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Mid long term and systems integrated energy storage

EIC Programme Managers

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Outline

- The process for challenge definition and the portfolio approach
- The challenge: scope and scientific background
- Categories for portfolio building
- Portfolio considerations

Guiding principles for selection of challenges

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High innovation potential and recognized industrial interest/market needs

Relevance for EU technological autonomy and expected economic/societal implications

Synergies with other Horizon EU programmes

Non incremental research opportunities (Pathfinder)

EU positioning in the global innovation ecosystem and critical mass of EU stakeholders/researchers

Process of Selection (Methodology)

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Programme Manager's Role(s)

Initiation

- PMs competences and know-how
- Foresight reports, key scientific literature assessment
- Overview of ERC/EIC funded projects and related innovation/research trends

Guidance

- EIC internal brainstorming for preliminary challenges definition
- Structured interviews with selected scientists and key experts

Outcome

- Assessment of Horizon EU funding programmes/ topics
- Challenges

Approach for selection of challenges

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January-May 2021

- Informal meetings with experts coming from science/business/financial field
- EIC and EC internal Discussion

September/October 2021

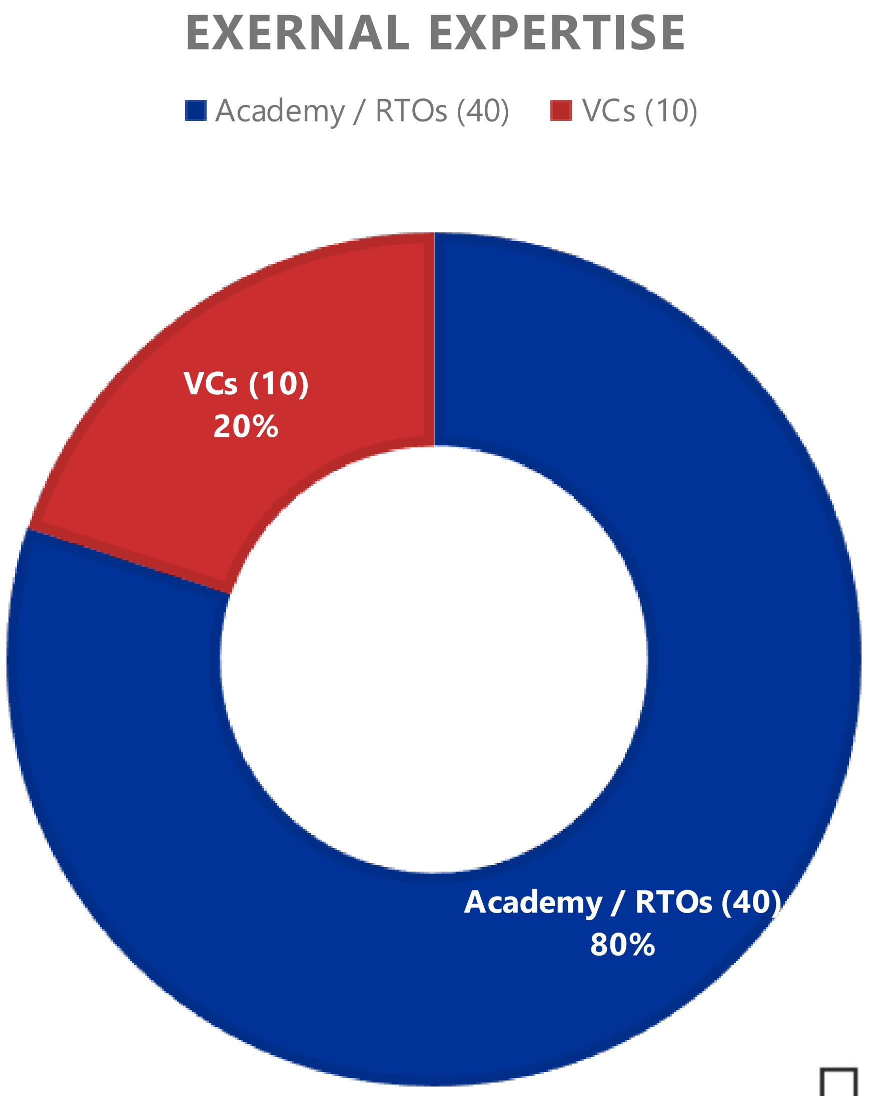
- Interservice consultation, opinion of PC, adoption of WP with challenge calls
- Discussion in PC on selection of EIC Challenges for 2022 WP
- External expert advice (workshops etc.)

Jan - April 2022

- Discussion with experts and study of the recent updates in the fields

April/May 2022

- Challenge guide writing

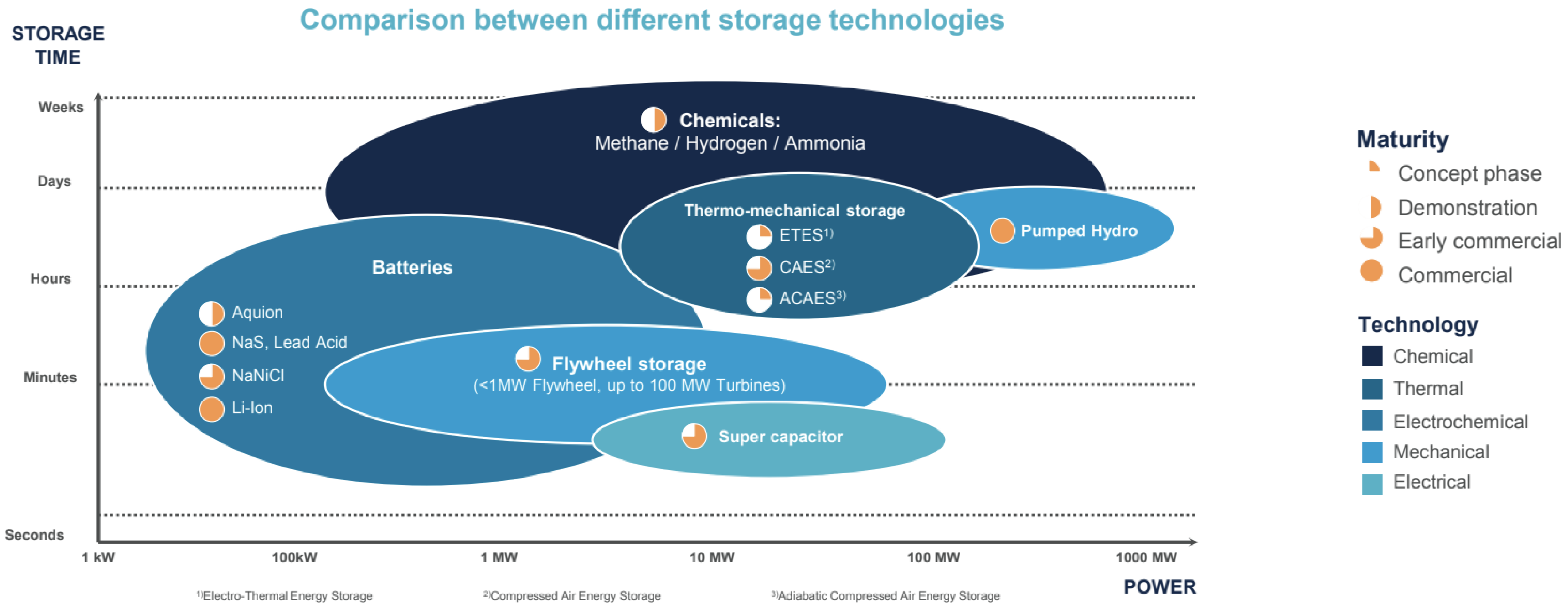


Green Deal - Mid/long-term energy storage

- What
  - mid and long-term energy storage, including thermal (heating and cooling) and chemical/electrochemical technologies
  - technologies and systems not using critical raw materials and including system integration opportunities (industrial symbiosis).
- Why now

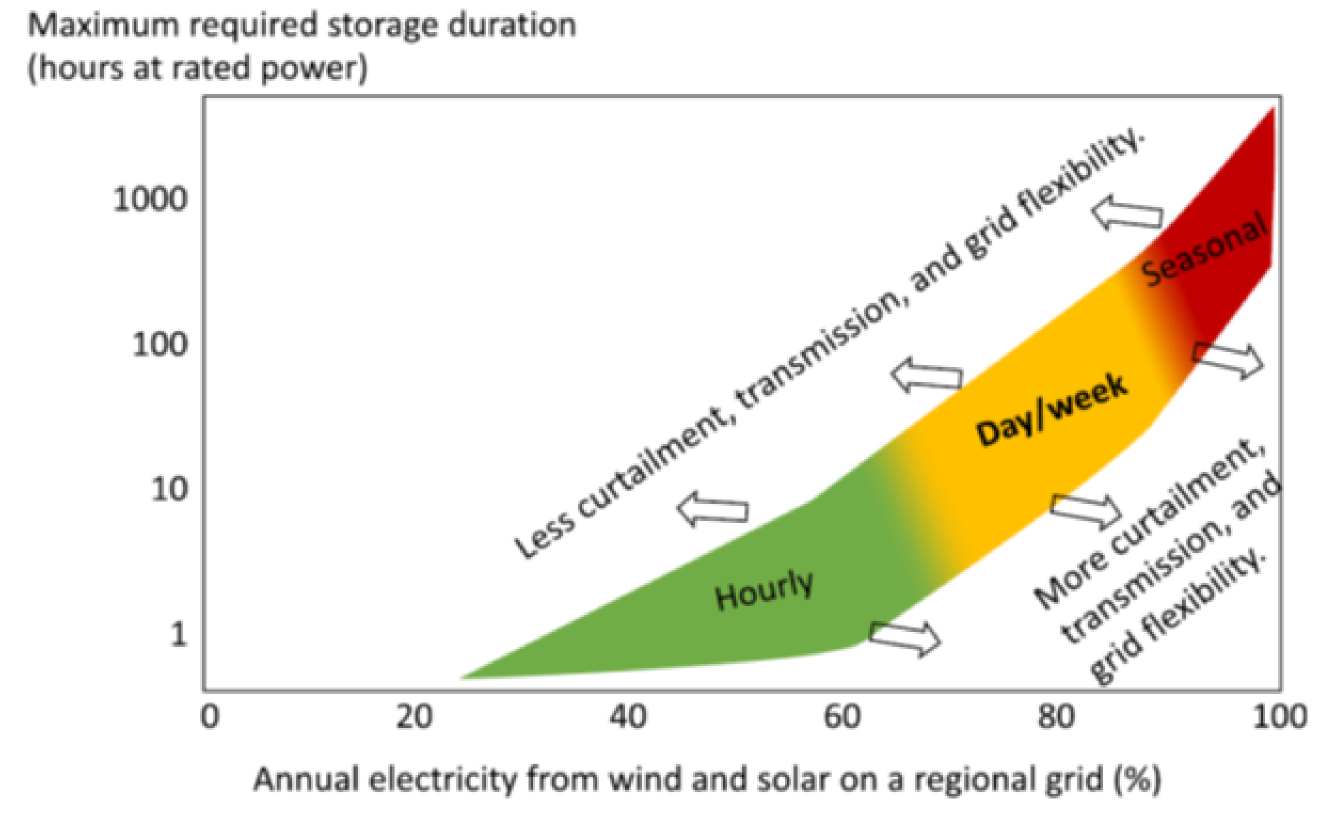
  To implement the Fit for 55 package and RepowerEU there is the need to:
  - enable the sector coupling in energy systems,
  - decarbonize energy system through the integration of renewable energy,
  - design "energy" products without critical raw materials and systemic approach
  - develop energy storage solutions for new market application (e.g. cooling)

Medium-long term energy storage

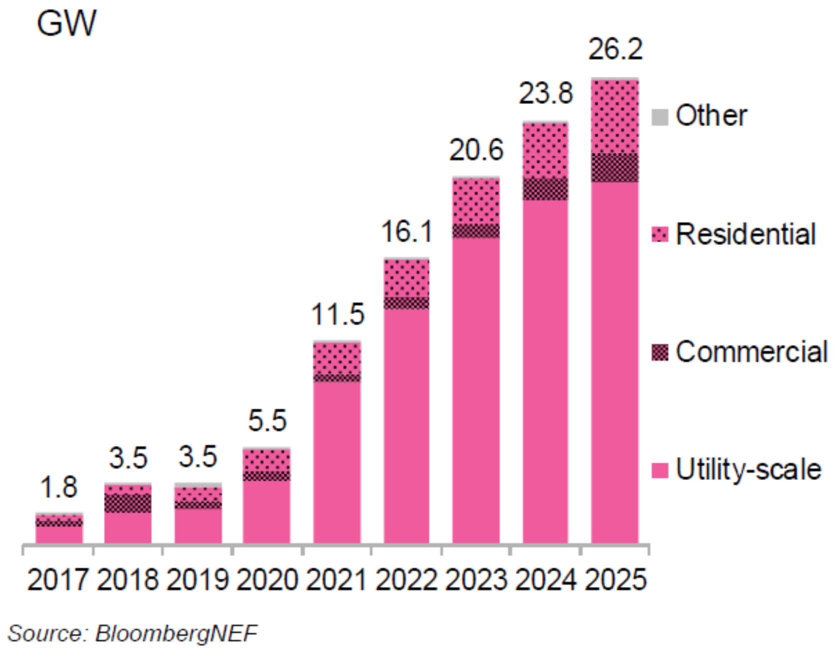


Source: U.S. Department of Energy Fuel Cell Technologies Office

Need for medium-long term energy storage



P. Albertus, et. al. “Long Duration Electricity Storage Applications, Economics, and Technologies, Joule (2020)



Spectacular growth is expected for energy storage

Scope of the challenge (I)

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- **thermal, electrical or combined thermal/electrical energy storage** with duration from days (mid-term) to seasons (long-term) for stationary applications in the **mid to large scale size range** (not micro, portable, or single building solutions)
- non incremental research to produce a **proof of concept** of a process/technology/material tailored for a specific sector/application and that, from the single component design explores interactions and integration at the device and whole systems level
- Technologies based on mechanical (e.g., flywheels, gravimetric) or pumped hydro storage are out of the scope
- Proposals that aim to spatially decouple the storage charging (from thermal/electric energy to energy carrier) and its discharging (i.e., reconversion from energy carrier to thermal-electric energy) should specifically address the **storage of the energy carrier**. potential sectors coupling opportunities should be also addressed (i.e., combined energy carrier storage and thermal energy management).
- Technologies to enable **increased flexibility and mid-long term storage capabilities of large- scale centralized power plants**, or their refurbishment for a reconversion to energy storage assets are also included
- Proposals can also target the **integration of long-term energy storage and short-term storage** for fast dynamic response, in order to enable access to the energy markets for ancillary grid services

Scope of the challenge (II)

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- **Secondary benefits** of the proposed energy storage solutions, such as cooling management in industrial/tertiary sectors, water management (i.e., desalinization), carbon capture and management (i.e., calcium looping), emissions reduction, environmental remediation or intermediate chemicals production for industrial symbiosis (i.e., reactive metals), will be also in scope with the call.

- Storage technologies **specifically designed for renewable heating/electricity** (solar, geothermal, biomass, wind) or waste heat recovery are in scope with the call, to the extent the primary focus is on storage of produced energy (included its charging/discharging).

- Proposals should mention their **deployment strategy** and the steps required to scale up the process.

Range of technologies: thermal and electric storage (I)

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- **Thermal energy based on sensible, latent or thermochemical** storage: advancement at materials, components, processes and system integration level, (i.e. high volumetric / gravimetric energy densities, use of non-toxic, low cost, bio-based, long-term stability and low degradation rate materials, high heat transfer rates and rapid kinetics, use of computational chemistry)
- **Sorption heat storage** (via liquid absorption, solid adsorption, reversible chemical reaction or composite materials): it implies the use of physical or chemical bonds to store energy
- **Molecule based storage solutions**, i.e. photo-switchable or thermally switchable molecules, where heat (or light) is stored in specific intramolecular mechanical degrees of freedom, eventually applying mechanical forces or electric fields, and can be then released with limited energy losses
- thermochemical pumpable fluids to enable efficient long distance heat transmission (**thermal fuels**)
- **topological optimization** of flows and heat transfer surfaces to enable high heat transfer during charging and discharging (i.e. solutions based on 3D optimized design of heating/cooling working fluid flow via additive manufacturing for the pipes and metal foams for surface enhancement)

Range of technologies: thermal and electric storage (II)

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- **thermomechanical energy storage** (power to heat to power): operation of pumps and compressors at very high/low temperatures and pressures or at extended T ranges, combination of two or more functions in a single component, increased part load efficiencies, smart charging/discharging, decoupling power and energy elements, in order to enable ancillary services provision to the grid)
- **unconventional cycles** with vapour compression operated by electrochemical, instead of mechanical means, or by making use of a different form of entropy change, such as via redox couples, thermoelectricity, thermoacoustics or barocaloric materials
- **chemical energy carriers** (H2, methanol, ammonia etc): proposals addressing power to X technologies should specifically address the storage and handling of the produced energy carrier and could include the reverse conversion for the final use, or the sector coupling opportunities (use as input materials for the chemical industry or as transport fuels, eventually in combination to CCU solutions). The maximization of the overall (production-storage-utilization) process efficiency and the assessment of new impurity-tolerant low-cost non-critical raw materials are key research challenges.

Range of technologies: thermal and electric storage (III)

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- **Long duration electrochemical storage** (i.e. metal air batteries) including its integration with thermal storage (combined thermal/elettrochemical storage) and with energy systems/infrastructures
- use of **reactive metals** as energy storage media, i.e. metals that can be produced via electrochemical processes such as aluminium, sodium and magnesium, but also Ca, Fe, Zn, etc. Their optimum exploitation can be achieved through an efficient combination of different energy conversion paths (power-to-metal combined with metal-to-power or metal-to-heat) and industrial symbiosis with metallurgical industries or in secondary batteries such as metal-air batteries (power-to-power configurations).
- **Redox-flow batteries** (promising for their long lifetime, low cost and capability to decouple power and energy) in particular focus on metal-organic redox molecules, electrode surfaces and electrolytes selection, aqueous / non-aqueous reactors optimization, in order to reduce costs and increase performance (efficiency, stability, energy/power densities, and smart controls)

Portfolio considerations

- portfolio building process based on a balance of complementarities and diversities among the proposals
- The evaluation committee will firstly identify a sufficiently broad range of diverse and competing approaches, methodologies, and technologies among the portfolio proposals
- In combination to the aim to diversify the range of technologies/ approaches, the evaluation committee will also look at complementarities and/or shared components among them.

Portfolio categories

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- <u>Technologies</u>: e.g., for thermal or electric energy storage, or a combination of both. Different intermediate storage technologies are possible.
- <u>Systems integration</u>: aspects of integration of storage, such as coupling to renewable sources, or to existing power plants, to waste energy recovery, to demand response strategies at end users’ level, or to the built environment.
- <u>Methodologies for materials and components selection</u>: different approaches, such as computational chemistry, to select the storage materials and their properties (e.g., thermo-physical, chemical), and/or their interoperability at components/devices/system level (e.g., multi-physics simulations).
- <u>Methodologies for monitoring and control</u>: such as strategies to charge/discharge systems, to control/monitor the durability/performances of materials/components/device/systems, or for the purpose to enable fast demand response or grid ancillary services.

Portfolio criteria

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- The portfolio should include **diverse technologies** for thermal and electric energy storage, **comparing their relative competitiveness and market uptake potentials** for different applications and end-user requirements.
- In the portfolio, diversity will be also sought with respect to methods for integration of storage into energy systems, methodologies for materials selection, dynamic performance and control systems. The aim is to develop a portfolio of **potential technology solutions for different applications, contexts and end user requirements**.
- The projects in the portfolio should, if possible, share **similar or complementary approaches** and methodologies in areas where this can be a clear **added value for the development of synergies**, such as materials, components integration, control systems.
- Other outcomes being equal, preference will be given to proposals which enable increased flexibility of energy systems, **higher penetration of intermittent renewable energies** and **enhanced demand response strategies**
- Furthermore, potential synergies could be explored in the **typology of secondary added values** eventually captured by the proposals, such as the combined carbon management, freshwater production, emissions reduction, or industrial symbiosis.

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Thank you

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Medium-long term energy storage

Challenge will support proposals from the following fields:

- mid/long term electricity storage, technologies such as metal air batteries, power to heat to power, chemical looping and industrial processes integrated systems, or electrochemical/thermal combined solutions are particularly interesting;
- heating/cooling storage, building integrated solutions, long term storage of solar energy, high/low temperature energy storage integrated to pumped heat and computational materials assisted approaches, or combined storage of thermal and electric energy