European Innovation Council

EIC Pathfinder Portfolio

Mid to long term and systems integrated energy storage

Portfolio Strategic Plan

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Contents

1. Introduction

1.1. Background

Energy storage is required to increase energy systems flexibility, sectors coupling, demand response and smart interoperability solutions. Storage technologies facilitate high penetration of intermittent renewable energy, enable energy efficiency technologies such as waste heat recovery, increase the efficiency of cold supply chains and in turn contribute to a secure, affordable and sustainable energy transition.

1.2. The Challenge

In 2022, the EIC launched the **EIC Pathfinder Challenge** call "**Mid to long term and systems integrated energy storage**"[1], which aims to **develop a range of breakthrough solutions for thermal and electrical mid-long term and system integrated energy storage (MDLES), minimizing or avoiding the use of critical raw materials and capturing processes and system integration opportunities**. Energy storage solutions are needed to increase the spatial and temporal matching between intermittent renewable generation and energy demand, and to facilitate the implementation of active demand response and energy efficiency measures. These technologies should rely on the use of non-critical raw materials (CRM) to enhance the EU sovereignty, be cost competitive, adopt circular approaches in their whole lifetime, and address the specific systems integration opportunities and strengths of the EU energy systems and industrial sectors. Considering this, the specific focus of the portfolio is to support reliable solutions for mid to long duration energy storage (MDLES), which represent critical technologies for flexible, sustainable, and fully integrated energy systems.

The challenge addresses both thermal, electrical, or combined thermal/electrical MDLES with duration from days (mid-term) to seasons (long-term) for stationary applications at mid to large scale size. More specifically, the selected proposals of this Challenge support the following technologies and systems for stationary applications:

- MDLES for power systems, with technologies such as metal air or redox flow batteries, power to heat to power, chemical bonds, electrochemical/chemical/thermal hybrid solutions, integration of energy carriers and 'storage to X' strategies; concepts for centralised or decentralised applications at grid, industrial or district level;
- MDLES (heating or cooling) at different temperature, such as building integrated and process systems integrated solutions, chemical looping or thermochemical storage, solar

[1] EIC Pathfinder Challenge: Mid to long term and systems integrated energy storage (europa.eu)

thermal energy harvesting and storage, combined storage of thermal and electrical energy as well as other energy vectors, storage systems integrated in cold chains and in industrial processes.

1.3. The Portfolio Strategic Plan

According to the call: "*The beneficiaries are expected to contribute to the Portfolio's objectives under the guidance of the EIC Programme Managers (PMs). The PMs will work with the beneficiaries to define the governance of the Portfolio, to establish expectations from the projects' collaboration, to define rules for resources and data sharing in accordance to Annex 7 of the EIC 2022 WP, and to identify the common exploitation, communication, and dissemination strategies for the Portfolio. All these elements will be defined at the Portfolio kick-off meeting and in the Portfolio Implementation Plan, being updated during the portfolio implementation.*
The projects are expected to include a task for portfolio activities and to allocate a proper budget. *They should carry out the following activities and associated deliverables:*

- *Portfolio kick-off and annual meetings.*
- *Portfolio web page with communication plan.*
- *Portfolio Implementation Plan, with specific technical tasks herein described."*

The Portfolio Strategic Plan defines the objectives of the portfolio, identifies the activities to reach those objectives and guides their implementation by establishing a **governance structure**. It is the product of a collaboration between the portfolio projects, the Project Officers (POs) and the PMs. It will be revised once per year. Further requests for an update can come either from the PMs, the POs, or the steering committee of the portfolio (see Governance).

More information, including the rational for the portfolio approach and the motivation of the Portfolio Strategic Plan, is provided on page 9 of the **Challenge Guide** "Mid to long term and systems integrated energy storage"[2].

[2] Challenge guide Mid to long term and systems integrated energy storage (europa.eu)

2. The Portfolio

2.1 Thematic areas

The portfolio composition aimed at including a broad range of technological areas to guarantee the diversification of energy storage technologies, enable demand response strategies and capabilities to host higher penetration of intermittent renewable technologies, and explore different synergies with the existing energy systems and infrastructures. The projects within the portfolio were selected based on a balance of complementarities and diversities among the proposals. The following technological areas were identified, with proposals allocated to one of them:

- Area A: Electrochemical energy storage
- Area B: Thermal energy storage
- Area C: Chemical looping and storage of energy carriers
- Area D: Thermomechanical energy storage

The portfolio composition criteria included the potential synergies within each category and across the categories in terms of (listed in priority order):

- Synergy type 1: type of conversion processes within the same technological area
- Synergy type 2: materials used, including their synthesis and characterization
- Synergy type 3: temperature level of the thermal storage
- Synergy type 4: integration of energy storage in industrial systems
- Synergy type 5: applications for buildings and centralized large-scale storage

The retained proposals and their technological classification are reported in Table 1 and 2.

The portfolio originally consisted of 8 projects, which started on 1 October 2023 and that will run for up to 48 months, with a total budget of around €29 million. Upon judgement of a panel of experts chaired by the PMs, EIC Pathfinder Open project MeBattery was granted an EIC Booster grant and invited to be added to the portfolio. This means that the portfolio is composed of 9 projects, with a budget allocated from the EIC of around €31.5 million. Further projects may be invited to the portfolio, according to technical and scientific commonalities.

Table 1. Portfolio overview

Acronym	Number	Principal Investigator	Start Date	End Date	Project Website	EIC PO
PUSH-CCC Large-scale energy storage via optimized combined cycle CAES	101115601	Fernando Ruiz del Olmo	01/10/2023	30/09/2027	push-ccc.com	Adelina NICOLAIE
SULPHURREAL Solid sulphur chemical looping with high T solar heat input for long duration storage	101115601	Christos Agrafiotis	01/10/2023	30/09/2026	sulphurreal.eu	Nikolaos STERGIANNIS
ReZilient Redox-mediated hybrid zinc-air flow batteries	101115538	Roberto Scipioni	01/10/2023	30/09/2027	rezilientproject.eu	Adelina NICOLAIE
HIPERZAB Electrically rechargeable zinc-air batteries	101115535	Nagore Ortiz	01/10/2023	30/09/2027	hiperzab.eu	Nikolaos STERGIANNIS
M-TES Metallic phase change material-composites for Thermal Energy management	101115421	Elisabetta Gariboldi	01/10/2023	30/09/2026	m-tes.eu	Adelina NICOLAIE
VanillaFlow Artificial Intelligence Guided Development of Vanillin-based Flow Batteries	101115307	Ulrich Hirn	01/09/2023	31/08/2026	www.vanillaflow.eu	Adelina NICOLAIE
AELECTRA Mid- to long-term storage of electrical energy via ammonia production	101115293	Emil Drazevic	01/10/2023	30/09/2027	projects.au.dk/aelectra	Nikolaos STERGIANNIS
Muspell Medium to long duration thermal energy storage with embedded heat pumping capability	101115264	Roberto Fedrizzi	01/10/2023	30/09/2027	muspell.eu	Nikolaos STERGIANNIS
MeBattery Mediated Biphasic Battery	101046742	Edgar Ventosa Arbaizar	01/05/2022	30/04/2025	mebattery-project.eu	Olivier DAHON

Table 2. Details of portfolio projects

Acronym	Technological area	Input	Output	Description
PUSH-CCC	D	Electricity	Electricity	PUSH-CCC adopts a variable volume cushion fluid to maintain a constant pressure during charging and discharging, aiming to solve the existing challenges of maintaining steady pressure during charging, to develop a high-efficient (> 80% round-trip) and cost-effective large-scale (>100MW) energy storage technology with massive scaling up potential (increasing energy density up to 11.8 kWh/m3). The technology is suitable for hard-rock areas which are very common worldwide, it minimizes heat losses and fracking risks.

SULPHURREAL	C	Heat	Energy carrier, electricity	SULPHURREAL uses heat from concentrated solar energy (or other clean energy resources) at 800-900ºC, to drive a series of chemical reactions that interconvert sulphuric acid and sulphur. The harvested solar thermal energy is stored to solid elemental sulphur, which can be combusted on-demand to produce renewable energy (i.e. heat or power when combined with a suitable thermodynamic cycle) at a temperature higher than that of the original heat input (1100-1200ºC) and with an overall solar-to-electricity efficiency > 20 %. The cycle can also be operated using sulphuric acid and sulphur feedstocks from existing large-scale industrial processes.
ReZilient	A	Electricity	Electricity	ReZilient aims to fill the gap between short-duration electrochemical energy storage and long-duration chemical storage by developing and demonstrating at lab-scale (0.5-1.5kW/6kWh) a completely new Zn-air flow battery technology. The estimated capital cost for large-scale deployment is approximately 80 €/kWh, with a levelized-cost-of-storage ~0.07 €/kWh/cycle (24h discharge duration) and ~0.43 €/kWh/cycle (based on 100 kW/1000 kWh system, 1 week discharge duration). A disruptive redox-mediated strategy for enhanced charge transfer processes is employed with the goal of confining the Zn/Zn2+ redox reaction in the negative reservoir and eliminating the electroplating process inside the cell to improve battery lifetime. This will allow discharge times beyond days, contrary to conventional zinc-based batteries where long discharge is hampered by the formation of a cm-thick zinc anode.
HIPERZAB	A	Electricity	Electricity	HIPERZAB aims to develop low cost and competitive solutions (Electrically Rechargeable Zinc-Air Battery (ERZAB), with high round-trip efficiency, high energy density and reliable solutions for mid to long term energy storage (from days to months), through non-critical raw materials (CRMs)-based systems and processes integrated, life cycle-driven technologies. DoD > 60%, energy density > 150 Wh/kgcell, areal capacity > 24 mAh/cm2, prospective energy cost at stack level ≈0.05 €/kWhcycle. Under mid current densities (5-10 mA/cm2) and > 24 h/cycle (day-by-day storage).
M-TES	B	Heat	Heat	M-TES aims to design and develop metallic materials for thermal energy storage (sensible and latent heat) in the medium-low temperature range (100-300°C). Potential applications for active heat exchangers are identified, together with solutions for intermittent waste heat recovery and integrated storage
VanillaFlow	A	Electricity y, vanillin	Electricity	VanillaFlow proposes a "safe and sustainable" Redox Flow Battery, using organic and non-toxic electrolytes, ideally coming from European waste streams – e.g. the pulp & paper or sugar "industry". The project specifically focuses on the relevant electrolytes, the stacks and the subsequent business models – concentrating on large scale B2B projects (>100kW / 500kWh) and not B2C. Like all other energy storage projects, grid integration will be crucial.
AELECTRA	C	Water, atmosphe ric air, electricity	Energy carriers (ammonia)	AELECTRA will develop a groundbreaking energy efficient system for long-term electrical energy storage via ammonia, produced from nitrogen captured from the air, water and renewable energy. The ambition is to outperform conventional thermochemical Haber-Bosch Reactor (HBR) in CAPEX, at similar OPEX. It is suitable for decentralized applications, filling a gap in the market for cost efficient production scales <1,000 kg/h NH3 (1 kW - 10 MW). AELECTRA aims to deliver a turnkey system that will demonstrate NH3 synthesis and separation at lab scale. The state of the art will be advanced by identification of optimal reactor conditions, developing reactor & system components and AC/DC power supply. It has the potential to disrupt the chemical industry by utilizing spatial and temporal variations in intermittent renewable energy production, to locally deliver the same product as Haber-Bosch Process at significantly lower capital cost, without compromising the operational expenses. The AELECTRA system will be relevant for multiple industry sectors, including power production, food, pharma, shipping as well as fertilizer production.
Muspell	B	Heat, electricity	Heat, electricity	Muspell aims to develop a Thermal Storage System exploiting renewable, excess energy to charge a TCM (thermo-chemical materials) based storage, while making rejected heat available in the range of 100°C to 200°C, for utilisation in industrial processes.

MeBattery	A	Electricity	Electricity	MeBattery aims to lay the foundations of a next-generation battery technology that will potentially help overcome the critical limitations of established flow and static battery systems in energy storage. The proposed battery technology will leverage the intrinsic benefits of a redox flow battery system. It will rely on a combination of radically new thermodynamical concepts that should enable achieving an excellent balance between all key performance indicators: sustainability, cycle life, recyclability, energy and power decoupling, cost and energy density. MeBattery brings together a team of specialists who will contribute with their complementary expertise in computational science, materials science, organic chemistry, environmental chemistry, chemical engineering, electrochemistry and battery prototyping.

Table 3. Key performance indicators of portfolio projects

Acronym	CAPEX [€/kWh]	LCOS* [€/kWh/cycle] *discharge cycle 24h	Round-trip efficiency [%]	Discharge duration [h]	Lifetime [years or cycles]
	Target	Target	Target	Target	Target
SULPHURREAL	n.a [1]	n.a [1]	solar (thermal)-to Sulphur > 20 %	n.a [1]	> 5 years[2]
ReZilient [3]	80[4]	0.07	> 70	170	> 10 000 cycles
HIPERZAB [5]	80	0.05	> 65-70	12-16	> 1000 cycles
M-TES	320-480	n.a [6]	n.a [6]	1-10 [7]	>1000 cycles [7]
VanillaFlow	200	0,10	>75	10	>10000 cycles
AELECTRA	1,240 [8]	0.12 [9]	Around 30	Days-Months	10 years
Muspell [10]	-[11]	-[11]	1.4-1.6	3-10	>10000 cycles
MeBattery	**500**	**0.10**	**>70**	**5-20**	**>5.000 cycles**
PUSH-CCC	90	< 0,04	> 80	8-14	> 10.000 cycles

Table 4. notes for Table 3.

Project	Note to Table 3 and comparisons with State of Art (SoA)
Sulphurreal	[1]No data available due to low TRL of proposed technology;[2] Expected lifetime of catalyst materials without significant activity loss.
ReZilient	[3]SoA for all columns: CAPEX: 700-1000 €/kWh; LCOS: 0.07-0.14 €/kWh/cycle; Round-trip efficiency: 70 %; Discharge duration: 12-24 hr; Lifetime: 20 000 cycles; [4]SoA LCOS (0.07-0.14 €/kWh/cycle, calculated on 12h or 24h discharge duration), Target (0.07-0.43€/kWh/cycle, calculated on 24h- or 1 week-discharge duration).
HIPERZAB	[5] SoA for Round-trip efficiency: <60% . Discharge duration: 1-2 hours

M-TES	[6] LCOS and Round-trip efficiency greatly depends on the systems in which novel M-TES materials are used; [7] Estimated figures. The assessment of those parameters is not foreseen in the project implementation due to the materials' low TRL.
AELECTRA	[8] SoA CAPEX: 2.750 €/kWh. Assuming EUR 5.72 million to deploy conventional production of grey (CO2 emitting) ammonia based on Haber-Bosch (HB) process at a baseline production capacity of 400 kg/hour. CAPEX target for AELECTRA is EUR 2.58 million (55% lower than HB) equivalent to 1,240 €/kWh; [9] SoA LCOS: 0.12 €/kWh/cycle. Levelized Cost of Storage (LCoS) assuming a CO2 emitting grey ammonia production scheme (HB) comes at a cost at 595 €/ton (400 kg/hour). AELECTRA development target for the Levelized Cost of Ammonia (LCoA) is 618 €/ton resulting in a comparable LCoS of 0.12 €/kWh/cycle. The competitive advantage increases exponential in the range below 400 kg/hour where HB process is more expensive. The process can be sector-coupled to i.e. stationary power production, fertilizer or protein industry.
Muspell	[10] SoA CAPEX: 1000 €/kWh, Lifetime: >10.000 cycles; [11] The material and the system design are at an early stage, which does not allow to define accurate target ranges.

2.2 Sub-portfolios and potential synergies

As indicated in the portfolio description, **two broad sub-portfolios** can be identified, sharing similar scientific expertise and communities, research methodologies, materials characterization, and Key Performance Indicators. These sub-portfolios are (a) electrochemical storage and (b) thermal, thermo-mechanical and chemical storage, and the allocation of projects to them is reported in table 5.

Table 5. Sub-portfolios of the MLDS portfolio

Electrochemical storage	Thermo-mechanical and chemical storage
Rezilient	Aelectra
HiperZab	M-TES
MeBattery	Muspell
VanillaFlow	Push-CCC
	Sulphurreal

The main synergies among the projects will be explored in the areas of:

I. Materials synthesis and characterization for energy storage: the segmentation of the portfolio in the two mentioned thematic sub-portfolios will facilitate deeper synergies;
II. Materials screening, simulation, and data management;
III. Combination of technologies to achieve enhanced functionalities and performance (included hybridization of short-mid-long duration storage and thermal management of electrochemical storage or combination of electricity and heating storage);
IV. Sustainability / life cycle analysis (LCA, LCCA, LCSA);

V. Techno economic analysis (TEA) including the evaluation of system-level benefits (i.e. provision of ancillary services to the power system) and profitability for different end users and markets;
VI. Exploitation strategies and in particular comparison of different business models to facilitate market implementation of storage technologies (i.e. storage as a service) or optimal integration to other facility management services.
VII. Assessment of policy and regulations to reward the overall benefits of storage, included possible amendments to energy markets configurations at Member State level and proposals for a common approach to systems integration of energy storage.

The identification of **further synergies and complementarities among the projects** is also possible and will be actively explored during the execution of the projects and with the specific knowledge sharing and networking tools put in practice.

2.3 Governance

The portfolio is governed on two levels: strategic steering and operational steering. The two levels are connected through the project coordinators (see Figure 3).

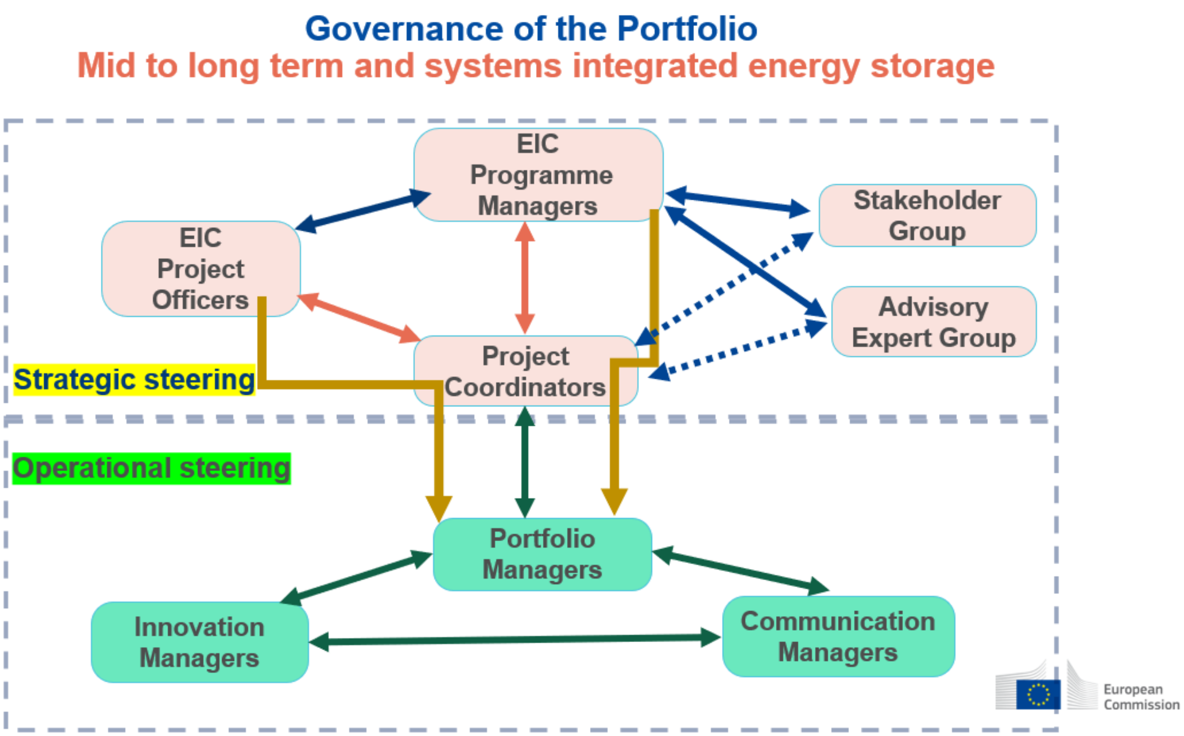

Figure 3. Interactions among the key actors of the portfolio

The high-level strategic steering of the portfolio is done by the EIC Programme Managers **in close collaboration** with:

- the **Project Officers**;
- the **9 project coordinators**;
- the **Advisory Expert Group**, composed by external experts selected by the EISMEA on their expertise and ability to contribute to steer the portfolio with independent and impartial advice. All the experts have signed a **Non-disclosure Agreement** (NDA) with the EIC and hence are entitled to discuss the detailed characteristics of each project. The experts can propose and conduct activities beneficial to the whole portfolio;
- the **Stakeholder Group**, composed of global value chain actors such as industry representatives, potential end-users, investors as well as policy makers. This group serves to foster portfolio exploitation activities through the exchange and engagement of industrial stakeholders belonging to the energy storage value chains. The members of the stakeholder group are called stakeholders. They provide non-binding strategic advice to the portfolio, or to a project. The stakeholders agreed to become part of the Stakeholder Group on a voluntary basis. There is no requirement on invested time and commitment, nor any obligation to share any data between the involved parties. Stakeholders are not allowed to ask the EIC or any involved party for financial renumeration; on the other hand, the EIC and the portfolio projects understand that the commitment by the stakeholders is purely voluntarily and upon the stakeholders' decision and willingness to engage. Portfolio projects are invited to suggest stakeholders to the PMs. There is neither a minimum nor a maximum number of stakeholders.

  The stakeholder group meets virtually for the first time when at least three board members have assumed their role. The PMs will present the portfolio projects to the stakeholder group. During this meeting, the stakeholders exchange their contact details, and further interaction is upon their initiative. The stakeholders are encouraged to proactively reach out to the projects in the portfolio, to advise them in their area of expertise and to update fellow stakeholder group members. They are likewise encouraged to exchange regularly with the PMs. Finally, projects can reach out to stakeholder board members as well.

On the **operational side**, each project was asked to nominate specific managers for each of the **three activity pillars** to ensure targeted workflows within the portfolio and a clear hierarchy within the project consortia, and Table 6 reports this allocation to each project. These managers and their specific roles are:

- **Innovation managers**, who oversee the exploitation strategies and elaborate the **exploitation plan** (this includes also the IPR strategy); they also identify the market potentials, manage the stakeholder's assessment, and stimulate innovation within the portfolio.
- **Portfolio managers**, who oversee the portfolio activities and management and governance of the portfolio. They are also in charge of the identification of synergies, shared components, and collaboration opportunities with one or more projects and of the assessment of the competitiveness of the proposed technologies for different applications.
- **Communication managers**, who oversee the implementation of portfolio dissemination and exploitation activities. They are in charge of the elaboration of a joint communication strategy, including common database for events on an online platform, communication activities and shared database of scientific instruments.

Table 6. Allocation of the operational roles

Project	Portfolio Manager	Innovation Manager	Communication Manager
PUSH-CCC	Fernando Ruiz Vincueria & Fernando Ruiz del Olmo	Lillo Isidoro	Santiago Diaz
SULPHURREAL	Christos Agrafiotis	Josua Vieten	Elke Reuschenbach
ReZilient	Roberto Scipioni	Søren Bødker	Fride Vullum Bruer, Erik Kelder & Anders Bentien
HIPERZAB	Nagore Ortiz	Raquel Ferret	Elena Guinea
M-TES	Monica Favaro & Paola Bassani	Andrea Lucchini	Donatella Giuranno & Rafal Nowak
VanillaFlow	Wolfgang Zitz	Stefan Pachmajer	Stefan Spirk
AELECTRA	Nicolai Fossar Fabritius	Nicolai Fossar Fabritius	Nicolai Fossar Fabritius
Muspell	Roberto Fedrizzi	Vlad Iorgulescu	Roberto Fedrizzi
MeBattery	Virginia Ruiz	Jesus Palma	Heiko Poth

2.4 Portfolio activities

The Portfolio has the overall objective to position Europe strategically at the forefront of the sustainable technologies for energy systems flexibility and integration of energy technologies through mid to long duration storage assets, without use of Critical Raw Materials and relying on circular and system-integrated resources. The overarching portfolio goal is hence to contribute to identify and accelerate the development of the most promising energy storage technologies to address the EU energy security, while contributing to other sustainability goals such as dispatchability of renewable electricity, demand side management sectors coupling, in agreement with the Repower EU and Green Deal targets. The portfolio activities will stimulate the collaboration among the projects and the networking with the innovation ecosystem to enhance the development of the EU technological autonomy in this field.

The portfolio's activities target three main dimensions: **technology**, **regulatory,** and **innovation journey.** In addition, there is a layer of portfolio management and communication activities to facilitate the collaboration between the projects.
The technological dimension is addressed by leveraging synergies between projects to scale up technologies, explore adoption of similar research methodologies, compare results against similar metrics, embrace multidisciplinary approaches, share laboratory equipment. This dimension also includes the techno-economic and environmental comparison of the different technologies proposed in the portfolio to produce **high level policy feedback** on the optimal routes from a **system level perspective**.

The regulatory dimension of the portfolio is also particularly relevant, considering that most of the proposed solutions need public support and proper market mechanisms to be economically competitive, included reliable and effective standardization and certification systems. The grouping of projects in sub-portfolios helps to engage with the scientific communities they belong to, streamline communication on their specific requirements to catalyze and foster innovation, and to ensures their visibility in front of stakeholders, policymakers, regulatory and policy bodies. The creation of the portfolio is also a step towards the critical mass necessary to achieve policy changes and to enable technological development.

Finally, the projects work together to improve their exploitation strategies, nurture entrepreneurial mindsets and bring their innovations to the market.

The details of these activities are reported in the following.

2.4.1 Portfolio activities in the technological dimension

Table 7 describes the technological areas where commonalities among the projects have been identified, that can bring to specific technical activities among projects.

Table 7. Potential technological portfolio activities

Project	Technological areas of potential common interest for portfolio activities
All projects	• LCA and environmental impact assessment with shared metrics and methodologies • Techno-economic assessment (TEA) and comparative cost benefit analyses • Hybridization of different storage technologies • Common approaches on simulation tools, control techniques, research equipment • New materials design (e.g. use of AI/ML), synthesis, characterization (e.g. in operando) and testing in real environmental conditions

SULPHURREAL	• Synthesis of advanced catalysts via various synthesis routes and on coating/shaping them into porous structures and particles. • Sulphuric acid catalytic chemistry and advanced characterization techniques. • Materials testing in "harsh" environments • Computational screening of material compositions per targeted applications. • Design, modelling, simulation and construction of high-temperature chemical reactors. • Combustion technology (chemistry and chemical kinetics) for liquid fuels and power generation • Safety and environmental impact analysis.
ReZilient	• Zinc dendrites. Developing and testing innovative approaches to prevent or mitigate zinc dendrite formation during charging cycles (potential collaboration with HIPERZAB) • Mediators. More efficient redox mediators for enhanced charge transfer processes (potential collaboration with MeBattery) • Stack development to meet the needs of the new type of hybrid flow battery (collaboration with MeBattery, VanillaFlow)
M-TES	• Development of new metallic materials for heat storage based on recycled alloys.
VanillaFlow	• Development of organic electrolytes (Quinons) based on European waste streams • Use of Redox Flow Battery stacks for new electrolytes (membranes, carbon felts, electrodes..)
AELECTRA	• Corrosive liquids management and material science • Design modelling and simulation of medium pressure reactors • Chemical kinetics and synthesis of new catalysts • Heat recovery and storage
Muspell	• Exploration of novel potential applications for the investigated materials • Materials corrosion science and materials characterization techniques
MeBattery	• Modelling of redox potential and selectivity of organic compounds • Development of new electrochemical reactors • Establishment of analytical tools to evaluate kinetics

2.4.2 Portfolio activities in the regulatory dimension

There is a clear need for proper legal, administrative and regulatory framework to facilitate the adoption of mid to long-term energy storage solutions. In the case of electricity in particular, specific incentives are needed to reward the increased system flexibility generated by storage, together with market mechanisms that allow to operate in prosumer mode (selling and withdrawing energy in the same connection point), so maximizing the profitability of storage solutions. Firm capacity market regulation and capacity payment is crucial to mobilize innovations in energy storage, and proper electricity market regulations are needed in this direction. The dimension of grid integration of electricity storage is particularly important, since the functionalities and operational standards of these storage assets should be agreed with the Transmission System Operators and Distribution System Operators to guarantee the required power system adequacy and reliability. The portfolio aims to foster interactions with energy regulators at EU level to propose together with key stakeholders the market regulations amendments needed.

Some portfolio projects would also benefit from clear regulatory framework on the production, transport, handling and storing of energy carriers (i.e. sulphur or green ammonia). As the portfolio projects range from 1–4 TRL, it is relevant to have standardized protocols for the certification of low TRL technologies. Another challenge faced by projects developing fully innovative technology is the lack of existing certification, as in the case of VanillaFlow.

In the field of thermal storage, standardization issues are also important to facilitate the integration of storage at both build environment and industrial sector, and the same issues of electricity storage occur when power to heat to power solutions are explored.

Table 8 reports the areas where portfolio activities can be identified in the assessment of regulatory issues and barriers preventing the full development of the proposed technologies.

Table 8. **Areas where potential portfolio activities in the regulatory dimension are foreseen**

Project	Potential portfolio activities in the regulatory field
General to all projects	**Regulatory mapping and engagement**. Conducting comprehensive mapping of the regulatory landscape, identifying gaps, challenges, and opportunities. Actively engaging with Partnerships, Standardization Bodies, or technical and standardization committees relevant to storage. Promote reward market mechanisms for coupling renewable energy generation with mid-long duration storage, in particular in the electricity sector and at TSO and DSO level
SULPHURREAL	Certificate of green origin for produced sulphur Regulations for transportation, handling and storing of chemicals (sulphur, sulphuric acid) Safety regulations for emissions of toxic gases i.e. $SO2$, $SO3$ Regulations regarding heliostat fields and solar towers (zoning licenses, height, location restrictions etc.)
ReZilient	**Taskforce on standard and safety protocols for redox flow battery:** the Task Forces on Standardization, Safety, Hybridisation from Batteries Europe ETIP are working on position papers for defining standards, and safety protocols for Battery Technologies. The portfolio can contribute to the drafting of a document to promote standards at the national and EU level. (ReZilient has several participants in the Batteries Europe ETIP and its coordinator is also the Technical Leader of Batteries Europe).
HIPERZAB	Developing standardized protocols and certification processes of the technologies developed in the projects at low TRLs is challenging.
M-TES	Assessment of potential regulatory issues related to the use of the selected materials and relative standards/safety issues in place
VanillaFlow	Certification for the proposed new organic electrolytes; Standards and safety protocols for RedoxFlow Batteries;
AELECTRA	Ammonia production, storage and usage is heavily regulated by the chemical and refrigeration industry where clear guidelines are available. Grid regulation and grid compliance for electrolysers in chemical industry should apply here. Certification of ammonia and its green origin.
MeBattery	Firm capacity market regulation: unless firm capacity is paid, it will be very difficult for projects including energy storage to be competitive in renewable generation public tenders

2.4.3 Portfolio activities in the innovation journey

The portfolio activities that can be developed to foster innovation among the projects are listed in table 9.

Table 9. Portfolio activities related to the innovation journey

Project	Suggested portfolio activities in the foreseen innovation journey
All projects	**Market and industry analysis:** identification of sectors with the highest demand for mid long duration energy storage, such as renewable energy integration, grid stabilization, electric mobility, remote power systems, intermittent waste heat recovery and valorization. **Stakeholder Engagement** to gather insights into their specific energy storage needs, performance requirements, and operational constraints to initiate early collaboration and feedback. Leverage on the EIC network to engage with relevant stakeholders, such as large manufacturers of materials, energy suppliers, grid operators (DSO/TSOs), facilitating technology transfer, from laboratory to market products. **Use case and pilot design drafting.** When the portfolio technologies become closer to lab-validation, it is necessary to draft a detailed pilot design proposals that outline the scope, objectives, technology specifications, integration plans for the specific use case. **Draft and compare different exploitation plans** using the same template including business models proposed by the portfolio projects and their suitability for various market segments. **Share expertise** on IPR and on different exploitation strategies such as start-up creation.
SULPHURREAL	The project will perform a techno-economic assessment and technology roadmap, benchmarking the proposed solution to PV and conventional CSP, including storage options (batteries, heat respectively). Sulphurreal aims to collaborate with all projects providing relevant assessments/metrics for these or additional storage technologies. Key Stakeholders for the specific project: Sulphuric acid industries: Direct end-user of one of the products of the cycle. Turbine developers/Sulphur burner manufacturers: Market for sulphur combustors tailored specifically for power generation. New market creation. CSP plant developers/EPCs: Definition of a novel, high energy density TES system for 24/7 operation of a CSP plant. Increased competitiveness of CSP vs. other RE sectors in areas with ‘’duck-curve’’ issues. Oil and gas industries: Exploitation of huge sulphur by-product amounts. Links to solar industry, especially in geographical areas where oil/gas production coincides with high insolation.
Vanillaflow	Interaction with key stakeholders for: • Organic waste streams as the basis for Vanillaflow’s electrolytes • Stacks that are capable of workingg with Vanillaflow’s electrolytes
Muspell	Identification of a common set of technical, economic and sustainability benchmarks for the proposed novel thermal energy storage systems;
MeBattery	Fabrication and value chain assessment of non-commercial components, in particular upscaling of electroactive materials at competitive cost

2.5 Collaborations among projects

Based on the initial focus of the challenge, of the portfolio composition criteria, of the peculiarities of the individual projects, and in the light of the identified potential synergies among them, several potential collaborations within the portfolio can be identified, as reported in Table 10.

In some cases, these collaborations will be undertaken through specific comparisons among alternative options using comparable KPIs (Key performance indicators), such as in the case of Sulphurreal and Push-CCC, that both aim at electricity storage at large scale level, but with different market segments. Sulphurreal needs high temperature heat and can decouple spatially other than temporally the supply and demand, while Push-ccc needs specific location for the energy storage in rocks. They hence share similarities and differences, and a techno-economic comparison among them is a specific aim of the portfolio.

Table 10. Planned collaborations within the portfolio

	PUSH-CCC	SULPHURREAL	ReZilient	HIPERZAB	M-TES	VanillaFlow	AELECTRA	Muspell	MeBattery
PUSH-CCC		7, 14, 15, 16	7, 14, 15	7, 14, 15	7, 8	7, 14, 15	7, 14, 15	7, 8	7, 14, 15
SULPHURREAL	7, 14, 15, 16		7, 9, 14, 15	14, 15	9	9, 14, 15	7, 8, 14, 15	9, 12, 13	5, 9, 14, 15
ReZilient	7, 14, 15	7, 9, 14, 15		1, 2, 4, 6, 14, 15		1, 5, 6, 14, 15	7, 13, 14, 15	7	1, 3, 5, 6, 14, 15
HIPERZAB	7, 14, 15	14, 15	1, 2, 4, 6, 14, 15			9, 14, 15	7, 13, 14, 15		1, 10, 14, 15
M-TES	7, 8	9					7, 13	7, 8	
VanillaFlow	7, 14, 15	9, 14, 15	1, 5, 6, 14, 15	9, 14, 15			7, 13, 14, 15		1, 5, 11, 14, 15
AELECTRA	7, 14, 15	7, 8, 14, 15	7, 13, 14, 15	7, 13, 14, 15	7, 13	7, 13, 14, 15			14, 15
Muspell	7, 8	9, 12, 13			7, 8				
MeBattery	7, 14	5, 9, 14, 15	1, 3, 5, 6, 14, 15	1, 10, 14, 15		1, 5, 11, 14, 15	14, 15		

Shared inputs / methodologies / others	Materials	Equipment	Regulatory Field

[1] Joint workshop on Long Duration Electrochemical Energy Storage
[2] Zinc-based anode optimisation
[3] Redox mediators and booster development
[4] Testing of Zn anodes (porous structures, cyclability, in-operando dendrites characterisation).
[5] Flow battery stack testing/development
[6] Regulatory mapping/engagement and stakeholders mapping (Electrochemical energy storage)
[7] Regulatory mapping/engagement on hybrid energy storage (thermal, thermomechanical and energy carriers)
[8] Thermal energy storage
[9] Computational methods for compound screening
[10] In operando characterization, multiscale modelling and characterization of interfaces (solid/solid, solid/liquid, liquid/liquid).
[11] Joint validation of AI/ML selected option and exploration of chemistries with AI tools (e.g. redox mediator/booster voltage coupling, mediator solubility limits, etc).
[12] Corrosive liquids and material science
[13] Life Cycle Assessment (LCA), safety and Environmental Impact Analysis (EIA).
[14] Thermoeconomic assessment of electricity storage

[15]Thermoeconomic assessment of energy storage in the form of thermal energy
[16] Design modelling and simulation of medium pressure reactors

3. Implementation of the portfolio

3.1 Portfolio work package

The work package relating to portfolio activities that is included in each project's signed Grant Agreement includes the following tasks.

#	Task	Responsible
Task 1	**Portfolio management and project governance** • Regular meetings and exchanges among the portfolio projects. • Set up an operational internal governance.	Portfolio Manager
Task 2	**Portfolio action plan** • Collaborations, synergies, and joint activities among projects	Portfolio Manager
Task 3	**Portfolio actions to foster innovation** • Creating opportunities to nurture innovations arising from the projects • Performing actions aimed at strengthening the EU research community on energy storage i. Mapping, categorization of the stakeholders and potential establishment of key partnership(s) ii. Exchanging of market research analysis results between projects iii. Continuous engagement with strategic partners and stakeholders	Innovation Manager

Task 4	**Implementation of portfolio dissemination and exploitation activities** • Organization and participation to outreach events at the portfolio level	Communication Manager
Task 5	**Techno-economic benchmark and comparative assessment** • Comparing techno-economic performance of energy storage solutions among portfolio projects with similar metrics	Portfolio Manager

These tasks are implemented through a series of actions agreed during the Portfolio kick-off meeting in November 2023 and that will be updated. Each activity will be lead and coordinated by a project of the portfolio. Additionally, there are three working groups, each consisting of at least eight members (one representative from each project):

- WG Coordinators;
- WG Innovation and Portfolio Managers;
- WG Communication Managers.

All portfolio activities are allocated to at least one of the working groups.

3.2 Deliverables

Annual report on portfolio activities:

The report will present the collaboration activities that have been carried out in each reporting period and contain relevant deliverables (e.g. slides, minutes of meetings, etc.). It also explains how the portfolio activities and the EIC proactive project management approach contribute to the achievement of the objectives and help the transition to market. This annual report is elaborated by the Communication Managers.

Joint technical report:

Contribution to a joint technical report with other projects in the portfolio on the key factors affecting the penetration of the proposed technologies in each market segment and the relative competitiveness of each solution in different end user applications. This report includes the following three components:

- Materials selection and potential interactions for the use of non-critical raw materials;

- Techno-economic and LCA comparison of proposed technologies with common methodology

Annex A) Portfolio Composition

A.1 Portfolio composition

The portfolio is composed of 60 partner organisations, representing 19 EU member states. A significant part of the participating organizations are universities or other higher education institutions, with the presence also of research and technology organisations (RTOs) and private, for-profit entities, as reported in Fig A.1 and A.2.

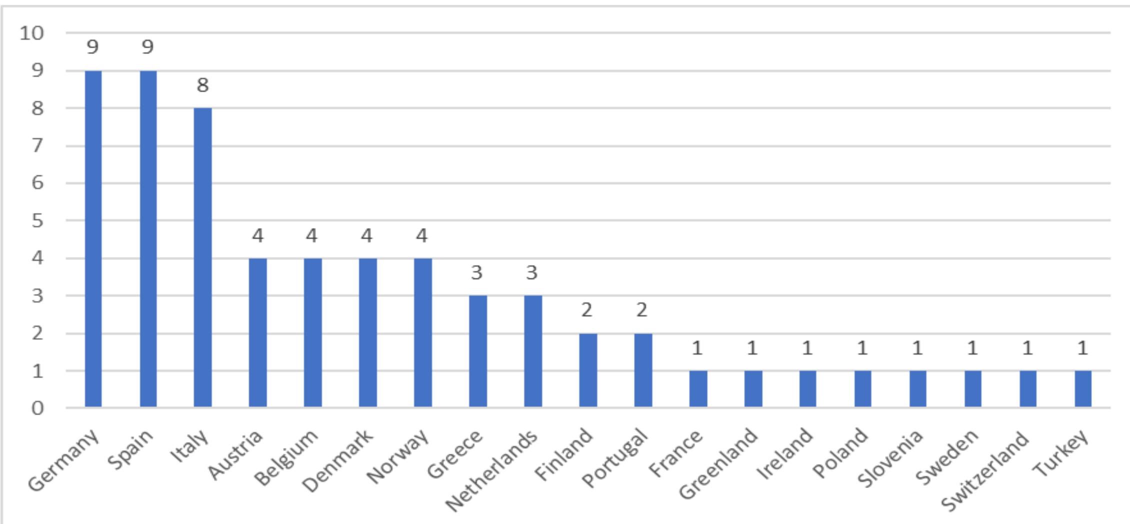

Figure A.1. Number of partners per Country

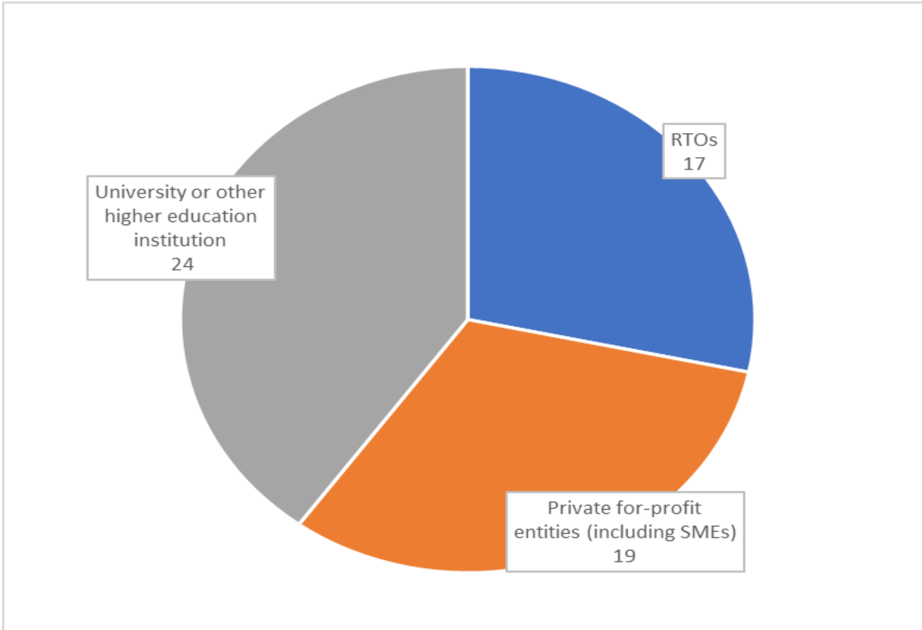

Figure A.2. Number of partners per type of organization

Annex B) Portfolio meetings

The Portfolio kick-off meeting took place in Brussels in hybrid model in November 2023 with the participation in person of all team leaders of the portfolio.

The first Portfolio meeting took place on 1 July 2024 in Rhodes, Greece, followed by a workshop on energy storage organized during the ECOS Conference with participation of broader audience.

These meetings are also an opportunity to identify new specific collaborations between two or more projects leading to additional portfolio activities (e.g. session with SMEs and corporations, or with investors or etc.) or needs for a revision of the portfolio activities. The PMs can also propose sessions to be added to the annual meeting and invite key stakeholders.

Portfolio Meeting and Lead	Date and location to be determined by	Date of the Portfolio Meeting	Finalized Location of the Portfolio Meeting

1st Portfolio Meeting	N/A	November 2023	Brussels, Belgium
2nd Portfolio Meeting	PUSH-CCC	July 2024	Rhodes, Greece
3rd Portfolio Meeting	AELECTRA	Summer 2025	Aarhus, Denmark

Annex C) Portfolio activities

Portfolio actions include collaborations between two or more of the projects. The following list of portfolio actions will be revised and adapted, in accordance with the interests and needs of the projects. The aim of the project partners within the portfolio is to address the specific challenge objectives described in the call by carrying out, among others, the following actions.

Activity	Coordinating actor	Project in charge
Participants list with access rights on TEAMS	Portfolio manager	EIC
Strategic portfolio plan – communication managers	Communication manager	All projects
Strategic portfolio plan – innovation and portfolio managers	Portfolio manager / innovation manager	All projects
Comments to the final strategic portfolio plan	Portfolio manager / innovation manager	All projects
Techno-economic comparison for thermal storage	Portfolio manager	Muspell + Push-CCC
Techno-economic comparison for electricity	Portfolio manager	VanillaFlow + ReZilient + PUSH-CCC
Portfolio meeting in 2025	Portfolio manager / innovation manager	AELECTRA

Materials assessment	Portfolio manager	HiperZab from the electrochemical storage sub-portfolio M-Tes / Sulphurreal from the thermo-mechanical and chemical storage sub-portfolio
Policy, Regulatory and standardization analysis	Portfolio manager	Rezilient & Push-CCC
Stakeholder mapping		Muspell + VanillaFlow
Innovation training course – nominate participants	Portfolio manager	All projects + EIC
Potential cooperation with other relevant HE funded projects	Innovation manager	MeBattery + SULPHURREAL
Identification of the proper in-operando characterization		Muspell + Hiperzab
Exploitation plan	Innovation manager	One/two representative/s per project, nominated to participate in the "How do we turn this into a business course"
Identify research areas that need more support	Principle investigator	ReZilient + SULPHURREAL
Portfolio website	Communication manager	HIPERZAB
Communication guidelines	Communication manager	HIPERZAB and SULPHURREAL
Vertical webinars (Workshop on topics of common interests)	Communication manager	PUSH-CCC
Junior scientists meeting	Communication manager	ReZilient + VanillaFlow
List of participants including role, tasks and WPs involved	Communication manager	M-TES
Equipment that can be shared with other projects	Communication manager	M-TES
Newsletter	Communication manager	AELECTRA
Project pitch deck for portfolio website	Communication manager	Muspell
Portfolio pitch video	Communication manager	EIC

Annex D) Non-disclosure obligations and Non-disclosure Agreements (NDAs):

According to the call[3]:

"Where beneficiaries are informed on or given access or disclosure to any preliminary findings, results or other intellectual property generated by other EIC actions, and where this information is earmarked as "confidential" in accordance with section 2.1.b, they must:

- *keep it strictly confidential; and not disclose it to any person without the prior written consent of the owner, and then only under conditions of confidentiality equal to those provided under this section; and*
- *use the same degree of care to protect its confidentiality as the beneficiary uses to protect its own confidential information of a similar nature; and*
- *act in good faith at all times; and*
- *not use any of it for any purpose other than assessing opportunities to propose other research or innovation activities to the EIC, or any other initiative agreed by the owner.*

The EIC beneficiary may disclose any such information to its employees and, with the prior authorisation of the owner, to its subcontractors established in a Member State or an Associated Country and:

- *who have a need to access it for the performance of their work with respect to the purpose permitted above; and*
- *who are bound by a written agreement or professional obligation to protect its confidentiality in the way described in this section.*

No obligations are imposed upon the EIC beneficiary where such information:

- *is already known to the EIC beneficiary before and is not subject to any other obligation of confidentiality; or*

[3] https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2021/wp_horizon-eic-2021_en.pdf

- *is or becomes publicly known through no act by or default by/of the EIC beneficiary; or*
- *is obtained by the EIC beneficiary from a third party and in circumstances where the EIC beneficiary has no reason to believe that there has been a breach of an obligation of confidentiality.*

The restrictions in this section do not apply to the extent that any such information is required to be disclosed by any law or regulation, by any judicial or governmental order or request, or pursuant to disclosure requirements relating to the listing of the stock of the EIC beneficiary on any recognised stock exchange. Upon the end or termination of the grant agreement or of the participation of the EIC beneficiary, it must immediately cease to use the said information, except if otherwise directly agreed with the owner, or if the beneficiary remains a member of the EIC Community referred to under section 2.1.b. The provisions of this section shall continue to be in force for a period of 60 months following the end or the termination of this grant agreement or of the participation of the EIC beneficiary, at the end of which period they will cease to have effect."

Facilitating exchange of information within the Portfolio. Knowledge on the other projects is necessary for the definition of this strategy plan. As of October 2023, the only public information on the projects is title, abstract and information on project partners as well as received funding. If considered relevant, projects are encouraged to set-up and sign NDAs.

Facilitating exchange of information with "externals". If activities are organized with the participation of externals, the projects will assess whether an NDA with these external parties is needed and proceed accordingly.