STORAGE RESEARCH INFRASTRUCTURE ECO-SYSTEM

WORK PLAN
WORKING GROUP 4

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

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2 ABBREVIATIONS AND ACRONYMS

AB	Advisory Board
AC	Associated Countries
ES	Energy Storage
GB	Governing Board
LoI	Letter of Intent
LTP	Linked Third Party
MS	Member States
R&I	Research and Innovation
RI	Research Infrastructure
RTO	Research and Technology Operator
SC	Steering Committee
SRIA	Strategic Research and Innovation Agenda
TNA	Transnational Access
ToR	Terms of Reference
WG	Working Group
WP	Work Package

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3 INTRODUCTION

The current energy crisis and geopolitical situation in Europe today has shifted the focus even more onto clean energy technologies, accelerating the move away from fossil fuel generation and ensuring energy security. The need to reduce the EU's reliance on fossil fuel imports especially natural gas is emphasised in the European Commission's recent REPowerEU plan, which proposes an increased renewable energy target for 2030 of 45%. To achieve this 45% target, over 1200 GW of wind and solar will need to be installed by 2030 according to the Commission's report[1]. This is more than 3 times today's wind and solar capacity in the next 8 years.

This transition away from the traditional centralised, fossil fuel generation towards more decentralised renewable generation introduces fundamental changes to how the energy system operates and comes with several challenges. The most important challenge is matching supply and demand based on variable renewable energy production. Variable renewable generation is 'non-dispatchable' and relies on the weather, meaning the system cannot respond to an increase in demand in real time. This means there will be 'gaps' or shortfalls in energy production where renewable supply does not meet demand or there could be overproduction from renewables when demand is low. In the case where renewable generation does not meet demand, fossil fuel generation typically gas turbines are run to make up the energy shortfalls today. On the other-hand, on a very windy day for example where demand is low, excess wind generation is curtailed and essentially wasted. Furthermore, as traditional fossil generators are phased out, the system loses the inherent benefits of synchronous generators such as inertia and other grid support services. Thus, the system must ensure that these grid support services are still available in order to reliably integrate the rising shares of wind and solar generation.

It becomes clear that if the EU is to reduce reliance on fossil fuel generation and maximise renewable utilisation by avoiding curtailment there is a need for a clean, flexibility solution. This is where energy storage and hybrid energy storage have a critical role to play in ensuring energy security with low carbon technologies in line with EU's GHG reduction targets and providing critical system flexibility services needed to integrate variable renewable generation. The important role of energy storage is highlighted clearly in the REPowerEU plan which states:

"Energy storage plays a significant role in ensuring flexibility and security of supply in the energy system by facilitating the integration of renewable generation, supporting the grid, and shifting energy to the time when it is most needed. Ultimately, energy storage reduces the use of gas power plants in the energy system[1]"

In this context, WG4 aims to identify the existing and future energy system challenges that can be solved by (hybrid) energy storage, for example providing solutions to reducing reliance on fossil fuel use across all sectors and addressing system challenges to integrating high shares of wind and solar generation. Energy storage offers a unique solution to integrating wind and solar, providing both energy shifting over different timescales and flexibility services using low emission technologies. WG4 addresses the technical and non-technical barriers (techno-economic, policies, market & regulation, standardisation, social acceptance) that can affect the widespread application of hybrid energy storage technologies which in many cases will be the same barriers for single storage solutions.

[1] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS REPowerEU Plan. (2022).

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Specifically, WG4 aims to understand and provide solutions to unfavourable regulatory and market conditions. The value energy storage solutions provide to the system are still not fully recognised or remunerated over fossil fuel counterparts today. As such, storage deployment in Europe is lagging behind wind and solar. Market design does not present favourable investment signals for storage and the business case for storage is limited in Europe. Comparison of countries where markets are more positive for storage e.g., UK, Ireland, US can provide important insights for proposing new market mechanism for storage in Europe. A drive toward energy independence in Europe presents new opportunities for storage and new products such as curtailment minimisation to maximise Europe's own energy resources. Other barriers related to standardisation and societal acceptance will also be covered, exploiting synergies between other work packages. WG4 will address these challenges, with the major task of developing strategies to mitigate the proposed barriers and contribute important recommendations to the roadmap report.

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4 OBJECTIVES AND EXPECTED RESULTS

The overarching question for StoRIES and specifically related to WG4 is: What challenges does the energy system face today and in the future that cannot be solved with existing single storage technologies? Therefore, where can hybrid storage either enhance existing solutions or provide a completely new solution. With this in mind, we set out the key objectives of WG4 and detail expected results stemming from these objectives.

4.1 Key objectives:

The following key objectives have been identified for WG4 which will feed into the roadmap report and Task 1.2:

1) Call for identification of (i) existing and (ii) future energy system challenges where storage and hybrid storage could provide a solution (related to T1.2 Identify Energy Storage Actor's Needs).
2) Narrow down the scope to key challenges most urgent in Europe today. Need input from Energy providers, DSO, TSO – without gas what are the problems?
3) Identify possible solutions to these challenges where hybrid energy storage can either (i) enhance an existing single storage solution or (ii) provide a new solution which is not possible with a single energy storage solution.
4) Propose specific recommendations to accelerate hybrid storage uptake which will be mostly the same as for single storage solutions e.g. dedicated policy initiatives, funding programs and supporting research for reducing socio-economics barriers; demonstration projects to overcome community acceptance barriers, scale-up/demonstration support, recognition of storage as an own asset class, remuneration matching value creation of energy security and low emissions, CO2 free balancing requirements, curtailment minimisation incentives etc.

4.2 Expected Results: Identify Existing and future challenges that could be addressed by hybrid energy storage

In light of current geopolitical situation in Europe and ambitious climate ambitions of the EU, the energy system faces a number of critical challenges today. In this section we summarise the scope of the challenges to be addressed in WG4 and provide an overview of expected results.

4.2.1 Key Challenges to be addressed in WG4

The following key challenges have been identified and will be elaborated further in WG4. This list is not exhaustive and further engagement with energy storage actors across the value chain would be beneficial in providing more detailed feedback on specific challenges from different perspectives and could also be included here. The following key challenges will be the focus of WG4:

4.2.1.1 Curtailment minimisation

The issue of curtailment of wind and solar energy is not well documented across all EU countries, there are however detailed studies and data on specific regions where this issue is prevalent for example in Germany. Reducing curtailment of renewable energy sources is critical for achieving EU's ambitions to ensure energy security, reduce fossil fuel use and create an affordable energy system. Energy storage can address many of the issues resulting from curtailment of wind and solar energy and in turn provide a number of benefits to the energy system including:

- Maximising utilisation of clean, locally produced renewable energy by absorbing excess energy production and storing it to be used at a later moment when it is needed.

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- Minimising costs associated with curtailment payments which filter down to the consumer
- Reducing reliance on fossil fuel backup, typically gas, which is used to cover energy shortfalls when renewable energy cannot be transported through the transmission system due to congestion.

In order for these benefits to be realised it is important that a clear understanding of the magnitude of the curtailment issue is understood across the EU at a member state level. WG4 will collect relevant information on curtailment data with inputs from experts and create a comprehensive overview of the magnitude of the challenge with a particular focus on understanding the following points:

1) the magnitude (GWh) renewable energy curtailed in the EU from wind and solar sources
2) The prevalence of curtailment events based on energy source i.e. the influence of wind or solar generation on curtailment
3) Durations of curtailment events (this will give an idea of storage durations required to absorb excess energy production)
4) Annual occurrence of curtailment events
5) Associated costs of curtailment
6) The correlation between % variable RES in the energy system and curtailment events
7) To what extent will grid expansion alleviate this problem and is storage a more economical solution?

With these questions answered WG4 will be better informed to identify energy storage technologies and combinations of technologies that would be suitable to provide a solution. Possible recommendations for overcoming barriers to implementation of these solutions can then be investigated which feeds into the recommendations section of the roadmap report.

4.2.1.2 Minimising natural gas use across different sectors

Europe is reliant on natural gas across different sectors, most notably heating, industry and electricity production. Figure 1 below adapted from IRENA Roadmap to 2050 report, shows that approx. 48 % of overall energy demand in 2030 will be in the form of heat. More specifically, about 16% of the overall energy will be needed as medium to high temperature heat, at temperatures higher than 150 °C. Additionally, about 9 % of the overall energy demand will be electricity produced in thermal power plants, generally working at temperatures higher than 150°C[2].

Hybrid storage technologies can provide a potential solution to reducing the use of natural gas across different sectors. Specific sectors which will be investigated and further elaborated in WG4 are listed below:

a) **Heating Sector**
electrification of the heating sector with heat pumps and complementary storage solutions

b) **Electricity Sector**
wind and solar generation coupled with different storage solutions can essentially create a dispatchable energy source and in turn phase out expensive, polluting gas turbines

c) **Industry Sector**
utilising waste heat for district heating

[2] International Renewable Energy Agency. *IRENA (2019), Global Energy Transformation: A Roadmap to 2050. Global Energy Transformation. A Roadmap to 2050* (2019).

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WG4 will elaborate the potential challenges across these sectors to replacing natural gas and propose innovative solutions with possible energy storage and hybrid storage solutions.

4.2.1.3 Quantify short, medium, long duration storage needs in EU (GWh)

The storage needs for different durations short, medium and longer is not well understood today and is further complicated by the lack of a standard comparison metric that applies to all different storage technologies. For example, it is important that for applications of longer duration energy storage the volume of energy that can be stored must is quantified in GWh.

Furthermore, seasonal storage poses a big challenge to provide an alternative to the current natural gas used to meet heat and electricity demand in winter. Alternative low carbon solutions need to be investigated in WG4 e.g. hydrogen and underground thermal energy storage for example could be possible solutions.

In the case of hydrogen, open questions today around the actual storage capacity required for hydrogen needs to be addressed. The current capacity of salt caverns for storing hydrogen in Europe is 50 TWh. However, recent studies indicate that 70 TWh of hydrogen in 2030 and 450 TWh in 2050 may be needed in Europe. Therefore, salt cavern storage alone do not provide sufficient capacity and underground hydrogen storage in porous reservoirs, especially depleted oil- and gas fields, may have to be used in the future to achieve such capacities for storage.

4.2.1.4 Policy, Market, funding etc. Recommendations

Given that today the energy storage policy and market landscape is in many ways still in its infancy, it is logical that many recommendations coming from WG4 will be based on single energy storage policy and market recommendations. However specific hybrid storage barriers and recommendations should also be identified and included.

<u>Hybrid storage recommendations</u>

The development of hybrid energy storage solutions is especially important for integrating renewable energy sources and improving the performance of energy systems. This is particularly true for isolated energy markets, such as those in Ireland and the United Kingdom. Examples of solutions as Liquid Air Energy Storage systems, integrated with grids following hybrid solutions comprised of Supercapacitors and Flywheels, can address all the challenges observed in the UK market in 2019, among others inertia and frequency containment. But European islands can also benefit from hybrid energy storage systems. As described in the preceding section, hybridizing conventional power plants can provide a number of benefits.

- Develop a common methodology to assess the value that energy storage assets bring to the energy sector as a whole. The methodology should include storage contribution to security of supply, system operability, integration of renewable energy.
- Develop open-source tools such as SAM and DER VET to assist in calculating, understanding, and optimizing the value of flexibility solutions, including hybrid energy storage ones, based on their technical merits and constraints.
- Accelerate the pace of the development of systems services. To do so, it is key to identify future system needs, taking lessons from projects such as EU Sys Flex, converting this into

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product specifications and then creating adequate commercial frameworks for their procurement.

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5 COURSE OF ACTION

WG4 will identify key challenges and barriers to widespread deployment of hybrid energy storage systems in the context of the energy system challenges today and, in the future, as renewable penetration accelerates to 2030 and beyond.

The activities planned for WG4 for are as follows:

1) WG4 will map all existing and future foreseen energy system challenges (this links to Task 1.2 of the StoRIEs project and identifying the needs of all energy storage actors)

2) Focus on key challenges in the energy system today and identify possible solutions from hybrid energy storage:
   a. Curtailment Minimisation
   b. Minimising natural gas use across different sectors
   c. Quantify short, medium, long duration storage needs in EU (GWh)

3) Identify barriers to deployment and mitigation strategies to these barriers including recommendations for policy, market, funding etc. recommendations (Roadmap Report)

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6 KEY DELIVERABLES

WG4 will prepare a short 10-15 page report that will summarise all information collected. This document will serve as a reference for information to feed into the roadmap report. The diagram below illustrates the key areas of the roadmap report where WG4 will provide inputs and includes:

(i) Energy storage actors needs T1.2
(ii) Policy and market recommendations
(iii) Barriers and challenges

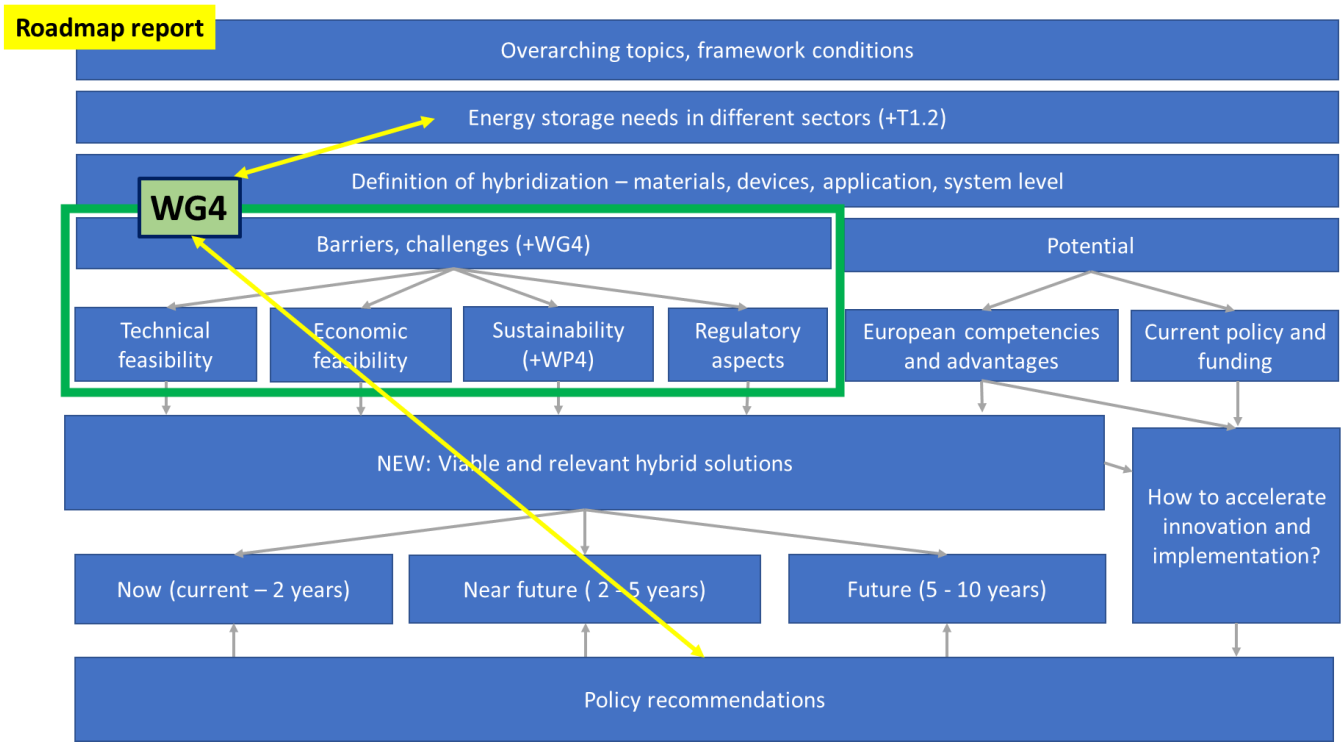

Figure 2: Roadmap Report layout and WG4 contributions

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7 TIMELINE

Table 1: Example of Table

Action	Timeline	Comments
Identify key challenges and Energy storage actors needs	*January 2023*	Collect EASE data already available on existing applications, challenges /barriers for storage
Focus on key challenges and mapping of possible solutions with hybrid energy storage		
Topic 1: Curtailment	*March 2023*	
Topic 2: Replacing gas across different sectors and timescales	*May 2023*	
Topic 3: Seasonal storage	*July 2023*	
First Draft Report	*Nov/Dec 2023*	
Recommendations for policy, market, funding etc. to enable hybrid storage	*March/April 2023*	
…….		

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8 MEANS AND TOOLS

- Engagement with energy storage actors to understand current and future energy system challenges
- Data sharing on MS Teams. Access has been granted to all WG4 experts
    - Dedicated folder to collect publications and other data materials provided by experts

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9 IDENTIFIED RISKS

One main risk was identified in WG4:

- Low participation of WG4 Members in the provision of inputs for the different research papers that will be written.
    - Mitigation measure: Active participation of the Chair to encourage participation, clear table of content with clear division of work. Regular meetings with WG4 members.

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10 ANNEX I – WG MEMBERS

Provide a table with the WG members (mention the date).

Surname	Name	Country	Organisation	Signed Letter of Intent
StoRIES consortium members				
Di Noto	Vito	ITALY	University of Padova	Yes
Bouchotrouch	Faisal	FRANCE	CENER	Yes
Krueger	Klaus	GERMANY	Voith Hydro	Yes
Erdil	Erkan	TURKEY	Middle East Technical University Department of Economics	Yes
Ding	Yulong	UNITED KINGDOM	University of Birmingham Centre for Energy Storage	Yes
Nikoletatos	John	GREECE	Centre for Renewable Energy Sources and Saving (C.R.E.S)	Yes
Malek	Kourosh	GERMANY	Institute of Energy and Climate Research (IEK-13)	Yes
Tacca	Alessandra	ITALY	Eni	Yes
Trilla	Lluís	SPAIN	IREC -Institut de Recerca en Energia de Catalunya	Yes
Nonnenmacher	Lukas	GERMANY	Uniper Kraftwerke GmbH	Yes
Zadeh	Mehdi	NORWAY	Department of Marine Technology, Norwegian University of Science and Technology (NTNU)	Yes
Hentunen	Ari	FINLAND	VTT Technical Research Centre of Finland Ltd	Yes
Mahmood	Nasir	AUSTRALIA	School of Engineering, Melbourne	Yes
Congiu	Annalisa	ITALY	Novara Laboratories (CENTR)	Yes
EASE members				
Stephan	Lars	GERMANY	Fluence	Yes
Barbu	Corneliu	NETHERLANDS	Aarhus univesity	Yes
Vee	Mario	ESTONIA	Energia Salv	Yes
Di Persio	Franco	SPAIN	CIRCE - Centro Tecnologico	Yes
Rodrigo Llanos	Marta	SPAIN	Naturgy	No
Marquardt	Gunnar	SPAIN	MaltaInc	No
Koornneef	Joris	NETHERLANDS	TNO	No
Groenberg	Remco	NETHERLANDS	TNO	Yes
Serodio	Susana	PORTUGAL	APREN	Yes
Vandemborgh	Rob	DENMARK	EVAPCO	Yes
Nguyen	Phuong	FRANCE	RTE	Yes

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