European Commission

INVESTORS DIALOGUE ON ENERGY

Financial instruments and models for energy storage

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Acronyms

CEF	Connecting Europe Facility
BTM	Behind the meter
CF	Cohesion Fund
CfD	Contract for Difference
DFI	Development Financial Institution
DG	Directorate General
DSM	Demand-Side Management
EaaS	Energy-as-a-Service
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EE	Energy efficiency
EIB	European Investment Bank
EIC	European Innovation Council
EIF	European Investment Fund
ERDF	European Regional Development Fund
ESCO	Energy Service Company
ETS	Emission Trading System
EU	European Union
FTM	Front of the meter
GBER	General Block Exemption Regulation
GDP	Gross Domestic Product
GHG	Greenhouse gas
HHI	Herfindahl-Hirschman Index
ID-E	Investors Dialogue on Energy

IEA	International Energy Agency
LCOE	Levelised Cost of Energy
LCOS	Levelised Cost of Storage
LDES	Long-Duration Energy Storage
MF	Modernisation Fund
NECP	National Energy and Climate Plan
NRRP	National Recovery and Resilience Plan
NZIA	Net-Zero Industry Act
PPA	Power Purchase Agreement
PV	Photovoltaic
RDI	Research, Development, and Innovation
RES	Renewable Energy Source
RRF	Recovery and Resilience Facility
SME	Small and medium-sized enterprise
T&D	Transmission and Distribution
TRL	Technology Readiness Level
UK	United Kingdom
UoP	Use of Proceeds
US	United States
WACC	Weighted Average Cost of Capital

Executive summary

Energy storage is pivotal for the successful achievement of Fit for 55 and REPowerEU targets and objectives. A broader deployment of energy storage solutions will contribute to lowering electricity prices during peak times, increase share of renewables in the mix, reducing price fluctuations, and empowering consumers to use the energy they produce.

Storage projects "financeability" is affected by three main aspects: 1) Technology: their TRL, that is their stage of maturity, 2) Economic: the levelized cost of storage, and 3) the range of services they are able to provide (e.g., ancillary, capacity, arbitrage).

Investments in energy storage are affected by barriers of different nature, some stemming from market failures, others - from technical aspects. WG members found the lack of revenue mechanisms and access to capital the barriers affecting most of the energy storage sector.

Financial instruments can address some of the barriers to investment that are slowing down the decarbonisation of the EU energy sector. Through a range of instruments available at EU and Member State level, policy makers and investors can overcome some of the obstacles making energy projects, particularly innovative ones, too risky for the private sector alone. The presence of non-financial barriers affecting storage investments requires additional measures beyond financial instruments to create a truly enabling environment for energy storage investments.

A mapping of financial support schemes at Member State level resulted in the identification of 272 schemes available for energy storage in the 27 Member States. In line with other segments of the energy value chain, several trends can be observed in the offering of financial support schemes for energy storage:

- Loans and grants are the most used types of financial schemes;
- Only three schemes are designed specifically for energy storage only, whereas all the others target at least one more energy segment, and 176 schemes target all segments of the energy value chain;
- Despite being a highly innovative sector, most of the mapped instrument for storage target mature and market-ready projects, and only to a lesser extent less mature technologies/solutions.
- SMEs and larger companies are the most supported category of beneficiaries of the mapped financial support schemes.

Three characteristics were identified as key for a financial support scheme to be effective in the energy storage sector: the seamless provision of different types of financing, long-term stability and visibility, and the provision of technical assistance services together with financing.

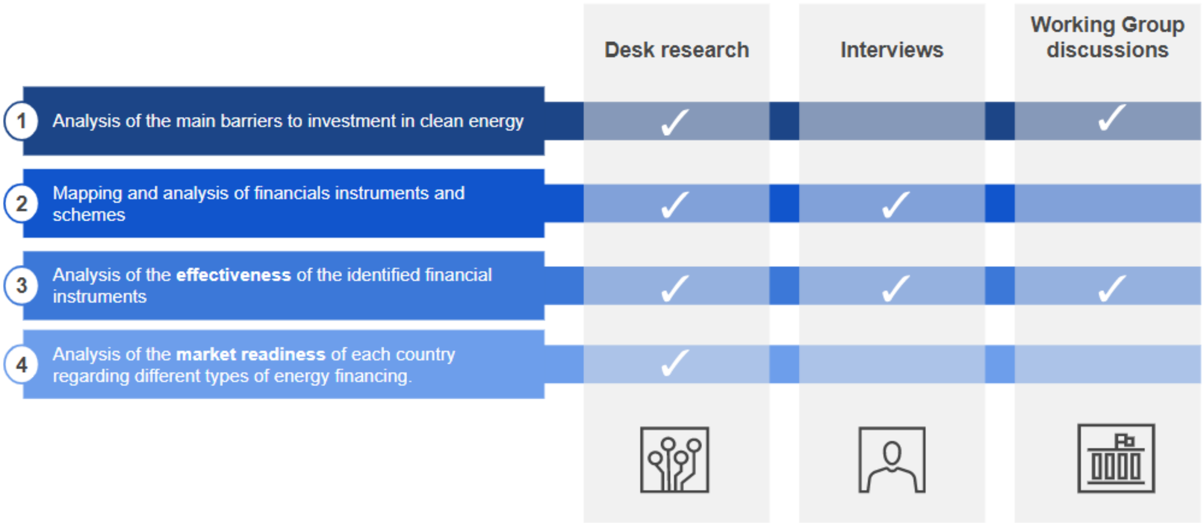
The availability of a comprehensive offering of financial instruments for energy storage is particularly important in countries with low market maturity. In general, the use of equity and guarantee schemes should be leveraged more, particularly in those countries with very high storage capacity targets.

1. Introduction

This Study presents the results of the "Study on current energy sector investment instruments and schemes" in the energy storage sector in the EU. The Study has been carried out as part of the Investors Dialogue on Energy – an initiative launched by the European Commission, DG Energy in 2022 as a multi-stakeholder platform bringing together experts from energy and finance sectors in all EU countries to assess and upgrade financing schemes and propose new ones to mobilise financing in the context of the European Green Deal.

This Study focuses on the energy storage sector and is part of a series covering also energy production, transmission and distribution, heating and cooling, and services and prosumers. The Study has been prepared on the basis of research carried out in 2022 and 2023, and incorporates data collected via desk research and interviews, as well as feedback from the stakeholders participating in the discussion of Working Group 3 of the Investors Dialogue for Energy that focuses on energy storage.

Figure 1: Overview of main topics and data sources



This Study will set the basis for further work under the Investors Dialogue on Energy on the identification of new or upgraded solutions for financing energy storage in order to support the achievement of the EU's 2030 climate and energy targets.

2. The investment context for energy storage

2.1. The new macroeconomic conditions for energy investment

Over the last couple of years, Europe has experienced a period of profound macroeconomic and geopolitical change, characterized by often unpredictable events that have made it necessary to accelerate the energy transition process and to adapt funding flows to the evolving needs. The following four macroeconomic trends have been identified which will make the coming years, and the next MFF budgeting period, fundamentally different than the past decade.

1. Tackling the climate crisis

At the end of 2019, the European Union published the European Green Deal[1], which outlined its aim to become the first climate-neutral, resource efficient, and sustainable economy by 2050. As an intermediate step towards climate neutrality, the EU strengthened its commitments to climate and energy, pledging to reduce 55% of net GHG emissions by 2030, while ensuring Europe's security of energy supply. In order to align current laws with the 2030 and 2050 ambitions, the Commission tabled the Fit for 55 package[2] of legislative measures which, among other targets, proposed to increase the share of renewable energy sources in the overall energy mix from 32% to 40% to speed up the decarbonization of the energy system. These new and updated targets represent a major challenge and a necessary acceleration of green investments. The impact of these policy shifts is already being felt strongly in the European financial sector. Example of notable shifts include:

- The publication of the European Taxonomy, which provides companies, investors, and policymakers with appropriate definitions for which economic activities can be considered environmentally sustainable, thus helping the EU to mobilize private investors to scale up sustainable investment and implement the European Green Deal.
- The transformation of the EIB into the European Climate Bank, and the ensuing commitment to gradually increasing its share of finance dedicated to green investment to over 50% by 2025 and beyond.
- The commitment expressed by EBRD in its new Green Economy Transition (GET) approach for 2021-25, which is part of the Bank's overall strategy for the next five years, to have more than 50% of its investments in green activities by 2025.

The urgency of the climate crisis is increasingly reshaping the investment environment for energy production, with an ever-stronger focus on low carbon solutions.

2. Ending the EU's dependence on Russian fossil fuels

The energy crisis, intensified by Russia's unprovoked aggression in Ukraine in February 2022, has had a significant impact on the EU's energy system and the European financial sector. Turbulence in energy markets, the all-time high energy prices, and the risk of supply shortages across the EU have further exposed the EU's over-reliance on Russian fossil fuels, highlighting the need to accelerate the green transition under the European Green Deal and to ensure a more secure, affordable, resilient, and independent energy system[3]. To respond to these

[1] The European Green Deal, *European Commission*, December 2019.

[2] 'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality, *European Commission,* 2021.

[3] Progress on competitiveness of clean energy technologies, *EU Commission,* November 2022.

hardships, in May 2022 the European Commission presented updated energy targets in the REPowerEU plan[4] and the emergency electricity market design interventions. The REPowerEU plan, which aims to cut the EU's energy dependency on Russian gas well before 2030, confirms the EU's commitment to achieving the European Green Deal's long-term goal of climate neutrality by 2050 and fully implementing the Fit for 55 Package, proposing to increase the headline 2030 target for renewables from 40% to 45%[5].

Broadly speaking, the European Green Deal as an EU growth strategy, the war in Ukraine and REPowerEU are expected to reshape the direction of financial flows. In particular, investments in gas-related projects are focused mainly on projects, which serve the objectives of energy transition, Security of Supply and diversification of gas/energy supply. Examples of such projects may include directional changes to pipeline flows (e.g. establishing north-south pipeline connections), or the repurposing of gas infrastructure for transportation and storage of hydrogen or other low-carbon gases.

3. Rising interest rates in an inflationary context

The global economy is confronting a challenging situation not witnessed for decades, with inflation persistently high amidst increased economic and geopolitical uncertainties, as well as disruptions in energy and commodity markets and supply chains bottlenecks caused by the COVID-19 pandemic and Russia's ongoing invasion of Ukraine. In past years, in the aftermath of the global financial crisis, central banks maintained low interest rates for extended periods of time, leading to a low-volatility environment and easy financial conditions that investors grew accustomed to. In the coming decade, rising interest rates mean that capital is more expensive, and harder to get to, which could prove especially daunting for nascent climate tech industries attempting to establish themselves on the market. This adverse impact of rising interest rates is likely to be compounded by the related phenomena of inflation and supply chain bottlenecks. This is why it is important to create a favourable financing environment that prevents the energy transition and the development of clean technologies from slowing down.

4. Rising global climate tech competition

Europe's partners are increasingly introducing policies and stimulus programmes to seize the net-zero industrial opportunities. The prime example of rising competition for global climate tech dominance is the US Inflation Reduction Act (US IRA), which will mobilize over USD 360 billion by 2033. Japan, India, China, the UK, and Canada have also put forward their own national programmes to stimulate their own climate tech leadership. While competition is beneficial to the overall global climate race to net zero, the EU is also increasingly looking to cement its own positioning in the climate tech space and prevent the outflow of its own industrial champions overseas. Therefore, to facilitate the achievement of its climate objectives and enable the necessary greening and competitiveness of the EU industry, in January 2023 the Commission put forward the Green Deal Industrial Plan[6]. This plan will enable the EU to access key technologies, products, and solutions needed for a successful transition to net-zero, which will in turn boost economic growth and generate quality jobs. The Green Deal Industrial Plan will thus attract investments in the net-zero industrial base, with a focus on innovative technologies, helping them to overcome the so-called 'valley of death' before commercialization[7]. In line with the Green Deal Industrial Plan the European Commission has adopted a new Temporary Crisis and Transition Framework which, together

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[4] REPowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition, *European Commission*, May 2022.

[5] In March 2023, the European Parliament and the Council reached a provisional agreement to raise the binding renewable energy target to at least 42.5% by 2030 (available at this link).

[6] A Green Deal Industrial Plan for the Net-Zero Age, *European Commission,* February 2023.

[7] Questions and Answers: Green Deal Industrial Plan for the Net-Zero Age, *European Commission,* 2023.

with the amended General Block Exemption Regulation (GBER) will help to accelerate investment and financing for climate tech production within the European Union and allow Member States more flexibility to design and implement support measures in sectors that are key for the transition to climate neutrality[8]. In addition, a proposal for a Net Zero Industry Act (NZIA)[9] has been submitted with the aim of establishing a framework of measures directed at strengthening Europe's net-zero technology products manufacturing ecosystem and overcoming barriers to scaling up the manufacturing capacity in Europe. The Regulation encompasses products, components and equipment used in manufacturing net-zero technologies and it distinguishes between net-zero technologies and strategic net-zero technologies, whereby the latter is regarded as making a significant contribution to decarbonisation by 2030.

Meeting the objectives of the European Green Deal and REPowerEU will entail, among other things, an increase in the share of renewable energy in the energy mix, electrification of end-use sectors, shift to hydrogen and other type of low-carbon gas in the hard-to-abate sectors, growth in the share of grid-connected distributed energy, and an ever-larger customer engagement including via demand response.

2.2. The investments needed to reach European Green Deal objectives

Conventional and innovative energy storage solutions will play an **important role in ensuring the integration of renewable energy sources into the grid at the lowest cost**. This will help the EU reach its 2030 and 2050 decarbonization objectives under the European Green Deal and the Fit for 55 Package.

The role of energy storage has become even more important in the light of the REPowerEU Plan. This means there will be a growing need for technologies and solutions which can support high levels of electrification by temporarily storing and feeding electricity back to the system at times when it is convenient to do so. Investing in energy storage research, demonstration, and deployment is thus becoming essential to support the EU's global leadership in clean energy technologies and support the rapid evolution of the European energy system[10].

In the fast-changing energy storage context, meeting the Green Deal and REPowerEU objectives will require **investments in at least the following assets or project types**:

- **Front of the meter (FTM) storage** which can be either connected to transmission and distribution networks or to power generation assets, providing grid services and generating value from energy arbitrage, network support and frequency management. Main FTM technologies include:
    - Batteries
    - Pumped hydro
    - Hydrogen
    - Thermal storage[11]

[8] Temporary Crisis and Transition Framework, *European Commission,* March 2023.

[9] Available at the following link.

[10] Policy priorities, *European Association for Storage of Energy (EASE)*, available at this link.

[11] Despite the growing role of FTM thermal storage, this technology is not a focus of this study as it is treated more closely in Study 4 – Heating and Colling.

  - Natural or renewable gas storage[12]

- **Behind the meter (BTM) storage,** which refers to customer-sited storage systems that are connected to the distribution system on the customer's side of the utility's service meter[13]. Common examples of behind-the-meter resources are distributed energy resources (DERs) such as solar panels combined with energy storage such as batteries, whereby the solar power is either used immediately or stored in a battery for later use. Behind the meter storage can be subject to different applications, including:
  - Residential
  - Commercial and Industrial

In this context of profound transformation of the energy system, **hydrogen storage** is worth a separate mention. Given its potential to substitute fossil fuels in hard-to-abate sectors and to store excess electricity generated from renewable sources in large quantities and for long periods of time, hydrogen has immense potential. In this regard, the European Commission's hydrogen strategy presented in July 2020 has set the strategic objective to install 40 GW of renewable hydrogen electrolyser capacity within the EU, based upon an estimated demand of up to 10 Mt per year of renewable hydrogen in the EU by 2030[14]. On top of this, with the publication of the REPowerEU plan in May 2022, the European Commission presented the 'hydrogen accelerator' concept to scale up the deployment of renewable hydrogen, with the ambition to produce 10 Mt and import 10 Mt of renewable hydrogen in the EU by 2030 to satisfy the increasing yearly demand of hydrogen[15]. To meet this ambition a significant deployment of hydrogen storage will be required. One way to accelerate the deployment of hydrogen storage could be the repurposing of existing natural gas storage. However, there are currently no EU-level rules to guide the process of storage assets repurposing from natural gas to hydrogen, which is considered a driver of regulatory uncertainty that discourages investment in storage.

Energy storage will play a crucial role providing vital **system flexibility as well as stability and a wide range of services**, such as:

- Integration of high shares of variable renewables and low-carbon gases
- Programmable capacity to cover peak demand, ensuring system adequacy
- Support energy efficiency and energy optimization behind-the-meter
- Empower consumers to participate in the energy system
- Link the energy sector with gas, heating and cooling, and mobility.
- Ensure security of supply.

Electricity and thermal storage solutions are developing at a fast pace and different technological solutions compete for storing electricity over time frames between fractions of seconds and seasons. Although a focus is typically applied on electricity and hydrogen storage options, it is worth further investigating the storage potential that **other technologies may provide at competitive costs**. For instance, thermal energy storage and other thermochemical energy storage technologies provide valuable services to the system through sector integration as they absorb electricity surpluses through power-to-heat solutions,

[12] Mind that the gas storage is not energy storage according to the definition in the recast of the Directive (EU) 2019/944, chapter 1, art 2 (59), which defines storage as *'deferring the final use of electricity to a moment later than when it was generated, or the conversion of electrical energy into a form of energy which can be stored, the storing of such energy, and the subsequent reconversion of such energy into electrical energy or use as another energy carrier'*.

[13] Behind-the-meter battery energy storage: Frequently asked questions, *NREL,* August 2021.

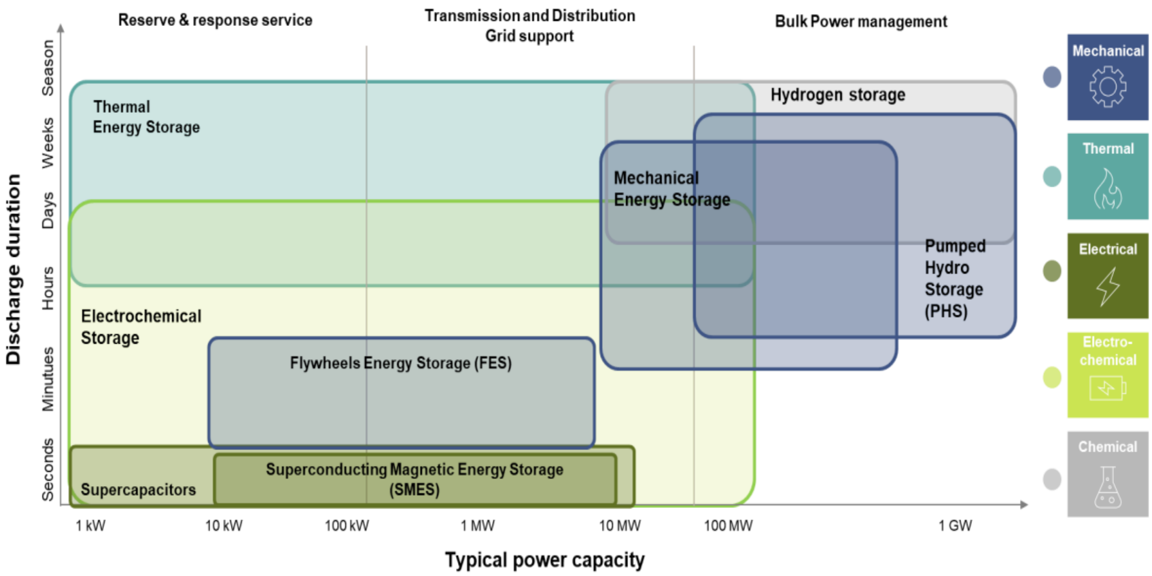
[14] A hydrogen strategy for a climate-neutral Europe, COM (2020) 301 final, *European Commission*, 2020

[15] Link

facilitating the recovery of heat that would otherwise go to waste. They can also play a key role in retrofitting existing fossil fuel power plants, avoiding the combustion of fossil fuels. Furthermore, thermal storage is one of few **long-duration storage technologies** that can store vast amounts of energy up to tens of GWh per cycle on a seasonal timescale[16].

Long Duration Energy Storage (LDES) encompasses a range of conventional and novel technologies, including mechanical, thermal, electrochemical, and chemical storage. While pumped hydro is a well-known conventional technology for LDES, the various novel LDES technologies are at different levels of maturity and market readiness and tend to require different investment support in order to reach scale and a commercial readiness. An increased deployment of long-duration energy-storage can be a source of multiple system benefits by way of providing **system flexibility and security of supply**. In that sense, LDES presents a way to effectively manage the daily and seasonal variability of variable renewable energy; when used in hydrogen, decarbonized gases, and power to heat applications, LDES can also be an enabler of energy system integration and thus of decarbonizing the economy more broadly.

Figure 2: Overview of different electricity storage technologies



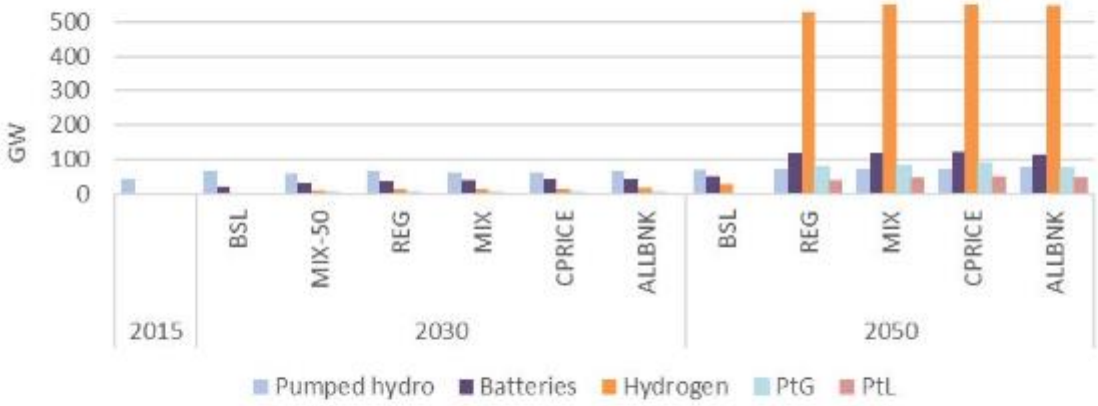
Source: EASE, Energy Storage Targets 2030-2050, June 2022.

According to the Climate Target Plan Impact Assessment[17] by 2030, the Pumped Hydro Storage (PHS) capacity will grow from currently 45 GW to 64 GW in the BSL scenario and to 63 (CPRICE) – 65 (REG) GW in the different policy scenarios. Batteries will add another 21 GW of electricity storage in the BSL scenario and 34 (REG) – 43 GW (CPRICE) in the policy scenarios.

[16] Energy Storage Targets 2030 and 2050, *EASE*, 2022.

[17] Stepping up Europe's 2030 climate ambition. Investing in a climate-neutral future for the benefit of our people, Impact Assessment, *European Commission*, SWD (2020) 176 final, Brussels 2020. Main scenarios identified are: BSL (achieving the existing 2030 GHG, RES and EE EU targets); REG (a regulatory-based measures scenario that achieves around 55% reductions); CPRICE (a carbon-pricing based scenario that achieves around 55% reductions); MIX (following a combined approach of REG and CPRICE, which achieves around 55% GHG reductions); MIX-50 (an increased ambition scenario achieving at least 50% GHG reductions); ALLBNK (the most ambitious scenario in GHG emissions reduction, based on MIX and further intensifying fuel mandates for aviation and maritime sectors).

Figure 3: Electricity storage and new fuels production capacity (PtG: Power to Gas; PtL: Power to Liquids)



Source: Stepping up Europe's 2030 climate ambition, Impact Assessment, SWD (2020) 176 final, Brussels 2020

Moreover, although there are no formal binding targets for energy storage in the European Union, the European Association for Storage of Energy (EASE) has estimated that energy storage power capacity requirements at EU level will be approximately 200 GW by 2030 and 600 GW by 2050[18]. The financing required to support this major step-up in energy storage technology uptake up to 2050 is estimated at between €100 and 300bn.[19] This does not take into account additional investments needed to meet the objectives of REPowerEU, which are estimated at an additional €10bn for storage on top of the Fit for 55 Package[20].

In their National Energy and Climate Plans, some Member States have estimated investment needs for energy storage, **despite not having national targets**, Table 2 below provides an overview of such investments in the 2021-2030 period, and the investment gap that needs to be bridged with additional resources, based on NECPs and Resilience and Recovery Plans (RRPs) data. Due to the absence of clearly defined targets and inconsistencies in data availability related to planned investments, estimations on investment needs are not present for all countries. Because of this, estimations for investments gaps per country have proven difficult to elaborate. Please note that Member States are expected to provide updated versions of the NECPS by mid-2023 providing more detailed data estimates and quantification[21]. In view of compensating for this incompleteness of investment gap data, figures related to measures planned under the Resilience and Recovery Facility (RRF) have been added to the quantification. These figures relate to measures aimed at promoting investments in storage systems[22] in each Member State in the 2021 - 2026 timeframe that is specific to the RRF[23]. Figures from the NECPs and the RRF are not always comparable, therefore the estimates presented in this table are to be considered with care and only for the purpose of this study.

[18] EASE, Energy Storage Targets 2030-2050, June 2022

[19] Andrey, C., Barberi, P., Nuffel, L., et al., Study on energy storage: contribution to the security of the electricity supply in Europe, *European Commission, DG ENER,* Publications Office, 2020

[20] Implementing the REPowerEU action Plan: Investment needs, Hydrogen accelerator and achieving the bio-methane targets, SWD (2022) 230 final, European Commission, 2022

[21] Commission Recommendation 2023/C103/01 of 14 March 2023 encourages Member States to strengthen, in their updates of the national energy and climate plans, the objectives and related policies and measures that aim to cost effectively promote the deployment of energy storage, both utility-scale and behind-the-meter storage, demand response and flexibility. The same Recommendation states that Member States should identify potential financing gaps for short-, medium- and long-term energy storage.

[22] Including the development of H2 storage.

[23] For several countries (Austria, Belgium, Bulgaria, Germany, Italy and Poland) some measures aggregated investments in energy storage systems related to hydrogen with other investments dedicated to the development of the rest of the hydrogen value chain. Some investments were aggregated also with investments in the transport sector, concerning specifically the use of hydrogen. Lack of granular data concerning the amount that should be dedicated to energy storage specifically has prevented to isolate such investments, therefore these measures were classified in energy storage in their entirety.

Due to the difference in the publication time between the NECPs (2019-2020) and the RRPs (2022), in some cases investments foreseen in the RRPs may exceed estimated investment needs in the NECPs, resulting in negative values for investments gaps. In addition, several Member States do not have any figures on energy storage in their NECPs, and values are thus marked as "N/A". In addition, upcoming updates of investment needs as part of the NECP that will be finalised in mid-2024 will need to take into account the higher FitFor55 ambitions and REPowerEU objectives.

The Investment gap has been calculated based on the following approach:

i) firstly, investments necessary to reach targets declared within NECPs have been identified;

ii) secondly, investments foreseen under existing policies have been identified and subtracted from investment needs identified at point i). Since information for existing investments is consistently lacking across NECPs, the result of this calculation often was equal to the investment needs;

iii) to compensate for the lack of information for investments under existing policies, investments from the RRF have been mapped for the storage sector. The calculation is as follow: i – ii – iii = investment gap.

Table 1: Member States' estimated investment need and investment gap in energy storage to achieve 2030 renewable energy and climate targets[24]

Country	Investment needed to reach 2030 objectives - RE generation (€ bn)	Notes on investments need	Investment gap (€ bn)	Notes on investment gap
Austria	2.70	For hydrogen infrastructure (also synthetic methane storage), of which €1.2 bn from IPCEI	2.58	€0.12 bn of foreseen investments under the RRP concern measures for the entire H2 value chain (generation + transport)
Belgium	5		4.72	€0.28 bn of foreseen investments under the RRP concern measures for the entire H2 value chain (production, transport, storage, and consumption)
Bulgaria	0.62		N/A	€0.03 bn of foreseen investments under the RRP concern measures for both the entire H2 value chain and also biogas.
Croatia	N/A		N/A	
Cyprus	1		N/A	
Czech Republic	N/A		N/A	
Denmark	0.02		0.02	

[24] Investment needs do not reflect new targets proposed with the revision of the RED II and the REPowerEU Plan.

Country	Investment needed to reach 2030 objectives - RE generation (€ bn)	Notes on investments need	Investment gap (€ bn)	Notes on investment gap
Estonia	N/A		N/A	
Finland	N/A	The NECP provides information on sectoral investment needs (€11 bn in total). However, it does not include complete overall figures for all energy-related investment needs throughout the 2021-2030 period.	N/A	
France	N/A		N/A	
Germany	1.00		N/A	€1.5 bn of foreseen investments under the RRP concern the entire H2 value chain, while 0.58 bn concern the transport sector.
Greece	3.30		2.85	
Hungary	N/A		N/A	
Ireland	N/A		N/A	
Italy	10		8.70	€0.45 bn of foreseen investments under the RRP concern measures for the entire H2 value chain
Latvia	N/A		N/A	
Lithuania	N/A		N/A	
Luxembourg	N/A		N/A	
Malta	N/A	€1.66 bn necessary for the whole RES sector	N/A	
Netherlands	N/A		N/A	
Poland	0.26		N/A	€0.80 bn of foreseen investments under the RRP concern measures for H2 for the transport sector
Portugal	N/A		N/A	
Romania	N/A		N/A	
Slovakia	N/A		N/A	
Slovenia	N/A		N/A	
Spain	N/A		N/A	

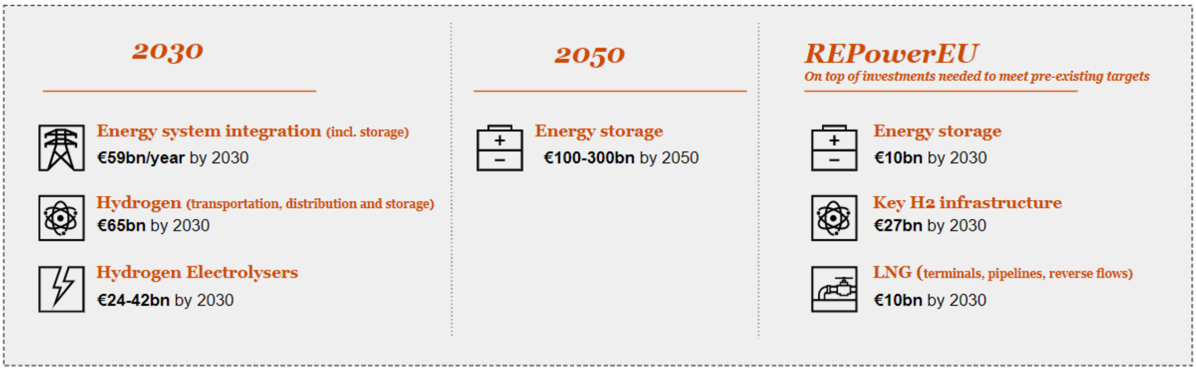
Country	Investment needed to reach 2030 objectives - RE generation (€ bn)	Notes on investments need	Investment gap (€ bn)	Notes on investment gap
Sweden	N/A		N/A	

Source: Member States' National Energy and Climate Plans (NECPs) and Recovery and Resilience Facility (RRF)

In view of the 2030 objectives and the envisaged energy system integration, in its assessment of Member States' NECPs, the European Commission estimated that the energy infrastructure investment needs (including transmission and distribution networks, heating and cooling, transport, and **energy storage**) are at the level of €59 billion per year.

In light of the **role hydrogen can play to contribute to the decarbonization of the energy sector**, the Commission estimated that about €65 billion is needed for hydrogen transport, distribution, and storage, while about €24-42 billion of total investments will be needed in hydrogen electrolysers[25].

Figure 4: Estimated investment needs in storage to meet the EU2030 climate and energy targets, to achieve climate neutrality by 2050 and under the REPowerEU Plan[26]



Source: EU Commission and REPowerEU

2.3. Economics of energy storage

Being a broad umbrella concept for a diverse set of mature and emerging technologies, used in different market contexts and business models, energy storage is characterized by complex economics. For the needs of this study, we examine its economics through the lens of financeability and what broad types of financing are needed for different investment typologies. As in other segments of the energy value chain, economics of storage ultimately reflects the investment's risk profile. In this regard, understanding the risks associated with each technology and the use cases (i.e., demand charge reduction, backup power and transmission deferral, among other; please refer to Figure 7 in the next section for a more detailed overview of all possible use cases) that these technologies can provide to the system as a whole is pivotal to ensure the bankability of projects. In this section we will review these concepts.

[25] An EU-wide assessment of National Energy and Climate Plans Driving forward the green transition and promoting economic recovery through integrated energy and climate planning, *EU Commission,* Bruxelles 2020.

[26] Information on financing need in energy storage are retrieved from: 1) Implementing the REPowerEU action Plan: Investment needs, Hydrogen accelerator and achieving the bio-methane targets, SWD (2022) 230 final, European *Commission,* 2022. 2) A hydrogen strategy for a climate-neutral Europe, COM (2020) 301 final, *European Commission*, 2020. 3) An EU-wide assessment of National Energy and Climate Plans Driving forward the green transition and promoting economic recovery through integrated energy and climate planning, *EU Commission,* Bruxelles 2020. 4) Study on energy storage: contribution to the security of the electricity supply in Europe, *European Commission, DG ENER,* Publications Office, 2020

Financeability

Financeability can be understood as a project's ability to meet its financing requirements and to raise capital efficiently and, specifically in the area of energy storage, it is driven by considerations on technology readiness, levelized cost of storage, and how revenue streams are generated and secured. Energy storage is an essential enabler of the energy transition, but investors will respond to the need for investments only if specific investment opportunities present acceptable rates of return and a risk level commensurate with the investor's risk appetite in terms of expected financial returns and impacts. In this study, we explore the financeability of energy storage project through the following three dimensions:

1. **Technology Readiness Level** (TRL) and the investment risk related to technologies
2. **Levelized cost of Storage** (LCOS)
3. **How revenues are generated**, which itself is a function of what use cases are applied.

Technology Readiness Level (TRL)

Different technologies have different TRLs, which in turn imply different levels of risk. This means that financing models used for investments are not homogenous among energy storage projects. The TRL is an important indicator of the financial viability of a project as it is of utmost importance for energy investors to know the current stage of the storage technology used: An R&D technology project implies more risks and potentially higher returns in the long-run, whereas a commercial-stage storage unit tends to have lower Internal Rate of Return (IRR) expectations but real cash flow in the near term. The level of TRL achieved will influence the appetite of banks and investors for providing the required financing, as well as the type of instrument used. As a general rule, low TRL technologies typically require public or venture capital instruments, while commercial-stage technologies tend to be "bankable" and are more likely to have access to debt and equity markets.

While it is true that different technologies may be affected by different barriers, we use the logic of Technology Readiness Level (TRL) to investigate the most relevant barriers impacting technologies at different maturity level. For example, technologies with a low TRL are likely to be more affected by technical and economic barriers such as high upfront costs, while technologies with a high TRL (including mature technologies) are likely to face barriers of political and regulatory nature.

For the needs of this study, we use the TRL scale as understood by the annual IEA Energy Technology Perspectives publication which, compared to the traditional scale which ends when a technology can be commercially available (TRL 9), extends the scale to incorporate the need of technologies to be further developed in order to be integrated within the existing energy system, to reach scale, or to develop mature supply chains. For this study, the TRL scale provides a useful framework to think about barriers to investment and investment schemes, given that reasoning at the level of individual technologies would be unfeasible. For the sake of simplicity, we refer to three broader readiness categories, each of which comprises different ranges of the full TRL scale[27]:

[27] We use the TRL framework explained in The Energy Technology Perspectives — Clean Energy Technology Guide, *IEA*, 2022.

Figure 5: Technology Readiness Level of energy storage technologies

TRL	Stage	Technologies
1	**Initial idea** Basic principles have been defined	
2	**Application formulated** Concept and application of solution have been formulated	
3	**Concepts needs validation** Solution needs to be prototyped and applied	• Hydrogen: depleted oil and gas field
4	**Early prototype** Prototype proven in test conditions	• Thermochemical: chemical reactions
5	**Large prototype** Components proven in conditions to be deployed	
6	**Full prototype at scale** Prototype prove at scale in conditions to be deployed	• Thermochemical: sorption process
7	**Pre-commercial demonstration** Solution working in expected conditions	
8	**First of a kind commercial** Commercial demonstration, full scale deployment in final form	• Batteries: Redox flow • Compressed air energy storage
9	**Commercial operation in relevant environment** Solution is commercially available, needs evolutionary improvement to stay competitive	• Batteries: Lithium-ion • Flywheel • Liquid air energy storage • Sensible heat storage • Latent heat storage: ice storage • Flow batteries
10	**Integration needed at scale** Solution is commercial and competitive but needs further integration efforts	• Hydrogen: salt cavern storage
11	**Proof of stability reached** Predictable growth	• Pumped hydro storage • Hydrogen: storage tank

Legend:
Pre-Commercial
Demonstration / First-of-a kind
Commercial scale

Source: PwC elaboration of IEA Energy Technology Perspective data, 2022

The Levelized Cost of Storage (LCOS)

Storage costs are still relatively high, despite significant cost reductions which took place over the past two decades. Cost reductions are expected to continue in a significant way, making storage more viable in the future. Costs are an important driver of the financeability of an energy storage project: as the costs of different technologies decline, more opportunities for financing and bankability open up. As for the energy generation segment of the value chain, when analysing costs of an energy storage project, we must consider all costs that occur during the whole lifecycle of the project itself.

Energy storage technologies serve a variety of use cases and each of them requires different operating parameters which affect the costs itself. Therefore, energy storage system costs are not only dependent on the technology chosen, but also on the defined use case. With that in mind, the most important cost components of energy storage projects include (but are not limited to)[28]:

- **Capital costs (CAPEX),** which include the total value of all the initial equipment purchased for the project as well as the planned replacement of equipment over the life of the project[29]. Capital costs vary by technology type and can be relatively higher for battery storage than for other storage solutions.
- **Capacity Maintenance** refers to the costs incurred either for maintenance/replacement of certain components of the storage system to cope with degradation (loss of capacity over the operating life) or to maintain the storage capacity or charge/discharge rate of the system.
- **Operation and maintenance costs** which are critical to understanding project's actual value over its operating life and entail all costs incurring to maintain the system in order to have the facility operate as planned or contracted.

[28] Energy Storage Financing: Project and Portfolio Valuation, *Sandia National Laboratories,* January 2021.

[29] The general cost structure of energy storage systems used across all energy storage technologies include the following components: storage module, balance of system, battery energy storage system, power conversion system, energy management software, energy storage system, grid integration, engineering, procurement and construction (Ibid).

- **Project costs** which include i) project development costs related to the structuring of the project entity (including financial and legal relationships with external organizations); and ii) Engineering, Procurement, and Construction costs (EPC) which consist of site design costs, costs related to equipment procurement/transportation, and the costs of labour for installation.
- **End of life costs** which refer to the costs incurred to deploy a responsible end of life process, including procedures on decommissioning, transportation, and disposal. This cost component tends to be relatively higher for batteries than for other storage solutions.

To incorporate all of these cost components into a common framework used to determine which energy storage technology would provide the most competitive project, given the same starting market conditions and project return expectations, there is growing use of the levelized cost approach (which refers to the total lifetime cost of the investment in an electricity storage technology divided by its cumulative delivered electricity).

Energy storage modules needs to be measured in two dimensions:

- **The power rating**, (measured in kW) refers to the maximum amount of energy that the storage system can store and release in any given instant
- **Energy capacity**, (measured in MW/h) is the measure of how much electricity the system can deliver or absorb over the course of an hour.

Knowing the use case of the energy storage system is essential to estimating the cost of storage, as different end-uses call for different energy-to-power ratio. For example, if the energy storage system is able to charge and discharge many times in a short time period, it will be particularly suited to provide frequency regulation, while if the energy system is able to charge and discharge over a longer period, it will be likely used to provide backup power or peak-shifting. Lazard's Levelized Cost of Storage (LCOS) is used to compare different technologies for a specific use case or market opportunity which would describe a project's lifespan[30].

The charts below show the cost of providing 1 kW of power capacity with a storage device for a year, when accounting for all cost incurred throughout the lifetime of the device (Figure 6) and the price of electricity discharged from a storage system when accounting for all cost incurred and energy produced throughout the lifetime of the device (Figure 7). The various energy storage use cases each get their own calculated LCOS. Understanding that energy systems have different capacity-to-energy ratios helps illustrate why it is difficult to compare costs even among the same technologies. For this reason, having clearly defined use cases is crucial for making an accurate cost estimate and define which technology is better to use for the specified use case.

[30] Lazard's Levelized Cost Of Storage Analysis, Version 7.0., 2021

Figure 6: Unsubsidized Levelized Cost of Storage Comparison - Capacity ($ / kW-year)

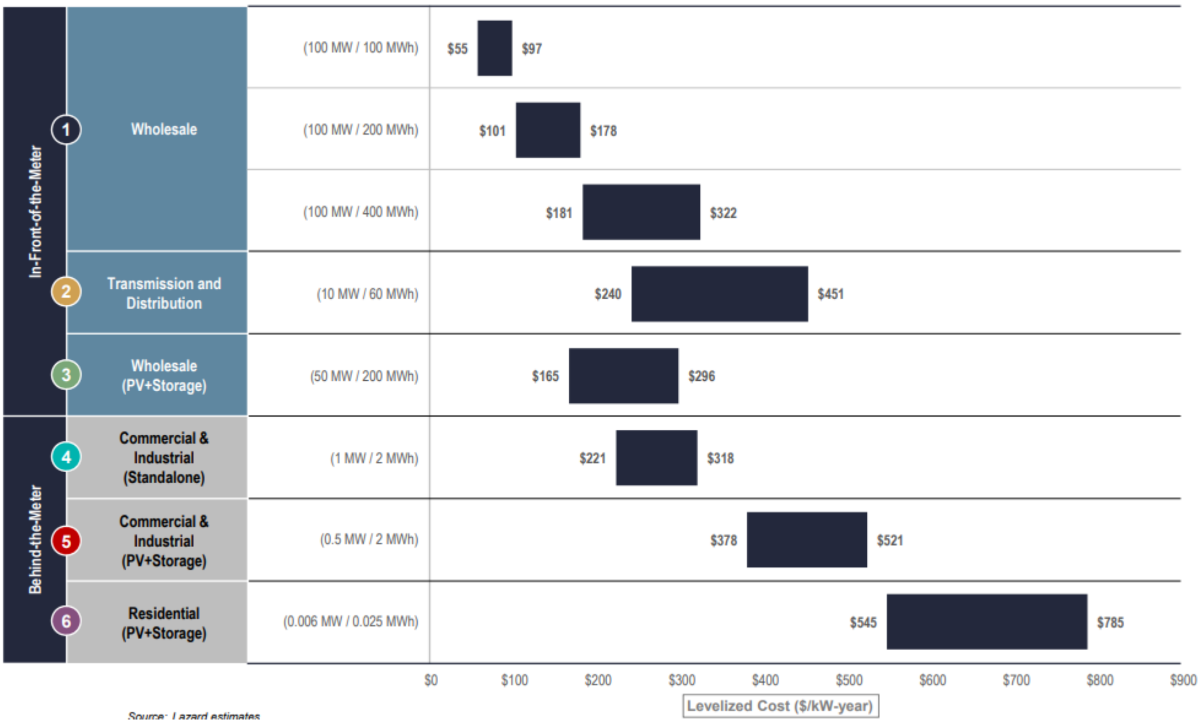


Figure 7: Unsubsidized Levelized Cost of Storage Comparison – Energy ($ / MWh)

Source: Lazard, 2021

How revenues are generated

Energy storage has many valuable applications across the energy system**.** The range of services which energy storage installations can provide is rapidly evolving, both because of the ongoing development of new energy storage technologies, but also because of the evolving and growing flexibility needs of the energy system. As a capital-driven investment, a storage unit needs reasonably secure **long-term revenue streams** to ensure its viability, but while some applications have clear value that can be written as revenue contracts, others provide revenue streams that are not as easily monetized or that are currently not perceived as service by the system. Visibility on revenue streams is an important aspect of the development of a storage project because it will also affect the cost of capital for the project, thus impacting its development path.

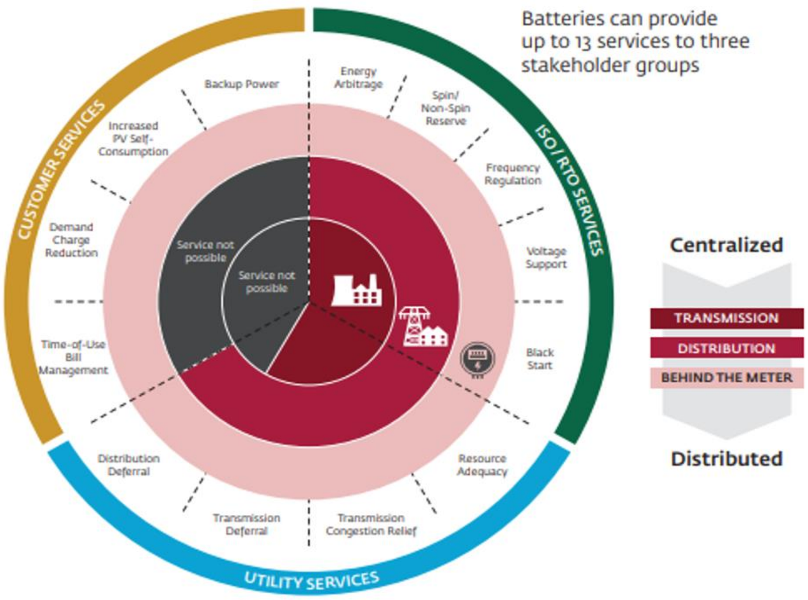
As a general rule, the financing model applied to a storage solution will depend on the type of revenue stream that the storage can secure and, as a consequence, its risk profile. For example, a storage project with a long-term capacity market contract in place would face low market risk (thanks to the long-term visibility of revenues) and therefore tend to have solid access to debt, typically via a project finance structure. Conversely, for a storage project where the remuneration model is fully merchant (e.g., arbitrage or ancillary services), the risk profile tends to be higher. In this case access to debt could be constrained and the project may rely more on equity financing.

Main energy storage revenue streams come from (but are not limited to):

- **Ancillary services** which refer to the range of services that help grid operators maintain a reliable electricity system, e.g., frequency control, voltage control, black starts etc.
- **Capacity service** can provide a form of revenue e.g., on the basis of a long-term Power-purchasing agreement (PPA) under which a storage system owner receives a fixed monthly fee from the utility for its rights to charge or discharge the storage within pre-agreed upon use parameters. The fee is basically a capacity payment or reservation charge[31].
- **Energy arbitrage or time shifting** entails buying energy during off-peak period when energy is cheap and sell it back to the grid during peak hours when is more expensive (e.g., large-scale pumped hydro projects were built for this purpose).

Although referring specifically to batteries, Figure 8 below is illustrative and provides a more exhaustive view on the use cases and services that energy storage can provide to the broad energy system. The remuneration and revenue stream from each use case is specific to individual Member States, although participation in ancillary market mechanisms (either spot or via long-term capacity payments) is the most frequently seen practice to date.

Figure 8: Overview of services and use cases which battery storage can provide



Source: Rocky Mountain Institute. The Economics of Battery Energy Storage, 2015

[31] Implementing Sustainable Business Models for Hydro Storage, *GE Renewable Energy, 2019.*

Battery Energy Storage Systems in Italy: Pilot project in the ancillary service market

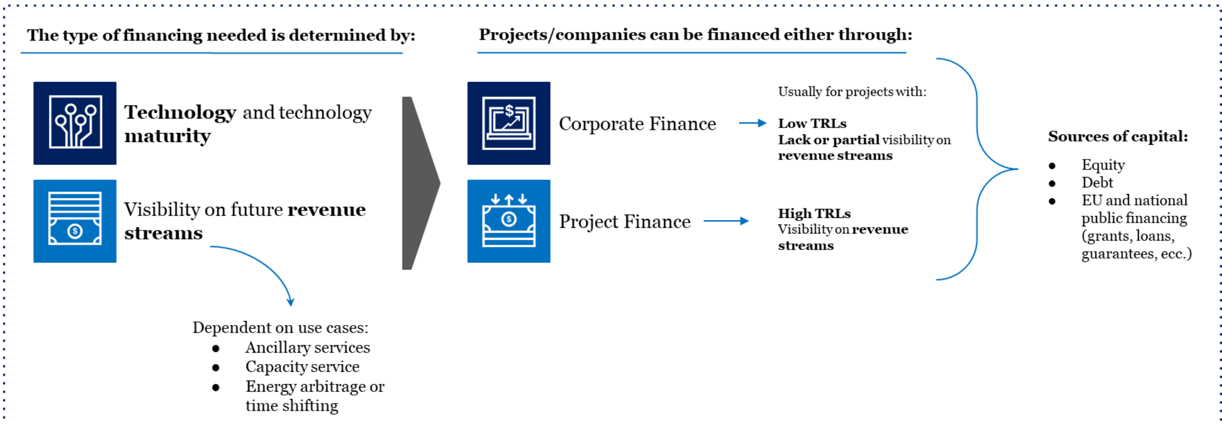
As a way of opening the Ancillary Services Market to new players, the regulator ARERA (*Autorità di Regolazione per Energia Reti Ambiente*) introduced (with Decree 300/2017/R/eel)[32] a number of pilot projects designed to introduce new sources of dispatch capacity as below.

Pilot project UVAM (Virtually Aggregated Mixed Units), launched in November 2018, allows distributed resources (consumption and production units) as well as storage systems of capacity as small as 1MW to participate, in an aggregated form, in ancillary services markets. The economic regulation of UVAM differs from that of large plants because it involves not only ordinary remuneration linked to energy activated (€/MWh), but also remuneration for resource availability (€/MW).

In another pilot project, in December 2020 Terna, the Italian TSO, held an auction of fast reserve frequency response (response time under 1 second). Five-year contracts were awarded to around 250MW of Battery Energy Storge System (BESS) to provide fast reserve services, at an average weighted price of €29,500 / MW / year. Projects will be called on by Terna to provide the Fast Reserve frequency regulation for 1,000 hours per year from 2023-2027, but BESS assets will also be able to stack revenues from other available market opportunities such as reserves or wholesale markets[33].

What type of financing is needed

Figure 9: What type of financing is needed



In energy storage, the type of funding needed for a project is mainly determined by:

- the technology used and its level of maturity
- the visibility on future revenues

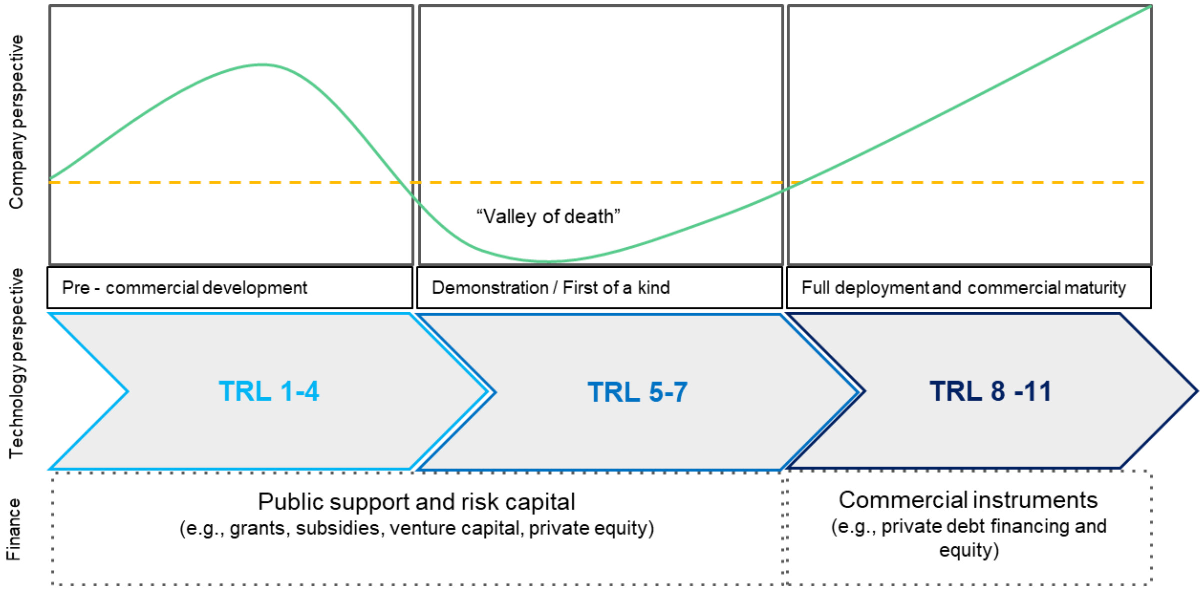
For a sector in transition such as energy storage, it is important to acknowledge the **changing nature of financing needs over the life cycle of projects and technologies**. Different sources of finance are optimal in different stages of the life cycle as projects have different risk/return profiles and these need to match different investors' expectations, sentiments and decision making. Correspondingly, private and public actors would need to make the required

[32] Deliberation 5 May 2017, *ARERA,* 300/2017/R/EEL.

[33] Batteries awarded five-year grid services contracts in Italy through low-price auction. A. Colthorpe, *Energy Storage News*, 2020.

resources available at the right time and in the suitable form if the transition is to happen. Taking a life cycle and technology maturity approach implies understanding risks associated with different TRL stages and the type of financing most suitable for each stage of the lifecycle in order to effectively support the development and deployment of energy storage technologies[34].

Figure 10: Financing models during the life cycle of a technology



Source: PwC elaboration of Polzin F., Sanders M., and U.S. DOE Loan Program Office.

As shown in the Figure above, projects can be financed either through corporate finance or project finance and this usually depends on the risks that can be reasonably associated with the project itself:

- **Corporate Finance**: best suited for projects with a low TRL and a high degree of risk where future cash flows from the investments are uncertain or difficult to estimate (e.g., energy storage systems with unpredictable revenue streams)
- **Project Finance**: best suited for projects featuring mature technologies with a high degree of certainty surrounding future returns or revenue streams (e.g., battery storage combined with renewable generation assets).

In both corporate and project finance, the main sources of capital are **equity and debt**.

Equity which can take the form of internal equity, external equity from investors or venture capital. Equity financing in energy storage assets has long been the major source of financing for storage projects. This is especially true for FTM projects which have the potential to provide a number of ancillary services to support the grid, such as frequency regulation, spinning reserves and voltage support, but face difficulty to monetize these services at this time due to a lack of compensatory structures in wholesale markets. The higher risk profile of FTM projects, compared with BTM assets (which have been able to demonstrate a rate of return that is acceptable to lenders based on e.g., revenues from capacity payments from a utility) implies a greater need for promoters to access equity financing (or grants). Regarding technology maturity, technologies that are in the **low TRL area** tend to be characterized by high risk, as concepts and ideas might prove wrong or ahead of their time to be commercially feasible. Furthermore, economic returns if they are present, are not considered sufficient to receive commercial-rate financing. In this case, **venture capital** has proved particularly

[34] Polzin F., Sanders M., How to fill the financing gap for the transition to low-carbon energy in Europe? *Utrecht School of Economics,* 2019.

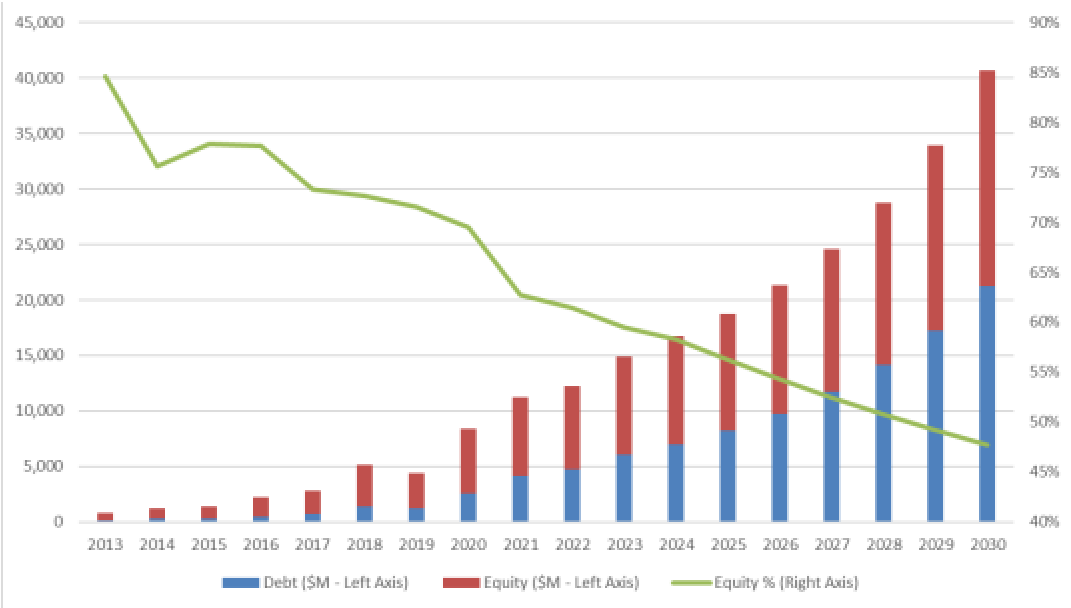
effective at providing support to promising technologies that lack financial resources to scale up production.

Debt can take several forms, including bonds, leases, and loans. For both FTM and BTM energy storage assets, access to debt may vary depending on the asset type, the risk profile, the performance of each specific technology as well as on the country in which the project is carried out and regulation in place. **Access to debt in energy storage projects is relatively low compared to equity financing** as the **emerging nature** of some storage technologies (e.g., batteries) and **lack of long-term visibility on revenue streams and remuneration models** makes debt financing not attractive for a large range of risk-adverse investors. Yet, the Figure below shows that over the last few years, the share of debt financing in electricity storage has grown and is expected to make up an ever-larger component of the financing sources[35]. Only when reaching **the fully commercial** phase is the company expected to be **profitable** and, more importantly, **bankable[36]**. However, when a technology has reached the commercial stage, it is important to have enabling regulatory environment that strengthen business cases by creating frameworks that adequately remunerate storage services.

Bond financing tends to be most suited for large projects / corporates, which may make it unsuitable for some forms of energy storage. Private debt financing is best suited for maximum-TRL technologies, where the generally low risk profile makes this attractive for institutional investors.

In the case of BTM storage projects, **leasing** seems to be a financial model typically used, especially for commercial and industrial customers. BTM energy storage systems are typically offered by developers as a 10-year operating lease, keeping them off the balance sheet of the commercial customer, thus ensuring that commercial customer has no direct capital or operating costs as the unit is owned and operated by the developer[37].

Figure 11: Global energy storage financing sources (estimate)



Source: Energy Storage Financing: Project and Portfolio Valuation, Sandia National Laboratories, January 2021

[35] Energy Storage Financing: Project and Portfolio Valuation, *Sandia National Laboratories,* January 2021.

[36] With bankability we refer to 3 dimensions:

1. Product (performance, characteristics, maturity, ...)
2. Company (financial strength to face warranties, solvency of the supply chain being used, ...)
3. Off-taker (quality of their organisation, credibility of their projects, track record as payers, ...)

[37] Energy Storage Financing: Performance Impacts on Project Financing, *Sandia National Laboratories,* September 2018.

EU and national public financing come in the form of grants, debt, tax incentives and de-risking instruments. In the beginning of the technology lifecycle public support in the form of grants, loans, and R&D subsidies are needed to lead to a positive cash flow for the company developing a new technology. The demonstration and first-of-kind phase is the most problematic as cash-flows typically turn hugely negative. In this phase, it is important to provide technologies with the financing required to avoid the so called “valley of death” and support the technological uptake up to the commercial deployment. As the energy storage market goes through a period of technological growth (e.g., batteries, hydrogen, and thermal storage), targeted public and EU support can have an important role in crowding in private financing: for low TRL technologies, the issue in accessing financing is mostly related to the nascent nature of the technology, which makes it difficult to build viable business cases. Working Group 3 members highlighted the importance of **EU support schemes** to guide technologies from the initial phase up to the commercialization stage, to reduce CAPEX requirements, mitigate the risks on their performance up to a level which is acceptable to risk-conscious investors. Different EU funding programmes are available to support innovative low-carbon technologies, including Innovation Fund, Horizon Europe, the LIFE Program, programmes provided by the EIB and EBRD.

This categorization serves to provide a high-level overview and is subject to numerous exceptions. Mature technologies can also benefit from public support in the form of governmental incentives, guarantees and subsidies, even though to a lesser extent in comparison to emerging technologies. Similarly, private equity and venture capital can also be provided for projects or companies with a high maturity development phase.

Focus: EU financial instruments which proved particularly effective for energy storage

The WG members' discussion brought to light some examples of EU instruments considered effective for financing storage solutions. The emphasis was placed on the difference between high and low TRL technologies and the ability of EU instruments to adequately respond to specific needs at different maturity levels.

For technologies with low TRL, a particularly effective tool identified is the European Innovation Council (EIC) Pathfinder and potentially EIC Transition.

- The EIC Pathfinder supports the exploration of bold ideas for radically new technologies (TRLs 1-3). It welcomes the high-risk / high gain and interdisciplinary cutting-edge science collaborations that underpin technological breakthroughs. Applicants participating in EIC Pathfinder projects are typically visionary scientists and entrepreneurial researchers from universities, research organisations, start-ups, high-tech SMEs or industrial stakeholders interested in technological research and innovation. Grants are up to 4 million euro and projects admitted to this scheme can also receive additional funding for testing the innovation potential of their research outputs.
- The EIC Transition funds innovation activities that go beyond the experimental proof of principle in laboratory (TRLs 5-6) to support both: the maturation and validation of novel technology in the lab and in relevant application environments, and the development of a business case and (business) model towards the innovation’s future commercialisation.
- EIC Transition projects address both technology and market/business development, possibly including iterative learning processes based on early customer or user feedback. Grants of up to €2.5 million are available to validate and demonstrate technology in application-relevant environment and develop market readiness.

Another interesting instrument is the EIC Accelerator which supports the development of technologies starting from TRL 6.

For technologies with high TRL, a particularly effective instrument has been identified in the new edition of CEF Transport, which under the most recent Call for Proposals 2021, has featured a €1.57bn co-financing under a new thematic envelope – the Alternative Fuels Infrastructure Facility (AFIF). While this facility does not directly fund energy storage projects, it represents a very effective EU support scheme to deploy innovative decarbonisation technologies, which could be replicated also in the energy storage sector. The grants offered by AFIF can be complemented by debt and advisory services provided by the InvestEU programme, providing an example of important synergies between different EU programmes. In addition, two-third of the AFIF budget is earmarked for projects supported by a financial contribution (no less than 10% of the overall project costs) of implementing partners, thus also generating synergies between EU funds and resources made available by the EIB and National Promotional Banks and Institutions. Participants argued that an important element of success of this instrument is its organizational setup: even before submitting the application for the grant, the implementing body can liaise with the Commission to address questions and potential project-to-project specificities ahead of the submission deadline. This helps to establish fit to investments targeted early on, thereby reducing bureaucracy, renders the application process less cumbersome, and ultimately increases the chances that a project will correctly meet the criteria and contribute to the AFIF objectives.

Chapter 3 of this study provides further detail on financing schemes and instruments for energy storage technologies.

2.4. Barriers to investment

While the role of energy storage is unquestionably crucial in the energy transition, a wide range of uncertainties persist concerning the amount of storage needed, the technologies and solutions that will drive it, and the revenue streams that will ensure a return on investment for different storage applications / use cases within energy markets.

In order to enable storage technologies to effectively deliver their services in a competitive market-based approach, different barriers need to be addressed. The cost and technical performance of some storage technologies have improved already - opening up opportunities for viable business cases necessary to stimulate investments. However, in the shorter term, various policy and economic barriers still hamper the development of energy storage in the EU and lead to uncertainty concerning the revenue streams needed to cover the project costs and risks.[38]

This chapter provides an overview of barriers affecting energy storage technologies. For the purpose of this study, the barriers have been identified following a two-step process:

1. **Literature review** to identify a long list of barriers to energy storage investments from different reliable sources (e.g., The European Association for Storage of Energy - EASE, European Commission, the International Energy Agency - IEA, etc.).

   The identified barriers were grouped into three categories, namely:

   - **Political and regulatory,** associated with risks and barriers concerning compliance with the regulatory and policy frameworks, the permitting framework, as well as social acceptance of storage projects on behalf of the general population.

[38] Andrey, C., Barberi, P., Nuffel, L., et al., Study on energy storage: contribution to the security of the electricity supply in Europe, *European Commission, DG ENER*, Publications Office, 2020

- **Economic,** associated with risks and barriers deriving from economic factors like market dynamics and organization, access to capital, upfront costs, off-taker risks, incentive schemes.
- **Technical**, associated with risks arising from technical features of projects like technology and the supply of technical components.

Following this classification, the **Technology Readiness Level** framework was proposed as an instrument to rate the acuteness of barriers in function of the maturity of storage technologies (see section 2.3 for further detail).

2. **Deliberations of the Working Group (WG)** to identify the barriers considered most acute. Working Group participants were asked, firstly during the WG meeting and subsequently via a follow-up survey, the following questions:
   - Select 5 barriers out of those identified in step 1 which you consider most relevant for each of the three technology types
   - Provide examples of the barriers you found most pertinent, for specific technology types and / or specific Member States.

Table 2 provides a view of the barriers identified as most acute, or most relevant, for each technology type. In the sections that follow, we provide more detailed information about participant's views of the barriers, as well as several examples of the effect of barriers on energy storage.

Table 2: List of barriers to investments in energy storage

Risk Group	Barrier	Technology type		
		Pre-commercial development	Demonstration / First of a kind	Commercial scale deployment
Political and regulatory	Double taxation and grid access fees	0%	13%	40%
	Restricted or limited access to energy markets (e.g., ancillary services, capacity markets etc.)	7%	40%	53%
	Lack of revenue generating mechanisms / revenue streams	47%	40%	67%
	Administrative requirements (permitting)	20%	20%	53%
Economic	Market risk	20%	27%	40%
	Availability of finance & access to capital	40%	60%	47%
	Lack of long-term contracts	7%	7%	53%

Risk Group	Barrier	Technology type		
		Pre-commercial development	Demonstration / First of a kind	Commercial scale deployment
Technical	High upfront costs	53%	40%	20%
	Technology risk	53%	27%	7%
	Supply chain risk	13%	20%	40%

Source: The Consortium's own elaboration based on the results of the online survey circulated amongst WG members

Political and regulatory

Double taxation and grid fees[39]: Missing or outdated definitions of energy storage have resulted in classifying it as either or both a consumer and a generator of electricity: as energy storage can both charge and discharge, it can fall both under the generation and demand sides of the value chain. This causes double taxation or unnecessary grid fees on feeding or withdrawing energy. WG3 survey results suggest that the issue of double taxation and grid fees is perceived as an important barrier to investments, with 40% of respondents converging on the opinion that it affects especially commercial-scale and mature technologies while not being relevant for emerging ones[40].

Restricted or limited access to energy markets: Outdated policy design originally set for traditional power sources and specific market parameters, such as minimum bid sizes, price caps or excessive pre-qualification requirements, can limit the access to flexibility and balancing markets (such as ancillary markets) for energy storage technologies**.** Most of the stakeholders of the WG3, including project developers, investors, association, and regulatory bodies, agreed on considering restricted access to energy markets as a particularly acute barrier for both commercial scale and first-of-a-kind technologies, with respectively 53% and 40% of votes. The level of access to wholesale markets differs significantly from country to country within the European Union but WG members generally noted that in most Member States electricity markets are designed in a way that does not allow for the emergence of viable business models for energy storage. Some Member States have allowed access to the wholesale market but not yet to capacity mechanisms (please refer to the box below for a concrete example in Greece), whereas other non-EU countries such as the UK have allowed energy storage to compete directly in technology-neutral capacity market auctions[41] helping providing predictability of revenues for longer period of time. In some countries, participation in the capacity market is possible in theory[42], but effective participation is limited by large size

[39] Although this barrier is being addressed by the revision of the Energy Taxation Directive (ETD) ongoing since 2021, the transposition at Member State level may still pose challenges in terms of timeline and accuracy. Moreover, it is important to note that the revision of the ETD is not completed yet and the Directive has not been adopted. This means that the final version of the ETD – if approved at unanimity from the Council – might not address this specific barrier. To avoid double taxation and grid fees the Clean Energy Package introduced a definition of "energy storage" as "*deferring the final use of electricity to a moment later than when it was generated, or the conversion of electrical energy into a form of energy which can be stored, the storing of such energy, and the subsequent reconversion of such energy into electrical energy or use as another energy carrier*".

[40] Commission Recommendation 2023/C103/01 of 14 March 2023 encourages Member States to act on the double taxation issue by "taking into account the double role (generator-consumer) of energy storage when defining the applicable regulatory framework and procedures". This includes preventing double taxation and facilitating permit-granting procedures.

[41] Energy storage - Proposed policy principles and definition, *EU Commission,* 2016

[42] The proposal for the reform of the electricity market released by the Commission in mid-March requires participation in the capacity market to be extended to technologies such as storage and demand response (text of the proposal available at this link).

requirements which tend to be prohibitive for storage developers if aggregation of multiple resources is not allowed[43], as well as rules uncertainty about storage participation. As outlined by a study of the European Commission[44], although energy storage can provide a lot of value to energy markets, its effective participation is highly influenced by the technical characteristics of each different storage technology (e.g., energy, capacity, and self-discharge rates). One possible solution identified by WG3 members is making energy market mechanisms (e.g., auctions) technology neutral, allowing storage technologies to compete in a level playing field in order to avoid discrimination because of market structure and requirements.

Proposed capacity remuneration mechanisms in Greece[45]

Greece is currently undergoing major energy sector reforms, aiming to transform the operation of the energy system, foster competitive energy markets, create significant investment opportunities, reduce greenhouse gas emissions, and ultimately facilitate a green energy transition.

The National Energy and Climate Plan foresees the development of pumped-hydro projects and the deployment of battery storage of electricity of different sizes. Developers have already expressed their interest in these projects, especially in battery systems, however the level of investments in new storage facilities is currently uncertain as it still heavily depends on investment support by the State.

One possible solution identified by the Greek government to scale up private investments is to provide revenue assurance to all flexibility providing resources through a capacity remuneration mechanism: the market reform plan intends to fully integrate demand-response and storage in **all the stages of the wholesale markets, including in the balancing market**. In this way, demand-response and storage will be fully eligible in the CRM (Capacity Remuneration Mechanism) being proposed, thus helping ensure long-term visibility on future revenues.

Lack of revenue generating mechanisms to support energy storage business cases: Storage technologies can offer a wide range of services generating value for the overall energy system. For the time being, most existing energy storage business models rely on single or few main use cases (e.g., frequency regulation or renewable capacity firming) with few additional revenue streams. Using a technology for a single revenue stream also means the technology may be underutilized and that payback times end up being longer than necessary. More importantly, the lack of appropriate market mechanisms often means that storage provides a value somewhere in the system (e.g., by shifting and reducing peak load), but there is no formal means of valuing and monetizing that service for the storage owner. Lack of remuneration mechanisms leads to uncertainty on revenue which is the most important barrier to further deployment of energy storage, identified during the first WG3 discussion from both the demand and supply side of financing. Most of the WG3 stakeholders converged on identifying this barrier as particularly relevant for the deployment of mature technologies (67% of votes), but with a major impact also on first-of-a-kind (40% of votes) and pre-commercial (47% of votes) technologies. In this regard, during the second meeting of the WG3, most members placed emphasis on the importance of remunerating energy storage services which are still not considered as such. For instance, some WG members pointed out that ancillary services - provided by high TRL technologies – are usually underrated or taken for granted in the energy system because they used to be provided by the TSOs as part of their regulated function. Storage can also be used to defer investments on transmission and distribution grid

[43] Different technologies can provide flexibility; however, only very large customers are able to sell their services participating in the flexibility market today. Smaller residential and commercial customers may face high barriers in accessing these markets. Aggregation offers the opportunity for smaller residential and commercial customers to exploit their flexibility potential.

[44] Andrey, C., Barberi, P., Nuffel, L., et al., Study on energy storage: contribution to the security of the electricity supply in Europe, *European Commission, DG ENER*, Publications Office, 2020

[45] Market reform plan for Greece, *European Commission,* July 2021

renovation and upgrade to avoid congestions; however, there is no formal mechanism for the storage owner and/or operator to earn returns on this service. Finally, another example regards natural gas storage, which contribute to the security of supply (by ensuring seasonal storage and coverage of winter demand) and decarbonization (by allowing unlocking full biomethane production potential); these services should be properly remunerated, especially to avoid de-investing in strategic assets. In general, the revenue mechanisms that exist (e.g., arbitrage or peak demand management) tend to undervalue the service provided to the system as a whole. This often leads to a situation in which the costs of storage are privatised while the benefits are socialised. When relying on market mechanisms without direct support or revenue certainty, it can be difficult for developers and investors to establish robust business cases and thus consider a project financeable. In order to support a major step-up in investments in storage, new long-term competitive remuneration mechanisms specific for storage are needed to reduce merchant risk and lower cost of capital[46].

Lack of revenue generating mechanisms / revenue streams for front-of-the-meter storage projects

The technological features of battery storage systems make them uniquely positioned to provide a range of services, including, for example, ancillary services (due to their rapid response times) as well as energy time shifting and peak shaving (due to their capacity to store electricity for longer periods, up to several hours). The ability to earn revenues on each service that the battery system provides, a practice frequently referred to as revenue stacking, enhances the revenue stream and improves the investment attractiveness of battery systems. On the other hand, from the investor point of view, WG participants noted that revenue stacking can be challenging for business models concerning short-term storage with different revenue streams. In some markets for example different business models would need to be stacked to reduce risks but not in all markets is it possible to stack revenues.

In many countries, however, battery systems are not allowed to stack revenues from different services, as participation in one market segment may preclude participation in another. Additionally, in countries with less liquid day-ahead and intraday energy markets, storage may face barriers in accessing even a single revenue stream, due to limitations on market entry (e.g., excessive pre-qualification requirements in ancillary services markets) or limitations on participation (e.g., excessively high minimum bid size on intraday markets). By extension, the barrier on revenue stream translates into an absence of sufficiently robust business cases, and therefore difficulty in accessing finance.

Lack of revenue generating mechanisms for Long Duration Energy Storage (LDES)

A key element that emerged from the presentation of LDES during the 2nd WG meeting is that only inexpensive technologies are suitable for long duration energy storage, given that the low charge and discharge rates imply a low return on investments. The WG members pointed out that, although LDES can in theory provide time-arbitrage services, the potential returns on such arbitrage are diminished by the low round-trip efficiency and relatively small seasonal

[46] In the Staff-working document for the Commission Recommendation 2023/C103/01 of 14 March 2023, emphasis is put on the issue that not all services are properly valued and monetized yet, and this limits the stacking of revenue streams and prolongs the payback times of an investment. The document highlights the importance of this matter for storage projects, stating that currently, revenues for energy storage in the EU mostly come from participation in arbitrage trading and balancing. The obstacles to revenue stacking either derive from insufficiently developed regulatory frameworks, or from physical constraints of the distribution networks which prevent the proliferation of flexibility services at the distribution level. Because of this, the Recommendation encourages Member States Member States, to assess the flexibility needs of their energy systems when planning transmission and distribution networks, including the potential of energy storage (short- and long-term duration) and whether energy storage can be a more cost-effective alternative to grid investments. They should also consider the full potential of flexibility sources, in particular energy storage, when assessing their connection capacity (e.g. considering flexible connection contracts) and operating the system.

price differentials. All of the above implies a difficulty in structuring robust business case for LDES, and thus a difficulty in obtaining funding.

Participants also discussed the relevance of developing longer term financing models and having more visibility on future prices. Capacity payments were signalled as a good instrument to remunerate the security of supply service which is provided by long-term energy storage. Participants noted that a possible remuneration mechanism for LDES could come from long-term contracts via tolling mechanisms, where storage is made available to the TSO for charging and discharging in line with system needs and within specified operating parameters. The storage provider receives a capacity payment, which is adjusted for the storage system's availability and round-trip efficiency, and a variable O&M payment for energy dispatched from the system.

Examples of public support schemes for early applications of LDES include:

- UK, where the government launched a $100 million LDES demonstration competition in early 2021 to accelerate project commercialization[47].
- United States: Earthshot program set a target to reduce the cost of grid-scale energy storage by 90% for systems that deliver 10+ hours of duration within a decade. In support of this target, the program will provide funding opportunities worth $1 billion program[48].

Administrative requirements (permitting). Permitting is considered as a major barrier to investment in energy storage projects, with 53% of WG3 participants converging on the opinion that it affects especially commercial scale technologies. The WG3 discussions and survey results suggest that permitting procedures are perceived having significant relevance for industry associations and investors. In particular, from the point of view of investors, lengthy permitting processes are a critical aspect in developing storage projects as they entail high transaction costs and uncertainties concerning timelines and even whether the project will be realized. This is particularly true for large storage facilities such as pumped hydro, for which both building and environmental permits are required considering their high environmental impact. In addition, most of the Member States do not have specific permitting rules applicable to storage[49]. In this regard, the Net Zero Industrial Act (NZIA) aims to lower the administrative burden for developing net-zero manufacturing projects including by streamlining administrative requirements and facilitating permitting, setting up regulatory sandboxes and ensuring access to information. Several stakeholders from both the demand and supply side of financing converge on manifesting concern about the long permitting procedures and the time window for accessing EU funds, pointing out that administrative delays can have a negative influence on investments.

Economic Barriers

Market risk refers to the extent to which a project may be negatively impacted by significant changes in the market environment, such as **energy price fluctuations** on the input and/or the output side. This risk has been subject of major debate during the WG3 discussions, and 40% of survey respondents indicated it as an important barrier for commercial scale storage technologies while affecting only to a certain extent pre-commercial and first-of-a-kind technologies.

The key source of this risk is driven by the fact that revenue streams available for mature storage projects tend to be fully merchant-based and are highly dependent on market prices

[47] Source at this link

[48] Full detail on the form of funding is forthcoming. Source at this link

[49] Andrey, C., Barberi, P., Nuffel, L., et al., Study on energy storage: contribution to the security of the electricity supply in Europe, *European Commission, DG ENER*, Publications Office, 2020

(Day Ahead Market, ancillary services, etc.), with only few countries having a capacity market in place that provides stable long-term payments. Both investors and developers of the WG3 converged on the opinion that the difficulty of predicting prices in flexibility markets and the lack of long-term contracts have the effect of restricting access to capital, as investors tend to be reluctant on taking on market risk of fully merchant projects. One proposed solution emerging from the survey would be to introduce an EU guarantee in the form of first-loss guarantee (to cover International Financial Institutions, National Promotional Institutions as well as commercial banks), and a Capacity Remuneration Mechanism (CRM) or competitive remuneration mechanisms specific for storage to help ensure more predictability on revenue streams over the longer term.

Availability of finance and access to capital is considered by survey respondents as highly relevant for first-of-a-kind technologies as expressed by 60% of votes of WG3 members, although a moderate degree of concern regarding access to finance was expressed for all kind of technologies. This result confirms the “valley of the death” problem: once technologies reach the demonstration phase, it is important to ensure continuity up to market deployment. During the fourth meeting of the WG3, members highlighted how guarantees are particularly suited financial instruments to provide business continuity to first-of-a kind energy storage projects helping to build market confidence of their business model. If continuity is not ensured, promising European companies might have to move abroad or might get bought by non-EU entities. There must be support, in different forms, throughout the entire technology lifecycle. Low TRL technologies tend to have more difficulty in securing finance due to implicit risks such as technical performance. On the contrary, for high TRL technologies availability of finance is seen as less of an issue as long as favourable regulatory conditions allow for the creation of profit-driven business models.

Grant support has also been considered as crucial for financing energy storage projects, as it can make projects more bankable and reduce capital expenditures. However, WG members identified two major concerns regarding the effectiveness of grants, namely:

- The need to improve grant coverage since some grants only cover a small portion of the overall project cost, which may not be sufficient to make it bankable despite receiving the grant. In this regard, it is important to find the balance between subsidies and “real” bankability.
- The requirement for grants to be dynamic and linked to variations in project costs. The WG observed that grant contributions are always fixed in value, while project costs (e.g., raw materials and energy - OPEX) are not, resulting in scenarios where a project that was economically viable when the grant application was submitted becomes unviable after receiving the funding due to cost fluctuations. This is especially relevant in high inflation contexts.

High upfront costs related to the need to complete feasibility studies, permit, license, design, build, and operate new storage facilities are considered one of the most significant barriers to the development of new storage projects with low TRLs. Project promoters could afford these costs, but uncertainty about the monetary value and future cost recovery of new storage facilities elevate the degree of risk. This is particularly true for energy storage technologies with lower TRLs, as pointed out by WG3 members when asked to comment on barriers hampering the bankability of energy storage projects. 53% of respondents identified this barrier as having an important impact on the development and deployment of pre-commercial and first-of-a-kind technologies. Some investors in the WG3 argued that while usually large companies are able to finance these costs with corporate debt, in energy storage this is less feasible due to the fragmentation of the sector and the fact that many project sponsors are smaller and have limited internal financing capabilities.

Lack of clear capacity targets and high costs may hinder clean hydrogen storage deployment

Green and low-carbon hydrogen currently faces higher LCOE (levelized cost of energy) compared to existing alternatives such as grey hydrogen. High production, transportation, storage, and application costs, as well as lack of monetisation mechanisms to reward avoided emissions are among the main reasons behind this economic disadvantage. For example, there is no hydrogen transport and storage infrastructure today to enable a large-scale deployment of renewable and low carbon hydrogen across the energy system.

As suggested by a study jointly conducted by the European Commission and the European Investment Bank, the economic viability gap which reduces returns on investment is present across practically all areas of the clean and low-carbon hydrogen value chain, thus making it difficult to build strong business cases which can boost investments. The underlying drivers of the economic viability gap include:

1. **Upfront costs:** the cost of clean electricity and the cost of electrolyser equipment make the production of clean hydrogen particularly costly compared to other technologies.
2. **High costs for transporting and storing hydrogen** through pipelines, liquefaction, or hydrogen carriers add substantially to the final cost of hydrogen**.**
3. **Lack of scale and maturity of applications also keeps costs high.** For example, the use of hydrogen in steelmaking is found to add significant costs to the process.

Although measures to overcome these barriers are being taken (e.g., locating hydrogen projects close to low-cost sources of renewable energy and in proximity to customers in order to reduce transport costs), these appear to be still insufficient to speed up the roll out of this technology[50].

Lack of long-term contracts is considered by WG3 members as a particularly acute barrier for commercial scale technologies, while not having a significant impact on pre-commercial and first- of-a-kind technologies. This barrier is driven by the fact that most business cases for storage rely on short-term revenue streams (e.g., provision of ancillary services on balancing markets), which in turn elevates the risk profile of an investment and reduces access to finance. As long-term revenue certainty is important to unlock investments in storage, capacity markets (like in the UK and Italy) and forward contracts (such as PPAs) can serve as important instruments for storage operators to complement revenue streams and ensure more certain returns on investment. In recent times some countries have also started conceiving long-term support mechanism specifically designed for storage[51] to help achieve their decarbonization targets[52]. Some WG members stressed the importance of having stacked revenues to

[50] Unlocking the hydrogen economy — stimulating investment across the hydrogen value chain. Investor perspectives on risks, challenges, and the role of the public sector. European Investment Bank, 2022

[51] While also capacity markets offer long-term revenue visibility to storage projects, they might have some shortcomings when trying to attract considerable investments in this specific technology:

- are not specifically targeted for storage (the same service might be provided by other technologies, such as gas turbines)
- the product procured (adequacy) and related contract obligations do not usually cover storage most distinctive service: energy time shifting and renewables integration
- adequacy demand distribution may differ significantly from storage demand in the system (e.g., Italy capacity auctions highlighted a need for new peaking capacity mostly in the northern bidding zones and Sardinia while almost no new capacity was needed for adequacy in the southern part, where instead new storage is most needed due to heavy renewables build-up and scarcity of existing pumped hydro plants)

[52] For instance, the Italian NRA has released in August 2022 a consultation document on a new long-term procurement scheme for electricity storage mainly aimed at energy time-shifting. Greece has also announced plans for a 700 MW storage tender.

increase the bankability of a storage project. Nevertheless, it was pointed out that revenue stacking is effective only if there is long-term visibility and predictability on the revenues themselves. In other words, revenues need to be clearly forecasted in order to attract long-term financing. Long-term contracts, therefore, are essential to stimulate investments in storage[53]. During the meetings, WG members stressed the importance of new and additional support schemes such as guarantees which usually play a crucial role in mitigating counterparty risk in these types of contracts.

Technical barriers

Technology risk is associated with uncertain future performance of technologies and the extent to which a project may face technology-related operating challenges. This barrier is considered as the most relevant risk for emerging technologies as voted by 53% of WG3 participants, which is to be expected considering the inherent performance uncertainties of emerging and yet unproven technologies. An example of this is the considerable technical developments that are still needed for hydrogen in depleted oil and gas field and ice storage to reach a scalable potential[54]. Additionally, electrochemical batteries present a unique set of risks related to safety concerns, the lifetime and life cycle of the resource, and efficiency[55].

Supply chain risks[56] were discussed extensively by WG3 members, mainly for Li-ion batteries, which significantly rely on imported raw materials and/or non-EU manufacturing with consequent geopolitical risks[57]. Energy storage technologies require a large amount of metals and minerals, including critical minerals[58]. Following the Covid-19 pandemic and Russia's invasion of Ukraine, raw material supply chains have suffered further disruptions, and prices of some raw materials - such as nickel and aluminium[59] - have soared.

Broadly speaking, **supply chain disruptions** have been identified as an important risk for commercial scale technologies, as expressed by 40% of survey's respondents, and to a lesser extent to first-of-a-kind technologies, which received 20% of votes. Not all types of stakeholders have expressed the same level of concern: project developers are the most concerned about their exposure to potential supply chain disruptions. Considering how some storage technologies are highly dependent on raw materials (e.g., battery technologies), a close management of supply chains including via concentrated buildout of domestic EU raw materials capacities will be key to mitigating supply chain risks.

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[53] A Staff Working document from the European Commission (Recommendation 2023/C103/01) suggests several supporting tools and enabling signals that can help increase predictability of revenues for storage projects and lower their risk profile: (i) decarbonized capacity contracts; (ii) floor and ceiling pricing; (iii) 24/7 clean power purchase agreements; (iv) contracts for difference; (v) hourly energy attribute certificates; or (vi) energy savings contracts.

[54] Charge! – Deploying secure & flexible energy storage, *Eurelectric,* October 2020

[55] During the WG3 discussion a stakeholder pointed out that, as of today, there are few or no technologies with a good round-trip efficiency for long duration storage.

[56] The NZIA aims at reducing Europe's high dependency on imports and single suppliers of net-zero technologies and instead increase the resilience of Europe's clean energy supply chains to avoid disruption in global energy market supply chains. The NZIA proposes to do this for example by developing EU cross-border supply chains based on regular exchanges with relevant industrial alliances and increased investments into the European net-zero technology manufacturing (especially of critical components for batteries, wind and solar energy, electrolysers, fuel cells and heat pumps).

[57] It is worth noting that the industry is moving to address these issues by adopting LFP (Lithium, Iron, Phosphate) chemistry for batteries, which doesn't require neither cobalt, nickel, nor manganese.

[58] What to know about critical minerals – the key to our energy future, *World Economic Forum,* September 2020

[59] Critical minerals threaten a decades-long trend of cost declines for clean energy technologies, *IEA,* May 2022.

Figure 12: Minerals required for clean energy technologies

	Solar technology	Wind technology	Electric vehicles, energy storage
Bauxite and aluminium	x	x	x
Cadmium	x		
Chromium		x	
Cobalt		x	x
Copper	x	x	x
Gallium	x		
Germanium	x		
Graphite			x
Indium	x		
Iron	x	x	x
Lead	x	x	x
Lithium			x
Manganese		x	x
Molybdenum		x	
Nickel	x		x
Rare earths		x	x
Selenium	x		
Silicon	x		x
Silver	x		
Tellurium	x		
Tin	x		
Titanium			x
Zinc	x	x	

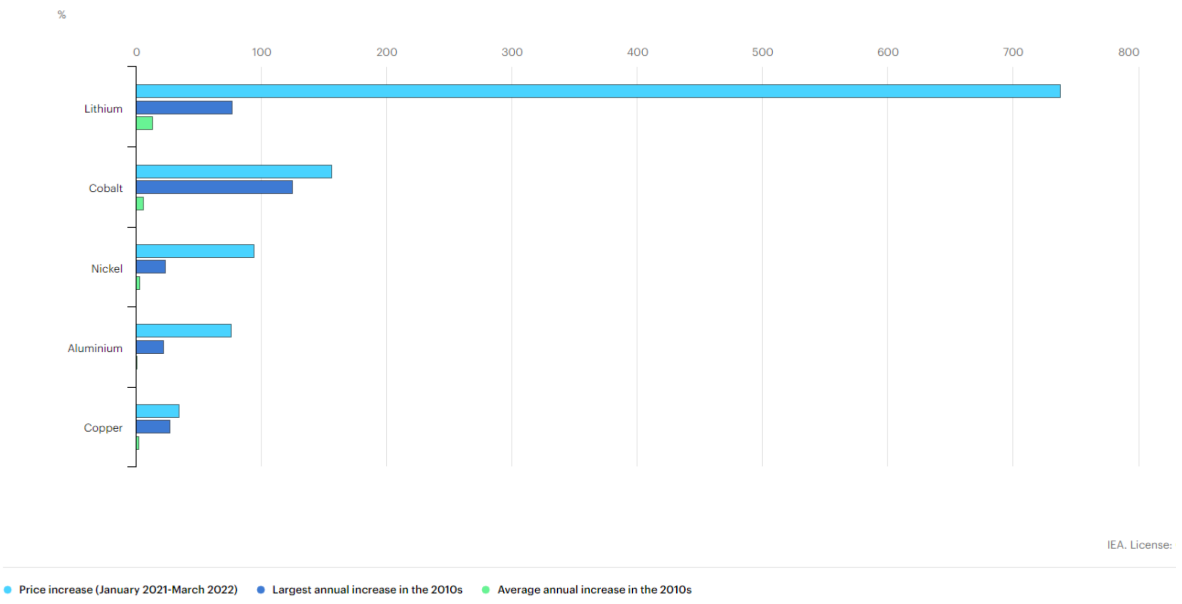
Source: IISD, November 2018

Price increase in minerals and metals needed for clean energy technologies

Price of minerals and metals required for clean energy technologies increased in the last years on the back of rising demand, the geopolitical situation and supply chain bottlenecks. The International Energy Agency (IEA) indicated that prices of lithium and cobalt more than doubled in 2021, and those for copper, nickel and aluminium all rose by around 25% to 40%[60]. For most minerals and metals that are vital to the clean energy transition, the price increases since 2021 exceed by a wide margin the largest annual increases seen in the 2010s, slowing down the process of costs reduction of clean energy technologies led by innovation and economies of scale. A surge in raw materials prices has the potential to impact financing needs to step up the deployment of these technologies crucial for the energy transition.

[60] Critical minerals threaten a decades-long trend of cost declines for clean energy technologies, *IEA,* May 2022.

Figure 13: Scale of price increase for selected energy transition minerals and metals



Since raw materials now account for a significant share of total costs, growing concerns surround lithium-ion batteries: cathode materials (lithium, nickel, cobalt, and manganese), which are essential for Li-ion batteries manufacturing, now account for 20% of lithium-ion batteries pack costs, compared to an estimated 5% in 2020. This recent surge in cathode materials prices needs to be offset by measures to contain or reduce overall costs to sustain investment in this technology.

3. Mapping and benchmarking of storage financing schemes and investment products

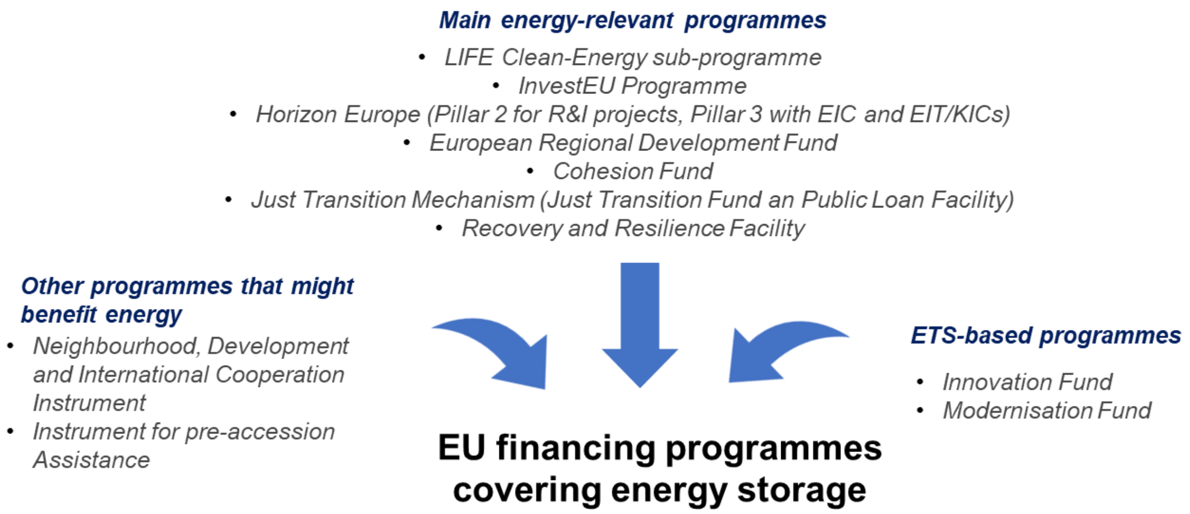
This chapter presents the financial schemes and programmes available for energy storage projects in the EU. The first part focuses on funding programmes at EU level, both under central and shared management that can be used to support energy storage projects. The second part presents the instruments and schemes identified at Member State level that are available for energy storage based on the findings from a mapping carried out across all EU Member States in 2022.

3.1. EU financing programmes for Energy storage

The purpose of this section is to provide an overview of the financing instruments at EU level that target the energy storage sector.

To support the region's green transition, the EU has made it a priority to support the enhancement of development, construction, and operationalisation of transmission and distribution projects through several funds and programmes. Such programmes are either managed directly by the European Commission or by other EU bodies via *ad hoc* agreements. Starting from the 2014-2020 multiannual financial framework, the Commission has also adopted the **Climate Mainstreaming** approach, which requires all programmes – regardless of their policy area – to take climate issues into account. For the 2021-2027 period, the EU budget is expected to deploy €557 billion (31% of the overall budget) for climate investments across different sectors and programmes.

Figure 14: EU financing programmes relevant for energy storage



All the programmes funded by the EU budget fall under one of three types of implementation modes depending on the nature of the funding concerned:

1. **Direct management**: EU funding is managed directly by the European Commission
2. **Indirect management**: funding is managed by partner organisations or other authorities inside or outside the EU
3. **Shared management**: the European Commission and national authorities jointly manage the funding.

In addition to these three management modes, this Study analyses programmes that are not financed from the EU budget but through the **EU Emission Trading System** (ETS)[61].

Direct management

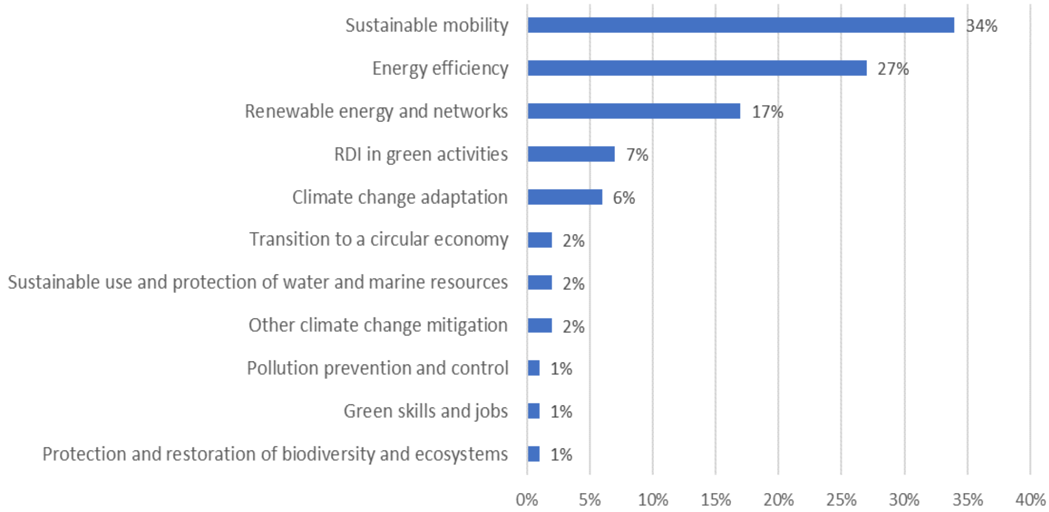
In direct management, the European Commission is directly responsible for all steps in a programme's implementation. These tasks are carried out by the Commission's departments, at its headquarters, in the EU delegations or through EU executive agencies; there are no third parties. Programmes implemented in direct management account for around 20% of the EU budget 2021-2027[62].

NextGenerationEU: Recovery and Resilience Facility:

The **NextGenerationEU**, is a temporary recovery instrument with a budget of more than €800 billion aiming to support Member States in repairing the economic and social damage brought on by the Covid-19 Pandemic and build greater resilience to face incoming challenges. At its centre is the **Recovery and Resilience Facility (RRF)**, a programme providing financing to enable Member States to increase resilience and prepare for their digital and green transitions. It has a total budget of €723.8 billion, out of which €385.8 billion take the form of loans and €338 billion of grants. To access these funds, Member States prepared tailored **National Recovery and Resilience Plans** (NRRPs) reflecting the allocation of the funds in each country and detailing the investment and reforms they plan on undertaking with the RRF resources to make their economies more sustainable, resilient, and digital by end of 2026. All 27 Plans have been officially adopted.

The Facility is structured around **six pillars: green transition; digital transformation; social and territorial cohesion; health, economic, social and institutional resilience;** and **policies for the next generation**. Green transition is the pillar with the largest share of allocated RRF funds, amounting to 38.85% of the funds. Within the green transition pillar, sustainable mobility is the area with the largest share of allocated funds by the NRRPs, followed by energy efficiency, and renewable energy and networks (see Figure 15).

Figure 15: Breakdown of expenditure towards climate objectives per policy area (Pillar 1)



Source: RRF Scoreboard – Green Transition

[61] European Commission. EU Emission Trading System. https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets_en

[62] European Commission. Funding by management type. https://commission.europa.eu/funding-tenders/find-funding/funding-management-mode_en

When it comes specifically to energy storage, there is **only one investment currently planned under the RRF** that explicitly mentions energy storage, namely Italy's "Renewables and batteries" investment, with a total investment of €1 billion. More specifically, €500 million are earmarked for sub-investment in the battery/electrochemical storage sector, €400 million for sub-investment in PV technologies and the remaining €100 million for the wind energy industry. Cyprus on the other hand has a reform of the energy storage regulatory framework planned under its NRRP, but no dedicated investments. **Most of the investments in energy storage that will be financed with the RRF will likely be included in broader schemes that also cover energy storage but are not focused on it**. This is the case, for instance, for Greece's buildings renovation programme ("*EXOIKONOMΩ*")[63], which provides grants to households to undertake energy efficiency renovations, including the installation of energy efficient heating and cooling systems and of energy storage solutions.

The InvestEU Programme

The **InvestEU Programme** combines thirteen centrally managed EU financial instruments[64] and the European Fund for Strategic Investments (EFSI) into a single instrument. The program is structured around three blocks, of which two are under direct management of the European Commission:

- *InvestEU Fund* (indirect management) which, through an EU budget guarantee of €26.2 billion, aims at raising more than €372 billion of public and private investments. The guarantee is deployed to back investments from selected implementing partners, with the EIB Group being the main one with 75% of the whole instrument. The guarantee supports investments in four policy windows: sustainable infrastructure, research, innovation, and digitalisation, SMEs, and Social investments and skills.
- *InvestEU Advisory Hub* (direct management) providing support and technical assistance;
- *InvestEU Portal* (direct management) brings together investors and project promoters on a single EU-wide platform, by providing an accessible and user-friendly database of investment opportunities

Connecting Europe Facility

The **Connecting Europe Facility** (CEF) is one of the main EU funding instruments for infrastructure with grants to develop trans-European networks in the fields of transport, energy and digitalisation. In 2018, the CEF was renewed for 2021-2027 with a budget of €42.3 billion, 60% of it is meant to contribute to climate objectives. Additionally, for the current budgetary period, a new category of eligible projects under CEF Energy has been added, namely Cross-border renewable energy projects. Such category is not focused on infrastructure per se, but rather it is focused on cross-border projects in RES contributing to decarbonisation. The first CEF Energy PCI call for proposal was launched in September 2021, making €785 million available to finance clean energy infrastructure projects. On November 2021, the Commission adopted the 5th PCI list in the form of a delegated act, in force as of 28 April 2022. The list consists of 98 projects, of which 67 in the field of electricity transmission and storage.

[63] https://exoikonomo2021.gov.gr/

[64] *CEF Debt Instrument, CEF Equity Instrument, Loan Guarantee Facility under COSME, Equity facility for Growth under COSME, Innovfin Equity, Innovfin SME guarantee, Innovfin Loan Services for R&I Facility, Private Finance for Energy Efficiency Instrument, Natural Capital Financing Facility, EaSI Capacity Building Investments, EaSI Microfinance and Social Enterprise Guarantees, Student Loan Guarantee Facility, Cultural and creative sectors Guarantee facility*

Horizon Europe

Horizon Europe has an overall budget of €95.5 billion for the 2021-2027 period and aims to support research and innovation in the EU. Its resources are divided into three pillars and fifteen components. Energy storage projects can fall under different components, mostly in the “Sustainable, secure and competitive energy supply” destination under Cluster 5 “Climate, Energy and Mobility”[65].

Part of Horizon Europe pillar III – Innovative Europe, **European Innovation Council (EIC**) can finance storage-related projects. For spin-offs, start-ups, or SMEs with a disruptive technological proposal, the instruments created by the EIC are particularly recommendable. These are the EIC Pathfinder, the EIC Transition, and the EIC Accelerator. The most attractive – but also the most competitive – is the latter, with a total budget of €1.16 billion in 2023. In 2023, the EIC Accelerator has a dedicated investment window for energy storage. Approximately €100 million shall be invested in ground-breaking storage innovations. Already in 2022, the EIC Accelerator has selected 2-3 storage-related innovations for investment. While batteries were quite prominent (battery management systems, materials, recycling, etc), also long-term energy storage innovations were selected.

The **European Institute of Innovation & Technology** is also an integral part of Horizon Europe. It contributes to Pillar III with a budget of €3 billion. At the same time, through its nine Knowledge and Innovation Communities, it contributes to find meaningful solutions to societal challenges in areas with high innovation potential. EIT InnoEnergy is the Innovation Community dedicated to *achieving a sustainable energy future for Europe* and – among its thematic fields – there is one dedicated entirely to energy storage.

LIFE Programme

The **LIFE Programme** was originally created in 1992 to fund environmental projects and climate action. For the 2021-2027 programming period it has been allocated a total budget of €5.45 billion, whereby €1 billion is dedicated to the *Clean Energy Transition* sub-programme. Funds are allocated through yearly calls for proposals managed by CINEA. Under the LIFE Clean Energy Transition sub-programme, projects are financed in the following five areas of intervention[66]:

- Building a national, regional and local policy framework supporting the clean energy transition;
- Accelerating technology roll-out, digitalisation, new services and business models and enhancement of the related professional skills on the market;
- Attracting private finance for sustainable energy;
- Supporting the development of local and regional investment projects;
- Involving and empowering citizens in the clean energy transition.

While the LIFE Programme does not have a specific focus on energy storage, it can provide funding for projects that include energy storage as a component and contribute to the Programme's objectives in the areas of climate action and environmental sustainability under the LIFE Clean Energy Transition sub-programme.

[65] European Commission. Horizon Europe Work Programme 2023-2024. 8. Climate, energy and mobility. https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2023-2024/wp-8-climate-energy-and-mobility_horizon-2023-2024_en.pdf

[66] https://cinea.ec.europa.eu/programmes/life/clean-energy-transition_en

Indirect management

Some funding programmes are partly or fully implemented with the support of entities, e.g., national authorities or international organisations. The majority of the EU budget allocated to humanitarian aid and international development, for instance, is implemented under indirect management. Under this management mode, the Commission delegates budget execution tasks to different types of implementing partners.

The InvestEU Programme

The **InvestEU Programme** combines thirteen centrally managed EU financial instruments[67] and the European Fund for Strategic Investments (EFSI) into a single instrument. The program is structured around three blocks, of which, as mentioned above, only one is under indirect management:

1. *InvestEU Fund* (indirect management) which, through an EU budget guarantee of €26.2 billion, aims at raising more than €372 billion of public and private investments. The guarantee is deployed to back investments from selected implementing partners, with the EIB Group being the main one with 75% of the whole instrument. The guarantee supports investments in four policy windows: sustainable infrastructure, research, innovation, and digitalisation, SMEs, and Social investments and skills.
2. *InvestEU Advisory Hub* (direct management) providing support and technical assistance;
3. *InvestEU Portal* (direct management) brings together investors and project promoters on a single EU-wide platform, by providing an accessible and user-friendly database of investment opportunities.

Shared programmes

In shared management, both the European Commission and national authorities in Member States, such as ministries and public institutions, are in charge of running a particular programme. Around 70% of EU programmes are run this way. For what concerns the energy production sector, the European Regional Development Fund is the main relevant shared-management programme.

European Regional Development Fund

The **European Regional Development Fund (ERDF)** aims to strengthen economic, social, and territorial cohesion in the EU and to enable investments in greener and smarter practices. It functions through financing programmes in shared responsibility between the European Commission and national or regional authorities of Member States. Member States receive support for investments aligned with one or more of the ERDF's five policy objectives aimed at making the EU:

1. More competitive and smarter
2. Greener, low carbon and resilient
3. More connected
4. More social

[67] *CEF Debt Instrument, CEF Equity Instrument, Loan Guarantee Facility under COSME, Equity facility for Growth under COSME, Innovfin Equity, Innovfin SME guarantee, Innovfin Loan Services for R&I Facility, Private Finance for Energy Efficiency Instrument, Natural Capital Financing Facility, EaSI Capacity Building Investments, EaSI Microfinance and Social Enterprise Guarantees, Student Loan Guarantee Facility, Cultural and creative sectors Guarantee facility*

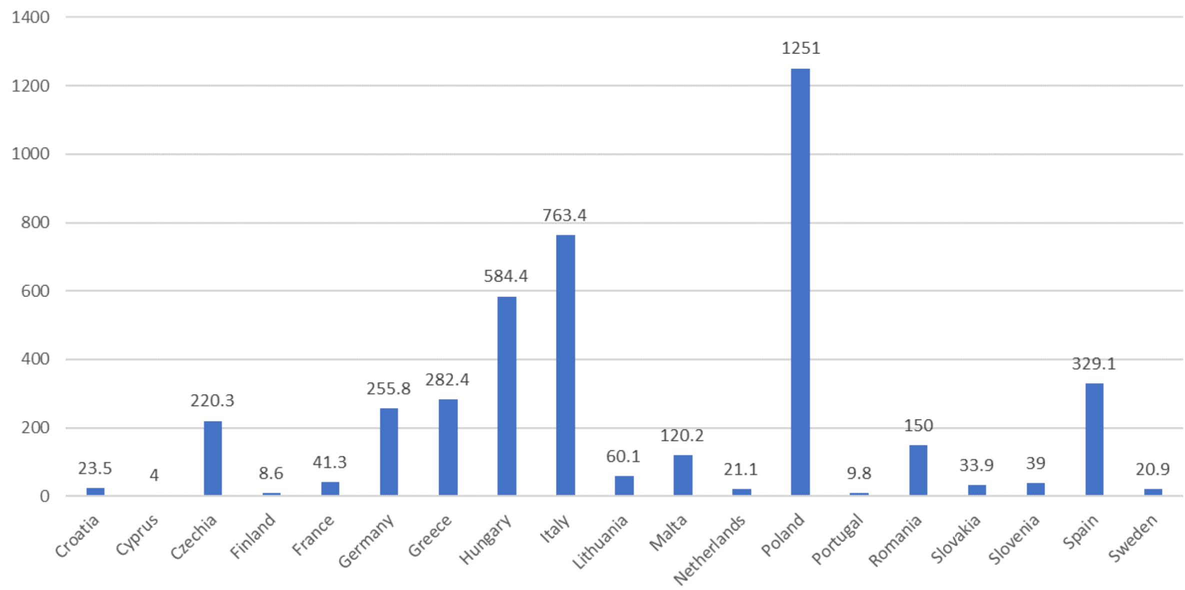
5. Closer to citizens

The total budget of the ERDF is around €212 billion, to which around €97 billion of national co-financing by Member States should be added, for a total of around €308.8 billion[68]. A particularity of the fund is that less-developed regions will benefit from co-financing rates of up to 85% of the cost of the projects, while rates for transition regions and for more-developed regions will be up to 60% and 0% respectively.

Greener Europe is the Policy Objective with the second highest share of ERDF resources, €102.9 billion, second only to Smarter Europe with €112.95 billion. Through these resources, a significant number of national programmes have been financed in different Member States. Some of these programmes have been financed in full with ERDF resources, others have combined ERDF with other public resources. The Table below presents some of these schemes and shows that the instrument is being used and thus is relevant for Member States' ability to finance their transition.

The Greener Europe pillar provides a special focus on smart energy systems, category that includes energy storage systems. The ERDF does not have a project category specific to energy storage, as it rather adopts a holistic approach and puts energy storage, smart grids and digitalisation together under the "smart energy systems" category. Nevertheless, it is interesting to note that the current cycle has seen €4.2 billion planned investments in smart energy systems and related storage. Poland is the Member State with the largest share of planned investments for this category (€1.2 billion) followed by Italy (€763 million), Hungary (€584 million) and Greece (€282 million).

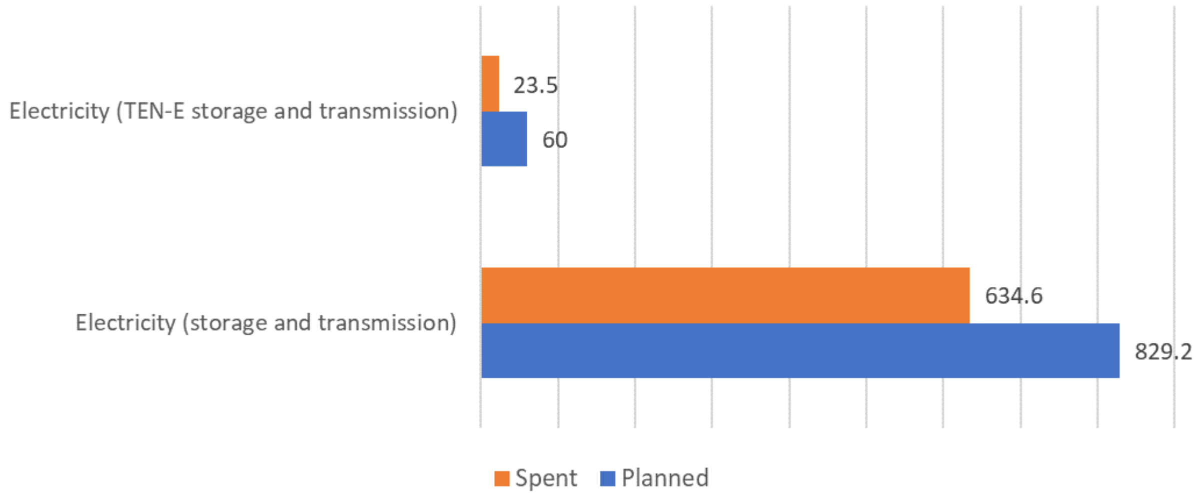
Figure 16: ERDF planned disbursement in "Smart Energy Systems and related storage" (2021-2027 programming cycle, in € M)



In the previous programming period, 2014-2020, the ERDF funded energy storage projects through the category "Electricity (storage and transmission)". While also in this case there was no specific earmarking for storage itself, Figure 17 below provides an overview on the planned and spent ERDF resources for the project category that includes energy storage.

[68] European Commission. Cohesion Open Data Platform. https://cohesiondata.ec.europa.eu/funds/erdf/21-27

Figure 17: Planned and spent 2014-2020 ERDF resources for electricity (storage and transmission) (in € M)



Just Transition Mechanism

The **Just Transition Mechanism** supports the fair transition to climate neutrality across the EU. For the 2021-2027 period it is expected to mobilise nearly €55 billion targeting industries and workers in most affected regions. The program is structured around three pillars:

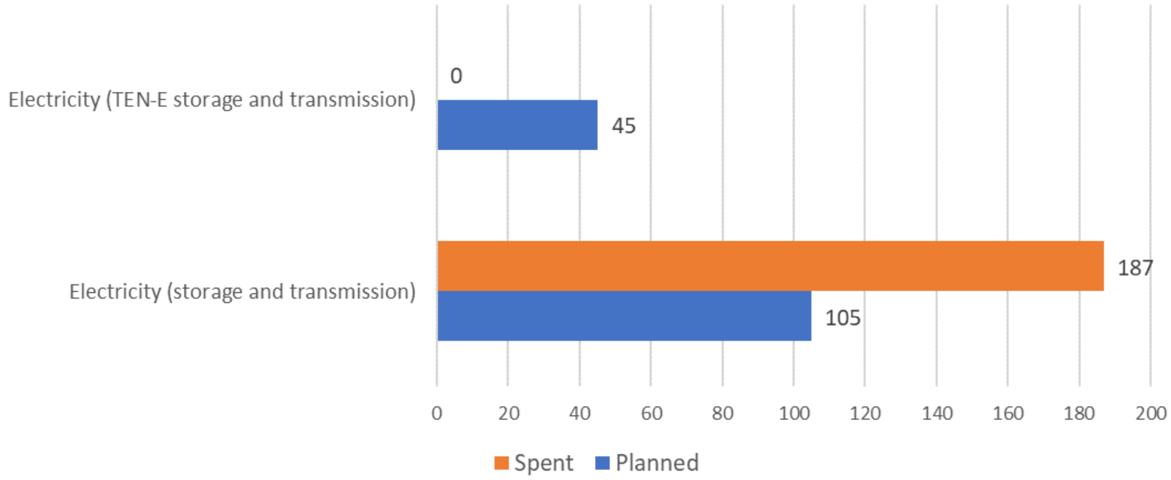
- *Just Transition Fund,* which aims to raise €25.4 billion of investments starting from a budget of €19.2 billion in current prices. The Fund has clean energy among its goals but there is no direct earmarking of budget for the sector;
- *InvestEU "Just Transition" scheme*, providing – under InvestEU – a guarantee and an advisory hub with the objective of mobilising €10-15 billion, predominantly from private sector. This is going to cover energy but there is no specific allocation to it.
- *Public Sector Loan Facility,* managed by CINEA, which combines resources from the EU budget (€1.5 billion) with those provided by the EIB (€10 billion). It will also provide technical assistance under the InvestEU Advisory Hub. By blending these resources, the Facility aims to raise around €18.5 billion of public investments to be used by public sector entities.

Cohesion Fund

The **Cohesion Fund,** with a total budget of around €37 billion, supports Member States with lower gross national incomes in the field of environment and trans-European networks in the area of transport infrastructure. Around 37% of the overall budget is allocated to climate goals. For the 2021-2027 period, the Cohesion Fund concerns Bulgaria, Czechia, Estonia, Greece, Croatia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Portugal, Romania, Slovakia and Slovenia.

In the programming period 2014-2020, the Cohesion Fund allocated €105 million to electricity storage and transmission projects in Poland and €45 million for TEN-E electricity transmission and distribution projects, also in Poland. In the period 2021-2027, the Cohesion Fund has allocated €426.7 million to Smart energy systems, which include also storage.

Figure 18: Cohesion Fund 2014-2020 planned and spent funding for storage and transmission (in € M)



ETS-based programmes

Innovation Fund

The **Innovation Fund** is expected to provide €38 billion[69] between 2020 and 2030 for the commercial demonstration of innovative low-carbon technologies. This scheme is funded by the EU Emissions Trading System, so the exact amount of resources will ultimately depend on the carbon price. The fund is managed by CINEA and resources are allocated through regular calls for proposals for both large and small-scale projects Around the theme of energy storage specifically, the Innovation Fund is open to projects for breakthrough technologies for all energy-intensive industry sectors covered by Annex I to the EU Emission Trading System Directive, including products substituting carbon-intensive ones; renewable energy; energy storage; carbon capture and storage (CCS); carbon capture and utilisation (CCU).

Box 1: Innovation Fund financing of energy storage-related projects[70]

The Innovation Fund has provided financing to multiple innovative energy storage projects. Overall, it provided support to 37 projects across the energy and innovation sectors.

For instance, Granges Finspang AB, a Swedish company, has been awarded a sum of €2.6 million to develop a Low CO_2 Footprint battery foil for Li-ion battery production for energy storage.

Similarly, a German initiative has received €4.5 million of support to develop energy storage containers, made from vehicle batteries, thus enabling high-cost savings for industry and grid operators by 2026. In Italy, a project has obtained €2.3 million to provide a second life to electric vehicles' batteries and operate them for less demanding applications such as providing stationary energy storage services at lower cost and reducing thereby environmental impacts and GHG emissions of served energy systems, as well as of the battery supply and recycling chain in general.

[69] Estimated assuming a carbon price of €75/tCO2

[70] Source: Innovation Fund – Portfolio of signed projects.

Modernisation Fund

The **Modernisation Fund** was set up by the European Commission to support the ten lower-income Member States[71] in their transition to climate neutrality and to increase energy security. The Fund supports investments in energy production, energy efficiency, energy storage, modernisation of energy networks, and just transition in carbon-dependent regions.

The Modernisation Fund is an ETS-based instrument and not an EU budgetary programme. **It is funded from revenues from the auctioning of 2% of the total CO_2 allowances** for 2021-2030. At the price of €75/tCO_2, the total budget of the MF amounts to around €48 billion from 2021 to 2030, but this amount can change depending on the carbon prices. In addition to the MF budget, beneficiary Member States can transfer additional allowances from other programmes under the ETS system. This can further increase the financial resources available to Member States to finance energy transition. To date, five Member States (Croatia, Czech Republic, Lithuania, Romania, Slovakia) have opted to do so.

When it comes to energy storage, **the Modernisation Fund has financed, to date, 24 projects**, of which, however, **only two dedicated to solely to energy storage**, and the other 22 covering multiple eligible categories among which energy storage. The two storage-only projects are one in Croatia and one in Hungary, with a MF contribution of €19.8 million and €51.4 million, respectively. Figure 19 and Figure 20 below provide an overview of the approved energy storage projects under the Modernisation Fund. As can be noticed, **Poland and the Czech Republic have the largest share of approved projects and MF resources**, followed by Croatia, Hungary, and Latvia, the latter with only one approved project.

Figure 19: Number of confirmed investments in "energy storage" (among other MF categories), by country

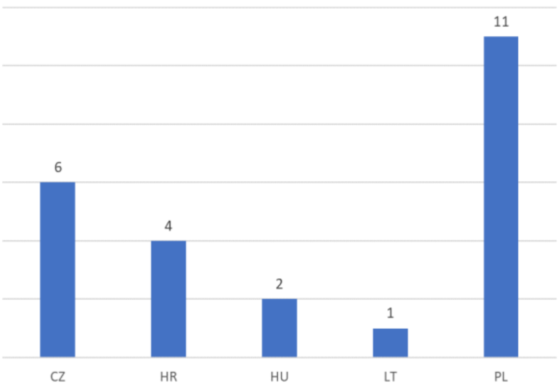
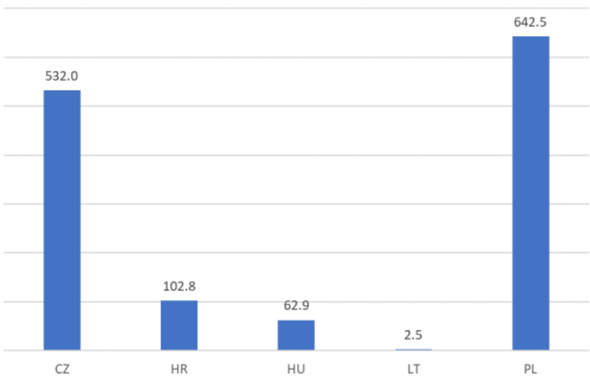


Figure 20: Amount of approved MF resources for investments in "energy storage" (among other MF categories, no earmarking) by country (in € M)



On May 2023, the revised EU ETS regulation was published in the Official journal of the EU[72]. The revised regulation strengthens the System and extends the ETS to new sectors of the economy, such as buildings, road transport and shipping, and to three additional Member States: Portugal, Greece and Slovenia. This will result in the Modernisation Fund to increase its size.

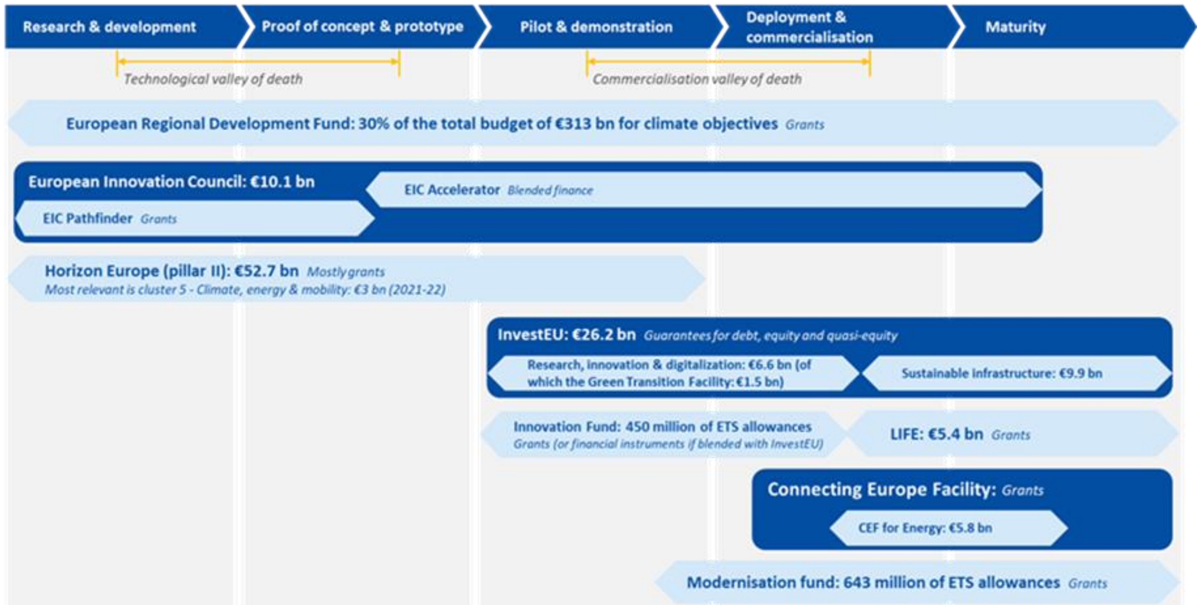
Maturity stages covered

EU financing programmes target beneficiaries and projects at different levels of maturity and TRLs, aiming to address their specific barriers to investment. By focusing on different TRLs, programmes can better address the barriers to investment relevant for different

[71] Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia.
[72] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2023:130:TOC

companies in the sector. As can be seen from the Figure below, **EU financing programmes provide complete coverage across different stages of maturity**. The ERDF provides support across all maturity stages, based on how Member States decide to allocate such funding. For less mature technologies still in the research & development stage, Horizon Europe and the EIC Pathfinder provide support primarily in the form of grants, which tend to be the most suited type of financial support for technologies that are still far from commercial maturity. The Innovation Fund and InvestEU's RDI investment window provide then support for more developed technologies, which are nonetheless still not fully mature. This support comes in the form of blended finance, grants and guarantees for debt and equity financing. Same is the EIC Accelerator, which supports individual projects with a maturity level close to commercialisation (TRL 5 to 9). It funds highly innovative projects with very high risk and growth potential. Under the new CEF CB RES, innovative solutions can be financed as well, although the actual level of maturity supported is not specified. Finally, InvestEU's Sustainable infrastructure window, the LIFE Programme, CEF and the Modernisation Fund provide financial support for mature technologies, in the form of grants and guarantees.

Figure 21: Overview of EU financing programmes according to their targeted TRL levels.[73]



The European Investment Bank Group

Although not an EU programme, the **European Investment Bank Group** (composed of European Investment Bank and European Investment Fund) also plays a central and key role in the energy financing landscape beyond its central role as biggest implementing partner of InvestEU. While the EIBG does not have specific investment programmes or schemes for energy, in its **energy lending policy**[74], energy storage is mentioned as a key component for both the **decarbonisation of the energy supply** and for the **energy transformation**. For this, the EIB wants to invest in new types of energy infrastructure, including battery storage.

Ten storage-related projects have been financed directly by the EIB in the period from 2017 to 2022, for a total of €567 million. Italy is the country with the most financing received, for two gas transmission and storage projects, followed by Cyprus, with one project also on gas transmission and storage. France is the country with the most projects financed (5), and

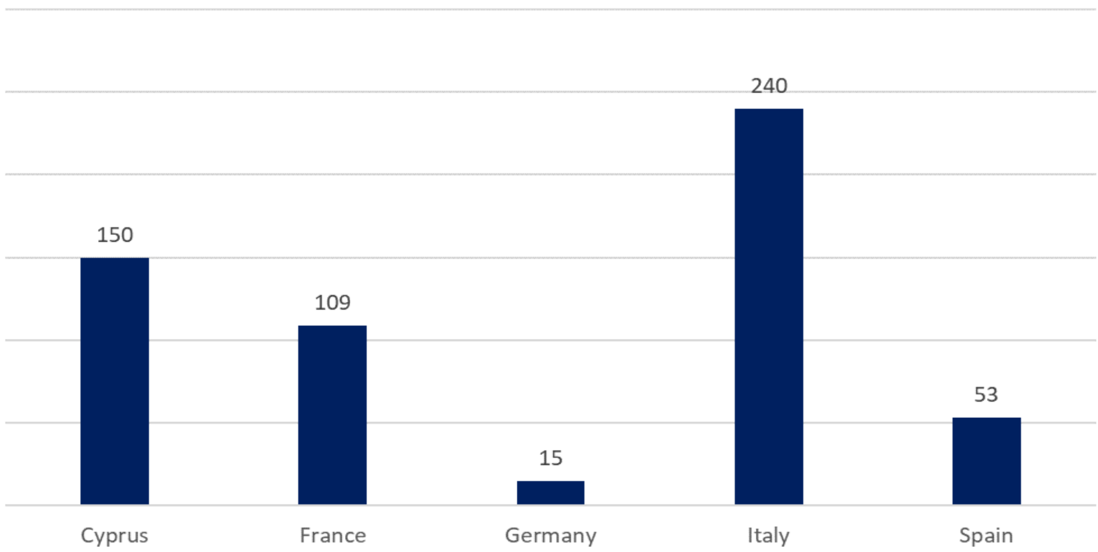
[73] Innovation Fund: Second large-scale call for projects info day, CINEA, 10 November 2021

[74] EIB. Energy lending policy. https://www.eib.org/attachments/strategies/eib_energy_lending_policy_en.pdf

the only one with also equity financing, although to a Fund that is located in France but that invests in all EU countries[75].

The amounts presented below do not include any national co-investment/contribution, and include financing in the form of **loans, equity, and quasi-equity (venture debt)**.

Figure 22: EIB contribution to energy storage projects in the 2017-2022 period (in € M)[76]



Source: PwC analysis of eib.org data on 559 financed projects in the energy sector from 2017 to 2022.

The EIF also invests in the energy sector, although not directly but through other funds. Under the InvestEU equity product, EIF seeks to increase the availability of risk capital across all stages of company development, accelerating growth of European scale-ups accompanying and supporting them in accessing public markets, as well as other EU policy objectives. Under the InvestEU Climate & Infrastructure Product, the EIF provides equity investments to, or alongside, climate & infrastructure funds investing in, among others, energy storage[77]. EIF is also leading the Europe Tech Champion Initiative to mobilize investments in later rounds that today are served through US funds.

3.2. Financial support schemes at Member State level

To address the challenges faced by energy storage projects and to enhance investments in energy storage to achieve policy goals, the public sector can implement a series of financial support schemes. Financial instruments not only improve the financing conditions for a specific type of project (e.g., by de-risking it, increasing the financing available, improving the financing conditions, etc.), but also send a strong signal to market players about governments' and public authorities' commitment to that sector.

A mapping exercise was conducted to gather an overview on the existing financial support schemes available for energy projects, including energy storage. The purpose of the mapping was to assess the current availability of instruments and schemes to support energy storage projects, in order to assess to what extent they are effective in addressing barriers and mobilising additional finance. This will prove to be useful and functional for the

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[75] EIB. Eurofideme 4 Fund. https://www.eib.org/en/projects/pipelines/all/20180029

[76] Double counting possible. For projects investing in more than one energy segment, the full amount of the transaction was counted for under all energy segments, as no explicit earmarking was available.

[77] EIF. Climate & Infrastructure Funds. https://engage.eif.org/investeu/climate-infrastructure-funds

development of future financial support schemes to support the energy transition in the EU, both new instruments or existing ones being continued and improved.

Financial support schemes are not the solution for all barriers and bottlenecks faced by energy projects. They are the most relevant to address economic barriers such as high upfront costs and financing conditions, and less suitable for social and regulatory ones. This relevance is further explored in section 4.1 Relevance of instruments in addressing investment barriers: theory and evidence.

The mapping was conducted through a combination of **desk research and interviews** with selected stakeholders to obtain complementary information. Instruments were categorised by segments of the energy value chain they can support, eligible beneficiaries, targeted development phase, and type of financing provided (see Annex 1). Some instruments have been flagged as **relevant for more than one single dimension**. This is the case, for instance, for those instruments covering the installation of both PV panels and of batteries or providing both loans and grants. These instruments were categorised under all the relevant categories, to reflect the scope of the instrument. This note should be kept in mind when reading the data presented below as, for instance, when it is stated that 100% of mapped instruments in Cyprus target energy storage, it does not mean that all the mapped instruments target only energy storage, but that they target also energy storage and none of the mapped instruments do not target it.

Instruments targeting solely energy efficiency (e.g., for the renovation of buildings, for industries, etc.) – albeit particularly popular – have been excluded from the analysis, as already covered by the work on the Energy Efficiency Financial Institutions Group (EEFIG). Energy efficiency instruments were mapped only if they included also support for transmission and distribution. For the purpose of the analysis and to identify regional trends, EU Member States have also been aggregated in four geographical areas, following the classification from EuroVoc[78]: Central and Eastern Europe[79], Northern Europe[80], Southern Europe[81], and Western Europe[82].

Furthermore, Important Projects of Common European Interest (IPCEIs) are a relevant category of projects deployed at MS level. While not constituting an EU programme or instrument per se, , IPCEIs are a category of transnational projects with an important contribution to growth, employment and competitiveness of the European Union industry and economy. Because of this recognised contribution, IPCEIs can be supported through Member States' state aid. The Box below provides an example IPCEIs in the field of energy storage.

[78] Available on: https://www.researchgate.net/figure/European-subregions-defined-by-EuroVoc-Blue-Northern-Europe-green-Western-Europe_fig1_321354391

[79] Bulgaria, Czech Republic, Croatia, Hungary, Poland, Romania, Slovakia, Slovenia

[80] Denmark, Estonia, Finland, Iceland, Latvia, Lithuania, Norway, Sweden

[81] Greece, Italy, Malta, Portugal, Spain

[82] Austria, Belgium, France, Germany, Ireland, Luxembourg, the Netherlands

Box 2: IPCEIs on Batteries

A two-part IPCEI[83] has been implemented to promote battery production: the IPCEI on Batteries and the IPCEI European Battery Innovation (EuBatIn). Both IPCEIs have in common that their participants represent the complete value chain, from material through the cells to the battery system and the final step of recycling. At the same time, there is a high degree of networking between the companies themselves and the two IPCEIs.

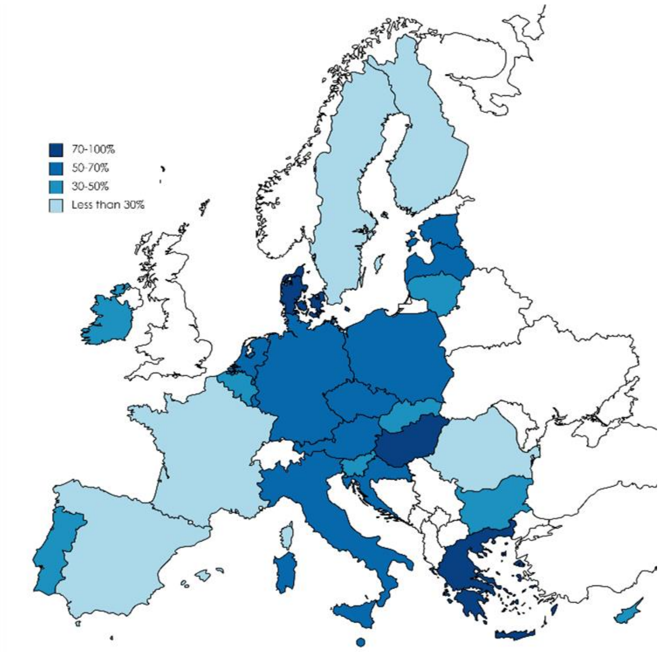
The IPCEI on Batteries brings together key European players headquartered in Belgium, Finland, France, Germany, Italy, Poland and Sweden, operating in different Member States of the EU, and at various level of the battery value chain, from mining to repurposing, recycling and refining, through development of advanced materials and manufacturing of cells, modules and systems as well as dedicated software and testing systems and solutions.

IPCEI European Battery Innovation aims to support national research and innovation efforts and the industrial pilot production based on them across the complete battery value chain.

General overview: energy storage instruments

The mapping has produced a database of 565 instruments across the 27 EU Member States. Poland (44), Germany (39), Italy (39), and France (35) are the four countries in which the highest number of identified instruments. On the contrary, Denmark (10), Cyprus (10), and Finland (9) are the countries with the lowest number of identified instruments.

Figure 23: Share of Energy storage instruments out of the total mapped



On average, around 48% of the mapped instruments supports energy storage, 272 in total. However, out of these that have been identified as available for this segment**, just 3 are targeting only Energy storage**. Additionally, 9 of them support storage and another segment (Production 7 times, Transmission and Distribution twice). Finally, 173 instruments support all the five segments (energy production, transmission and distribution, energy storage, heating and cooling, services and prosumers).

All EU Member States present at least 1 instrument supporting Energy storage. Denmark, Hungary, and Greece are the only Member States with a share of instruments supporting energy storage which is equal or higher than 70%. On the contrary, in both Spain and Romania such ratio is lower than 20%. **Instruments which only target energy storage have been found in 3 Member States, namely Finland, France, and Spain.**

The mapping also looked for information about the **volumes of financing** provided. Information about the total budget of the instruments as well as the amount already deployed have been collected where available, to understand what the available magnitude of financing for different target groups is and how it is channelled through different funding

[83] IPCEI Batteries. https://www.ipcei-batteries.eu/

instruments/financial schemes. However, the mapping was able to gather only partial information on volumes, as such data was publicly available for less than half of all instruments relevant for energy storage (130 instruments of the total 272 instruments) and information on deployment was missing in most of the cases.

Figure 24: Instruments mapped per country

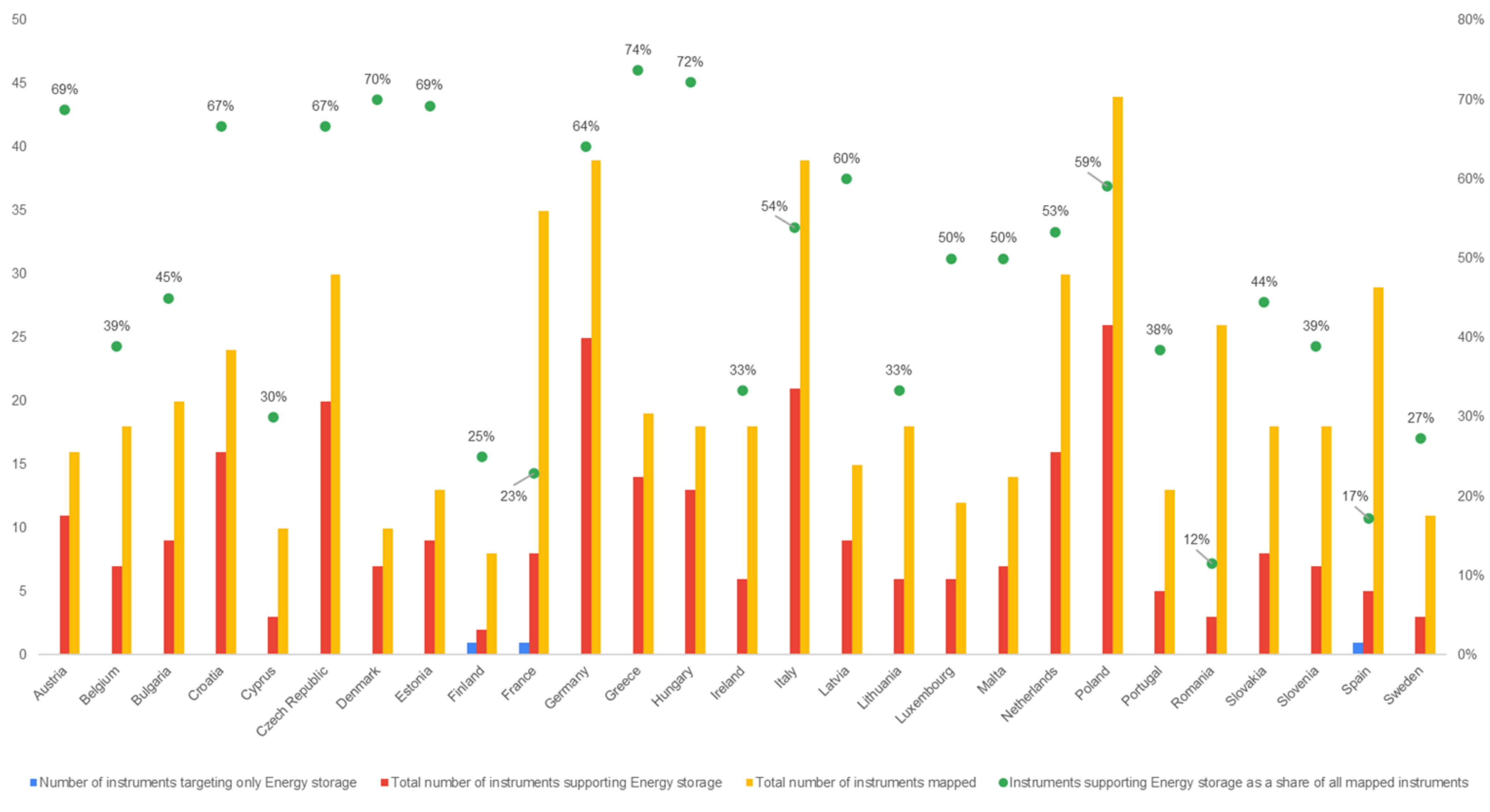
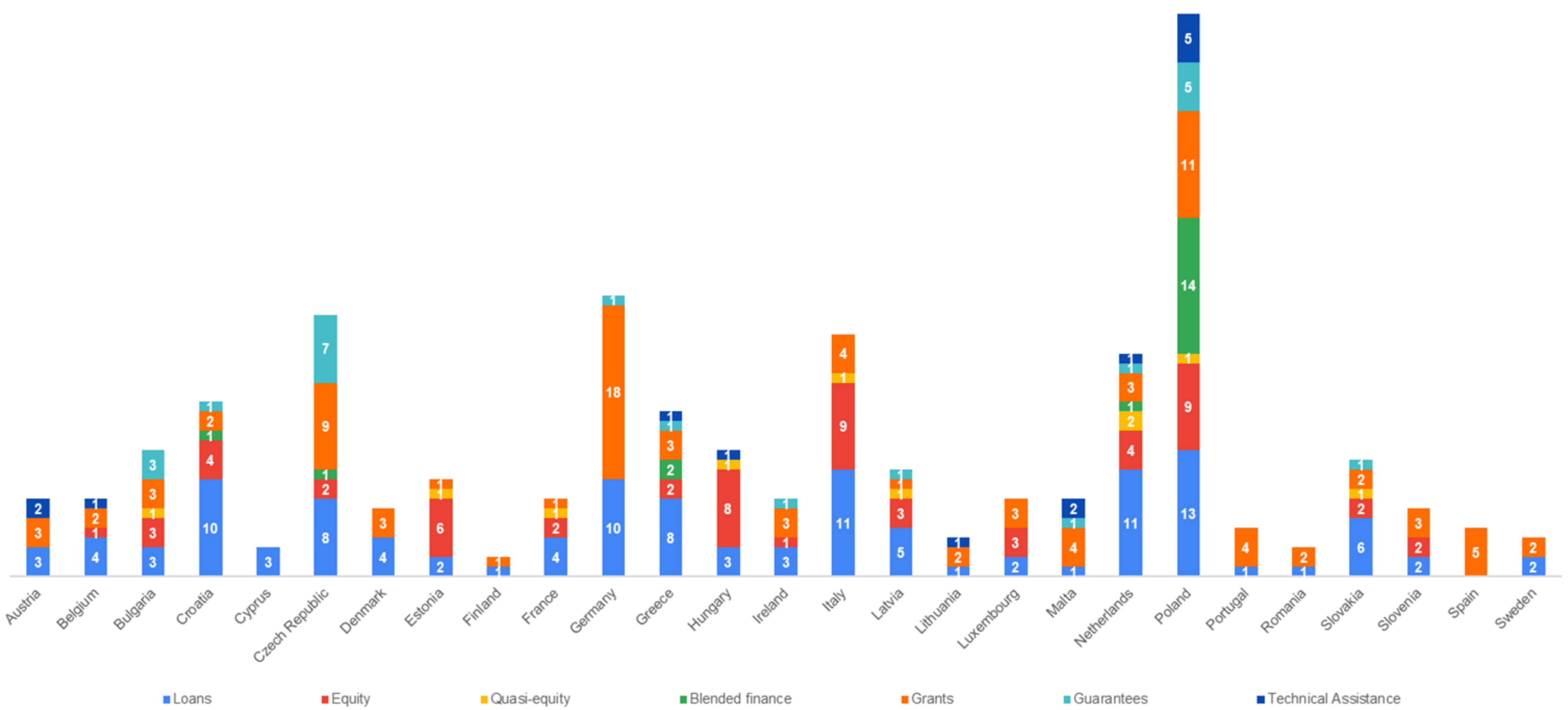


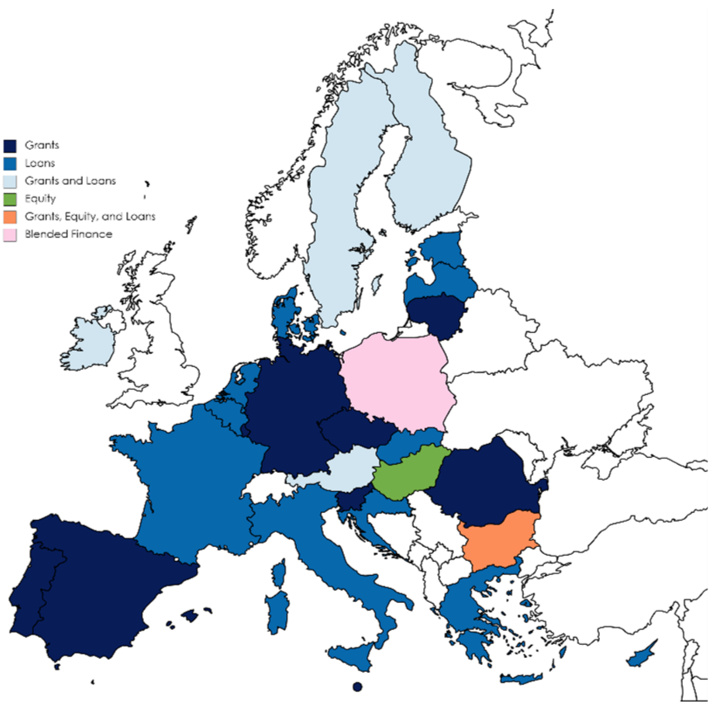
Figure 25: Number of financial instruments for transmission and distribution per country and per type of instrument



Financing instruments by type

Loans and grants are the most widespread across the set of 272 instruments that the mapping identified as relevant for Energy storage. Only in Hungary equity instruments are the most widely available.

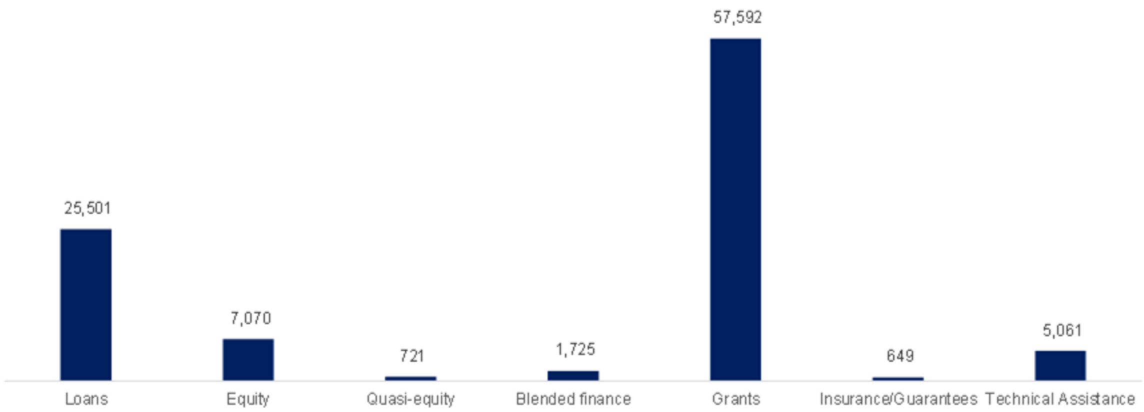
Figure 26: Most mapped type of instrument per country



On aggregate, **a total amount of around €113 billion has been estimated to be available inter alia for Energy storage projects by taking into account the resources coming from the EU, national public authorities, and private institutions.** As displayed in the figure below, overall, the amount allocated to grants, €57 billion, is more than twice the size of what is allocated to loans (€25 billion). For guarantees, the maximum leveraged investments due to the respective guarantee has been considered for the calculation, and not the amount of guarantees disbursed, which was not available. These estimates are based on information for 132 instruments.

These volumes also include the total volume of instruments targeting also but not only Energy storage, and for which there is no specific pre-allocation. This means that these volumes are not guaranteed to be spent in Energy storage only. Additionally, some schemes for which it was impossible to determine the exact type of instrument through which money will be deployed are excluded from the break-down figure which follows. **The fraction of these resources that is channelled through instruments targeting only energy storage is about €368 million.**

Figure 27: Volume of financing per instrument (€ M)



The mapping identified a total of 95 grants supporting energy storage and **Germany is the country with the highest number of registered grant instruments** (18). This data is explained by the fact that many of these schemes come from the investment arms of the Länder, reflecting the federal governance of the country. As emerged during the WG Discussions, **grants still play a very important**

role in financing energy storage projects. They are particularly useful to reduce CAPEX expenditures and reduce the technology risk.

Box 3: Focus on: Grants for energy storage only – the Finnish National Battery Strategy 2025 Case

Grants represent around 2 of the 3 mapped instruments supporting only Energy storage. These schemes are located one in Spain, one in Finland, for a total amount of €350 million.

The Finnish National Battery Strategy 2025

Starting from 2020, **the Ministry of Economic Affairs and Employment of Finland began developing a National Battery Strategy with the aim of boosting the country's position in the battery and electrification sector**, focusing on responsibly sourced raw materials and research related to battery materials and recycling.

The national strategy outlines seven objectives for the 2021-2025 period:

1. Growth and renewal of the battery and electrification cluster
2. Growth of investments
3. Promotion of competitiveness
4. Increased international awareness of the strategy
5. Responsibility
6. Definition of key roles in the sector's new value chains
7. Promotion of circular economy and digital solutions

In the 2021 budget, to promote investments in the production of precursor and cathode active materials used in lithium-ion batteries within the country, the **Finnish government allocated an additional €300 million in funding for the Finnish Minerals Group,** a special-purpose company wholly owned by the State of Finland and responsible for managing the state's mining industry investments and advancing the country's minerals strategy.

Loans (122 in total) come mostly from market-oriented public institutions such as national promotional banks (NPBs) or the EIB Group and we found them across all Member States. Some products coming from private banks and funds are also present. Loans are prevalent in all geographic areas and no specific differences or trend was identified. Poland (13), Italy (11) and the Netherlands (11) are the countries with the highest number instruments.

Box 4: Focus on: Loan for Energy storage

The single mapped loan exclusive to Energy storage, for a total amount of €16 million, has been disbursed by the EIB for a project which contributes to increasing battery storage capacity in the New Aquitaine region in France.

Such intervention aims to enhance the power system's flexibility and guarantee a secure supply of energy while also aiding in the integration of more renewable energy sources, ultimately reducing the CO2 emissions produced by the power sector. The project operates on a merchant basis and implements an innovative business model under new market-based procurement schemes in France's electricity market design.

The mapping found 61 equity instruments, across 16 EU countries[84]. Poland is the country with the highest number of equity instruments identified (9). **There are no equity instruments targeting exclusively Energy storage.**

Quasi-equity, which is a more complex financial instrument, is less present and was found in 9 Member States[85], for a total of 10 instruments. Blended finance schemes have been identified in only 5 countries[86] (19 instruments overall), with Poland accounting for the biggest shares by volume. **The provision of more sophisticated financial instruments such as (quasi)equity and blended finance require a high degree of cooperation between public and private providers of finance.** Most of the identified instrument are provided by or in cooperation with NPBIs and the EIB Group.

During the WG discussion, **participants emphasised the significance of VC financing to facilitate innovative storage solutions and the importance of encouraging PE investing**. Nevertheless, as also mentioned by members, **the long-term storage market remains relatively underdeveloped, and energy storage projects are finding it challenging to obtain equity financing**. Institutional investors require a better understanding of the energy storage market and models to accurately evaluate project proposals and solutions.

One or more guarantee schemes for energy storage are available in 11 EU Member States[87], for a total of 23. The Czech Republic has 7 instruments, followed by Poland with 5 and Bulgaria with 3, while all the other countries only have 1. In the majority of the cases, guarantees are provided by the public sector, especially through facilities financed by the EIB Group or EU funds.

During the discussion, **it was pointed out that guarantees can effectively facilitate the mobilization of private financing for energy storage projects**, which, according to WG members, currently face some challenges such as the absence of a regulated revenue stream and a strong company history, that can discourage potential investors. Guarantee providers are then faced with the question of determining which risks are acceptable to the market and which risks require coverage through guarantees. With this regard, **WG Participants agreed that technical risks and revenue risks associated with energy storage projects are suitable for guarantees as private investors are often hesitant to bear them.**

Finally, **14 instruments also including technical assistance have been mapped across 8 MS[88]**. Poland is the country in which the most technical assistance programmes are provided.

[84] Belgium, Bulgaria, Croatia, Czech Republic, Estonia, France, Greece, Hungary, Ireland, Italy, Latvia

[85] Bulgaria, Estonia, France, Hungary, Italy, Latvia, Netherlands, Poland, Slovakia

[86] Croatia, Czech Republic, Greece. Netherlands, Poland

[87] Bulgaria, Croatia, Czech Republic, Germany, Greece, Ireland, Latvia, Malta, Netherlands, Poland, and Slovakia

[88] Austria, Belgium, Greece, Hungary, Lithuania, Malta, Netherlands, Poland

In 9 occasions this instrument was paired with loans. 4 times it was offered together with a grant. In 3 occasions guarantee instruments were offered alongside technical assistance. Overall, as showcased in Figure 29 above, the volume of money channelled through programmes, mostly loans and grants, that come with a technical assistance part is around €5 billion.

Box 5: Green bonds

Green Bonds are expected to be an increasingly important instrument to finance sustainable activities over the next years. In the last decade in the EU, both public and private sector entities have started tapping the green bond market, following the increasing attention to sustainable finance. Although China has been in 2022 the largest global issuer by number of issuances, the European market remained the largest in terms of issued volumes, with a supply of around $219.03 billion. Historically, European entities have been pioneers in this field, with the EIB being the first issuer of a green bond in the world back in 2007.

1,960 or around 58%, of all GSSSBs of EU issuers between January 2015 and February 2023 were relevant for renewable energy. The following figures will focus on the **use-of-proceeds bonds** (i.e., Green bonds, social Bonds, Sustainability Bonds, **1915 in total**) which had renewable energy as one of the declared uses of proceeds[89, 90]**.**

Energy storage is not a use-of-proceeds category that is used in the issuance of green bonds. Therefore, it was not possible to identify and analyse green bonds based only on their relevance for energy storage. When energy storage is an eligible category, it is included under the broader umbrella of “Renewable energy”. For this reason, the following analysis focuses on GSS bonds for renewable energy.

<u>**Corporate bonds**</u>

Sweden has the highest number of issued corporate UoP whose proceeds are entirely or partially earmarked for renewable energy projects among all Member States. This result is largely due to the high number of issuances from real estate companies and housing associations, which account for more than 80% of the total Swedish issuances. **Spain ranks second with 83 bonds in total**, and it leads in terms of the number of issuances from energy sector companies (68). **Germany ranks third overall**, with a total of 70 issuances, including 48 from energy sector companies.

Corporates issued around €216 billion of UoP bonds with proceeds designated for financing renewable energy projects. German and French companies have issued just around €35 billion each, **with an average issuance of around €510 million and €662 million**, respectively. The Netherlands and Spain are next, with €28 billion each, and average issuances of €535 million

[89] Based on data from Environmental Finance retrieved on 29 March 2023.
[90] For EU companies that have operations outside the Union, as well as for DFIs, a non-quantifiable of the raised funds may have been directed towards projects in extra-EU countries

and €340 million, respectively. On the other hand, Swedish companies issued only around €21 billion, with an average issuance of just €66 million.

Figure 2: Number of UoP bonds relevant for renewable energy issued by companies from 2013 to 2023, per country

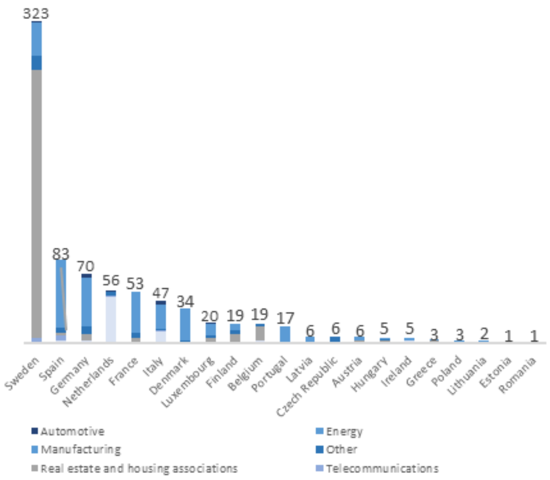
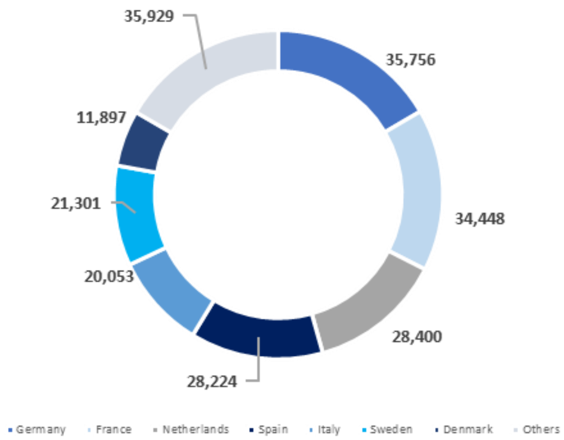


Figure 1: Aggregate volumes of UoP bonds issuances relevant for renewable energy issued by companies from 2013 to 2023 per country (In € M)



Sovereign bonds

Over the analysed period, a total of 230 UoP bonds whose proceeds are totally or partially earmarked to renewable energy projects were issued by European sovereign and sub-sovereign entities, with sub-sovereigns accounting for 145 issuances and national governments accounting for the remaining 85**.** The Stockholm Regional Council was the sub-sovereign entity with the highest number of bond issuances, while the French State was the leading issuer among sovereign entities.

In terms of volumes, sovereign entities (€182 billion) raised almost seven times the amount of the sub-sovereign ones (€27 billion). This trend could reflect the different – and larger – financial needs that national governments generally have compared to sub-sovereign entities, which are responsible for a narrower range of activities.

On aggregate, **sovereign green bonds accounted for nearly €177 bn.** France is the Member State that issued the most, with €56 bn, followed by Germany, and Italy. This result is not surprising considering that these are also the three largest economies in the EU.

Figure 3: Number of UoP bonds issuances relevant for renewable energy issued by sovereign and sub-sovereign entities from 2013 Q1 to 2023 Q1

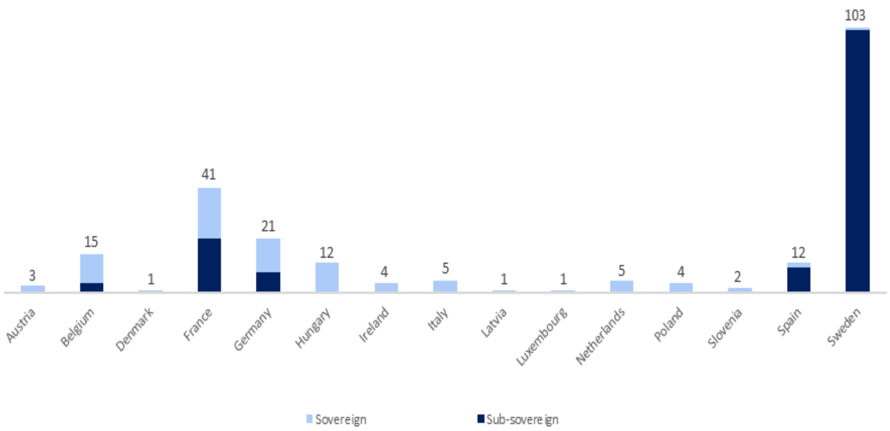
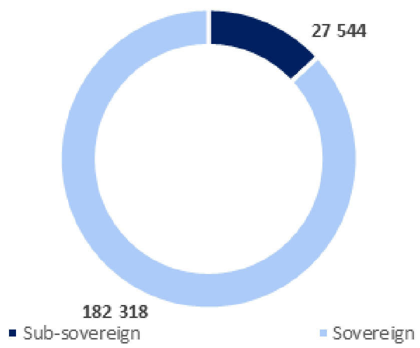


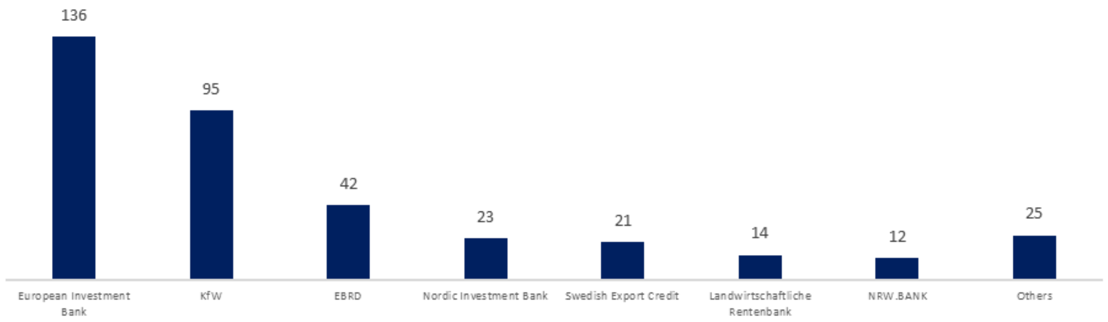
Figure 41: Aggregate volumes of UoP bonds issuances relevant for renewable energy issued by sovereign and sub-sovereign entities from 2013 to 2023 (In € M)



DFIs

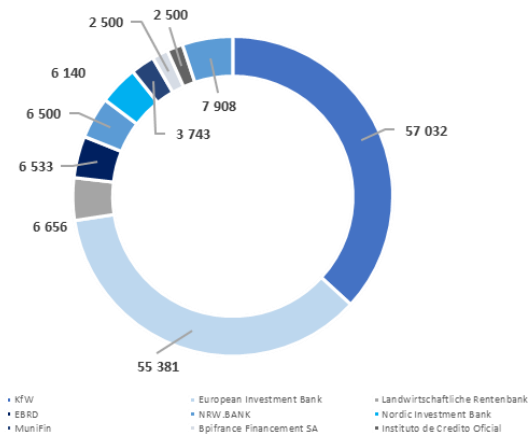
In the analysed dataset, **368 bonds whose proceeds are totally or partially earmarked to renewable energy projects were issued by DFIs, with the EIB (136) accounting for around a third of them**. The EBRD and the Nordic Investment Bank rank third and fourth, after the German NPB, KfW. This category of issuers plays an important role in financing sustainable energy projects. Typically, they issue bonds to raise funds that they can then lend out to support selected projects.

Figure 32: Number of UoP bonds issuances relevant for renewable energy issued by DFIs from 2013 Q1 to 2023 Q+



In terms of volumes of bond issuances, KfW is the largest issuer with around €57 billion worth of GBs. The bank commenced building its global portfolio in collaboration with the German Ministry for the Environment, Nature Conservation, and Nuclear Safety in 2015. The EIB comes in second place with €55 billion and the combined bond issuances of these two institutions make up over 70% of the total for this category.

Figure 5: Aggregate volumes of UoP bonds issuances relevant for renewable energy issued by DFIs from 2013 to 2023 (In € M)

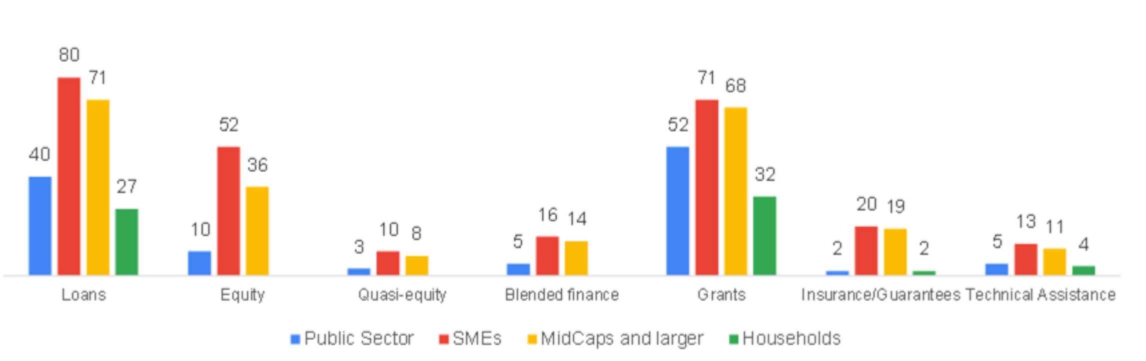


Financing instruments by beneficiary

SMEs and larger companies are the most supported recipients by financial instruments in most EU Member States. They are the most supported type of beneficiary due to their higher investment needs in general, which lead to the need for greater support. "Financing costs" was indeed indicated by both SMEs and large companies as a relevant obstacle for their green transition activities in a recent Commission report on EU SMEs[91], showing an existing need for support in the field. Croatia and Poland are the two countries which have the highest number of loan instruments towards the private sector (10) while Germany and the Czech Republic have the highest number of grants (13 and 8).

The vast majority of equity, quasi-equity and blended finance is directed towards SMEs and larger companies. Indeed, 85% of equity instruments target SMEs and 59% for Midcaps and larger companies. The share that is dedicated to public companies is negligible in all the EU countries. Similar results are found also for quasi-equity, where all instruments are directed towards SMEs and 80% to Midcaps and large companies.

Figure 34: Number of instruments by final recipient per type of instrument



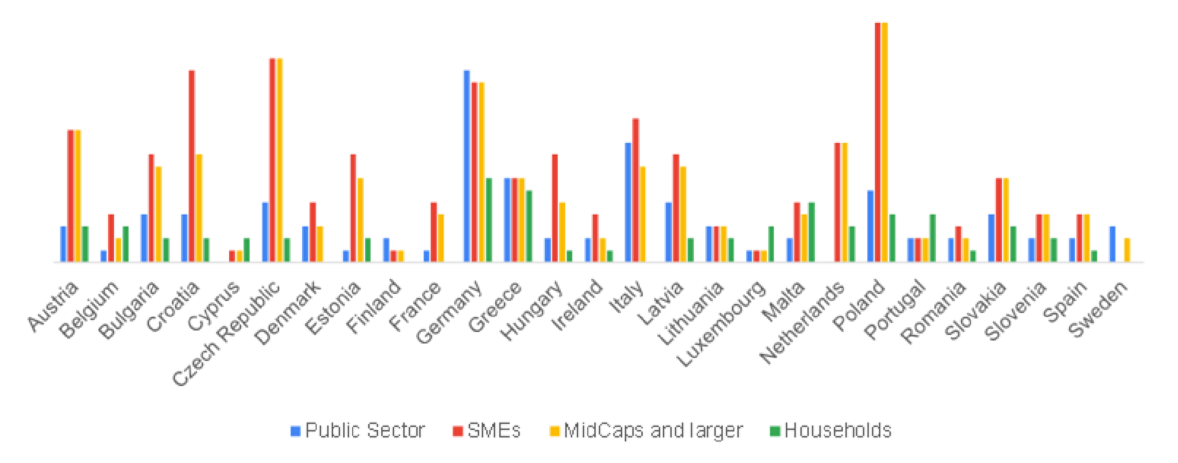
Public-owned companies and public administrations ("public sector") are supported by about a third of the mapped instruments. The lower support for public sector entities could be linked to the extent such entities receive direct budget support from the state budget and their expenditures might not need to be financed through external instruments. Only 40 loans were found towards these recipients, mostly in Italy and Germany, while grant instruments for public sector are 52, mostly in Germany (14).

Households are the least supported group by the mapped instruments. This can be explained by the fact that pure energy-efficiency instruments – the ones most suited for households - were excluded from the mapping. Grants are also the most used tool to support households, followed by loans (32 and 27 instruments, respectively).

According to WG Members, **to prevent larger entities from having an advantage due to their ability to install larger storage capacities, smaller companies and households should not be disadvantaged and receive dedicated financial support schemes for smaller installations.**

[91] European Commission (2021). Annual report on European SMEs 2021/2022. SMEs and environmental sustainability.

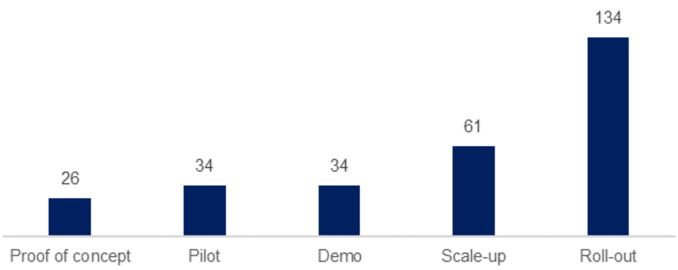
Figure 35: Number of mapped instruments per supported beneficiary by Country



Financing instruments by targeted TRL

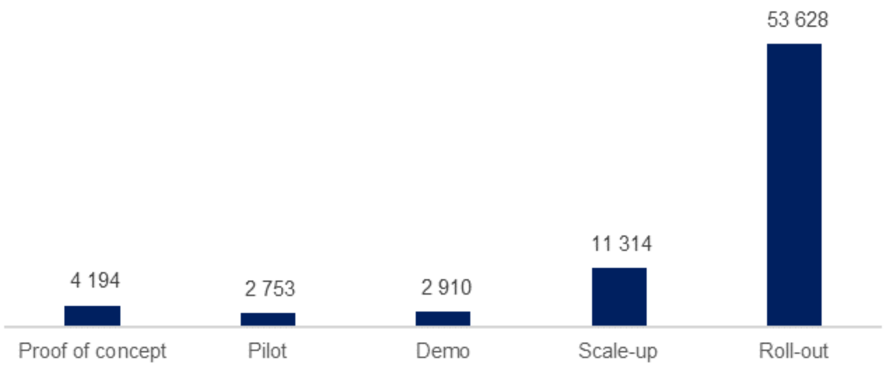
Financial instruments in energy storage target mainly projects that are mature and market-ready ("roll-out" stage). Most instruments target mature technologies and roll-out stage projects/activities and the availability of instruments decreases as the maturity stage decreases towards lower TRL and early-stage technologies. Indeed, about 49% of the identified instruments target roll-out stage and 22% are aimed at scale-up stages. This trend stays the same across the different types of instruments mapped. As it has been showcased in the previous chapter, programmes at EU level like the Innovation Fund or Horizon Europe have been put in place to provide financing for innovative but less mature technologies that would otherwise struggle to access financing opportunities in the market. Despite not being specific to energy storage, these programmes can also finance such types of projects.

Figure 36: Number of instruments per maturity stage



Nevertheless, based on the available data, about €4 billion are available by financial instruments targeting proof of concept stage and slightly less than €3 billion for pilot and demo stage. The trend in terms of volumes of financing understandably replicates the one of absolute number of instruments. Significantly higher volumes of financing are available for scale-up and – above all – roll-out stage projects/activities. Indeed, the latest stage alone receives more than double the amount of all the other stages combined, reflecting the higher amounts of financing needed to deploy a mature technology at scale.

Figure 37: Volume of financing per maturity stage (€ M)



WG Members suggested **that financial support schemes should be based on the additional storage capacity to be installed, rather than specific storage technologies or entities**. This approach would create a competitive environment among storage technologies and ultimately result in the most effective technologies being brought to the market.

4. Assessing the relevance and effectiveness of instruments

As referred to in Section 2.2, energy storage projects continue to face a series of barriers limiting the provision of financing and stemming from lack of stable revenue generating mechanisms, high technical risks or complex permitting frameworks.

This chapter focuses on the role financial support schemes can play in addressing investment barriers affecting energy storage investments, and attempts to assess, based on the mapping of financial support schemes conducted, to what extent existing instruments are effective. Contractual schemes such as PPAs, while useful in addressing revenue risks faced by storage projects, are not analysed under this chapter as they are contractual arrangements between two parties rather than financial products.

Section 4.1 provides more conceptual considerations and evidence from the mapping on the capacity of different types of instruments to address barriers. Indeed, not all barriers can be addressed through financial instruments and not all instruments address all barriers. Section 4.2 presents findings on instruments' effectiveness in addressing relevant barriers and reaching their objectives, drawing on evidence from the mapping and existing instrument evaluation studies.

4.1. Relevance of instruments in addressing investment barriers: theory and evidence

Theoretical considerations

This section focuses on the main types of instruments identified in the mapping. We present a conceptual analysis of their relevance for addressing different barriers to investment affecting energy storage projects, based on the way they function and their effects on the project's bankability. This framework will then be used in sub-section 4.2 to analyse the findings from the mapping.

Loans

As referred to in Section 2, the **emerging nature** of many storage technologies and the **lack of long-term visibility on revenue streams and remuneration models** limits the attractiveness of debt financing to the energy storage sector for a large range of risk-averse investors. In addition, banks typically require **historical data** to help assess counterparty risk, risk-weighted cost of financing and to inform the setting of financial covenants. In the case of energy storage projects and companies, such data is often limited, which constrains the scope of traditional bank lending to the sector[92].

Considering the above, **bank loans are mostly relevant for improving access to finance for high-TRL energy storage technologies and for storage projects with long-term capacity market contracts in place**. Tested technologies can offer some compensation against limited historical data of particular companies or their past projects, helping lenders establish sufficient comfort to offer debt to new projects. Lithium-ion batteries, for instance, have shown to be able to access commercial financing through project-finance modalities, as lenders have had time to acquaint themselves with this technology since it was first

[92] In relation to the availability of historical data for companies/projects in the energy storage sector, the US Department of Energy recently reported that only 14 utility-scale batteries have been operating for more than 10 years, not just in the US, but globally.

commercialized in the 1980s[93]. Debt financing can also be an efficient way to finance energy storage projects with long-term capacity market contracts in place, such as solar-plus-storage projects backed by long-term PPAs with regular capacity payments. Capacity deals resemble an availability type of construct, where, in order to earn revenues, the project owner simply needs to ensure having the battery on and available for use. As such, this type of contractual structure limits market risk and improves the long-term visibility of revenues, allowing bank lending to play an important role in **improving the financing options** for such energy storage projects.

Guarantees

Guarantees cover the risk of no payment to the money provider. They are relevant for improving access to finance and financing conditions for projects entailing high real or perceived risks, making them a particularly suited tool for crowding in investments for both commercial and emerging energy storage technologies.

As discussed in WG meetings, commercial scale storage technologies can display high market risks due to the absence of a capacity market in many countries able to provide stable long-term payments to storage projects. As a result, and as referred to in Section 2, the revenue streams of mature storage projects tend to be highly dependent on market prices (e.g., the Day Ahead Market), which are difficult to forecast in the long-term. This has the effect of restricting access to capital for commercial scale technologies, as investors tend to be reluctant to invest on fully merchant projects with no compensation for market risk. In relation to emerging technologies, their inherent technical risks and the limited examples of other such technologies operating in the market can also deter private investment unless there are adequate de-risking mechanisms in place. Lastly, young energy storage companies seeking financing at good terms can face difficulties convincing investors of their credit quality or of their ability to offer adequate collateral. WG members noted that these challenges are even more acute in the current market conditions. Inflation and high interest rates are further limiting the provision of financing at acceptable conditions ("credit crunch") for innovative and riskier companies in the storage sector.

In light of these market, technology and counterparty risks facing the sector, guarantees provided to financial intermediaries and covering default risks on underlying loans or equity can be particularly useful to crowd in private financing for energy storage projects, by helping to reduce the cost of capital and the risk profile of underlying investments. This, in turn, can allow banks or other intermediaries to provide larger amounts of debt or equity to energy storage investments, at lower cost/interest rates.

Guarantees can be individual or portfolio instruments, depending on whether the guarantee covers one specific investment/project, usually a large-scale one, or multiple, often smaller ones. Portfolio guarantees can be functional at **aggregating smaller-scale energy storage projects** that would otherwise struggle to access finance due to the small amount of financing they need. In the case of portfolio guarantees, a further differentiation can be found in how the risk is split in case of default of one or more investments in the portfolio. In the case of **pari passu guarantees**, the risk is shared between the guarantor and the intermediary on all investments based on a pre-determined allocation (e.g., 50%-50% or 60%-40%). In case of **first-loss portfolio guarantees**, the guarantor covers the risks of a first tranche of defaults within the portfolio based on a pre-determined coverage rate (e.g., 80% coverage on 20% of the portfolio). First-loss portfolio guarantees are particularly useful when developing **portfolios of projects with different levels of maturity**, as the intermediary will be more protected if less mature and riskier investments default (as they are more likely to default first).

[93] Norton Rose Fulbright, a leading law firm frequently acting as lenders' legal adviser in project-finance transactions, recently reported that c. 90% of energy storage transactions they take part in in the US involve lithium-ion batteries.

In relation to the nature of guarantor entities, **guarantees provided by public sector entities**, such as sovereign or regional governments, can be particularly effective in supporting private borrowers raise sufficient debt for new investments. A public sector guarantee can be a helpful tool to **attract private investors with a risk averse profile** towards new projects, as any losses would be at least partly covered by the public sector. By issuing a guarantee rather than contributing directly to the financing of an investment, the public sector avoids a **crowding-out effect** because of its intervention. In addition, for the public sector budget, a guarantee constitutes an **off-balance sheet instrument** which is not considered public sector debt as long as the revenues of the underlying project make it economically viable. This makes guarantees an **efficient tool** for governments to improve access to finance and financing conditions in target energy storage sectors, without the public authority having to disburse any public resources unless there is a case of default.

Equity

Equity instruments are relevant for financing high-TRL energy storage projects with revenue risks and for providing early- as well as late-stage financing for the development and scaling-up of disruptive (low-TRL) energy storage technologies, including manufacturing and deployment. Equity-type instruments expose equity providers to a higher degree of risk but also to potentially higher returns and can be tailored to support both mature and less established technologies in energy storage. As referred to in Section 4.1, equity instruments are well suited to finance **front of the meter** projects (e.g., various types of battery or pumped hydro installations) which have the potential to provide a number of ancillary services to support the grid, but which face a **high revenue and market risk** as they are not typically able to benefit from stable capacity payments. In relation to pumped storage hydropower (PSH), generally considered as a high-TRL technology, the high development and construction costs of PSH plants add to the financing risks of these investments, rendering public equity interventions a useful tool to mitigate risk for such type of large infrastructure projects[94].

Publicly supported equity schemes operating through funds-of-funds structures or providing direct stake participations in companies can improve access to capital for disruptive energy storage technologies, both during their early- and later-stage financing phases. Equity, along with grants, R&D funding and other de-risking instruments can support companies developing new technologies with having **sufficient cash flow to overcome the "valley of death"** as they reach the demonstration and first-of-a-kind phase of the technology lifecycle. Particularly for start-ups, whose ability to access commercial financing is restricted by their limited credit history, publicly backed equity schemes can offer necessary support to finance early-stage innovations until their economic returns are high enough to attract private investors.

In this respect, WG members have highlighted the relevance of the EIC Accelerator's dedicated investment window for energy storage, which will offer grants and direct equity investments in 2023 to energy storage innovations with a TRL of 6-9[95]. In addition, publicly supported equity schemes can **improve access to finance** for storage technologies that successfully reach commercial scale, and which require **growth-financing and larger tickets to compete on a global scale**. By crowding in venture capital funds, publicly supported equity schemes such as the EIBG's European Tech Champion Initiative (ETCI)[96] can help to maintain

[94] See example of recent PSH investment "Snowy Hydro 2.0" in Australia, a 2,000 MW/350 GWh project in which the Australian government made an AU$ 1.4 billion equity investment, or the case of Greenko, one of India's leading renewable energy companies, which received US$ 500 million in equity financing from the Abu Dhabi government and from Singapore's GIC in 2020 for the development of PSH hybrid projects in India.

[95] EIC Accelerator - Energy Storage investment window

[96] ETCI: European Tech Champions Initiative. It should be noted that this scheme is not specific to energy storage but rather has a broad scope of supporting European technology champions in their late-stage growth phase.

a **stable and sizeable flow of funding** to tech-driven companies as these continue to grow and develop. Intermediation through VC funds also opens the door for **institutional investors** and **corporates** to play a role in financing the scale-up of disruptive technologies, without having to develop expertise in the latest technological innovations in clean energy or other fields. A pure storage-VC fund was mentioned by WG members as an alternative means to increase availability of equity to storage companies.

Grants

Grants can be relevant in addressing a number of investment barriers, depending on the types of beneficiaries targeted and cost components covered. Grants like other forms of subsidies can be used to internalise externalities, which otherwise would not have been considered in investment decisions. These externalities can be of negative (e.g., climate externality) as well as positive (e.g., positive spill over effects) nature.

There are different types of grants that public authorities use to support energy investments, and which can support the deployment of energy storage solutions. The following paragraphs provide a description of some the most common types of support and the financing needs they address.

Investment/capital grants are usually provided to cover development costs, finance viability gaps and reduce the ultimate financing costs to increase projects' competitiveness. They are well suited to address **restrictions in access to finance** affecting emerging energy storage technologies, where private investors may be reluctant to invest due to a high degree of novelty and technology risks, uncertain revenues or high investment costs. In addition, private investors may not consider the **positive spill over effects** resulting from research, development and innovation in new energy storage technologies, leading to sub-optimal investment outcomes. In this case grants (whether stand alone or combined with other instruments) can provide a necessary financial incentive for the development and commercialisation of low TRL technologies until they are able to access commercial financing. In addition, investment grants can target **specific types of beneficiaries** with the purpose of encouraging economic investments from specific actors, such as SMEs or energy communities. In this sense grants also have an important **awareness-raising and market-signalling function** about relatively simple investments individuals and companies can perform to increase the deployment of energy storage, supporting a **greater citizen engagement** in local clean energy and storage solutions.

Interest rate or guarantee fee subsidies facilitate access of individuals and companies to existing lending or guarantee schemes. By improving the financing conditions of underlying financial products (loans, guarantees), such subsidies strengthen individuals' and companies' incentives for obtaining commercial financing for energy investments. This type of support can be particularly relevant for **smaller companies**, who may lack the ability or opportunity to negotiate bilaterally with banks the financing conditions of new loans they are interested in contracting.

Indirectly, grants covering project preparation costs, such as the costs needed to complete business plans, or to obtain necessary permits and licenses can also **address limitations in the planning and preparation capacity** affecting mainly smaller promoters who may lack the human capacities or internal financing capabilities to develop complex energy storage projects.

Bonds

Bond instruments are relevant for amplifying the sources of medium to long-term capital available to the energy storage sector. **Green bonds** in particular are a common type of bond instrument used to raise capital for climate-friendly projects and can be issued by sovereigns, NPBs, commercial banks or corporates directly. **By earmarking their proceeds** towards sustainable projects, green bonds can serve as an **important bridge** between providers of capital, such as institutional investors, and energy storage projects, whether these are carried out in a stand-alone way or as part of larger investment programmes combining investments in other segments of the energy value chain[97]. This type of capital market instrument can support the development of high-TRL energy storage technologies **by improving their access to medium to long-term and more diversified sources of capital**, complementing other sources of financing available to the sector.

Energy **storage projects are almost always financed as part of bigger renewable energy projects**, and it is rare to have storage-only companies issuing bonds. Storage projects are nonetheless aligned with the EU Taxonomy and their inclusion in companies' green financing frameworks is expected to increase.

The issuance of bonds, however, is expensive and requires dedicated technical and financial expertise, due to the efforts and costs they require in terms of rating, second-part opinions, monitoring and reporting. This is often something that smaller companies do not have, and thus makes bonds not particularly suited for smaller issuers. WG members noted that the use of "**basket bonds**", i.e., bonds that group in one single bond issuance different smaller companies. The use of green basket bonds for smaller innovative storage companies was identified during WG meetings as a possible solution that would require further analysis.

Blended finance

Blended finance instruments are a versatile tool that can support energy storage projects with easier access to private finance. Although the mapping did not include a large number of blended finance instruments, such instruments can help mobilise commercial investment towards energy storage projects, whilst limiting the use of scarce public resources only to the extent needed to crowd-in enough private finance. Blended finance interventions benefit from the possibility to be tailored to particular sectors and barriers (e.g., equity co-investment facilities providing growth finance to energy start-ups), making them a versatile tool to mobilise commercial financing towards priority energy segments and types of beneficiaries.

A blended finance instrument is typically developed by a public entity together with one or more private entities, where all involved entities pool their resources. The resources provided by the public entity are usually offered at below-market terms. Contrary to more standard financial instruments in which public resources crowd-in private ones after the launch of the instrument, in blended finance schemes private and public resources are combined since the creation of the instrument.

Common types of blended finance include below-market guarantees, concessional debt or equity combined with public grants. Blended finance is often also combined with technical assistance, to provide capacity building and knowledge-sharing to the beneficiary, to strengthen its commercial viability and support in the transaction preparation.

The main investment barriers for private investors addressed by blended finance are (i) high perceived and real risk, and (ii) poor returns for the risk relative to comparable investments. Blended finance aims at creating investable opportunities in developing market sectors, as well as in sectors with under optimal returns to attract sufficient private investments.

[97] See example of Recap Energy, a Swedish renewable energy project developer offering solar-PV and Battery Energy Storage Solutions and who recently issued one of the first green bonds (for €9 M) on a Commercial & Industrial solar power portfolio in Europe. Following this bond issuance, the company hopes to issue further securities in solar energy and energy storage in the coming years.

Technical Assistance

Technical assistance is relevant for improving the planning and preparation capacity of smaller energy storage project promoters and their ability to benefit from financial instruments. Technical assistance schemes identified through the mapping were primarily paired with loans or grants to SMEs, Midcaps or public sector entities and referred mostly to environmental impact assessments, feasibility studies or support on regulatory and policy matters.

TA can be particularly suitable for small developers, regional governments or energy communities lacking internal resources and specialised capabilities for project preparation and management. Dedicated assistance can help such promoters prepare a solid business plan for energy storage solutions that is ready to be submitted to investors, thus improving the investment readiness of local/regional energy storage projects and their ability to access external financing. Combining technical assistance with instruments such as loans or equity schemes can therefore facilitate the implementation and uptake of such instruments to support well-defined and more mature project proposals. EIT InnoEnergy could be considered a special case of TA, with services along the lines above and beyond (e.g. on governance, team, etc) offered against equity.

Evidence from the mapping

The mapping collected available evidence on the relevance of financial instruments for addressing investment barriers currently affecting energy storage projects[98]. For most instruments mapped, the instrument descriptions and guidelines would typically not refer to the investment barriers targeted. Therefore, for each instrument, its relevance for addressing barriers to investment was established/assessed based on the following sources of information:

- Instrument type: The instrument's type (e.g., loan, equity, guarantee) and typical functioning mechanism were taken into account to identify the investment barriers that are most likely to be targeted. To reduce the risk of self-confirmation bias based on the theory of instruments' relevance in addressing barriers, inferences made from the instrument type were contrasted with other sources of information (see following points).
- General description: Most instruments in the mapping came with a general description summarising the instrument's main features and eligibilities. Although usually limited in detail, some descriptions were able to provide insight on the investment barriers targeted by the respective schemes. This was mostly in the case of descriptions that explicitly referred to instruments' favourable financing terms, reduced collateral requirements or subordinated position, from which it was possible to infer the instrument's relevance for improving the financing conditions of underlying investments.
- Instrument-specific characteristics: In the case of instruments accompanied by more detailed guidelines, their relevance for addressing investment barriers was inferred from instrument-specific features that signalled relevance towards particular barriers. Some examples of such characteristics include:
    - **Targeted beneficiaries**: For instruments targeting beneficiaries who have not traditionally been key actors in the energy value chain, such as energy communities, it was generally possible to infer the instrument was promoting

[98] The set of barriers considered are those identified by WG participants as most relevant and presented in Section 2.3

greater citizen engagement in local clean energy solutions (e.g., generation and storage).

- **Targeted technology and innovation level**: For instruments targeting mainly newer technologies and innovative projects it was generally possible to infer instruments' relevance for addressing restrictions in availability of finance, which typically affect less-established technologies.
- **Eligible investments and project costs**: For instruments considering project and document preparation costs as eligible expenses covered by the instrument it was generally possible to infer instruments' relevance for supporting promoters' planning and preparation capacities.

However, some methodological caveats should be taken into consideration when reading the results presented below. The information presented in the graphs below should be interpreted as general trends rather than exact matches between instruments and specific barriers. This is because of two main reasons:

i) **Most instruments do not target only energy storage** investments, so the barriers identified as relevant may also be in relation to other segments of the energy value chain and particularly in relation to energy production, as 97% of instruments available to the energy storage sector also finance energy production investments.

ii) **Most barriers are correlated**, meaning that they are caused by intertwined conditions that might also lead to other barriers. For instance, a first-of-a-kind technology might face heavy regulatory barriers such as restricted access to energy markets due to such technology not yet being considered in the policy design of the Member State where it is being developed. At the same time, it might also present high technology risks, such as risks related to safety concerns, the lifecycle of the resource, or its efficiency. Furthermore, the technology might also be subject to worse financing conditions compared to other more mature technologies due to its inherent performance uncertainties or its perceived market risk. These three barriers all stem from the fact that the project is based on a new and innovative technology but are counted as different as they affect different aspects of the project. This of course poses challenges in the identification of barriers addressed by different instruments, as, from a theoretical perspective, addressing one barrier might also, indirectly and partially, address other barriers.

Financial instruments for energy storage investments target mostly investment barriers related to availability of finance, market risk and financing conditions of energy storage projects. The results of the mapping confirmed the expected relevance of instruments for these barriers, across all main types of instruments considered (see Figure 38 below). Around 85% of mapped instruments across the main instrument categories (loans, grants, equities and guarantees) address restrictions in the availability of finance and approximately 45% address restrictions in financing conditions. In relation to market risk, the mapping confirmed the relevance of guarantees in particular for tackling this barrier, with more than 80% of mapped guarantee instruments found relevant in dealing with this risk. Concerning the high number of mapped equity instruments found to address market risk, this could reflect the role of public equity schemes in de-risking new technologies and innovative demonstration projects. While investors may have some visibility on the future revenue stream of new storage technologies, unstable market prices may still pose a risk to future revenues and raise the risk profile of such investments. Publicly supported schemes, such as EIB's InnovFin Energy Demonstration could therefore be necessary to crowd in private investors and mobilise equity financing for emerging energy storage solutions.

Figure 38: Number of times investment barriers were identified as being "addressed" or "partially addressed" by the mapped financial instruments - by type of barrier

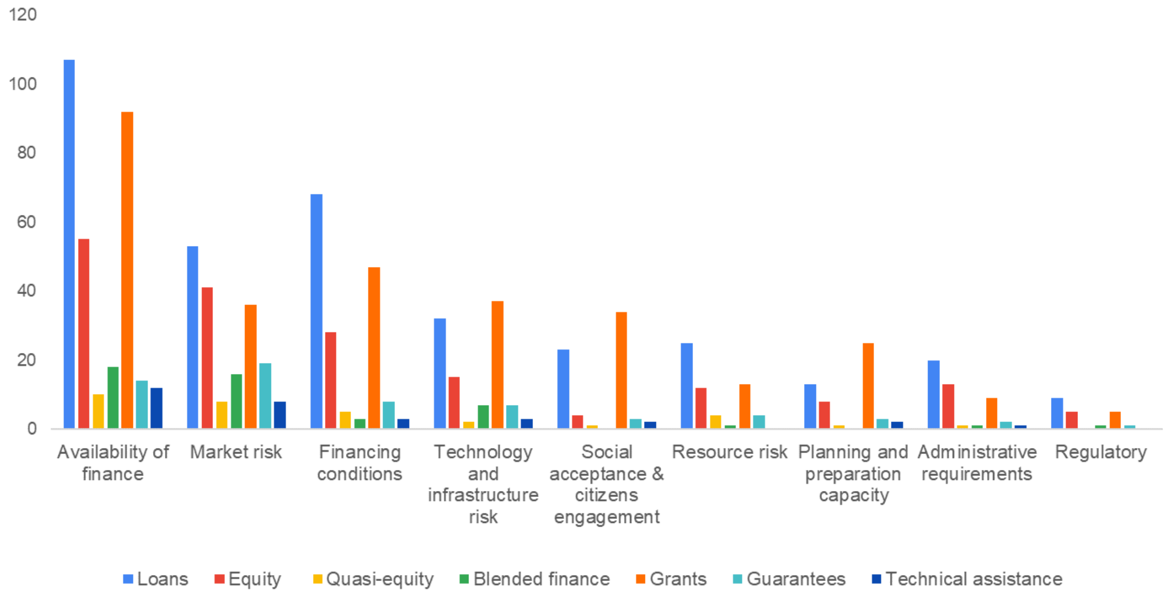


Table 3: Percentage of instruments mapped and identified as "addressing" or "partially addressing" particular barriers

	Availability of finance	Market risk	Financing conditions	Technology and infrastructure risk	Social acceptance & citizen engagem	Resource risk	Planning and preparation capacity	Administrative requirements	Regulatory risk
Loans	88%	43%	56%	26%	19%	20%	11%	16%	7%
Equity	89%	66%	45%	24%	6%	19%	13%	21%	8%
Quasi-equity	100%	80%	50%	20%	10%	40%	10%	10%	0%
Blended finance	95%	84%	16%	37%	0%	5%	0%	5%	5%
Grants	97%	38%	49%	39%	36%	14%	26%	9%	5%
Insurances & Guarantees	61%	83%	35%	30%	13%	17%	13%	9%	4%
Technical assistance	86%	57%	21%	21%	14%	0%	14%	7%	0%

Source: Mapping of financial instruments

Technology and infrastructure risk is mostly being targeted by grants, blended finance and guarantees, with an average of 35% of mapped instruments under these three categories addressing this barrier. For grants, this finding is in line with theoretical predictions they can be necessary to support research and development activities for new technologies in energy storage, where investors may be reluctant to finance the initial testing, validation and refinement stages of new technologies. Similarly, the findings support the theoretical prediction that guarantees can be helpful in de-risking energy storage investments, where the nascent nature of some innovations can reduce investor appetite for taking on technology risk in their investments. A similar reasoning (i.e., combination of de-risking and support to R&D) can be used to explain why blended instruments were found to address this barrier.

Social acceptance and citizen engagement is partially targeted through grants, but in general financial instruments are not the most relevant way of addressing this barrier. The identified examples were mainly in relation to schemes with broad eligibilities across the energy value chain and encouraging citizen participation in the energy transition, e.g., through RE renovations with the possibility to be complemented by energy storage installations in residences, commercial or public sector buildings. This finding is in line with theoretical predictions that grants can incentivise investments outside the household/company's usual business needs by improving the economic incentives for such energy investments. However, in parallel to financial incentives, improving the general public's understanding of energy storage as an essential enabler of the energy transition is likely to require broader information campaigns that help to demystify the sector for non-technical audiences, such as EASE's recent campaign[99] which successfully reached new audiences.

Resource risk also found some relevance in the mapping, particularly from loans[100] targeting this barrier. While loan funding can provide project developers with necessary cash flow to pay suppliers and secure raw materials for the construction of new energy storage plants, financial instruments are an insufficient tool to tackle this barrier effectively. Addressing shortages in key raw materials like nickel and aluminium needed for new energy storage infrastructure will require a more holistic policy response at EU level, where better access to finance for strategic supply chain projects is likely to be one of several measures needed to build more resilient supply chains[101].

As expected, financial instruments were not found relevant for addressing regulatory barriers or those related to lengthy administrative requirements. Regulatory barriers such as the need for long-term competitive remuneration mechanisms that will properly monetise the different services offered by storage technologies cannot effectively or efficiently be addressed through financial schemes, as they require policy and/or legislative changes to the framework governing the sector. Similarly, responding to the risks of long permitting procedures causing delays and cost-overruns for large storage facilities will require more targeted interventions at key bottlenecks of the permitting process, such as improving human capacities at the responsible public administration bodies.

The findings indicate there is further room for instruments combining technical assistance support to project promoters pursuing investments in energy storage. The barrier related to **planning and preparation capacity** was identified as being only modestly addressed by the mapped instruments. Grants were found to be the most relevant type of instrument for this barrier, although with only a 26% rate, likely to be composed of those grant scheme under which planning and preparatory costs are eligible. Nonetheless, the findings from the mapping suggest there is further room for financial schemes combining technical assistance support. TA could be targeted to small companies lacking internal capacities for project preparation, or to energy communities interested in producing, managing and consuming their own energy and for which practical business and legal support could be particularly beneficial[102].

4.2. Evidence on the effectiveness of financial instruments – Findings from the mapping

Effectiveness of a financial support scheme can be defined as the instrument's capacity to achieve its objectives and targets, intended as addressing barriers and market failures,

[99] EASE 2021 social media campaign #EnergyStorageMadeEasy

[100] Reference is made to loans rather than quasi-equity considering the four main instrument categories in the mapping (loans, guarantees, equity and grants).

[101] Critical Raw Materials Act _ securing the new gas oil at the heart of our economy I Blog of Commissioner Thierry _Breton.pdf

[102] See example of two recent initiatives by the European Commission providing technical assistance to energy communities: the Energy Communities Repository and the Rural Energy Community Advisory Hub

make a project bankable, mobilising additional financing, and contributing to the achievement of energy and climate objectives.

However, this type of assessment can be done only once the scheme has been fully deployed and when the projects that have received financing are completed. Since the mapping exercise covered only ongoing and recently closed financial schemes, only in very few cases there was an available analysis on instruments' effectiveness so far. Quantitative and qualitative metrics on the deployment and impacts of the schemes are not yet available. Data on resources disbursed, financing crowded-in, GW of new capacity installed and jobs created will likely be public only once mid-term and ex-post evaluations are conducted. This is not the case for the mapped instruments.

Given these limitations in data availability, the analysis of effectiveness has been structured around the factors supporting effectiveness, that is the characteristics and features that a financial support scheme can have that are functional to its effectiveness. These factors were defined based on consultations with WG members and other stakeholders from different Member States. During the WG meetings, **the three main factors identified as key for effectiveness are: broad and flexible scope of application, long-term stability and visibility, and accessibility**, intended as having an easy, periodic, and rapid application process, in turn leading to decreased time-to-money. Based on the findings from the mapping, it was possible to assess to what extent some of these factors are present in existing financial support schemes, and provide examples of effectiveness in addressing barriers to investment and in mobilising additional financing.

Enabling factors for instruments' effectiveness

Combination of different types of financing

During WG discussions, WG members noted that the **availability of a diversified range of financing solutions** is key for the effectiveness of financial support schemes. While the innovative, and thus riskier, nature of many storage projects make them more suited for grant support, WG members remarked how equity financing, bonds, and long-term loans should be used more to finance energy storage. Seamlessness of the offer for the benefit of beneficiaries was stressed.

Grant support still plays a very important role in financing energy storage projects. Grants are particularly useful to reduce CAPEX expenditures and reduce technology risk. However, to the extent possible, they should be **dynamic and linked to the variations in project costs,** according to WG members**.** Grant contributions are always fixed in value, but the project costs are not, such as is the case for the cost of raw materials and that of energy, both of which have experienced strong fluctuations in the last years. This leads to situations where the project that was bankable at the moment of the submission of the grant application is not bankable anymore when it receives the funding, due to costs changes. To effectively support innovative storage projects, grants should reflect real costs.

The market for long-term storage is still too immature and energy storage projects struggle to raise equity and debt financing. As evidence of this, **only three schemes were identified as energy storage-specific in the mapping**. Of these three, two are grants and one is a loan.

Name	Country	Implementing entity	Type	Budget (in € M)
Finland's battery cluster development	Finland	Ministry of Economic Affairs and Employment	Grant	300

Bordeaux Lithium-Ion Battery Storage (EDP)	France	EIB	Loan	16
Grants for innovative R&D on energy storage	Spain	IDAE	Grant	50

The lack of dedicated equity schemes could be explained by the fact that investment funds often have a broader investment strategy which includes but is not exclusive to energy storage. However, WG members noted that VC financing is key to support innovative storage solutions and its provision should be further increased and incentivised through **dedicated technical assistance and capacity building initiatives** (see more details below).

Similarly, the fact that **the only loan specific for storage is from a public institution (EIB)** could be a sign of the need to increase investors' risk-taking appetite through risk-sharing schemes, and the uncertainty around technology risks and long-term revenue generation disincentivise banks from providing finance. WG members advanced the proposal of **creating guarantees specific for energy storage projects and for low TRL technologies**. This would help tackling **revenue and technology risks** affecting energy storage projects.

A country-level analysis of the different instruments available for energy storage is presented in Section 5.

Long-term stability and visibility

The stability of the instrument over long-term, intended as both the regular provision of financing, and the lack of unforeseen changes occurring during the instrument's lifetime helps creating trust among investors, thus incentivising them to invest. Sudden and unforeseen changes would negatively affect investors' trust and confidence in the instrument, reducing their engagement with the instrument.

Furthermore, the process for ideating, developing and structuring a storage project is long and complex, and requires **project promoters to have visibility on the long-term conditions on which the project will be implemented**, so as to adequately plan their business and financial models. Even smaller changes in application requirements, eligibility criteria, or instrument functioning can derail the project preparation. While this point is true for most projects, it is even more important for energy storage ones, which often rely on very few revenue streams, as explained above in Section 2.

The necessity and risk-reducing effect of long-term visibility and stability is also recognised by the Commission[103]. The Commission identifies capacity contracts, floor and ceiling pricing, power purchase agreements, contracts for difference, energy attribute certificate, and power purchase agreements as relevant mechanisms to support long-term visibility.

Long-term stability and visibility can however only be assessed in the long-term. Since the mapping covered ongoing and new instruments, it was not able to capture this aspect. Nonetheless, this feature should be taken into consideration for the development of future new financial support schemes, as pointed out in discussions in the Working Group on energy storage.

Technical assistance and capacity building

The provision of TA and more broadly capacity building services, in combination with financial support schemes, are essential to enable a smooth growth and deployment of

[103] European Commission. Staff Working Document on energy storage. SWD(2023) 57 final. https://energy.ec.europa.eu/publications/staff-working-document-energy-storage-underpinning-decarbonised-and-secure-eu-energy-system_en

storage solutions across the EU, WG members stressed. This applies to both project promoters, investors, and local authorities in charge of planning and permitting.

Energy storage is an energy segment that requires a **high degree of technical expertise and specialised knowledge to design, implement and maintain**. Technical assistance and capacity building can provide energy storage project developers with the tools and knowledge they need to **navigate complex regulations**, evaluate technical feasibility, access funding opportunities, and develop sustainable and socially responsible projects.

The provision of TA, despite coming with a cost for the proponent (e.g., the public sector in the case of a public-support financial scheme), provides benefits that ultimately outweigh the costs by helping to:

- reduce the cost of capital;
- reduce the risk profile of the project;
- allow banks to provide larger debt with lower interest rates;
- allow business continuity.

An example of TA programme specific for storage is the World Bank's Energy Sector Management Assistance Program (ESMAP), which has been working to scale up sustainable energy storage investments and generate global knowledge on storage solutions in a selection of countries[104]. The TA package provided by the ESMAP notably includes **market assessments and roadmaps**, **project feasibility studies, risk assessments** and **study on legal and regulatory local frameworks.** The result of this was an **increase of investments in energy storage solutions**, starting with commitments from the World Bank.

4.3. Examples of effectiveness

Effectiveness in addressing barriers: evidence from the mapping and case studies

The mapping identified a number of financial support schemes with evidence on their effectiveness in addressing barriers, summarized in the table below. As the mapping concentrated on ongoing instruments for which there are no formal evaluations yet, evidence was primarily collected from available news and press releases reporting on instruments' results and impacts achieved so far, as well as feedback from stakeholders consulted in the process of data collection and the views of WG members shared in the context of the Investors Dialogue on Energy.

Grant or tax rebate schemes found to be effective have attracted a high number of applications and supported many projects. This suggests the schemes are effective in **strengthening the economic incentives** for energy storage investments, whether these are developed as stand-alone projects or as part of solar-plus-storage solutions. In the case of grants, which are disbursable instruments, a high interest by applicants also suggests the schemes concerned are relevant in **improving the availability of finance for target beneficiaries**. Examples identified through the mapping include Denmark's EUDP grant programme, which focuses on supporting innovative green energy technologies[105], or Austria's tax rebate scheme for small-scale solar-plus-storage projects, which already allocated EUR 40m to 11,000 projects in the first round of the scheme. These examples also

[104] World Bank Group, https://www.worldbank.org/en/results/2023/02/08/scaling-up-energy-storage-to-accelerate-renewables-esmap-s-energy-storage-program

[105] The case study in this section provides more details on the EUDP scheme and its achieved impact.

show the role grants and tax incentives can play in raising awareness and **stimulating greater citizen engagement** by actors such as homeowners or members of academia in local energy projects.

In relation to **loan instruments**, EIB's recent loan to solar energy company Amarenco for the development of a 105 MW battery storage asset is an example of an instrument with evidence of effectively supporting the deployment of pioneering battery facilities in Europe. As highlighted in press releases[106], the financing of this project represents an important milestone for the development of batteries in continental Europe, as it is **the first battery asset financed on a non-recourse basis in France to date.** The commitment from EIB in the form of a EUR 16m loan is expected to provide stability to the borrower's financing by including an anchor lender with a long-term investment view for c. 50% of the senior debt. The chosen financing structure included several financing mitigants[107] to accommodate the market risk of the project, which shows the role that **repayable instruments that are well-tailored to the specificities and risks** of energy storage can play in financing innovative and riskier projects in the sector.

In relation to **equity instruments**, the mapping identified three schemes with evidence of targeting barriers across different types of investments:

- Italy's IEFF II equity scheme specialises in energy efficiency, small-scale RE and in innovation and infrastructure for the energy transition and has been effective in **amplifying the available sources of capital** for sectors that have traditionally struggled to attract investment. The scheme's effectiveness can be seen through the Fund's raising of around €200 million by January 2022, above the initial target of €175 million. Supported by the EIB, the Fund has successfully mobilised capital from institutional investors and family offices and has already completed its first five transactions in companies active in different segments of the energy value chain. In relation to energy storage, the Fund has invested € 11 million[108] in Corre Energy, a company specialising in the development of hydrogen-based energy storage solutions.
- Estonia's Green Fund scheme targets **green technology companies** and seeks to address the **shortage in capital** for innovative green products, services and technologies. The scheme's eligibilities include energy storage solutions. Benefiting from a contribution of €100m in RRF funds, this instrument aims to increase the supply of venture capital to new green technologies by making investments via other venture capital funds or directly into innovative or research-intensive green technology companies. The scheme's effectiveness so far can be seen through the **interest it has generated among private fund managers**, who showed good responsiveness to the scheme's recent fund call, as well as from the **interest shown by start-ups for receiving direct investments** by the Fund[109].
- The Eiffel Transition Infrastructure fund[110] specializes in **larger renewable energy infrastructure projects** and provides a pioneering solution to **financing gaps during the project development phase.** The Fund provides equity or quasi equity bridge facilities to projects across the EU to finance project development activities (e.g., securing the land or designing the project engineering) which can take years and are capital intensive. The provision of this type of innovative financial product is expected

106 Baringa March 2023 press release

107 It was not possible to obtain information on the precise mitigants included in EIB's financing facility.

108 IEEF II invested € 11 million by subscribing to a convertible debt instrument, committing to invest up to € 15 million, increasable to € 20 million at its discretion.

109 SmartCap's recent call to select up to two private fund managers for establishing and managing green technology investment funds received six applications. In addition, SmartCap recently reported that just one month after the launch of the Greentech Investment Programme in October 2022, start-ups demonstrated considerable interest in SmartCap joining their investment round.

110 The Eiffel Transition Infrastructure Fund

to **accelerate the development** of RE and RE-plus-storage assets in Europe. The scheme's effectiveness so far can be seen through the commitments secured by several top tier institutional investors including the EIF (as sponsor of the initiative), Allianz, Abeille Assurances, and others. In addition, the scheme has already concluded its first inaugural investments, supporting the construction of solar assets in Ireland and solar-plus-storage agrivoltaic projects in Italy[111]

Effective bond instruments identified through desk research include recent convertible green bond or note issuances by French power producer Neoen and Sweden's battery developer Northvolt. In both cases, the bonds or notes were effective in **improving the diversification of capital sources available** for energy storage investments; Neoen's issuance of a 5-year security further improved the availability of **medium-term** financing available to the sector. Examples of eligible projects under Neoen's €300 M convertible green bond issuance include solar PV, wind power or energy storage facilities that comply with the company's green bond framework. The instruments' effectiveness can be seen through the **favourable terms** with which the issuances were completed (Neoen's bond conversion price was set at a premium of 35% above the reference price), as well as from the interest shown by **institutional and top-tier investors** (Northvolt's issuance attracted Volkswagen Group and Goldman Sachs Asset Management, among other investors).

Table 4: Mapped instruments[112] considered effective in addressing barriers

Instrument name	Instrument type	Instrument description	Member State	Barriers addressed	Evidence of Effectiveness
Energy Technology Development and Demonstration Programme (EUDP)	Grant	Grant scheme to support work by enterprises and universities on demonstration of new green energy technologies (renewables, energy efficiency, energy storage, hydrogen)	Denmark	Bridging initial financing gap for innovative projects	Applications for funding as of March 2022 more than three times the size of the grant pool.
Second round of solar-storage rebate programme	Subsidy (Tax rebate)	Tax rebate scheme for solar-plus-storage installations, where the PV installations shall be up to 10 kW in size	Austria	Establishment of sufficiently strong economic incentives for solar-storage installations; Improvement in citizen engagement	Number of projects supported in first round of call; need for a budget increase (from €20 M to €40 M) in second round of the programme
EIB Loan for Bordeaux Lithium-Ion Battery Storage	Loan	EIB loan to Amarenco Solar for developing 105MW lithium-ion battery storage asset in Gironde, France	France	Availability of long-term debt finance for energy storage facilities	High expected additionality and impact of the financing for the borrower and project

[111] Pacifico Energy Partners December 2022 press release. Agrivoltaic concepts refer to the simultaneous use of areas of land for both solar PV power generation and agriculture.

[112] Bond instruments included in this table were identified through press releases issued by Neoen and Northvolt and are not included in the mapping. Similarly, the Eiffel Infrastructure Fund (pan-European instrument) was identified through desk research and is not included in the mapping

Instrument name	Instrument type	Instrument description	Member State	Barriers addressed	Evidence of Effectiveness
Superbonus 110%	Subsidy (Tax rebate)	Mechanism of tax break for building renovations and energy requalification projects.	Italy	Favour the installation of PV systems combined with storage	In 2022 the Italian storage systems installed are 227.477 (152.075 at the end of 2021) of which 99.9% combined with domestic PV plants.
IEEF II – Italian Energy Efficiency Fund II	Equity	Closed-end alternative investment fund focused on energy transition projects.	Italy	Availability of equity financing for projects in energy storage and other innovative segments of the energy value chain	Fund achieved closing in Jan 2022 1.15 times above the initial target; successful completion of inaugural investments across energy value chain, including energy storage
Smartcap green technology investment fund	Equity	Investment programme for green technology companies, offering direct investments and investments in private venture capital funds	Estonia	Availability of private capital for innovative green technology companies, including energy storage	Number of applications received by private fund managers to the scheme's recent fund call; interest shown by start-ups for direct investments by the Fund
Eiffel Transition Infrastructure Fund	Equity	Innovative fund providing equity bridge financing for clean energy infrastructure assets in Europe	EU-level	Availability of bridge capital for RE and RE-plus-storage projects	Participation of top tier institutional investors to fund's first close and successful execution of inaugural investments
Neoen September 2022 green convertible bond issuance	Convertible bond	5-year green convertible bond to finance or refinance renewable energy production and storage projects	France	Availability of medium/long-term financing for renewable energy and storage projects	Strong investor demand, which resulted in the bond's conversion/exchange price being 35% higher than the reference share price
Northvolt July 2022 convertible note issuance	Convertible note	Convertible note to finance the company's factory rollout plans	Sweden	Availability of institutional capital for energy storage projects	Size of the capital raise (USD 1.1 bn); interest shown by large, diversified, and top-tier investors

Further insight on the role financial instruments can play in addressing investment barriers for energy storage projects can be gained from two additional case studies shown below. The first scheme concerns Denmark's EUDP programme included in the table above and for which additional information was obtained from an interview with an EUDP representative. The second case study looks at Northvolt in more detail, a Swedish company manufacturing advanced lithium-ion batteries and whose funding journey was supported by direct EIB financing before the company was able to autonomously raise finance from the markets.

Box 6: Case study on EUDP by the Danish Energy Agency

The Energy Technology Development and Demonstration Program, run by the Danish Energy Agency, is a structured funding program that each year provides technology-neutral grants to projects in the energy field. Since its establishment in 2007, it has supported **more than 1,000 innovative projects** with about DKK 5.7 billion (€765.6 million) on aggregate. Every year, there are **several cut-off dates for presenting projects**.

During an interview with an EUDP representative, it has been stated how the rationale behind this scheme and its longstanding success is to **help innovative projects in crowding in initial resources to accelerate the business** after selecting them based on nine criteria such as innovation height, climate-policy targets, and commercialisation potential. Given its success, **the programme has not seen many changes during the 15 years it has been operational**, proving the benefits of **long-term stability and consistency** in the public financing offer. The EUDP representative confirmed that the programme seeks to provide applicants with good predictability on the scope, financing model and next application deadlines candidates can expect, to ensure a good visibility of the instrument for interested projects.

The scheme has supported **multiple projects in the field of energy storage**, such as the development of large-scale electrical energy storage systems[113], of compact thermal energy storage solutions[114], or of latent isothermal flow battery for industries[115].

Over the time dedicated to the collaboration with EUDP, projects are expected to find a self-financed amount of money that is the same size of public funding. When the collaboration with EUDP is over, there is still the possibility to receive support from another public entity, namely the Danish Green Investment Fund, which however does co-financing through loans. Reaching the completion of the EUDP, it is expected that **projects can seek more and different types of funding** to get ready for the market. Those which have been in the program then perform better than their peers which have not in attracting further financial resources.

Source: PwC

The example from EUDP shows how long-term stability and visibility, evidenced by the scheme's limited changes since its launch, can support a financing scheme in reaching its objectives. Indeed, the programme has been successful in bridging the initial financing gap affecting innovative energy projects during their demonstration and early development phases, where market failures (e.g., imperfect information about the performance and risks of new innovations) are likely to be most acute. The case study is also a good example of how different publicly supported financing schemes, in this case grants and loans, can be complemented to assist a business through its different development phases until it is ready to access commercial finance from the market. The scheme's effectiveness can be seen through the high number of innovative projects supported to date, including solutions in energy storage, and from the observation that, by the end of the program, beneficiaries tend to perform better in attracting additional financing resources compared to projects that did not benefit from EUDP.

[113] EUDP.https://www.eudp.dk/projekter/uphs-storskala-elektrisk-energilagring

[114] EUDP.https://www.eudp.dk/projekter/deltagelse-samlet-iea-shc-task-67-es-task-40-compact-thermal-energy-storage-materials

[115] EUDP.https://www.eudp.dk/projekter/flowstore-latent-isotermisk-flow-batteri-til-industriel-damp

The second case study provides additional evidence on the role that loans, as opposed to purely or primarily grants, can play in enabling market-creating innovations in energy storage. Similar to EIB's recent loan to Amarenco for a battery storage project in France, the Bank's financing of Northvolt's factory expansion plans in Sweden was a key stepping-stone towards building a competitive and sustainable battery value chain in the EU. The case study is also a good example of the **role of guarantees** in unlocking bank financing to the sector, as EIB's support to Northvolt would not have been possible, or not to the same extent, without the EU guarantee covering the Bank's exposure to the project. Lastly, the Bank's provision of **technical and financing structuring advice** to Northvolt in addition to direct financing for the battery plant shows the role that **technical assistance** can play in improving the investment-readiness of innovative energy storage projects.

Box 7: EIB EFSI loan for Northvolt's Gigafactory in Sweden

Northvolt is a Swedish company founded in 2016 with the mission to build the **world's greenest battery**, with a minimal carbon footprint and high compatibility for recycling.

In 2018, Northvolt planned to build a large-scale lithium-ion battery manufacturing facility in Skellefteå in the north of Sweden. The intention behind the facility was for this to serve as the company's primary production site, hosting active material preparation, cell assembly, recycling and auxiliaries. The advanced batteries to be manufactured at the plant would be targeted for use in transport, stationary storage and industrial and consumer applications.

The EIB alone financed the company's first-of-a-kind demonstration plant in Västerås, which was an important milestone for the company to prove the commercial viability of its concept and to secure deals with key clients before establishing a large-scale factory in Skellefteå. EIB's loan to Northvolt in 2018 of up to €52.5 million was supported by the European Commission through InnovFin, under the Energy Demo Projects facility. The EIB investment also provides a crucial signal to the market of EU backing for the domestic batteries value chain.

As the company moved from demonstration to scale-up phase, the EIB provided a second **EFSI-backed loan to Northvolt in 2020 worth €384 million** to support the construction and operation of its Gigafactory in Skellefeå. The EIB financing was deemed necessary to address the **sub-optimal investment situation** faced by the company and stemming from **limited access to finance** and **high financing costs** charged by investors due to **high perceived risks**[116] **and lack of collateral**. Furthermore, EU support in the form of an **EFSI guarantee to EIB** was deemed necessary for the Bank to be able to provide a large loan ticket to Northvolt and the largest ever direct EIB financing for battery technology up to that point.

The EIB loan was effective in addressing those barriers, helping Northvolt finance the construction of its new factory, which is expected to be fully expanded by 2023 and to employ c. 3,000 individuals on-site by 2025. The Bank's support and early involvement in the project sent a strong signal to other project parties (equity as well as debt investors) about the viability of the company's storage technology and the company's own creditworthiness. Today the company is able to **raise finance autonomously from the markets**, as demonstrated by its recent issuance of €1.2 billion-worth of convertible notes, and ongoing discussions to access further €5 billion of debt financing from banks[117].

[116] Particular risks highlighted in the project's EFSI Operation Scoreboard included the project's exposure to the transformation of the automotive and energy storage industry, the possible rise in rival technologies and risk regarding the sourcing of feedstock for the cells.

[117] Reuters. Battery maker Northvolt in talks for over $5 billion in financing -FT. https://www.reuters.com/technology/battery-maker-northvolt-talks-over-5-billion-financing-ft-2023-03-26/

Source: Adapted from EIB website and Showroom Skelleftea, plus expert insights

Effectiveness in mobilising private finance

An important element of an instrument's effectiveness is its multiplier effect, that is the instrument's capacity to attract additional private financing compared to the instrument's initial public budget, and channel funds to the targeted projects. By crowding in and unlocking private financing, financial instruments aim to **increase the overall capital available** to achieve EU policy goals more efficiently[118].

Because an instrument's multiplier is usually only calculated as part of evaluations conducted at the end of the instrument's life, the mapping was able to provide very limited information on the achieved multiplier effects or amount of additional investment crowded in. Information on the current multiplier effect was available for only one loan instrument launched in 2021 and implemented by the Croatian Bank for Reconstruction and Development (HBOR). This instrument targets investments by micro, small and medium-sized private sector businesses under three broad categories (green transition, digital transition, and competitiveness and resilience) and has achieved a current multiplier effect of 1.18x[119]. This result is somewhat lower than the leverage or multiplier effect achieved by previous loan instruments implemented under ERDF/CF (leverage of 1.3x) or EIB's Covid 19 MBIL programme loan (multiplier of 1.9x). EIB's ABS Covid 19 programme loan was a higher-leverage instrument through which capital released from intermediaries' securitised portfolios could be used to generate new lending[120].

For what concerns the **target multiplier** of instruments in the sample, the table below compares the target multiplier for the main types of instruments in the mapping[121] against the achieved leverage effect for similar types of instruments implemented under ERDF and CF in the 2014-2020 programming period. It should be noted that, in most cases, the mapping considered the target multiplier as the ratio of target private finance attracted based on the amount of public financing. On the other hand, the achieved leverage effect for the instruments included below considers the total amount of finance reaching final recipients divided by the public (ESIF) support. As a result, target multipliers from the mapping are likely to have lower values compared to achieved leverage figures. The information presented below should therefore be used for general observations rather than for making exact comparisons on the effectiveness of current and past instruments. Grants have been excluded from this analysis as the intention behind grant support is not typically to generate simultaneous private co-

[118] In addition to the multiplier effect, impact indicators (e.g. tons of CO2 avoided, jobs created) are also important to assess the effectiveness of financial instruments. This section focuses exclusively on the multiplier effect as the mapping did not provide information on the impact generated by ongoing financial schemes. As such, this section should not be interpreted as a complete evaluation of the effectiveness of instruments in the mapping but rather as a presentation of findings related to their crowd-in potential. Crowding in of private funds in turn remains an important feature of financial instruments, as the initial public budget allocated to an instrument is typically not enough to cover all the investment costs and to ensure a timely deployment of the underlying target investment(s).

[119] It was not possible to verify the calculation of the multiplier.

[120] ERDF and CF loan instruments implemented from 2014-2020 (aggregate information across 451 instruments) achieved a median leverage of 1.3x as at 31 December 2020. An evaluation of the EIB L4SMEs intermediated lending product for the period 2005-2011 highlighted that loan products like L4SMEs generally provide for limited leverage potential and that leverage can be better achieved through higher risk products such as equity investments, or guarantee/risk sharing products (with higher risk and capital consumption). More recent EIB loan instruments implemented as a response to the Covid-19 crisis achieved multipliers (at mid-2021) of 1.89x (EIB Covid 19 programme loan for MBILs) and 6.81x (EIB Covid 19 programme loan for asset backed securities). It should be noted that the comparison with HBOR's instrument in the mapping does not focus on the instruments being energy-specific but rather being of the same type, in this case loan instruments. In addition, as calculation methods on the multiplier and leverage effect can vary across the literature, it is not possible to verify that HBOR's instrument and the examples identified in the literature all follow the same multiplier or leverage calculation methodology.

[121] Given the lack of instruments in the mapping dedicated exclusively to energy storage, the instruments considered in this analysis are those identified as being available for storage investments, among other possible investments/eligibilities.

investment but rather to cover part of the costs of the project and support early-stage projects so that they can access private investment at a later stage.

Table 5: Average target multiplier by type of instrument in the mapping

Type of financial instrument from mapping	Average target multiplier from mapping	Median achieved leverage as at 31 Dec 2020 – financial instruments under ERDF/CF[122]
Loans	1.64x[123] (based on 16 instruments with available target multiplier)	1.3x (based on 451 instruments)
Equity	1x (based on 1 instrument with available target multiplier)	1.8x (based on 211 instruments)
Guarantees	1.82x (based on 8 instruments with available target multiplier)	4.8x (based on 87 instruments)

Loan instruments in the mapping show on average a multiplier target that is slightly higher than the median leverage achieved by ERDF/CF loan instruments until 2020. This could signal a good potential for current active loan schemes to mobilise private capital for energy projects, although such potential could differ depending on projects' position in the energy value chain (i.e., the multiplier may be reflecting primarily crowd-in expectations for energy generation investments). Alternatively, results could also be influenced by the fact that many instruments in the mapping were developed during or right after the pandemic, which was characterised by increased bank lending to businesses[124] and a successful avoidance of a credit crunch. These observations may have positively influenced the expected crowd-in potential of new loan instruments.

The target multiplier of the mapped equity scheme with information on this variable and covering energy and digital infrastructure investments in Bulgaria is slightly lower than the leverage effect achieved by ERDF/CF equity schemes. The mapping identified one equity scheme – Bulgaria's *Economic Transformation Programme: Fund 3* – whose eligibility includes, among other investments, projects in energy storage infrastructure, and which has an expected multiplier effect of 1x. This lower target multiplier compared to ERDF/CF equity schemes identified in the literature could be due to differences in the multiplier vs. leverage calculation methodologies referred to above or due to the younger nature of Bulgaria's venture capital ecosystem compared to other European countries[125], which can limit opportunities for significant private co-financing in the form of equity.

Finally, guarantee schemes in the mapping with eligibilities that include energy storage have a lower target multiplier than the leverage achieved by ERDF/CF guarantee schemes under the previous Multiannual Financial Framework. In addition to differences coming from multiplier and leverage calculation methodologies, this could signal some constraints in the current use of guarantees to mobilise large volumes of capital for energy projects, or that guarantee schemes for energy are designed for riskier projects which may struggle to attract high levels of investor appetite.

[122] European Commission (2021). Financial instruments under the European Structural and Investment Funds – Summaries of the data on the progress made in financing and implementing the financial instruments for the programming period 2014-2020.

[123] In the case of instruments presenting a numerical range for their targeted multiplier e.g. 1.4-2x, the calculation of the average considered midpoint values (1.7x in given example). Combined loan/guarantee instruments were taken into account both for the calculation of the average target multiplier for loans and separately for guarantees.

[124] At the euro area level, outstanding loans to the non-financial private sector stood at €12.6 trillion before the pandemic crisis, and they increased by approximately 7% by the end of 2021 (European Stability Mechanism, 2022).

[125] Recent analysis shows that with around EUR 60 VC funding per capita, Bulgaria ranks fifteenth in the European funding per capita rankings (The Recursive, 2022).

Summary findings on instrument relevance and effectiveness

- **Evidence from the mapping on the relevance of financial instruments for addressing investment barriers** affecting energy storage projects indicates that**:**
    1. **Financial instruments for energy storage investments are primarily relevant for targeting investment barriers related to the availability of finance, financing conditions and market risk of energy storage projects**.
    2. **Financial instruments are not relevant for addressing regulatory barriers or those related to administrative requirements**. A similar situation can be said to apply to the barriers related to **resource risks**, which are caused by elements outside the financial market landscape, despite affecting it.
    3. **The mapping seems to suggest that there is further need for schemes combining the provision of finance with technical assistance support.** This should support in further tackling barriers related to the execution of complex storage projects and to limitations in promoters' **planning and preparation capacity.**
- **Examples of mapped instruments found to be effective in addressing barriers include grants and tax rebates, EIB direct loans, equity schemes, and convertible bonds/notes**[126] **in a number of EU Member States.** In general, evidence of the schemes' effectiveness could be seen from their **well-tailored features** for addressing the inherent risks of storage investments and from the direct interest **shown by the target beneficiaries or investors** in the different schemes. More specifically, and considering the different types of instruments mapped:
    1. For grant and tax rebate schemes, evidence of their effectiveness in improving availability of finance and the economic incentives for target recipients was seen through a **high number of applications**[127] **and a high number of projects supported** under such schemes**.**
    2. In the case of EIB's recent loan for a battery storage project in France being developed under an innovative business model, the Bank's financing has a high expected **additionality and impact** thanks to the **stability it is expected to provide** to the borrower's financing and the **strong signalling effect** it is expected to have about the bankability of battery storage assets developed on a merchant basis.
    3. For equity schemes, evidence of their effectiveness in improving the availability of equity financing for storage technologies was seen through the schemes' **successful fundraising and inaugural investment activities**, or, in the case of more recent schemes, from the **active interest shown by private investors and start-ups** to co-invest or receive direct investment under the schemes.
    4. In the case of convertible bond and note issuances, evidence of their effectiveness in amplifying medium/long-term finance and institutional capital for storage projects was seen through **strong and diverse investor demand for the issued bonds.**
- **The mapping provided limited information on the multiplier effect (current or target) of currently active financial instruments.** Loan instruments from the mapping show on average a target multiplier that is slightly higher than comparisons

[126] As referred in Section 4.2., bond instruments were identified through separate desk research and are not included in the mapping.

[127] While the number of applications alone is not sufficient to define the effectiveness of a grant, it is nonetheless essential to define its uptake, attractiveness and visibility in the market, which are key elements of effectiveness.

from the literature, which could signal a good potential for current active loan schemes to mobilise private capital for energy projects, although not exclusively for energy storage investments. The mapped equity scheme with information on its target multiplier showed slightly lower results than examples from the literature, while guarantee schemes showed the highest deviation (i.e., lower target multiplier results) compared to examples from the literature. In addition to differences coming from multiplier and leverage calculation methodologies, this could signal some constraints in the current use of guarantees to mobilise large volumes of capital for energy projects, or that guarantee schemes for energy are designed for riskier projects which may struggle to attract high levels of investor appetite.

5. Market maturity

This section analyses the **level of maturity of finance markets specific to energy storage** across EU Member States.

NECPs are the main document in which Member States detail and list their objectives, targets and estimated investment needs in the coming years in the different sectors related to energy and climate. However, unlike for energy production (WG1) and transmission and distribution (WG2), NECPs have not set quantitative targets for energy storage, neither in general nor for specific energy storage types of technologies. As a result, market maturity cannot be directly assessed regarding such explicit targets. In addition, **energy storage comprises a variety of technologies with very different levels of maturity**, ranging from mature technologies with a rather limited potential for expansion, such as pumped storage hydropower[128], to less mature technologies that are still in the development / demonstration / upscaling stage. As a result, the finance streams differ significantly from one technology to another. Moreover, these different technologies come with various unit costs[129], which are likely to fluctuate due to progress in the technological development process or due to variations in resources cost.

As a result, **there is no precise assessment of the total investment needs for energy storage**.

Table 6: Types of technologies[130]

Type of storage	Examples of technologies
Electrochemical	• Batteries (Sodium-based, Flow, Lithium-Ion, Lead-acid, …)
Mechanical	• Pumped hydropower energy storage • Compressed Air Energy Storage • Gravitational storage
Thermal	• Thermal Hot Water Storage
Electrical	• Super-capacitors
Chemical	• Hydrogen • Methane • Ammonia

The section is organised as follows:

- Section 5.1 details the chosen methodology and indicators to assess the level of maturity of finance markets specific to energy storage, while accounting for the specificities of energy storage
- Section 5.2 shows the considered data and presents the results of the analysis

[128] WWF 2019, Hydropower pressure on European Rivers: the Story in Numbers, available at: https://wwfeu.awsassets.panda.org/downloads/hydropower_pressure_on_european_rivers_the_story_in_numbers_web.pdf

[129] IRENA 2017, Electricity storage and renewables: Costs and markets to 2030, Available at: https://www.irena.org/Publications/2017/Oct/Electricity-storage-and-renewables-costs-and-markets

[130] EASE 2023, Technologies, available at: https://ease-storage.eu/energy-storage/technologies/

5.1. Approach to assessing market maturity

While there are no estimated investment needs or storage-specific targets, the European Association for Storage of Energy (EASE) stated in a 2022 study that the EU needs to increase its storage capacity by at least 14 GW/year to reach a total of approximately 200 GW in 2030. This would be necessary to match the increase in energy production from renewable yet intermittent sources.

In this context, the **maturity of finance markets specific to energy storage** was assessed based on Member States' hypothetical contribution to the estimated yearly increase needed by 2030. These contributions were assumed to be proportional to each MS's renewable energy production targets in 2030 (i.e., Member States with higher RES production targets will contribute more to the achievement of storage capacity by 2030). In particular, this has been done considering the criteria and indicators presented in the following table:

Criteria	**Description** *Why we have chosen this characteristic*	**Key metric/indicators** *How we will measure it*
Sufficient supply of finance for investments in energy storage	• Historical levels of investment related to energy storage can help assess the supply of finance.	• Eurostat provides aggregate data on annual **gross investment levels by enterprises** for each EU MS. Data is available for the manufacturing of electrical equipment (NACE code C27), which contains the manufacturing of batteries and accumulators. • However, there is a limited availability of aggregated data on past investment levels for energy storage in general or for specific technologies. As a result, two indicators exploiting available data on the manufacturing of batteries and accumulators and on hydrogen projects have been selected. • In addition, the **EIA's Clean Energy Demonstration Projects Database** provides investment data on **major hydrogen projects** that were announced.
Overall availability of finance	• Best (2017)[131] finds that the availability of financial capital contributes to investments in more capital-intensive energy technologies in the energy transition. • Moreover, several of the considered technologies must still go through development, upscaling or optimization.[132] Therefore, the overall supply of finance for innovation can help better understand the differences among MS in terms of availability of finance for	The overall availability of finance in each Member State is measured through: • **Banking debt of corporates** • **Stock market capitalisation** • **Green bond market** • **Public finance** In addition, the European Investment Scoreboard provides national scores when it comes to **public and firm investment in R&D and innovation**.

[131] Best R (2017) Switching towards coal or renewable energy? The effects of financial capital on energy transitions. Energy Econ 63:75–83. https://doi.org/10.1016/j.eneco.2017.01.019

[132] European Commission, Why the EU supports energy storage research and innovation, available at: https://research-and-innovation.ec.europa.eu/research-area/energy/energy-storage_en

Criteria	**Description** *Why we have chosen this characteristic*	**Key metric/indicators** *How we will measure it*
	energy storage.	
Low cost of capital - WACC	• The WACC incorporates the level of interest rates and several country risks, such as regulatory, economic, political and legal. Furthermore, WACC can also reflect technological advancements and increased experience in the energy financing sector, signalling a high level of maturity. • For these reasons, low values of WACC signal mature finance markets and a low country risk.	To evaluate the **cost of capital**, WACC values have been calculated for each Member State for a selection of industry sectors that are connected to most of the considered energy storage technologies (specialized chemical industry, electrical equipment, green and renewable energy, power and semi-conductor). Industry-specific inputs for the computations have been taken from Damodaran's website database.[133] The obtained values have then been aggregated for each EU MS through a simple average.
Presence of a diverse set of financial instruments, including the targeted use of grants	• Finance markets that come with a broader and balanced diversity of financing instruments may be considered as more mature. • In addition, grants can play a pivotal role when used in a targeted way that supports innovation and riskier projects rather than technologies that are already in a rollout stage.	Comprehensive data on the instruments used for investments in energy storage technologies is not available. However, the mapping of financing instruments enables an assessment of their diversity and targeted use in each country, using the following indicators: • **Diversity of financing** instruments for energy storage technologies, measured through a repurposed use of the Herfindahl-Hirschman Index (HHI) • **Percentage of grants** and in particular share of them that are open for rollout stage projects

5.2 Estimated increase needed in energy storage capacity

As a reference-point, the table hereunder provides an **estimate of the increase needed in energy storage capacity (in GW) per EU MS to 2030**. These estimates were computed as follows:

- Renewable Energy generation targets (in %) and Final energy consumption targets (in Mtoe) from the Member States' NECPs[134] were combined to derive the Renewable generation target (in Mtoe) for 2030.
- This value is one of the main driving factors in the need for additional energy storage capacity to make networks more flexible and balance energy production and supply,

[133] Available at: https://pages.stern.nyu.edu/~adamodar/

[134] The current version of the NECPs (as of June 2023) was approved in 2019, and, therefore, does not include new investment needs and targets stemming from REPowerEU. The revised NECPs should be approved in 2024 and are expected to significantly increase investment needs, planned investments and raise the targets reflecting FF55 and RepowerEU.

as renewable energy sources such as wind or solar energy are intermittent. The yearly increase estimate from EASE amounts to 14 GW for EU as a whole.

- This yearly increase was distributed among EU MS for the 2022-2030 period, with the simplifying assumption that energy storage capacity would overall be proportional to Renewable Energy generation capacity.

The latter assumption can be discussed, as not all countries start with the same situation in terms of energy storage capacity. However, the resulting capacity increase estimates help to better understand the magnitude of efforts needed for each MS, which can serve as a reference-point to compare the maturity of national finance markets specific to energy storage.

It should be noted that the Table below indicates the estimated storage capacity increase need proportional to and based on countries' renewable energy targets. The estimation does not consider whether this need is planned to be tackled through measures of the NRRP or NECP. Therefore, higher values on the right column in the Table below simply indicate a higher need for the country to increase storage capacity based on the country's RES targets, and not a larger gap that is not covered. Some countries are already planning to surpass the estimated need to increase capacity. Italy, for instance, in its NECP details plans to increase its storage capacity by at least 10.5 GW (6 GW of new storage systems and 4.5 GW of storage systems coupled with distributed systems) against the 8.7 GW-need estimated in the Table below. However, the vast majority of NECPs do not detail specific storage targets or values, thus making this comparison not possible for most Member States.

Table 7: Estimates of the needed increase in energy storage capacity to 2030

Country	RE 2030 target (%)	Final energy consumption 2030 target (Mtoe)	Energy storage capacity increase need to 2030 (GW)
Austria	48%	25.6	3.4
Belgium	40%	35.2	4.0
Bulgaria	27%	10.3	0.8
Croatia	36%	6.9	0.7
Cyprus	23%	2	0.1
Czech Republic	22%	23.7	1.5
Denmark	55%	15.8	2.4
Estonia	42%	2.9	0.3
Finland	54%	25	3.8
France	33%	120.9	11.2
Germany	80%	185	41.5
Greece	35%	16.5	1.6
Hungary	21%	18.8	1.1

Country	RE 2030 target (%)	Final energy consumption 2030 target (Mtoe)	Energy storage capacity increase need to 2030 (GW)
Ireland	80%	11.2	2.5
Italy	30%	103.8	8. 7
Latvia	50%	3.6	0.5
Lithuania	45%	4.5	0.6
Luxembourg	25%	3.06	0.2
Malta	12%	0.7	0.0
Netherlands	27%	43.9	3.3
Poland	23%	67.1	4.3
Portugal	47%	14.9	2.0
Romania	31%	25.7	2.2
Slovakia	19%	10.3	0.6
Slovenia	35%	4.7	0.5
Spain	42%	73.6	8.7
Sweden	65%	29.67	5.4

Sources: 2030 targets extracted from NCEPs[135], Energy storage increase computed using EASE's 2030 target[136]

5.3 Analysis of market maturity

This section provides an assessment of the level of maturity of energy storage-specific finance markets across EU Member States, based on the four dimensions previously presented.

Overall investment level in energy storage technologies

As was previously mentioned, the availability of aggregate data for energy storage at EU MS level is limited. The same goes for technology-specific data. Nevertheless, Eurostat and the

[135] European Commission, NECPs, available at: https://energy.ec.europa.eu/topics/energy-strategy/national-energy-and-climate-plans-necps_en. It should be noted that current NECPs were approved in 2019, before the Covid pandemic and the energy crisis, and, therefore, do not take into consideration the changed energy landscape. Revised NECPs will be approved in 2024 and will provide updated figures.

[136] EASE 2022, Energy Storage Targets 2030 and 2050: Ensuring Europe's Energy Security in a Renewable Energy System, available at: https://ease-storage.eu/publication/energy-storage-targets-2030-and-2050/

EIA provide data pertaining to batteries and hydrogen that can feed **two proxies of the investment level in energy storage technologies.**

Enterprise investment in manufacturing of batteries and accumulators

Eurostat provides aggregate data on annual **gross investment levels by enterprises** for each EU MS. Data is available for the **manufacturing of electrical equipment** (NACE code C27)[137], which contains the manufacturing of batteries and accumulators (NACE code C27.2)[138].

Table 8 shows the average annual gross investment level for each country over the 2016-2020 period. Although the manufacturing of electrical equipment encompasses other activities than that of batteries and accumulators, the obtained average still enables a comparison across EU MS.

Funding for major hydrogen storage projects

The **EIA's Clean Energy Demonstration Projects Database**[139] provides information on **major hydrogen storage projects** across the world. With the last update (September 2022), 92 projects are listed worldwide, of which 38 in a limited number of EU MS (Austria, Denmark, Finland, France, Germany, Italy, Netherlands, Portugal, Spain and Sweden). Although the EIA database may not be exhaustive and may not exhaustively cover hydrogen-related R&I funding, the concentration of major hydrogen storage projects in a limited number of EU MS may suggest a higher investment level than in EU countries that do not appear in the database. In addition, the database provides the total funding for some of the projects, or at least the corresponding amount of public funding. The table hereunder includes the number of projects listed in the EIA database, as well as the total funding, when available.

Table 8: Metrics for investment levels in batteries (Eurostat) and in hydrogen storage (EIA).

Country	Average enterprise annual gross investment in electrical equipment manufacturing as % of GDP	Number of hydrogen storage projects listed in the EIA database	Proxy of the corresponding funding for hydrogen storage (USD million)
Austria	0.11%	1	N/A
Belgium	0.03%	0	-
Bulgaria	0.16%	0	-
Croatia	0.06%	0	-
Cyprus	N/A	0	-
Czechia	0.27%	0	-
Denmark	0.02%	1	N/A
Estonia	0.07%	0	-
Finland	0.05%	2	110.0*

[137] Eurostat, Annual enterprise statistics for special aggregates of activities (NACE Rev. 2), available at: https://ec.europa.eu/eurostat/databrowser/view/SBS_NA_SCA_R2__custom_5850802/default/table?lang=en

[138] European Commission, List of NACE codes, available at: https://ec.europa.eu/competition/mergers/cases/index/nace_all.html

[139] EIA, Clean Energy Demonstrator Project Database, Sector: Hydrogen, last updated September 2022, available at: https://www.iea.org/data-and-statistics/data-tools/clean-energy-demonstration-projects-database?subsector=Hydrogen

Country	Average enterprise annual gross investment in electrical equipment manufacturing as % of GDP	Number of hydrogen storage projects listed in the EIA database	Proxy of the corresponding funding for hydrogen storage (USD million)
France	0.05%	6	4.9*
Germany	0.10%	11	131.6*
Greece	0.03%	0	-
Hungary	0.54%	0	-
Ireland	0.00%	0	-
Italy	0.06%	1	9.0
Latvia	0.05%	0	-
Lithuania	0.03%	0	-
Luxembourg	0.01%	0	-
Malta	0.02%	0	-
Netherlands	0.02%	9	3,110.7*
Poland	0.24%	0	-
Portugal	0.07%	6	550.1*
Romania	0.16%	0	-
Slovakia	0.22%	0	-
Slovenia	0.38%	0	-
Spain	0.04%	1	12.2*
Sweden	0.03%	1	39.9

** Total funding data was not available for all projects. In some cases, only the share of public funding was available. The displayed sums reflect only available data.*

Source: Eurostat (Gross investment data and GDP), EIA (Hydrogen projects data)

Overall availability of finance

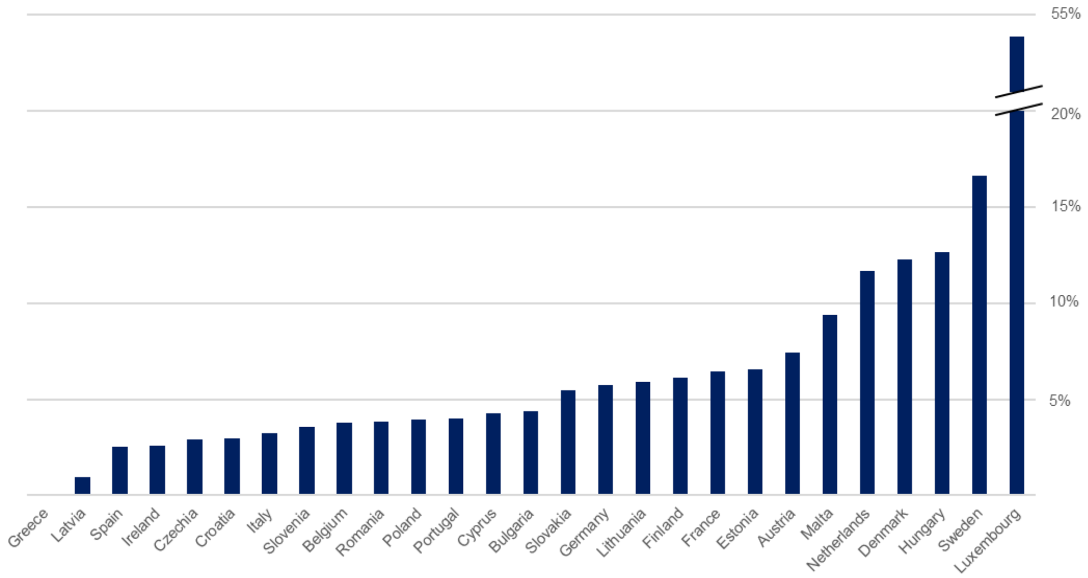
Considering the variety of technologies for energy storage as well as the diverse stakeholders (public authorities, TSOs, DSOs, innovative private firms, etc.) involved in the increase of energy storage capacity, there are many potential financing sources. Consequently, **an overall healthy financial system makes it easier to address investment needs or to diversify financing sources** for the increase in energy storage capacity. This is assessed here through bank financing, stock market capitalisation, issued green bonds and public financing.

Moreover, as many energy storage technologies are not yet mature, the indicators provided by the European Innovation Scoreboard about **finance and support to innovation** (indicator 2.1) and **R&D expenditure in the business sector** (indicator 2.2.1) can help grasp the availability of finance for innovation in general and therefore for innovative energy storage technologies in particular.

Bank financing

Bank financing is the main source of external finance for firms in general in the EU. Data from EIBIS 2021 shows that, on average, bank loans represented 59% of external funding for companies in the EU. An adequately high, but sustainable, stock of debt to non-financial corporates can be an indicator of a well-functioning banking system. In countries where the banking system is in distress or constrained by high cost of financing or high ratios of non-performing loans, financial institutions will limit their lending to corporates and households, therefore increasing pressure on other sources of financing. The indicator "Debt securities and loans of the private non-financial sector as a ratio of GDP, 2021", reported by the European Central Bank, can be used as an indicator of the amount of credit and debt financing that firms in general can access in each Member State, which is one of the financing streams that can support the increase in energy storage capacity in the EU.

Figure 39: Debt securities and loans of the private non-financial sector as a ratio of GDP, 2021



Source: European Central Bank[140]

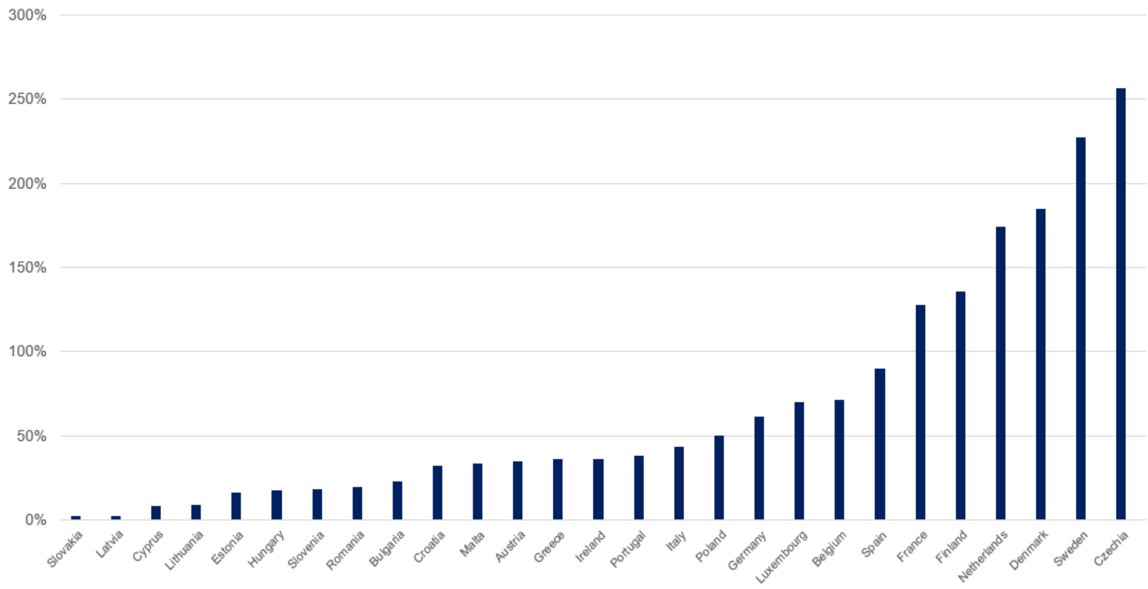
Stock market

The stock market capitalisation of each Member State, divided by their GDP, is generally used as a measure of under – or – over-valuation of a country's stock market[141]. For the purpose of the analysis, it can be directly used as an indicator of access to equity capital markets, which is one of the main potential sources of financing for the increase of energy storage capacity.

[140] Available at: Link

[141] Stock Market Capitalization-to-GDP Ratio: Definition and Formula, available at: Link

Figure 40: Stock market capitalization as % of GDP (2021)



Source: CEIC[142]

Green bonds

The volume of issued green bonds is another element that can help assessing the access to capital markets for financing the energy transition, including energy storage technologies such as batteries, pumped hydropower, power-to-hydrogen, power-to-ammonia, underground thermal energy storage, or aquifer energy storage.[143]

According to data from the Climate Bonds Initiative[144], energy represents on average 44% of the use of the proceeds of green bonds issued in Europe, between 2014 and the first half of 2022, equivalent to over USD 32 billion. Unfortunately, publicly available data does not enable to look into details and see which share of green bonds is actually used to finance energy storage technologies.

The chart below shows the stock of green bonds (in USD millions) in 23 EU countries[145] issued as of the first half of 2022 as share of their GDP[146]. This analysis allows to compare bond issuance to the relative size of a country's economy. Larger Member States have issued more Green bonds than smaller ones, but such larger issued amounts might represent a smaller share of that country's GDP. For instance, Germany and France are the two countries with the highest issued amounts, but rank 7th and 4th, respectively, if ranked by issuances as share of their GDP. Italy has the 6th highest issued total amount, but ranks only 14th if the issued amount is assessed proportionally to Italy's GDP. Luxembourg is the country with the highest Green bond issuance if assessed in relation to its GDP, despite being 11th in terms of absolute amounts.

142 Available at: https://www.ceicdata.com/en/indicator/market-capitalization--nominal-gdp

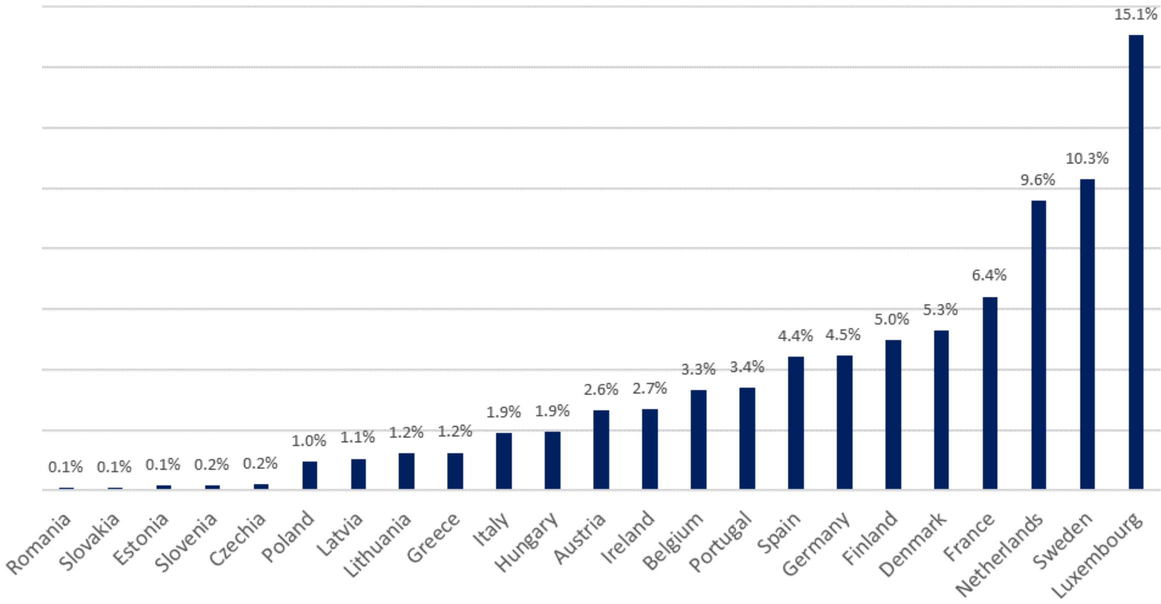
143 Commission Delegated Regulation (EU) 2021/2139 of 4 June 2021

144 Available at: https://www.climatebonds.net/market/data/#use-of-proceeds-charts

145 Green Bonds data have been extracted by the Climate Bonds Initiative database, which did not include all EU-27 countries. Available at: https://www.climatebonds.net/market/data/#use-of-proceeds-charts

146 World Bank data on GDP per capita data (USD current, 2021). Available at: Link

Figure 41: Ratio between Green Bond market size (USD million, as of H12022) and GDP (USD, 2021)



Source: Climate Bonds Initiative[147], The World Bank[148]

Availability of public finance

The increase of energy storage capacity involves a variety of stakeholders which can benefit from public financing, such as TSOs and DSOs, as well as specialized innovative firms.

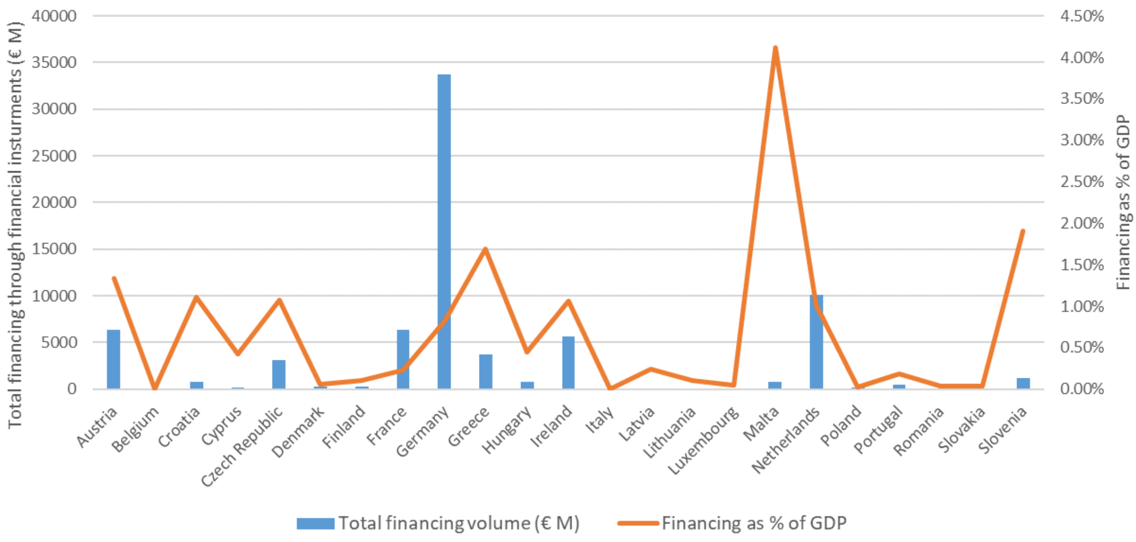
The Figure below presents an overview of the **volumes of financing available inter alia for energy storage** and their value as share of the country's GDP. As can be seen, there is quite high variety in the results. Germany is by far the country with the highest available volume, but it represents less than 1% of its GDP. On the contrary, Malta has a moderate amount potentially available for energy storage projects, but it constitutes more than 4% of its GDP.

The analysis of this data should be interpreted while keeping in mind that it does not capture the full spectrum of public financing.

[147] Available at: https://www.climatebonds.net/market/data/#use-of-proceeds-charts

[148] Source of GDP per capita data (USD current, 2021): https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?end=2019&locations=EU&start=2019

Figure 42: Amount of public financing through mapped financial instruments for energy storage as a % of GDP[149]



Source: PwC mapping, the World Bank[150]

Disclaimer: As written in Section 3.2, only 3 schemes were identified as targeting only energy storage. The other mapped schemes have energy storage as eligible category but are not exclusive for it and it is not possible to estimate the earmarking for it.

European Innovation Scoreboard: Finance and support to innovation scores

The European Innovation Scoreboard[151] provides indicators assessing the **level of finance and support to innovation** (indicator 2.1 aggregating R&D expenditure in the public sector, Venture capital and Direct government funding and government tax support for business R&D) and **the R&D expenditure in the business sector** (indicator 2.2.1) for each MS. Although these indicators are not specific to energy storage technologies, they help assess the overall availability of finance for innovation, which concerns several of the considered energy storage technologies.

Table 9: Finance and support to innovation and R&D expenditure in the business sector scores

Country	Score for finance and support	Score for R&D expenditure in the business sector
Austria	140.9	168.2
Belgium	156.7	192.2
Bulgaria	27.5	41.1
Croatia	81.7	42.6
Cyprus	80.0	24.8
Czechia	104.7	89.9
Denmark	135.1	138.8

[149] Only instruments mapped as being energy-specific were analysed.

[150] Source of GDP per capita data (USD current, 2021): https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?end=2019&locations=EU&start=2019

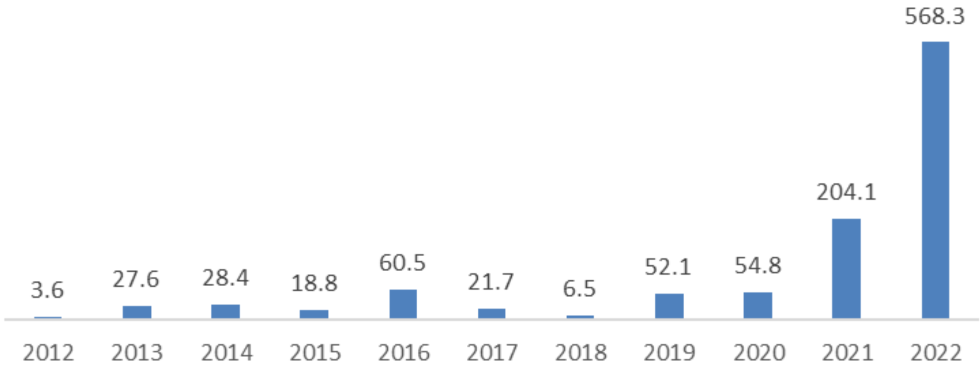
[151] European Commission, European Innovation Scoreboard (EIS) 2022, available at: https://ec.europa.eu/research-and-innovation/en/statistics/performance-indicators/european-innovation-scoreboard/eis

Country	Score for finance and support	Score for R&D expenditure in the business sector
Estonia	112.7	72.1
Finland	123.0	148.8
France	160.9	117.1
Germany	113.4	159.7
Greece	73.7	49.6
Hungary	96.8	91.5
Ireland	95.9	66.7
Italy	96.6	68.2
Latvia	45.7	13.2
Lithuania	92.3	38.8
Luxembourg	82.7	43.4
Malta	21.1	29.5
Netherlands	144.0	115.5
Poland	72.7	64.3
Portugal	106.4	67.4
Romania	35.9	17.8
Slovakia	46.9	34.1
Slovenia	79.4	117.8
Spain	90.5	56.6
Sweden	136.7	193.8

Source: EIS 2022

While already included in the European Innovation Scoreboard, it is interesting to have a look separately to data on Venture Capital financing, since it plays a central role in the financing of innovative and emerging storage solutions. Figure 43 below shows the total amount of recorded VC financing in EU-based companies active in the sectors of energy storage (including LDES) in the period from beginning of 2012 to end of 2022. As can be noticed, there is an overall growing trend of VC investments, with a significant increase from 2021 to 2022 (2.8x).

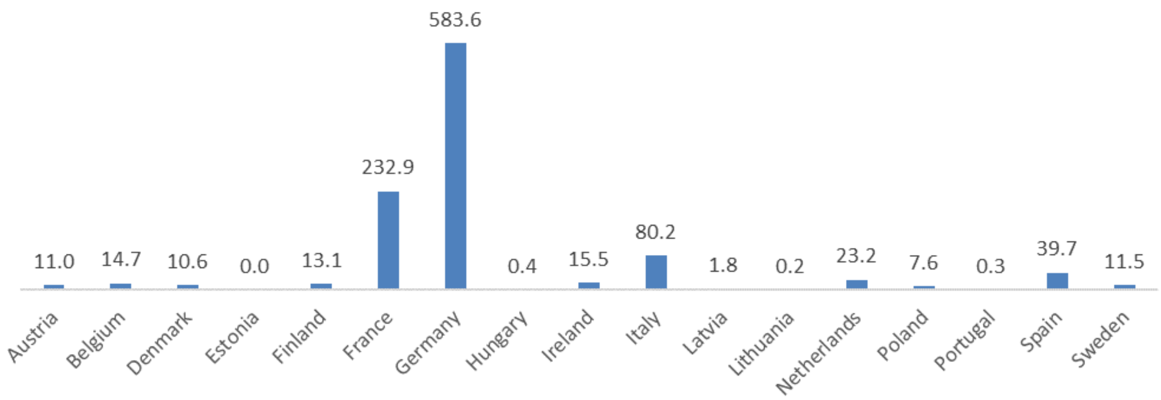
Figure 43: Volumes of VC financing in energy storage in EU countries (2012-2022, in USD M)



Source: PwC analysis of VC data

Below, Figure 44 shows the total amount of VC financing received between 2012 and 2022 by companies with headquarters in EU countries and active in energy storage. Storage companies located in 17 EU countries raised VC capital in the period between 2012-2022. As can be noticed, Germany is by far the country with the largest VC volume. Most of Germany's financing took place in 2022, with four deals alone amounting in total to USD 350 M. France is the second in terms of mobilised VC investments for energy storage, also this time mostly taking place in 2022 with one deal of USD 160 M.

Figure 44: Total volumes of VC financing for energy storage in EU countries (2012-2022, in USD M)



Source: PwC analysis of VC data

Cost of financing – Weighted Average Cost of Capital (WACC)

To evaluate the **cost of capital**, the calculation of the WACC must be done using data specific to the industry sector. However, in the case of energy storage, which encompasses a broad variety of technologies, there are several industry sectors that can be relevant: specialised chemical industry, electrical equipment, green and renewable energy, power and semi-conductor. PwC has calculated the WACC of these sectors for each Member State relying on Damodaran's website database for industry specific inputs.[152]

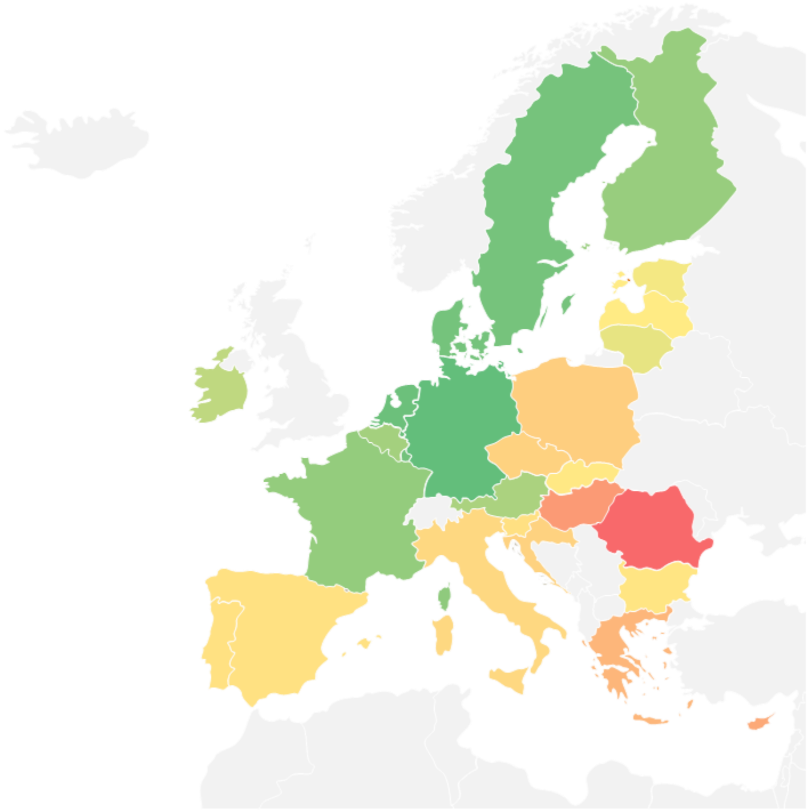
The different sector specific WACC values have then been aggregated through a simple average. Nevertheless, the resulting figures should not be interpreted as WACC values for the energy storage sector in the strict sense. Indeed, the considered sectors include other activities not directly related to energy storage. Moreover, there is no guarantee that the diversity of energy storage technologies is covered exhaustively by the selection of considered

[152] Cost of equity and capital for Western Europe, updated on the 5th of January 2023, Available at: https://pages.stern.nyu.edu/~adamodar/

sectors, nor that those sectors have an equal weight in the overall field of energy storage. However, the obtained average values can serve as a proxy for the cost of capital regarding energy storage, and, most of all, enable a comparison across EU MS, which is the main purpose of the present analysis.

A relatively low WACC proxy can be considered as an indicator of more available financing for projects that contribute to increasing energy storage capacity. Indeed, it reflects abundance of capital at relatively low cost and a low country risk, thanks to an enabling regulatory and economic environment for investments. The Figure below shows the obtained proxy values for the cost of capital for energy storage across EU MS. Details on the calculation and data sources are available in Annex 1: Methodology for WACC Calculation.

Figure 45: Proxy values for the WACC for energy storage by EU MS



Country	WACC proxy for energy storage
Romania	15.03%
Hungary	12.75%
Cyprus	12.07%
Greece	11.46%
Poland	10.33%
Czechia	10.11%
Croatia	10.10%
Italy	9.82%
Slovenia	9.48%
Spain	9.42%
Portugal	9.41%
Bulgaria	9.21%
Slovakia	9.10%
Latvia	8.92%
Estonia	8.77%
Lithuania	8.57%
Malta	8.26%
Ireland	7.97%
Austria	7.68%
Belgium	7.57%
Finland	7.39%
France	7.33%
Sweden	6.89%
Denmark	6.87%
Luxembourg	6.83%
Netherlands	6.74%
Germany	6.59%

Source: PwC analysis of Statista, Aswath Damodaran (Stern, New York University)

Diversity of instruments available for energy storage

The **mapping of financial instruments** conducted as part of the present study can be used to identify the instruments available for energy storage projects. This sheds further light on the diversity of available financial instruments at MS level.

It should be noted that there are few instruments specifically targeting energy storage. A larger number includes energy storage among other eligible investment projects. For the following indicators, every instrument that potentially support the increase in energy storage capacity across EU MS was considered.

Overall diversity of the available financing instruments

A first **proxy of the diversity of mapped financing instruments** available for each Member States can be obtained through a repurposed use of the Herfindahl-Hirschman Index (HHI).

Usually, this indicator is employed to study market share concentration among active firms. In the present case, it is used to measure the concentration of identified financing instruments among different types of instruments.

For the scope of this Study, the HHI is based on the share of each type of instrument over the total number of instruments mapped for a given country. The value of the HHI was obtained by squaring the share of each type of instrument and then summing the resulting numbers. It should be noted that some of the mapped financing schemes combine different kinds of instruments. In the mapping, those were consistently tagged in several categories of financing instruments. Nevertheless, this does not change the interpretation that can be made for financing instruments: countries with a high HHI offer a limited number of financing instrument types, whereas countries with a lower HHI provide a diversity that can address relevant barriers to investment.

The obtained HHI values for each Member-State are available in the summary table at the end of this section.

Grant-based instruments and share of grants open for rollout stage projects

In general, markets with a balanced mix of financial instruments, including repayable-finance ones, can be considered more mature. On the other hand, markets that rely solely or mainly on grants can be considered less mature.

Nevertheless, in the case of innovative technologies, this dichotomy must be pondered: recourse to repayable-finance instruments is not preferable to that of grants *per se*. For R&I, demo or upscaling projects, grant-based financing may play a pivotal role to enable development before risk gets lower and repayable-finance can take over. Yet, **grant-based financing should then specifically target highly innovative projects that come with a higher level of risk**, rather than technologies that are already in a rollout phase and that could attract repayable-financing instead.

The percentage of grant-based instruments and the corresponding share of grants that are open to rollout-phase projects are provided for each Member State in the summary table hereunder.

Table 10: HHI index and % of grants for rollout stage projects by MS

Country	Concentration Index (HHI)	Share of grant-based instruments (%)	of which are open to rollout stage projects (%)
Austria	3438	38%	33%
Belgium	3438	25%	50%
Bulgaria	2189	23%	33%
Croatia	3765	11%	100%
Cyprus	10000	0%	N/A
Czech Republic	2730	33%	78%
Denmark	5102	43%	67%
Estonia	4200	10%	100%
Finland	5000	50%	0%
France	3438	13%	0%

Country	Concentration Index (HHI)	Share of grant-based instruments (%)	of which are open to rollout stage projects (%)
Germany	5054	62%	17%
Greece	2872	18%	67%
Hungary	4438	0%	N/A
Ireland	3125	38%	33%
Italy	3504	16%	25%
Latvia	3058	9%	100%
Lithuania	3750	50%	50%
Luxembourg	3438	38%	100%
Malta	3438	50%	75%
Netherlands	2892	13%	0%
Poland	1837	19%	82%
Portugal	6800	80%	100%
Romania	5556	67%	0%
Slovakia	3194	17%	100%
Slovenia	3469	43%	0%
Spain	10000	100%	60%
Sweden	5000	50%	0%

Summary of findings on market maturity

The following table combines all the indicators presented in this section for each EU MS. Except for the estimate of the needed increase in energy storage capacity to 2030, countries have been ranked from 1 to 27 for each indicator, where 1 is the best and 27 is the worst. For the funding of major hydrogen projects, the ranking was established based on available data on funding rather than the number of projects. Countries with projects but no data on the corresponding funding have been ranked *ex aequo* after the other countries with projects and data about the funding. For the WACC and the EIS score, the average of the respectively considered sectors and scores was used for the ranking, which is why there is only one corresponding column in the table.

Table 11: Summary table – Maturity of the finance markets specific to energy storage

	Market maturity									Instruments availability	
Country	**Estimate of the needed capacity increase to 2030 (GW)**	**Average enterprise gross investment in electrical equipment manufacturing**	**Funding for major hydrogen projects**	**EIS average score for finance and support and R&D expenditure in the business sector**	**Debt and loans of corporates**	**Stock market capitalisation**	**Green Bond Market**	**Public finance**	**WACC**	**Concentration Index (HHI)**	**Targeted use of grants (not for rollout stage projects)**
Austria	3.4	8	8	3	7	16	12	4	9	9	4
Belgium	4.0	21	9	1	19	8	10	22	8	10	5
Bulgaria	0.8	6	9	24	14	19	N/A	N/A	16	2	4
Croatia	0.7	13	9	20	22	18	N/A	5	21	17	11
Cyprus	0.1	N/A	9	22	15	25	N/A	11	25	26	N/A
Czechia	1.5	3	9	10	23	1	19	6	22	3	10
Denmark	2.4	22	8	5	4	3	5	17	4	23	7
Estonia	0.3	11	9	12	8	23	21	N/A	13	18	11
Finland	3.8	15	4	7	10	5	6	15	7	20	1
France	11.2	16	6	4	9	6	4	13	6	11	1
Germany	41.5	9	3	6	12	10	7	9	1	22	2

	Market maturity									Instruments availability	
Country	**Estimate of the needed capacity increase to 2030 (GW)**	**Average enterprise gross investment in electrical equipment manufacturing**	**Funding for major hydrogen projects**	**EIS average score for finance and support and R&D expenditure in the business sector**	**Debt and loans of corporates**	**Stock market capitalisation**	**Green Bond Market**	**Public finance**	**WACC**	**Concentration Index (HHI)**	**Targeted use of grants (not for rollout stage projects)**
Greece	1.6	20	9	21	27	15	15	3	24	4	7
Hungary	1.1	1	9	11	3	22	13	10	26	19	N/A
Ireland	2.5	26	9	15	24	14	11	7	10	7	4
Italy	8.7	12	9	14	21	12	14	23	20	15	3
Latvia	0.5	14	9	25	26	26	17	12	14	6	11
Lithuania	0.6	18	9	18	11	24	16	16	12	16	5
Luxembourg	0.2	25	9	19	1	9	1	18	3	12	11
Malta	0.0	24	9	27	6	17	N/A	1	11	13	9
Netherlands	3.3	23	1	8	5	4	3	8	2	5	1
Poland	4.3	4	9	17	17	11	18	21	23	1	8
Portugal	2.0	10	2	13	16	13	9	14	17	25	11
Romania	2.2	7	9	26	18	20	23	19	27	24	1
Slovakia	0.6	5	9	23	13	27	22	20	15	8	5

	Market maturity									Instruments availability	
Country	**Estimate of the needed capacity increase to 2030 (GW)**	**Average enterprise gross investment in electrical equipment manufacturing**	**Funding for major hydrogen projects**	**EIS average score for finance and support and R&D expenditure in the business sector**	**Debt and loans of corporates**	**Stock market capitalisation**	**Green Bond Market**	**Public finance**	**WACC**	**Concentration Index (HHI)**	**Targeted use of grants (not for rollout stage projects)**
Slovenia	0.5	2	9	9	20	21	20	2	19	14	1
Spain	8.7	17	7	16	25	7	8	N/A	18	26	6
Sweden	5.4	19	5	2	2	2	2	N/A	5	21	1

Interpretation of the results at Member State level

The complex picture of indicators collected in the summary table does not always present a clear-cut conclusion regarding the state of market maturity for the financing of energy storage technologies. However, it can lay the ground for some general findings at country level.

As can be seen from the following table, it is possible to group the EU Member States based on the magnitude of needed increase in energy storage capacity to 2030, the degree of market maturity (understood as level of finance availability given the criteria considered above) and the extent to which the current offering of financial instruments is relevant (based on concentration and target use of grants). The interpretation is provided per group in the following paragraphs.

Table 12: Grouping of countries by magnitude of needed increase in energy storage capacity and market maturity

	High market maturity	Medium market maturity	Low market maturity
Minor increase in capacity needed	Luxembourg	Czech Republic, Slovenia, Malta, Hungary	Bulgaria, Greece, Slovakia, Latvia, Lithuania, Croatia, Estonia, Cyprus
Medium increase in capacity needed	Netherlands, Austria, Denmark, Finland	Ireland, Belgium, Portugal	Romania, Poland
Major increase in capacity needed	Sweden, Germany, France	Italy, Spain	-

Note: Countries coloured in green are considered to have a relevant offering of financial instruments, whereas those in red have some room for improvement.

Countries with high market maturity and:

- **Minor increase in energy storage capacity needed by 2030 – Luxembourg** is the only country in this category. It has relatively limited efforts to make in terms of energy storage increase, compared to other EU countries. While benefitting from a high market maturity, Luxembourg displays a quite high degree of grant usage for mature technologies and a medium concentration of the available financing instruments, consisting of loans, grants and equity.
- **Medium increase** – **Austria** and **Finland** are facing similar magnitudes of efforts to increase energy capacity storage, combined with a slightly less favourable overall availability of financing. Both countries offer an intermediate variety of financing instruments, with only grants and loans identified for Finland, which could then benefit from a wider range of schemes. While Finland appears to use grants in a targeted way, Austria still has a minority of grants open to rollout-stage projects. In comparison, the **Netherlands**, with a similarly intermediate effort ahead and a favourable overall availability of finance not only offers a diversified set of financing instruments, but also uses grants in a highly targeted way. On the other hand, **Denmark** offers only loans and grants, the majority of which also available for mature technologies.
- **Major increase** – Due to its very ambitious renewable energy generation target for 2030, **Germany** is the EU country that will probably have to increase its energy storage capacity the most. In doing so, Germany can leverage its overall healthy financial system, which comes with a low cost of capital, as well as its position as a leading country in terms of investments for electrical equipment manufacturing and hydrogen projects. However, the diversity of instrument identified through the mapping is low, with instruments consisting mostly in loans and grants. The absence of other more complex instruments may be a sign that private finance is already very active for energy storage projects. Nevertheless, considering the significant need for financing the increase in energy storage capacity, Germany may benefit from a diversification of instruments, as more sophisticated financing options may be an enabling factor for some projects. In any case, most of the identified grants are used in a targeted manner, as they are not open for rollout-stage projects. **France** is facing a somewhat smaller, yet still significant, need to increase its energy storage capacity by 2030, which can be explained by the different direction of the country's energy production strategy. It benefits from a similarly favourable overall availability of finance, with innovation-oriented support and financing and an extensive green bond market. The offer of financing instrument is more diverse than in Germany, although no blended finance, guarantee or technical assistance instruments have been identified. When it comes to grants, they are used

in a highly targeted way, as they are not open to rollout-stage projects. **Sweden** has a big effort to increase energy storage capacity to 2030. Its overall financial availability is quite favourable, for instance with a high ranking in terms of support and financing for innovation. Nevertheless, the mapped instruments consist only of loans and grants. This may be a sign that private finance is already significantly supporting activities related to energy storage. Identified grants are used in a targeted way that benefits innovative projects.

Countries with medium market maturity and:

- **Minor increase in energy storage capacity needed to 2030** – **Czechia** has a relatively limited effort to make in terms of increase in energy storage capacity. It shows an overall intermediate availability of financing and a high diversity of available financing instruments, with the caveat that most grants are open to rollout-stage projects. **Slovenia** offers a moderate diversity of instruments and it uses its grants in a highly targeted way. **Malta** is one of the EU countries with the lowest estimated increase needed in storage capacity. However, being an island, the estimation may be lower than the real need. Malta faces a relatively limited overall availability of financing with an intermediate diversity of instruments and a targeted use of its grants. **Hungary** has a high WACC and a more limited offer of financing instruments. In particular, no grants were identified, which may be a problem for innovative and risky projects.
- **Medium increase** – **Ireland**'s need to increase energy storage capacity is intermediate. The overall availability of finance is intermediate as well, and the offer of financing instruments rather diversified. Most of the identified grants are used in a targeted manner. **Belgium** has a higher need to increase energy storage capacity. The offering of financial support schemes consists mostly in loans and grants, with one individual scheme for equity and technical assistance. Belgium could benefit from a more targeted use of grants, as well as from using guarantees and blended schemes. **Portugal** exhibits similar characteristics in terms of effort ahead or of overall financing availability. However, the variety of offered financing instruments is rather limited with grants mostly and loans secondarily. Moreover, most grants are open to rollout-stage projects.
- **Major increase** – After Germany and France, **Italy** is the EU MS that will probably need to increase their energy storage capacity the most. It has an overall intermediate availability of finance. When it comes to the identified financing instruments, Italy offers an intermediate diversity of instruments and exhibits a rather targeted use of grants. **Spain** follows in terms on capacity need. The country has an overall moderate market maturity, and a moderate level of funding for hydrogen projects or financing from the EIB for energy storage projects. When it comes to the identified financing instruments, only grants have been identified for Spain, of which the majority are still open to rollout-stage projects.

Countries with low market maturity and:

- **Minor increase in energy storage capacity needed to 2030 –** With a similar magnitude of efforts ahead in terms of energy storage capacity and a similar level of financing availability, **Croatia** and **Estonia** offer a more limited diversity of financing instruments: more than half of the identified instruments are loans in Croatia and equity in Estonia. In addition, most if not all of the identified grants are open to rollout-stage projects. **Lithuania** and **Slovakia** are in similar situations, although Lithuania shows a partly targeted use of grants whereas Slovakia offers a broader variety of instruments. **Latvia** exhibits similar characteristics than Slovakia, but with a higher share of grants targeting mature technologies. **Cyprus** is one of the EU countries for which the estimated increase needed in capacity storage is the lowest. However, as it is an island, similarly to Malta, the estimation may be lower than the real need. The set of identified instruments for Cyprus is quite limited and consists only in loans. **Greece** displays a rather diversified offer of financing instruments. However, most grants are not targeting only innovative projects and are still open to mature technologies. **Bulgaria**'s need to increase energy storage capacity is relatively small compared to other EU countries. However, it faces a relatively limited overall availability of financing. Despite this context, it offers a diverse set of financial instruments, including grants that are mostly targeted for innovative projects.

- **Medium increase – Romania** faces intermediate efforts in terms of additional energy storage capacity. For now, the overall availability of finance is limited in this country and the cost of capital is one of the highest across the EU. The mapping underlines a limited offer of financing instrument, with loans and grants only. One positive aspect is the targeted use of all the identified grants. **Poland** also has a medium effort to increase energy storage capacity to 2030. The overall availability of financing is intermediate. Despite a rather high level of enterprise investment in the manufacturing of electrical equipment, Poland does not benefit from a high ranking when it comes to support and financing to innovation, nor from a low cost of capital, compared to other EU MS. The offer in financing instrument is quite diversified. However, grants could be used in a more targeted way, as most of them are still open to rollout-stage projects for now.

6. Findings and recommendations

6.1. Summary view on effectiveness of instruments

Energy storage plays a critical role in meeting the EU's Fit for 55 and REPowerEU targets and objectives. Wider deployment of energy storage solutions can help reduce electricity prices during peak hours, minimize price fluctuations, and enable consumers to utilize their own energy. However, storage project "financeability" is affected by their Technology Readiness Level (TRL), levelized cost of storage, and the range of services they can provide.

The energy storage sector faces obstacles such as the lack of revenue mechanisms and limited access to capital, which hinder the decarbonization of the EU's energy sector. Financial instruments, however, can address some of the barriers to investment by making projects more appealing for investors. Non-financial barriers, such as political and regulatory barriers also need to be addressed, to create a proper investing environment.

A mapping of financial instruments at Member State level resulted in data on 272 instruments available for financing energy storage in the 27 EU Member States. Among these 272, loans and grants are the most popular instruments across the EU. All instruments together provide an estimated cumulative financing for up to €113 billion. However, while only three schemes are specifically designed for energy storage, most schemes target at least one more energy segment, and 176 schemes target all segments of the energy value chain. **Most of the mapped instruments only support mature and market-ready projects, favouring SMEs and larger companies, but smaller companies and households should not be at a disadvantage.** Therefore, dedicated financial support schemes for smaller installations could be implemented.

Three characteristics emerged as key for a financial instrument to be effective: a combination of different types of financing, long-term stability and visibility, and technical assistance services with financing. The expansion of the offering of financial schemes emerged as particularly important for countries with lower market maturity, and the use of equity and guarantee schemes should be leveraged more to mobilise private financing, particularly in countries with high storage capacity targets.

6.2. Recommendations and next steps

Based on the analysis conducted, it was possible to broadly identify the direction in which the next generation of financial support schemes for energy storage should move towards:

- **Countries with low availability of diverse financial instruments and less mature financial markets would benefit from targeted efforts to develop and expand the offering of schemes for storage**, so as to cover a broader range of investment needs and progressively move away from grant-supported investments and more towards repayable instruments. WG members particularly underlined that guarantees and equity (Venture Capital) schemes and investments are needed for energy storage in order to provide financing and de-risk innovative storage solutions and start-ups.
- **National funding authorities should foster and strengthen cooperation with implementing partners such as European institutions and NPBIs.** Implementing partners can contribute to the identification of relevant projects, ensure that the funding application is in line with the purpose of the funding scheme, co-finance the relevant investment with their own resources, and attract other private investors. This would contribute to improving financing schemes' accessibility, long-term stability, variety in financing, and, to some extent, also helps tailor the financing to the needs of energy storage solution providers.

- **Technical assistance services are needed for all stakeholders in the storage sector** (companies, investors, and public authorities), and should thus be deployed more broadly, particularly in countries with low market maturity, to foster capacity building and increase effectiveness and impact of instruments, also through dedicated support in the preparation of applications for funding opportunities. The innovative nature of the energy storage sector also makes this technical assistance support an ongoing need, since the market is likely to change fast.
- While the analysis did not cover regulatory environments in the EU27 and does not aim to do so, **remuneration mechanisms are essential for the correct functioning of energy storage projects** and, therefore, to enable financial support schemes to foster projects. It is crucial to ensure that energy storage solutions are remunerated for all the services they can provide and that, as it is already happening in some Member States, can get access to some form of long-term and/or regulated revenues. Secure, stable, and predictable future revenue streams tend to create a strong foundation for bankability of a project.
- The mapping covered mainly instruments targeting mature technologies. While EU programmes like the Innovation Fund and Horizon Europe have financed innovative and first-of-a-kind storage projects, WG members remarked a generalised **need to provide more targeted support for innovation in this field**. For low TRL technologies, the issue in accessing financing is mostly related to the nascent nature of the technology, which makes it difficult to build viable business cases. Support schemes can guide technologies from the initial phase through the so called “valley of death” up to the commercialization stage, to mitigate the risks on their performance up to a level which is acceptable to risk-conscious investors. WG members also highlighted the important role that venture capital, grants and technical assistance can play in supporting and fostering lower-TRL innovative storage solutions.
- **New and improved financial support schemes should also take into consideration the storage value chain dimension**, as storage projects are currently exposed to high uncertainty and costs of raw material and logistics. While this aspect cannot be tackled with individual schemes, it should nonetheless be taken into account by the public sector when designing broader strategies for renewables and storage.
- **Financial support schemes should be open to all storage technologies**, so as to not favour one type of storage over others. This would create competitive dynamics among storage technologies that will lead to the best ones developing and making it to the market.

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Annexes

Annex 1: Methodology for WACC Calculation

Weighted Average Costs of Capital (WACC) have been calculated for several sectors related to energy storage across EU MS (specialized chemical industry, electrical equipment, green and renewable energy, power and semi-conductor). The following formula was used:

$$WACC = \frac{D}{D+E} * Cd * (1-t) + \frac{E}{D+E} * Ce$$

Where:

- *D* is the market value of a firm's debt
- *E* is the market value of a firm's equity
- *t* is the corporate tax rate
- *Cd* is the cost of debt after tax, calculated as follows: $Cd = (risk\ free\ rate + sector\ specific\ spread) * (1-t)$
  We have applied a +2% assumption for lenders' margins to risk free rate and the sector specific spread, based on the literature on energy finance[153]. We have selected the country specific risk-free rate to reflect country risks[154].
- *Ce* is the cost of equity, calculated as follows: $Ce = risk\ free + \beta * ERP$, where ERP is the equity risk premium of every country and β is a measure of the volatility — or systematic risk — of a security or portfolio (or a specific sector/transaction) compared to the market as a whole. ERP is country-specific and β is specific to the renewable energy sector. Both data are extracted from Aswath Damodaran (Stern, New York University)[155].

One note on $\frac{D}{D+E}$ and $\frac{E}{D+E}$. They are sector-specific, reflecting the levels of debt and equity normally used for renewable energy projects. However, in absence of country-specific data, we have assumed that these variables are the same across the whole EU. This is of course an important caveat, as differences in $\frac{D}{D+E}$ and $\frac{E}{D+E}$ across countries might exist and they would significantly affect the WACC.

The tables below show the calculation of the WACC for each sector and for each country.

[153] Source: IRENA, RENEWABLE POWER GENERATION COSTS IN 2021, available at: https://www.irena.org/publications/2022/Jul/Renewable-Power-Generation-Costs-in-2021#:~:text=The%20global%20weighted%20average%20levelised,%25%20to%20USD%200.075%2FkWh.

[154] Source: Statista, available at: https://www.statista.com/statistics/885915/average-risk-free-rate-europe/

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Table 14: WACC calculation for the specialized chemical industry sector across EU MS

Country	ERP - Total Equity Risk Premium	Country Risk Premium	Beta - Power	Risk free (Nov-2022)	CoE - Cost of Equity	Tax rate	E/(D+E)	D/(D+E)	CoD - After Tax Cost of Debt	WACC
Austria	6.57%	0.56%	1.12	1.80%	9.16%	25%	84.62%	15.38%	2.85%	8.1%
Belgium	6.85%	0.84%	1.12	1.40%	9.07%	25%	84.62%	15.38%	2.55%	8.0%
Bulgaria	8.24%	2.23%	1.12	1.60%	10.83%	10%	84.62%	15.38%	3.24%	9.6%
Croatia	9.51%	3.50%	1.12	1.50%	12.15%	18%	84.62%	15.38%	2.87%	10.6%
Cyprus	9.51%	3.50%	1.12	3.50%	14.15%	13%	84.62%	15.38%	4.81%	12.6%
Czechia	6.85%	0.84%	1.12	4.10%	11.77%	19%	84.62%	15.38%	4.94%	10.6%
Denmark	6.01%	0.00%	1.12	1.40%	8.13%	22%	84.62%	15.38%	2.65%	7.2%
Estonia	7.00%	0.99%	1.12	2.50%	10.34%	20%	84.62%	15.38%	3.60%	9.2%
Finland	6.57%	0.56%	1.12	1.40%	8.76%	20%	84.62%	15.38%	2.72%	7.7%
France	6.70%	0.69%	1.12	1.30%	8.80%	27%	84.62%	15.38%	2.43%	7.7%
Germany	6.01%	0.00%	1.12	1.20%	7.93%	30%	84.62%	15.38%	2.24%	7.0%
Greece	11.04%	5.03%	1.12	1.60%	13.96%	24%	84.62%	15.38%	2.74%	12.1%
Hungary	8.67%	2.66%	1.12	4.90%	14.61%	9%	84.62%	15.38%	6.28%	13.2%
Ireland	7.00%	0.99%	1.12	1.50%	9.34%	13%	84.62%	15.38%	3.06%	8.3%
Italy	9.08%	3.07%	1.12	1.70%	11.87%	24%	84.62%	15.38%	2.81%	10.4%

Country	ERP - Total Equity Risk Premium	Country Risk Premium	Beta - Power	Risk free (Nov-2022)	CoE - Cost of Equity	Tax rate	E/(D+E)	D/(D+E)	CoD - After Tax Cost of Debt	WACC
Latvia	7.69%	1.68%	1.12	2.00%	10.61%	20%	84.62%	15.38%	3.20%	9.4%
Lithuania	7.19%	1.18%	1.12	2.00%	10.06%	15%	84.62%	15.38%	3.40%	9.0%
Luxembourg	6.01%	0.00%	1.12	1.40%	8.13%	25%	84.62%	15.38%	2.55%	7.2%
Malta	7.19%	1.18%	1.12	2.00%	10.06%	35%	84.62%	15.38%	2.60%	8.8%
Netherlands	6.01%	0.00%	1.12	1.30%	8.03%	25%	84.62%	15.38%	2.48%	7.1%
Poland	7.19%	1.18%	1.12	4.00%	12.06%	19%	84.62%	15.38%	4.86%	10.8%
Portugal	8.67%	2.66%	1.12	1.60%	11.31%	21%	84.62%	15.38%	2.84%	9.9%
Romania	9.08%	3.07%	1.12	7.20%	17.37%	16%	84.62%	15.38%	7.73%	15.7%
Slovakia	7.19%	1.18%	1.12	2.70%	10.76%	21%	84.62%	15.38%	3.71%	9.6%
Slovenia	7.69%	1.68%	1.12	2.60%	11.21%	19%	84.62%	15.38%	3.73%	9.9%
Spain	8.24%	2.23%	1.12	2.10%	11.33%	25%	84.62%	15.38%	3.08%	9.9%
Sweden	6.01%	0.00%	1.12	1.40%	8.13%	21%	84.62%	15.38%	2.70%	7.2%

Table 15: WACC calculation for the electrical equipment industry sector across EU MS

Country	ERP - Total Equity Risk Premium	Country Risk Premium	Beta - Power	Risk free (Nov-2022)	CoE - Cost of Equity	Tax rate	E/(D+E)	D/(D+E)	CoD - After Tax Cost of Debt	WACC
Austria	6.57%	0.56%	1.34	1.80%	10.60%	25%	85.72%	14.28%	2.85%	9.4%
Belgium	6.85%	0.84%	1.34	1.40%	10.58%	25%	85.72%	14.28%	2.55%	9.3%
Bulgaria	8.24%	2.23%	1.34	1.60%	12.65%	10%	85.72%	14.28%	3.24%	11.3%
Croatia	9.51%	3.50%	1.34	1.50%	14.24%	18%	85.72%	14.28%	2.87%	12.5%
Cyprus	9.51%	3.50%	1.34	3.50%	16.24%	13%	85.72%	14.28%	4.81%	14.5%
Czechia	6.85%	0.84%	1.34	4.10%	13.28%	19%	85.72%	14.28%	4.94%	12.0%
Denmark	6.01%	0.00%	1.34	1.40%	9.45%	22%	85.72%	14.28%	2.65%	8.4%
Estonia	7.00%	0.99%	1.34	2.50%	11.87%	20%	85.72%	14.28%	3.60%	10.6%
Finland	6.57%	0.56%	1.34	1.40%	10.20%	20%	85.72%	14.28%	2.72%	9.1%
France	6.70%	0.69%	1.34	1.30%	10.28%	27%	85.72%	14.28%	2.43%	9.1%
Germany	6.01%	0.00%	1.34	1.20%	9.25%	30%	85.72%	14.28%	2.24%	8.2%
Greece	11.04%	5.03%	1.34	1.60%	16.39%	24%	85.72%	14.28%	2.74%	14.3%
Hungary	8.67%	2.66%	1.34	4.90%	16.52%	9%	85.72%	14.28%	6.28%	15.0%
Ireland	7.00%	0.99%	1.34	1.50%	10.87%	13%	85.72%	14.28%	3.06%	9.7%
Italy	9.08%	3.07%	1.34	1.70%	13.87%	24%	85.72%	14.28%	2.81%	12.2%

Latvia	7.69%	1.68%	1.34	2.00%	12.30%	20%	85.72%	14.28%	3.20%	10.9%
Lithuania	7.19%	1.18%	1.34	2.00%	11.64%	15%	85.72%	14.28%	3.40%	10.4%
Luxembourg	6.01%	0.00%	1.34	1.40%	9.45%	25%	85.72%	14.28%	2.55%	8.4%
Malta	7.19%	1.18%	1.34	2.00%	11.64%	35%	85.72%	14.28%	2.60%	10.2%
Netherlands	6.01%	0.00%	1.34	1.30%	9.35%	25%	85.72%	14.28%	2.48%	8.3%
Poland	7.19%	1.18%	1.34	4.00%	13.64%	19%	85.72%	14.28%	4.86%	12.3%
Portugal	8.67%	2.66%	1.34	1.60%	13.22%	21%	85.72%	14.28%	2.84%	11.7%
Romania	9.08%	3.07%	1.34	7.20%	19.37%	16%	85.72%	14.28%	7.73%	17.5%
Slovakia	7.19%	1.18%	1.34	2.70%	12.34%	21%	85.72%	14.28%	3.71%	11.0%
Slovenia	7.69%	1.68%	1.34	2.60%	12.90%	19%	85.72%	14.28%	3.73%	11.5%
Spain	8.24%	2.23%	1.34	2.10%	13.15%	25%	85.72%	14.28%	3.08%	11.6%
Sweden	6.01%	0.00%	1.34	1.40%	9.45%	21%	85.72%	14.28%	2.70%	8.4%

Table 16: WACC calculation for the green and renewable energy industry sector across EU MS

Country	ERP - Total Equity Risk Premium	Country Risk Premium	Beta - Power	Risk free (Nov-2022)	CoE - Cost of Equity	Tax rate	E/(D+E)	D/(D+E)	CoD - After Tax Cost of Debt	WACC
Austria	6.57%	0.56%	0.91	1.80%	7.78%	25%	62.98%	37.02%	2.85%	5.7%
Belgium	6.85%	0.84%	0.91	1.40%	7.63%	25%	62.98%	37.02%	2.55%	5.5%
Bulgaria	8.24%	2.23%	0.91	1.60%	9.10%	10%	62.98%	37.02%	3.24%	6.8%
Croatia	9.51%	3.50%	0.91	1.50%	10.15%	18%	62.98%	37.02%	2.87%	7.3%
Cyprus	9.51%	3.50%	0.91	3.50%	12.15%	13%	62.98%	37.02%	4.81%	9.2%
Czechia	6.85%	0.84%	0.91	4.10%	10.33%	19%	62.98%	37.02%	4.94%	8.0%
Denmark	6.01%	0.00%	0.91	1.40%	6.87%	22%	62.98%	37.02%	2.65%	5.1%
Estonia	7.00%	0.99%	0.91	2.50%	8.87%	20%	62.98%	37.02%	3.60%	6.7%
Finland	6.57%	0.56%	0.91	1.40%	7.38%	20%	62.98%	37.02%	2.72%	5.5%
France	6.70%	0.69%	0.91	1.30%	7.40%	27%	62.98%	37.02%	2.43%	5.3%
Germany	6.01%	0.00%	0.91	1.20%	6.67%	30%	62.98%	37.02%	2.24%	4.8%
Greece	11.04%	5.03%	0.91	1.60%	11.65%	24%	62.98%	37.02%	2.74%	8.1%
Hungary	8.67%	2.66%	0.91	4.90%	12.79%	9%	62.98%	37.02%	6.28%	10.2%
Ireland	7.00%	0.99%	0.91	1.50%	7.87%	13%	62.98%	37.02%	3.06%	5.9%
Italy	9.08%	3.07%	0.91	1.70%	9.97%	24%	62.98%	37.02%	2.81%	7.1%

Country	ERP - Total Equity Risk Premium	Country Risk Premium	Beta - Power	Risk free (Nov-2022)	CoE - Cost of Equity	Tax rate	E/(D+E)	D/(D+E)	CoD - After Tax Cost of Debt	WACC
Latvia	7.69%	1.68%	0.91	2.00%	8.99%	20%	62.98%	37.02%	3.20%	6.6%
Lithuania	7.19%	1.18%	0.91	2.00%	8.55%	15%	62.98%	37.02%	3.40%	6.5%
Luxembourg	6.01%	0.00%	0.91	1.40%	6.87%	25%	62.98%	37.02%	2.55%	5.0%
Malta	7.19%	1.18%	0.91	2.00%	8.55%	35%	62.98%	37.02%	2.60%	6.0%
Netherlands	6.01%	0.00%	0.91	1.30%	6.77%	25%	62.98%	37.02%	2.48%	5.0%
Poland	7.19%	1.18%	0.91	4.00%	10.55%	19%	62.98%	37.02%	4.86%	8.1%
Portugal	8.67%	2.66%	0.91	1.60%	9.49%	21%	62.98%	37.02%	2.84%	6.8%
Romania	9.08%	3.07%	0.91	7.20%	15.47%	16%	62.98%	37.02%	7.73%	12.1%
Slovakia	7.19%	1.18%	0.91	2.70%	9.25%	21%	62.98%	37.02%	3.71%	6.9%
Slovenia	7.69%	1.68%	0.91	2.60%	9.59%	19%	62.98%	37.02%	3.73%	7.2%
Spain	8.24%	2.23%	0.91	2.10%	9.60%	25%	62.98%	37.02%	3.08%	6.9%
Sweden	6.01%	0.00%	0.91	1.40%	6.87%	21%	62.98%	37.02%	2.70%	5.1%

Table 17: WACC calculation for the green and power industry sector across EU MS

Country	ERP - Total Equity Risk Premium	Country Risk Premium	Beta - Power	Risk free (Nov-2022)	CoE - Cost of Equity	Tax rate	E/(D+E)	D/(D+E)	CoD - After Tax Cost of Debt	WACC
Austria	6.57%	0.56%	0.82	1.80%	7.19%	25%	54.38%	45.62%	2.85%	4.9%
Belgium	6.85%	0.84%	0.82	1.40%	7.02%	25%	54.38%	45.62%	2.55%	4.7%
Bulgaria	8.24%	2.23%	0.82	1.60%	8.36%	10%	54.38%	45.62%	3.24%	5.9%
Croatia	9.51%	3.50%	0.82	1.50%	9.30%	18%	54.38%	45.62%	2.87%	6.1%
Cyprus	9.51%	3.50%	0.82	3.50%	11.30%	13%	54.38%	45.62%	4.81%	8.1%
Czechia	6.85%	0.84%	0.82	4.10%	9.72%	19%	54.38%	45.62%	4.94%	7.1%
Denmark	6.01%	0.00%	0.82	1.40%	6.33%	22%	54.38%	45.62%	2.65%	4.4%
Estonia	7.00%	0.99%	0.82	2.50%	8.24%	20%	54.38%	45.62%	3.60%	5.8%
Finland	6.57%	0.56%	0.82	1.40%	6.79%	20%	54.38%	45.62%	2.72%	4.7%
France	6.70%	0.69%	0.82	1.30%	6.79%	27%	54.38%	45.62%	2.43%	4.5%
Germany	6.01%	0.00%	0.82	1.20%	6.13%	30%	54.38%	45.62%	2.24%	4.0%
Greece	11.04%	5.03%	0.82	1.60%	10.65%	24%	54.38%	45.62%	2.74%	6.7%
Hungary	8.67%	2.66%	0.82	4.90%	12.01%	9%	54.38%	45.62%	6.28%	9.1%
Ireland	7.00%	0.99%	0.82	1.50%	7.24%	13%	54.38%	45.62%	3.06%	5.2%
Italy	9.08%	3.07%	0.82	1.70%	9.15%	24%	54.38%	45.62%	2.81%	5.9%

Latvia	7.69%	1.68%	0.82	2.00%	8.30%	20%	54.38%	45.62%	3.20%	5.7%
Lithuania	7.19%	1.18%	0.82	2.00%	7.90%	15%	54.38%	45.62%	3.40%	5.6%
Luxembourg	6.01%	0.00%	0.82	1.40%	6.33%	25%	54.38%	45.62%	2.55%	4.3%
Malta	7.19%	1.18%	0.82	2.00%	7.90%	35%	54.38%	45.62%	2.60%	5.1%
Netherlands	6.01%	0.00%	0.82	1.30%	6.23%	25%	54.38%	45.62%	2.48%	4.2%
Poland	7.19%	1.18%	0.82	4.00%	9.90%	19%	54.38%	45.62%	4.86%	7.2%
Portugal	8.67%	2.66%	0.82	1.60%	8.71%	21%	54.38%	45.62%	2.84%	5.8%
Romania	9.08%	3.07%	0.82	7.20%	14.65%	16%	54.38%	45.62%	7.73%	10.9%
Slovakia	7.19%	1.18%	0.82	2.70%	8.60%	21%	54.38%	45.62%	3.71%	6.0%
Slovenia	7.69%	1.68%	0.82	2.60%	8.90%	19%	54.38%	45.62%	3.73%	6.2%
Spain	8.24%	2.23%	0.82	2.10%	8.86%	25%	54.38%	45.62%	3.08%	5.9%
Sweden	6.01%	0.00%	0.82	1.40%	6.33%	21%	54.38%	45.62%	2.70%	4.4%

Table 18: WACC calculation for the semiconductors industry sector across EU MS

Country	ERP - Total Equity Risk Premium	Country Risk Premium	Beta - Power	Risk free (Nov-2022)	CoE - Cost of Equity	Tax rate	E/(D+E)	D/(D+E)	CoD - After Tax Cost of Debt	WACC
Austria	6.57%	0.56%	1.53	1.80%	11.85%	25%	84.53%	15.47%	2.85%	10.3%
Belgium	6.85%	0.84%	1.53	1.40%	11.88%	25%	84.53%	15.47%	2.55%	10.3%
Bulgaria	8.24%	2.23%	1.53	1.60%	14.21%	10%	84.53%	15.47%	3.24%	12.5%
Croatia	9.51%	3.50%	1.53	1.50%	16.05%	18%	84.53%	15.47%	2.87%	13.9%
Cyprus	9.51%	3.50%	1.53	3.50%	18.05%	13%	84.53%	15.47%	4.81%	15.9%
Czechia	6.85%	0.84%	1.53	4.10%	14.58%	19%	84.53%	15.47%	4.94%	12.9%
Denmark	6.01%	0.00%	1.53	1.40%	10.60%	22%	84.53%	15.47%	2.65%	9.3%
Estonia	7.00%	0.99%	1.53	2.50%	13.20%	20%	84.53%	15.47%	3.60%	11.6%
Finland	6.57%	0.56%	1.53	1.40%	11.45%	20%	84.53%	15.47%	2.72%	10.0%
France	6.70%	0.69%	1.53	1.30%	11.55%	27%	84.53%	15.47%	2.43%	10.0%
Germany	6.01%	0.00%	1.53	1.20%	10.40%	30%	84.53%	15.47%	2.24%	9.0%
Greece	11.04%	5.03%	1.53	1.60%	18.49%	24%	84.53%	15.47%	2.74%	16.0%
Hungary	8.67%	2.66%	1.53	4.90%	18.17%	9%	84.53%	15.47%	6.28%	16.2%
Ireland	7.00%	0.99%	1.53	1.50%	12.20%	13%	84.53%	15.47%	3.06%	10.7%

Country	ERP - Total Equity Risk Premium	Country Risk Premium	Beta - Power	Risk free (Nov-2022)	CoE - Cost of Equity	Tax rate	E/(D+E)	D/(D+E)	CoD - After Tax Cost of Debt	WACC
Italy	9.08%	3.07%	1.53	1.70%	15.60%	24%	84.53%	15.47%	2.81%	13.5%
Latvia	7.69%	1.68%	1.53	2.00%	13.76%	20%	84.53%	15.47%	3.20%	12.0%
Lithuania	7.19%	1.18%	1.53	2.00%	13.01%	15%	84.53%	15.47%	3.40%	11.4%
Luxembourg	6.01%	0.00%	1.53	1.40%	10.60%	25%	84.53%	15.47%	2.55%	9.3%
Malta	7.19%	1.18%	1.53	2.00%	13.01%	35%	84.53%	15.47%	2.60%	11.3%
Netherlands	6.01%	0.00%	1.53	1.30%	10.50%	25%	84.53%	15.47%	2.48%	9.2%
Poland	7.19%	1.18%	1.53	4.00%	15.01%	19%	84.53%	15.47%	4.86%	13.3%
Portugal	8.67%	2.66%	1.53	1.60%	14.87%	21%	84.53%	15.47%	2.84%	12.9%
Romania	9.08%	3.07%	1.53	7.20%	21.10%	16%	84.53%	15.47%	7.73%	18.8%
Slovakia	7.19%	1.18%	1.53	2.70%	13.71%	21%	84.53%	15.47%	3.71%	12.0%
Slovenia	7.69%	1.68%	1.53	2.60%	14.36%	19%	84.53%	15.47%	3.73%	12.6%
Spain	8.24%	2.23%	1.53	2.10%	14.71%	25%	84.53%	15.47%	3.08%	12.8%
Sweden	6.01%	0.00%	1.53	1.40%	10.60%	21%	84.53%	15.47%	2.70%	9.3%

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