HYBRIS

Enhanced Hybrid Storage Systems

WP8. Project Management & Coordination

Task 8.1

Project technical coordination and management

Deliverable 8.3

First Year Progress Report

***HYBRIS**: HYbrid Battery energy stoRage system for applications in advanced grid and behInd-the-meter Systems segments, has received funding from the European Commission H2020 Programme under Grant Agreement No. 963652*

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WP No.	WP 8
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1 EXECUTIVE SUMMARY

HYBRIS' basis is the optimisation of advanced hybrid systems as high-performant, cost-effective and environmentally-friendly solutions in microgrid applications. HYBRIS is an integrated industrially driven action, that will answer to this challenge in 4 key points:

1) Viability and cost effectiveness: of the use and integration of novel HEES system coupled with innovative microgrid system local RREE generation and loads (residential, tertiary buildings and EV charges stations), achieved by the integration and validation of a suite of technologies, tools and methods enabling their easy application and massive deployment.
2) Technical: pursuing the technical optimization of the HEES system in 3 use case applications covering respectively:
    1) Energy services in island grids
    2) Energy services in private grids
    3) EV charging stations in e-mobility.
3) Optimization and integration.
4) Validation: by using the 3 demonstration sites as open case studies representing the 3 different use case applications and situations found throughout Europe, to leverage knowledge, key exploitable results, adapted business models and market-oriented dissemination for maximizing impact and wide adoption of these novel heating and cooling technologies and approach.

HYBRIS features a fully systematic, collaborative and integrated approach to the development and deployment of innovative battery-based hybrid storage system, coupling diverse and complementary breakthrough TRL 5-6 technology assets brought by leading industrials, universities and RTOs, plus ICT tools for viable and cost-effective optimization and further market introduction. All will reach TRL6 by the demonstration and validation of its concepts in 3 use cases applications in 3 pilot sites in three countries.

The purpose and of this deliverable in short is to summarise and integrate in a single document the state of development of HYBRIS project, the respect of the work plan and how far project's objectives and milestones have been achieved during its first year in accordance with the Grant Agreement and with later amendments (1 submitted and accepted while another one is under way at the moment of writing this document).

This deliverable has been written in Work Package 8. Its full name is "First Year Progress Report", which covers the period from 1st January 2021 to 31st December 2021.Target audience of this report is HYBRIS Consortium Partners as well as European Commission coordinators/evaluators.

On behalf of Authors

Mikel Borràs, IDP

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2 INTRODUCTION

2.1 Scope

The purpose and of this deliverable in short is to summarise and integrate in a single document the state of development of HYBRIS project, the respect of the work plan and how far project's objectives and milestones have been achieved during its first year in accordance with the Grant Agreement and with later amendments (1 submitted and accepted while another one is under way at the moment of writing this document).

2.2 Audience

This deliverable has been written in Work Package 8. Its full name is "First Year Progress Report", which covers the period from 1st January 2021 to 31st December 2021. Target audience of this report is HYBRIS Consortium Partners as well as European Commission coordinators/evaluators. The objective is to make everyone aware of the progress done during this first year within HYBRIS project.

2.3 Abbreviations

WP: Work Package

GA: Grant Agreement

HESS: Hybrid Electricity Storage System

LCA: Life Cycle Assessment

LCOS: Levelized Cost Of Storage

2.4 Contributions of partners (M12)

All HYBRIS partners have contributed to this deliverable providing inputs in regards with their contributions to respective WPs and HYBRIS Project overall from a technical perspective. These contributions have been collected, validated and integrated by respective WP Leaders.

2.5 Relation to other activities

Inputs were received by all other WPs in order to develop and submit this deliverable. No outputs are expected from this deliverable by other WPs.

2.6 Structure

- **Section 1:** Contains an overview of this document, providing its Scope, Audience, and Structure
- **Section 2:** Contains an overview of the work carried out during the first year in terms of WPs/Tasks already started and/or carried out.

- **Section 3:** Provides a detailed description of the work done and achievements fulfilled under each respective WP.
- **Section 4:** Gives conclusions regarding this deliverable.

3 WORK CARRIED OUT AND OVERVIEW OF THE PROGRESS

During the first twelve months of HYBRIS project, the Consortium has followed the plan included in the Annex I of the Grant Agreement, and also recommendations received from the European Commission.

The WPs/tasks already initiated according to the Gantt chart of the Action during the covered period are listed below:

- WP1 KPIs and Project Requirements
    - Task 1.1: Specifications and requirements
    - Task 1.2: Applications KPIs and usage impacts
    - Task 1.3: Overview HESS related EasS business models
    - Task 1.4: Regulatory review
    - Task 1.5: Preliminary sustainability, energy storage and material safety assessment
- WP2 Development and characterisation of the battery components
    - Task 2.1: Early Concept
    - Task 2.2: Assessment of high-power battery module based on LB
    - Task 2.3: Assessment of high-energy battery based on ORFB
- WP3 Advanced BMS, electrical architecture and power conversion
    - Task 3.1. Battery model development
    - Task 3.2: Advanced BMS and health management
    - Task 3.3: Optimal electrical architecture of each BESS and the HESS
    - Task 3.4: Optimal converter design and validation
- WP4 Hybrid Storage Optimal Sizing and Control
    - Task 4.1 Use case definitions, HESS modelling and specification of simulations
- WP7 Stakeholder-oriented exploitation, dissemination, communication and training
    - Task 7.1 Exploitation activities
    - Task 7.2. HYBRIS Communication
    - Task 7.3: Data and Knowledge Management
- WP8 Project Management & Coordination:
    - Task 8.1 Project technical coordination and management
    - Task 8.2 Contractual Administration
    - Task 8.3 Risk Management
    - Task 8.4 Financial & Administrative Administration

4 PROJECT PROGRESS

4.1 Project objectives for the period (WP Leaders)

From a project viewpoint and according to the project plan, the main objectives of this 1st year have been the following:

- WP1 KPIs and Project Requirements
  - Define the requirements and specifications of the technologies under evaluation: lithium titanate and organic redox flow batteries.
  - Identify a list of KPIs which can be used throughout the overall HYBRIS project
  - Analyse the new business models for hybrid batteries in the paradigm of energy as a service, especially in providing frequency containment reserve services
  - Provide a regulatory review which includes technical and market codes, both at national and EU levels.
  - Provide preliminary ecodesign recommendations, including environmental, safety and recyclibility concerns, through a LCA perspective, to design HYBRIS system out of the main impacts.
  - Calculate HYBRIS concept baseline levelized cost of storage (LCOS) for technology positioning versus the state-of-the art.
- WP2 Development and characterisation of the battery components
  - Coordination between WP2 partners and other WP members to define prototype requirements and distribution of tasks.
  - Definition of prototype dimensions, power and energy capabilities, electronic coupling architecture, containerization.
  - Ongoing characterization of SCiB modules and AORFB stack reactor
  - Study & characterization of Li diffusion in LTO anodes and electrode degradation processes
- WP3 Advanced BMS, electrical architecture and power conversion
  - Modelling of LTO and AORFB batteries: performance and ageing models,
  - Specification of ABMS skeleton, embedded features and communication architecture,
  - Modelling of converter for HESS electrical architecture optimization and converter design optimization
- WP4 Hybrid Storage Optimal Sizing and Control
  - Coordinate with Work Packages 2 and 3 to facilitate alignment in specifications, KPIs, and case study definitions between the battery development and digital twin environments.
- WP5 System integration and validation
  - Coordinate with Battery Providers to define dimensions and needs from a battery perspective to define HESS integration/assembly needs

- WP6 Demonstration and Evaluation
    - Coordinate with all partners to define early needs from an implemnetation perspective overall and focusing on HESS developers (TOS, KEMI, HESStec) as well as Demo Site owners to identify potential risks, problems, etc. at an early stage.
- WP7 Stakeholder-oriented exploitation, dissemination, communication and training
    - Establish and maintain the mechanisms for effective and timely communication
    - Inform stakeholders of the project progress (targeting end users, technology stakeholders, commercial actors, academia and other projects with similar focus)
    - Conduct the scientific diffusion of the R&D works performed within the project
    - Continuously assess both communication and dissemination activities
    - Establish and maintain an exploitation culture throughout the project
    - Identification of the HYBRIS key exploitable results
    - Development of business models
    - Implementation and management of IPR
    - Standardization and regulation support
- WP8 Project Management & Coordination:
    - Manage efficiently the project and the consortium, including Grant Agreement Amendments
    - Review and assess the work being carried out from a technical point of view
    - Ensure that all aspects of the EC requirements for communication and reporting are met
    - Creating an appropriate management framework linking together all the project partners/components

4.2 Work progress and achievements during the period

WP 1: KPIs and Project Requirements definition					
Leading Partner	CNR	Start Date	M1	End Date	M12

Objectives for the period M1-M12

This WP, led by CNR, aims at describing the application contexts and the requirements of the system. The requirements are being proposed integrating technical, environmental and economic issues. Key Performance Indicators (KPI) are being defined in order to ensure a proper assessment of the impact of the solutions, as a function of the various cases of application. This WP aims also to set-up a benchmark and adaptation of the proposed solution during the project according to market analysis. Moreover, the scale of commercial demand for the developed system within and beyond the EU will be estimated. WP1 will provide inputs for the other WPs, addressing the associated tasks in a market focused way and ensuring that the HESS will be compliant with requirements of power network sector in every country and end users prescription, thus providing coherent line up for the research objectives development. Finally, WP1 will provide preliminary parameters in terms of environmental and material safety requirements, costs of energy storage and recyclability capacity via LCA screening. The development of the business model and the analysis of standards and regulation for the market acceptance are foreseen as well.

Description of work carried out and achievements

Task 1.1: Specifications and requirements

This task includes the following specific tasks:

- This task collected the main specifications about the single technology sub-systems, the hybrid system under development, including guidelines to develop the interfaces of the control architecture. Moreover, a preliminary identification of the electrical, mechanical, electronic, and communication interfaces was carried out, as well as working conditions, safety indications and compliance with international standards. The task provided details on ICT and interoperability of the technologies investigated
- In the overall system, two topics were particularly focused on. The services flexibility evaluation, since the digital twin development in design phase, was defined through the State of Function (SoF) indicator. On the other hand, the user point of view was considered by the identification of guidelines addressed to the User Centred Design (UCD) to improve user experience and system usability. These guidelines were drafted by COMET.

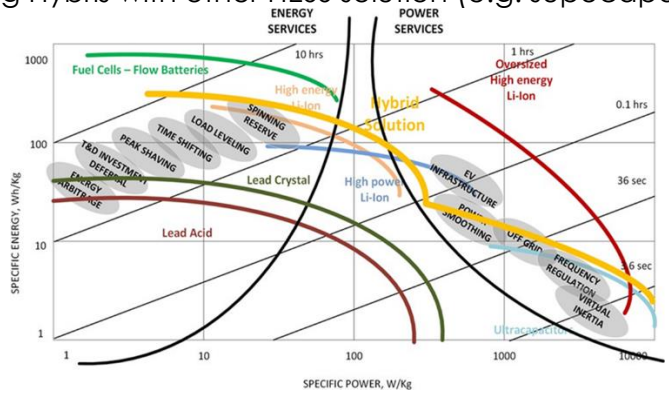
Task 1.2: Applications KPIs and usage impacts

This task provided a clear picture of the areas in which the HYBRIS partners expect to deliver value in this project and described how performance in these areas can be evaluated. A range of KPIs has been discussed covering social, technical, and financial aspects. This reflects the broad scope of the HYBRIS project and the many areas in which the partners expect to demonstrate value. Finally, the multi-target evaluation provided a description of KPIs that can give a high-level view of what has been achieved in HYBRIS, encompassing elements of all the other KPI sections.

Task 1.3: Overview HESS related EasS business models

An overview of BESS based EaaS business models with discussion on how HESS based business models can provide advantages has been carried out. Specific focus has been given to HYBRIS as an alternative to typical HESS technologies to highlight

potential advantages of the novel technology. An assessment on the main services for HESS has been developed. Services have been analysed in the contest of Hybris solution, comparing Hybris with other HESS solution (e.g. supecapacitors/batteries)



Main advantages are the following:
Thanks to LTO batteries: high symmetrical C-rate (up to 5C) comparing with other batteries and high energy content compared with supercap.
AORF battery:

- reduction of CAPEX in the next future (compared to VRF), to reduce the cost per kWh
- Long discharge duration

Thanks to the hybris solution:

- Advanced asset modelling, consisting in behavioral and degradation models of the storage technologies and other assets.
- State of Function (SoF), as the virtualisation layer, based on a dimensionless vector that shows, on a very compact way, the availability of an asset (or set of assets) to different simultaneous services and the maximum capability to perform them at any moment, depending on the state of the system and past operation.
- Optimal sizing and multi-service operation, based on economics (IRR, payback, LCOE…) and/or performance (stability, self-consumption…).
- Hybridisation algorithms, operating each technology within its comfort region to leverage the maximum synergies between energy storage technologies

Task 1.4: Regulatory review
The scope of the work performed under this task led by COMET is to establish the framework to drive the HYBRIS project products near to the energy storage technology market. It is expected that the innovative research and development tasks from idea to market will allow the support of next stages in the value chain through a roadmap for walking closer-to-market steps and through an improved framework of public-private partnership with targeted products which are able to penetrate the next generation of hybrid energy storage systems. Search for information related to energy storage systems market trends, barriers and opportunities, policies and funds framework, technology drivers for the potential market of HYBRIS innovations and products, standardization and certification frameworks, and national and international codes.
In particular, the following barriers and approach to reduce them are summarized following:
Barrier 1: High cost
Barrier 2: Technical implementation

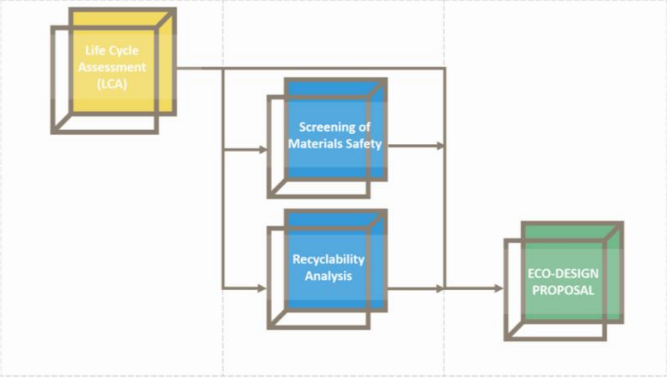
Barrier 3: Lack of standardization
Barrier 4: Outdated regulatory policy and market design
Barrier 5: Incomplete definition of energy storage
Approach:

1. To reach average reductions of 15-40% in CAPEX and 20-40% in OPEX. The whole system and main applications will provide a life extension up to 3 years longer the benchmark BESS with a payback time up to 7 years.
2. Hybris will increase the overall system energy and power performances by combining features of two sub-systems (LiTO and ORFB), increasing lifetime and energy capacity without losing power response availability at feasible cost.
3. High-level control allows continuous adaptation of the operation according to the real state and degradation evolution of the storage chemistries.
4. Thanks to the system integration methodology and validation via digital twin, the HYBRIS solution will facilitate the creation of a business model for every specific application that will be assessed and solved with the created HESS technology.

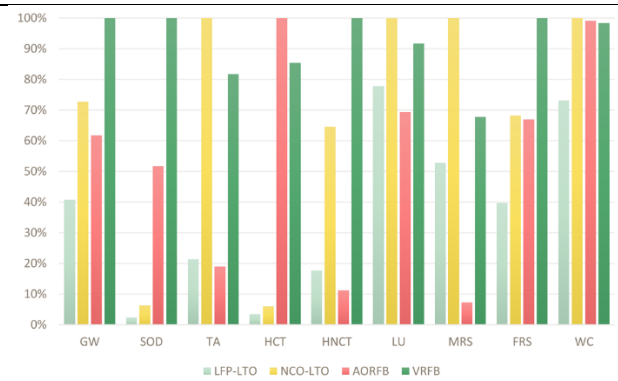
The outputs are gathered in Deliverable D1.4 'Technical and market review codes studies, national and European certification frameworks' submitted in M12.

Task 1.5: Preliminary sustainability, energy storage and material safety assessment
This task includes the following specific tasks:

- Materials and manufacturing processes of both intended battery chemistries have been thoroughly disembowelled and analysed with the input of battery manufacturing partners, and through specific scientific literature consultation. With this information, by using life cycle assessment (LCA) methodology, main environmental impacts have been quantified and assigned to the specific hotspots. Toxicity and ecotoxicity life-cycle impacts have been then complemented with a study of materials safety, including hazard levels, risk assessments and safety recommendations. Next, a profound review on the possible end-of-life of HYBRIS system has been carried out, analysing currently industrial and under research recycling/revalorisation methods, and highlighting special synergies and identifying needs for a superior overall materials efficiency. Finally, all this information has been utilised to build HYBRIS eco-design recommendations, to be followed as far as possible at the design/construction project stages and beyond, during technology improvement and further replication.



Eco-design approach



Example of output of environmental impact: comparison among LFP-LTO, NCO-LTO, AORFB and VRFB

All this information was compiled in D1.5 : *Preliminary Report on Ecodesign, sustainability, energy storage and material safety assessment*, delivered in due time in June 21.

- A preliminary techno-economic evaluation of the hybridised energy storage system proposed in HYBRIS was also accomplished within this task to position its economic performance with respect to the state-of-the-art. To do so, the characteristic cost parameters of both intended battery technologies combined in HYBRIS have been thoroughly analysed with the input of TOSHIBA and KEMIWATT.
  LCOS for the hybrid solution has been proposed ad following

$$LCOS_{HESS} = \frac{SPECS + p_{elec}\left(\frac{E_{LTO}}{\eta_{LTO}} + \frac{E_{AORFB}}{\eta_{AORFB}}\right)}{E_{LTO} + E_{AORFB}}$$

$$SPECS = [CAPEX_{LTO} + CAPEX_{AORFB}] + \left[O\&M_{LTO} \cdot \sum_{n=1}^{N} \frac{1}{(1+r_{LTO})^n} + O\&M_{AORFB} \cdot \sum_{n=1}^{N} \frac{1}{(1+r_{AORFB})^n}\right] - \left[\frac{v_{res,LTO}}{(1+r_{LTO})^{N+1}} + \frac{v_{res,AORFB}}{(1+r_{AORFB})^{N+1}}\right]$$

Moreover, relevant information of the three different pilot sites has been captured (from pilot site owners and specific regional data) to leverage the final costs according to each particular condition known at current project stage. With this information, by using Levelized cost of storage (LCOS) equations for batteries from the literature, the costs of these types of batteries per kWh returned have been determined. By developing the LCOS equation for a hybrid storage system, the LCOS values for the hybrid electricity storage system (HESS) proposed in HYBRIS have been estimated. The LCOS for both batteries and the HESS have been studied for different charging costs, assuming electricity prices taken from the literature. The reduced cost emerged from a series of optimisation strategies envisioned within the project has also been evaluated. Moreover, different assumptions on the electricity prices due to different contributions of the photovoltaic panels to charge the HESS batteries have been simulated for the three pilot sites.

Electricity cost	Site		
	Messina, IT	The Hague, NL	Brasschaat, BE
Grid [€/kWh]	0.4200	0.1361	0.2702
PV-generated [€/kWh]	0.0237	0.0661	0.04403

A final positioning analysis has been performed by comparing the LCOS results in HYBRIS with those of state-of-the-art batteries and HESS.
Calcution in terms of In-Front-the-meter (ITM) and Behind-the-meter (BTM) cases have been done.
ITM Scenarios where PV was assumed to be 100% the charging source, obtained LCOS for the testing sites were: IT: 0.076 €/kWh, NL: 0.131 €/kWh, and BL: 0.102 €/kWh.
BTM Scenarios HYBRIS was modelled as relying completely on the electric grid for charging, this is with a PV share of 0%, the resulting LCOS values were: IT: 0.584 €/kWh, NL: 0.220 €/kWh, and BL: 0.392 €/kWh.

- All this information has produced the deliverable D1.6 : *Levelized Cost of Storage (LCOS) analysis*, delivered in due time in July 21.

Deviation from Work Plan & remedial actions

WP1 has not registered particular deviation from the planned activity. The WP closed in M12, required more time in providing the respective deliverables, also due to corrections suggested by the PO. At this stage, all the deliverables were provided and accepted, apart the deliverable 1.2, which is under final review for its submission and, therefore, still pending.
In terms of PM dedication from partners, some have spent slightly more or less PMs than expected but always being able to carry out foreseen respective activities. These deviations are considered normal and will be compensated with other WPs higher or lower dedication.

WP 2: Development and characterisation of the battery components					
Leading Partner	IREC	Start Date	M3	End Date	M24

Objectives for the period M1-M12

The aim of this work package, led by IREC, is to enhance and optimize the different components required to the construction of the two energy storages system based on lithium ion and redox flow technologies required for the hybridization looking for the equilibrium between efficiency and economic cost optimizing life expectancy. It is based on the combination of the advanced new generation of Redox-Flow Batteries using organic (ORFB) as high-energy battery being the baseload manager and the Lithium Titanate (LTO) for the high-power component satisfying the peak demand situation. The trade-off between the losses of RFB and the degradation and cost of LiB is optimizing the hybrid performances. Specifically, WP2 is overseeing the:

- Performance optimization of the different batteries, characterizing their components in relation to their expected behaviour as part of the hybrid system:
    - LTO modules including all required sub-components.
    - ORFB modules including all required sub-components
- Assessment of the characteristics of each improved Energy Storage technology as part of the hybrid system considering capacity and power response.
- Characterize electrochemically and validate each technology at different levels: cells, modules and stacks

WP2 receives specifications on design from WP1, and provides technologies and characteristics for WP3 and WP4 (inputs for ABMS inputs and degradation models) and WP5 to system integration (scale up)

Description of work carried out and achievements

Task 2.1: Early Concept

- IREC has summarized activities carried out in WP1 and discussed with members of WP2, especially considering the specific goals for WP2 and HYBRIS project. IREC has asked demo site partners the requirements and services that the HESS has to perform.
- All partners have contributed to prototype design, optimization & batteries dimensions determination. This has been performed according to specifications concerning expected responses, energy efficiencies, capacities, discharge depth limits and any other parameter proposed as battery sizes taking into account pilot site and manufacturers requirements and limitations.

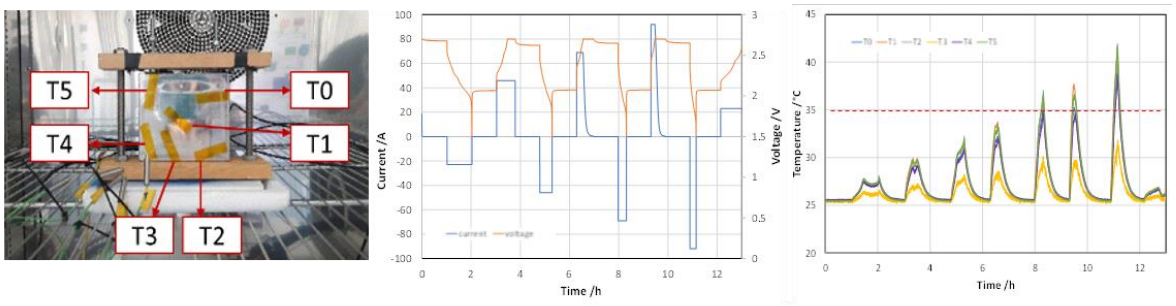
Results: one single system of 55kW/10kWh, maximizing power, has been determined. This system has been determined to be containerized to optimize displacement between demo sites and protection.

Task 2.2: Assessment of high-power battery module based on LB

This task has included the following specific tasks:

- Assessment of high-power battery module based on LB (M7-M14) [TOS, CNR, IREC]
- BDES has selected, prepared and delivered the LTO based modules
- CNR has tested the LTO battery module

LiB temperature characterization for different C-rates

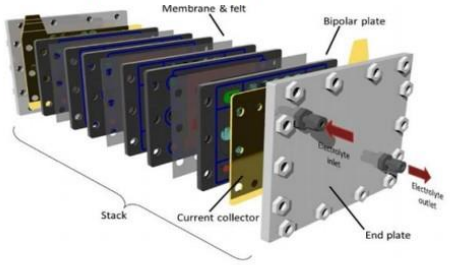


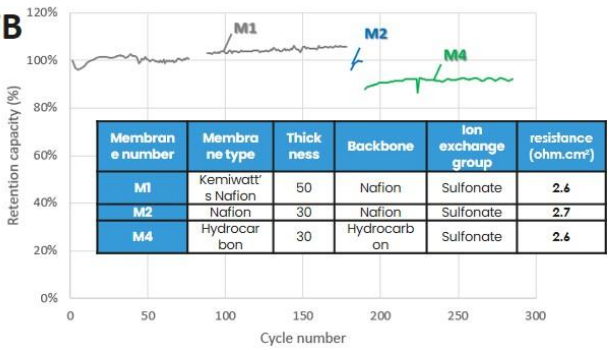
- IREC has studied LTO cells to understand degradation mechanisms under high power applications
- In parallel, a communication with BMS will be established by analyzing Toshiba protocol and developing a system interface in LABVIEW environment

Task 2.3: Assessment of high-energy battery based on AORFB
This task has included the following specific tasks:

- Kemi has validated the characteristics of the AORFB through the assessment of different components: i) Membrane; ii) Electrode/Electrolyte; and iii) Material structuration.
- KEMI has tested these three different components in laboratory scale and has chosen the best ones to enhance AORFB performance containing the costs. I) Kemiwatt's Nafion outcomes over other membranes tested, ii) Ni-foam performs better exchanging electrons to electrolyte, new formulation for active molecules delivers higher energy, iii) the reactor is determined to be made of 55 monocell in series configuration.

Components optimization AORFB





Membrane number	Membrane type	Thickness	Backbone	Ion exchange group	resistance (ohm.cm²)
M1	Kemiwatt's Nafion	50	Nafion	Sulfonate	2.6
M2	Nafion	30	Nafion	Sulfonate	2.7
M4	Hydrocarbon	30	Hydrocarbon	Sulfonate	2.6

Results: Nafion membrane is chosen due to better stability, Ni foam cannot be used due to increase in manufacturing costs impacting end energy price, new formulation electrolyte is chosen for better AORFB performance.

Deviation from Work Plan & remedial actions
Prototype dimensions' definition, coordinating manufacturers and pilot site requirements, has been longer than expected but it came to a final product. It has required an earlier activation of HESStec tasks to asses prototype containerization.

WP 3: Advanced BMS, electrical architecture and power conversion					
Leading Partner	CEA	Start Date	M3	End Date	M26

Objectives for the period M1-M12
The intent of WP3, led by CEA, is to develop innovations that allows to go from battery technologies to battery systems with optimized hybridisation. This covers three major aspects: Advanced Battery Management Systems (ABMS), power conversion and Power Management System (PMS). This concerns the intermediary step between batteries with individual BMS and fully hybridised ESS with EMS. In specific, WP3 is to carry out the following tasks: - Develop a predictive model of each battery technology - Develop an ABMS which will continuously diagnostic and prognostic each battery and will provide updated performance/ageing models - Study the optimal conversion architecture and design the associated power electronics structure - Specify the communication architecture between ABMS-EMS and ABMS-SCADA.
Description of work carried out and achievements
Task 3.1 Battery model development This task includes the following specific tasks: • Gather LTO and AORFB battery manufacturers information as pre-requirements • Specify battery models interfaces • Define algorithms related to battery cell technologies behaviour • Identify battery cell parameters based on manufacturers tests data • Specify battery model scales up from cell to stack level • Test and validate battery models behaviour on used case scenarios. Document and package created battery models Results: Based on TOS and Kemi manufacturer data, the following performance and ageing models are delivered by CEA: ▪ **LTO** • Coupling electro-thermal and ageing cell model, • Model scaled up from cell to stack level ▪ **AORFB** • Simplified electrical & ageing model due to limited available data    ▪ **Protected model supplied** ▪ **Common IO for both technologies** ▪ **Embedding Hybris Stack architecture with customization parameters** ▪ **Embedding Hybris battery reference characteristics (cartographies)** ▪ **Model calibration based on manufacturers test data and datasheets (TOS & KEMI)** Task 3.2: Advanced BMS and health management This task includes the following specific tasks: • Specify ABMS SAAS: architecture, key features and interfaces

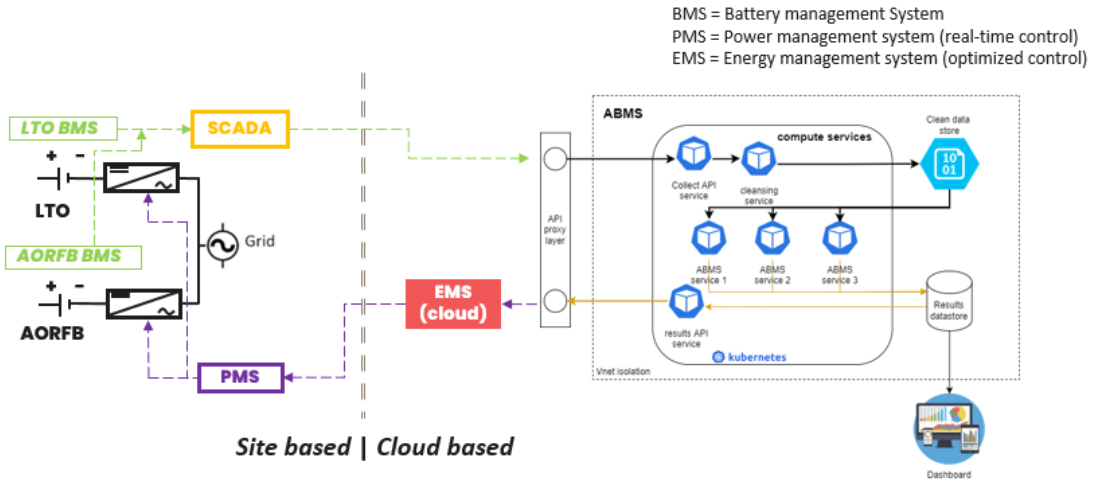
- Define and implement algorithms of ABMS features embedding battery models (diagnostic and prognostic features)
- Define and implement methodology for battery models update
- Specify ABMS infrastructure on a cloud platform embedding ABMS algorithms
- First integration Test and validation of the ABMS Solution with demonstrators data

Results:

CEA and PWP specified the ABMS skeleton, embedded features and communication architecture. CEA developed ABMS services algorithms and packaged them before performing platform integration tests supported by PWP. The services are gathered into the following main categories:

- Diagnostic services: BMS SOC & SOH consistency checks, availability & round trip computation.
- Control services: EMS mappings updates based on operation data (Pmax (SOC,T); ΔT(T,P); η(SOC,T,P)), & battery preference index computation (considering yield & SOH)
- Prognostic services: short term / long term battery KPIs & lifetime assessment based on battery models
- Update services: Electro-thermal and ageing mappings update based on operation data

Hereunder the Architecture of developed ABMS platform:



Task 3.3: Optimal electrical architecture of each BESS and the HESS

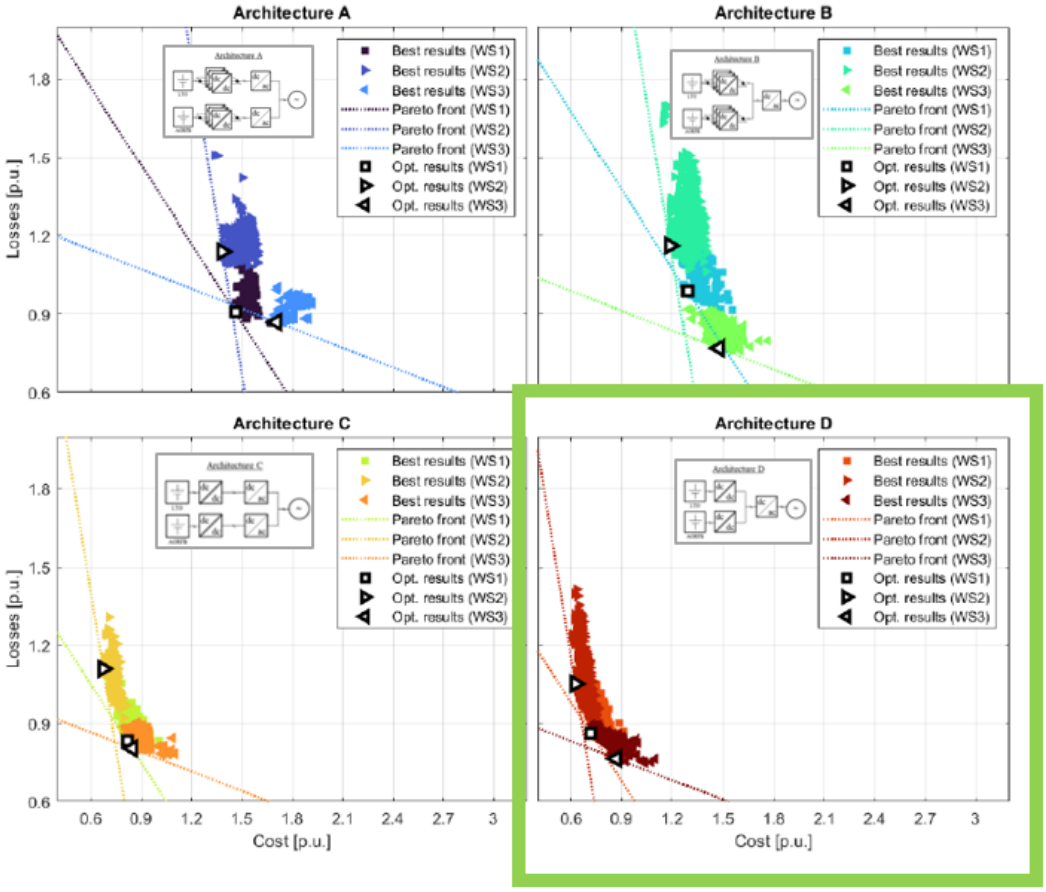
This task includes the following specific tasks:

- Specify studied architectures and converter internal topologies
- Modelling of converters (efficiency, reliability, costs aspects)
- Concept comparison of 4 architectures

Results:

IREC with CEA support performed an ooptimization study of Hybris Hybrid Energy Storage System architecture and selected the best trade of:

- Comparative analysis of 4 electrical architectures in term of efficiency, reliability and costs to define the optimum electrical architecture of the HESS.
- Aim to find the optimum converter architecture that shows the best trade-off in terms of losses (ζ), failure rate, and cost (σ). This is accomplished by



exploring and comparing the optimum ζ-λ-σ Pareto front of each architecture shown here under:

Task 3.4: Optimal converter design and validation
This task includes the following specific tasks:

- Converter design : component selection and sizing
- Converter model development
- Control design development
- Test and validation of developed models
- Prototype design
- Prototype construction
- Control implementation
- Prototype design and validation

All these tasks are to be pursued until M32.
Results:
IREC specified the optimal converter prototype architecture based on T3.3 results

Deviation from Work Plan & remedial actions
No deviations can be accounted for.

WP 4: Hybrid Storage Optimal Sizing and Control					
Leading Partner	TH	Start Date	M12	End Date	M36

Objectives for the period M1-M12
The intent of WP4, led by TH, is to serve as the link between the key innovations in the HESS battery design and the intelligent control of the overall system. The control system architecture and integration with the greater EMS system will be developed and validated for integration with cloud-based ARM controllers considering the intended operation conditions and corresponding certification requirements. Each stage will be tested directly within Digital Twin models to ensure planned sub-system and complete system behaviour functions as intended in near real-life conditions. To accomplish this, the work will utilize the Key Performance Indicators identified in WP1 and will be performed in parallel with WP2 and WP3 in order to ensure maximum efficiency in the design and development phase of the battery system. The outputs of WP4 will provide the basis for the system integration and final testing in WP5. Specifically, the WP4 objectives are: - To provide pre-prototype validation of the battery designs and battery management systems developed in WP2 and WP3 - To identify the optimal battery sizing considering the use cases to be explored - To develop the EMS architecture that enables both cloud-based and edge optimization of the battery - To pre-validate the overall system implementation to support system integration work in WP5
Description of work carried out and achievements
Task 4.1 Use case definitions, HESS modelling and specification of simulations This task includes the following specific tasks: • Gathering of initial specifications of battery technologies and key performance indicators based on work from previous work packages. • Coordination regarding modeling software used in WP2 and WP3 to ensure compatibility and facilitate benchmarking using the HIL digital twin model environment.
Deviation from Work Plan & remedial actions
No deviations can be accounted for.

WP 5: System integration and validation					
Leading Partner	HESStec	Start Date	M25	End Date	M36
Objectives for the period M1-M12					
The intent of WP5, led by HESStec is to integrate all the different components that comprise the HESS (batteries, PMS, EMS, etc) into a single and seamless HESS solution and perform its validation at laboratory scale (with significant power) under real conditions. These tests are fundamental for ensuring the success at pilot demonstrations, allowing a reduction of the testing period and the site and minimizing possible failures. In specific, WP5 objectives are: - Manufacture and integrate the HESS solution. - Validate the HESS solution at lab scale under emulated conditions by means of HIL/PHIL. - Achieve the highest performance characterization of the HESS prior to the test demonstration and minimize any risk.					
Description of work carried out and achievements					

Task 5.1 Manufacturing of each BESS and shipment to HESSTec site Coordination with BESS providers to define integration/assembly needs for later integration within HESSTec's premises.
Deviation from Work Plan & remedial actions
No deviations can be accounted for.

WP 6: Demonstration and Evaluation					
Leading Partner	IDP	Start Date	M13	End Date	M36
Objectives for the period M1-M12					
The goal of WP6, led by IDP, is to integrate all HYBRIS systems into the respective Demonstration Sites after an Implementation and Evaluation Plan has been agreed with all Demo Site Owners and respective technology providers. This shall provide the guidelines for the implementation of HYBRIS system in the different Demo Sites and later evaluation of their performance.					
Description of work carried out and achievements					
WP6 has not started yet so no achievements are to be mentioned under this WP. However, given the duration of the project and the fact that HYBRIS HESS must be implemented in 3 demo sites, some topics of discussion have been addressed under WP6 before its actual starting date. These include matters such as the shipment of HIL prototype devices as well as export licenses, needs in terms of Communication architecture and infrastructure. Also, information about the HESS batteries including BIM models if available and their dimensions/weight and needs for auxiliary systems has been requested (and provided) as well as information on Demo Sites' premises, installations and systems (actual). Finally, needs and/or specifications for the integration/assembly of the HESS were also discussed.					
Deviation from Work Plan & remedial actions					
As mentioned before, the only deviation from Work Plan is that WP6 has started earlier to address early risks and requirements from Demo Site Owners as well as HYBRIS HESS implementation/installation. This though, did not require an amendment					

WP 7: Stakeholder-oriented exploitation, dissemination, communication and training					
Leading Partner	COMET	Start Date	M1	End Date	M36
Objectives for the period M1-M12					
WP7, led by COMET, has a proactive and a project–long focus on aligning, in a strategic way, the implementation of communication and dissemination activities to maximise HYBRIS impact. The objectives of WP7 are: - To establish and maintain the mechanisms for effective and timely communication coordinating all levels and types of communication in relation to the HYBRIS;					

- To inform stakeholders of the project progress (targeting end users, technology stakeholders, commercial actors, academia and other projects with similar focus).
- To conduct the scientific diffusion of the R&D works performed within the project.
- To continuously assess both communication and dissemination activities.

WP7 will receive as input the knowledge and results generated by each of the technical work packages, the demonstration activities, and knowledge attained from the stakeholder group and outreach activities. WP7will provide as output relevant input to functional requirements, effective communication and dissemination activities, and exploitation-related insights that posture the project foreground for post project impact.

Finally, WP7 will contribute, upon invitation by the INEA, to common information and dissemination activities to increase the visibility and synergies between H2020 supported actions.

Description of work carried out and achievements

Task 7.1 Exploitation activities

This task includes the following specific tasks:

- Plan for the Exploitation and Dissemination of Results (PEDR). Definition of a complete strategy for the exploitation and dissemination of results aiming to maximize the project impact. The plan corresponds to deliverable D7.4 submitted in M6.
- Identification of Exploitable Results (ERs). The process started with an exploitation workshop during the General Assembly 1 (within the presentation of WP7) to provide a definition for results and exploitable result categories. Then, an online form was provided to partners to collect information related to the ERs previously identified. In October, a first draft of the deliverable D7.5 was sent to all partners. Information collected for each ER includes ER identified, ER type, ER manager, why it is innovative, exploitation vision, estimated TRL, actions, STO (relation of the ER with the project Scientific and Technical Objectives).
- HYBRIS dissemination network. Creation of the dissemination network collecting contacts provided by all partners. This is a baseline-level document that serves to initiate bilateral communications with stakeholders of the project by classifying them and collecting their confidential contact data and specific topics of interest and map the exploitation space. It corresponds to deliverable D7.1.
- Fairs and workshops. Initial plan and approach for the HYBRIS workshops and training series. This initial plan is being collected in deliverable D7.10.
- Clustering activities. Project-long opportunities are being sought and developed to connect to other like research activities to increase the visibility and synergies between H2020 supported actions. Joint dissemination, clustering and workshop opportunities are being cultivated and supported. HYBRIS is part of the FLORES network (network of Flow Battery Research Initiatives).

Task 7.2. HYBRIS Communication

This task includes the following specific tasks:

- HYBRIS website. The project website was launched in M3 and is being updated with news, new information, public deliverables, etc. Deliverable

D7.8 HYBRIS project website describing and documenting the website was submitted in M3. Website: https://hybris-project.eu/

- Social media: HYBRIS has been active, publishing and networking, on Twitter and LinkedIn since M6 and currently counts more than 140 followers between both platforms and also publications are shared in FLORES Network LinkedIn, which counts more than 520 followers. A publication schedule was set together with partners to generate content to feed the website and social media. YouTube channel has been launched after the 1st HYBRIS workshop with the addition of several video presentations.
  Twitter: https://twitter.com/hybriseu
  LinkedIn: https://www.linkedin.com/company/hybris-project/
  YouTube: https://www.youtube.com/channel/UCgAG_vr-Ie8wkH4GYUbNlCQ
- Public communication and branding materials. Regarding branding, HYBRIS' visual identity, with its set of logos and corporate manual, was presented in the PEDR (D7.4). Materials developed and made available to the consortium include a Public Project Presentation, roll-up, poster, brochure and Newsletter, which were presented in D7.9 HYBRIS public communication materials in M6. These materials have been slightly updated along the project and new materials will be produced when necessary and required by project partners. An activity report template is available so all partners can report any communication/dissemination activity they participate in.
- Community outreach: in order to boost impact, HYBRIS aims to present the project within educational, innovation or training events organized by partners. To date, HYBRIS was presented to the whole FLORES Network in December 2021.

- Monitoring of communication and dissemination activities impact. A set of KPI was defined in the PEDR (D7.4) to check whether HYBRIS is achieving the expected impact of dissemination and communication. COMET prepared a communication monitoring tool (shared excel file) to monitor events, press articles, technical publications, webinars, workshops, videos and website articles and posts. Progress is being measured regularly using these indicators. In addition, a contingency plan is being developed to anticipate possible alternatives in the event that the various activities do not produce good results. Table below shows the KPI expected, and progress made by M18.

HYBRIS' GA KPIs		M12
Visits to the website (cumulative page views)	TARGET	5.000
	PROGRESS	366
Newsletter's recipients	TARGET	100
	PROGRESS	76
Linkedin's group members	TARGET	50
	PROGRESS	22
Twitter's followers	TARGET	50
	PROGRESS	14
Articles or appearances in the media	TARGET	1
	PROGRESS	0
HYBRIS Videos	TARGET	0
	PROGRESS	0
Scientific Publications	TARGET	2
	PROGRESS	0
Events / conference participations	TARGET	2
	PROGRESS	1
Clustering events	TARGET	0
	PROGRESS	1
Marketing & Community Partner Events	TARGET	2
	PROGRESS	0
Thematic workshops	TARGET	0
	PROGRESS	0
Training programs' attendants	TARGET	0
	PROGRESS	0
Printed/online communication materials distributed	TARGET	200
	PROGRESS	240

Some additional figures below:
Web publications: 17
LinkedIn publications: 46
Twitter publications: 37
Events, conference participation and clustering events:

- EMRS Symposium on battery and energy storage devices: from materials to eco-design (20-23 Sept. 2021)
- H2020 Batteries projects clustering event (17-18 Nov. 2021)

Task 7.3: Data and Knowledge Management
This task has included the following specific tasks:

- Outline how data collected or generated within the HYBRIS project is to be organised, stored and shared.
- It has been conceived according to the Guidelines on FAIR Data Management in Horizon 2020.

- Specific data typologies have been identified and labelled in terms of public or restricted access and suitable tools for ensuring data storage and public access to open data have been selected.
- Furthermore, responsible Consortium members have been appointed for each data typology and standard formats for data sets have been chosen.
- D7.3, which consists in a Data Management Plan will ensure that HYBRIS results are correctly labelled, safely stored, accessible and meet all requirements set by the European Commission in the FAIR guidelines

Deviation from Work Plan & remedial actions

Deliverable D7.10 due in M12 was postponed (to M15) as there were some open discussions to start defining the workshops and we wanted to take advantage of the General Assembly held in January 2022 to make some decisions.

WP 8: Project Management & Coordination					
Leading Partner	IDP	Start Date	M1	End Date	M36

Objectives for the period M1-M12

This work package is designed as effective and efficient structural framework for all partners from interdisciplinary institutions to ensure a proper accomplishment of all project-related goals and scientific and managing tasks. The project management & coordination encompasses the financial, administrative and contractual components including the risk monitoring and mitigation during the entire project period. For this, clear management structures and techniques have been defined to build the framework for the implementation of the project goals, in particular:

- Establish an appropriate liaison with the EC for financial administration and reporting,
- Establish and maintain a common understanding within the interdisciplinary team by fostering the exchange of project-related information,
- Supervise and monitor the implementation and project progress according to the scheduled work plan including tasks, deliverables and milestones,
- Assure high-quality documentation of project results in line with the reporting periods,
- Organise meetings of the consortium at all stages and provide minutes and documentation,
- Oversee gender equity as well as ethics and responsible research during the entire project duration.
- The work package assures the realisation of all the project's tasks and objectives on time and within budget including complete visibility of on-going activities for attainment of high-quality outcome.

Description of work carried out and achievements

Task 8.1 Project technical coordination and management

This task includes the following specific tasks:

- Technical Reporting
- Encouraging collaboration between partners to achieve the defined deliverables and milestones
- Organizing and submitting the project deliverables

At the beginning of the project, COMET prepared and shared with the rest of consortium members several templates for project reporting of deliverables. All of

them were explained by email and later on explained again during the 1st General Assembly carried out in a virtual/online way due to COVID-19 situation, in order to make sure that everyone understood how to fill them in. Also, the Deliverable template itself was edited to ensure the compact 1st-page executive summary section and the readability of each deliverable as a single document

Task 8.2 Contractual Administration
This task includes the following specific tasks:

- Communication with the European Commission
- Finalizing the consortium agreement, including management of IPR
- Resolving Contractual and consortium coordination issues involving the Grant Agreement and potential amendments.

A 1st amendment was requested and submitted in order to address certain partner requests that are summarised hereunder:

- 4YEF PMs/Budget almost completely transferred to ILECO due to ILECO managing 4YEF Demonstration de facto.
- SME Owner budget change for COMET
- T1.2 lead shift from TH to ILECO
- T1.3 extension to M12 as deliverable 1.3 under this Task is to be submitted in M12
- Correction of D5.3 and D5.4 leaderships in "Description of Deliverables" table in WP5.
- Participation of TH erased from T5.2 as it is not participating.

Task 8.3 Risk Management
This task includes the following specific tasks:

- Management related to any potential risks that may arise during the duration of the project and the activation of contingency actions whenever needed.

So far, risks detected and/or raised were successfully tackled by HYBRIS members. Main risk addressed was the impossibility of providing a HESS that could be implemented in HYBRIS Demo Sites and that could meet Demo Sites' expectations in terms of Power and Energy performances.

Task 8.4 Financial Administration & Administrative Management
This task includes the following specific tasks:

- Aiding HYBRIS consortium members with financial/cost monitoring throughout the project.
- Collection of internal reporting documents on partners' related costs.
- Organizing and reporting/submitting cost statements
- Organization of internal and external meetings
- Writing and distributing the minutes
- Resolving administrative issues from HYBRIS Partners with the EC Commission and PO.

Deviation from Work Plan & remedial actions
Deviations from DoA in regards with the "single" HESS to be provided and its sizing definition (55kW – 30kWh)

4.3 Summary of Deliverables

The deliverables that fall under this 1st year are listed hereunder, including whether they have been delivered or not:

D#	Name	Delivered	Summary and Comments
D1.1	Requirements and specifications	Yes	Requirements and specifications of both LTO and ORFB batteries have been provided, as well as Electrical, electronics, communication, and mechanical characteristics, useful as inputs for the design of the batteries in WP2. Finally, first assumptions on the technical hybridization and of the overall performance of the hybrid are also provided as input for WP3 and WP4. This deliverable corresponds with Task 1.1
D1.2	KPIs with detailed explanation and ready to be used for operational implementation	Yes	Identification and definition of a list of KPIs that accurately capture the economic and technological values of HESS as a service. This should be compared with SoA KPIs for similar technologies. This deliverable corresponds with Task 1.2. This deliverable is expected to be re-submitted during the month of October 2022.
D1.3	Analysis of the HESS services and business model development	No	Analysis of HESS system and business models, which need to be much more lean and dynamically optimized to yield a descent and good return. This deliverable corresponds with Task 1.3
D1.4	Technical and market review codes studies, national and European certification frameworks	Yes	Country specific codes on target markets have been reviewed to guide the business development and the definition of realistic use case applications. This implies to set specifications to meet basic requirements in compliance with regulations affecting all HYBRIS technologies and concepts. This deliverable corresponds with Task 1.4
D1.5	Preliminary Report on Eco-design, sustainability, energy storage and material safety assessment	Yes	Based on the technical and regulatory KPIs and requirements, this deliverable aims at guiding chemistry, materials, and technology selections. It provides a comprehensive list of environmental criteria that the prototype should follow within its development and the critical points on which scientific partners should focus the ensure the best possible sustainability. The deliverable refers to Task 1.5.
D1.6	Levelized Cost of Storage (LCOS) analysis	Yes	This deliverable is directly linked to task 1.5. and more precisely to subtask 1.5.5. A general comparative analysis with different current hybrid energy storage technologies will be performed in order to provide a preliminary

			overview of the project feasibility and show a major efficiency of HYBRIS prototype. This deliverable corresponds with Task 1.5
D2.1	High-level concept of the hybrid energy storage and the requirements of each technology	Yes	The initial concept design and specification of the hybrid-energy-storage (holistically and individually) will be provided in this report. This deliverable corresponds with Task 2.1
D2.2	Assessment of high-power battery	No	Assessment through design and simulation of different management strategies, focusing on the cooling optimization to maximise the power density at high currents. This deliverable corresponds with Task 2.2
D2.3	Assessment of the high-energy battery	No	Development of the high energy battery system prototype 5kW/ 15 kWh based on a novelty organic redox flow battery. Since the redox flow allows to scale the capacity regardless of the performance by simple install larger tanks with more electrolyte. This deliverable corresponds with Task 2.3
D2.4	Characterisation and validation of modules	No	This report will provide the results and details on the tests performed for modules characterization and validation through lab tests. This deliverable corresponds with Task 2.5 and previous works in Task 2.4 This report's submission date was misleading since it had to be submitted before tasks T2.4 & T2.5 had started. This issue has been highlighted in 2nd AMENDMENT (Reference No AMD-963652-14) and it is shifted to M24.
D3.1	Report on Battery models	Yes	Behaviour models of each battery technology. These models are to be used in T3.2. and T3.3 in order to develop the Advanced BMS and to study the optimal electrical architecture. This deliverable corresponds with Task 3.1
D7.1	Dissemination Network: Database of project stakeholders	Yes	Definition of a group created early in the project and led by COMET and engaged in relevant events aiming at providing an "outsider view" of the project to the consortium towards driving development in the direction where it is most needed and where impact could be maximised. Deliverable linked with Task 7.1, Subtask 7.1.3. First version submitted in M12 (December 2021) and second version after RP1 submitted in M19 (early July 2022).
D7.2	D7.2 v1 Standardisation	Yes	This document includes the analysis of the applicable standardization landscape. It

	landscape and applicable standards		provides useful information for the development of the project and its work packages, by identifying the existing standards and technologies and the ongoing developments (at European and international levels) in the fields related with HYBRIS. This analysis of the standardization landscape includes the identification of the related standardization committees and organizations involved. Deliverable linked with Task 7.1, Subtask 7.1.3.
D7.3	Data Management Plan	Yes	Definition of the plan to manage all Knowledge gained during HYBRIS Project as well as Data collected in accordance to H2020 rules regarding Open Access to Research Data. Deliverable linked with Task 7.3.
D7.4	PEDR	Yes	A complete Plan for the Exploitation and Dissemination of Results will be elaborated following the approach described at the proposal phase. This deliverable will also include an specific section for communication management (communication plan) fully aligned with the exploitation and dissemination strategy, aiming to maximise the impact. This deliverable corresponds with Task 7.1.
D7.5	Exploitable Results Table	Yes	This table will identify and manage (including identification of adequate protection measures) project key exploitable results with the intent of unlocking innovation potential and innovation capacity of project partners. Deliverable linked with Task 7.1. First version submitted in M12 (December 2021) and second version after RP1 submitted in M19 (early July 2022).
D7.9	HYBRIS public communication materials	Yes	The first version included the creation of the project corporative identity (branding) and the communication materials (roll-up, poster, brochure, project presentation and newsletter template). Deliverable linked with Task 7.2 and Subtask 7.2.1. Communication materials will be updated periodically according to project needs/progress.
D7.10	HYBRIS workshop series and training	No	This deliverable will specify the scheduling and approach for all HYBRIS workshops and training series. Deliverable linked with Task 7.2, Subtask 7.2.2.
D7.11	D7.2 v2 - Standardization landscape and applicable standards	No	Extended version of previous D7.2 v1. Additionally, it includes a strategy for HYBRIS' contribution to standardization and a description of the types of standard documents which could be implemented.

D8.1	Project Management Plan	Yes	Plan to ensure the proper execution of the project in all scientific and technical aspects, defining the workflows and validation actions to ensure the quality of all deliverables and achievement of goals in due time during the First Reporting Period. It includes a Gantt chart and a Work Breakdown Structure (WBS), including a schedule per task, responsible partner related subtasks, related deliverables, and dependencies on other tasks. All contents will be revised in M18 (and updated in D8.4) and M36. This deliverable is linked with Task 8.1.
D8.2	First Risk and contingency plan	Yes	A first version of a risk management, mitigation and contingency plan developed by the consortium in order to mitigate risks and to ensure contingency to follow the innovative research work at its best during project lifetime. This deliverable is linked with Task 8.3.
D8.3	First Year Progress Report	Yes	A report on the progress carried out during the project's first year, including technical progress in all Work Packages as well as deliverables submitted, in anticipation of the First Periodic Report. This Deliverable is linked with Task 8.1.
D9.1	POPD - Requirement No. 1	Yes	If the beneficiaries collect personal data, they must provide a description of the security measures that will be implemented to prevent unauthorized access to personal data or the equipment used for processing. This must be submitted as a deliverable. In case that personal data will be transferred from a non-EU country to the EU, a confirmation that such transfers comply with the laws of the country in which the data was collected must be submitted as a deliverable. In case that the research involves profiling, the beneficiary must provide explanation how the data subjects will be informed of the existence of the profiling, its possible consequences and how their fundamental rights will be safeguarded. This must be submitted as a deliverable

4.4 Summary of Milestones

MS#	Name	Delivered	Summary and Comments
MS1	Overall requirements and KPIs definition	Yes	Overall requirements and KPIs definition. D1.1 and D1.2 as means of verification

MS2	Materials assessment and simplified LCA	Yes	Materials assessment and simplified LCA. Deliverable 1.5 as means of verification
MS3	ORFB and LTO assembled modules validated	No	This Milestone has not been achieved since D2.4 has been postponed.

5 CONCLUSIONS

Several findings can be outlined out of the results of the preliminary LCA on both battery technologies. During the assessment of the LTO batteries, the electrodes were identified as the most critical components in both analysed cell configurations, making them a hotspot when studying the environmental impacts of this technology. The development of the screening of material safety provided several highlights regarding the hazard level and toxicity impacts of the materials employed during the production of both battery technologies. From a hazard level perspective, the LFP–LTO technology represents lower safety concerns than NCO–LTO, having materials with overall lower occupational risks; similarly, the NCO–LTO materials reported consistently higher toxicity impacts than those of the LFP–LTO battery. In the case of the AORF battery, none of the materials employed in its production showed specially concerning or outstanding occupational hazard levels. The recyclability analysis provided useful insights regarding the different methods that can be implemented for both battery technologies. At large, lower environmental footprints are forecasted for direct recycling approaches. When focusing on LTO aged batteries, there exists methods for the simultaneous recovery of TiO_2, lithium and cathode precursors, based on leaching and precipitation routes, that can be beneficial for both energy and reagents saving. For AORF batteries, main issue falls into the electrolyte and membranes recycling, which can be addressed through established methods already tested for other electrochemical systems. Finally, several ecodesign recommendations were advised. For instance, for LTO batteries it was advised to increase the secondary raw material content in aluminium and copper parts, or to replace the metal parts in the cell container with plastic parts, which may also include some recycled plastic content; and to increase the recycled material content in the electrodes. Similarly, the titanium dioxide and lithium-based compounds could be obtained from recycled sources, either in closed- or open-loop schemes. The ecodesign recommendations for the AORF battery consisted of using bio-based renewable electrolytes to replace quinone-based electrolytes. KEMIWATT is highly committed to this issue, and more sustainable anthraquinone-based molecules have been developed; their synthesis path is under optimization to maximize their eco-friendliness. This new electrolyte generation will be used in HYBRIS demonstration systems, whose environmental footprint will also be assessed from a LCA perspective.

With respect to the LCOS study, the primary conclusion that can be drawn from the observed results is that – given the technical specifications disclosed by the battery manufacturers and the planned operation conditions for the pilot sites – HYBRIS proves to be competitive from a cost perspective. This affirmation is based on the LCOS values that were obtained when analysing each of the scenarios that were considered in D1.6. When comparing the least favourable LCOS results for all the pilot sites (these being the ones that assumed a PV share of 0%) to the compiled data from literature, HYBRIS positioned well within the range of reported values. This reinforces the conclusion that HYBRIS can be considered cost competitive when compared to other previously studied ESSs and HESSs

5.1 Summary of achievements

Overall, HYBRIS project has achieved the following achievements:

- Determination of the least environmentally harmful cathode chemistry for the LTO–based battery.
- Development of a pioneering assessment of the environmental impacts associated to AORFBs, a very novel technology with little information available in literature.
- Providing an integrated review of both occupational and environmental hazards associated with the materials employed in the production of the batteries.
- Development of a review on optimal efficiency material recovery methods for the recycling and life extension of the battery technologies.
- Determination of the Levelized Cost of Storage for the HYBRIS prototype on its different pilot locations.
- Positioning of HYBRIS within the state-of-the-art of energy storage systems from a costs perspective.
- Insights regarding optimal operation conditions for the HESS, especially regarding the process of system charging.
- Preliminary insight on the effect of the implementation of KPI objectives on the LCOS for HYBRIS.

5.2 Relation to continued developments

In turn, the following actions will be undertaken in the following months in order to guarantee the continuation of developments and implementation of HYBRIS solutions:

- The results from D1.5, and especially, the ecodesign proposal, have direct implications on the development of each battery technology (Task 2.4), which will take advantage as much as possible of the highlights here determined. Similarly, results from D1.6 will be considered in the determination of the life cycle cost impacts (Task 6.6) and for exploitation purposes. All these results constitute the state-of-the-art baseline to be surpassed under an improved sustainability within HYBRIS implementation, which will be assessed from last project year.