EERA JP Energy Storage and Stories project: the hybrid battery technologies

Marco Ferraro
National Research Council of Italy – Institute for Advance Energy Technologies «Nicola Giorano»
EERA JP ES: Deputy SP6 Energy Storage Technologies: Techno-economics and Sustainability

WORKSHOP on energy storage and its crucial role in the energy transition with focus on hybrid solutions
Horcynus Orca Foundation, Messina, ITALY
June 23rd 2022

Toward a 100% RWE system in Europe

2020 climate & energy package

European Green Deal

Fit for 55

REPowerEU

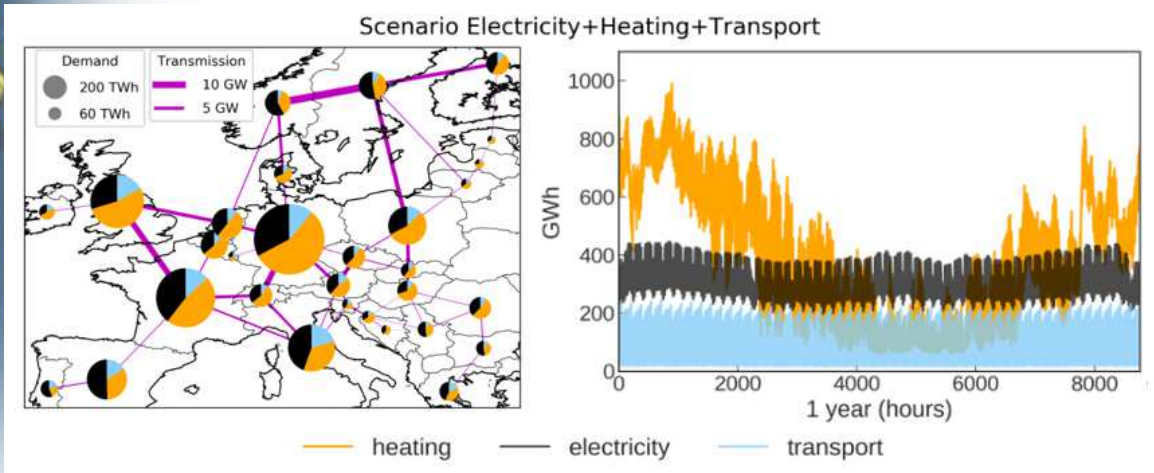
Climate Change

Security of Supply

Circular Economy

Resiliency

To achieve this, energy infrastructures (heating and cooling networks, electric grid, gas grid) have to be highly flexible to accommodate higher shares of renewable energy e.g., geothermal, biomass, concentrated solar power (CSP), photovoltaics (PV), solar thermal energy, hydropower and wind power in a secure and flexible way



M. Victoria, K. Zhu, et al., Energy Conversion and Management 201 (2019) 111977, DOI: https://doi.org/10.1016/j.enconman.2019.111977

EERA Joint Programme Energy Storage

Matching renewable generation intermittency to demand in an electricity supply system by Energy Storage System (ESS) technologies in the power systems

Rapid growth of the electric and hybrid vehicle technology opens a new era on ESS

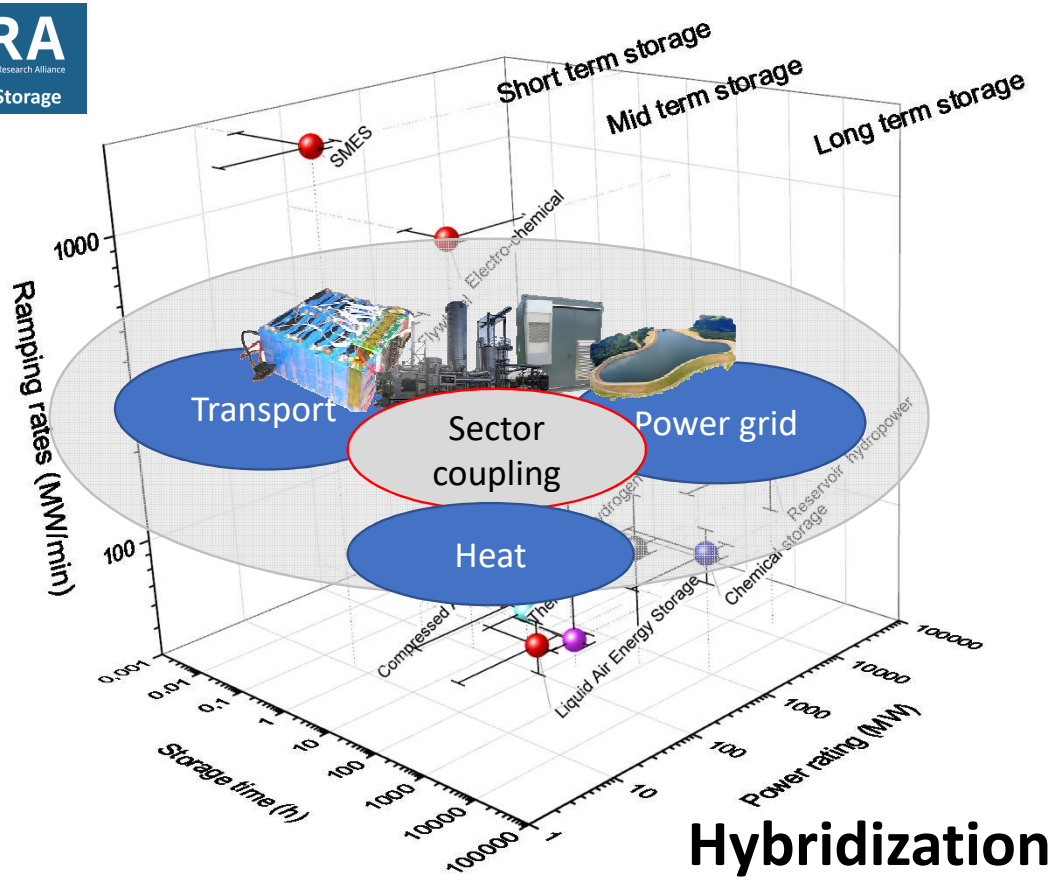
No optimal solution can be pr
a single technology. Rather a
technologies providing high s
different time and integration
spatial ranges is required

Hybrid Energy Storage Syster
lies on the fact that heteroge
Storage System (ESS) technol
complementary characteristics in terms of power and energy density, life cycle, response rate, and so on.

Promoting Hybrid Energy Storage Systems

- **Input Paper for the Clean Energy Transition Partnership**
- **STORIES Project**

			Renewable energy
			✓
			✓
			✓
	Battery		✓
CAES	Supercapacitor		✓
CAES	Flywheel		✓
Fuel Cell	Supercapacitor	✓	✓
Fuel Cell	SMES		✓
Fuel Cell	Battery	✓	✓



The ESS technologies are different in terms of cost and technical properties such as:

Energy and power rating
Volumetric and gravimetri cenergy density
Volumetric and gravimetric power density
Discharge time
Response time
Operating temperature
Self-discharge rate
Round-trip efficiency
Life time(years and cycles)
Investment power and energy cost
Spatial requirement
Environmental impact
(…)

Hybridization

- **To reduce Environmental Impact**

Combining different ES technologies HESS can adopt technologies with lower impact (e.g. with already well established recycling processes) guaranteeing the same performance

- **To overcome CRMs constrains**
- **To reduce Social Impact**
- **To foster EU supply chains**

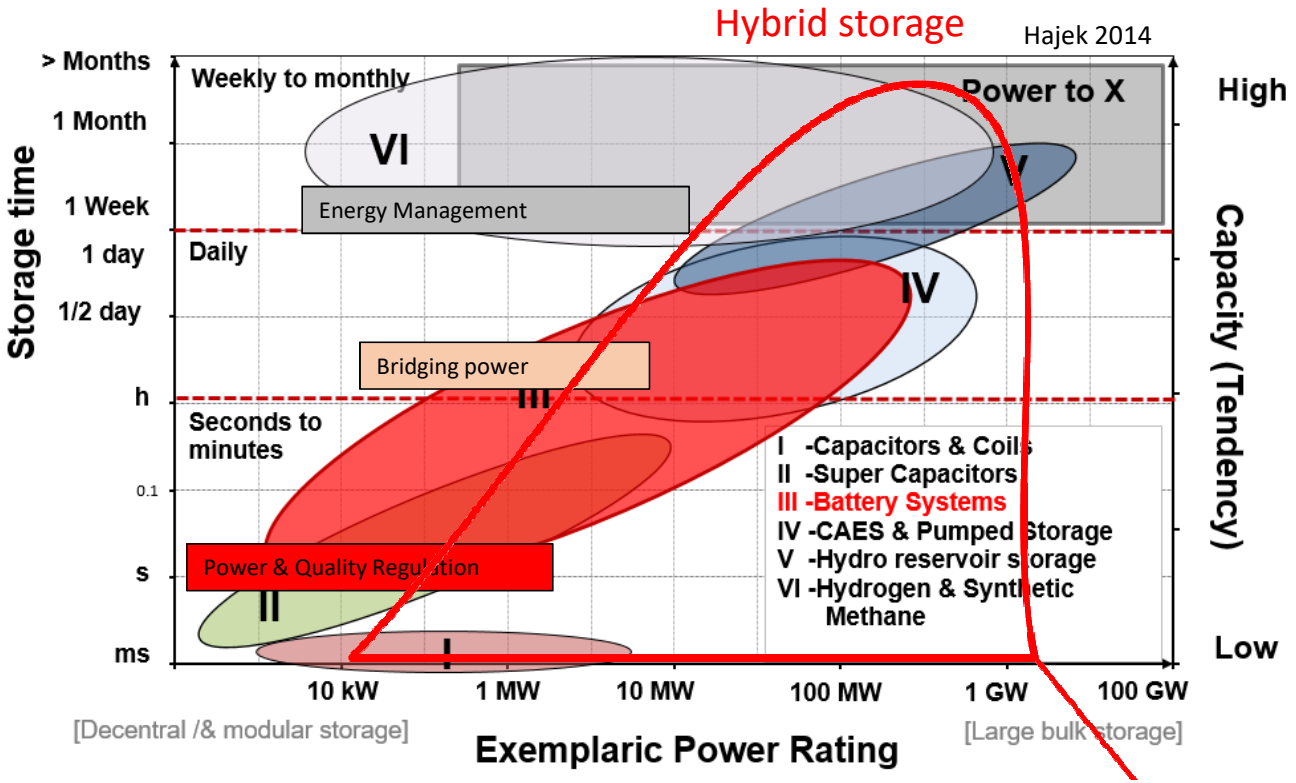
Combining different BES technologies HESS can compete with single technologies using CRMs (such as Ni, Co, Mg, PGM, Li, Ti, V)

Several application fields
Multiple technologies

ESSs can increase power system operation and planning resiliency and efficiency by means of many applications including:

- Energy timeshift
- Supply capacity
- Load following
- Area regulation
- Fast regulation
- Supply spinning reserve
- Voltage support
- Transmission congestion relief
- Transmission and Distribution upgrade deferral
- Power quality
- Renewable energy time shift
- Renewable capacity firming
- Renewable energy smoothing
- Service reliability
- Black-start

Stacking of services, aggregation of complementary benefits through the provision of multiple services might outweigh cost



RESEARCH NEEDS

HESS is considered to be a favorable solution in the future in various applications.
However, further research and development should to be conducted to demonstrate their feasibility and advance their functionalities.

Power Electronics and Control Strategies have to be developed to harmonize the HESS features.

In particular, (H)ESS business cases could also become challenging or even inviable according to some stakeholders*, if they depend on revenue streams from the provision of services in multiple energy markets, in a fast changing environment.

The volatility of electricity market prices (affected by the increasing share of intermittent renewable energy sources) and the reaction of market actors for providing the required flexibility will have an important impact on the deployment of storage. As a capital-driven investment, a storage unit does need reasonably secure long-term revenue streams to ensure its viability.

* Study on energy storage – Contribution to the security of the electricity supply in Europe
ISBN 978-92-76-03377-6
doi: 10.2833/077257

The StoRIES project is born with the idea of addressing this challenge, bringing together a consortium of beneficiaries like facilities from the **European Strategy Forum on Research Facilities (ESFRI)**, technology institutes, universities and industrial partners to jointly improve the economic performance of storage technologies. The main technological objectives of StoRIES are linked to the energy storage development by providing access to world-class research infrastructures and services, with a focus on improving materials for devices and optimizing hybrid energy systems with a view to make energy technologies more competitive and reducing costs. In addition, StoRIES focuses on the analysis of socio-technical and environmental aspects of new developments and systems, in order to provide training and education on these issues.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement N. 101036910

StoRIES

Storage Research Infrastructure Eco-System

Main OBjectives

- Foster a European ecosystem of industry and research organisations on hybrid ES technologies
- Provide access to world-class materials and ES related research infrastructures
- Enlarge and advance the integration of the European ES community
- Enhance innovation by involving industry experts in the setting up and implementing of a pro-active innovation support scheme
- Ensure the long-term sustainability of ES research:

  - by defining scenarios and strategic roadmaps
  - by setting up a framework for the scientific and technical training of young researchers

- Promote and coordinate the international cooperation in ES research from and to Europe

Energy Storage Eco-System

- Start: 1st November 2021
- Duration: 4 years (2021-2025)
- Budget: 7 Mio €
- Beneficiaries: 47
- Research Infrastructures: 64
- Countries involved: 17
- Coordinator: KIT (DE)

BENEFICIARIES

Partners and RI providers:

KIT (DE)	EDF (FR)
AIT (AT)	ENEA (IT)
CIEMAT (ES)	ENI (IT)
CNR (IT)	FZJ (DE)
CSIC (ES)	SINTEF AS (NO)
DTU (DK)	SINTEF EN (NO)

Partners:

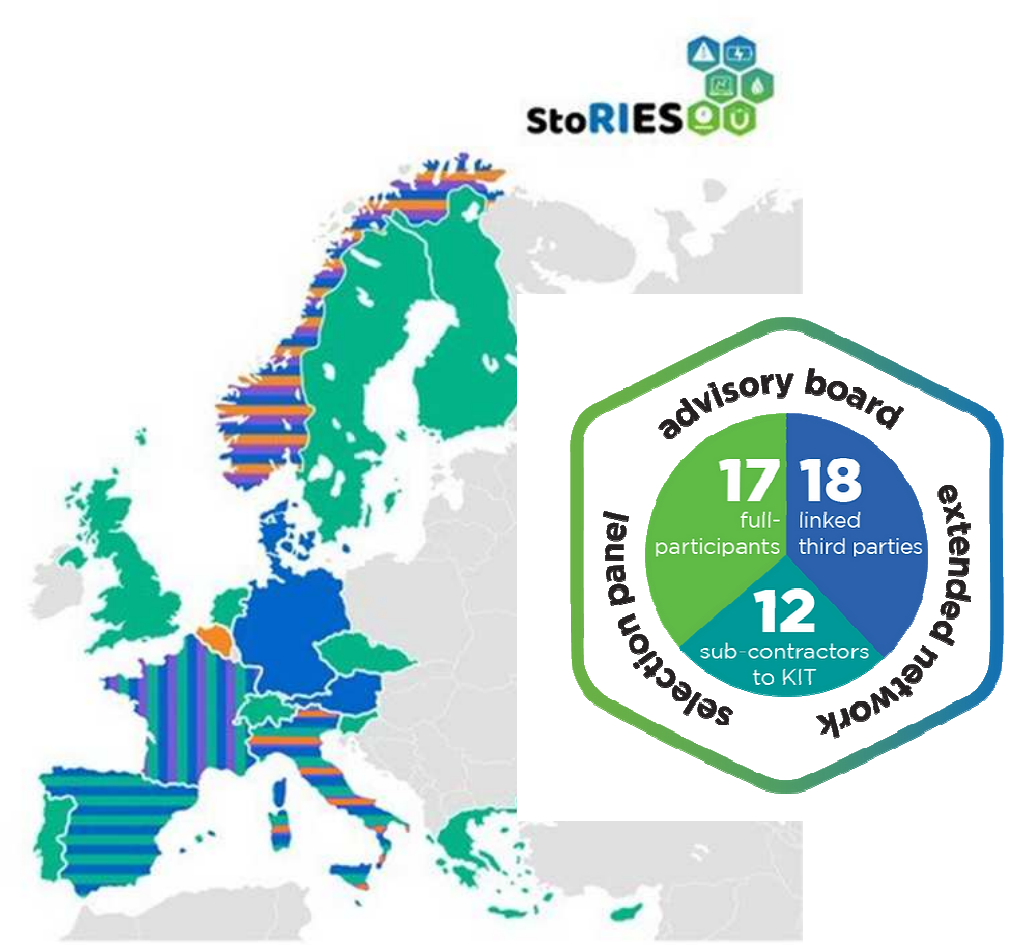
EASE (BE)	EERA AISBL (BE)
CLERENS (BE)	UNIPG (IT)
ECCSEL ERIC (NO)	

RI providers:

CENER (ES)	CERTH (GR)
TBU (CZ)	CICe (ES)
TNO (NL)	CyI (CY)
BGS (UK)	FHa (ES)
BRGM (FR)	HSLU (CH)
ISTO (FR)	HMU (GR)
SOTACARBO (IT)	IREC (ES)
EMPA (CH)	KTH (SE)
LUT (FI)	LNEG (PT)
RSE (IT)	NIC (SI)
UNIBO (IT)	UDL (ES)
UNIPA (IT)	UoB (UK)
UNIPD (IT)	RINA (IT)
VTT (FI)	

Linked Third parties:

IFE (NO)	RTE (FR)
HVL (NO)	



PROJECT CORE

- **17 Full Participants (P)**
- **18 Linked Third Parties (LTP)**
  - 10 to EERA AISBL from academia and ressearch
  - 4 to EASE from industry
  - 4 to ECCSEL ERIC From large research infrastructure
- **12 Sub- Contractors (SubC) to KIT**

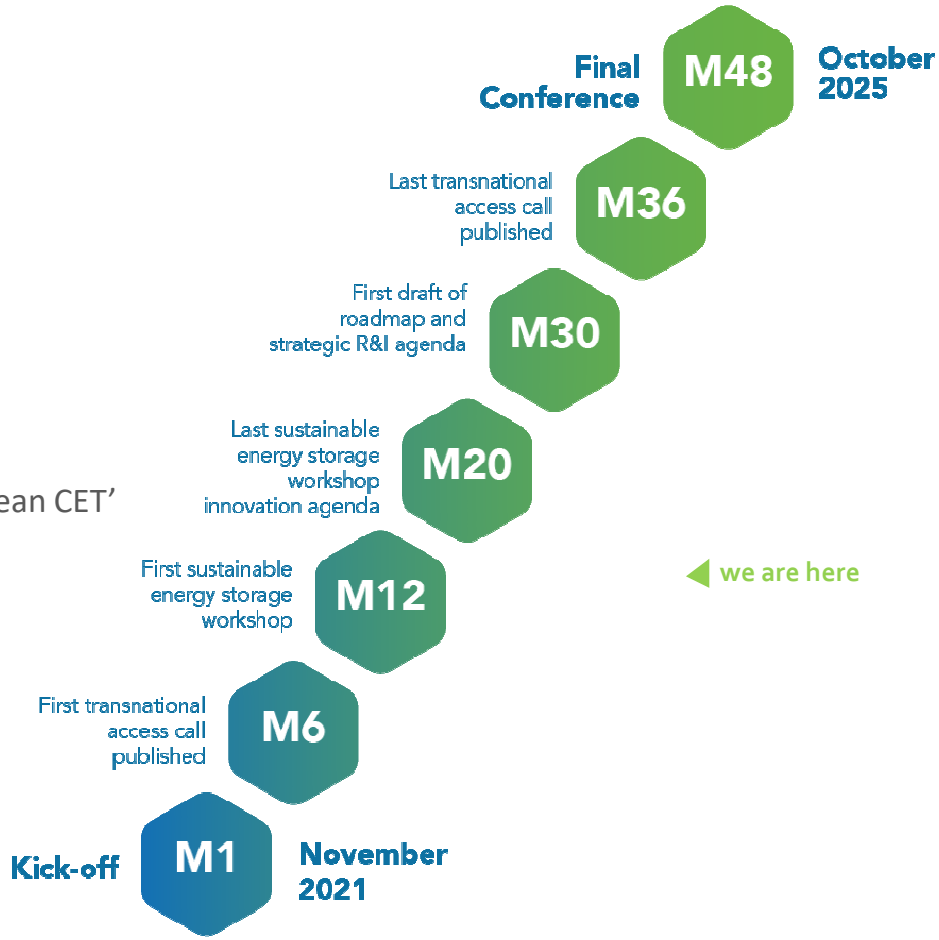
EXTERNAL LAYER

- **Selection Panel (SP)**
- **Advisory Board (AB)**
- **Extended Network (EN)**

Main Outcomes

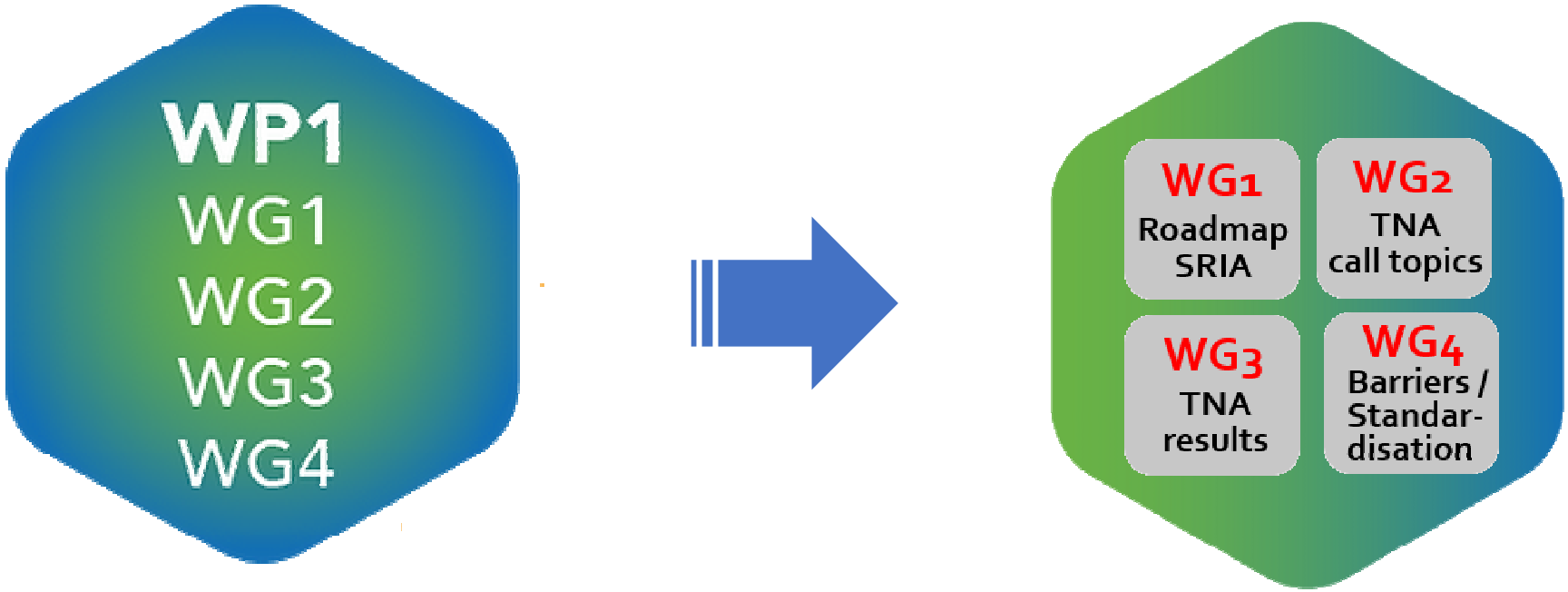
- 6 Transnational Access calls (TNA)
- Materials Acceleration Platform for ES (MAPs)
- Roadmap for hybridisation of Energy Storage
- Strategic Research and Innovation Agenda (SRIA)
- White Paper on ‘Open Data in the ES community’
- Sustainable ES Workshop Series
- White paper on ‘Sustainable hybrid ES for the European CET’
- International Mobility Scheme
- University Master Programme on hybridisation of ES
- 3 Summer Schools

StoRIES
Storage Research Infrastructure Eco-System



Working Groups

StoRIES
Storage Research Infrastructure Eco-System



StoRIES Eco-System

More than **100 Stakeholders** of StoRIES involved in:

- Definition of gaps
- Standarization challenges
- Roadmap and SRIA
- Transnational Access call definition
- Analysis of Transnational Access results

- If you are interested, contact us: **INFO@STORIESPROJECT.EU**

StoRIES Network

Working Group 1

StoRIES
Storage Research Infrastructure Eco-System

WHO?

StoRIES eco-system (stakeholders)

WHY?

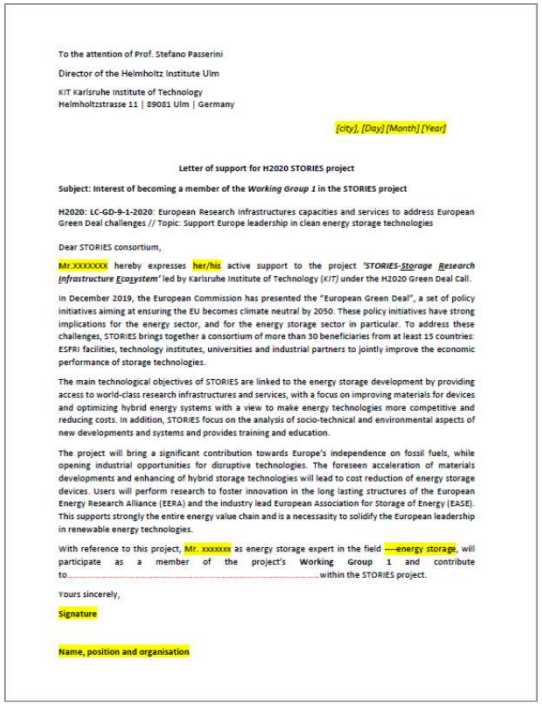
Opportunity to give your feedback/statements to the Roadmap and SRIA on hybridisation of energy storage

WHAT?

2-3 workshops a year for giving feedback at the different stages of the Roadmap/SRIA

HOW to join?

By signing a Letter of Intent (members will appear on StoRIES website)



To the attention of Prof. Stefano Passerini

Director of the Helmholtz Institute Ulm

KIT Karlsruhe Institute of Technology
Helmholtzstrasse 11 | 89081 Ulm | Germany

[city], [Day] [Month] [Year]

Letter of support for H2020 STORIES project

Subject: Interest of becoming a member of the *Working Group 1* in the STORIES project

H2020: LC-GD-9-1-2020: European Research Infrastructures capacities and services to address European Green Deal challenges // Topic: Support Europe leadership in clean energy storage technologies

Dear STORIES consortium,

Mr XXXXXXX hereby expresses her/his active support to the project *'STORIES-Storage Research Infrastructure Ecosystem'* led by Karlsruhe Institute of Technology (*KIT*) under the H2020 Green Deal Call.

In December 2019, the European Commission has presented the "European Green Deal", a set of policy initiatives aiming at ensuring the EU becomes climate neutral by 2050. These policy initiatives have strong implications for the energy sector, and for the energy storage sector in particular. To address these challenges, STORIES brings together a consortium of more than 30 beneficiaries from at least 15 countries: ESFRI facilities, technology institutes, universities and industrial partners to jointly improve the economic performance of storage technologies.

The main technological objectives of STORIES are linked to the energy storage development by providing access to world-class research infrastructures and services, with a focus on improving materials for devices and optimizing hybrid energy systems with a view to make energy technologies more competitive and reducing costs. In addition, STORIES focus on the analysis of socio-technical and environmental aspects of new developments and systems and provides training and education.

The project will bring a significant contribution towards Europe's independence on fossil fuels, while opening industrial opportunities for disruptive technologies. The foreseen acceleration of materials developments and enhancing of hybrid storage technologies will lead to cost reduction of energy storage devices. Users will perform research to foster innovation in the long lasting structures of the European Energy Research Alliance (EERA) and the industry lead European Association for Storage of Energy (EASE). This supports strongly the entire energy value chain and is a necessasity to solidify the European leadership in renewable energy technologies.

With reference to this project, Mr. xxxxxx as energy storage expert in the field ---energy storage, will participate as a member of the project's **Working Group 1** and contribute to.....within the STORIES project.

Yours sincerely,

Signature

Name, position and organisation

WG 1: Roadmap and SRIA

- The roadmap and SRIA will gather experience and knowledge from all stakeholders in the StoRIES eco-system, and use this to identify knowledge gaps and needs for research and innovation in order to make hybrid storage solutions viable
- The roadmap and SRIA will give a set of policy recommendations. The perceived audience will be EU-level officials and funding agencies, SET-Plan members, other national and local bodies, as well as stakeholders in industry, academia and universities.
- The roadmap and SRIA will be developed in an iterative process where the documents are drafted by the partners in Task 3.3 and then sent to WG1 and other stakeholders for expert feedback.

What means “hybridization” in the energy storage sector

There is no real definition for hybrid energy storage available

Hybridisation of energy storage refers to the utilisation of two or more energy storage technologies together on either a system, device, or material level to provide technical and economic advantages beyond what any single energy storage technology can provide, also considering the sustainability and reliability over the lifetime of the hybridised solution.

Levels of hybridization

1. Hybridization on a system level
   - integrating two or more energy storage technologies in an energy network (e.g. joint operation of two or more grid-scale batteries in the same grid by the same operator)
   - using two different processes for integration or sector-coupling in an area (e.g. thermal and hydrogen storage in an industrial park)
2. Hybridization in integrated storage systems
   - two or more storage systems operated together and dispatchable as one system (e.g. fuel cells with batteries)
3. Hybridization on the device level
   - utilizing serial or parallel combinations of devices (e.g. supercapacitors and batteries, battery packs)
4. Hybridization on the material level
   - using the same material across different technologies, where materials also include metals, fuels and chemicals that can be used for different processes and devices.

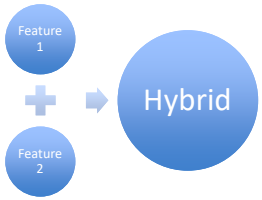
Mechanisms for hybridization

1. Hard-wired integration
   - Integration in hardware of components, e.g. a solution that is built to utilise the same device/carrier to produce different outputs (heat, hydrogen, electricity), or a device that can utilize two or processes/carriers to produce one output
2. Soft-wired integration
   - Integration in the architecture of the solution, e.g. in power electronics or conversion technologies, or serial or parallel combinations of similar or different devices
3. Software integration
   - Integration in software, e.g. common energy management system to dispatch the combined unit as one, but the devices/components are not themselves interconnected in any way other than communication through the energy management system

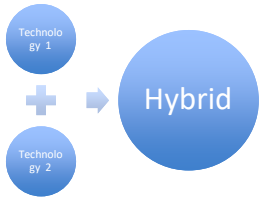
Structure of the guideline document

StoRIES
Storage Research Infrastructure Eco-System

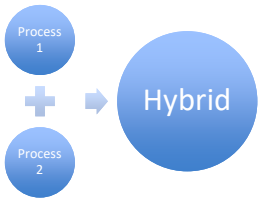
Combining two or more inherent features to meet specific needs



Combining two or more storage technologies to meet specific needs

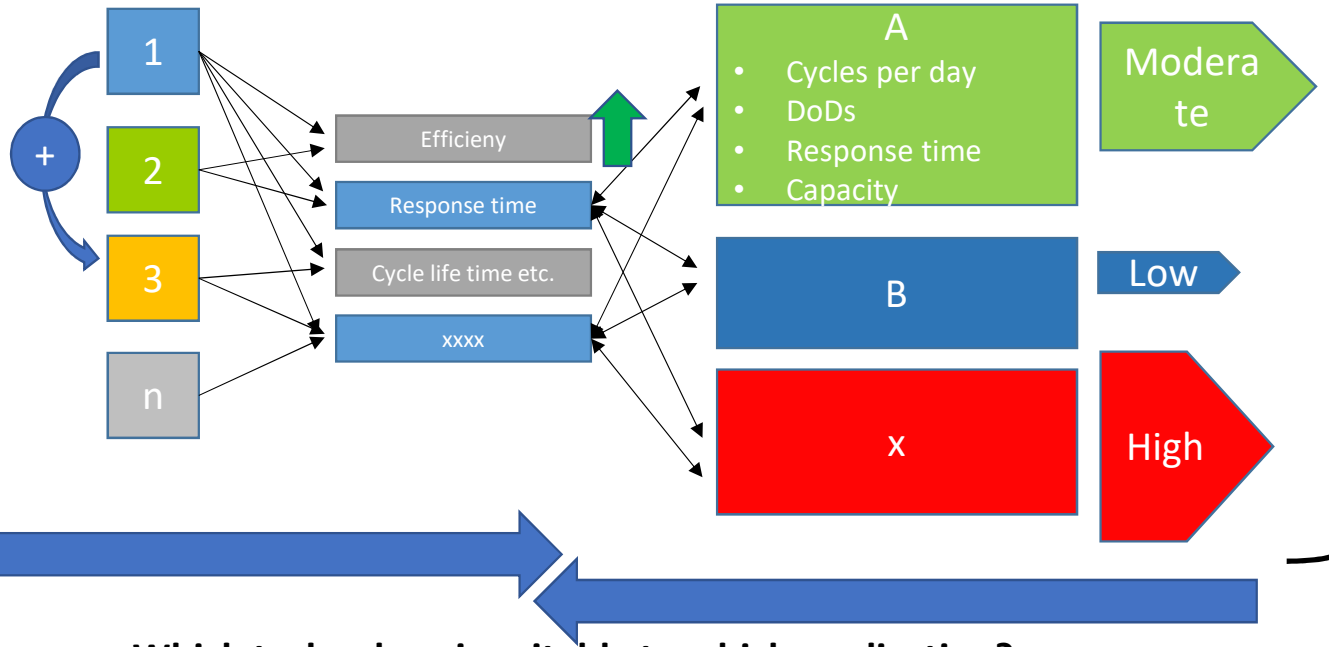


Combining two or more processes to meet specific needs



Hybridization

Hybridization at higher level → Energy storage characteristics → Application field / Business case definition/requirements → Value Streams → Performance metrics / Benchmark KPIs



Which technology is suitable to which application?
Which one performs best in terms of sustainability?

1st StoRIES TNA Call

What is Transnational Access (TNA)?

StoRIES
Storage Research Infrastructure Eco-System

- Lab access is provided to **the best European RIs**
- offering them **for free for THE FIRST TIME**

->If you **apply** for it **through StoRIES**

->If you go **to another country**

In more detail:

- The **selection of the applications** will be done through the evaluation of the received user project proposals by an independent review **panel of experts**
- The user group leader and the majority of the user group members should work in an entity **located in a different country** to the country where the lab is located ('trans-national' characteristic of the lab access)

1st StoRIES TNA Call

"Application oriented hybrid and sustainable energy storage solutions"

StoRIES
Storage Research Infrastructure Eco-System

The call topic foresees **three** different **sources of innovation**: material research, development and testing of a component, device or device cluster and the integration of the innovation in the energy system.

Proposals concentrating on the same innovation source and **investigating** it **from different scientific directions** (proposal cluster) with the aim of fast and successful implementation of the innovation to the market, will receive **additional points** by the proposal evaluation. This approach will support solutions with a clear and predefined path for an uptake to the market.

The proposals should include **sustainability-oriented** assessments regarding e.g. the use of critical raw materials, possible environmental and economic impacts over the entire lifecycle of the storage solution, as well as indications about the potential recyclability of used materials. Beyond that, social implications related to relevant upstream value chains, the use and end of life phase should be considered.

To apply for the call please use the **application form** available at the StoRIES website.

Only proposals submitted by the **31st of July 2022** will be evaluated.

1st StoRIES TNA Call

Who can apply?

Researchers from

- academia and industry entities
- EU members and EU associated states (Iceland, Norway, Albania, Bosnia and Herzegovina, the former Yugoslav Republic of Macedonia, Montenegro, Serbia, Turkey, Israel, Moldova, Switzerland, Faroe Islands, Ukraine)

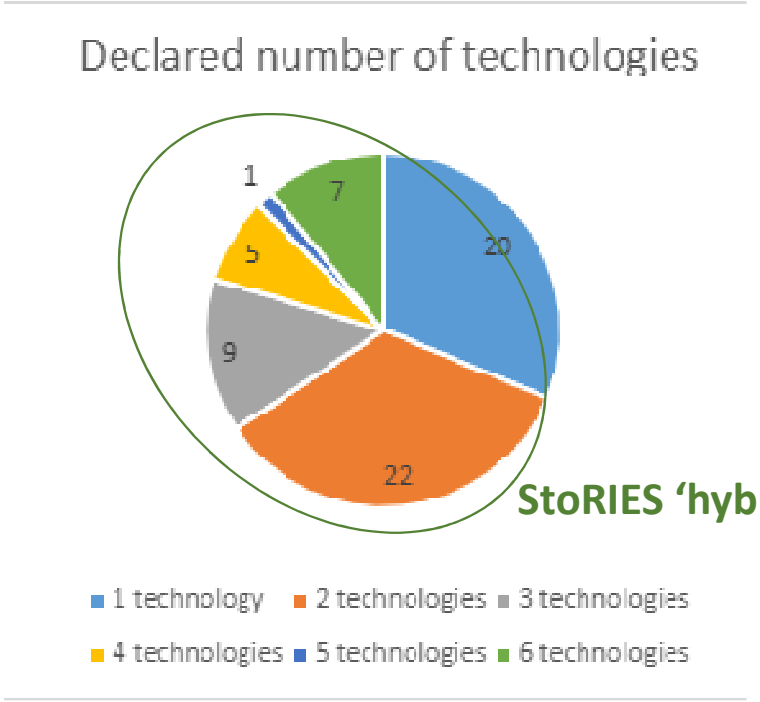
1st StoRIES TNA Call

Where to find the RIs of StoRIES?

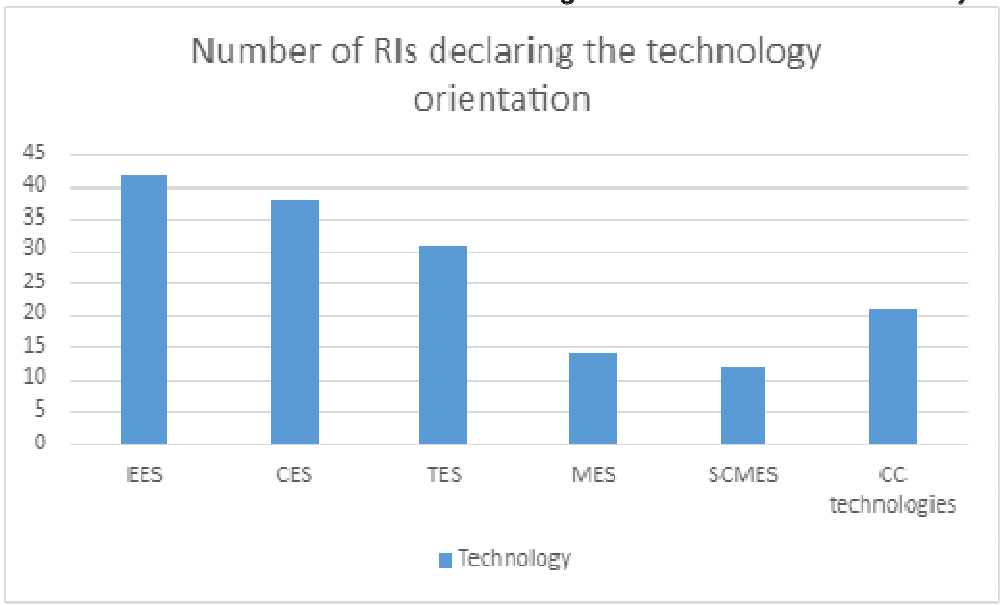
- [Research Infrastructures | StoRIES (storiesproject.eu)]

1st StoRIES TNA Call

64 Research Infrastructures and more …



StoRIES 'hybrid' labs



5 energy storage technologies:

- Electrochemical (EES)
- Chemical (CES)
- Thermal (TES)
- Mechanical (MES)
- Superconducting – Magnetic (SCMES)

Cross-cutting infrastructures (CC technologies)

Next Calls

- TNA calls:
  - 2022: April and October
  - 2023: April and October
  - 2024: April and October
- International Research Exchanges calls (Canada):
  - 2022: October
  - 2023: April and October
  - 2024: April and October