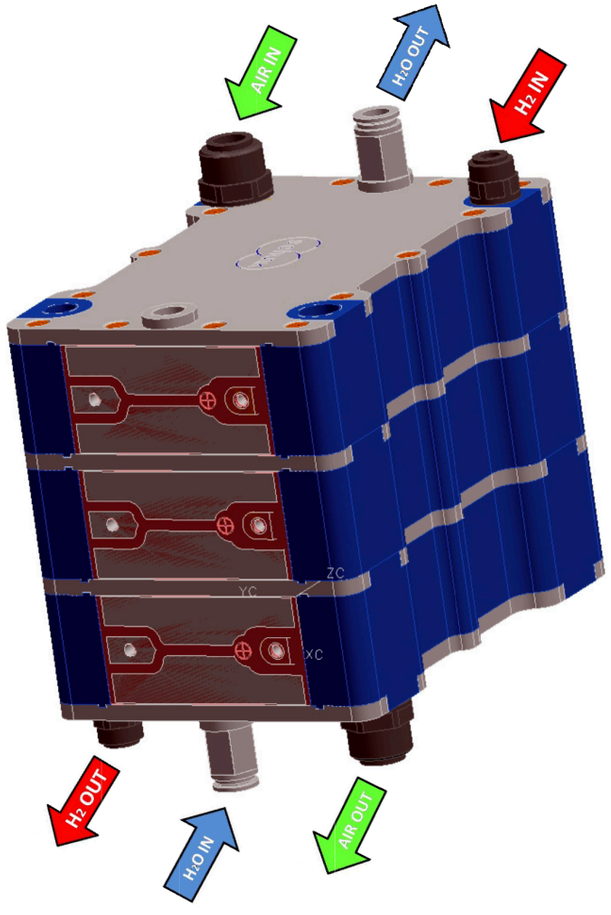
This is what all the accessories mounted around the fuel cell are used for (humidifier, air pump, cooling system, sensors, etc.)

The automaton has an all the more essential role, because it is responsible for acquiring and analyzing sensor data and regulating actuators.



Courbe caractéristique U/I Schunk FC-42

Features	
Number of cells	42
Nominal voltage	24 V
Nominal current	15 A
Minimum voltage	15 V
Maximum current	30 A
Maximum voltage (open circuit)	36 V à 42 V
Operating temperature	5 to 55 °C (not humidified) <75 °C (humidified)
Quality of hydrogen	99,99 % (No trace of CO)
Air	Approx 25 l/min at full load and λ= 2 35
Cooling (water/glycol)	Approx 3 l/min at full load
Moisture management	Self-humidified (5 to 55 °C) External humidifier (> 55 °C)



Consumption

Autonomy calculation

With a 50 l tank at a pressure of 200 bar at 15 °C that contains 0.83 kg of dihydrogen.

Knowing that the volume consumption of a single fuel cell is 16 l/m at full power with a molar mass of dihydrogen of 2.016 g/mol and if we apply the perfect gas formula, we obtain a consumption for the 2 fuel cell of 0.0010017 kg/min. To this, we must add the loss of purges that occur every minute for a second, i.e. 0.000407 kg/s + 0.0010017 kg/min = 0.0010424 kg/min

Therefore, with a tank of 0.83 kg of dihydrogen we obtain an operating time of 794.58 minutes ÷ 60 = 13,243 hours.

If we reduce this in kilometers, taking into account the electrical efficiency of the fuel cell: (2.88 kW - 0.280 kW) x 13,243 h = 34.43 kWh / 0.150 kWh/km = 229.5 km to this, it is possible to add the original 6.1 kWh battery and we arrive at 270 km.

If the 50 l tank is compressed to 400 bars at 15°C, it contains 1.68281 kg of dihydrogen. This makes it possible to operate the CAP for 26.87 hours, i.e. a theoretical production of 69.86 kWh. That is 465 km and 506 km with the battery.

$$n = \frac{(4 \times 10^7\ \text{Pa}) \times (0.05\ \text{m}^3)}{(8.314\ \text{J·mol}^{-1}\text{·K}^{-1}) \times (288.15\ \text{K})}$$

$$\text{Masse} = 834.43\ \text{moles} \times 2.016\ \text{g/mol}$$

$$\text{Masse} \approx 1682.81\ \text{g}$$

Automaton

NI cRIO 9063

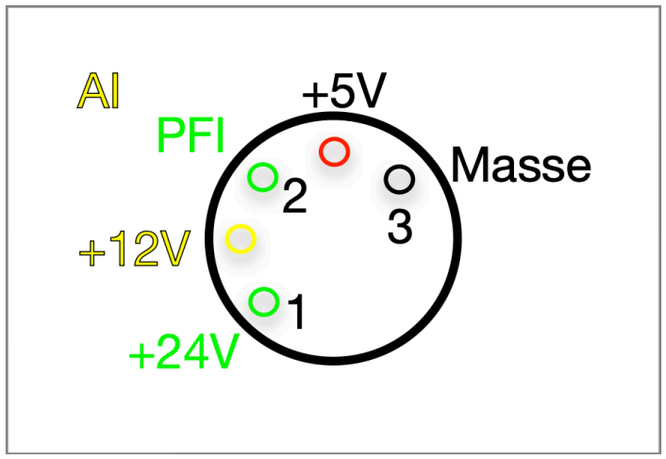
National Instruments CompactRIO systems are intended for research, they have the particularity of running a program in real time or in FPGA directly on the chassis. This chassis has 4 slots to accommodate as many modules, acquisition or control.

It is mounted with the following module:

Chassis number	Module		Number of lanes used
1	NI-9401	C Series digital module, 100 ns, 8 two-way, 5 V/TTL	7
2	NI-9263	Analog output module, 4 channels, +/-10 V, 16 bits, 100 kech./s/channel	4
3	NI 9205	32-way analog input module, + / 10V, 16 bits, 100 kech./s/way	20
4	NI-9213	C-Series temperature input module, 16 channels, total 75 ech./s, ±78 mV	8
			39

The majority of sensors and actuators are connected to its modules via a 5-pin DIN socket standard.

Acquisition box



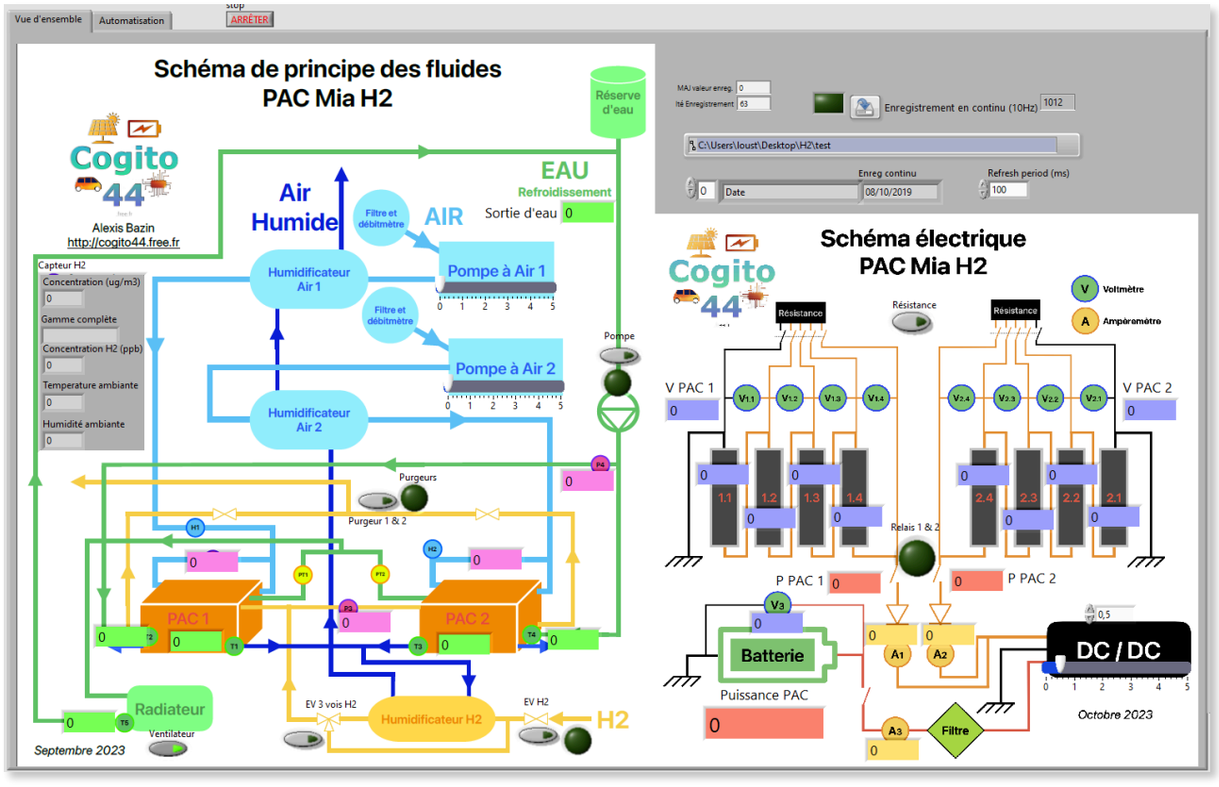
DIN 5 pin connector measurement and control

Programming

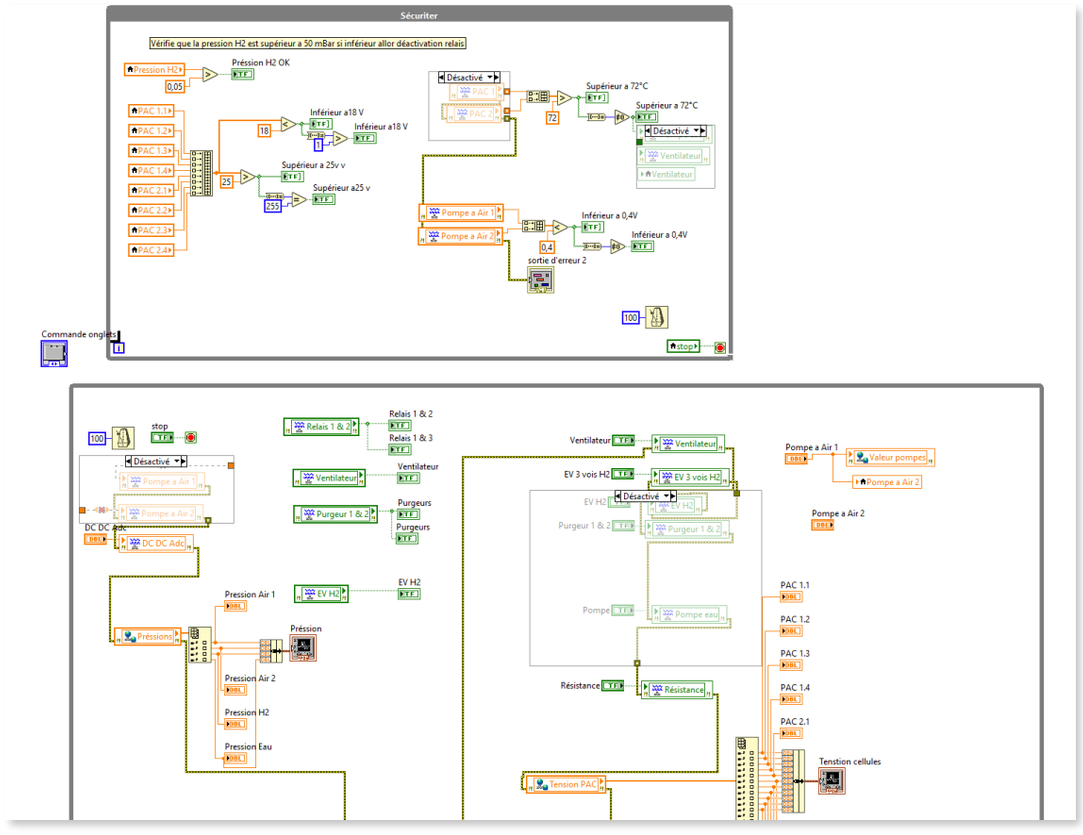
LabView

The system was programmed via **LabView**. There are 2 main programs, one directly injected into the CompactRIO programming in **real time**. And a user interface that runs on a computer to check the status of the stack and start it.

The real-time and self-managed program, it makes it possible to secure the CAP automatically in the event of a problem. It also has a data recording system.



Front of the IHM program



Part of the HMI program