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Summary

This document reports on the programme and attendance of the second official project workshop organized by the HIGREEW coordinator CIC energiGUNE in Vitoria-Gasteiz (Spain) on the 16th and 17th of May 2023. The workshop focused on the technology development of Redox Flow Batteries (RFB) and successfully addressed all critical steps of the RFB value chain: high-level scientific presentations on materials and components; different solutions for possible applications and the related challenges; market perspective and legislation-related aspects.

As stated in the Description of Work (under task 7.1), the HIGREEW project organised 2 project workshops addressing the energy sector, battery manufacturers, and material developers: for centraland local governments and for other relevant stakeholders.

The two workshops are linked to two project deliverables: the first project workshop at M29 (D7.4, March 2022) and the second one in the final stage of the project at M43 (D7.5, May 2023).



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1 Introduction

The final HIGREEW Workshop was organised by CIC energiGUNE, project Coordinator, with support from Uniresearch, in its premises, located close to the beautiful medieval city Vitoria-Gasteiz (Spain) on 16th and 17th May 2023. CIC energiGUNE is a Basque energy research center specialized in electrochemical energy storage, thermal energy storage and conversion and hydrogen technologies, that aims to generate disruptive scientific knowledge in materials and technological solutions related to energy and contribute to improving industry competitiveness and sustainable development. CIC energiGUNE was born in 2011 to generate excellent research in materials and systems for energy storage and therefore constituted the perfect location to hold the final HIGREEW workshop, where the participants also got the opportunity to visit its labs and open technology platforms.

The workshop was organized as face-to-face event over one-and-half-day, where more than 70 participants representing 12 different EU countries, met for two days to discuss the future of Redox Flow technology. The workshop successfully addressed all critical steps of the RFB value chain: high-level scientific presentations on materials and components; different solutions for possible applications and the related challenges; market perspective and legislation-related aspects.





Figure 1-1: Pictures from the 2nd HIGREEW workshop held in Vitoria-Gasteiz (Spain).



2 Final project workshop

In over three years, the HIGREEW project has bridged the organic materials from the lab to the battery prototype installed last March at the Siemens Gamesa hybrid renewable plant in La Plana (Zaragoza, Spain), and the final project workshop aimed at bringing to the stage the voice of the industry to give new market trends on energy storage, a scientific overview to different chemistries while policymakers would give insights on new regulation on batteries.

"In the three years of project development, the HIGREEW consortium has managed to take the concept of organic active materials from the laboratory to the battery prototype and, therefore, we are one step closer to bringing the technology to the market", Raquel Ferret - Business Development Director at CIC energiGUNE.

In this context, and under the title "Flow batteries, bringing technology closer to the market", the workshop showed use cases of redox batteries by the most relevant industrial players in the field of stationary energy storage, as well as of developers of materials and batteries. Likewise, it allowed access to new market trends, together with a scientific vision of the key components of batteries, and ideas were even outlined, from a political point of view, on the new regulation of batteries.

Besides HIGREEW consortium members, not only the scientific community but also the industry and the public were targeted as audience for our workshop. The programme was assembled to cover all relevant and emerging topics related to organic redox flow batteries. The workshop focused on the industry needs and trends, and how redox flow technology could contribute to the decarbonization of the economy by facilitating the storage of renewable energy. The scientific and academic sectors illustrated the latest research on different chemistries, organic and inorganic, accompanied by companies' use cases demonstrating the added value of their technologies. Moreover, the new battery regulation and its effects on redox flow technology was discussed by stakeholders.

In summary, the HIGREEW workshop was highly successful, packed with insightful discussions and engaging presentations as speakers from across the globe came together to discuss the advances and current needs in redox flow technology.

2.1 Agenda and programme

The scope of the workshop was discussed within the consortium during regular HIGREEW meetings. The full agenda and programme are listed in Figure 2-1 and Figure 2-2. An overview of lectures given by invited experts is presented in Chapter 2.3 Presentations.

The programme was <u>available on the project website</u> prior to the workshop¹. The invitations were provided to consortium members and relevant contacts within the HIGREEW network, important institutional contacts, policy makers, associations and clusters, such as the <u>FLORES Group</u> (FLORES stands for a network of Flow Battery Research Initiatives, created under the Horizon Results Booster, initiated by the Commission). In fact, during the HIGREEW workshop the projects MELODY, HyFlow and SONAR, part of the FLORES Group, presented their findings, further enriching the overall discussion on redox flow batteries (RFB). The event was advertised through project webpages and social networks (as reported in section 2.4 of this report).

The content of the first day started with an overarching session focused on the RFB market, where the application of redox flow batteries was presented, and several case studies and ongoing activities were introduced. Moreover, the EU policy in terms of RFB and the Battery Sustainability Regulation in the context of redox-flow technology was presented by the Scientific Officer from the Joint Research Centre of EC. This was followed by two focused sessions targeting the materials development and the battery stack design

¹ <u>https://higreew-project.eu/wp-content/uploads/2023/05/HIGREEW_Workshop-II_-final-programme-3.pdf</u>

and modelling, respectively. The topical programme of the first day was concluded with a visit to CIC energiGUNE's labs and open platforms. During the second day, the discussion focused on the existing RFB prototype and deployment, followed by a session on non-conventional RFB and the possibility of hybridisation. Finally, the workshop was concluded with a look to the future opportunities, novel hybridisations opportunities and next steps needed to bring the technology to the market.

Programme 16 May

Session: Market and Policy

08:30 Welcome session CIC energiGUNE

08:45 Energy storage and advanced grid functionalities: the missing piece of the 100% renewable

puzzle Managing director, Gamesa Electric - Juan Barandiaran

- 09:05 Why does the electricity grid need storage and what are the best options today and tomorrow Senior scientist, EDF R&D division, batteries group - Philippe Stevens
- 09:25 RFB Market Director Sales Microgrid Solutions, Enerox GmbH / CellCube Juan-Carlos Mejia
- 09:45 Redox flow battery R&D in Shell Senior process development chemist, Shell Global Solutions

International B.V. Domain lead redox flow battery technology - Peter Klusener

10:05 Battery Sustainability Regulation in context of redox-flow technology Scientific officer at Joint Research Centre of EC - Marek Bielewski

> 10:25 - 11:00 Coffee Break Session: Materials

- 11:00 HIGREEW Project: a journey through new generation AORFB HIGREEW project coordinator and redox flow research line manager, CIC energiGUNE - Eduardo Sánchez
- 11:20 Characterization of AORFB Researcher, Laboratory of Energy Storage, NTC UWB and UCT Prague - Jiří Charvát
- 11:40 Modified anion exchange membranes and other perspectives PhD student, electrochemistry research group at Applied chemistry-physics faculty, University Autonomous of Madrid - Iván Salmerón Sánchez
- 12:00 The importante of the electrolyte-membrane combination for long lifetime Viologen-TEMPO AORFB PhD student, redox flow research line, CIC energiGUNE - Laura Pastor
- 12:20 Membranes for AORFB Senior Lecturer, Imperial College, Project coordinator of ERC Starting Grant NanoMMES - Qilei Song

12:40 - 14:10 Networking Lunch

ssion: Cell/stack design and modelli

14:10 Engineering Porous Electrodes for Redox Flow Batteries Assistant Professor, Membrane Materials and Processes Group, department of Chemical Engineering and Chemistry at Eindhoven University of Technology - Antoni Forner-Cuenca

- 14:30 How active can be the graphite felt electrode in redox flow battery electrolyte? Research director, CNRS - Mathieu Etienne
- 14:50 Development of a multiphysics model for an aqueous organic redox flow battery PhD student, redox flow research line, CIC energiGUNE- Aitor Beloki

15:10 Results of the European project SONAR with Deeper Insight into Microstructure Simulations of Flow Batteries Research associate, Institute of Mechanical Process Engineering and Mechanics. Karlsruhe Institute of Technology - Amadeus Wolf

15:30 Printed seals in redox flow batteries Principle engineer, C-Tech Innovation Ltd - John Collins 15:50 Ending day 1 - CIC energiGUNE

16:00 Visit to CIC energiGUNE's facilities: labs and open platforms (upon registration)

Figure 2-1. Programme Day 1



Programme 17 May				
Session: Prototypes and deployment				
08:30 Welcome session CIC energiGUNE				
08:40 Electrolyte regeneration of vanadium flow batteries PhD student, Electrochemical Energy				
Storage and Conversion Laboratory (EESCoLab), University Padova - Nicola Poli				
09:00 Design and manufacture of a 50 kW vanadium redox flow battery Composite Materials Gro				
Department of Materials Science at Spanish National Research Council - Ricardo Santamaría				
09:20 Scale-Up of AORFB Co-Founder, PFES - Jaromír Pocedič				
09:40 Modular balance of plant for mass-customized flow battery production Redox Flow Battery,				
Applied Electrochemistry, Fraunhofer Institute for Chemical Technology ICT - Michael Schäffer				
10:00 The installation of a commercial-scale flow battery in the Son Orlandis photovoltaic plant				
Project manager R&D Unit- Endesa - Pablo Fontela Martínez				
10:20 The importance of flow batteries for hybrid generation systems \textit{Head} of section renewables &				
storage power plants integration testing, SGRE - Alberto Alonso Cantalapiedra				
10:40 - 11:00 Coffee Break				
Session: Non-conventional RFB and hybridization				
11.00 Hydrogen bronnine, case studies to upscale the technology. MELODT project Serior				
electrochemist, Elestor and scientific project manager, MELODY project - Kamuran Yasadi				
11:30 Recent Advances and Future Challenges of Membrane Free Redox Flow Batteries Senior				
researcher, IMDEA Energy Institute - Rebeca Marcilla				
11:50 Hybrid redox flow batteries: technology upscaling, opportunities and challenges Senior				
scientist & team leader, Green Energy Storage - Eneko Azaceta				
12:10 Hybridization of RFB Scientific director, Hochschule Landshut, University of Applied Sciences,				
HyFlow project coodinator - Karl-Heinz Pettinger				
12:30 Redox-mediated flow batteries: first steps from fundaments to application Ramon y Cajal				
professor at the University of Burgos - Edgar Ventosa				
12:50 Closing remarks. End of HIGREEW workshop 13:15 Networking Lunch				

Figure 2-2 Programme Day 2

2.2 Participants

Experts from the Battery community came together in Vitoria-Gasteiz to discuss the contribution of redox flow technology to the decarbonisation of the economy, through the storage of renewable energy. The onsite event was attended by more than 70 participants, from 12 different EU countries, where the face-to-face format of the workshop greatly facilitated the discussion and networking among the attendees.

The registration form was shared via the HIGREEW website and invitations sent to all subscribers to the HIGREEW newsletter, moreover the workshop was also promoted via social media (see Figure 2-7)

Figure 2-7. The registrations grown consistently to 76 registered attendees and most of the participants stayed for the full duration of the event, taking part also to the organised social activities.

Among the participants also HIGREEW Advisory Board has been represented by the presence of Dr. Lubomir Kubac, Executive Head of COC (already invited and involved in previous meetings and the project first workshop).





Figure 2-3: Evolution of number of registered attendees.



Figure 2-4: Highlighted countries of registered attendees.

Table 1: Registered attendees by countries.

Attendees by Country						
Canada	1	The Netherlands	5			
Czechia	5	Norway	1			
France	4	Slovakia	1			
Germany	7	Spain	41			
Italy	3	Sweden	2			
Morocco	1	United Kingdom	5			
TOTAL	76					



The 'broad spectrum' programme of the workshop, offering different perspectives and presentations/discussions ranging from fundamental research to market applications, allowed a wellbalanced distribution of participants. In total 17 different industries, 12 Research Institutes and 13 universities have been represented (see Figure 2-5).



Figure 2-5 Distribution represented organisations: 40% participants from industry, 29% from research organisation and 31% from universities)

Of all registered participants, only one last-minute cancellation was reported. Due to a COVID-19 infection, one of the speakers – Dr. Philippe Stevens, Senior Scientist at EDF R&D division – sent his apologies for missing the meeting.

2.3 Presentations

As reported, the HIGREEW workshop gave the opportunity to hear lectures of excellent speakers from European well-known institutions and companies.

Javier Olarte, Technology Transfer Director at CIC energiGUNE, opened as chair the first meeting of the project event and welcomed all participants. Project coordinator Ms. Estibaliz Crespo and technical coordinator Dr. Eduardo Sánchez offered a short summary of the project, its targets, results achieved and target of the workshop.

Juan Barandiaran, Managing Director at Gamesa Electric, kicked off the session on market and policy addressing the current challenges of energy storage (almost exponential growth linked to difficulties in managing/balancing renewables). The current market possibilities for RFB and current applications were addressed in the speech from Juan-Carlos Mejia, Director Sales Microgrid Solutions at CellCube, long duration energy storage (LDES) could significantly help reaching the targeted capacity of use of renewable (70% of the global power mix by 2050) and solving current Li-ion batteries limitation.

Peter Klusener, Senior process development chemist at Shell Global Solutions, offered a summary of the importance of RFB and their critical role in the future of energy storage.

The session was closed by the contribution from Marek Bielewski, Scientific officer at Joint Research Centre, presenting the current policy context for the sector and how RFB could/should get more attention in the policy agenda. The JRC requested participants to complete a questionnaire about trends in redox flow technology and how EC could support its deployment. For this support and input from all workshop participants have been requested.

The second session of the first day was chaired by Rodriguez Paramaconi, hydrogen technologies research group leader at CIC energiGUNE, the focus was on RFB materials and different HIGREEW partners presented



the work and findings from the project: i) Eduardo Sánchez, Associate researcher at CIC energiGUNE, presenting the HIGREEW journey to design and synthetise the materials for RFB; ii) Jírì Charvát, researcher at NTC UWB, reporting results from the characterization of the HIGREEW components; iii) Ivan Salmerón, PhD student at electrochemistry research group at Applied chemistry-physics faculty, University Autonomous of Madrid, on the work done for optimising the battery membranes. The session was enriched by the contributions from Laura Pastor, PhD student redox flow research line at CIC energiGUNE, on the importance of the electrolyte-membrane combination for long lifetime materials for energy storage and from Qilei Song, Senior Lecturer at Imperial College, reporting on recent state-of-start and innovative research on RFB membranes.

The afternoon session, and last one of the first day, was chaired by Peter Fischer, Fraunhofer ICT, focused on the next step of the production value chain for RFB: cell/stack design and modelling. Associate Professor at Eindhoven University of Technology, Antoni Forner-Cuenca presented some of the most recent developments with respect to engineering of porous electrodes and how they can influence the performances of the cell. HIGREEW partner Mathieu Etienne, Research Director at CNRS, reported on the studies performed on the graphite felt electrode and the linked rate of electron transfer in redox flow batteries (allowing also ageing phenomena). Studies on multiphysics modelling including linked results both for Fluid-dynamic and for electrochemical models were presented by Aitor Beloki, PhD student redox flow research line at CIC energiGUNE. Further insight on simulations – in particular how kinetic parameters play a crucial role in cell design - were reported in the contribution by the <u>SONAR</u> project presented by Amadeus Wolf, Research associate at Karlsruhe Institute of Technology. Presentations for the first day workshop were concluded by HIGREEW partner John Collins, Principal engineer at C-Tech Innovation, on the challenges and opportunities offered by printed seal technology in RFB.

Juraj Kosek, Full Professor at UTC Prague and NTC UWB Pilsen, opened as a chairperson the second day of the workshop with the session on prototypes and deployment.

The sessions started with the contribution from Nicola Poli, PhD student Electrochemical Energy Storage and Conversion Laboratory at Padua University, on the challenges – and possible solutions - related to electrolyte regeneration in vanadium flow batteries. The electrochemical rebalancing process studied, if properly optimized, can present a total cost (investment plus operation) lower than a chemical rebalancing process using oxalic acid as reducing agent. Ricardo Santamaria, Composite Materials Group at INCAR-CSIC, presented the status and strategy for large scale electrical energy storage (for vanadium redox flow batteries-50kW) HIGREEW partners i) Jaromir Pocedic, Co-founder of Pinflow Energy Storage, explained the steps taken during the project for the scale-up of the RFB; while ii) Michael Schäffer, researcher at Fraunhofer ICT, described the work done for the design and assembly of the HIGREEW prototype including current stack performances and lesson learnt.

Pablo Fontela Martinez, Project Manager R&D Unit at Endesa/ENEL, brought the discussion a step further, offering a glimpse into the installation and operation of a commercial-scale flow battery in a photovoltaic plant in Mallorca, Spain. The session was concluded by HIGREEW project partner Alberto Alonso Cantalapiedra, Head of section renewable at Siemens Gamesa, on the future of renewable power plant and the role RFB could play. He also presented HIGREEW contribution and performances by Siemens Gamesa facilities in La Plana.

The last workshop session was chaired by HIGREEW project coordinator Eduardo Sánchez, Associate researcher at CIC energiGUNE, and focused on non-conventional RFB and hybridisation solutions. Kamuran Yasadi, Senior electrochemist at Elestor, reported the results from the <u>MELODY</u> project combining electrolyser and Fuel Cell using hydrogen-bromine technology. Rebeca Marcilla, Senior researcher at IMDEA Energy Institute, presented new visionary strategies for the development of membranes-free RFB. Eneko Azaceta, Senior scientist at Green Energy Storage, offered an insight on the work done on hybrid RFB and the challenges related to possible upscale of hybridised systems. The results from the <u>HyFLOW</u> project, focusing on the hybridisation of high-power vanadium redox flow batteries combined with green aqueous based supercapacitors, was presented by Karl-Heinz Pettiger, Professor and scientific director at



Hochschule Landshut (and HyFLOW project coordinator). Last presentation of the event was given by Edgar Ventosa, Professor at Burgos University, on new concepts for mediated RFB.

All sessions for both days also included Q&A sessions and further discussions and networking activities.

2.4 Used dissemination and communication tools and documents

To both promote the event, and – at the same time – inform and update the general public on the project workshop and its purpose, several dissemination tools and documents have been created.

Communication activities started months before the Workshop to share practical information, such as:

- Programme of the 2nd HIGREEW Workshop
- Practical info for the event and how to reach the venue.



Figure 2-6 HIGREEW Workshop II final programme