STORAGE RESEARCH INFRASTRUCTURE ECO-SYSTEM

RI Information sheet 2022

CSIC, FLOWBAT (TA5.3)

Technologies of Energy Storage: vanadium redox flow battery and polymer electrolyte membrane fuel cells (electrochemical)

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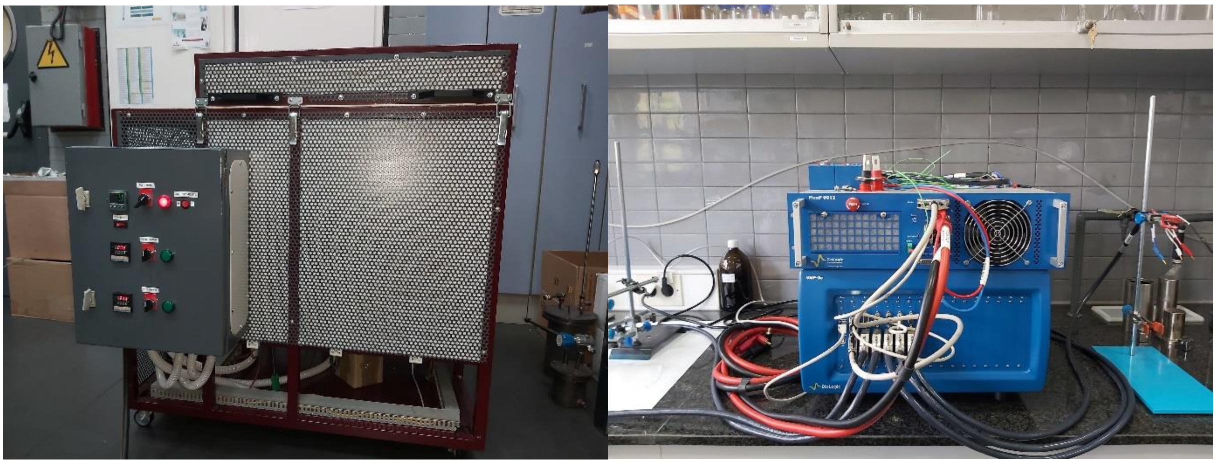
Project Acronym	StoRIES
Call	H2020-LC-GD-2020
Grant Agreement No.	101036910
Project Start Date	01-11-2021
Project End Date	31-10-2025
Duration	48 months

1. Photo

Photovoltaic panels from the solar field mounted on the roof deck of the main LIFTEC building (left). 10 kW VRFB designed and fabricated in the framework of FLOWBAT works (right)



Home-made furnace to large scale fabrication of electrode materials (40 x 40 cm) for the VRFB (left). Multichannel potentiostat/galvanostat equipped with impedance modules and a 200 A booster (right)

2. Geographical coordinates (˚, “, … N/S, E/W)

- Institute of Carbon Science and Technology (INCAR): 43.389773, -5.824831. Composites Group: production, characterization and electrochemical assessment of active electrode materials with enhanced electrochemical performance for VRFBs.

- Fluid Dynamics Research Laboratory and Combustion Technology (LIFTEC): 41.681569, -0.887747. Battery design, manufacture, conditioning and operational tests.

- Institut de Robòtica i Informàtica Industrial (IRI): 41.382956, 2.115517.

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Automatic control group: development of the acquisition and monitoring system for both sensors measurement and battery performance.

- Carbochemical Institute (ICB): 41.681439, -0.888323

Fuels Conversion Group: synthesis of advance electrode materials based on carbon.

- Institute of Materials Science of Barcelona (ICMAB): 41.502204, 2.110323

Solid State Chemistry Group: study of the electrode/electrolyte interactions and investigation of the role that additives and mediators play on the electrolyte to improve the kinetics and reversibility of the redox reactions involved in the battery operation.

- Institute of Chemical Technology (ITQ): 39°28′41″N 0°20′21″O

Conversion and storage of renewable and fossil energies Group: development of electrode materials with improved electrocatalytic activity, selectivity and stability. Production of membranes with improved behaviour contributing to enhance the battery performance. Ex-situ characterization measurements of membranes, electrodes and electrolytes.

- Institute of Polymer Science and Technology (ICTP): 40.443240, -3.685029

Polymer Composite Group: polymer membrane processing/preparation/characterization

- Institute of Materials Science of Madrid (ICMM): 40.543911, -3.689570

Bioinspired Materials Group: synthesis and characterization of advanced electrolytes (partially diluted water-in-salt, WIS, of solvent-in-salt, SIS, electrolytes). Study of the electrode/electrolyte interface. Correlation of the molecular structure in partially diluted electrolytes with the electrochemical energy storage performance.

3. Description of the research infrastructure for the webpage

FLOWBAT is an interdisciplinary thematic platform of applied character offering a solid basement for Redox Flow Batteries development, created by the Spanish National Research Council (CSIC), fully aligned with SGD 7 (affordable and clean

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energy) which, at the same time, is related to SGD 13 (Take urgent action to combat climate change and its impacts). There are eight research groups involved, located in eight different research institutions belonging to CSIC. These groups are characterized by their extensive experience in the development of energy conversion devices, the synthesis of improved electrode materials for electrochemical energy storage systems, the optimization of separation membranes, advanced fluid dynamics control, the development of other electrolyte chemistries, electronic control, etc. On the basis of previously acquired knowledge, the main goal of the FLOWBAT is to develop (for the end of 2022) a 50 kW Vanadium Redox Flow Battery (VRFB), optimizing the different components that conform the battery and its design.

FLOWBAT offers both, a highly interdisciplinary group with deep knowledge on different subjects and access to different infrastructures, equipment and services which are distributed among the different research groups involved. Furthermore, different research lines are also supported.

Services and experimental facilities offered by the infrastructure:

1. Tubular furnaces, stoves, a home-made furnace for large scale fabrication, and gas lines for thermal pretreatment of commercially available raw materials (able to prepare electrode materials up to 40 x 40 cm).
2. Memmert VO49 Vacuum oven. Reaches up to 200 ºC and down to 5 mbar with programmed temperature/vacuum ramps. Adequate for special drying conditions and/or casting of membranes.
3. Home-made electrochemical cells (lab and large scales available) to carry out the electrochemical modification of different starting carbon-based materials (both commercial and previously pre-treated).
4. Redox flow battery stations for single cell characterization of components (electrodes, membranes, active area 25 cm^2)
5. Automated catalyst ink spray system on paper, cloth of felt.
6. Laboratory press to form membrane-electrode assemblies (up to 400 bar and 250°C)
7. Biologic VMP Multichannel (equipped with impedance module) Potentiostat/Galvanostat workstations (with boosters of 2, 10 and 200 A) to

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carry out the electrochemical characterization of the materials synthesized in half or whole cells.

8. Metrohm Autolab PGSTAT302 Potentiostat/Galvanostat for electrochemical impedance spectroscopy.
9. Metrohm Autolab PGSTAT204 Potentiostat/Galvanostat equipped with electrochemical impedance spectroscopy module (1 MHz) and booster to reach 10 A.
10. Metrohm VIONIC Potentiostat/Galvanostat (6 A, 50 V) with incorporated electrochemical impedance spectroscopy (10 MHz).
11. Potentiostat/Galvanostat Metrohm Autolab 302N (equipped with FRA module and BA module).
12. Potentiostat/Galvanostat Metrohm microAutolab.
13. RRDE and RDE equipment (Metrohm)
14. Arbin multichannel (e.g., 16 channels) equipment for cycling experiments
15. Equipment for advanced characterization (morphological, structural, physicochemical) of the electrode materials.
16. A well-equipped laboratory for the synthesis of monomers and polymers with extractor hoods, vacuum ovens, furnaces, glovebox workstation, glass hardware, reactors, mechanical stirrers, and vacuum pumps.
17. A well-equipped laboratory for the preparation of polymer-based membranes with leveled hot plates (from ambient to 200 °C), systems for controlled evaporation of solvent in the casting process, Teflon and glass separators to obtain homogeneous thick films, ovens (from ambient to 200-400 °C) that can work under vacuum or inert atmosphere, a high-speed stirrer (ultraturraxTM) for dispersion of solids in solution, and a magnetic induction coating thickness test instrument. Furthermore, appropriate equipment to perform the physicochemical (SEC/GCP, DSC, TGA, SEM, AFM, etc) and electrochemical characterization of the polymer membranes is available.
18. Anton Paar equipment DSA 5000 M with a LOVIS 2000 ME module for viscosimeter, densitometer and propagation of ultrasound waves measurements for characterization of electrolytes.
19. RHD closable cell coupled to an Autolab workstation with FRA2 module for ionic conductivity measurements of the electrolytes.
20. Metrohm equipment for Karl-Fisher titration, either coulometric (851 Titrando with generator electrode with diaphragm) for water concentration

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5-100 ppm and volumetric (888 Titrando) for concentrations above 100 ppm

21. A 10 kW (10 kWh) all-vanadium redox flow battery (VRFB) formed by 4 stacks with its own hydraulic circuit and BMS, including pressure, temperature, current, voltage, flow rate, individual cells differential voltage sensors, and an auxiliary cell to measure half-cell open circuit potentials, pH, temperature and conductivity of the electrolytes.
22. A 35 kWp photovoltaic solar facility formed by 62 panels, DC/AC inverters, and a real-time operation monitoring system. It is also equipped with a weather station comprising sensors for solar irradiation, ambient temperature, as well as wind speed and direction.
23. A smart-microgrid mainly formed by the 10 kW-VRFB and the 35 kWp-photovoltaic solar facility. It will be also arranged to couple and test some other different (long-, medium-, or short-term) energy storage systems, generating the wave signal needed for every study, providing controllable power flow from dispatchable sources during load dynamics and allowing the VRFB to operate in island mode.
24. Different test benches to study and characterize both single cells and stacks of VRFBs with electrical power from tenths Watts up to 50 kW. They are fully equipped with accurate control of current and voltage for charge/discharge processes, electrolytes flow rate, pressure and temperature sensors, state of charge and open circuit potential monitoring in-operando. Degradation mechanisms of the cell components can also be studied.
25. A horizontal CNC milling machine with a working area of 1300mm x 2500mm x 280mm that is coupled with design-assisted software to manufacture optimal flow frames and bipolar plates for VRFBs.
26. Different facilities and techniques to characterize the performance of VRFBs, such as pressure drop and laser induced fluorescence for the fluid dynamics performance of flow field geometries for flow frames and bipolar plates, "in house" electrochemical cells for SOC and SOH measurements, etc.

Computational facilities offered by the infrastructure:

1. Beowulf computational cluster with Intel Xeon CPU [X5650 / E5-2697 v3] and 980 GB of RAM, consisting of 10 nodes, 20 processors and 150 cores.

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2. Different "in house" 3-D codes, written in C, C++ and Fortran, as well as fluid-dynamics oriented programming tools (OpenFOAM, Deal.II, ANSYS FLUENT) specifically developed for the numerical analysis of VRFBs and PEMFCs in order to both optimize the operation and study the degradation mechanisms of the cell components.

3. Mathematical models encoded in MATLAB/SIMULINK to simulate and control the performance of the VRFB to be integrated in both battery and energy management systems.

4. Availability of the research infrastructure

(Please indicate time periods in which infrastructure <u>will not be available</u> for StoRIES in the next 2 years – if already known)

All the research institutes involved in FLOWBAT are usually closed during the regular holidays: Summer (August), Easter, Christmas and New Year. Applicants should contact the coordinator of the project. Dr Ricardo Santamaria (riqui@incar.csic.es) for detailed information.

5. Special considerations (confidentiality / NDA agreements, insurance requirement, special training, HSE training)

Both confidentiality or NDA agreements, labour liability insurance, training in the institute's occupational health and safety standards, as well as those of the specific experimental facilities, will be mandatory.

6. Energy storage technology that can be analysed/studied by using the research infrastructure

- Electrochemical ☒
- Chemical ☐
- Thermal ☐
- Mechanical ☐
- Superconducting Magnetic ☐
- Cross-cutting ☐ (Specifically: …)

7. Key words for the webpage

All-vanadium redox flow batteries, electrodes, membranes, advanced electrolytes, electrocatalysts, solar photovoltaic, microgrid, test bench, CFD codes

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8. TRL level (if applicable):

- 1-3 ☐
- 4-6 ☒
- Above ☐

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