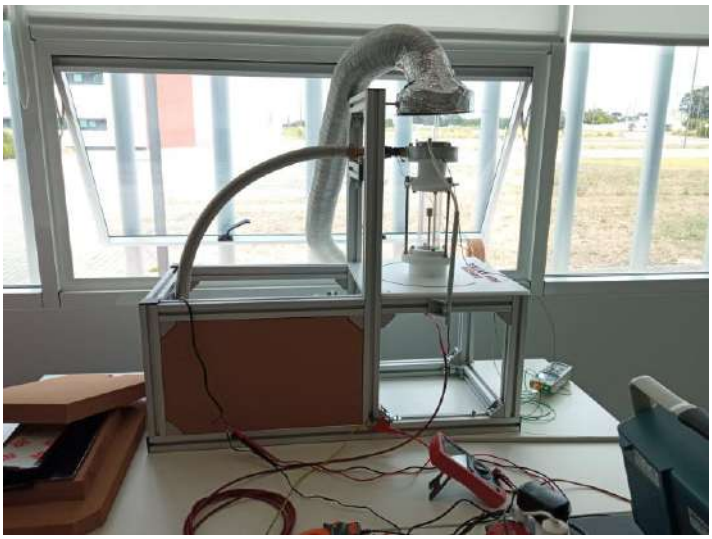
EnergyNetIQ LDA

PCI Creative Science Park,

Ílhavo, 3880, Portugal

Energy Cell's COP Measurement



Cell's General View

Cell's Ignited View

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1. General Data

1.1. Testing Place:

Address	PCI Creative Science Park, Room 2002
Municipality	3880, Ílhavo
District	Aveiro

1.2. Client's Identification:

Name	EnergyNetIQ LDA

1.3. Service Providing:

Dates	2023, July to October

1.4. Attendance:

Costumer	Mr. Haslen Back, Mrs. Valeria Tutina
IEP	Modesto de Morais, Tiago Teixeira and Teresa Canelas

1.5. Measurement Equipment and Calibrations

Identification

Electric Energy Quality Measurement: HT SOLAR 300N SN: 19032890; M-2022-1000
Electric Current Measurement Clamp: FLUKE 376FC SN: 43510155WS; M-2022-1111
Thermal Imager: FLIR E75 SN: 78505439; M-2020-0513
K-type-Thermocouple: AKTAKOM, SN: 668860 M-2022-3481, M2022-3482, M-2022-3483,
Air Flow Meter: Rainbow S400, CL-42824CD-22
Gamma and X radiation: Graetz GammaTwin;
Non-Ionizing radiation: Narda NBM-550 +GER Y2008 (SN: A-0551) + EHP-50F (SN: 100WY70291)

1.6. Environment Conditions

Temperature	24 ºC
Relative Humidity	65 %

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2. Scope

IEP was contracted to witness the relevant parameters measurement concerned to the calculation of the Coefficient of Performance (CoP) tests carried out by EnergyNetIQ LDA to show:

- COP of the *EnergiCell* (DC electric energy input divided by the thermic energy output).
- COP of the system comprising the *EnergiCell* power supply.

3. Proposed Measurements

Three tests were carried out (A, B and C) at different time periods and with a 30-minute interval between each test (this interval is to allow time for the *EnergiCell* to cool down).

In the first test (A), 4 measurements were taken, iterated 5 minutes apart, over a period of 20 minutes.

In the second test (B), 10 measurements were taken, iterated 10 seconds apart, over a period of 1 minute and 40 seconds.

In the last test (C), 8 measurements were taken, iterated 2 minutes apart, over a period of 16 minutes.

It was decided to carry out several tests, with different durations and with different periods of interval between measurements, in order to guarantee the accuracy of the results obtained during the visit.

The following measurements were witnessed:

- Temperature input;
- Temperature output;
- Mass flow in/out;
- Electrical consumption of the DC power supply unit;
- Electrical consumption of the *EnergiCell*;
- Electrical consumption of the *EnergiCell* power supply;

We were requested to measure also the:

- Ionising radiation (X Radiations and Gamma Radiation);

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4. Calculations

The equation [1] is used to calculate the CoP:

$$CoP = \frac{G_2(C_{pout}T_2 - C_{pin}T_1)}{N_{el}} \quad [1]$$

Where the:

- C_{pi} is the heat capacity of the air at the corresponding temperatures (kWh/(kg.K)),
- G_2 is the air mass flow (kg).
- T_1 is the air temperature at the system input and T2 is the air temperature at the system output measured in Kelvin (K).
- N_{el} is the electrical energy consumption (kWh) by the system.

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5. Test Results

The test results presented below were obtained during the operation process of the *EnergyCell* (Test A, Measurement 4 - 20 minutes test). During the validation process the following were measured: the electrical voltage (DC and AC), the electrical current (DC and AC), the total energy consumption, the air temperature (inlet and outlet) and the volume of air passing through the EnergyCell. The measured values are presented in Table 1.

Description:	Values:	Units:	Comments:	
Test Running Time Dt	0,333	h		
AC Power	**0,760**	**kW**		
DC Current	0,654	A		
DC Voltage	0,800	kV		
DC Power	**0,523**	**kW**		
Air Heat Capacity at Input	**1,006**	**kJ/(kg.K)**	307,15	K
Air Heat Capacity Average at Output	**1,046**	**kJ/(kg.K)**	572,85	K
Air Density @ 1 atm & 300 K	**1,275**	**kg/m³**		
Temperature @ Cell Input (in let)	**307,15**	**K**	34,0	ºC
Temperature OUT 1	657,65	K	384,5	ºC
Temperature OUT 2	488,05	K	214,9	ºC
Temperature Average @ Cell OUT	**572,85**	**K**	299,7	ºC
Thermal Energy	**0,3958**	**kWh**		
Electrical Energy (AC)	**0,2533**	**kWh**		
Electrical Energy (DC)	**0,1744**	**kWh**		
DC Power supply efficiency	68,84 %			
COP (DC)	**2,27**		Without DC power source losses	

Table 1: Measurement results presentation.

At the customer's request, the potential emission of ionising radiation (X-rays and g-rays) was checked at the very beginning of the test process.

The following values for ionising radiation were obtained (for the above measurement). For each of these radiations, 2 measurements were made at different distances, one close to the *EnergyCell* and one far away, and the following results were obtained:

- Gamma and X radiation: 34 nSv/h (Far), 61 nSv/h (Near).
- Electric Field (between 100 kHz and 3 GHz): 0,3 v/m (Far), 13,75 v/m (Near).

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6. Discussion

From the testing results that are presented on the section 5 of this report, first of all, we should stat the following:

- There is no relevant harmful radiation emission for the human bean, like X radiation or Gamma radiation.

By using the data presented on the table [1] and by the equation [1] we calculated the Coefficient of Performance of the *EnergyCell* (CoP). This CoP was calculated for just one situation:

1. Considering only the electric DC energy that is delivered into the cell excluding the power loss on the DC power source;

On the table 1 we can see the following results:

- CoP (DC): 2,27.

Excluding all secondary losses, we note that the EnergyCell alone can provide a surplus of energy [CoP (DC)], presented in the form of heat, which increases the injected DC electrical energy.

We emphasize that Table 1 is just an example of one of the several measurements. For this reason, the CoP value shown in this table may not be the actual CoP value.

To provide a, more accurate EnergyCell CoP value, the total CoP obtained from all measurements taken have been averaged.

Thus, Table 2 presents all the CoP values obtained for each of the measurements performed, the mean value, the maximum value and the minimum value.

As a result, we got the following values:

• CoP (DC): 2,40.

In addition to this information, a standard deviation and an uncertainty were calculated for each of the measurements.

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Table 2: List of CoP obtained and their Standard Deviation and Uncertainty.

Tests	Measures	COP	Arithmetic Average	Weighted Average	Standard Deviation	Uncertainty	
		DC	DC	DC	DC	DC	DC
A	1	2,41	2,43	2,50	0,18	0,23	2,50 ± 0,23
	2	2,31					
	3	2,73					
	4	**2,27**					
B	1	2,66	2,39	2,34	0,38	0,32	2,34 ± 0,32
	2	2,61					
	3	2,46					
	4	2,64					
	5	2,35					
	6	2,03					
	7	2,11					
	8	2,08					
	9	2,44					
	10	**2,50**					
C	1	2,33	2,41	2,39	0,38	0,18	2,39 ± 0,18
	2	2,33					
	3	2,52					
	4	2,54					
	5	2,21					
	6	2,26					
	7	2,57					
	8	**2,50**					
Average		**2,40**	**2,41**	**2,41**	**0,31**	**0,24**	**2,41 ± 0,24**
Lower		**2,03**	**2,39**	**2,34**	**0,18**	**0,18**	
Highest		**2,73**	**2,43**	**2,50**	**0,38**	**0,32**	

The final CoP values to be considered should be as follows (with their associated uncertainty):

- CoP (DC): 2,41 ± 0,24.

These uncertainty values are due to the fact that the CoP value is not constant and varies greatly over time, as can be seen in the graphs below. Each of the graphs translates one of the tests (A, B and C) and graphically displays the respective error bars for each measurement taken.

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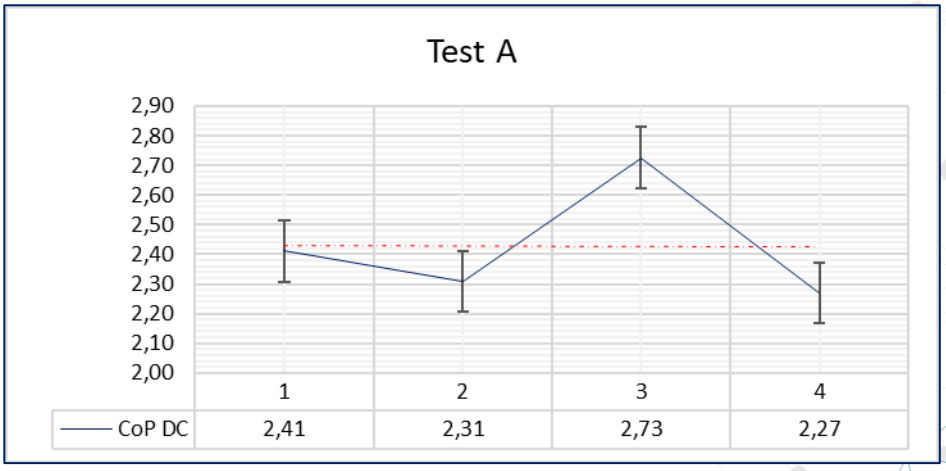

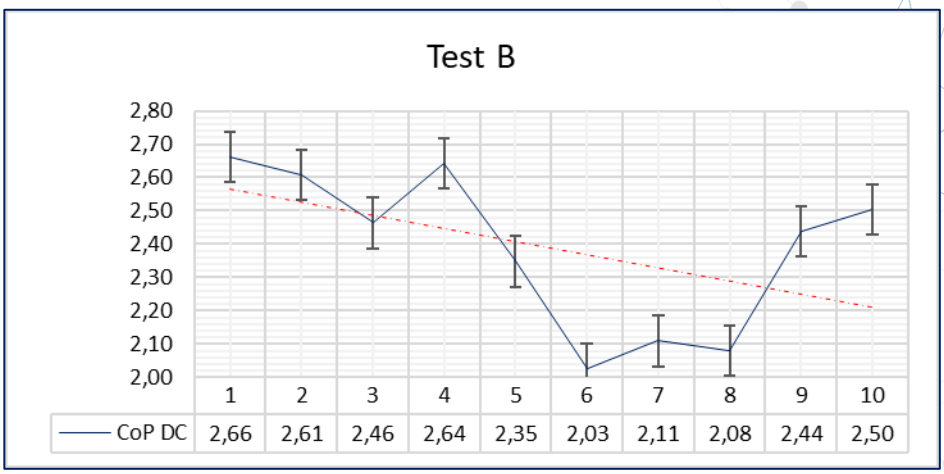

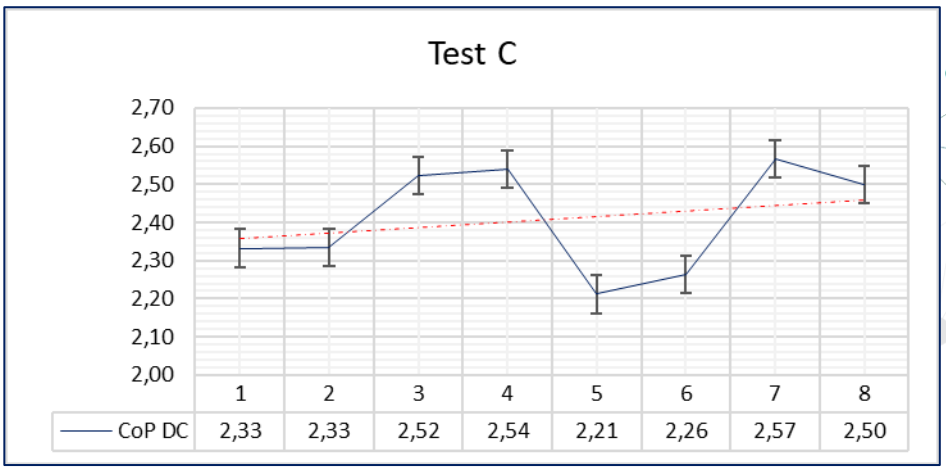

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7. Conclusion

Indeed, from the measurements results we obtained we witnessed a calculation of a Coefficient of Performance of the device *EnergyCell* that increases significantly, for CoP DC approximately two times, the electric energy that was injected in the device.

All the environmental conditions and relevant electric and thermodynamic parameters was monitored using calibrated instruments.

Also, there no perceptible emission of harmful ionizing radiations or radio frequencies that could cause any kind of injure for human body or other electric or electronic equipment's.

Note that since the last visit, one of the thermocouples has been removed (thermocouple T3 which was in the centre of the EnergyCell outlet), leaving only 3 thermocouples, one at the inlet and two at the outlet of the cell. This thermocouple was removed because the injection of air into the cell causes a swirl effect, which will cause the temperature on the side of the cell to be higher than the temperature in the centre. Thus, it did not make sense to have a third thermocouple installed in the centre, since it would only drastically lower the average temperature at the outlet and would not translate the real value of the CoP at the end.

Note: The IEP's personnel, that assisted and audited the *in loco* measurement process, treated all the *EnergyCell* system as a black box. We only did control the injected electric energy, the quantity of insufflate air and the outputted thermal energy. From that, using the relevant standard constants, we accessed the CoP values.

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8. Diagram

Schematic representation of the EnergyCell and all the inputs and outputs that could be monitored for the evaluating of the cell's efficiency.

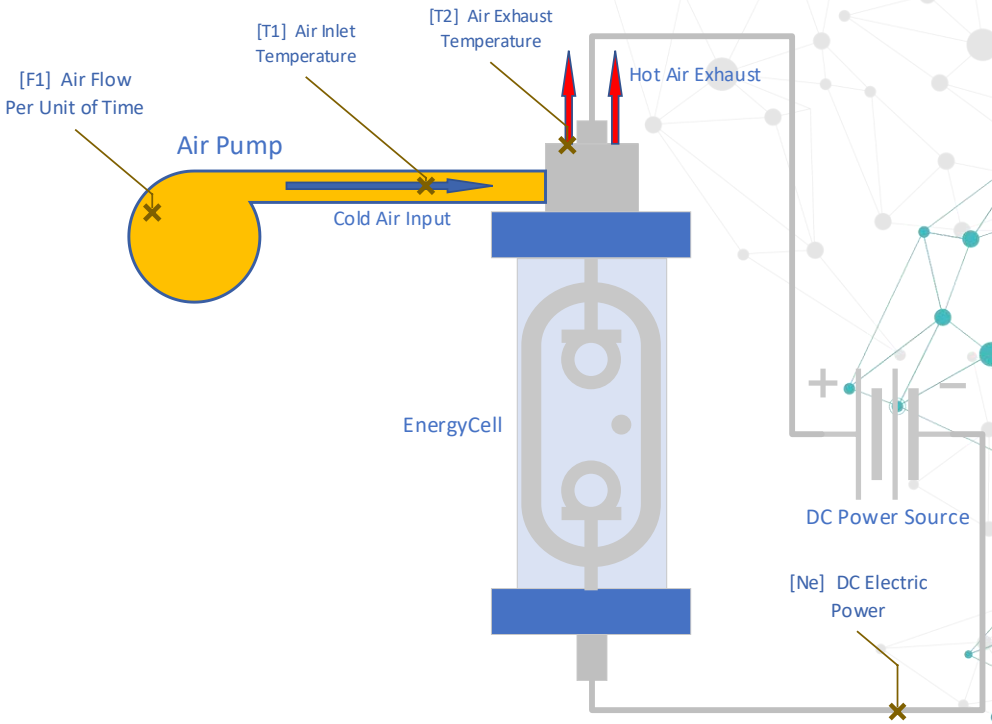

Figure – 1: Schematic representation of the EnergyCell.

Custóias, October 10th, 2023

IEP Team:
Modesto de Morais (Mcs.)
Tiago Teixeira (Eng.)
Teresa Canelas (Eng.)

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