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Energy Storage:

A Challenge Romania Must Overcome

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Energy Storage: A Challenge Romania Must Overcome

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About EPG

EPG is an independent, non-profit think tank focused on energy and climate policy in Romania and the European Union. Founded in 2014, EPG operates as a policy research institute primarily financed through competitive grants, philanthropic organisations and, to a limited extent, private sector projects. EPG aims to promote an evidence-based dialogue on how to balance decarbonisation, economic competitiveness and social fairness, engaging decision-makers, industry, and the public.

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Key Findings

The present report analyses the status, challenges, and opportunities for energy storage in Romania, focusing on technological, regulatory, financial, and business aspects. It emphasizes the urgent need to accelerate storage deployment in parallel with the expansion of renewable energy sources (RES) and proposes policy measures to support this effort.

A review of available technologies is provided, with focus on pumped hydro energy storage (PHES), lithium-ion batteries, and vehicle-to-grid (V2G). PHES remains the most mature and cost-efficient solution for large-scale, long-duration storage but faces environmental and geographic barriers. Lithium-ion batteries, whose costs have declined significantly, offer rapid response for short- and medium-term applications. V2G, though still emerging, could transform Romania's growing electric vehicle fleet into a valuable distributed storage resource.

Storage's role in supporting grid ancillary services – including frequency regulation, voltage control, congestion management, and black start – is highlighted, along with its potential to complement or replace conventional generation. International case studies showcase proven integration of batteries and PHES in stabilizing renewable-heavy systems.

Despite its potential, Romania's installed total storage capacity remains low. Barriers include the absence of explicit national targets, regulatory ambiguity, lengthy grid connection approvals, limited funding, and weak market incentives. Investor interest is present but constrained by low project bankability and lack of proven business models.

This report recommends strategic alignment of Romania's energy strategy with the EU objectives, adoption of clear storage targets, and policies supportive of storage deployment. It proposes regulatory reforms, streamlined approvals, support schemes such as capacity markets, contracts for difference, and the use of EU funding. Additionally, pilot projects and incentives for emerging solutions like V2G are encouraged to diversify the storage mix.

Romania's decarbonisation path, energy security, and investment attractiveness hinge on the rapid and diversified deployment of energy storage. A favourable and coherent policy framework will likely turn storage into a cornerstone of the country's clean energy transition.

Executive Summary

Romania's energy sector is undergoing a profound transformation as it gradually shifts away from fossil-fuel-based generation toward renewable energy sources (RES). Nonetheless, the growing share of intermittent wind and solar introduces volatility, imbalance between supply and demand, and risks to grid stability. To address these challenges, the accelerated installation of energy storage capacities has become indispensable.

This report examines the technological, regulatory, financial, and business dimensions of energy storage in Romania, identifying critical gaps and proposing policy measures to ensure the sector's sustainable growth.

The role of energy storage

Energy storage provides the flexibility needed to integrate variable renewables into the grid, ensuring system reliability and resilience. Internationally, storage is increasingly recognized as a strategic enabler of the energy transition, with ambitious deployment targets set under REPowerEU. Storage systems support key grid services including frequency control, voltage regulation, congestion management, black start, and ancillary services.

Three main storage pathways are emphasized in this report: pumped hydro storage (PHES), lithium-ion battery storage (BESS), and vehicle-to-grid (V2G). Pumped hydro remains the most mature and cost-effective long-duration option, but new projects face geographic and environmental constraints. Batteries have rapidly expanded due to declining costs and fast response times, though they are better suited for short-to-medium-term applications. V2G represents an emerging opportunity to leverage Romania's growing electric vehicle fleet, potentially unlocking substantial distributed storage capacity if supported by infrastructure and regulation.

Status in Romania

Romania's storage capacity is among the lowest in the EU relative to RES penetration. The installed base of 348 MW as of October 2025 represents only 1.8% of total generation capacity, split between batteries and pumped hydro. Development has been hindered by several factors:

- Absence of a clear strategic vision or targets for storage capacity in national plans.
- Market mechanisms that favour arbitrage but offer few incentives for long-duration storage or hybrid RES-storage projects.
- Regulatory ambiguities regarding whether stored and reinjected energy qualifies as renewable. Clear provisions are required to identify the conditions in which energy discharged from a storage unit can be considered renewable.
- Limited access to private financing, on account of low project bankability and lack of proven business models.

Despite these barriers, investor interest is strong, supported by EU-level financing opportunities and Romania's increasing reliance on RES (now over 40% of capacity when including prosumers).

Key policy gaps and risks

High reliance on batteries risks leaving the system vulnerable, given their unsuitability for long-term, large-scale storage. Pumped hydro projects are stalling, while alternative

technologies receive little attention. Without diversified deployment, grid security and investment attractiveness could be undermined. Furthermore, technical approvals for grid connections are cumbersome, and congestion in transmission networks is still to be addressed.

Recommendations

To unlock Romania's energy storage potential, the following propositions are made:

- **Strategic alignment**: update the *Romanian Energy Strategy 2025–2035*, to include an energy storage roadmap and clear capacity targets.
- **Regulatory changes**: clarify the legal treatment of stored energy, simplify grid connection procedures, and develop supportive frameworks for hybrid RES-storage projects.
- **Market incentives**: introduce capacity mechanisms, tax incentives, feed-in tariffs, and contracts for difference to improve project bankability.
- **Financial support**: leverage EU and national funding, while expanding access to private finance through guarantees, green bonds, and insurance instruments.
- **V2G deployment**: promote V2G through purchase incentives for EVs, V2G-capable charging infrastructure, and enabling legislation.
- **Diversification**: encourage pilot projects for diversified innovative technologies, avoiding over-reliance on one single storage solution.

Conclusion

Romania stands at a decisive moment. Without rapid, coordinated action, the energy transition risks instability and lost investment opportunities. By implementing a clear, diversified, and supportive strategy for energy storage, Romania can secure grid stability, attract investment, and meet its decarbonisation commitments while strengthening long-term energy independence.

Sumar executiv

Sectorul energetic al României trece printr-o transformare profundă, trecând de la producția bazată pe combustibili fosili către surse regenerabile de energie (SRE). Dar creșterea ponderii energiei eoliene și solare introduce volatilitate, dezechilibre între cerere și ofertă și riscuri pentru stabilitatea rețelei. Pentru a răspunde acestor provocări, dezvoltarea accelerată a capacităților de stocare a energiei devine nu doar dezirabilă, ci indispensabilă.

Acest raport examinează dimensiunile tehnologice, de reglementare, financiare și de afaceri ale stocării energiei în România, identificând lacune și propunând măsuri de politică publică pentru asigurarea unei dezvoltări sustenabile a sectorului.

Rolul stocării energiei

Stocarea energiei oferă flexibilitatea necesară pentru integrarea surselor regenerabile variabile în rețea, asigurând fiabilitatea și reziliența sistemului. La nivel global și european, stocarea este recunoscută din ce în ce mai mult ca element strategic al tranziției energetice, cu ținte ambițioase de implementare prevăzute în REPowerEU. Tehnologiile de stocare sprijină servicii esențiale ale rețelei, inclusiv controlul frecvenței, reglajul tensiunii, gestionarea congestiilor, *black start* și alte servicii auxiliare.

Raportul pune accent pe trei tehnologii principale: centrale hidroelectrice cu acumulare prin pompaj (CHEAP), baterii litiu-ion și vehicule electrice conectate la rețea (V2G). CHEAP rămâne cea mai matură și rentabilă soluție pentru stocarea de lungă durată, însă proiectele noi se confruntă cu limitări geografice și de mediu. Bateriile s-au extins rapid datorită reducerii costurilor și timpului de răspuns rapid, fiind mai potrivite pentru aplicații pe termen scurt și mediu. V2G reprezintă o oportunitate emergentă de a valorifica flota de vehicule electrice din România, putând oferi o capacitate distribuită semnificativă dacă va fi susținută de infrastructură și reglementări.

Situația actuală în România

Capacitatea de stocare a României este printre cele mai scăzute din UE raportat la penetrarea SRE. Capacitatea instalată de stocare de 348 MW (in octombrie 2025) reprezintă doar 1,8% din capacitatea totală de generare, împărțită între baterii și acumulare prin pompaj. Dezvoltarea a fost încetinită de mai mulți factori:

- Lipsa unei viziuni strategice clare și a unor ținte pentru stocare în planurile naționale;
- Mecanisme de piață care favorizează arbitrajul, dar nu și stocarea pe termen lung sau proiectele hibride SRE-stocare;
- Ambiguități privind statutul energiei stocate și reintroduse în rețea ca energie regenerabilă;
- Acces limitat la finanțare privată, din cauza bancabilității reduse a proiectelor și a lipsei unor modele de afaceri validate.

Totuși, interesul investitorilor este ridicat, sprijinit de oportunități de finanțare la nivelul UE și de creșterea ponderii SRE (peste 40% din capacitate, incluzând prosumatorii).

Lacune și riscuri cheie

Dependența excesivă de baterii riscă să devină o vulnerabilitate a sistemului energetic național, dat fiind că acestea nu sunt potrivite pentru stocare pe termen lung. Proiectele de acumulare prin pompaj stagnează, iar tehnologiile alternative primesc prea puțină atenție.

Fără o diversificare a implementării, securitatea rețelei și atractivitatea investițiilor pot fi compromise. În plus, aprobările tehnice pentru racordare sunt greoaie, iar congestiile rețelei de transport reprezintă un aspect ce rămâne puțin abordat.

Recomandări

Pentru a valorifica potențialul de stocare al României, se propun următoarele soluții:

- **Aliniere strategică**: actualizarea *Strategiei Energetice a României 2025-2035*, prin includerea unei foi de parcurs pentru stocare, cu ținte clare de capacitate.
- **Modificări de reglementare**: clarificarea statutului legal al energiei stocate, simplificarea procedurilor de racordare și dezvoltarea unui cadru favorabil pentru proiecte hibride SRE-stocare.
- **Stimulente de piață**: introducerea de mecanisme de capacitate, facilități fiscale, tarife garantate și contracte pentru diferență pentru a îmbunătăți bancabilitatea proiectelor.
- **Sprijin financiar**: valorificarea fondurilor UE și naționale, extinderea accesului la finanțare privată prin garanții, obligațiuni verzi și instrumente de asigurare.
- **Implementarea V2G**: promovarea V2G prin stimulente pentru achiziția de vehicule electrice, infrastructură de încărcare compatibilă (bidirecțională) și legislație de sprijin.
- **Diversificare**: încurajarea proiectelor pilot pentru tehnologii inovatoare și diversificate de stocare a energiei.

Concluzie

România se află într-un moment decisiv. Fără acțiuni rapide și coordonate, tranziția energetică riscă instabilitate și pierderea oportunităților de investiții. Printr-o strategie clară, diversificată și favorabilă pentru stocarea energiei, România își poate asigura stabilitatea rețelei, poate atrage investiții și își poate îndeplini angajamentele de decarbonizare, consolidând totodată independența energetică pe termen lung.

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Acronyms

ANRE	Romanian Energy Regulatory Authority
ATR	Technical Approval for Connection
BESS	Battery Energy Storage Systems
CCGT	Combined Cycle Gas Turbine
CfD	Contract for Differences
DSO	Distribution System Operator
EASE	The European Association for Storage of Energy
ENTSO-E	the European Network of Transmission System Operators for Electricity
ETS	(EU) Emissions Trading System
EV	Electric Vehicle
FACTS	Flexible Alternating Current Transmission System
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IRENA	International Renewable Energy Agency
LSS	Large Scale Storage
MS	EU Member State
NECP	National Energy and Climate Plan
NRRP	National Recovery and Resilience Plan
PHES	Pumped Hydro Energy Storage
RES	Renewable Energy Source
SSS	Small Scale Storage
TSO	Transmission System Operator
TYNDP	Ten-Year Network Development Plan
V2G	Vehicle-to-Grid

1. Introduction

Mainly as a response to the European legislation, the Romanian power sector is transitioning from thermal-based energy production (mostly relying on fossil fuels) to a large share of renewable energy sources, inherently characterized by variability. The resulting system, although less carbon-intensive, is characterized by significant imbalances between production and consumption and even potential system instability, unless energy storage capacities are installed. The adoption of energy storage is, therefore, not only desirable (due to its benefits on better matching consumption and production), but also required for ensuring grid stability.

Information on the need for energy storage capacities is scarce and rather shallow, yet one thing is certain: Romania needs much more storage capacity than what is currently installed and the rate of development should be high, similar to or higher than the rate of development of RES production capacities.

In addition to quantifying the need for storage, the optimal path to reaching the target must be identified. This requires an implementation strategy that offers clarity and predictability to the energy market stakeholders.

It is important to make well-informed choices when it comes to selecting the most appropriate energy storage technology for any envisaged application. Focusing on one or two technologies as the answer to all problems poses the danger of developing a system with a lower level of performance than the optimal case. In a market as competitive as the energy market, a strong correlation can be established between hardware performance and energy prices, with a direct impact on economic competitivity. As a roadmap for the development of energy storage capabilities gradually emerges, it needs to be reinforced with a favourable regulatory framework, meant not only to encourage development, but also to guide it.

The current work aims to map the publicly available information on technical, regulatory, financial and business aspects of energy storage and identify the elements that need to be improved for reaching the goal of developing the energy storage sector in Romania. From this exercise, a set of policy measures is proposed to assist decision-makers in developing policies to achieve the stated goal.

2. Energy storage technologies

This section contains a description of the available energy storage technologies and the power grid services in which various technologies can be used. Special attention is paid to three storage technologies, since (i) they represent the bulk of energy storage today – pumped hydro storage, (ii) they represent a continuously increasing market in the near- and medium-term future – utility-scale battery storage, or (iii) they have the potential to provide a cost-effective storage solution in the medium- to long-term – vehicle-to-grid (V2G).

2.1. Overview of the available technologies

There are many technologies for energy storage, as shown in Table 1. Each of them can be characterised by a set of performance indicators. Any given combination of high scores on these indicators makes the technology more appropriate for the provision of a certain service to the power grid.

The concept of energy storage relies on the transformation of energy: electrical energy is transformed into a different type of energy (easier to store) which, in turn, can be converted back into electrical energy, when and where needed. Based on the intermediate form of energy, there are five main classes of energy storage technologies:

- **Electrical:** input electrical energy is stored directly, either in the form of electrostatic or electromagnetic energy.
- **Electrochemical:** input electrical energy activates reversible chemical reactions, resulting in electrical charge separation. When run in reverse mode, these chemical reactions restore electrical energy.
- **Chemical:** input electrical energy is converted, by means of non-reversible chemical reactions, into stable products that can be stored, in liquid or gaseous form. Such products can be converted back into electricity, usually through a process different from the one used for their production (e.g. combustion).
- **Thermal:** input electrical energy is converted to heat (thermal energy). The heat can be stored and, when needed, either used directly for heating purposes or converted back into electrical energy by means of a work-producing thermodynamic cycle.
- **Mechanical:** input electrical energy is transformed into mechanical energy (potential or kinetic).

The performance indicators given in Table 1 represent average values characterising a certain type of energy storage technologies. Most of these indicators are straightforward and self-explanatory (e.g. maximum power, maximum energy, response time). Others require additional explanations:

- The **discharge time** represents the order of magnitude of the duration in which a certain energy storage system fully releases the stored energy, assuming continuous operation at nominal (average) power. This offers an indication of how long the given system can provide the required service, in the absence of other sources of electrical energy.

- The **roundtrip efficiency** is defined as the amount of energy the system is able to restore to the grid, when completely discharged, relative to the amount of energy the system requires for becoming fully charged. By contrast, to produce ammonia and synthetic hydrocarbons, the efficiency is defined as the amount of chemical energy stored in these fuels relative to the electrical energy required for producing them.

Table 1 – Overview of energy storage technologies.

	Technology	Maximum power	Maximum energy	Discharge time	Response time	Roundtrip efficiency	Lifespan	CAPEX	TRL	Source
Electrical	Double layer capacitors	MW level	kWh level	minutes	~ 5 ms	90%	1 mil cycles	10 - 20 k€/kWh 0.1 - 0.5 k€/kW	9	(EASE, 2018)
	Superconducting magnetic energy storage	MW level	MWh level	hours	-	95%	unlimited	0.5 - 10 k€/kWh 0.1 - 0.5 k€/kW	5-8	(EnTEC, 2023)
	Power electronic capacitor	MW level	kWh level	seconds	ms	95%	40 years	-	-	(EASE, 2018)
Electrochemical	Conventional batteries									
	Li-based	hundreds of MW	hundreds of MWh	~ 4 hours	ms	90-98%	~ 10 000 cycles 15 - 20 years	~0.11 k€/kWh (in 2024)	6-9	(EASE, 2018)
	Na-based	hundreds of MW	~ 400 MWh	~ 6 hours	ms	70-90%	~ 4 500 cycles 15 -20 years	~0.085 k€/kWh	6-9	
	Lead Acid	MW level	~ 10 MWh	> 20 hours	ms	75-85%	~ 3 000 cycles 5 - 15 years	0.1 - 0.2 k€/kWh 0.1 - 0.5 k€/kW	9	
	other									
	Solid state batteries	MW level	-	-	ms	-	~10 000 cycles 15 - 20 years	0.38 - 0.77 k€/kWh	4-6	
	Flow batteries	MW level	MWh level	hours	ms	70-75%	>12 000 cycles 10 - 20 years	0.1 - 0.4 k€/kWh 0.5 - 1.3 k€/kW	2-9	
Chemical	Hydrogen	GW level	GWh level	weeks	s	20-40%	5-30 years	0.001-0.01 k€/kWh 2 - 5 k€/kW	6-9	(EASE, 2018)
	Ammonia	GW level	GWh level	-	s	50-55% *	30 years	1.9 - 2.9 k€/kW	6-9	
	Synthetic hydrocarbons	GW level	GWh level	-	s	48-55% *	30 years	1.9 - 3.8 k€/kW	6-9	
Thermal	Latent heat storage	MW level	MWh level	hour level	-	75-95%	10-30 years	0.035 - 0.35 k€/kWh	4-9	(Ho, 2020)
	Sensible heat storage	~ 100 MW	GWh level	~ 10 hours	-	30-50%	~ 40 years	0.0035 - 0.035 k€/kWh	4-9	
	Thermochemical storage	so far, mainly applied at building level						0.035 - 0.35 k€/kWh	4-7	
Mechanical	Air-based									
	Adiabatic compression	~ 100 MW	~ 10 GWh	~ 10 hours	min	> 70%	> 30 years	1.2 - 2 k€/kW	5-6	(EASE, 2018)
	Diabatic compression	~ 100 MW	~ 10 GWh	~ 10 hours	min	~ 55%	> 30 years	0.05 - 0.15 k€/kWh 0.4 - 1.2 k€/kW	8	
	Underwater	~ 100 MW	GWh level	~ 10 hours	-	~ 70%	~ 20 years	0.096 k€/kWh	3-5	(Blain, 2024)
	Liquid air	~ 650 MW	~ 7.8 GWh	~ 24 hours	> 5 min	50-100%	30 - 40 years	0.06 - 0.6 k€/kWh 0.5 - 3.5 k€/kW	7-8	(EASE, 2018)
	Pumped hydro									
	on land	~ 3 GW	~ 100 GWh	~ 10 hours	min	70-85%	> 80 years	0.04 - 0.15 k€/kWh 0.4 - 1.5 k€/kW	9	(EASE, 2018)
	underwater	600 MW	2.2 GWh	4-10 hours	-	-	-	0.43 k€/kWh	5-7	(Schmidt-Böcking, 2024)
	Pumped heat	~ 200 MW	~ 1GWh	~ 6 hours	1-2 s	70-75%	~15 000 cycles 20-30 years	~ 0.02 k€/kWh ~ 0.35 k€/kW	2-5	(EASE, 2018)
	Flywheels	~1 MW	kWh level	seconds	0.25 s	85-98%	~200 000 cycles > 20 years	~5.8 k€/kW 0.58 - 2.3 k€/kW	9	(Mongird, 2020)
	Gravity based storage	GW level	GWh level	-	s	80-90%	35 - 50 years	~ 0.025 k€/kWh	6-8	(Tong, 2022)

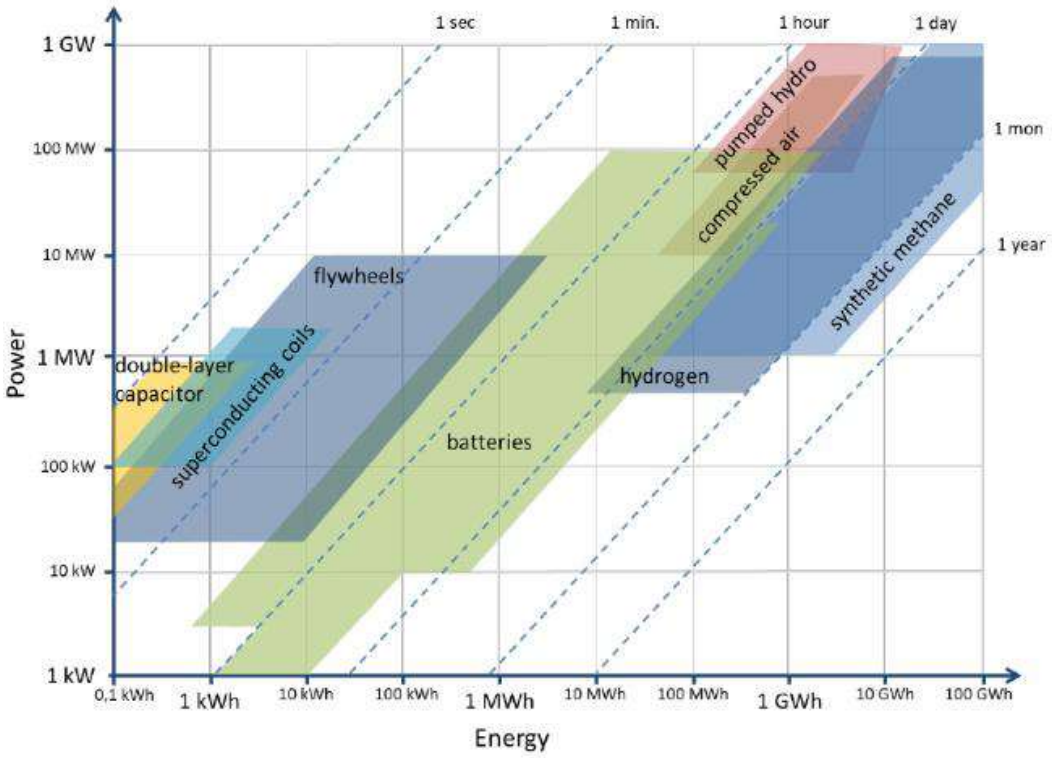
* efficiency relative to the energy content in the generated fuel (no re-conversion to electricity assumed)

Source: EPG

- The **lifespan** of a certain storage system can be expressed in the number of operating cycles (a **cycle** is defined as one full recharge and discharge). Expressing lifespan in years requires an assumption on the number of cycles per unit of time – this is a function of the share of RES in the power grid, the type of RES and the service the system is meant to fulfil.
- The **CAPEX** of the system is the full cost of development and introduction in operation.

- The **range of TRL** included in the table covers all sub-types of a specific type of technologies (some sub-types have lower TRL while others have higher TRL). A TRL of 8-9 signifies the technology has already reached commercial maturity, while a TRL 7 implies the technology can be implemented commercially, but there is little to no commercial implementation to date. A TRL of 6 or below signifies the technology has not evolved beyond R&D phase.
- One essential indicator that was not included in Table 1 is the rate of self-discharge. This indicates how fast the charge state of a given technology drops, without being connected to a load. Nevertheless, as for most technologies this indicator is expressed in days or weeks, it is only relevant for storage technologies meant to ensure long and very long-term storage.

Figure 1 – Power and energy ranges of different storage technologies.



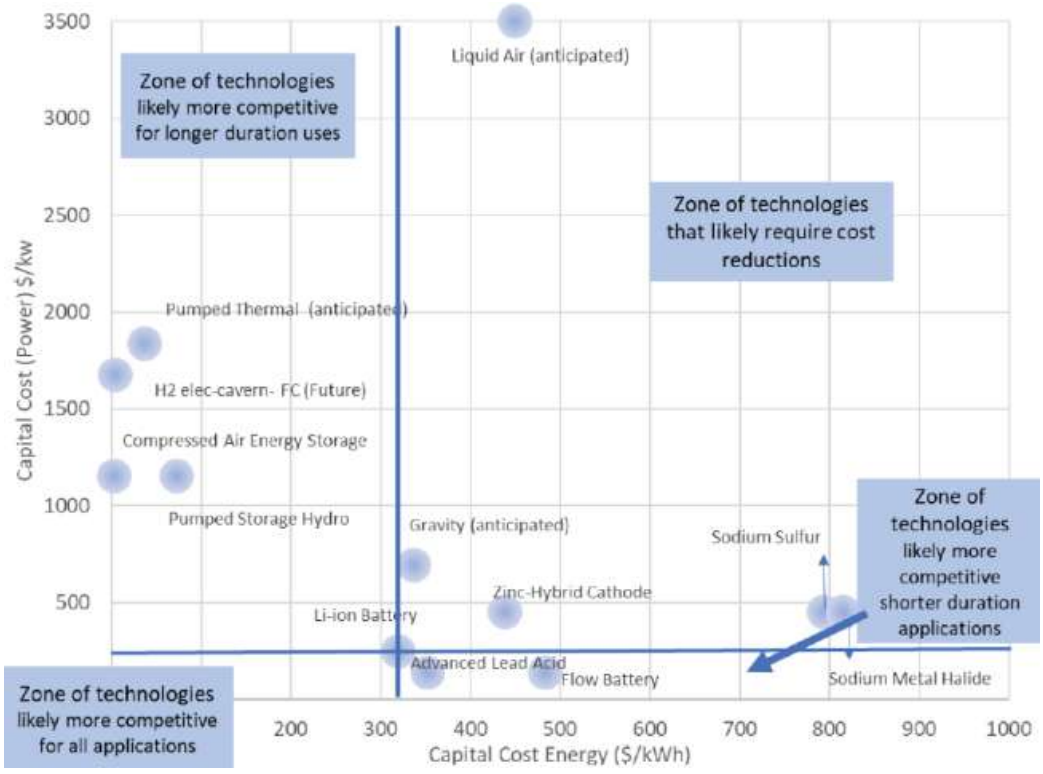
Source: (EnTEC, 2023)

Based on the performance indicators shown in Table 1 (maximum power, maximum energy and discharge time) the main types of energy storage technologies can be represented in a three-dimensional space, as shown in Figure 1. The plot allows identifying the most appropriate storage technology based on the technical requirements of the services it needs to fulfil.

For a more complete image of the appropriateness of a storage technology for a given power grid service, the technical characteristics extracted from Table 1 and Figure 1 need to be combined with the financial performance, as shown in Figure 2. Based on the average CAPEX per unit of delivered power and per unit of stored energy, each storage technology can be fitted in one of the four zones:

- Technologies more appropriate for high power, low energy applications – usually, short-term storage (quadrant IV – lower right corner)
- Technologies more appropriate for low power, high energy applications – usually, long term storage (quadrant II – upper left corner)
- Technologies that can be used for both long- and short-term storage, with similar level of financial performance (quadrant III – lower left corner). Unfortunately, no such technology has been identified so far, with Li-ion batteries being the closest technology to satisfying this condition.
- Technologies that are still too expensive for either type of application (quadrant I – upper right corner). Further cost reduction possibilities will decide the best type of application for such technologies.

Figure 2 – Capital cost of power and energy for different technologies.



Source: (EnTEC, 2023)

Once the available energy storage technologies are identified and described, one can analyse how appropriate these technologies are for providing the different services for supporting the power grid. According to the European Association for Storage of Energy (EASE), the power grid services can be grouped in five classes, as follows:

- **Services to Support Generation and Services to Support Bulk Storage** (EASE, 2020) – these are services that can ensure vast and clean energy generation from renewable sources.
- **Services to Support Transmission Infrastructure** (EASE, 2021d) – services that energy storage could provide as an alternative to or complement traditional transmission infrastructure assets.

- **Services to Support Distribution Infrastructure** (EASE, 2021c) – services that energy storage could provide as an alternative to or complement traditional grid infrastructure at the distribution level.
- **Ancillary Services** (EASE, 2021a) **–** services that support the efficient operation of the power grid. They are generally tendered by transmission and distribution system operators to ensure reliable power supply.
- **Services to Support Behind the Meter Customer Energy Management** (EASE, 2021b) – services that support end users to manage their energy supply and/or costs. In this context, customer can refer to either residential consumers or commercial and industrial customers.

Table 2 provides a match between the various types of energy storage technologies and the grid services they can support, from a technical point of view.

Table 2 – Technical suitability of energy storage technologies for various grid services.

Source:
○ European Association for Storage of Energy
□ EPG estimation

Energy Storage Technology		Power Grid Services: Services to Support Generation and Services to Support Bulk Storage	Services to Support Transmission Infrastructure	Services to Support Distribution Infrastructure	Ancillary services	Services to Support Behind the Meter Customer Energy Management
Electrical	Double layer capacitors			□	□	
	Superconducting magnetic energy storage				○	○
	Power electronic capacitor		○		○	○
Electrochemical	Conventional batteries	○	○	○	○	○
	Solid state batteries	□	□	□	□	□
	Flow batteries	○	○	○	○	○
Chemical	Hydrogen	○		○	○	
	Ammonia	□				
	Synthetic hydrocarbons	○				○
Thermal	Sensible heat storage	○			○	○
	Latent heat storage	○			○	○
	Thermochemical storage	○		○		
Mechanical	Compressed air (adiabatic)	○	○	○	○	○
	Compressed air (diabatic)	□			□	□
	Compressed air (underwater)	□	□	□	□	□
	Liquid air	○	○	○	○	○
	Pumped hydro (on land)	○	○	○	○	
	Pumped hydro (underwater)	□	□	□	□	
	Pumped heat	○	○	○	○	
	Flywheels		○		○	○
	Gravity based storage	□	□	□	□	□

Source: EPG

2.2. Battery storage

Although Na-based batteries promise at least similar, if not better performance compared to Li-based cells, as well as better costs, the lower technological maturity and lower lifespan (number of cycles) still prevent this technology from mass deployment for energy storage. According to (IEA, 2024), based on cost and energy density considerations, lithium iron phosphate (LFP) batteries, a subset of lithium-ion batteries, are still the preferred choice for grid-scale storage. More energy-dense chemistries of lithium-ion batteries, such as nickel

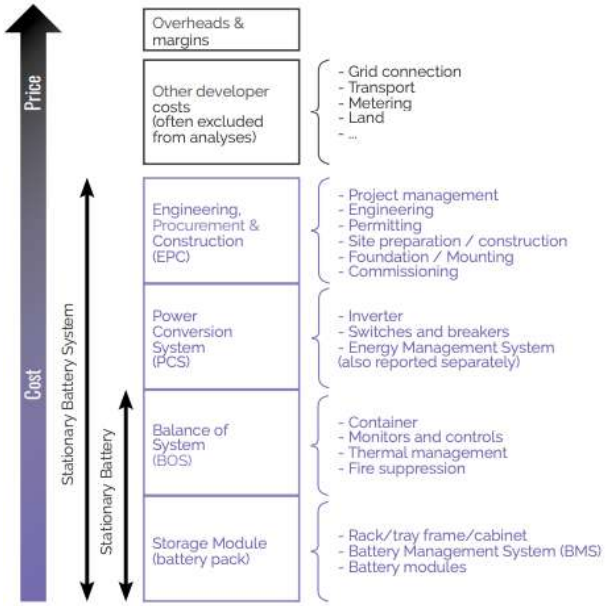
cobalt aluminium (NCA) and nickel manganese cobalt (NMC), are popular for home energy storage and other applications where space is limited.

The main advantages of Li-ion batteries are represented by high energy density (energy per unit of mass), high specific energy (energy per unit of volume), relatively high power, relatively long cycle life (thousands of cycles), safety of the system and maybe most importantly, low cost. On the downside, one can mainly identify the low availability of mineral resources, the monopolistic and geopolitically contentious supply chain (overwhelmingly based in China), the competition with other applications, like mobility and portable devices, and the impact on the environment.

In the last decade, the cost of Li-ion battery packs has seen a continuous decrease. According to (BNEF, 2024), while in 2013 the cost per pack was 774 €/kWh, in 2024 it dropped to 110 €/kWh (75 €/kWh for the cells and 35 €/kWh for the rest of the system).

The European Association for Storage of Energy (EASE) indicates that the rate of cost reduction of Li-based batteries has decreased in the last 2-3 years. Despite continuous technological improvement, the cost is likely to stall or even to see a slight increase in the future, as it is now mainly driven by the cost of mineral resources. Figure 3 shows a cost breakdown for the development of a battery-based energy storage system. The cost reduction seen over the past 10 years was mainly on the first segment – the Storage Module, which, in turn, was determined by the plummeting cost of battery modules. The rest of the cost components have seen relatively little variation over time and the same situation is also expected for the foreseeable future.

Figure 3 – Cost structure of a battery storage system.



Source: (Victanis, 2024)

As of the end of 2023 (Hinds, 2024), most of the battery capacity installed worldwide was in China (~27 GW) and the US (~16 GW), with countries like the UK, Australia, Germany, South Korea and Japan completing the list, but with significantly lower capacities (1 to 4 GW). The three largest (by energy volume) battery storage plants in the world are:

- Edwards & Sandborn Solar Plus Storage (California, USA): 875 MW / 3.3 GWh
- Blythe/McCoy/Arlington (BAM) facility (California, USA): 812 MW / 3.3 GWh
- Moss Landing Energy Storage Facility (California, USA): 750 MW / 3 GWh

The GigaBattery Jänschwalde 1000 project, with an installed power of 1 GW and storage capacity of 4 GWh, is currently in development in Germany (Jänschwalde municipality), as of November 2025. The project is being developed by LEAG, Germany's second-largest energy producer.

2.3. Pumped hydro storage

The pumped hydro energy storage (PHES) technology is one of the oldest and most mature energy storage technologies, relying on the hydrostatic pressure differential of water. Two main types of PHES can be identified: in **closed loop** (when both water bodies are isolated from other sources) and in **open loop**, when at least one of the water bodies is connected to an external source. The two bodies of water are connected through a power waterway, allowing water to flow downhill, due to gravity, thus powering a turbine – when energy needs to be released, or to be pumped uphill – when energy needs to be stored. In theory, there is no limit with respect to the maximum power such a system can deliver. The stored energy is a function of the size of the two water bodies.

The main advantages of a pumped hydro energy storage facilities are: i) high cycle efficiency, typically 70-85%, ii) large storage capacity, limited only by the volume of the water bodies and the difference in altitude, iii) very long lifespan, of the order of 50-100 years, iv) low operating costs, v) fast response time, allowing it to provide a multitude of power grid services.

Among disadvantages, one can indicate: i) high initial investment for infrastructure and site development, ii) geographic limitations, as specific terrain characteristics are required, iii) long construction time, with an equally high approval time, iv) significant environmental impact, v) limited flexibility given by the terrain-related constraint. Additional concerns can be identified related to the negative environmental impact. First, land-filling requirements can lead to population displacement and/or massive deforestation. Second, these projects impact subalpine and alpine biodiversity through multiple pathways: proliferation of exotic flora, habitat loss from vegetation clearing, altered landscape hydrology, and reduced water quality. (Normyle, 2019).

The analysis in (NREL, 2024) shows that an indicative total development cost for large PHES facilities (1.28 GW peak power) reaches 1,810 €/kW and 101.7 €/kWh, while for small PHES facilities (116 MW peak power) this cost is 4,384 €/kW and 439 €/kWh. Nevertheless, these costs are highly variable, based on factors such as project size, location, terrain, permitting, and grid connection.

At EU level, in 2023 there were 46 GW of installed PHES capacities, mostly in mountainous regions in countries like Italy (7.2 GW), France (7.1 GW), Germany (6.5 GW), Spain (6.4 GW) and Austria (5.8 GW) (EU – JRC, 2023). The largest PHES facility in the world is Bath County Pumped Storage Station, in Virginia, USA, with a power rating of 3 GW. The station was completed in 1985. The largest PHES facility in Europe is Grand'Maison Dam, in France, with a power of 1.8 GW, also commissioned in 1985. (Engineering New-Record, 2018).

2.1. Vehicle-to-grid

The concept of vehicle-to-grid (V2G) emerged as an alternative to the development of dedicated battery-based energy storage facilities. One can make use of the large number of existing EVs for satisfying some power grid services. A necessary (but not sufficient) condition is the capability of the EV to manage a bidirectional flow of electrical energy: from the grid to the battery (charge) and from the battery to the grid (discharge). Thus, the EV needs

to be equipped with a dedicated V2G interface. The approach is different from controlling the demand, by optimising the EV charging times – it actively uses the battery of the vehicle as an energy storage device. Hence, **the EV owner passes the control of the state of charge of their EV battery to the grid operator.**

A straightforward advantage of the V2G approach is the fast and cost-effective development of a significant battery storage capacity, at grid level, by making use of the existing EV fleet. In addition to cost, there is also an obvious environmental advantage, as the dedicated battery storage capacity can be drastically reduced or even eliminated. Another advantage is on the EV owner's side: by "renting" their vehicle's battery for the V2G scheme the owner of a V2G-capable EV can enjoy financial benefits.

The drawbacks of the V2G scheme consist in a potentially faster degradation of the EV battery due to the large number of charge/discharge cycles, a lack of infrastructure (chargers with V2G capabilities), a lack of V2G interfaces on most existing EVs, and a lack of a proven V2G management solution at grid level. Not least, the lack of legislative framework for a V2G scheme can be a showstopper.

Several pilot projects have recently been implemented for testing the V2G concept in real life scenarios. Here are some examples of such projects:

- For testing the technical feasibility:
  - At vehicle level: in November 2024, Renault started to deploy 500 V2G prototypes in Utrecht, Netherlands, with bidirectional charging capabilities (Latief, 2024)
  - At grid level: Turin, Italy. In 2020, Fiat Chrysler Automobiles deployed 32 dual bidirectional chargers for 64 vehicles to test the feasibility of using EVs to stabilize the electric grid and optimize energy costs (Stellantis, 2020)
- For testing the business model: project initiated in Gothenburg, Sweden, in 2024, with a duration of two years. Funded by the Swedish Innovation Agency Vinnova, the pilot involves a fleet of Polestar 3 cars aiming to explore scalable business models and use cases for V2G technology (V2G-hub, 2024).

As indicated in (Moldovan, 2025), at the beginning of 2025, there were 54,471 EVs in Romania, out of which 49,594 electric personal vehicles. Judging by the number and types of personal EVs registered in 2023 (Stan, 2024), the average EV battery size of personal EVs in Romania is 40 kWh. This implies that the total personal EV fleet in Romania has a combined battery energy storage capacity of almost 2 GWh. This potential energy storage capacity could reach 27 GWh by 2030, and 177 GWh by 2050 according to the forecasted evolution of the Romanian EV fleet in the NECP.

3.Grid ancillary services

In a National Power System, the system operators are the only actors who take care of maintaining the grid stability through different system services, such as frequency control, voltage regulation, power reserves availability, black start, etc.

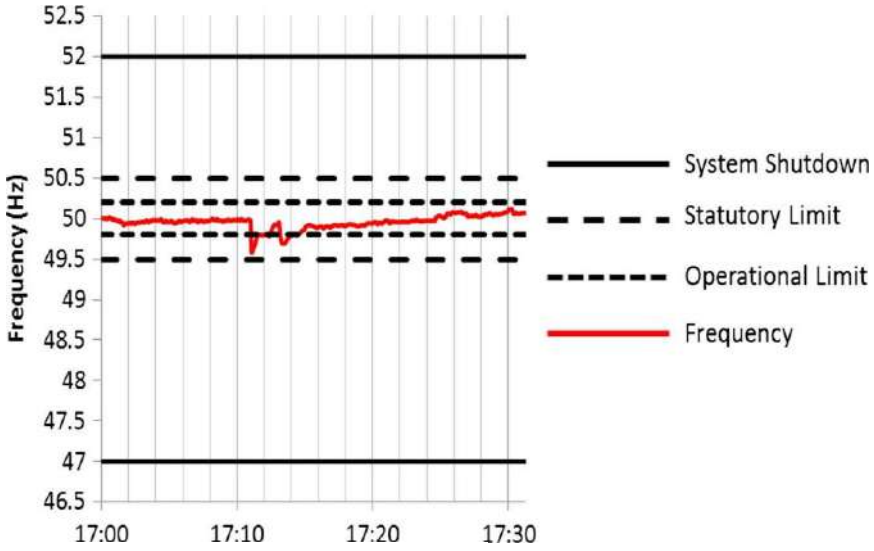
Traditional power systems rely on large synchronous generators (e.g. thermal, hydro, nuclear, gas power plants) that play a crucial role in maintaining the stability of the grid through their predictable character and availability to be used when needed for balancing the system.

But, as the power systems are switching from conventional power generation sources to RES, which are asynchronous, the balancing process managed by the TSOs is getting more challenging, given the unpredictability of RES and the lack of inertia needed to assure power reserves for the system. Therefore, usually the main factor affecting ancillary services is the variability and uncertainty of RES, which also affects the scheduling and pricing of those services. So, in this rapidly changing configuration of the power systems, storage installations are very much needed and will play a major role in assuring grid stability (Ancillary Services, 2025).

3.1. Frequency control

Frequency is a vital parameter in AC power systems, representing the balance between electricity generation and consumption. Any imbalance between these two factors will be translated in frequency deviations. For example, an excess of power injected in the grid causes the increase of frequency, while higher power consumption results in frequency drops. Significant frequency deviations can breach operational limits and disconnect generators and potentially lead to severe system failures. In such cases, power reserves managed by the TSOs can correct usual imbalances.

Figure 4 – Example of operational frequency limit in relation to the real frequency response for the Great Britain system.



Source: (D.M. Greenwood, 2017)

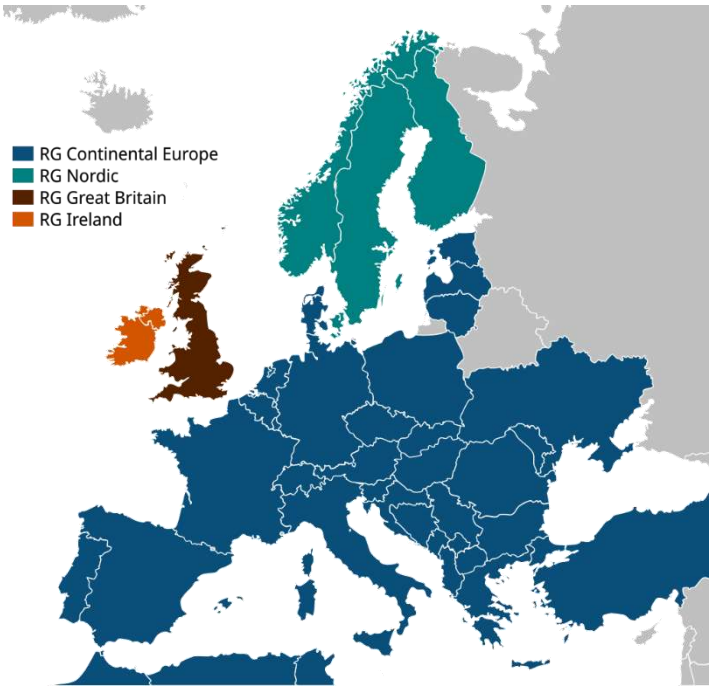
The frequency control at European level is used to maintain the power system's stability and the reliability of the interconnected power grids of different countries. This process is vital to ensure the frequency stands within its rated values – 50 Hz in Europe – despite fluctuations in

energy production and consumption (D.M. Greenwood, 2017).

Various factors can cause frequency deviations, and the methods of frequency regulation vary depending on their impact. Common imbalances, such as mismatches between power generation and demand, typically result in slow frequency variations over minutes. However, certain disturbances such as generator disconnections, short circuits, power cable failures, or lightning strikes can cause abrupt frequency changes within seconds or even sub-seconds.

The Synchronous Continental Europe (blue) is operating at 50 Hz and spans across most European countries, including Romania. This grid area is managed through coordinated frequency control strategies involving primary, secondary, and tertiary reserves to ensure a balanced and reliable power supply (Continental Europe Synchronous Area, 2025).

Figure 5 – Map of Synchronous Continental Europe & Non-Synchronous Regions.



Source: (Continental Europe Synchronous Area, 2025)

3.1.1. Primary reserve

Primary reserve, also known as Frequency Containment Reserve (FCR), is the fastest form of frequency regulation. According to EU rules it responds automatically within less than 30 seconds to stabilize the frequency deviations occurred during a disturbance (e.g. disconnection of a power generator or a power line) and the control is performed locally. In Romania, the FCR is activated when the grid frequency deviates by ± 0.2 Hz. Typical power generation units for primary control include large synchronous generators, such as hydropower plants with fast response capabilities like Vidraru or Porțile de Fier Hydro Power Plants in Romania. These power plants are equipped with control systems that continuously monitor grid frequency and automatically adjust it within limits (Ancillary Services, 2025).

3.1.2. Secondary reserve

Secondary reserve, also known as automatic Frequency Restoration Reserve (aFRR), activates after 30 seconds and no longer than 15 minutes and its purpose is to restore the system's frequency to the nominal value, while also restoring the primary reserves. This control is automatic but performed centrally by the TSO and can be typically handled through hydropower or gas power plants. In Romania, Transelectrica through the National Dispatch Centre (DEN) has the responsibility to activate the aFRR in order to take over the control of the frequency so that the FCR can be recovered and prepared for a subsequent event.

3.1.3. Tertiary reserve

Tertiary reserve, also known as manual Frequency Restoration Reserve (mFRR), is a slower but essential mechanism that can be activated in 15 minutes or more and its purpose is to restore the secondary and primary reserves. It is activated manually at the request of TSO's Dispatch Centre, through thermal or gas power plants, such as Rovinari or Turceni Thermal Power Plants in Romania. The tertiary reserve can be provided by both spinning generators (synchronized with the grid and actively rotating) and non-spinning generators (offline and not rotating, but can be started and synchronized within a relatively short period) (JABER, 2023) (Transelectrica, 2004).

The differences between these three types of power reserves lie in their response times, activation methods, and operational objectives. With the increasing penetration of RES that are unable to assure any of these three types of power reserves, and with the phase-out of conventional thermal capacities able to stabilize the grid in case of system disturbances, the frequency control becomes more complex.

3.2. Other services

Other than the frequency control, there are other services where storage capacities may play an important role in assuring other kinds of system requirements for grid stability and resilience, such as voltage regulation, grid congestion management, and even black start.

3.2.1. Voltage regulation

Voltage represents another very important parameter that the system operators maintain within the acceptable limits to ensure proper functioning of the power system's installations and overall grid stability. Daily, there are voltage fluctuations at any level, which is normal within certain limits, otherwise the equipment connected to the power supply will not function properly. Voltage fluctuations can occur for different reasons, such as load variation, changes in power generation, power losses or grid incidents (e.g. disconnection of a power line or transformer). For example, based on ENTSO-E and IEC regulations, the admissible limits for high voltage installations in Europe are ± 10% for 110 kV and 220 kV, and ± 5% for 400 kV.

As solar and wind power plants do not make use of a synchronous generator for controlling the voltage, different control methods need to be used for networks incorporating such power sources. This is a technological shift, rather than a disadvantage. The main mechanisms to control voltage levels both at TSO and DSO level are synchronous generators, shunt reactors, FACTS installations, tap-changing power transformers, load optimisation or storage systems. They can vary the reactive power in certain electrical substations to balance the voltage level within limits. For example, if the reactive power is consumed the voltage level will reduce, and if the reactive power is generated the voltage level will increase.

3.2.2. System Restoration

System Restoration represents the process of restoring a power system after major system disturbances that lead to partial or total blackout. All system operators have predefined procedures based on ENTSO-E and National Grid Codes, to ensure a safe and efficient

recovery after a blackout. The key aspects of these procedures involve in the first phase the allocation of specific power generation units capable of initiating the restoration process without any external power supply (e.g. big hydro power plants, due to their independent water reservoirs or gas power plants, due to their independent starting installations using diesel engines). Then, the TSO gradually coordinates the re-energisation of essential infrastructure, such as critical substations, other power plants or control centres. And, as more generation units are back online, then the frequency, voltage and phase angles of the grid are resynchronized. In Romania, the Porțile de Fier hydro power plant (1,460 MW) is able to support black start operations, and so is the Iernut gas power plant (800 MW).

3.2.3. Congestion management

Congestion management represents the process of maintaining the grid stability when power flows exceed the acceptable technical limitations of the grid. The TSO and DSOs will have to take measures to correct certain congestions that may occur, like overloads on power lines, transformers, or other grid equipment.

For instance, when many wind turbines in Romania's Dobrogea region begin injecting power into the grid due to favourable weather conditions, the southeastern part of the grid can become congested. This occurs because the transmission capacity of some power lines is exceeded and the energy must be distributed across the entire national grid.

In such cases, grid congestion management measures must be implemented to ensure the grid operates in a stable and normal state. Among the main causes of grid congestions are the unplanned power flows influenced by fast fluctuating wind/solar generation in specific regions, or cross-border energy exchanges. Other causes may also include unforeseen grid outages, or limited grid capacity due to maintenance activities or temporarily disconnected grid elements. The grid congestion is actually amplified by the localised installation of high number of renewable power plants, particularly wind turbines.

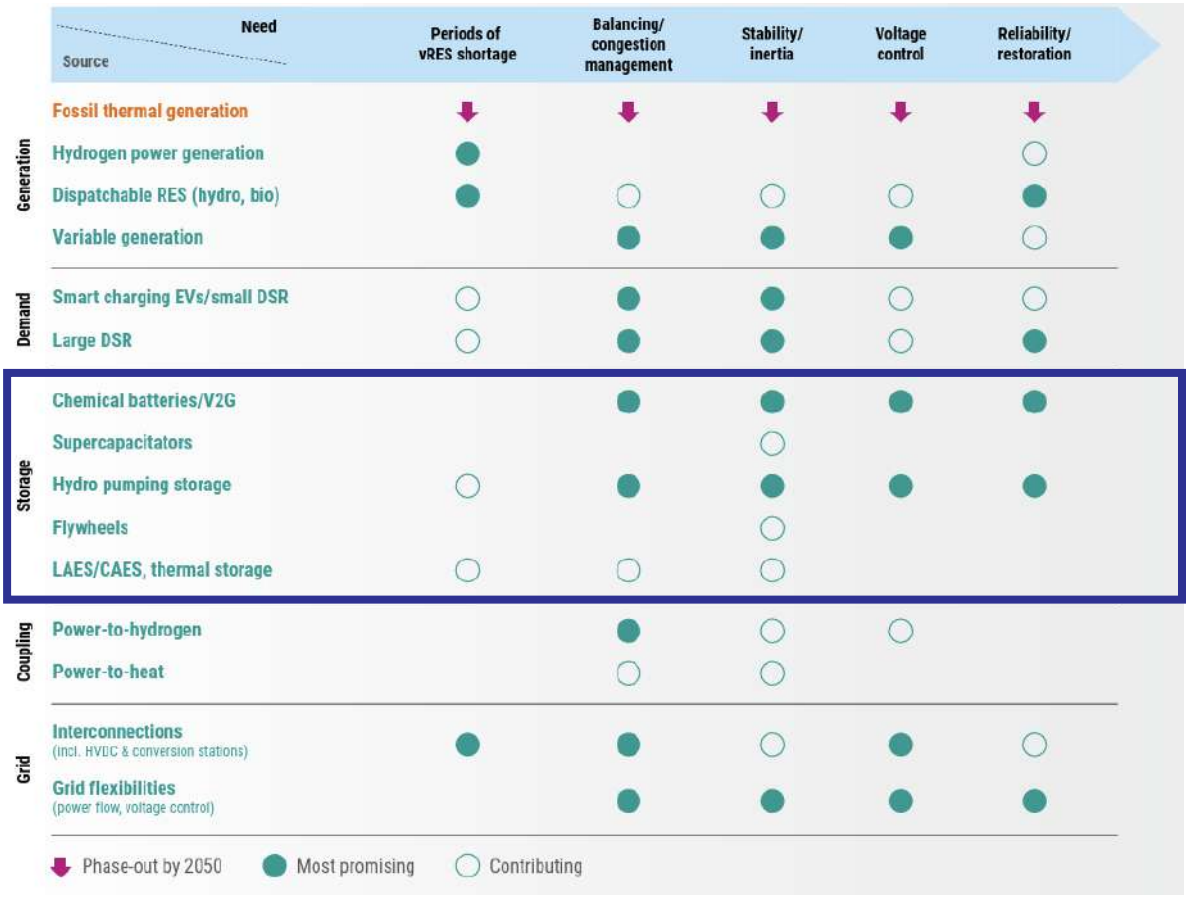
For each of these causes, there are different congestion management strategies that the TSO and DSOs may apply to limit the effects on the grid. They include dispatching activities (adjusting power flows in certain congested regions), curtailment activities (disconnection of specific power plants to protect the grid's stability) or even countertrading (coordination with neighbouring countries to modify the cross-border power flows) (Transelectrica, 2004).

3.3. Role of storage in grid ancillary services

The grid ancillary services presented above are managed daily by system operators to ensure system stability. The power systems undergo significant changes, with the phasing out of thermal power (traditionally key providers of ancillary services) and the rapid expansion of intermittent RES, which introduce challenges to the grid's stability, operation, control and power quality. Also, power grids must cope with the decrease of inertia due to non-synchronous generation. In this context, storage technologies offer a viable solution to all these challenges. Batteries have been a mature technology for many years, but their integration into power systems as a source of power generation and ancillary services is relatively recent (SHENG, 2018).

To better understand the implications that different storage technologies can have on the system's flexibility based on their potential, let us consider Figure 6 from ENTSO-E.

Figure 6 – Qualitative analysis of flexibility sources potential.



Source: (ENTSO-E Vision, 2022)

For the following grid ancillary services, the most promising or contributing storage technologies are:

- Periods of RES shortages: Hydro pumping and LAES/CAES are storage technologies that can contribute to reducing grid disturbances.
- Congestion Management: Hydro pumping and chemical batteries are the most promising storage technologies to solve this kind of bottlenecks.
- Inertia: It is the only type of ancillary service where all storage technologies can contribute, with hydro pumping and chemical batteries being the most promising.
- Voltage Control: For this important type of grid regulation, hydro pumping and chemical batteries are the only and most promising technologies that can be used.
- Restoration: For black start, the only and most promising storage technologies that can be used to restore the system are hydro pumping and chemical batteries.

One important conclusion here is that hydro pumping and chemical batteries are the most mature and promising storage technologies to be used for all the grid ancillary services managed by the system operators in Europe (ENTSO-E Vision, 2022).

More specifically for each type of grid ancillary services, the opportunities and challenges that storage technologies are associated with are as follows:

3.3.1. Frequency control

Of all storage technologies, Battery Energy Storage Systems (BESS) have the advantage of a fast response that can be used for both power generation and power consumption, and are well-suited as balancing reserves. But, unlike synchronous generators, batteries have limited availability for charging and discharging sessions. The most suitable types of regulation reserves where BESS can be used are the primary and secondary reserves, due to their response time. And there are cases where BESS were used to stabilize the grid during sudden power outages. The Hornsdale Power Reserve is a 150 MW (194 MWh) operational grid-connected energy storage system in South Australia that provides energy arbitrage, frequency control and stabilisation services, eliminating the need for a 35 MW fuel-powered conventional power plant for ancillary services (Hornsdale Power Reserve, 2025) (Abdelmotteleb, 2024).

3.3.2. Voltage regulation

Storage systems can either absorb or inject reactive power into the grid, thus helping the voltage control and improving the system's stability. They can act fast, but they require predictability on the duration of reactive power services supply, as they have limited availability, similar with frequency control. They can absorb excess renewable energy during peak production hours, mitigating overvoltage issues in the network and they can function as generators during peak demand to alleviate undervoltage problems (Tommaso Ferrucci, 2025).

And there are examples of successful cases where storage is used to provide reactive power control – in the UK, batteries are used to provide both frequency control and voltage regulation for system stabilisation. In Ireland, at DSO level, Statkraft's Kilathmoy (11 MW) and Kelwin-2 (26 MW) battery storage projects support grid stability by providing fast response to balance the voltage and frequency parameters (Abdelmotteleb, 2024) (statkraft.co.uk, 2021).

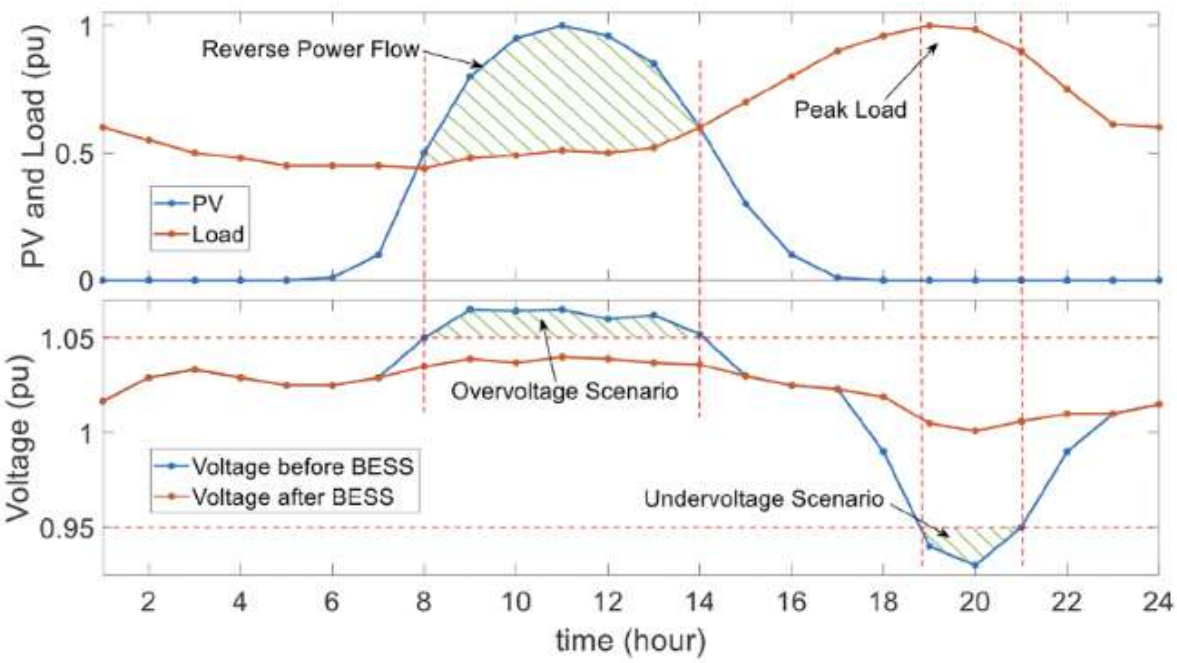
Figure 7 illustrates a typical BESS application for managing voltage fluctuations in the network. As an example, from 08:00 to 14:00, solar generation surpasses demand, causing a surplus of power flow in the electrical substation and leading to overvoltage issues. Also, between 19:00 and 21:00, high electricity consumption results in voltage drops. So, the BESS solves this bottleneck by charging during peak generation hours and discharging during peak demand periods to stabilize the voltage levels (Prakash K, 2022).

3.3.3. System Restoration

Apart from the hydro pumping storage that relies on a similar technology with other hydro power plants able to provide black start services to the system, in recent literature BESS also seems to be a widely accepted solution for black start in power grids due to their capacity to provide instant energy (Prakash K, 2022).

One of the most notable real-world examples comes from Fairbanks, Alaska, where what was then the world's largest BESS was commissioned in 2003 to mitigate frequent outages caused by extremely low temperatures. This system provides up to 27 MW for 15 minutes, significantly improving grid resilience. By 2010, it had reduced outage durations by more than 65%. Though no longer the largest, this project demonstrates that BESS can play a crucial role in system restoration. When implemented on a larger scale alongside conventional restoration mechanisms, this technology has the potential to greatly enhance grid reliability and recovery (Energy Storage for the Grid & Transportation, 2016).

Figure 7 – Typical application of BESS for voltage regulation



Source: (Prakash K, 2022)

3.3.4. Congestion management

Storage systems can significantly contribute to congestion management when strategically placed within the grid. By dynamically injecting or absorbing energy based on congestion levels, they can actively contribute to various congestion management strategies in order to solve different overloads that may occur in the operation of the grid (Abdelmotteleb, 2024).

A relevant example for this is the Antwerp Euroterminal in Belgium that uses a battery system to store the renewable energy produced next to the terminal and to supply energy for daily operations, optimizing on-site consumption. This solution reduces the pressure on the grid that the big energy consumption of the terminal may have, while also avoiding potential congestions (Atlas Copco, 2023).

4. Regulatory considerations

4.1. Global level

The **Global Energy Storage and Grids Pledge**, albeit not legally binding, is a notable inter-governmental effort to increase the penetration of energy storage projects. The pledge was first proposed and endorsed by the G7 energy ministers in April 2024, and aims to deploy 1,500 GW of energy storage in the power sector globally by 2030, a sixfold increase from 2022 levels (Global Renewables Alliance, 2025). The resulting average annual deployment rate is 158 GW/year, with a variety of storage technologies being considered, but with battery energy storage systems (BESS) being by far the most widespread technology. Romania is not among the signatories, which is a missed opportunity for the country to signal its interest for expanding in the storage area.

Romania, as a signatory to the **Paris Agreement**, is committed to reducing emissions and transitioning towards renewable energy, indirectly creating the need to expand electricity storage to manage renewable intermittency. Although the Paris Agreement does not explicitly mandate storage solutions, meeting emissions targets inherently requires storage infrastructure. For the EU Member States, the Nationally Determined Contributions to the implementation of the Paris Agreement stem from each individual National Energy and Climate Plan, encompassing targets, support schemes, and regulatory frameworks.

Romania's accession to the **Organisation for Economic Cooperation and Development (OECD)** requires alignment with OECD standards across various sectors, including energy. IEA's policy recommendations are particularly relevant for the accession process. Under the IEA's Net Zero Scenario, which would require a tripling of global renewable energy capacity by 2030, energy storage must grow sixfold, reaching 1,500 GW (IEA, 2024). Battery storage would drive 90% of this growth, requiring a 14-fold increase to 1,200 GW by 2030, with annual deployment rising by 25%. By fostering a friendly energy storage investment environment, Romania has a better chance to fulfil its OECD accession conditionalities (OECD, 2022).

The **International Renewable Energy Agency (IRENA)**, of which Romania is a member, actively promotes electricity storage globally as essential infrastructure to ensure renewable energy integration and grid stability (IRENA, 2019). IRENA's recommendations influence national policy directions through best-practice guidelines and knowledge sharing.

Various international organisations provide crucial technical guidelines for the safe and efficient deployment of energy storage systems (not legally binding). Examples:

- the **International Electrotechnical Commission (IEC).** Guidelines: IEC 62933 for BESS performance and safety, IEC 62109 for power converters, IEC 61400-21 for wind energy systems integration.
- the **International Organisation for Standardisation (ISO).** Guidelines: ISO 50001 for energy management, ISO/IEC 27001 for information security of energy systems.
- the **National Fire Protection Association (NFPA).** Guidelines: NFPA 855 for BESS fire safety.

4.2. EU level

REPowerEU aims to boost the manufacturing capacity of net-zero technologies, including batteries, and supports investments in energy infrastructure, including electricity grids and storage, to better integrate renewables. The plan sets an aspirational target of 200 GW of installed storage capacity by 2030, signalling a strong political will and creating a favourable environment for the growth of the energy storage market in the EU.

The Network Code on Electricity Balancing – Regulation (EU) 2017/2195 (consolidated on 19/06/2022) (European Commission, 2017a) harmonizes the rules for balancing electricity systems across the EU. The regulation sets common principles for procuring balancing services and settling imbalances, ensuring grid stability and efficient integration of renewable energy sources across borders. It establishes the market rules for balancing services. Energy storage can actively participate in providing frequency regulation and other balancing services, creating revenue streams and incentivizing its deployment as a crucial tool for grid stability and the efficient integration of variable renewables across the EU.

The Regulation on the Governance of the Energy Union and Climate Action – Regulation (EU) 2018/1999 (consolidated on 20/11/2023) (European Parliament, 2019a) establishes a framework for EU Member States to plan, report, and monitor their energy and climate policies towards the 2030 targets and Paris Agreement goals, ensuring coherence and collective progress in the energy transition. It requires Member States to outline their strategies to achieve renewable energy targets and enhance grid flexibility in their National Energy and Climate Plans (NECPs). This necessitates considering and planning for the deployment of energy storage as a key enabler for these goals, promoting its integration into national energy strategies and fostering investment.

Directive (EU) 2018/2002 on energy efficiency (European Parliament, 2018b)**.** The Directive (amending the original Energy Efficiency Directive (EU) 2012/27) is setting a binding EU energy efficiency target of at least 32.5% by 2030. It strengthens energy saving obligations, enhances consumer information, and promotes efficient heating and cooling to further reduce energy consumption. While primarily focused on reducing energy consumption, it indirectly supports energy storage by promoting a more flexible and optimized energy system. Achieving ambitious energy efficiency targets necessitates better demand-side management and the integration of variable renewables, both of which are enhanced by energy storage's ability to balance supply and demand and improve grid stability.

The Regulation on the Internal Market for Electricity – Regulation (EU) 2019/943 (consolidated on 16/07/2024) (European Parliament, 2019b) aims to modernize EU's electricity market rules to better integrate renewables, enhance competition, and empower consumers. It sets principles for grid access, wholesale and retail markets, cross-border trade, and the roles of market participants. It explicitly supports energy storage by aiming to remove barriers to its market participation and ensure non-discriminatory grid access. By defining energy storage as a market participant and establishing rules for its operation, it enables storage to provide grid services and compete fairly, enhancing grid flexibility and renewable energy integration.

The Directive on Common Rules for the Internal Market in Electricity – Directive (EU) 2019/944 (consolidated on 16/07/2024) (European Parliament, 2019c) complements Regulation (EU) 2019/943. It empowers consumers with rights to generate, store, and sell their own electricity. It promotes smart meters, dynamic pricing, demand response, and independent aggregators, fostering a more flexible and consumer-centric retail market. It explicitly supports energy storage deployment by granting consumers the right to store and sell their self-generated electricity. This empowers behind-the-meter storage, enhances energy independence, and enables participation in demand response programmes, contributing to a more flexible and resilient electricity system.

The EU Taxonomy – Regulation (EU) 2020/852 (European Parliament, 2020a) establishes a classification system to determine environmentally sustainable economic activities. It aims to channel public investments towards projects substantially contributing to the EU's environmental objectives, preventing greenwashing and supporting the European Green Deal. It defines criteria for environmentally sustainable investments. Energy storage projects that significantly contribute to climate change mitigation, such as enabling renewable energy integration or enhancing grid flexibility for decarbonisation, can be labelled as sustainable, attracting green financing and accelerating their deployment.

The Guidelines for trans-European energy infrastructure – Regulation (EU) 2022/869 (consolidated on 05/02/2025) (European Parliament, 2022a) is the latest iteration of the TEN-E Regulation. It updates energy network guidelines, prioritizing infrastructure supporting decarbonisation and renewable energy integration. It phases out fossil fuel projects (with some exceptions), streamlines permitting for key projects like cross-border electricity and hydrogen, and fosters a sustainable, interconnected EU energy system. It explicitly recognizes the essential role of energy storage in integrating renewable energy and enhancing grid flexibility. By prioritizing infrastructure projects supporting these goals, the regulation facilitates the development of energy storage as part of Projects of Common Interest, potentially unlocking funding and streamlining permitting for strategically important storage infrastructure across the EU.

The revised Renewable Energy Directive (RED III) – Directive (EU) 2023/2413 (European Parliament, 2023a), amending Directive (EU) 2018/2001 (RED II), accelerates renewable energy deployment, setting a binding EU target of at least 42.5% by 2030 (aiming for 45%). It simplifies permitting, promotes renewables in various sectors, enhances cross-border cooperation, and targets innovative renewable technologies. It indirectly amplifies the relevance of energy storage by mandating a much higher penetration of variable renewables. Energy storage becomes critical for managing this intermittency, ensuring grid stability, optimizing renewable energy use across sectors, and facilitating the achievement of the EU's ambitious renewable energy targets by 2030.

The European Commission Recommendation on Energy Storage (EU) 2023/C 103/01 (European Commission, 2023a) guides Member States on maximizing energy storage potential for a flexible and secure clean energy transition. It recommends actions on regulation, market participation, taxation, permitting, incentives, and grid integration. It is urging the countries to create supportive frameworks for energy storage. By recommending the removal of barriers, ensuring fair market access, streamlining permitting, and providing

incentives, it aims to accelerate the deployment of energy storage as a key enabler of the clean energy transition across the EU.

The EU Batteries Regulation (EU) 2023/1542 (consolidated on 18/07/2024) (European Parliament, 2023b) establishes lifecycle rules for batteries in the EU market, covering material sourcing, carbon footprint, recycled content, performance, labelling, and waste management, promoting sustainability and a circular economy for batteries. It sets sustainability and circularity standards for batteries, a core component of many storage systems. By addressing material sourcing, carbon footprint, and end-of-life management, it ensures the energy storage sector grows responsibly and contributes to a more sustainable and resource-efficient energy system within the EU.

The Critical Raw Materials Act – Regulation (EU) 2024/1252 (consolidated on 03/05/2024) (European Parliament, 2024a) seeks to guarantee the EU a secure and sustainable supply of vital materials for green and digital transitions. It diversifies sources, boosts domestic capacity, enhances circularity, and streamlines strategic project permits, ensuring economic resilience. It aims to secure the sustainable supply of critical materials like lithium and cobalt, essential for battery production. By diversifying sources and boosting EU capacity, it reduces supply chain risks and price volatility, fostering a stable and scalable energy storage deployment crucial for the green transition.

The Net-Zero Industry Act – Regulation (EU) 2024/1735 (consolidated on 28/06/2024) (European Parliament, 2024b) aims to scale up the EU's manufacturing capacity for key net-zero technologies, including solar, wind, heat pumps, and batteries. It sets benchmarks for domestic production and streamlines permitting processes to enhance the EU's industrial competitiveness and accelerate the clean energy transition. It prioritizes scaling up the EU's manufacturing capacity for batteries, a key energy storage technology. The Regulation also aims to reduce reliance on external suppliers, lower costs, and accelerate the deployment of energy storage capacities. It does this by setting domestic production benchmarks focused on scaling up the manufacturing capacity of net-zero technologies (such as solar panels, batteries, heat pumps, hydrogen and grid technologies, etc.) and streamlining permitting.

The European Association for Storage of Energy (EASE) is the leading European association representing organisations across the entire energy storage value chain within the EU. Its main proposals for the scale-up of storage capacities in the Member States consist of:

- Stronger legal framework for storage, especially supporting the uptake of long-duration solutions, not just short-duration (e.g., lithium-ion) systems.
- Expanding funding for long-duration storage, that can reduce reliance on fossil-fuel backup and lower overall transmission costs and consumer prices.
- Tackling grid connection barriers: elimination of stalled projects, the implementation of a first-ready, first-served grid connection model, improved transparency in grid data, and more flexible rules to speed up the rollout of storage infrastructure.
- Addressing network tariffs and market distortions by creating a fairer, more supportive market environment.
- Embedding storage in energy planning.

4.3. National level

The National Energy and Climate Plan (NECP) (final version – October 2024) (Romanian Ministry of Energy – NECP, 2024). The final version of the Romanian NECP foresees the installation of 1,200 MW of battery storage capacity by 2030, with the potential to increase this capacity to 2,000 MW (2,400 MWh) by 2035. Also, the document foresees the development of PHES with a total capacity of 800 MW by 2030.

The National Energy Strategy 2025-2035 with a Perspective to 2050 (approved through Government Decision 1491 from 21 November 2024) (Romanian Ministry of Energy – SER, 2024). The Strategy is a non-binding document that outlines the long-term vision for Romania's energy sector. It prioritizes energy security through diversified sources, reduced import dependence via the development of domestic resources, and digitalisation, including support for Moldova. A key focus of the Strategy is clean energy, aiming for a significant increase in RES. The strategy also emphasizes energy efficiency, affordability and economic competitiveness by ensuring low energy prices, efficient markets, and innovation and digitalisation through technological advancements.

The Strategy supports the use of national and EU funds, including the National Recovery and Resilience Plan (NRRP) and the Modernisation Fund, to finance energy storage projects. Allocations totalling hundreds of millions of euros have been announced for battery storage projects. While battery storage is prominently discussed, the strategy also acknowledges the potential of other storage technologies, including pumped storage hydropower plants, with plans for significant capacity development in this area as well.

Production of renewable hydrogen using excess renewable energy is also considered. The hydrogen would be injected into the national system for the transport of natural gas or stored for reconversion into electricity via fuel cells or CCGT power plants.

The Strategy emphasizes the need to integrate energy storage effectively into the electricity grid, recognizing its role in providing ancillary services, balancing supply and demand, and reducing grid congestion.

Government Emergency Ordinance (GEO) 134/2024 (amending **Law 123/2012 on Electricity and Natural Gas** and **Law 220/2008 on the promotion of energy production from renewable energy sources**) (Romanian Government – OUG 134, 2024). The GEO eliminates the double taxation of stored electrical energy (it amends Law 123/2012 to ensure that stored energy is no longer subject to taxation upon re-injection into the grid). It also exempts storage operators from certain tariffs (transmission, distribution, system services), the green certificates contribution, and the cogeneration contribution by amending Law 220/2008. The Romanian Energy Regulatory Authority (ANRE) is mandated to issue revised secondary regulations within 90 days of its entry into force – the methodology was released by ANRE on July 8, 2025 (ANRE, 2025). Also, the GEO introduces provisions targeting the promotion of pumped hydro storage pertaining to land associated with publicly funded permanent reservoirs and the use of water resources by pumped hydro storage operators.

Order No. 1355/2024 of the Romanian Ministry of Energy (Romanian Ministry of Energy – Order 1355, 2024) establishes a financial support mechanism for investments in new energy storage facilities (specifically batteries) that are connected to existing renewable energy production facilities (solar, wind, and hydro). The support scheme is valid until 31 December 2027 and is financed through the Modernisation Fund. The estimated total budget for this state aid scheme is **EUR 150 million**. Eligible applicants include existing economic operators (micro, small, medium, and large enterprises, excluding newly established ones) and autonomous public authorities legally established in Romania. A beneficiary can access **a maximum of EUR 10 million** for one or more submitted projects. The aid is granted as a reimbursement of eligible expenses. The state aid cannot exceed 100% of the eligible expenses of the project, and the value of state aid granted per MWh of installed storage is capped at **EUR 100,000**.

Order No. 3864/2024 of the Romanian Ministry of Transportation and Infrastructure (Romanian Ministry of Transportation, 2024) implements a State Aid Scheme for renewable energy and storage at commercial, civil aerodromes. The scheme supports investments in new capacities for producing electricity from renewable sources (primarily solar) for the self-consumption of certified civil aerodromes. Critically, this includes energy storage systems. Optionally, funded projects also include heat pumps. Funding (made available from the Modernisation Fund for energy efficiency in the transportation sector (Ministry of Transportation, 2025) is allocated through a competitive bidding process. While the focus is on self-consumption, strategically designed storage systems could potentially offer grid services, although this is not explicitly stated as a primary goal.

Order No. 198/2020 of the Romanian Energy Regulatory Authority – ANRE (ANRE – order 198, 2020) addresses the authorisation and licensing of the development and operation of electricity storage installations. More specifically, the order:

- establishes a clear pathway for obtaining the necessary authorisations and licenses specifically for energy storage facilities;
- clarifies that energy storage installations can be licensed either separately or integrated with electricity production capacities;
- ensures the financial responsibility of storage operators – the license holders for energy storage installations are obligated to establish financial guarantees amounting to 0.1% of the value of the assets corresponding to the licensed activities;
- offers owners of standalone storage installations complementary rights to perform electricity aggregation and to supply electricity to consumers directly connected to their storage facility;
- establishes specific rules to streamline the process for licensing energy storage, reduce bureaucratic hurdles and encourage investment in the sector.

Order No. 3/2023 of ANRE (ANRE – order 3, 2023) establishes the first specific technical regulations for the connection of energy storage facilities to the Romanian national electricity grid. More specifically, it:

- brings clarity to the connection procedures;

- sets out specific technical requirements that energy storage installations must meet to ensure safe and reliable grid connection (grid code compliance, protection systems, communication and control, metering);
- classifies storage installations based on their installed capacity;
- facilitates RES integration by establishing clear rules for connecting energy storage;
- encourages investment by reducing uncertainty for investors and developers;
- supports different deployment models: (i) added to existing operational projects, (ii) designed and permitted alongside new generation projects, (iii) developed and permitted as standalone facilities;
- aligns the Romanian legislation with the EU one, in particular with Regulation (EU) 2019/943 on the internal market for electricity.

ANRE's Regulation of 1 November 2023 (ANRE – regulation, 2023) grants the transmission system operators (TSOs) and distribution operators (DSOs) the right to own, develop, administer or operate electricity storage facilities that are fully integrated network components (i.e. storage assets directly used for grid management purposes, such as frequency regulation, voltage control, congestion management, and ancillary services). The adoption of this Regulation has a beneficial impact on the development of energy storage facilities in Romania, as it accelerates the deployment of grid-scale storage, it enhances grid stability, and facilitates the integration of renewable energy sources.

Insight into the potential for future development of the energy storage sector in Romania is provided by the governing programme of the Romanian Government, validated by Parliament on 23 June 2025 (Realitatea Media Group, 2025). However, the risk of non-implementation for the proposed measures is high, given their non-binding character. The main proposed measures related to energy storage are:

- installation of more than 5 GW of wind and solar capacities and 3 GWh of storage capacities by 2027, funded from the Resilience fund and the Modernisation Fund.
- Investment support for the battery production value chain
- Identification of funding sources for lithium and neodymium extraction, resources required in the production of batteries and electric motors, respectively.
- Development and finalisation of PHES systems.

5.Financial support mechanisms

The EU provides a variety of financial support mechanisms for the deployment and integration of Energy Storage Systems. The largest financial support framework at the EU level is the European Green Deal Investment Plan. Also known as the Sustainable Europe Investment Plan, it is the financial backbone of the European Green Deal, aiming to make Europe the first climate-neutral continent by 2050. It seeks to mobilize at least EUR 1 trillion in sustainable investments between 2021 and 2030. The plan is financed through a combination of funding mechanisms: the EU budget, the InvestEU programme, national cofinancing, EU ETS revenues (distributed through the Modernisation Fund and the Innovation Fund), the Just Transition Mechanism, the NextGenerationEU. Some of these are briefly described hereafter.

5.1. InvestEU

InvestEU is a financial instrument that aims to mobilize public and private investment in key sectors to achieve EU policy objectives. Its main goal is to provide a guarantee to financial partners by de-risking projects and making financing more accessible. For 2021-2027, EUR 372 billion has been mobilized under this programme. InvestEU comprises three pillars: the InvestEU Fund, the InvestEU Advisory Hub, and the InvestEU Portal. Eligible beneficiaries include private sector entities (SMEs, mid-caps, and large enterprises), public sector entities (national, regional, and local authorities, as well as public bodies), financial institutions (banks, investment funds, and other financial intermediaries), and others (research institutions, innovation agencies, and special purpose vehicles).

Relevance to Energy Storage: InvestEU supports investments in energy storage projects that contribute to energy security, grid stability, and the integration of renewable energy. The programme offers financing through guarantees and equity investments, targeting both small-scale and large-scale storage projects.

5.2. Modernisation Fund

The Modernisation Fund supports investments in modernising energy systems and improving energy efficiency in 13 lower-income EU Member States. It operates from 2021 to 2030 and is financed by revenues from the auctioning of emission allowances under the EU ETS. The funds can only be accessed by the EU Member States which, in turn, determine the eligibility of projects within their submitted proposals. The fund can provide support in various forms, including grants, premiums, guarantee instruments, loans, or capital injections, as decided by each beneficiary Member State.

Relevance to Energy Storage: The fund supports energy storage projects that help modernise the grid and integrate a higher share of renewable energy sources. Examples of funded energy projects: demand-side management, district heating pipelines, electricity transmission grids, interconnections between Member States, and infrastructure for zero-emission mobility.

5.3. Innovation Fund

The European Innovation Fund is a key EU funding programme for innovative low-carbon technologies and processes in energy-intensive industries, renewables, and energy storage. Financed by the EU Emissions Trading System, it supports projects that significantly reduce greenhouse gas emissions, aiming to bring industrial decarbonisation solutions to the market and help achieve EU climate neutrality.

Grants under the Innovation Fund are made available through calls for proposals, which are typically announced annually by the European Commission. These calls specify the topics, available budget, eligibility criteria, and the application and evaluation process. The average value of a grant can vary significantly, depending on the scale of the projects: more than EUR 100 mil/project for large-scale projects, EUR 20-100 mil/project for medium-scale projects and EUR 2.5-20 mil/project for small-scale projects. It typically finances up to 60% of the relevant costs (CAPEX and operational expenditure minus revenues) for the project duration.

Relevance to Energy Storage: The fund provides grants for projects that demonstrate highly innovative energy storage technologies, particularly those that have the potential to scale-up and reduce greenhouse gas emissions. Unfortunately, the number of Romanian projects funded through this mechanism is small, suggesting the country is focused on the implementation of mature, proven technologies, rather than exploring innovation.

5.4. Just Transition Mechanism (JTM)

The JTM is designed to support regions and sectors most affected by the transition to a green economy. It provides targeted support to diversify economies, reskill workers, and invest in a sustainable future in carbon-intensive regions. Eligible beneficiaries include public authorities, businesses, research and innovation institutions, NGOs, financial institutions, private entities entrusted with a public service mission. The JTM mobilizes funding through three pillars: the Just Transition Fund (JTF), the InvestEU Just Transition scheme, and the Public Sector Loan Facility (PSLF).

Relevance to Energy Storage: The JTM provides funding for projects that ensure a fair transition to a low-carbon economy, including energy storage projects that contribute to reducing dependency on fossil fuels and support the integration of renewables.

5.5. NextGenerationEU (NGEU)

The NGEU mechanism is a temporary recovery instrument of over EUR 800 billion designed to help Member States recover from the COVID-19 pandemic and build a greener, more digital, and more resilient future. The primary instrument under NGEU is the Recovery and Resilience Facility (RRF), which provides grants and loans to support reforms and investments outlined in the National Recovery and Resilience Plans (NRRPs) prepared by each Member State. Funding is made available to Member States based on the milestones and targets agreed upon in their respective recovery plans.

Relevance to Energy Storage: At least 37% of the NGEU funds are dedicated to the green transition. Energy projects related to this transition, including projects aimed at storing energy can be funded through this mechanism.

In addition to the Green Deal Investment Plan, the EU is implementing a variety of dedicated funding mechanisms to reduce differences between regions of the Union and to increase connectivity. Some programmes also facilitate the development of projects beneficial to the environment and/or human wellbeing, but that present significant financial risks or show limited potential for immediate return. Here is a non-exhaustive list of EU funding mechanisms serving these purposes.

5.6. Connecting Europe Facility (CEF)

CEF promotes growth, jobs, and competitiveness through targeted infrastructure investment at the European level. Funding under the CEF is primarily made available through calls for proposals published on the EU Funding & Tenders portal. EU Member States, international organisations and public or private undertakings are all eligible for grants. For the 2014-2021 funding period, the average grant offered through the CEF was EUR 15 mil. For 2021-2027, EUR 5.84 billion is available for projects in the field of energy across the EU.

Relevance to Energy Storage: CEF supports cross-border energy infrastructure projects that enhance the security of supply, integrate renewables, and increase the efficiency of the internal energy market. Energy storage projects that are part of these infrastructure projects can receive financial support, especially if they are recognised as Projects of Common Interest (PCIs). For projects in the field of energy, the standard cofinancing rate is generally 50%, and in specific cases, particularly for cross-border renewable energy projects, it can go up to 75%.

5.7. European Structural and Investment Funds (ESIF)

ESIF aims to invest in job creation and a sustainable and healthy European economy and environment. For 2021-2027, the ESIF comprises five distinct funds: the European Regional Development Fund (ERDF), the European Social Fund Plus (ESF+), the Cohesion Fund (CF), the European Agricultural Fund for Rural Development (EAFRD), and the European Maritime, Fisheries and Aquaculture Fund (EMFAF).

Funding from the ESIF is primarily managed through national and regional operational programmes developed by Member States in partnership with the European Commission. Calls for proposals are launched at the national or regional level by the Managing Authorities responsible for these programmes. Eligible beneficiaries include public authorities, businesses, research and innovation institutions, NGOs.

Relevance to Energy Storage: ESIF can be used by EU Member States to cofinance storage projects, particularly those that improve regional energy security, increase renewables penetration, and support local economic development. The ERDF and Cohesion Fund can cover a significant portion of eligible costs, often ranging from 50% to 85%, with the remainder coming from national or regional sources and/or private investment.

5.8. European Energy Efficiency Fund (EEEF)

The EEEF is a public-private partnership dedicated to mitigating climate change through energy efficiency measures and the use of renewable energy in the Member States. It aims to support the EU's climate goals by promoting a sustainable energy market and fostering climate protection through a collaborative approach, combining private and public capital for climate-related investments. It provides three types of financing instruments: direct investments, investments into financial institutions, technical assistance. The EEEF operates as an evergreen fund, meaning that returns from investments are reinvested. Eligible beneficiaries include municipal/local/regional authorities, public utilities and transport providers, social housing associations, energy service companies acting on behalf of public authorities, private entities with public concessions or energy supply agreements with public bodies.

Relevance to Energy Storage: Storage projects (in particular small-scale ones) that contribute to energy efficiency or are integrated with renewable projects can receive funding from the EEEF. Support can be in the form of equity, loans, and technical assistance to project developers.

5.9. European Investment Bank (EIB) Financing

The EIB is the EU's long-term lending institution, owned by its Member States. Its mission is to finance projects that contribute to achieving EU policy objectives, both within and outside the Union. The EIB borrows funds on capital markets and lends them on favourable terms to support investments that foster growth, jobs, and sustainable development. The EIB provides funding through a range of financial instruments: direct loans (typically above EUR 25 mil), intermediated loans (loans to local banks which, in turn, offer loans to smaller projects), equity and venture capital, guarantees (to reduce the risk for other lenders), advisory services. A variety of institutions are eligible for funding from the EIB: public and private sector entities, financial institutions, etc.

Relevance to Energy Storage: The EIB supports energy storage projects through loans, guarantees, and equity investments. The bank finances large-scale storage projects, including battery storage, pumped hydro storage, and innovative storage solutions, especially those that enhance grid flexibility and facilitate the transition to renewable energy. In 2024, the EIB provided over EUR 28 billion in financing for energy projects.

5.10. Horizon Europe

Horizon Europe is the EU's flagship funding programme for research and innovation, running from 2021 to 2027. It funds collaborative projects, aiming for the development of low TRL technologies (up to demonstration). The projects normally run between 3 and 5 years and funding levels of EUR 5-10 mil per project are common. A variety of organisations are eligible for participating in Horizon Europe: universities and other higher education institutions, research centres and institutes, businesses of all sizes, including SMEs and large enterprises, NGOs, public sector bodies (local, regional, and national authorities), international organisations.

Relevance to Energy Storage: Horizon supports research, development, and demonstration projects related to energy storage technologies. Funding is available for projects that focus on improving the efficiency, cost-effectiveness, and scalability of energy storage systems, including both electrochemical (batteries) and non-electrochemical storage (such as thermal or mechanical storage). A variety of pilot projects can be funded through this mechanism, aimed at demonstrating the feasibility and advantages of a certain energy storage concept.

5.11. Other funding tools

Institutions like the World Bank, the European Bank for Reconstruction and Development (EBRD), and the International Monetary Fund (IMF) offer a variety of financing tools (loans, investments and economic support programmes) for the development and implementation of storage projects, as they explicitly recognise energy storage as key infrastructure. The financial support offered by these institutions is increasingly conditioned by environmental sustainability. Consequently, investment in energy storage capabilities to complement renewable energy and increase power grid resilience perfectly aligns with these conditions.

Another way to support the development of energy storage infrastructure is indirect, by reducing the number and value of some taxes, meant to reduce either the initial investment, or the operational cost, or both. The reduction in the number of taxes could incentivise small-scale energy storage projects, as these taxes represent a relatively high share of the initial investment. On the other hand, the reduction in the value of certain taxes could incentivise large-scale energy storage projects by decreasing the cost of energy released to the grid from the storage system.

Some positive examples of tax reduction implemented through GEO 134/2024, all applicable on the electricity flow, include: exemption of storage operators from certain tariffs – transmission, distribution and system services; removal of contribution for green certificates (as storage operators are not considered end users), and cogeneration.

6.Storage in Romania – status and perspectives

According to IEA (IEA, 2024), the total worldwide energy storage capacity at the end of 2023 was roughly 250 GW, mainly represented by pumped hydro. This capacity must increase to 1,500 GW by 2030, out of which about 1,200 GW will be represented by batteries.

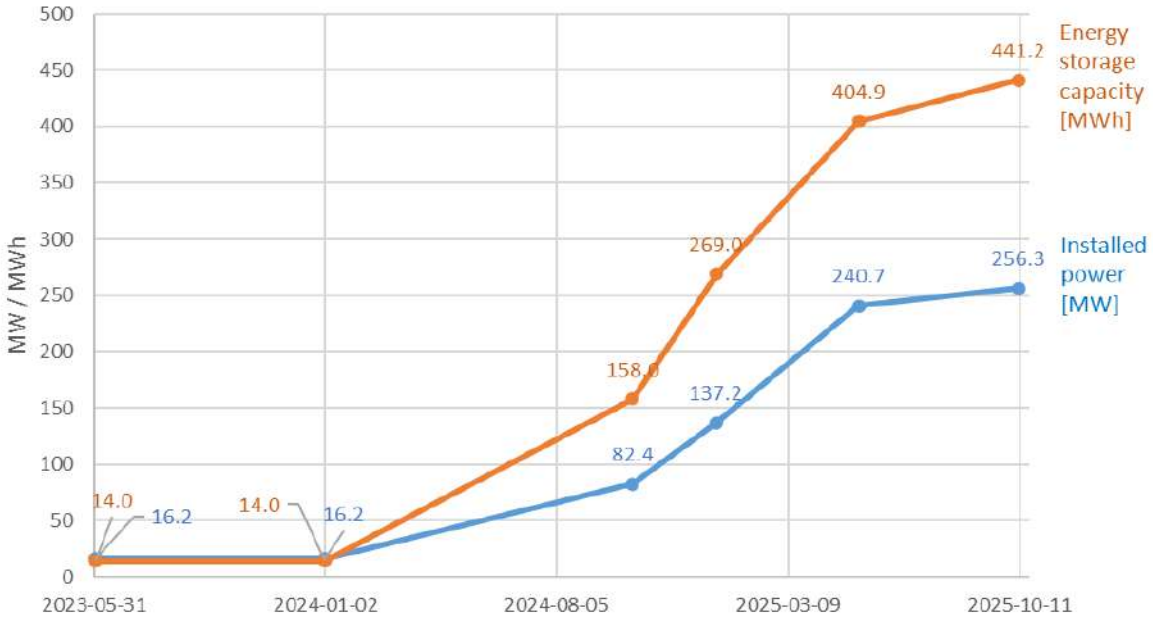
In Europe, the total energy storage capacity by the end of 2024 was 89 GW, represented mainly by pumped hydro (53 GW) and batteries (35 GW) (PV Magazine, 2025). The installed storage capacity in Europe is likely to see a steep increase, given the RES targets in the RepowerEU plan. Studies suggest the total storage capacity at EU level might increase to 200 GW in 2030 and 600 GW in 2050, driven mainly by the need of flexibility of an electricity system dominated by RES. Projections made by the Commission (European Commission, 2023) for the flexibility demand in the EU indicate 288 TWh in 2030 (24% of total EU electricity demand) and 2,189 TWh in 2050 (30% of total demand).

In Romania, in October 2025, the energy storage capacity was represented by:

- 256.3 MW of batteries, with an energy storage capacity of 441.2 MWh
- 91.5 MW of pumped hydro

Figure 8 shows the evolution of BESS capacity in Romania, since May 2023. The average time of discharge of the existing BESS capacity is 103 minutes (1.72 hours).

Figure 8 – Historical evolution of BESS capacities in Romania up to October 2025.



Source: Transelectrica

Two calls for investment have been launched by the Ministry of Energy for the development of BESS:

- EUR 79 mil for the first call, in 2024, funded from the Recovery and Resilience Fund. A total of 11 contracts were signed, unlocking a total investment of EUR 603 mil. The total storage capacity to be developed in this call is 1,546 MWh (Economica, 2024c)
- EUR 150 mil for the second call, at the beginning of 2025, supporting co-located battery storage (behind-the-meter battery systems developed in conjunction with existing renewables – wind, solar, or hydro) (Ministry of Energy, 2024). As of August 2025, no information was public regarding the number of awarded projects or the total capacity to be developed within the call. However, unofficial sources estimate that this call would lead to the development of roughly 3,000 MWh of battery storage, which is a plausible figure, assuming a cofinancing of 40-50%.

Regarding the pumped hydro storage (PHES) capacity, there are currently 291.5 MW available in Romania, all owned and operated by Hidroelectrica, out of which only 91.5 MW are operated in PHES mode[1]. The Romanian PHES capacities are:

- **200 MW** – Ipotești – Izbiceni hydroelectric plant (Olt county), comprising five hydro power plants on the lower Olt river (Ipoteşti, Drăgăneşti, Frunzaru, Rusăneşti and Izbiceni). Although the five plants were refurbished between 2011-2014, their operational characteristics do not allow profitable operation in pumped mode, according to Hidroelectrica (Economica, 2014). Profitability will be reached once the Islaz hydroelectric plant becomes operational in 2030 (according to the Romanian NECP). The Islaz plant will introduce an additional 13.2 MW of PHES (two modules of 6.6 MW each) (Hidroelectrica, 2012)
- **61.5 MW** – Lotru hydroelectric facility (Vâlcea county). Developed between 1977-1978, it contains three PHES open-circuit stations: Petrimanu – 31.5 MW, Jidoaia – 21 MW and Lotru-Aval – 9 MW (Hidroelectrica, 2024a).
- **20 MW** – PHES station Gâlceag (Alba county). Operational since 2023, the facility has two modules of 10 MW and transfers water from Cugir lake to Oașa lake (Hidroelectrica, 2024b).
- **10 MW** – PHES Săcuieu (Cluj county), operational since 1991 (Hidroelectrica, 2024).

There are prospects for the development of eight additional PHES facilities in Romania (Arambescu, 2023). Two projects stand out, in terms of magnitude and publicity so far:

- Tarnița-Lăpuștești, the most discussed project, with a total installed capacity of 1,000 MW (36,660 MWh) in four reversible 250 MW groups. The overall efficiency of the plant is expected to be 76% (Comisia Nationala de Strategie si Prognoza, 2019). Although the project was conceived before 1989 and advanced administratively between 2008-

[1] There is a debate on whether the 91.5 MW of capacity can really be used for storage, as their design goal was not to ensure energy storage, but to augment the water mass flow through the main turbine. As such, the pumping is ensured by a system of pumps, while the energy recovery is ensured by the main turbine (not reversible). Nevertheless, as the operating principle is the same (increasing potential energy of water by pumping it when energy is available and recovering this energy when the water passes through the turbines) it can be considered that these capacities can operate as energy storage facilities.

2010, there has been no progress on the ground. The project is affected by significant challenges, mainly related to the high upfront cost, political inconsistency leading to low investor confidence, grid and environmental challenges, etc.

- Frasin-Pângărați (Neamț county), a project of 314 MW total capacity, consisting in two reversible units (157 MW each). As of early 2025, it was incipient – issuing the environmental certificates and land acquisition procedures (Economica, 2024a). No clear date is given for completion.

Comparing Romania with other Member States in terms of total storage capacity is facilitated by the data publicly available on the ENTSO-E's Transparency platform (ENTSO-E Transparency, 2025), which aggregates data collected from individual Member States. Rather than comparing storage capacities in absolute values, it is more relevant to compare the ratio between the storage capacity and the total RES installed power.

Figure 9 shows this ratio for several EU Member States[2], including Romania. The data in the ENTSO-E platform was last updated on January 1, 2025. An additional datapoint was added for Romania, with the values of storage and RES reported by Transelectrica for October 2025.

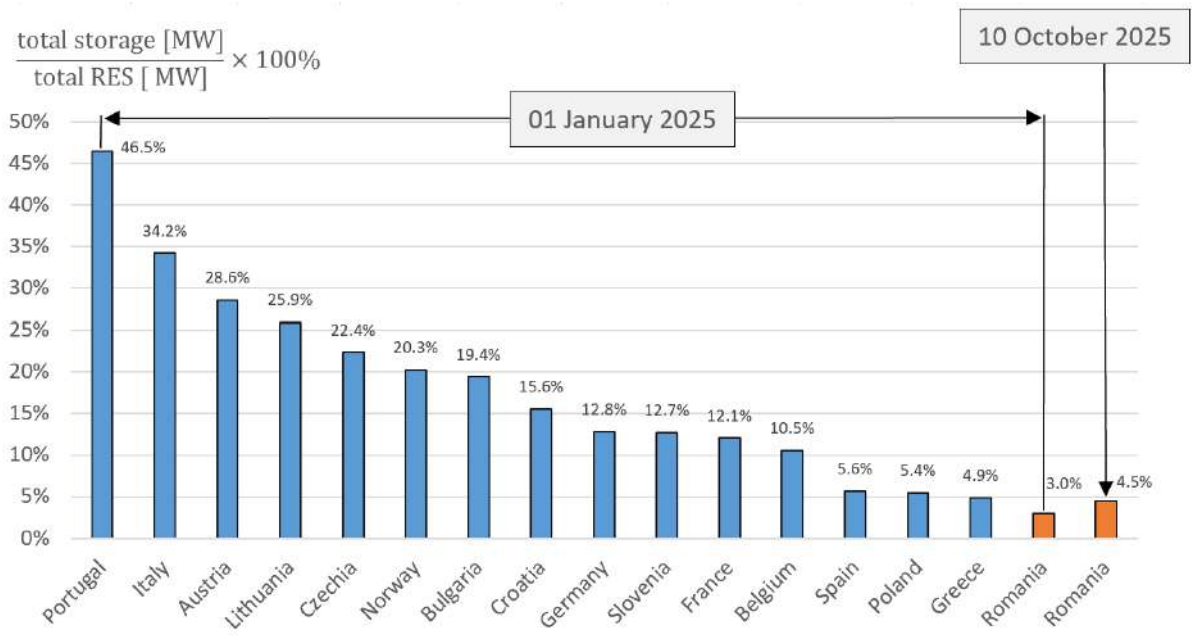
The data reported by ENTSO-E represent net production values. The total storage considered in this dataset contains both BESS and PHES, with the latter being predominant. The renewable sources in the dataset include solar PV, wind onshore and wind offshore. For Romania, only the utility-scale production and storage facilities are available in the ENTSO-E platform. Most likely, this is also the case for the other Member States. Consequently, the production and storage systems owned by prosumers are not included in this dataset.

There is limited information regarding the estimated need for energy storage capacity in Romania. The latest version of the Romanian NECP specifies that BESS systems to be developed amount to 1,200 MW (2,400 MWh) by 2030 and 2,000 MW by 2035. The document also specifies the development of 800 MW of PHES by 2030 (most likely the Tarnița-Lăpuștești project), along with hydrogen used as energy storage technology and demand response measures to achieve the objectives of adequacy and flexibility of the system.

A more detailed view on the need of storage capacity in Romania is given by Transelectrica (Economica, 2024b), according to which Romania must develop storage with installed power between 2,000 – 4,000 MW, and energy storage between 10,000 – 20,000 MWh, respectively. These characteristics would allow the operation of the storage facilities for 8 to 12 hours. These estimations would need to be refined in a dedicated study.

[2] Only the EU Member States for which data were available in the ENTSO-E Transparency platform are included in the chart.

Figure 9 – Total storage relative to total RES for a number of EU Member States.



Source: (ENTSO-E Transparency,

Regarding the storage technologies, Transelectrica suggests a balanced approach in which the quoted capacity represents a mix of BESS and PHES, in equal proportions. Other storage technologies, like hydrogen and compressed air are suggested as suitable. One important criterion when making an investment decision is the life of the storage plant. As Transelectrica points out, while the life duration of a PHES plant is 50 years (or more), that of a BESS facility is roughly 10 years. Consequently, the batteries would need to be changed five times during the lifetime of a pumped storage plant.

Transelectrica's assessment is mainly based on the challenges posed by the new structure of the Romanian power system, in which predictable power generation facilities have been replaced by variable RES capacities that do not follow the demand curve. As the RES share increases in the energy mix, balancing becomes more and more difficult. If the problems are not addressed, Transelectrica warns that even the risk of a total blackout[3] cannot be excluded, driven mainly by the unpredictability of wind turbine-based production capacities. The company suggests two methods for incentivising the development of storage capacities:

- public aid equivalent to at least 20% of the total investment
- reduction of various taxes, duties, excise duties, transport and distribution tariffs.

[3] At least two cases reported in the media can be given as examples in which grid frequency oscillations were observed (that can lead to blackout), mainly triggered by PV power plants behaviour:

- In Switzerland in 2024 "a significant rise was recorded in frequency deviations, mainly due to the growing difficulty of predicting solar power production". Unofficial sources state that this might be attributable to large-scale activation / deactivation of regulatory curtailments in Germany, although no official analysis seems to confirm this.
- In France in 2025 the TSO warned that abrupt cuts of RES generation during negative price periods could threaten grid stability. In April 2025, "9 GW of green generation, the equivalent of nine nuclear reactors, was halted simultaneously, triggering major frequency swings."

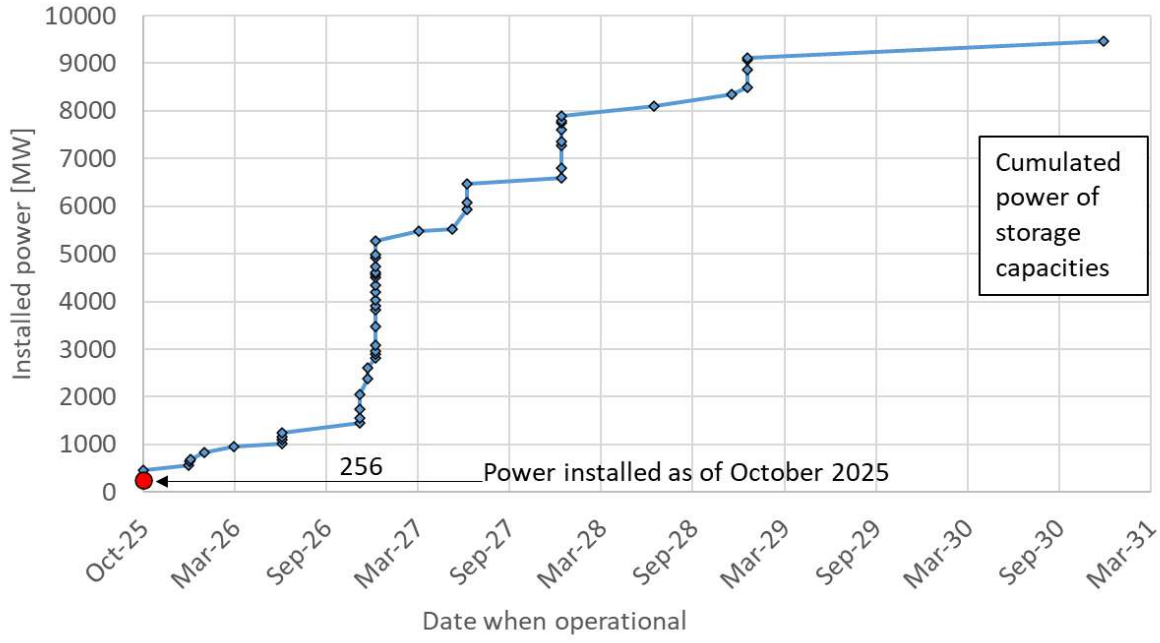
The potential evolution of the energy storage system can be characterised by looking at the ATRs (Technical Connection Approval) emitted so far for storage facilities. Figure 10 shows the status of ATRs already emitted by Transelectrica (Transelectrica, 2025).

There are an additional 209 MW worth of ATRs emitted by other entities in 2025: 36 MW in ATRs emitted by Delgaz Grid SA, 58 MW in ATRs emitted by Rețele Electrice Muntenia SA, and 115 MW in ATRs emitted by Rețele Electrice Dobrogea SA. However, it is not clear if the entire 209 MW capacity is to be considered on top of the existing capacity of 256 MW, or part of it is already included.

If most of the BESS capacity included in ATRs today materialises by 2030, and assuming an average discharge time of 2 h for this capacity, the total energy storage capacity in BESS by the end of 2030 is potentially estimated at roughly 19,000 MWh. However, most of these projects are unlikely to be finalised and operational. There are also additional BESS projects that are in early phases of development, not having obtained the ATR. Some examples of projects (Energy World, 2025):

- Hidroelectrica is willing to develop 64 MW (256 MWh) of BESS at Porțile de Fier 2 to use it for balancing services and to adjust hydro production intervals
- Engie Romania plans to install 20 MW (80 MWh) BESS co-located with its PV production plant in Prahova county
- Verbund (Austria) is planning the development of 50 MW (100 MWh) BESS in Tulcea county

Figure 10 – Evolution of BESS storage capacities according to ATRs emitted by Transelectrica



Source: (Transelectrica, 2025)

Additional storage facilities that must be accounted for are the facilities developed by prosumers. As of 31.08.2025, there are 257,451 prosumers registered in Romania (229,631 natural persons and 27,820 legal persons) with a total installed production capacity of

3,020.7 MW (ANRE, 2025). Out of these, 31,595 prosumers (30,235 natural persons and 1,360 legal persons) have storage capacities co-located with the production capacities. Should an average energy storage capacity of 5 kWh per storage capacity be considered (AMOS News, 2024), the prosumer energy storage capacity can be estimated at about 158 MWh, as of August 2025. Most likely this capacity will increase by the end of 2026, as the government (through the Environmental Fund Administration) made available RON 400 mil (EUR 79 mil) for incentivising prosumers to install battery storage systems. It is estimated that this measure will determine 50,000 prosumers to install storage capacities (Capital, 2025). This represents circa 250 MWh of capacity storage, again assuming an average of 5 kWh per storage unit.

7. Storage market attractiveness

Two broad classes of energy storage systems are considered in this assessment:

- **Small-scale energy storage systems (SSS)**. Also labelled as Commercial and Industrial (C&I) energy storage systems, these are between a few hundred kW and a few MW. These systems are designed to provide back-up power for short periods, usually up to 2-8 hours, and to reduce energy demand during peak hours. They are also used to improve power quality by providing voltage regulation and frequency control. Energy arbitrage can also be considered for these systems, to some extent. Battery energy storage systems (BESS) are representative for this class.
- **Large-scale (or grid scale) energy storage systems (LSS)**. These systems have much larger storage capacity, from tens of MW to hundreds of MW, and even GW. They can store energy for longer periods, usually from variable renewables, ranging from several hours to several days, and are used to provide grid services such as peak shaving, load balancing, and frequency regulation. Pumped hydro is representative for this class. Nevertheless, batteries have also been recently used, together with other technologies, like hydrogen generation, which allow energy storage over much longer durations, even seasonal.

As the CAPEX envelopes for the two classes of energy storage are significantly different, the investor profiles interested in the corresponding development are correspondingly different: while SSS is of interest for small and medium size companies, able to support all or a large part of the required capital, LSS typically require the involvement of the national/regional authorities and can, in most cases, only be developed by large companies, with a proven history in the development of large scale energy projects.

One can derive a series of indicators based on which the attractiveness of an investment in the energy storage market can be evaluated (Hutters, 2025). The indicators take values from 1 to 10, with a high value associated with high attractiveness. Such an approach allows for easy identification of the aspects in which progress is still required to enhance the attractiveness of an investment in the energy storage market. As described next, these indicators are grouped in four categories, based on the aspect of the energy market they reflect.

7.1. Status of the power grid

This category groups the indicators that characterise the national power grid at any moment in time. It offers a perspective of how suited/attractive the grid is for investments in energy storage, disregarding potential future grid evolutions or upgrades.

Available storage capacity (SSS: 2/10; LSS: 1/10)

Assuming no or little previous knowledge on the state of the grid and on the local energy market, the already installed energy storage capacity is a good indicator of the market opportunities for such investments. A large existing storage capacity (relative to the total installed capacity) indicates that either the potential for revenue is high, or that the policy,

regulatory and financial contexts are favourable – or both. An already significant installed storage capacity poses the risk of a saturated market, but in general it prompts the investor to further explore the market potential.

As of July 2025, the total installed energy storage capacity in Romania is 332.2 MW (240.7 MW of batteries and 91.5 MW of pumped hydro). This represents 1.7% of the total gross electricity production capacity of the country. This low value indicates a rather low attractiveness for investment.

Current share of wind and solar (SSS: 7/10; LSS: 7/10)

As wind and solar power generation are inherently variable, the higher their share in the total installed capacity, the higher the need for storage to match demand and supply.

In July 2025, Romania had 3,091 MW (gross) of wind capacity and 2,427 MW (gross) of solar capacity, not including the prosumers. These represent, respectively, 16% and 12.6% of the total gross installed capacity, amounting to a total of almost 28.6%. Considering the solar capacity installed by the prosumers (2,821 MW), too, this ratio reaches 43% of the installed gross capacity. Consequently, as it looks today, the power system seems to have significant potential for accommodating energy storage, both small and grid-scale.

Status of cross-border interconnections (SSS: 9/10; LSS: 9/10)

Given the unpredictable nature of wind and solar energy production, there are situations in which the wind and solar power plants do not produce for long periods of time or produce just enough to satisfy the demand. In such cases, the storage systems can be kept operational, thus producing revenue by importing from other regions in which renewable energy is in excess and/or at low prices. This operational mode is facilitated by robust trans-border interconnections.

At the end of January 2025, Romania had up to 4,000 MW of interconnection capacity, including 11 high-voltage (400 kV) transmission lines connecting Romania with Bulgaria, Serbia, Hungary, Ukraine and Moldova (Romanian Ministry of Energy – press release, 2025a). This represents almost 21% of the total installed capacity, an increase compared to the value reported for 2024 (2,500 MW for export and 3,000 MW for import), and 2015 (1,500 MW for export), according to Transelectrica (Transelectrica, 2022). Therefore, from an interconnectivity point of view, Romania is placed among the best performers in the EU. As such, this indicator suggests a high degree of attractivity for energy storage systems, for both large and small-scale storage systems.

Congestions of the transmission grid (SSS: 8/10; LSS: 2/10)

The congestion of transmission grids has a significant impact on the flow of energy in the national power grid. The impact congestion has on the two classes of storage systems is different:

- Mainly negative on large-scale energy storage systems. Should the production and energy storage occur in different geographical areas, which is almost always the case,

the flow of large quantities of energy between these two points puts pressure on the grid. Moreover, when large volumes of energy are released from the storage system, the grid maximum transmission capacity might be reached, if not carefully designed.

- Mainly positive on small-scale energy storage systems. As these systems are normally installed locally, in the proximity of power production plants, when the grid becomes saturated, part of the produced energy can be stored locally for later usage, rather than being transported, thus reducing the potential for congestion.

The Romanian transmission grid seems to be strongly affected by congestions (Matei, 2024). Between 2017-2024, due mainly to uneven distribution of production and consumption centres, the grid became congested at times when the demand peaked. Grid malfunctions also led to congestions, in particular in the absence of alternative transmission lines to take the load, when a certain line became incapacitated. Finally, the increase of energy imports over the last years, coupled with a lack of high-voltage transmission infrastructure in the west of the country, contributed to the congestion effect.

Therefore, in the current stage, the Romanian grid is rather favourable to the development of SSS and less favourable to LSS facilities.

7.1. Projected evolution of the power grid

There is a category of indicators that capture the envisaged evolution of the power grid, offering visibility over the long-term prospect of business potential in energy storage.

Share of wind and solar (SSS: 9/10; LSS: 9/10)

The evolution of the share of variable renewables in the energy mix plays a major role in assessing the potential for energy storage systems development, as this share correlates well with the required storage capacity.

According to the latest version of the Romanian NECP, the Romanian energy mix will see significant transformations in the future. In terms of installed capacity, wind and solar combined will amount to 15.5 GW (49.5%) in 2030, 34.2 GW (65.9%) in 2040, and 43.7 GW (62.3%) in 2050, where the values in parentheses represent the share of wind and solar in the total installed capacity. Energy-wise, 59.8% of the total electrical energy produced in Romania in 2030 will be produced from wind and solar sources. These relatively high shares of wind and solar sources indicate that energy storage will represent an important asset for grid balancing and probably for price control.

Grid investment plans (SSS: 8/10; LSS: 9/10)

A high level of planned grid investment suggests a significant energy storage capacity can be incorporated in the power grid, when and where needed, to ensure grid stability and provide grid services. Also, a grid development in line with the evolving requirements of the energy market can change the balance between the attractiveness for small- vs. large-scale energy storage facilities. As the grid becomes more robust and stable, capable of transporting higher loads over high distances with decreased losses, large-scale storage systems might become more advantageous.

In Romania, the investment required for the development of the transmission grid amounts to EUR 6.8 bn. This is an estimation produced by EPG (Arsani, 2024) based on the projects included in Transelectrica's TYNDP (2022-2031), ENTSO-E TYNDP and other public statements. Consequently, although this investment amount is not a commitment on behalf of the TSO, it is back-calculated based on the projects included in the power grid's development plan. The investments in the transmission grid are to be complemented by EUR 9.2-11.5 bn to be invested in the distribution grid.

Evolution of cross-border interconnections (SSS: 9/10; LSS: 9/10)

A further increase in the degree of interconnection can only reinforce the potential to trade energy internationally, making the energy storage business more profitable.

According to Transelectrica's development plan for 2024-2033 (Transelectrica, 2022), an increase of the interconnection capacity is planned for the western border (with Hungary and Serbia), for the southern border (with Bulgaria), and for the eastern border (with Moldova). Also, a reinforcement of the national transport network is foreseen so that it can cope with the increased load at the borders. The evolution between 2025 and 2030 of the net cross-border transfer capacity, as foreseen by Transelectrica, is given in Table 3. Cost-wise, 30% of the total investments in the grid (EUR 2.047 billion) is to be allocated for the increase in the interconnection capacity with the neighbouring countries, according to an EPG study (Arsani, 2024).

Table 3 – Interconnection capacities with neighbouring countries, in MW – forecast

	2025	2030
RO import/export	5510	7450
RO-HU	1520	1700
RO-BG	2190	2600
RO-RS	1000	2000
RO-UA	400	400
RO-MD	400	750

Source: Transelectrica's TYDP 2024-2033 (Transelectrica, 2022)

It can be concluded that the planned investments in the development of the interconnection capacity have a positive effect on the energy storage business.

Projected storage capacity increase (SSS: 9/10; LSS: 3/10)

As shown in Section 6, the potential for the increase in SSS capacity is much larger than the potential for LSS (represented mainly by PHES). The latter is limited, mainly because of the non-suitability of the sites, in particular because of the negative environmental and social impact. However, BESS development is significant, making the small-scale energy storage market extremely attractive.

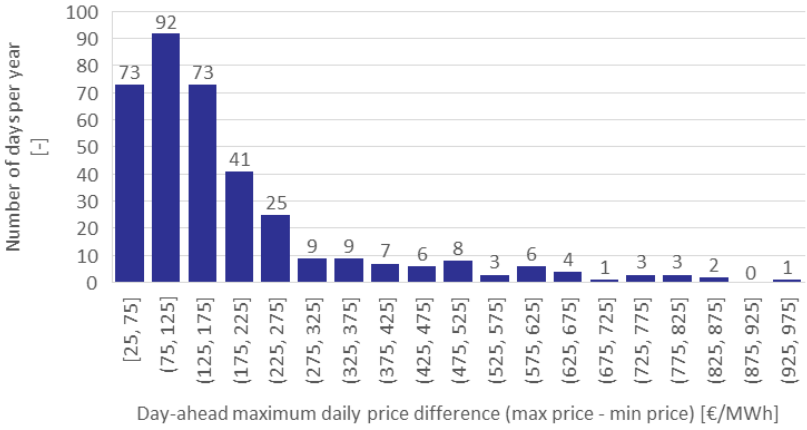
7.1. Accessibility of various electricity markets

In addition to the characteristics of the power grid, the business potential of energy storage can be analysed from the point of view of the markets on which these systems will operate. It is always advisable to have multiple sources of revenues, so understanding the market dynamics in which the storage system will operate is fundamental. Four types of markets are considered, deemed to represent the ones on which the bulk of the revenue will be produced through energy storage.

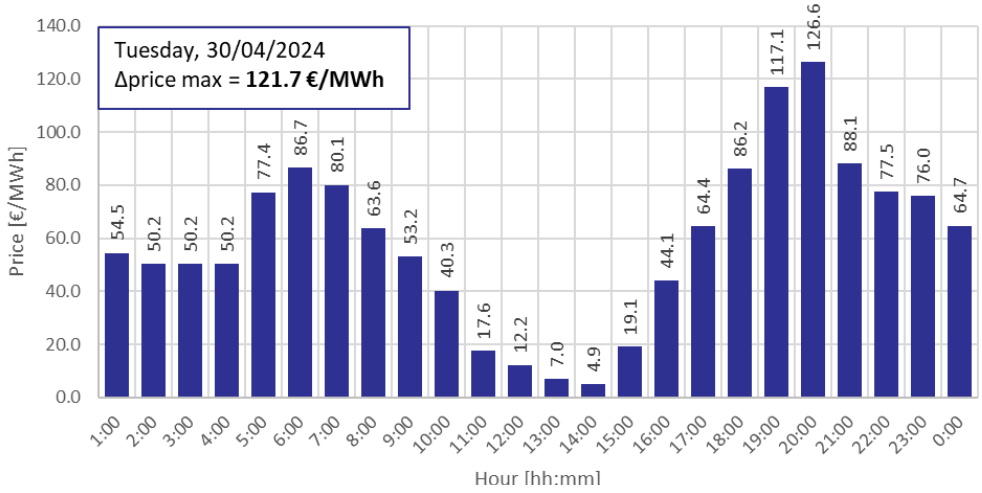
Wholesale market: day ahead price spreads (SSS: 10/10; LSS: 10/10)

For a company offering energy storage services, an essential characteristic of the wholesale market is the spread of the day ahead prices. This is defined as the difference between the maximum and the minimum price of energy during the day.

Figure 11 – Day ahead price spread in Romania, in 2024



a – Day-ahead price difference spread in 2024, in Romania



b – Day-ahead hourly price variation in Romania, example [EUR/MWh]

Source: EPG, with data from (ENTSO-E Transparency, 2025)

A large spread of the day-ahead prices facilitates the implementation of an energy arbitrage business, in which the operator buys cheap energy (usually, at times of low consumption and high production) and resells it when the price is higher (usually, at times when the consumptions peaks). A high spread in day ahead prices is specific to energy markets with a high share of variable RES and is favourable to the development and operation of both large- and small-scale energy storage systems. The day-ahead price spread for Romania was evaluated using data published by the ENTSO-E Transparency platform (ENTSO-E Transparency, 2025). For simplicity, only the data for 2024 are shown here.

Figure 11-a shows the distribution of the daily maximum day ahead price difference for 2024. This difference is calculated as the maximum hourly price minus the minimum hourly price

within a 24-hour interval. Of the 366 days of 2024, on 73 days the maximum difference was between 25-75 EUR/MWh, on 92 days the difference was between 75-125 EUR/MWh, and so on. On September 3, the difference was particularly high: 934.61 EUR/MWh.

Figure 11-b shows an example of hourly price distribution on one of the 92 days in which the price difference was between 75-125 EUR/MWh. On April 30, the maximum price difference was 121.7 EUR/MWh, with the lowest price (4.9 EUR/MWh) having occurred at 14:00, and the highest price (126.6 EUR/MWh) having occurred at 20:00. Should an energy storage operator have operated on that day, purchasing and storing electricity at 14:00 and reselling it at 20:00 would have been an advantageous transaction.

The spread in energy prices most likely will tend to increase in Romania, compared to the values in 2024, provided the share of RES increases. Consequently, energy arbitrage on the wholesale market represents an attractive market for energy storage.

Balancing market: prices and volumes (SSS: 8/10; LSS: 8/10)

In a high-performance energy system, the balancing market plays a limited role. The energy volumes traded on such a market are low and are a consequence of unforeseen deviations in demand or supply (or both) that are penalising for the energy generator. The share of energy on the balancing market can be correlated with the share of variable RES in the energy mix. For example, in countries like France, where the biggest energy source is highly stable and predictable nuclear, the balancing market is considerably smaller.

Starting with 2023, battery systems have been considered for balancing in the Romanian power grid. Transelectrica has qualified such a system in June 2023 (Nicut, 2023c). As energy storage systems are allowed to provide grid balancing services, the business profitability on this market is a function of the total volume and the average price of traded energy. According to Transelectrica, the average price on the balancing market for 2024 was 981 RON/MWh, 119% higher than the average price in 2023 (Transelectrica, 2025d). In some instances, the price on this market reached very high values – up to 16,000 RON/MWh, for example, on July 1 (Nicut, 2024), due to high consumption combined with low availability of wind, sun and water.

In 2023, the total energy traded on the balancing market represented 3.62% of the total gross consumption (Transelectrica, 2025e). It seems, therefore, that the balancing market is a good source of revenue for energy storage systems. However, as the number of operators providing this service increases, the price will decrease, given the increased competition. Also, according to Transelectrica, in an ideal case, a storage system operator should only consider the balancing market for 10-15% of total revenues, with the bulk of the gains to be generated from other markets (Mosoianu, 2024).

Capacity market (SSS: 1/10; LSS: 1/10)

This is a market in which production capacities are secured for supplying electrical power to the grid when needed. The operators of such capacities are remunerated simply for being ready to generate, if needed. On this market, the owner can enhance the bankability of its system by ensuring a stream of revenue, regardless of the volume of traded energy.

At the EU level, the necessity for the development of capacity markets (or capacity mechanisms) is judged by individual Member States. Romania has not developed such a market, although the Ministry of Energy launched discussions on this topic back in 2019 (Ministry of Energy, 2019). Romania implements an energy-only market, in the sense that capacity owners are only paid for the energy delivered to the grid. In Romania, the role of capacity markets is fulfilled by other tools, such as capacity reserve mechanisms (i.e. some capacity maintained to handle peak demand or emergencies.

Futures and forwards market (SSS: 7/10; LSS: 7 /10)

Futures and forwards contracts are used by market participants to buy or sell a specific volume of electricity, at a specific price, for settlement on a specific date in the future. The role of such agreements is to protect the buyer against potentially higher energy prices in the future. The futures and forwards markets are characterised by the volume of transactions, the hedging efficiency, the number and types of participants, etc.

In Romania, the futures market is implemented through the Romanian Operator for Electrical Energy and Natural Gas Market (OPCOM). OPCOM, however, does not offer financial future contracts, with clearing and mark-to-market, but only physically delivered futures. On the other hand, financial futures contracts are traded on external, financial platforms, which are not subject to ANRE's regulations, such as EEX (European Energy Exchange), but these are strictly cash-settled. The energy product derivatives market in Romania is projected to reach a nominal value of approx. USD 34.5 billion in 2025 (Statista, 2025).

In addition to the direct power futures contract, Romania also implements trading instruments like guarantees of origin and power purchase agreements, which can be structured with futures pricing mechanisms. Also, the country recently introduced a CfD mechanism for wind and solar energy projects, which is also a form of protection against potential future price variations, but meant to protect the provider, rather than the buyer.

7.1. Regulatory and financial aspects

The regulatory and financial category of indicators provide insights into additional aspects, like the regulatory framework in the energy sector and the available financial instruments that can be accessed for developing energy storage capacities. Although not hard-wired to the energy infrastructure, these aspects are essential for creating the momentum required by energy storage to develop.

Revenue stacking possibilities (SSS: 8/10; LSS: 8/10)

For any given energy storage system, small or large-scale, obtaining a return on investment in due time is highly dependent on the possibility of stacking multiple streams of revenue. There are multiple types of revenue-producing activities in which the owner of an energy storage system can engage. The concept of **revenue stacking** assumes that multiple such activities can be engaged simultaneously.

The Tarnița-Lăpuștești PHES, if completed, would provide services like power/frequency control, fast tertiary reserve and short-term emergency reserve, reactive power, etc. Given the

relatively low penetration of energy storage systems on the Romanian energy market, PHES and other technologies including the BESS, it is rather unclear whether the current legislation potentially impedes some aspects of the stacking of revenues approach. A first evaluation indicates that this is not the case, at least for the moment.

Grid tariffs (SSS: 10/10; LSS: 10/10)

This indicator reflects the way a series of taxes are applied to the stored energy. A low level of taxation has the effect of encouraging investment in energy storage systems.

The situation of the grid tariffs for stored energy in Romania was considerably improved with GEO 134 of 21/11/2024 (Romanian Government – OUG 134, 2024). This modifies the Romanian energy law (Law 123 of 10/07/2012) exempting the energy storage operator from the payment of the following taxes:

- The costs of energy transport (the component related to the extraction of energy from the grid), which include the transmission services tariffs, the distribution tariffs, and the cost of system services or their associated components
- The contribution for green certificates
- The cogeneration contribution

Thus, the double taxation of the stored energy is completely removed. These provisions are applicable for all energy storage systems, regardless of size and type of technology, provided the extracted energy is reinjected into the grid at a later time.

Ease of connection to the grid (SSS: 2/10; LSS: n-a/10)

The ease of the grid connection is an essential indicator for the attractivity of developing energy storage systems. It is an indication of complexity of the technical (and, to some extent, administrative) burden a developer undertakes for rendering their storage system commercially operational.

In Romania, obtaining the Technical Approval for Connection (ATR) is a lengthy and difficult process for small-scale energy storage systems. The reason is the large number of connection requests (amounting to more than 25 GW at the end of 2024), coupled with the low number of personnel in charge of processing these requests at Transelectrica. Although the technical conditions for the energy storage systems to be connected to the power grid are well defined, another difficulty, on the developer's side, is that depending on the geographical region, Transelectrica can consider the storage system either an energy consumer or an energy producer, as a function of the state of the local grid, from a congestion point of view.

Regarding the large-scale energy storage systems, the experience is rather limited. The only major PHES that is currently planned in Romania – the Tarnița-Lăpuștești facility – is not conclusive for the assessment of the complexity of the ATR, as the project still stagnates on account of investment, as well as environmental and social issues.

Storage strategies (SSS: 1/10; LSS: 1/10)

National/regional strategies for the development of the energy storage sector greatly facilitate investment by bringing clarity on the profit-producing mechanisms, an essential element for the bankability of a project. Some of the elements on which such a strategy can bring clarity are as follows:

- Vision: an assessment of the status of the energy system, and an image of how this system is projected to look/operate in the future;
- Stakeholders: the entities that will facilitate the development of the system, as envisioned (decision makers, developers, operators, beneficiaries, etc.), and the roles they play in the development process;
- The principles based on which the decisions will be made in the implementation of the strategy (e.g. cost-price, sustainability, jobs created, local production, etc.);
- The definition of goals and objectives, together with a set of KPIs to monitor and evaluate the progress of implementation;
- The resources available for the implementation of the strategy (e.g. financial, workforce, raw materials, etc.).

Unfortunately, neither the latest version of the NECP nor the Romanian Energy Strategy 2025-2035 offer clarity on most of these elements. The absence of a strategic vision for the energy storage sector in Romania is penalising from an investment point of view.

Financial support (SSS: 8/10; LSS: 6/10)

Financial support is to be understood as state aid or other form of public funding that the developer of an energy storage system can access. The existence of such support indicates the willingness of the authorities to encourage the development of the energy storage sector.

In Romania, the financial support for energy storage is focused on specific energy storage technologies. For example, GEO 28 from 28/08/2014 (Romanian Government – OUG 28, 2024) specifies that projects targeting the development of PHES facilities above 15 MW are entitled to receive state aid, if compliant with the corresponding national and European state aid rules. Also, two specific calls for BESS development have recently been issued by the Energy Ministry, as detailed in Section 6.

For energy storage projects other than BESS and PHES, there is no dedicated financial support available yet. Therefore, although the current level of existing financial support could be much improved, one can state that it is rather beneficial for investments in both small-scale (BESS) and large-scale (PHES) storage systems.

7.2. Synthesis

Table 4 summarises the indicators described above. The overall image they provide is of significant attractiveness of the energy storage market. This is in line with the perceived situation in which many private companies are willing to develop storage systems in Romania, mainly relying on batteries – more than 300 companies have expressed intentions of

developing energy storage projects in Romania in 2024. These indicators also suggest that the attractiveness for SSS is slightly higher than for LSS.

For small-scale energy storage systems, the main shortcomings point to:

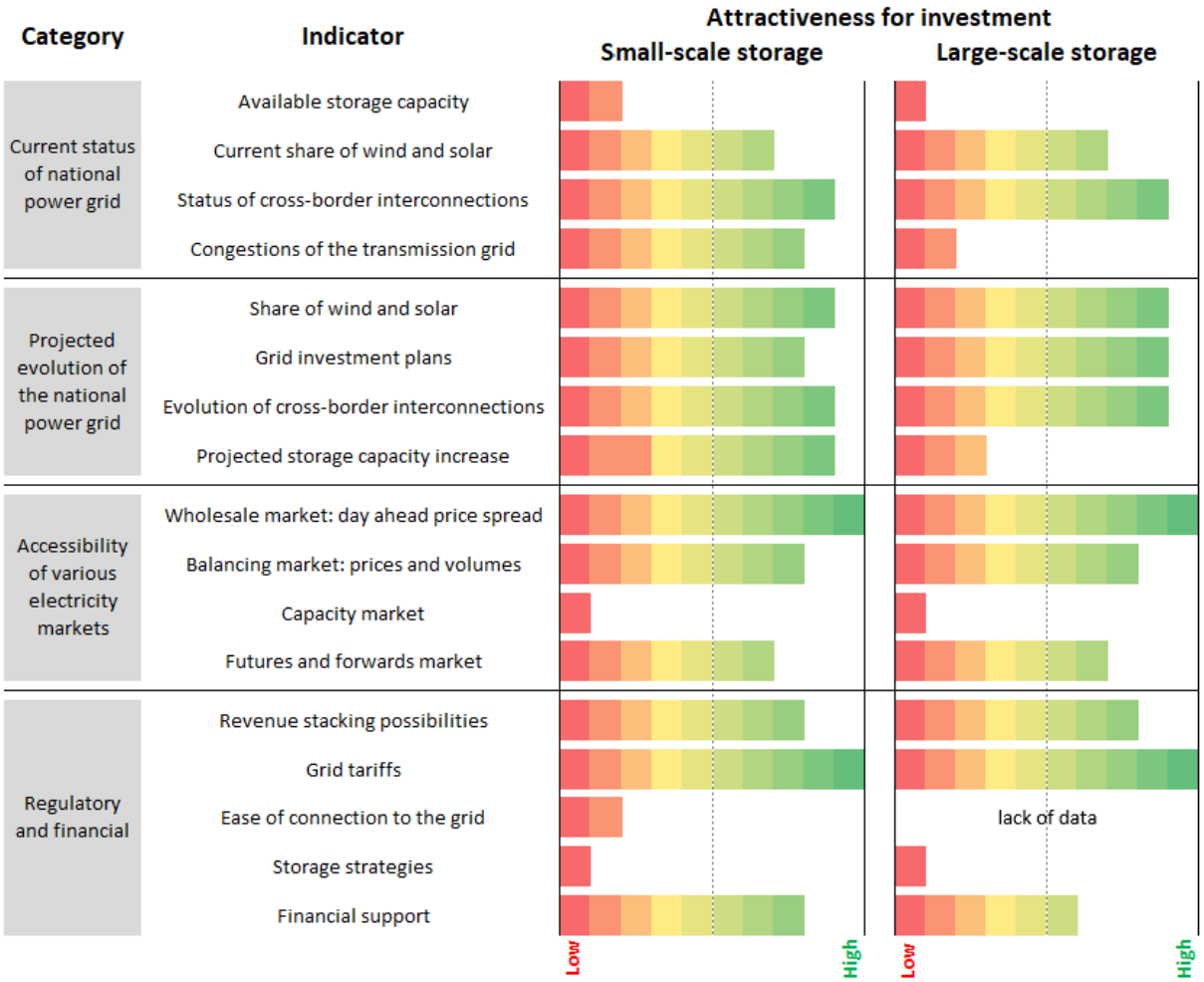
- Low maturity of the energy storage market, reflected in the low installed storage capacity. This results in low bankability of energy storage projects, in particular for small-scale storage. Financial institutions are reluctant to fund the development of energy storage projects, mainly because of the perceived high risk. Batteries, although technologically mature, have little accumulated operational experience to guarantee the robustness of a business model. The risk, for batteries and other low operational maturity systems, could be mitigated by dedicated policy tools addressing the issue.
- The absence of a capacity market, which depresses the bankability of energy storage projects, as revenue is generated only when energy is flowing. Therefore, guarantees are needed for a continuous flow of energy through these systems.
- The perceived difficulty of connecting the storage systems to the grid.
- The lack of a clear strategy that can guide the development of the market. Today, the evolution of the energy storage market seems to be steered by the potential for profit, but the circumstances in which this profit is to be achieved are not clear and need to be assessed by each market participant individually.

Besides, as the energy storage business becomes more mature, supply chain issues and increased market competition can become relevant.

On the LSS side, the shortcomings largely correspond to those for SSS, with some additions:

- Grid congestion makes LSS rather difficult. This prompts the requirement for further grid development, to increase its robustness under high loads.
- Mainly due to environmental and social issues, the potential for the development of PHES facilities seems rather limited. Other technologies need to be considered, with similar operational characteristics, but with lower environmental and social impact (e.g. underwater PHES, hydrogen or other power-to-liquid technologies, thermal storage, etc.)

Table 4 – Energy storage investment attractiveness in Romania



Source: EPG

8.Concluding remarks

This analysis indicates that the energy storage market in Romania is currently in its early stages of development. A broad range of aspects must be improved for a robust development of the sector. Some of these aspects are highlighted below.

The energy storage discussion in Romania should not be limited to batteries (Li-ion and flow batteries) and pumped hydro. Financial support should be diversified (a variety of support schemes, each scheme addressing a given type of technology) so that the organisations implementing storage projects can decide on the best technology for the given project. Moreover, the adoption of innovative storage technologies should be encouraged, as such projects have the potential to offer new perspectives in terms of storage efficiency, life span, low cost, etc.

As the Romanian power grid transitions to a higher share of RES, the need for methods to ensure grid ancillary services is more pressing. The facilities that traditionally provided these services are being gradually phased out (i.e., synchronous, thermal generators) and can be successfully substituted by energy storage systems. Batteries and hydro storage power plants seem to be most appropriate to provide most of the grid services: frequency control, voltage control, black start, congestion control. Consequently, in a high-RES power grid, energy storage becomes imperative for stability reasons.

With respect to the legislation facilitating the implementation of energy storage capacities, the EU-level legislation seems to be quite comprehensive and complete. The national legislation seems to be mainly driven by the European one (e.g. transposition of certain Directives, direct implementation of Regulations). Although the legal framework seems favourable, there is place for improvement, in particular on the following aspects:

- The technical approval for the development and connection of new energy storage capacities to the national grid is difficult and complex: the limited grid capacity can impose restrictions on the storage equipment (location, maximum power, etc.), the issuing of the approval is sometimes lengthy and complex, the regulatory and financial demands are not fully supportive of such developments, etc.
- There is no clear understanding of what the required storage capacity is, what technologies need to be implemented, and the best ratio of these technologies in the total storage capacity. There is no policy document on this. Both the Romanian Energy Strategy and the NECP lack clarity on these aspects. Consequently, a potential investor cannot have the certainty the investment is safe and lucrative.
- The energy market mechanisms currently in place seem not to favour the development of standalone storage systems, from a business point of view. Only the business case for arbitrage seems to be profitable. Moreover, there is ambiguity on the legal status of the energy released into the grid from an energy storage facility – whether it can be considered renewable or not, preventing (or, at least, not encouraging) the development of hybrid energy storage systems (RES production + storage). Consequently, RES owners tend to minimize CAPEX by not investing in storage associated to the plant, and to export overproduction.

- The point above is closely connected to the absence of capacity mechanisms, to incentivise the owners for availability, thus creating another stream of revenue, in addition to selling energy.

There seems to be a variety of EU financing sources for energy storage systems, either in the form of direct grants or as low interest loans. Except for the Innovation Fund, most funds cannot be accessed directly and independently by private organisations. In Romania, the Government issues call for projects, collects project proposals and rewards the eligible projects with EU-sourced funds. The Ministry of Energy has already organised two such calls for supporting energy storage projects, in 2024 and 2025 (Romanian Ministry of Energy – press release, 2025b).

Most public funds made available by the Romanian Government are from the Recovery and Resilience Fund or the Modernisation Fund. However, the government is providing little guidance (e.g. in the form of a one-stop-shop) to private entities willing to access other EU financial instruments. Such tools remain underused in the Romanian energy sector.

Fully private funding, such as loans or equity from financial institutions, are more difficult to access by investors in energy storage projects, as their bankability is relatively low. The lack of maturity of the storage market, with the absence of proven business models for storage equipment enhances this issue. This situation is aggravated by the lack of clarity about energy storage in the strategic documents. In this context, public funding is crucial for the initial development of the storage market.

Romania's total storage capacity relative to the RES installed capacity is among the lowest in the EU. Only two technologies are present: BESS and PHES. While the development of BESS is strongly encouraged and incentivised, PHES facilities are stalling. Moreover, there seems to be a lack of interest on the part of the decision makers for the development of alternative storage technologies. Overreliance on a single storage technology can potentially pose a risk to adequacy of the national power system, as BESS are not suited for long term storage or for storing large quantities of energy in a cost-effective manner.

The attractiveness of the energy storage market in Romania seems to be quite high for investors, for both small- and large-scale storage projects. However, as pointed out above, the attractiveness could be improved in some respects, notably by initiating a framework for storage capacity mechanisms, the elaboration of a clear and comprehensive strategy for the evolution of the energy storage sector, streamlining grid access (especially for large-scale projects), and addressing the transmission network congestion issues.

9.Policy recommendations

1. Update the Romanian Energy Strategy 2025-2035, with perspectives for 2050 by incorporating a section dedicated to energy storage:
    a. Clarify the long-term vision for the development of energy storage in Romania
    b. Define the objectives the energy storage capabilities will need to fulfil at grid level
    c. Create a roadmap for the development of storage capacities
    d. Identify the total need for investment and the funds that will be available
    e. Incorporate innovation into the development plan
2. Reduce complexity and financial burden for connecting new storage capacities to the grid.
3. Diversify the grant schemes for energy storage capacities, to address the development of multiple types of technologies (one grant scheme per technology). Provide a list of services that storage systems will need to provide to the grid. A top-down approach should be taken in defining these services, starting with the requirements at grid level.
4. Develop a support scheme (legislation + logistics + financial support) for the conversion of existing RES power plants (wind and solar) into hybrid power plants, also incorporating energy storage (technology-neutral). Allow each plant owner to identify and implement the energy storage technology that best suits their application. Bring clarity to the conditions that co-located storage systems must satisfy for the energy reinjected into the grid to be considered renewable.
5. Introduce mechanisms for increasing the bankability of energy storage projects, such as:
    a. capacity mechanisms for energy storage, also applicable to flexible energy production capacities to be used as peak load generators (for limited duration during the year)
    b. direct financial support – grants and low-interest loans for LSS and public subsidies for SSS
    c. green bonds and climate bonds
    d. guarantees and insurance products (e.g. offtake guarantees, payment guarantees, performance guarantees)
    e. Contracts for Difference (CfDs)
    f. bilateral contracts applicable only to low-carbon energy – the consequence of such an approach would be an incentive to complement RES power plants with storage in order to increase predictability of energy supply
    g. financial incentives for storage system owners/operators, as a function of where the storage system is connected to the grid. A similar approach was implemented in France in 2025, where two types of grid sectors have been defined: impacted by production and impacted by consumption. Storage systems connected to high generation grid sectors are incentivised to absorb energy at certain moments of the day, whereas storage systems connected to consumption-heavy grid sectors are incentivised to release energy in the grid at certain moments of the day.

6. Develop favourable legislation for the V2G energy storage methods. The main directions of the legislative process should include:
    a. Support the purchase of V2G vehicles through a dedicated financial scheme (higher incentives for the purchase of V2G-equipped vehicles, compared to the incentives for non-V2G electric vehicles). Promote the new scheme through an awareness campaign.
    b. Impose a minimum share of V2G-capable chargers for all newly developed public and private chargers. Create an obligation for large employers to develop parking lots equipped with V2G-capable chargers.
    c. Allow market mechanisms through which the owner of a V2G-capable vehicle can “rent” the battery of the vehicle to the TSO for energy storage.
    d. Incentivise the development of a control algorithm for incorporating the V2G capabilities in the national grid.
    e. Financially support the development of pilot projects for the validation of the V2G concept, both in urban and rural setups. Collaborate with organisations that have already implemented pilot projects in various EU Member States.
7. Encourage projects for the development of innovative energy storage capacities. International teams should be allowed and encouraged to access public grants, allowing technology transfer from abroad.
8. Implement projects meant to determine the best ways of using storage capabilities for the provision of grid ancillary services. Such capabilities can be developed and operated in parallel to the traditional systems used today for the provisions of these systems. A similar approach can be taken in testing the response of the system to unforeseen situations like localised or generalised network incidents potentially leading to outages like the one in Spain, on April 28, 2025.
9. Launch an information and transparency campaign, letting the industrial stakeholders become familiar with the EU streams of funding that are available directly or via the Romanian Government for the development of energy storage projects.

Table 5 – Recipient/responsible organisation for the recommended policy updates

No.	Recommendation topic	Recipient
1	Update the Romanian Energy Strategy 2025-2035, with perspectives for 2050	Ministry of Energy
2	Reduce bureaucratic complexities	Transelectrica ANRE
3	Grants for multiple types of storage technologies	Ministry of Energy
4	Conversion of existing RES power plants into hybrid power plants	Ministry of Energy
5	Mechanisms for increased bankability	Ministry of Energy
6	Development of V2G legislation	
6.1	Financial incentives for V2G vehicles + awareness campaign	Ministry of Transportation Ministry of Environment, Water and Forests
6.2	Minimum share of V2G chargers	Ministry of Energy
6.3	Mechanisms for using the V2G functions	Ministry of Energy ANRE
6.4	Control algorithm for incorporating V2G	Transelectrica Ministry of Energy
6.5	V2G pilot projects	Ministry of Energy
7	Innovation in storage technologies	Ministry of Research
8	Storage capacities for grid services	Transelectrica
9	Information and transparency campaign	Ministry of Energy

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