ELY4OFF
PEM ELECTROLYSERS FOR OPERATION WITH OFFGRID RENEWABLE INSTALLATIONS

Grant Agreement 700359

PEM Electrolyser for operation with off-grid Renewable Installations. ELY4OFF Project

Pedro Casero

Head of Innovation Department(FHa)

Huesca, 23 May 2019

epic power

liten ceatech

ITM POWER Energy Storage | Clean Fuel

Inycom innovation technologies

Ha FUNDACIÓN PARA EL DESARROLLO DE LAS NUEVAS TECNOLOGÍAS DEL HIDRÓGENO EN ARAGÓN

MOTIVATION OF THE PROJECT

1) Off-grid locations

4) Suitable storage systems for RES

2) Diesel pollution

3) Intermitance of RES

PROJECT SUMMARY

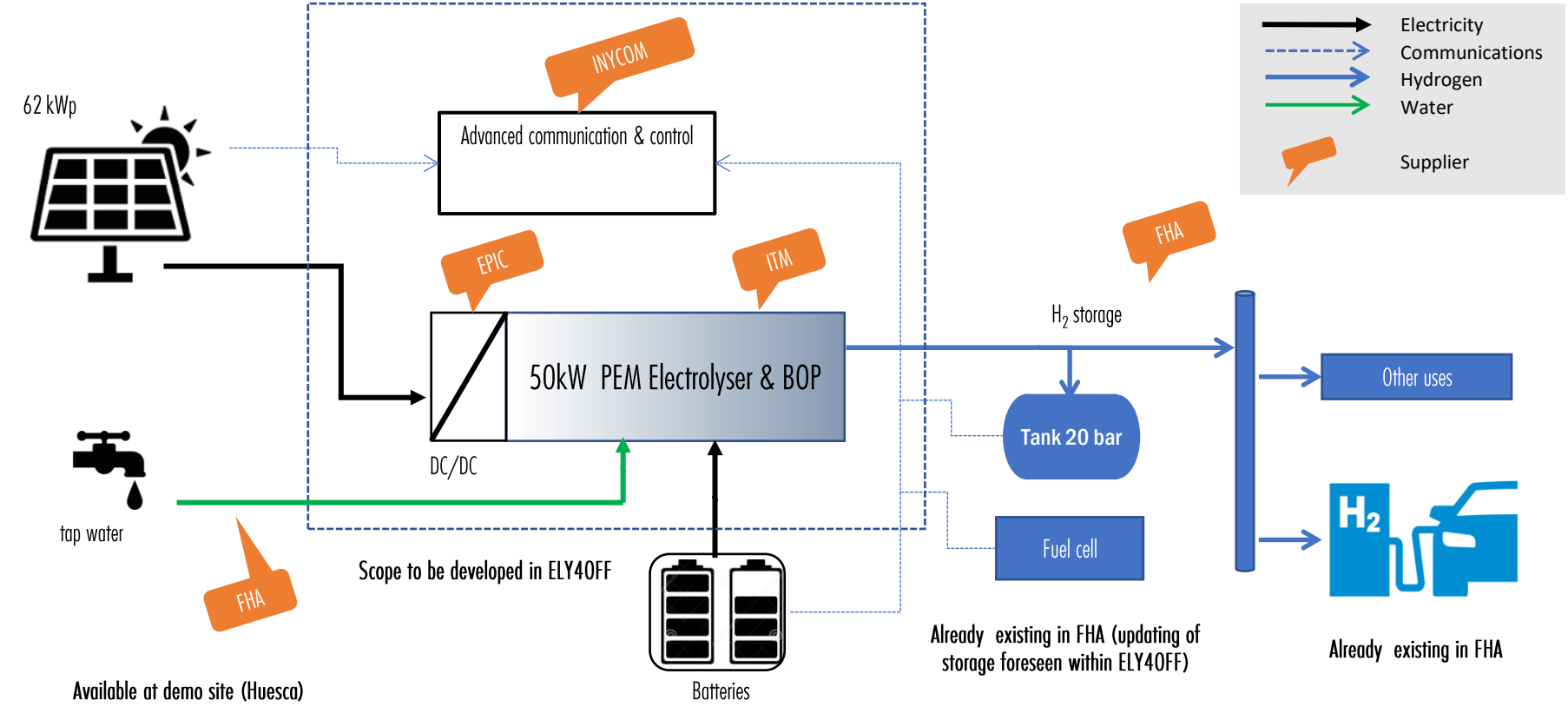
Purpose: the **development** and **demonstration** of an autonomous **off-grid** electrolysis system linked to **renewable energy sources**.

The ***PEMWE*** (Polymer Electrolyte Membrane Water Electrolyser) **industrial prototype** (50 kW) will be **directly linked** to track the solar **photovoltaic** power source producing over 1.5 tonnes of hydrogen per year and ensuring cold start and rapid response to changes

The ***demonstration*** **period** in a relevant environment (TRL 6) will last **8 months** and will take place in Huesca, Spain.

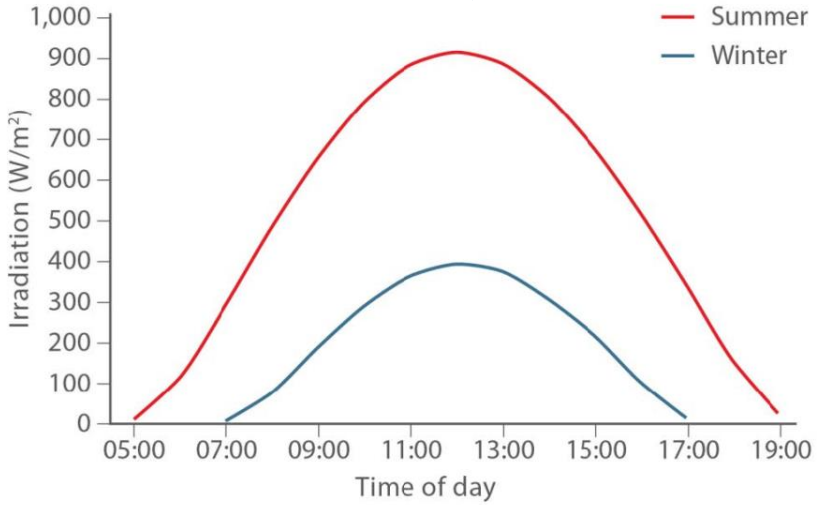
Grant number	700359
Start date	01/04/2016
End date	30/09/2019
Total Budget (€)	2.315.217,50 €

BASIC DIAGRAM

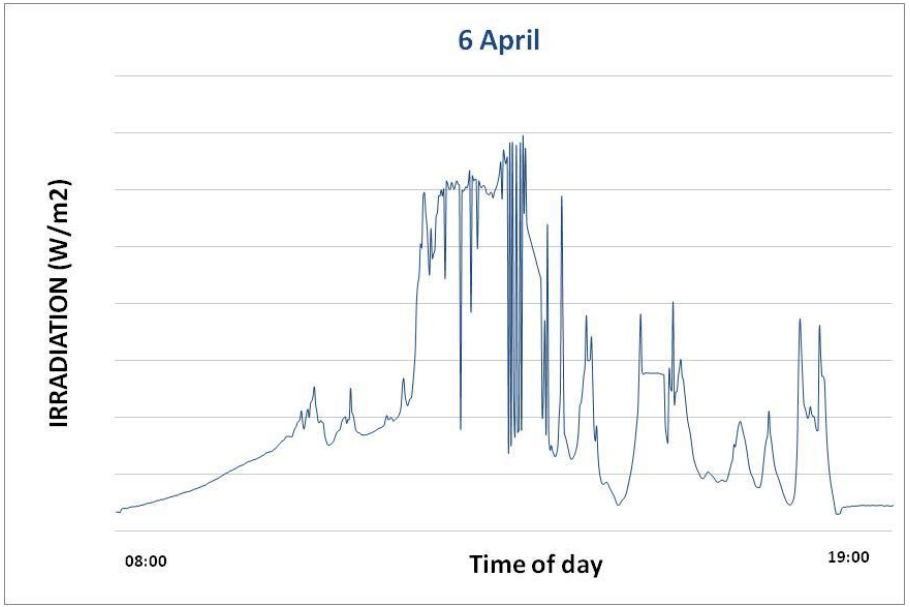


SINGLE ENERGY SUPPLY

Ideal profile



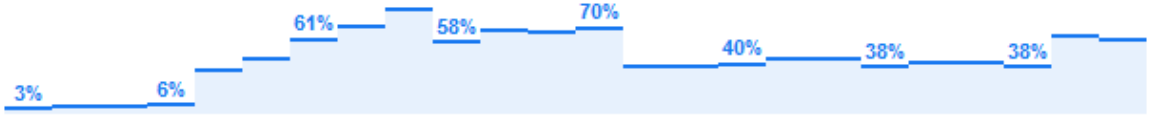
Real profile



SINGLE ENERGY SUPPLY

Precipitaciones: 90%
Humedad: 79%
Viento: 16 km/h

Temperatura | Precipitaciones | Viento



10:00	13:00	16:00	19:00	22:00	1:00	4:00	7:00
mar.	mié.	jue.	vie.	sáb.	dom.	lun.	mar.
21° 13°	20° 12°	23° 14°	24° 14°	26° 15°	26° 16°	24° 14°	24° 14°

SINGLE ENERGY SUPPLY

SINGLE ENERGY SUPPLY

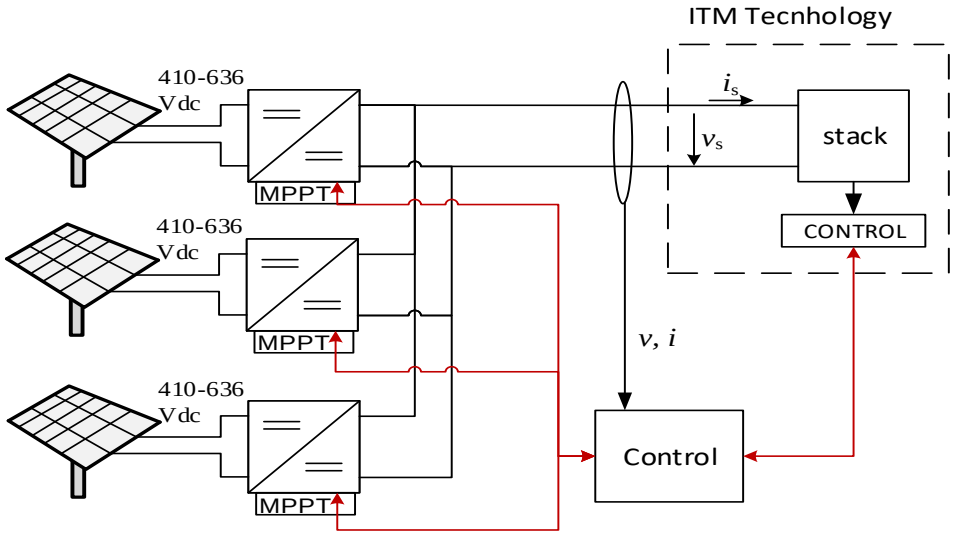
Challenge 1

Efficient and quick-response energy tapping

epic power

POWER ELECTRONICS SELECTION

Architecture	MPPT Efficiency	Conversion efficiency	Control complexity	Redundancy
DC/AC + AC/DC	Bad	Low	High	No
Parallel DC/AC + AC to DC	Good	Low	Very high	No
Parallel DC/DC + DC/AC + AC/DC	Good	Lowest	Very high	No
DC/DC	Bad	Good	Low	No
Parallel DC/DC	Good	Good	Low	Yes



Advantages:

- High conversion efficiency
- Optimal MPPT
- Redundancy
- Easy to control

Disadvantages:

- New DC/DC technology to be developed

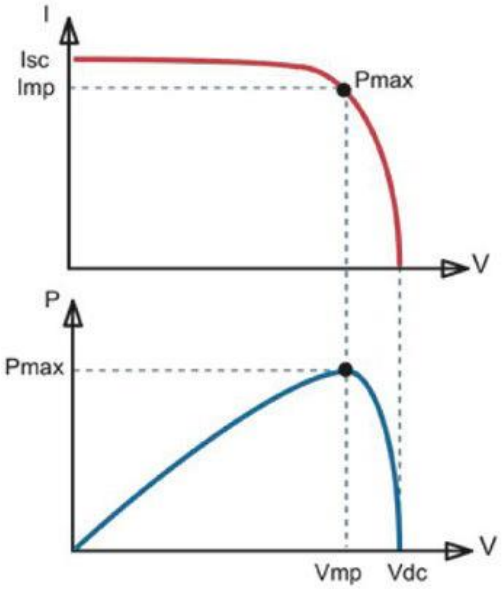
DCDC CONVERTERS

- ✓ To **adapt** the voltage produced by the PV field to the required voltage of the stack (with MPPT)
- ✓ Capable of following RES **variability** quickly
- ✓ **Novel** electronic structure
- ✓ Effiencies > **92%** in all conditions
- ✓ **13 units** (4,8 kW)

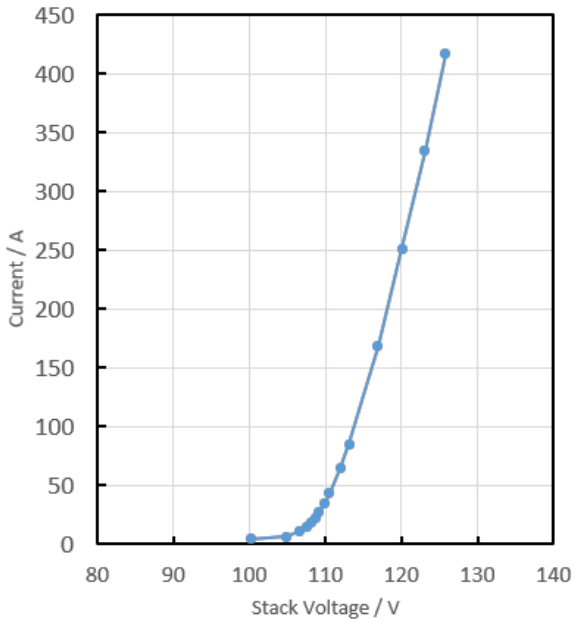
epic power

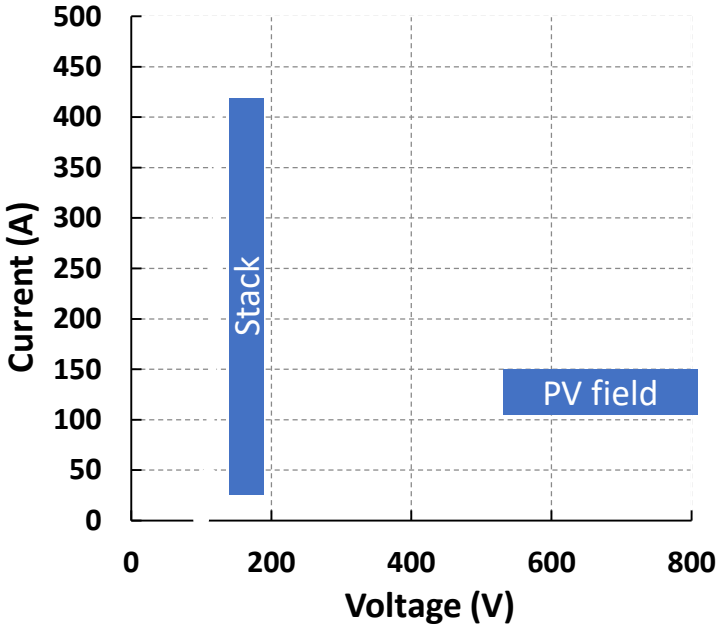
DCDC CONVERTERS

PV field output: 450 – 800 V



Stack requirements: 110 – 160 V



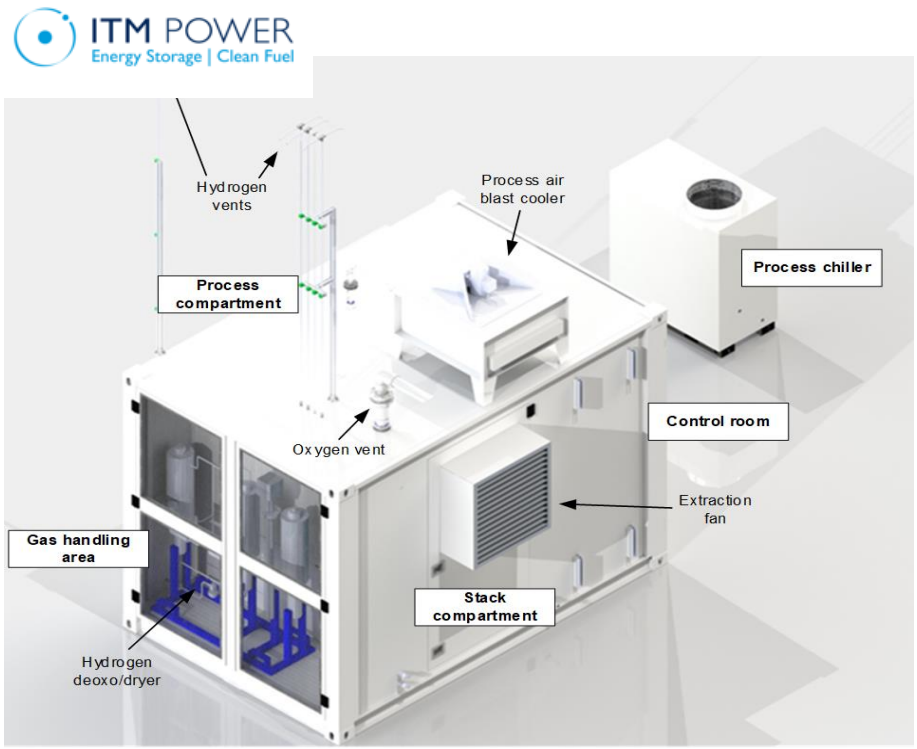


Challenge 2

Efficient and safe hydrogen production

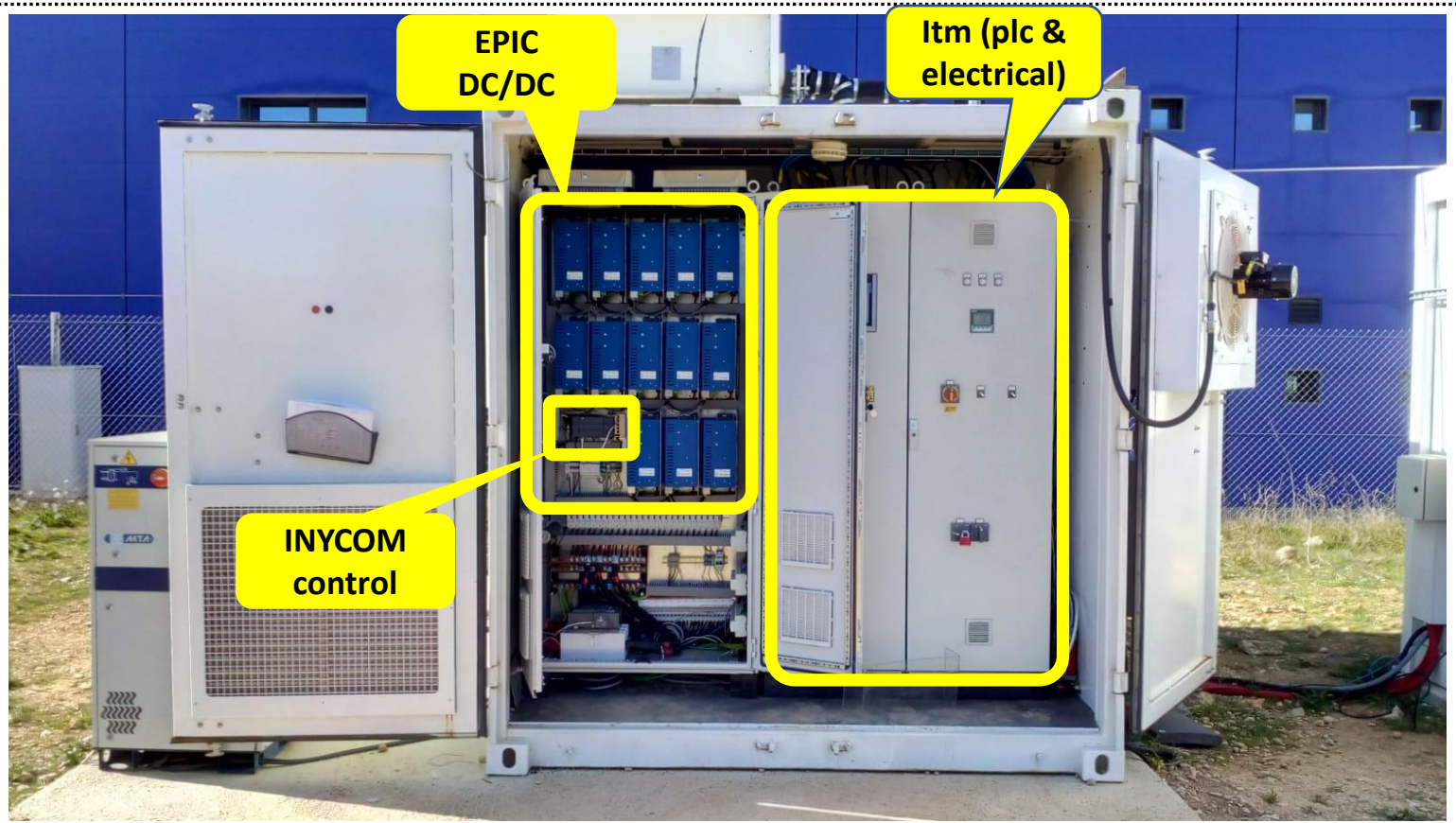
ITM POWER
Energy Storage | Clean Fuel

HGAS PEM ELECTROLYSER



- ✓ Promising results, but an MEA could not be developed in time -> a **commercial MEA** was tested
- ✓ Optimization of **BoP consumption** (variable pump, thermal insulation, …) < 1kW during nights (except anti-freezing actions)
- ✓ Non-typical **FAT:** no rectifier at factory -> on site after DCDC integration
- ✓ Final tests done 5-8 Feb 19 were successful: **good dynamic response**
- ✓ Many **control modifications** due to off-grid

ELECTROLYSER CONTAINER

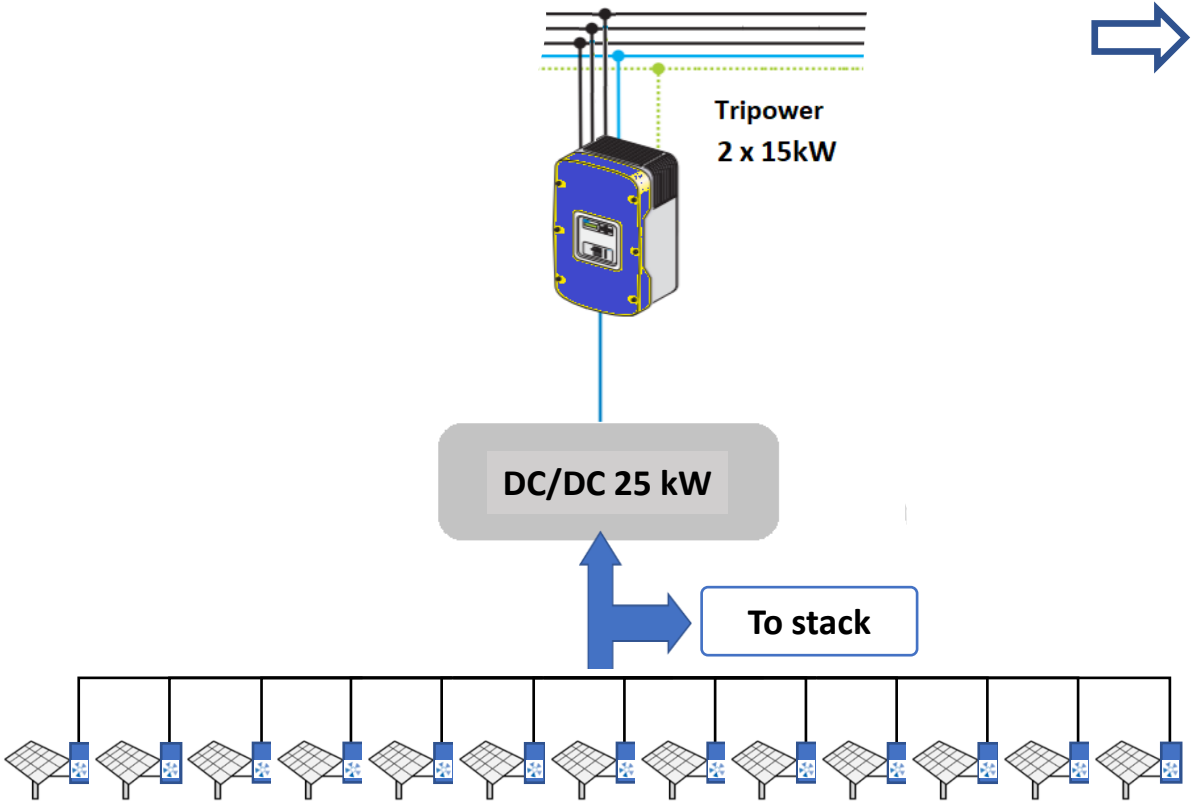


Challenge 3

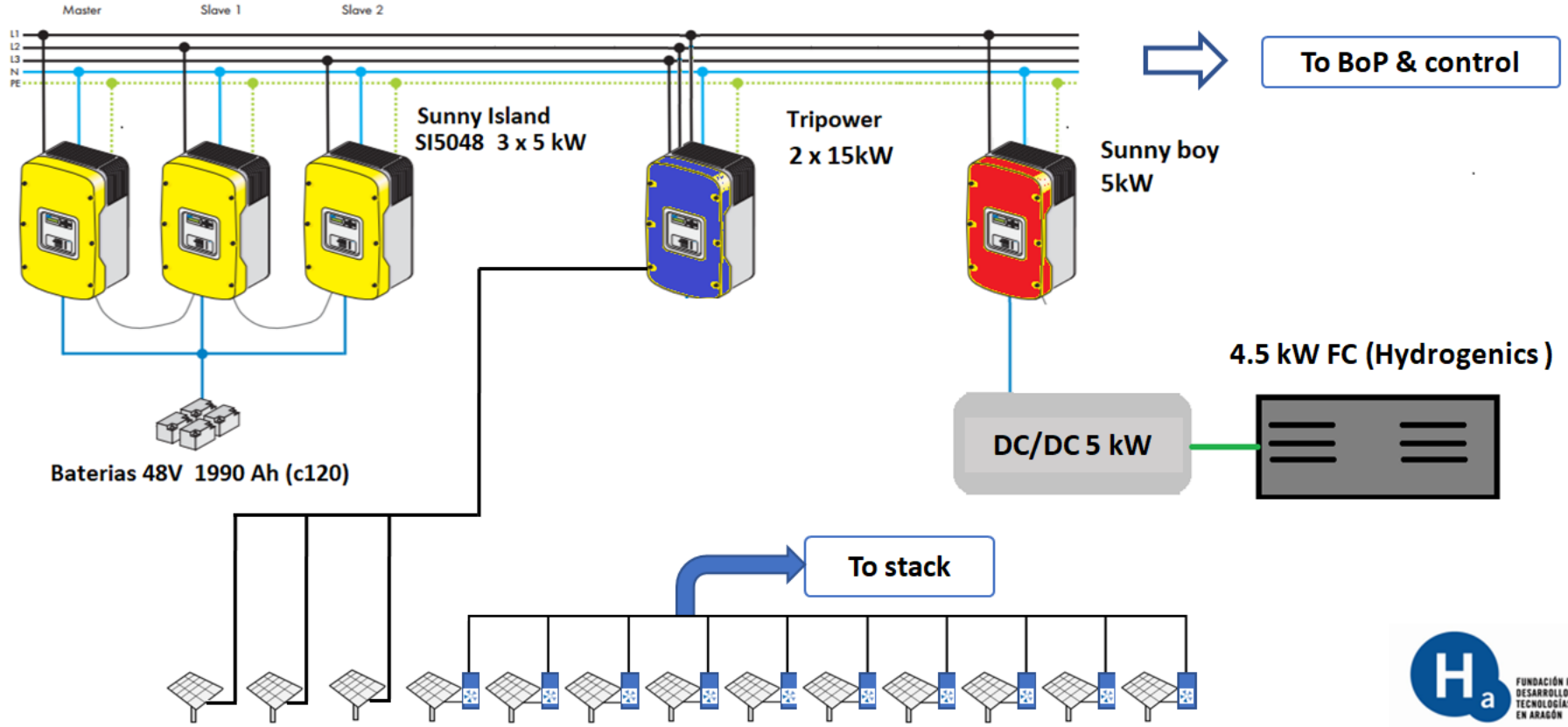
Robust energy management & vital support

FUNDACIÓN PARA EL DESARROLLO DE LAS NUEVAS TECNOLOGÍAS DEL HIDRÓGENO EN ARAGÓN

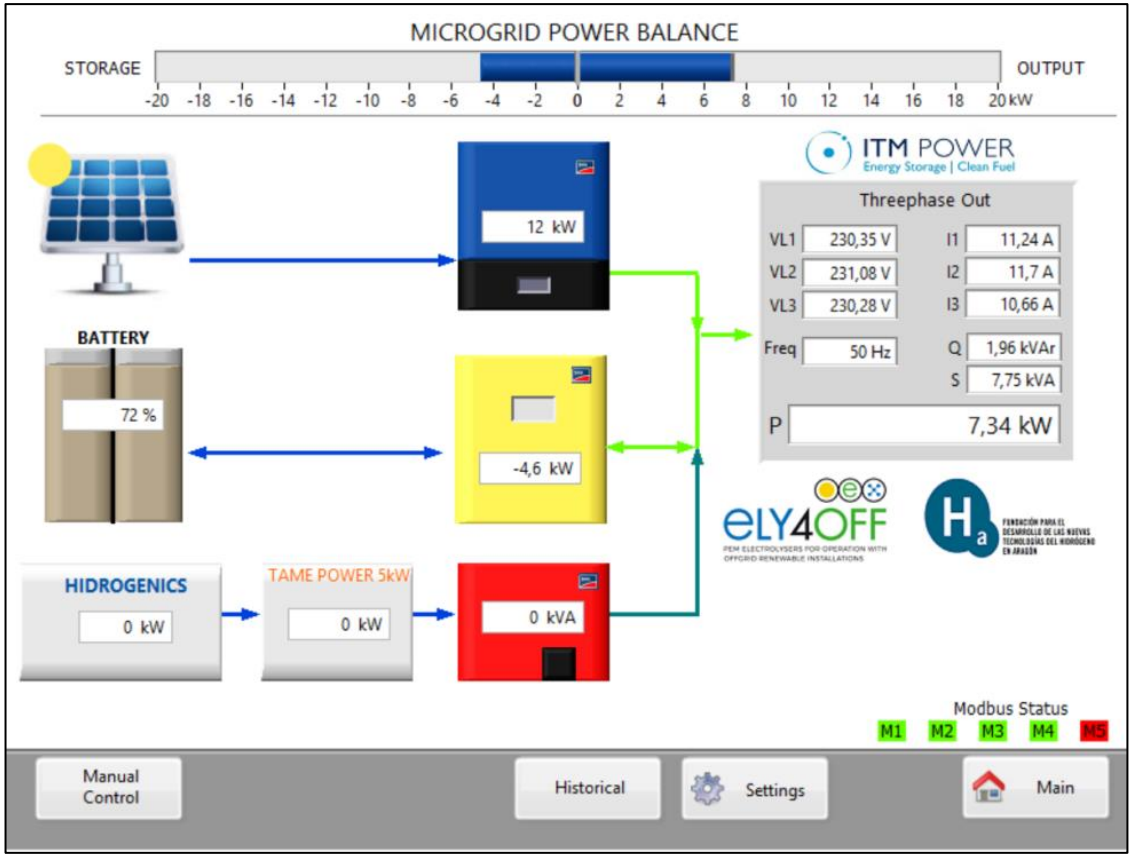
HYBRID STORAGE SYSTEM



HYBRID STORAGE SYSTEM (Approach 2)



FC AND MICROGRID SCADA SCREENSHOTS



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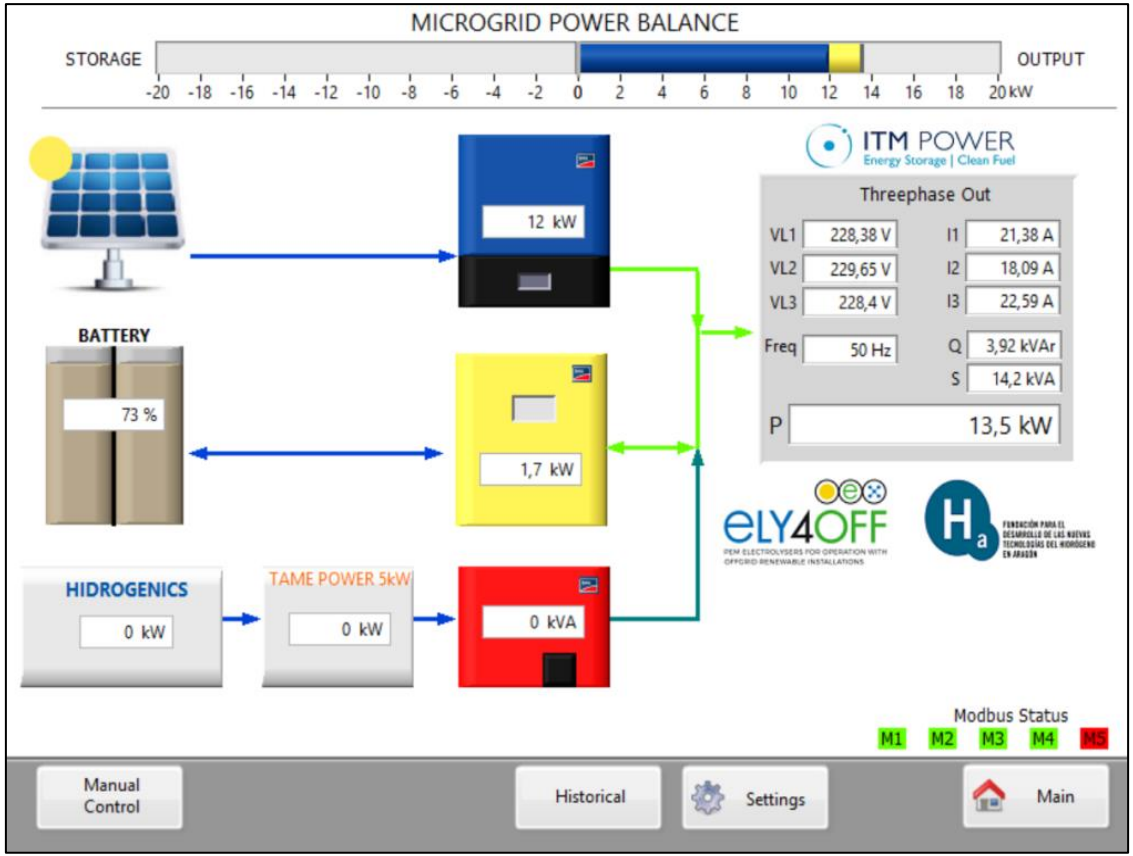

Challenge 4

An efficient and reliable control and command system of the whole plant

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OVERARCHING COMMUNICATION AND CONTROL

Inycom

Idle

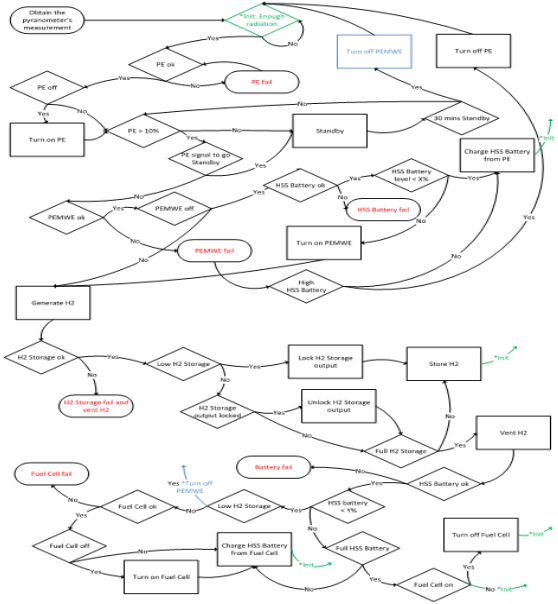
The PEMWE's BOP **essential consumptions** are covered (PLC, anti-freezing system) as well as the PLCs in the microgrid. **24/7**

Standby

The PEMWE's BOP **non essential consumptions** are covered, as well as those covered in the Idle status

Generation

The PEMWE's stack is **generating hydrogen**, being the BOP consumptions also covered.



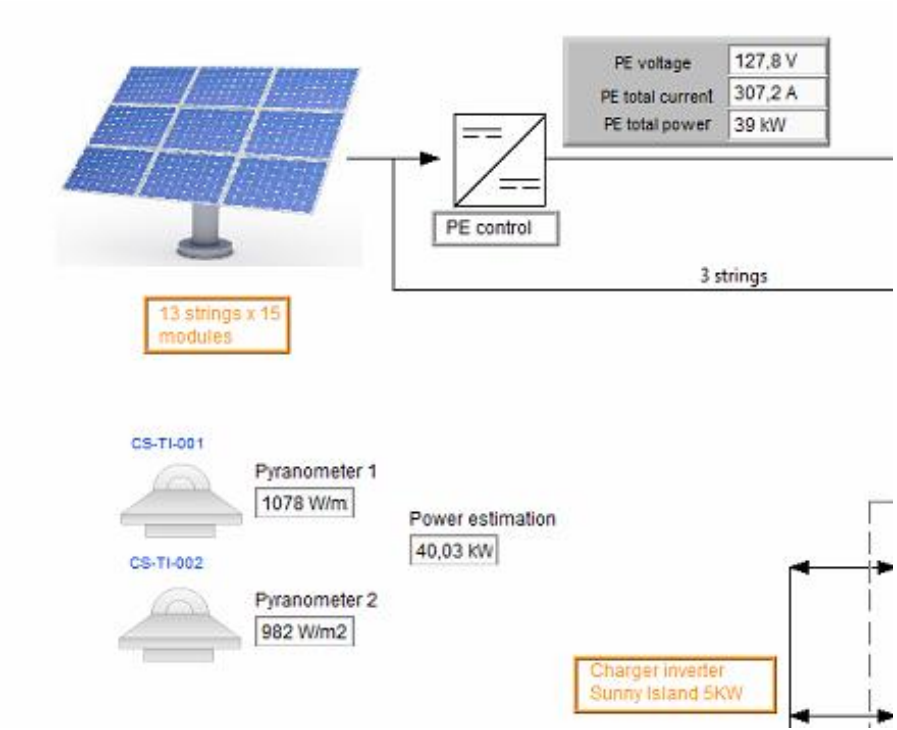
OVERARCHING COMMUNICATION AND CONTROL SYSTEM (C&CS)

CHALLENGE
To estimate available power when the PEMWE is not in generation to decide to enter in production

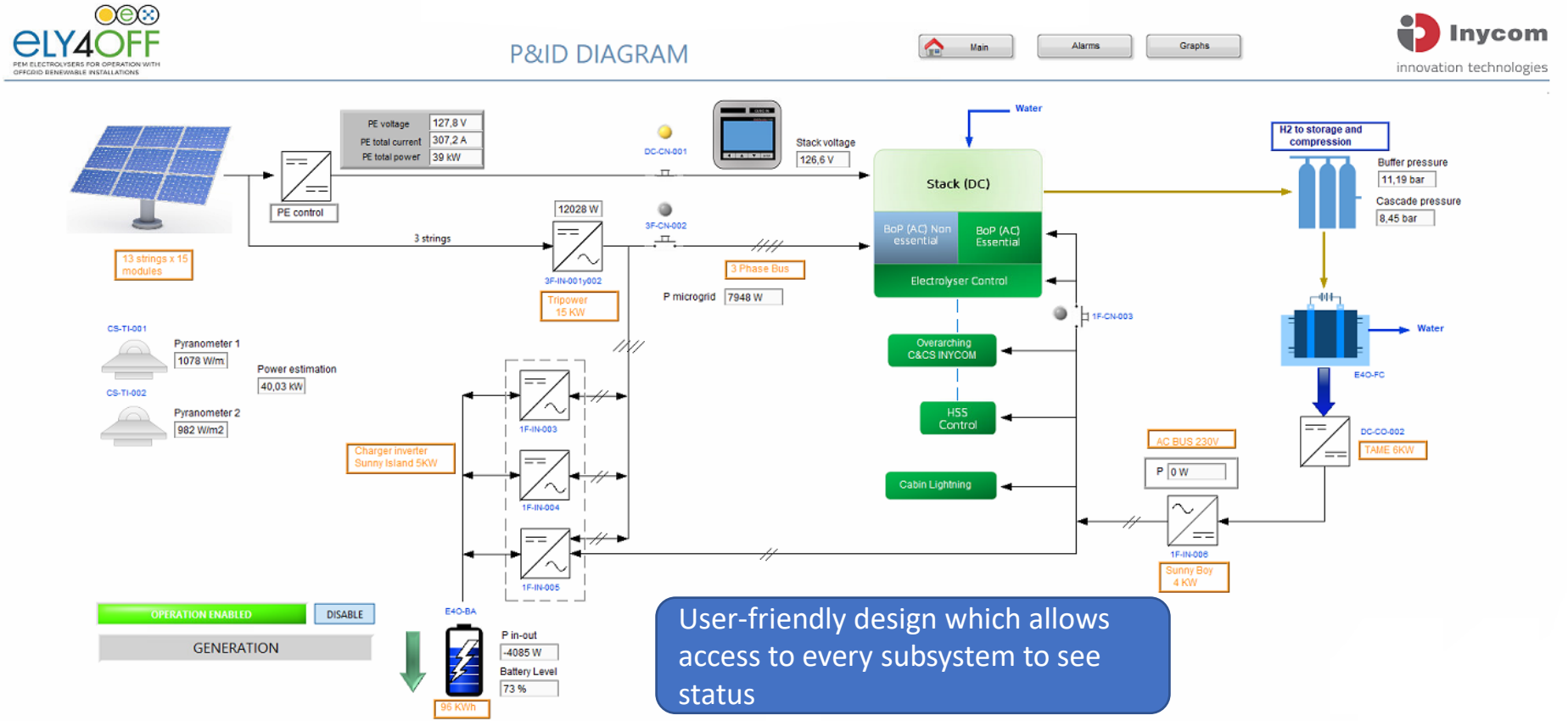
PROBLEM
power from PV is estimated with radiation

SOLUTION
Data analytics for power-radiation estimation:
a. Historical data (radiation, Tª amb)
b. Interpolation between hourly values of radiation

Plus shadow correction!



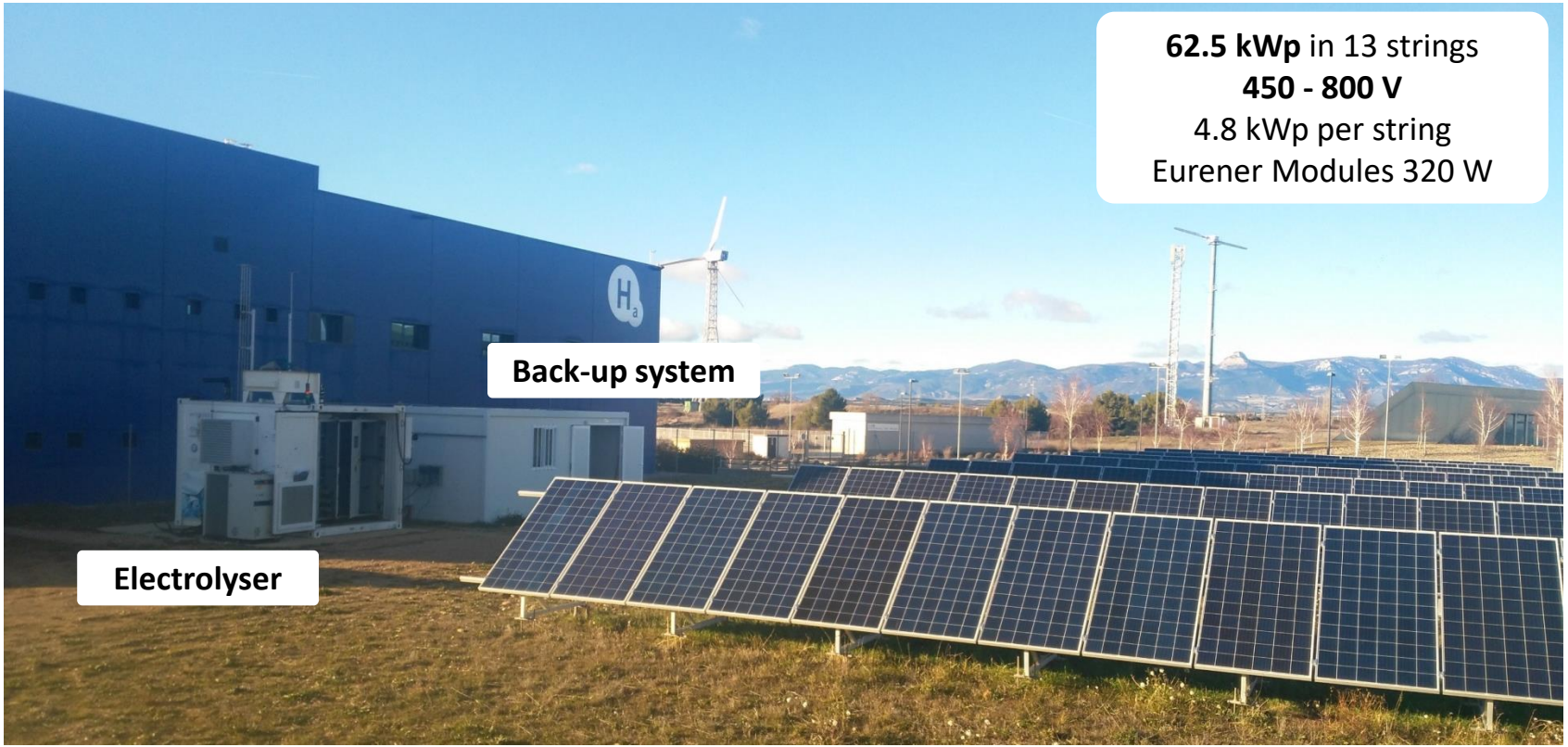
ELY4OFF SCADA SCREENSHOT



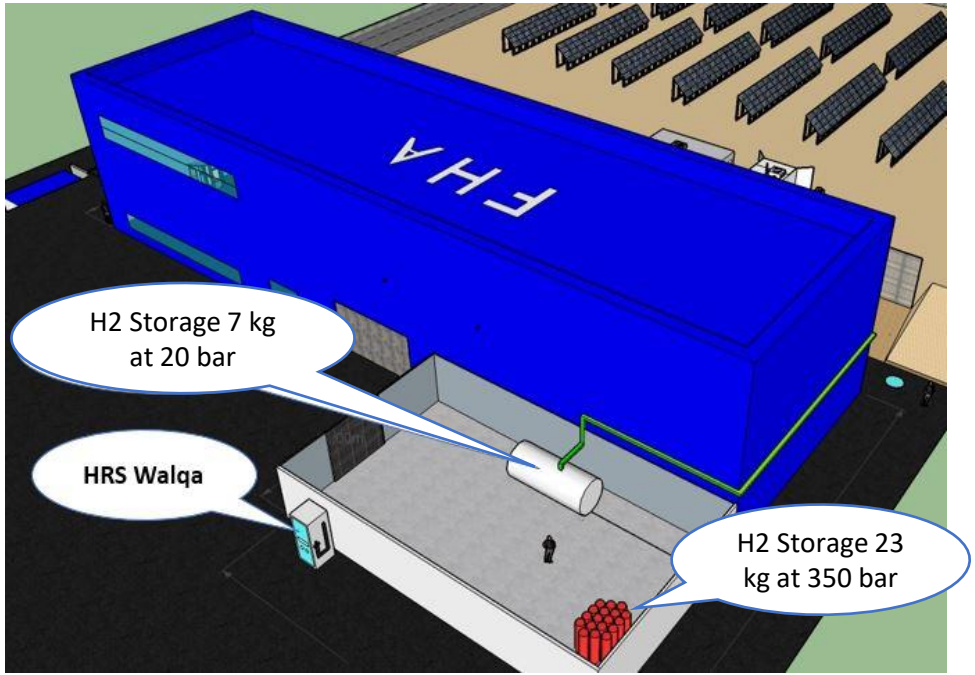
User-friendly design which allows access to every subsystem to see status


DEMO-SITE

DEMO SITE (Huesca)



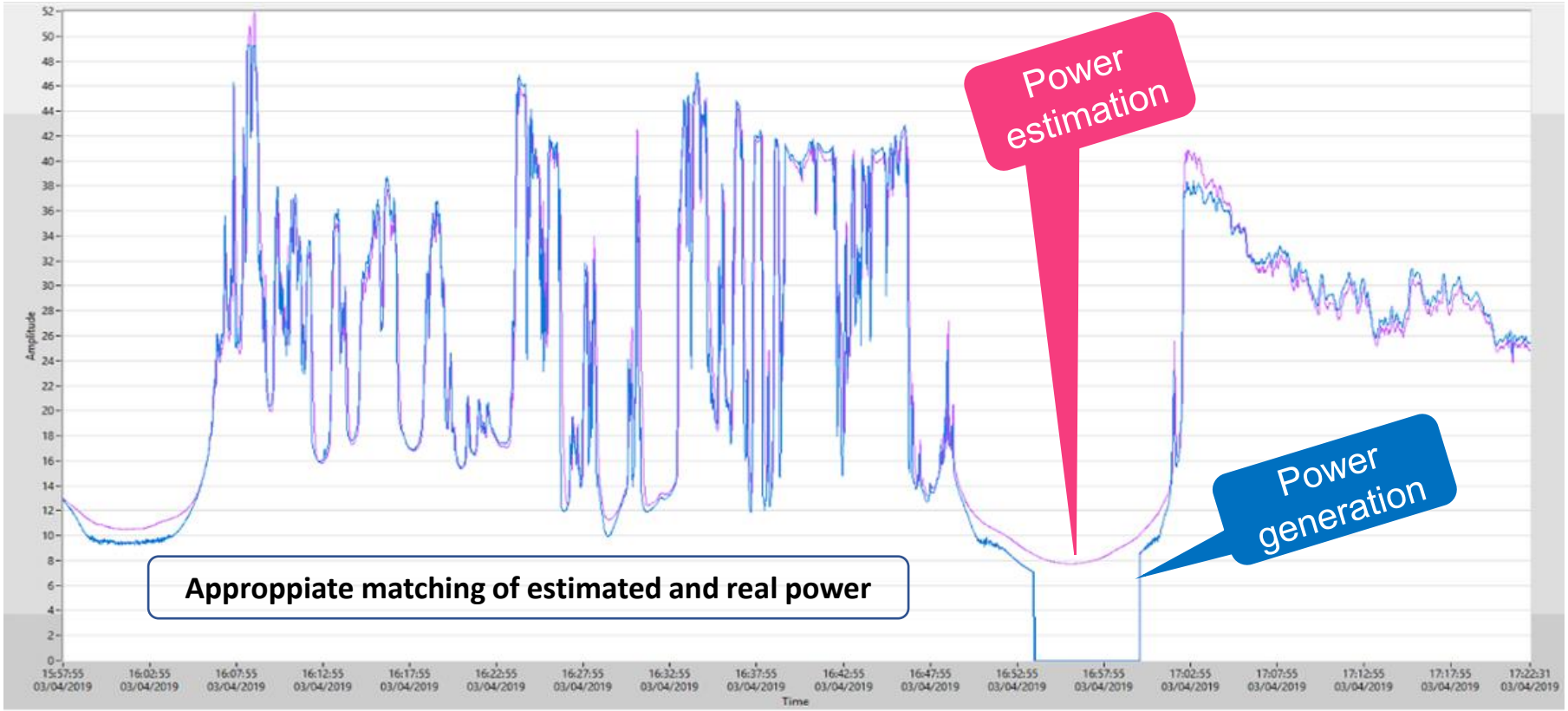
DEMO SITE (Huesca)



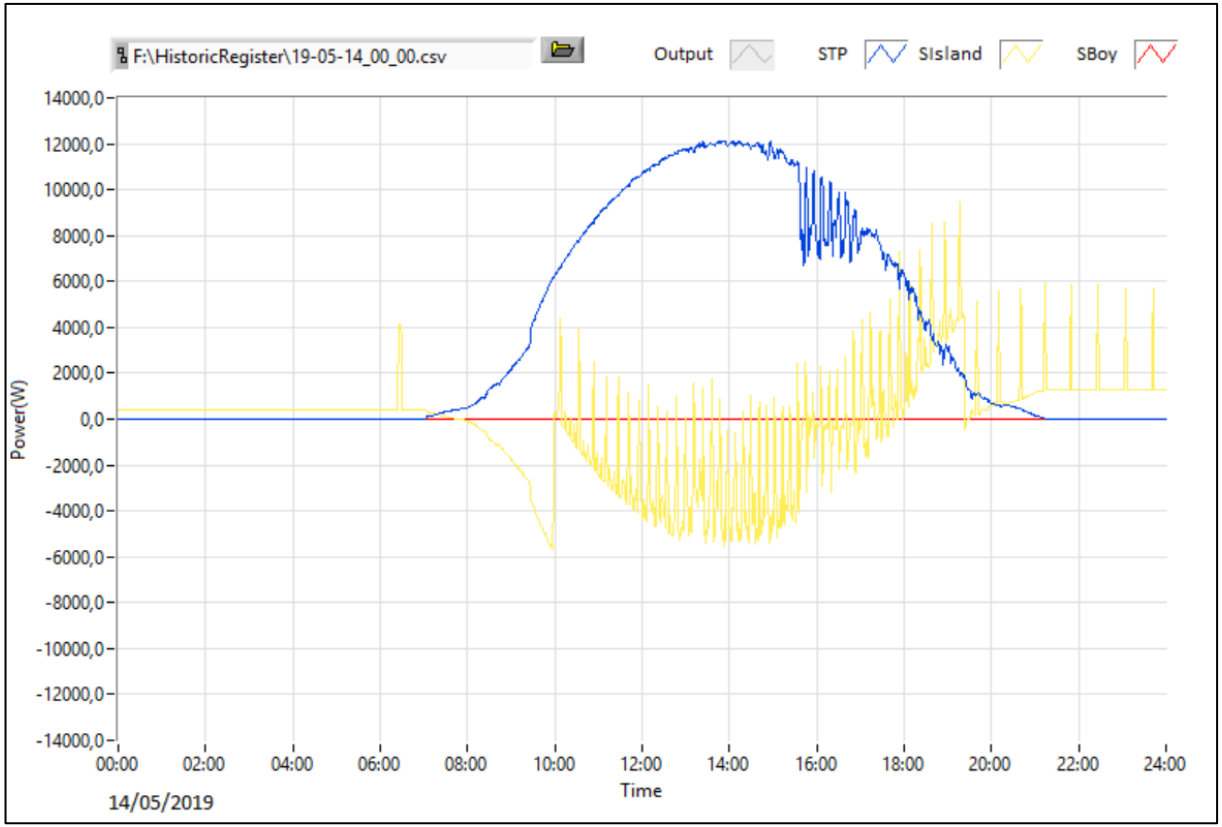
HYBRID STORAGE SYSTEM

DEMONSTRATION PHASE

Power profile



DEMO PHASE RESULTS



Sunny boy 5kW

Sunny Tripower 15kW

Sunny Island 3x15kW

DEMO PHASE RESULTS

113 kilograms of renewable hydrogen produced in 73 days!

KPIs of the system: on evaluation

Efficiency, lifetime and voltage degradation

Parameter	ID	Units	Ely4off target (proposal)
Efficiency	KPI_1	kWh/kg	System 50 Stack 42.4 92.5% *at 100% load*
	KPI_2	kWh/Nm³	4
Stack lifetime	KPI_3	h	
	KPI_4	years	8
System lifetime	KPI_5	h	
	KPI_6	years	20
Efficiency degradation	KPI_7	%/year 8000h	2
Availability	KPI_8	h/year	
	KPI_9	%	

Capital cost

Parameter	ID	Units	Ely4off target (proposal)
CAPEX	KPI_10	M€/(t/d)	6
	KPI_11	EUR/kW	

Stack

Parameter	ID	Units	Ely4off target (proposal)
Stack size	KPI_12	kW	50
Stack capacity	KPI_13	Nm³/h H_2	>13
		kg/d H2	

Operating conditions

Parameter	ID	Units	Ely4off target (proposal)
Current density	KPI_14	A/cm²	1
Output pressure	KPI_15	bar	20
Operating temperature	KPI_16	°C	60

Dynamic and flexible operation

Parameter	ID	Units	Ely4off target (proposal)
H_2 production flexibility with a degradation < 2%	KPI_17	Load Spanning Range (%)	5 – 150%
Hot start (min to max power)	KPI_18	seconds	2
Cold start (min to max power)	KPI_19	minutes	<5
Minimum part load	KPI_20	%	10
Ramp up (sec to full load)	KPI_21	% full load/s	2

Others

Parameter	Units	Objectives (D2.4)
Capacity of the system - rated	kW	56
Efficiency of the PSU	%	>96
Power of the control system when off	kW	<0.9
Footprint - hydrogen production unit	M2	4
Volume	M3	8
Nature of the electricity source		SOLAR
Fraction of renewable energy input	%	100
Quality required for water	µS	<1
Purity of the produced hydrogen - rated	%	99.9995
Type of power converter		DC-DC
Input voltage	V	800
Power usage of auxiliary equipment - idle	kW	0.9
Power usage of auxiliary equipment - max production	kW	7
Electrical efficiency of the system (rated - HHV - AC current)	%	82
Cost - capital cost of the system (per ton/day) @ mass production (estimate)	M€/t/d	0.015
Start date for reporting		
End date for reporting		
Number of safety incidents - total		
Electricity consumed		
Energy consumption for hydrogen compression		
Hours of operation		
Days of operation		

Wait, there are more …

Regulation, barriers, business cases, …

ODDISEY SOFTWARE

Inputs / Outputs of simulation

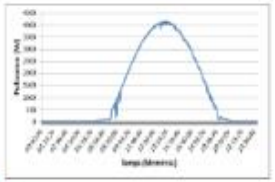
System inputs data

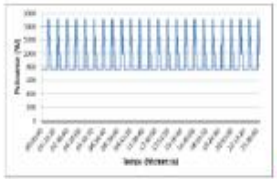
- Choice of the **components, models and parameters** (ex: investissement costs, life time of components, efficiency…)

- **Energy Management Strategy**

Inputs data of the application

- Times series

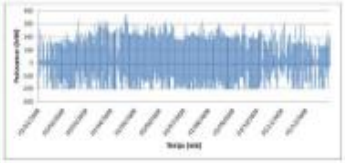


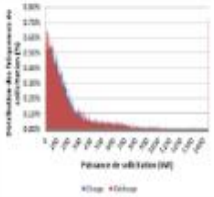


ODYSSEY

Outputs data

- Results of simulation specific to each component (times series, mass and energy balance sheets, …)





- Performance indicators of the systems:

Technical indicators (Rate of RE potential, the rate of satisfaction of the load, …)

Economic indicators (system costs, profit, yield (rate of return), time of return on investment)

Previous Next

BUSINESS CASES

CASE 1

RE-ELECTRIFICATION

CASE 2

POWER TO GAS

CASE 3

MOBILITY

CURRENT STATUS

- ✓ **Demo is on-going**:
  - ✓ Storage of information for data analytics
  - ✓ Currently criteria is to maximize H2 production, but forecasting of solar production and prediction of demand via self-learning may be useful
  - ✓ Predictive maintenance
  - ✓ Optimization of energy flows to increase overall efficiency (e.g. optimal usage of batteries avoiding very short isolated charging periods, etc.)
  - ✓ Study on adaptations for other configurations (e.g. micro-grid connected to main electricity network, connection of mini-wind turbines, etc.)
- ✓ Other **on-going activities**: LCA, cost analysis, exploitation plan, …

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No (700359). This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe research.

Many tanks for your attention,

Pedro Casero

Head of Innovation Department

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