GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN
PTI TRANSENER CSIC Consejo Superior de Investigaciones Científicas
Plan de Recuperación, Transformación y Resiliencia
Financiado por la Unión Europea NextGenerationEU
PTI-TRANSENER+
Transición Energética Sostenible

Vanadium redox flow battery - 50 kW

CSIC strategic initiative for stationary and large scale electrical energy storage

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Interdisciplinary network to drive energy transition
(PTI-TRANSENER+)
ww.pti-transener.csic.es

CSIC: Consejo Superior de Investigaciones Científicas
Spanish Council for Scientific Research

7th
Public research institution at global scale

Top 5
European institution by number of actions H2020

11,000
People

120
Institutes, centres, units

14,000
Articles published per year

+3,500
Ongoing projects

450
Protected technologies

+600
PhD Thesis defended per year

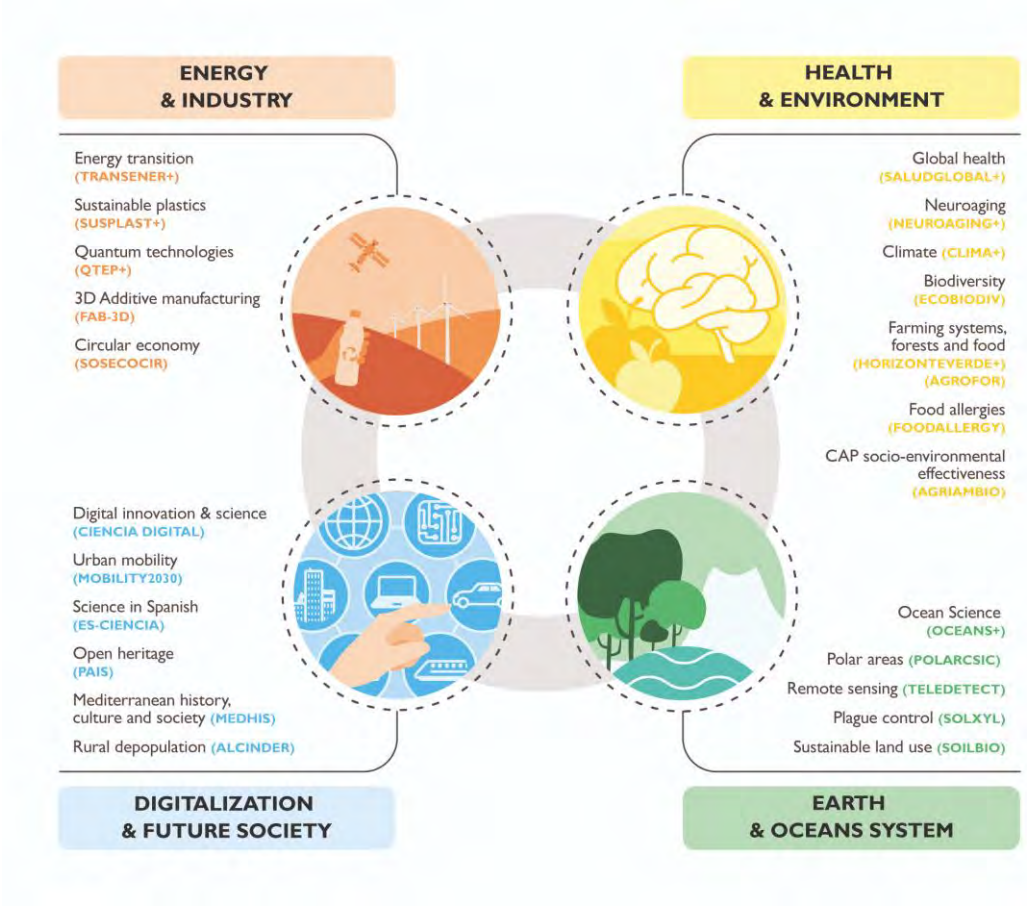
The creation of Interdisciplinary Networks

The PTIs are instruments of research and innovation, created to address multidisciplinary challenges of great scientific, economic, and social impact

Energy and Industry

PTI-Transener+

Digitalization and Future Society



Global Health

Earth Systems and Oceans

PTI-TransEner+

Sustainable Energy Transition

Our commitment to a clean, sustainable and smart energy future

IMPACT

Scientific: Increased knowledge of new materials and processes with application throughout the energy cycle (production, distribution, storage and use).

Technological: Availability of know-how, demonstrators and prototypes incorporating innovative technologies with a high technology readiness level and great application potential.

Social: Contribution to the development of an affordable, reliable, sustainable and competitive energy system, in a growing context of resource scarcity, increased energy needs and climate change.

THEMATIC AREAS AND INITIATIVES

The **PTI** groups its activities in different strategic areas in which the different initiatives or most relevant projects are integrated.

Renewable Generation

- *Demonstration of a biorefinery of agricultural residues for biofuels (CSIC-BIORREFINA).*

Efficient Energy Storage

- *Demonstrador of a 50 kW redox flow battery (VRFB-50k).*

Industrial Decarbonization

- *Demonstration of Calcium Looping technologies.*
- *Oxycombustion demonstration platform.*

Hydrogen Technologies

- *H_2 refuelling station with advanced energy managemente and renewable generation.*
- *Implementaction of a 5 kW water electrolyser with an anion exchange polymeric membrane.*
- *Development of high temperature SOEC electrolyzers.*

PTI-Flowbat-2021

July-2018: I was requested by the Vice-president of CSIC to create a new Interdisciplinary Network on energy storage

September-2018: First meeting of the PTI (8 research groups)

October-2019: we leveraged 0.5 M€ budget to develop a 1 kW VRFB before June-2021
(1 stack of 5 cells with 40x40 cm^2 electrodes)

PTI-Transener+

April 2021: we obtained 3.9 M€ budget to develop a 50 kW VRFB in 2 years
(40 stacks with 50x40 cm^2 electrodes)

Final demonstration in a real environment (July-December 2023 in an Energy Community in Salamanca)

From 1 cm^2 test in a 3 electrode cell to a 50 kW demonstrator in 5 years

The Carbon Science and Technology Institute

INCAR

The Institute of Chemical Technology

INSTITUTO DE TECNOLOGÍA QUÍMICA

The Materials Science Institute of Madrid

icmm

Institute of Polymer Science and Technology

ICTP
Instituto de Ciencia y Tecnología de Polímeros

The Materials Science Institute of Barcelona

ICMAB
INSTITUT DE CIÈNCIA DE MATERIALS DE BARCELONA

The Institute of Carbochemistry

icb INSTITUTO DE CARBOQUIMICA

The Institute of Carbochemistry

icb INSTITUTO DE CARBOQUIMICA

The Institute of Microelectronics of Barcelona

CNM Centro Nacional de Microelectrónica IMB

The Institute of Robotics and Industrial Informatics

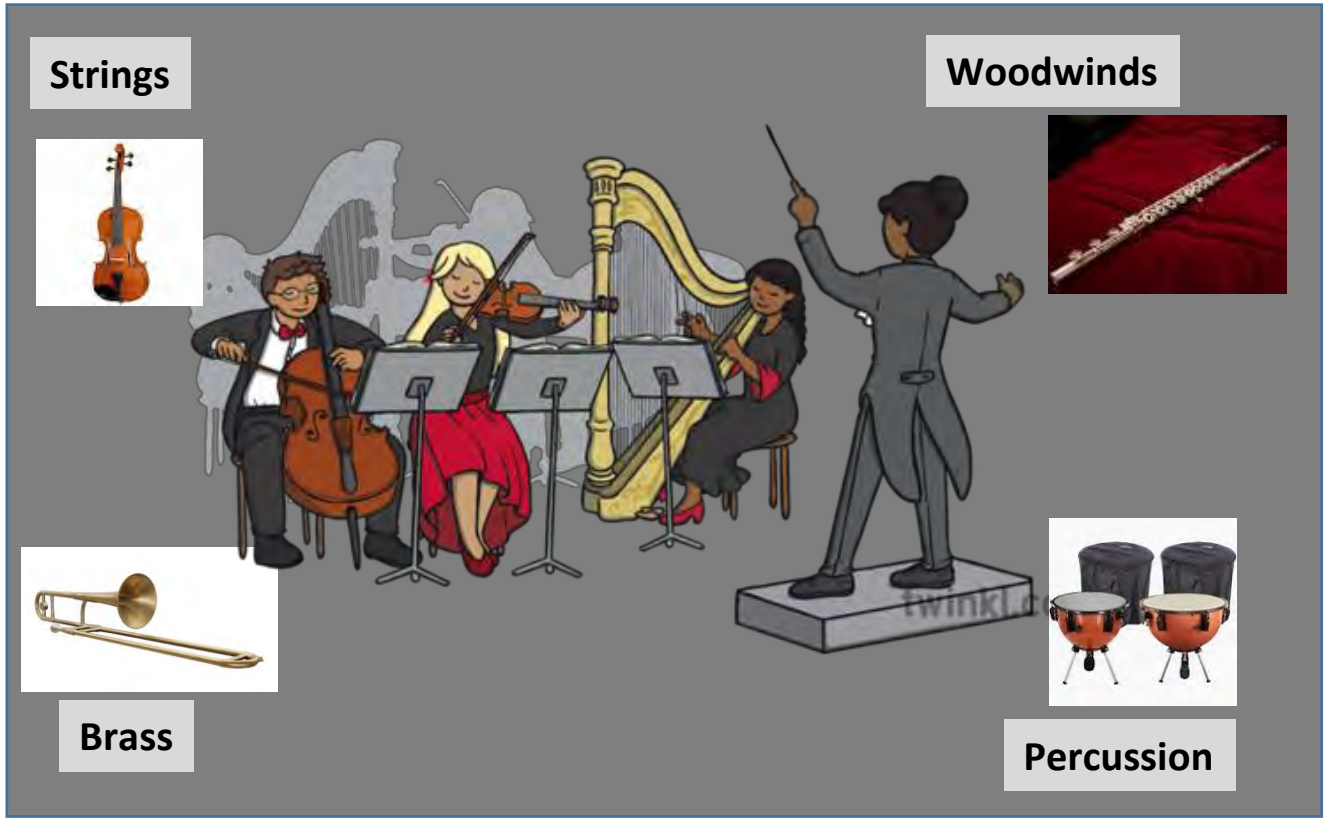
Institut de Robòtica i Informàtica Industrial

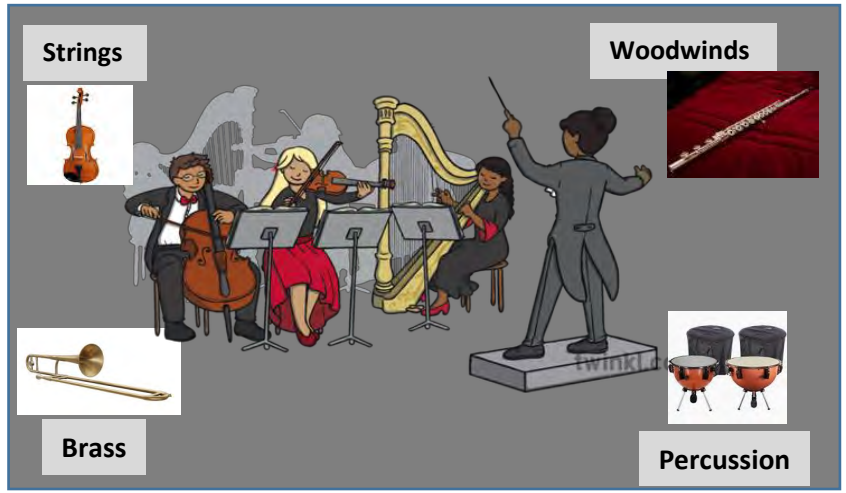
9 groups of 8 institutes

Chemists versus Engineers

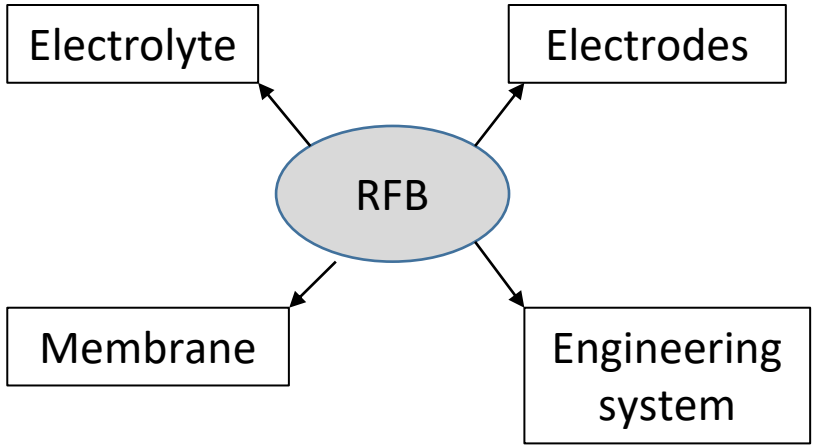
✓ **STAFF**: 27 researchers and **30 new recruitments**

RFB is like an orchestra

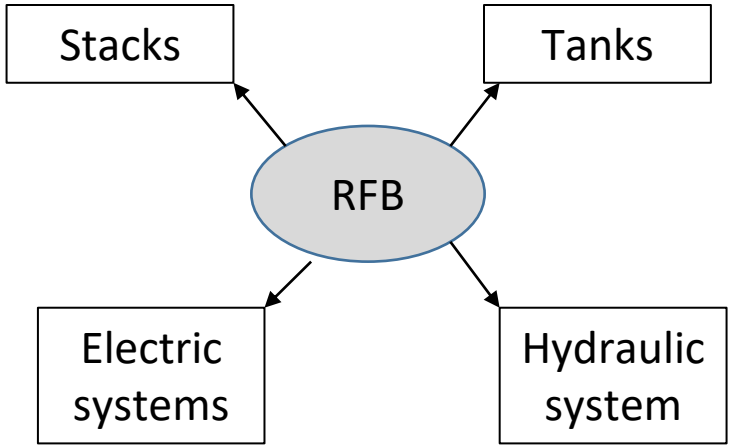




Main elements of a RFB for a chemist team

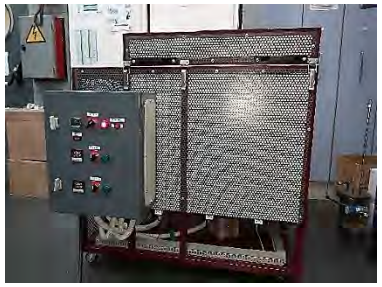


Main elements of a RFB for an engineering team



Main results

CHEMISTRY AND MATERIALS



1. Scaling up electrode fabrication by modifications of commercial carbon fiber felts (up to **20 felts** of 50 x 40 cm^2 per batch)
2. Modification of **commercial polymeric membranes** using different **additives and modifications of commercial electrolytes**

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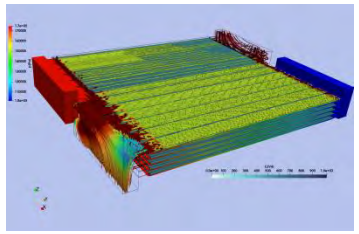
3. Design and characterization of **novel electrolytes**
4. Synthesis of **thin membranes** (sub-µm range)
5. Development of **advanced carbon materials** (GO, NFs and XGs) and other **novel** materials with **controlled porosity** and **enhanced surface properties**

Main results

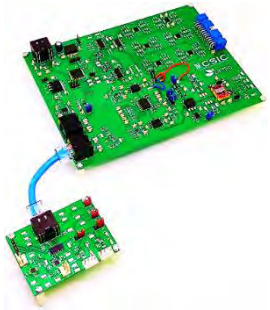
ENGINEERING AND CONTROL

1. Development of a **3D numerical code** using the **models** required to study the fluid-dynamics , thermal and electrochemical behavior of the VRFBs.



2. Design of an automatized **cycling system** (**hardware** and **software**) to check the **materials and operation strategies.**

3. Optimization of the **sealing systems**, aiming to avoid electrolyte leakages from the stacks.



4. Establishment of a **new electrochemical model** for **SOC** and **SOH** estimation, based on V_{RFB}, I_{RFB}, Q_{elect} y T_{elect} measurements.

5. Development of **in-house software and hardware** for **signal management** and **control** of the RFBs.

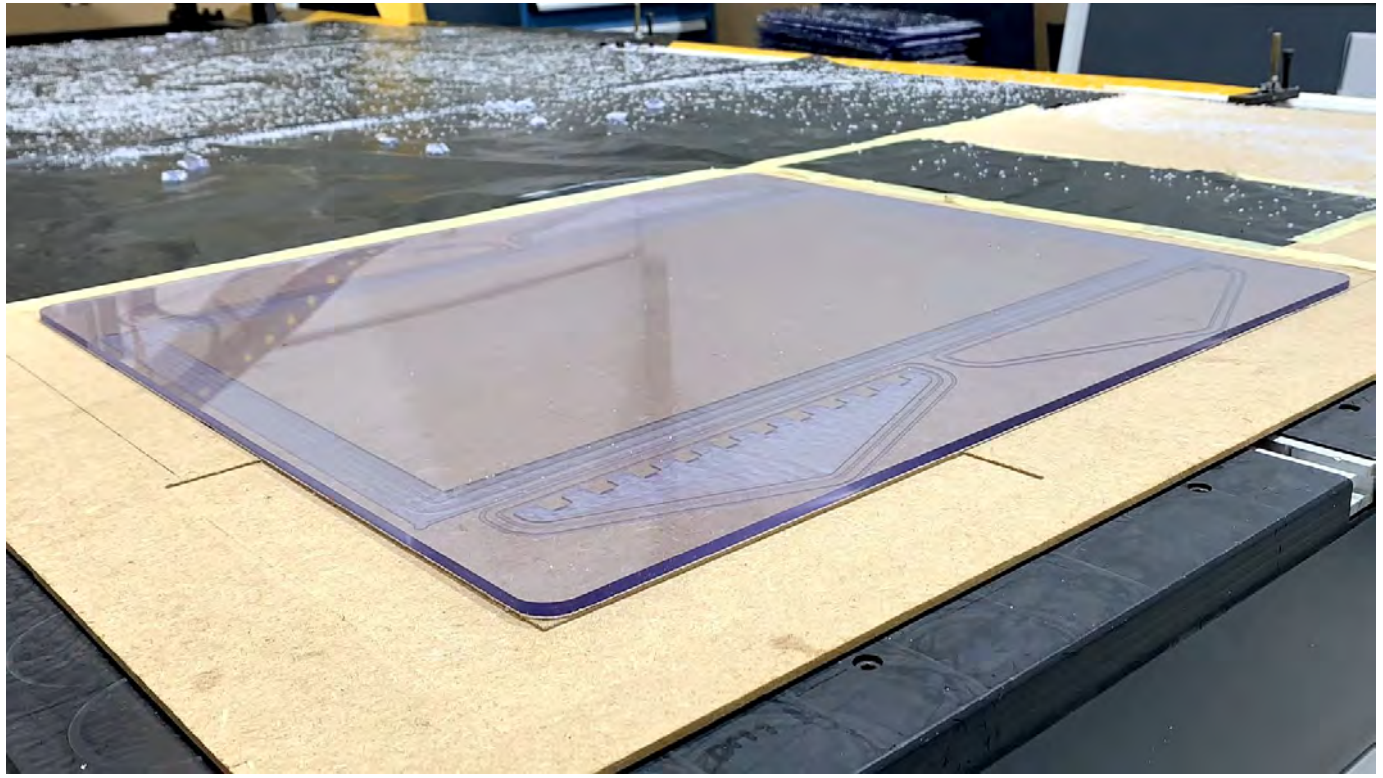
6. A **predictive control model** (PCM) has been developed for the **optimal control** of **energy flows** in a microgrid.

7. **The battery is already installed and testing is on**

VRFB manufacture: interesting data

➢ Stacks fabrication (40)

- ✓ **Mechanization** of **flow frames** (56 x stack)…… **2,240**



VRFB manufacture: interesting data

➢ Stacks fabrication (40)

✓ **Assembly** of the **flow frames** (**membranes and bipolar plates**)

- Cleaned surface…… **300 m²**
- Deposited adhesive 1… **9.5 km** (60 liters)
- Deposited adhesive 2…… **6.1 km** (3.5 liters)

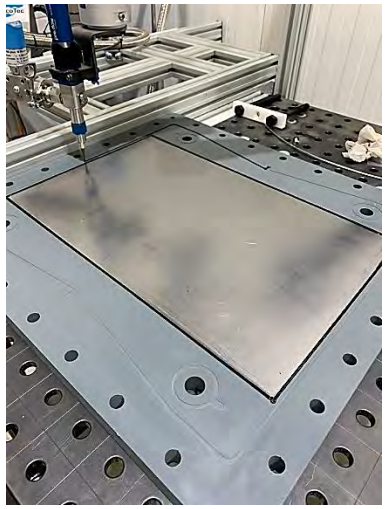
→ Assembly line with **3 ROBOTS CR5**

VRFB manufacture: interesting data

➢ Stacks fabrication (40)

✓ **Used elements**:

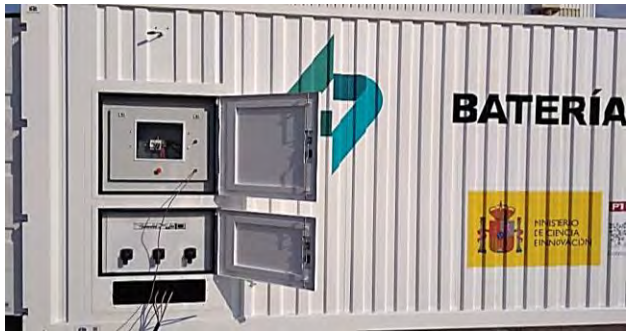
- **Bipolar plates** surface…….. **105 m²**
- **Electrodes** surface…… **160 m²**
- **Polymeric membranes** surface……. **95 m²**
- **Washers** …….. **10,100**
- 1,120 **threaded rods** …….. **270 m**
- **Flexible tubes** …….. **100 m**
- **Rigid tubes (PVC)** …… **75 m**



VRFB 50 kW/100 kWh

- **POWER**: **50 kW** (peak) - **40 kW** (nominal)
  8 strings oh **6,25 kW (**4 stacks each one, individually operated)
- **CAPACITY**: **100 kWh** (enegry stored)
- **TOTAL WEIGHT**: **15.6 ton**
- **DIMENSIONS**: CONTAINER, 40 feet (**12.2 x 2.5 x 3)m³**

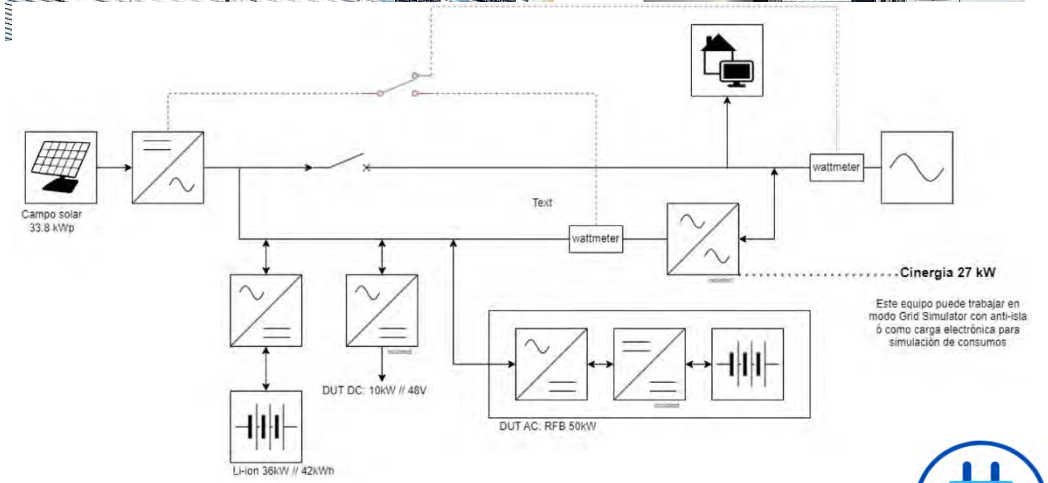
- **OUTPUT SIGNAL**: **AC Three phase** (400 V) or **DC** (600 V)
- **ELECTRIC CONNECTION: 5 pole hose** or **3 connectors ITT Cannon SNLF-S-C25-25S-BL**
- **COMUNICATION**: **MQTT Protocol,** using and **API** for the data management and monitoring
- **SECURITY AND CONTROL SYSTEMS**: **Air conditioning** unit (operating temperature. 5 - 45°C)
  Pressure, flow and temperature sensors
  SO_2, **H_2**, **CO_2** and **N_2** detectors
  Double **detection system of leakages** (ΔP y conductometric)
  Level control in tanks and **anti-intruder** sensor



In situ testing and Operating Protocol

The battery is **being tested while connected** to a **SMART MICROGRID** as part of the **energy storage system (ESS)** which is **made up** of:

- a **photovoltaic solar field** (**35 kWp**)
- a second-life **LIB** (**46 kWh**)
- different **bidirectional loads** and **converters**
- **energy management system**



For the **operational protocol**, the **VRFB** will be tested in two working modes

- ✓ **Connected to network**
- ✓ **Isolated**

Future of the Platform

Engineering team:

Six-months monitoring of our prototype in real environment

Automatization of the construction process

Improve performance (energy density, durability…)

Reduce cost and find financial support

Creation of a Spin-off: Vanaflow

Chemistry team:

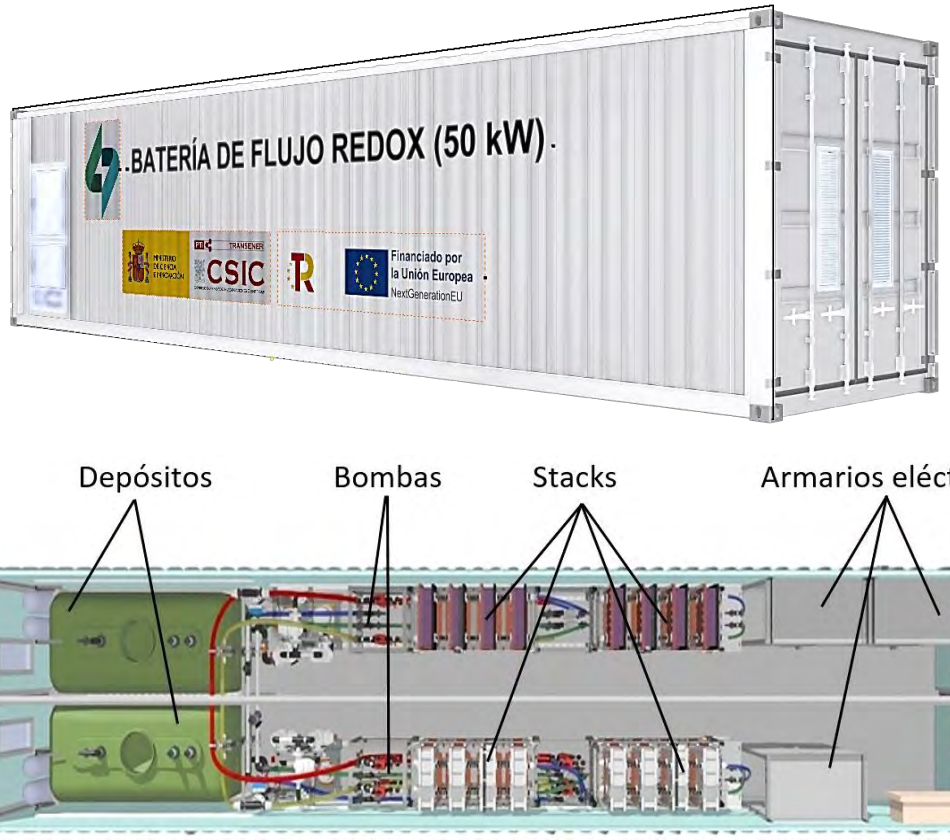
Developing a new chemistry based on Iron compounds

Developing 3D printed electrodes with new materials

Developing new specific membranes

Scale up materials and processes

THANK YOU!


BATERÍA DE FLUJO REDOX (50 kW)
CSIC
Financiado por la Unión Europea
NextGenerationEU
Depósitos
Bombas
Stacks
Armarios eléctricos

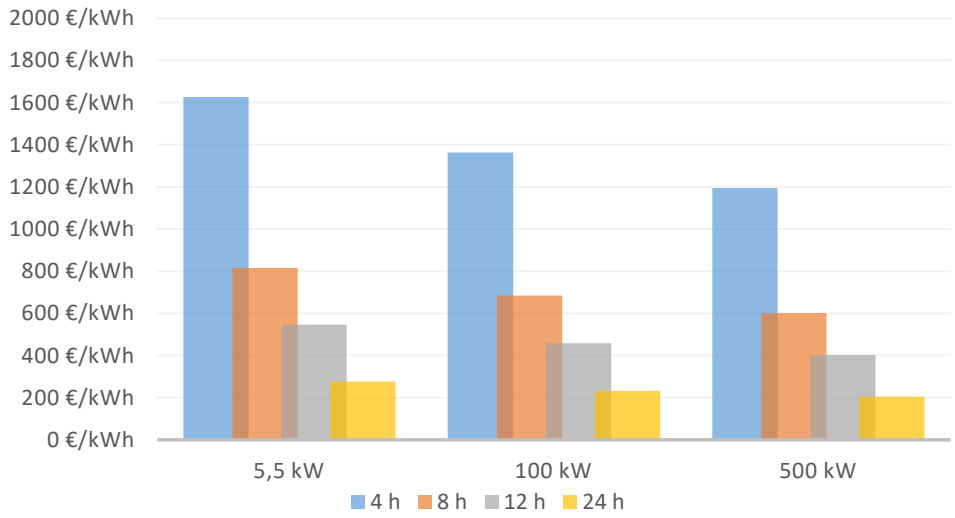
Cost analysis *vs.* autonomy

For **cost estimation,** it has been considered:

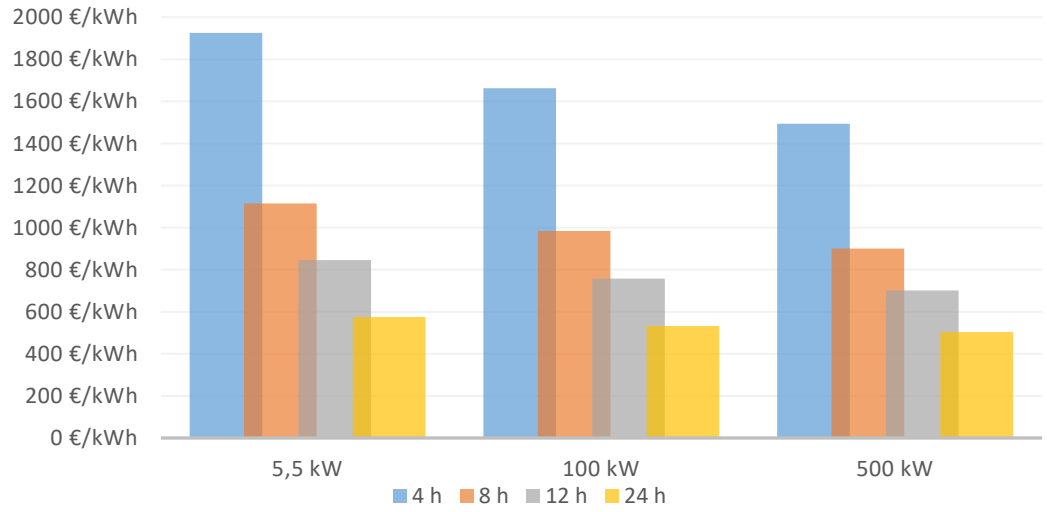
- State-of-the art of the technology
- Our production capabilities
- Cost of raw materials
- Cost of commercial elements (electrolyte, electrode and polymeric membrane)
- Costs of all electronic material (components, cables, converters, cards, etc.)
- Labor cost

Objetivos DOE
VRFB:
200 $/kWh de energía (precio actual 360 $/kWh)

Cost (€/kWh) without electrolyte



Cost (€/kWh) with electrolyte



Project milestones

- ✓ **START DATE**: **April/May 2021**
- ✓ **STAFF**: 27 researchers and **30 new employemnts**
- ✓ **PARTICIPATING CENTERS:**

INCAR · icb INSTITUTO DE CARBOQUIMICA · INSTITUTO DE TECNOLOGÍA QUÍMICA · Institut de Robòtica i Informàtica Industrial · ICMM · ICTP Instituto de Ciencia y Tecnología de Polímeros · ICMAB Institut de Ciència de Materials de Barcelona · CNM Centro Nacional de Microelectrónica IMB

Main research/work lines

1. **Improve the performance of commercial materials** as electrodes, electrolytes and membranes in **VRFBs**
2. **Develop new materials** (electrodes, catalysts and membranes), suitable **for advanced chemistries** (Fe-based electrolyte)
2. **Optimize the design**, **manufacturing** processes and **assembly** of all mechanical elements
3. **Develop new models and experimental techniques** to determine **the SOC and SOH** thus allowing to extend the **useful life of the battery**
4. **Improve** the **electric**, **display**, **telemetry** and **control/monitoring** systems for their **optimized integration** into the **application**