EPG
ENERGY POLICY GROUP

Romania's Energy Storage:

Assessment of Potential and Regulatory Framework

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DISCLAIMER:

The project also benefited from advice from relevant Romanian stakeholders (TSO, energy regulator, Ministry of Economy, Energy and the Business Environment, DSOs, distribution system operators, renewable energy producers, etc.). The viewpoints presented in this report do not reflect the official positions of these organisations.

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Contents

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Executive Summary

The European Green Deal, with its flagship policy, the Climate Law, is set to enshrine into law the target of net-zero greenhouse gas (GHG) emissions by 2050. In this context, the increased electrification of industry, transport, and buildings is a must for decarbonisation. The Commission's long-term strategy acknowledges that the further uptake and integration of renewable energy necessitates higher flexibility at system level. Its decarbonisation scenarios indicate the need for a tenfold of today's storage to deal with variability in the electricity sector. The EU's strategy for energy system integration lays out the groundwork for how an increasingly electrified economy can function efficiently.

In anticipation of these future developments, concrete steps have been taken at EU level to favour and accommodate an increase in storage capacity. As part of the Clean Energy Package, the Electricity Directive and Regulation that are the basis for a revamped EU electricity market design set energy storage on an equal footing in the market with power generation. In response to EU Regulation 2019/943, which clarifies the role of storage and its ownership status, the Romanian authorities transposed in Law 155/2020 (amending Energy Law 123/2012) specific provisions related to new storage facilities and their management rules. Among the most significant is the government's new and clear responsibilities of developing plans and actions for energy storage, aligned with the NECP, European Green Deal, and Next Generation EU. In addition, the ANRE provisions about licenses include references to storage capacities for energy producers. Nonetheless, the current Romanian legislation does not include sufficient details on future-proof systems and technologies. More elaborated provisions are needed for the adoption of different types of storage and norms related to storage system integration.

Such enhanced legislation is needed for implementing the Romanian National Energy and Climate Plan (NECP), which lists 'developing storage capacities' as an instrument to improve energy security but lacks detail on how storage technologies will be deployed until 2030. The plan makes reference to the assessment study of system adequacy by the TSO, Transelectrica SA, which mentions a minimum 400 MW of needed new storage capacity.

Against this background, it is important to understand the necessity for the domestic deployment of new storage technologies. To be able to invest in renewable energy capacities, the Romanian energy sector must first address its network adequacy issues. Increased storage capacity can contribute to overcoming this challenge, especially by increasing grid flexibility. Regardless of technology, energy storage will bring economic, structural and operational advantages.

Based on its renewable energy potential and considering the national energy sector's current characteristics – generation assets, interconnections, market design, regulatory landscape – Romanian authorities should plan for increased deployment of storage technologies. This report analyses the potential of some of the main energy storage technologies, presenting their respective advantages and disadvantages that need to be considered when evaluating the likelihood, scale, and speed of investment. It puts forward a set of policy recommendations.

First, the **regulatory framework** must be revised to address the need for the following:

- Detailed norms and procedures on technical integration of storage technology;
- Equal access to ancillary services auctions for utility-scale storage;
- Regulatory provisions for decommissioning of storage facilities;
- Regulatory framework for renewable Hybrid Power Plants (HPPs).

At the same time, **financing opportunities and subsidies** need to be developed, such as:

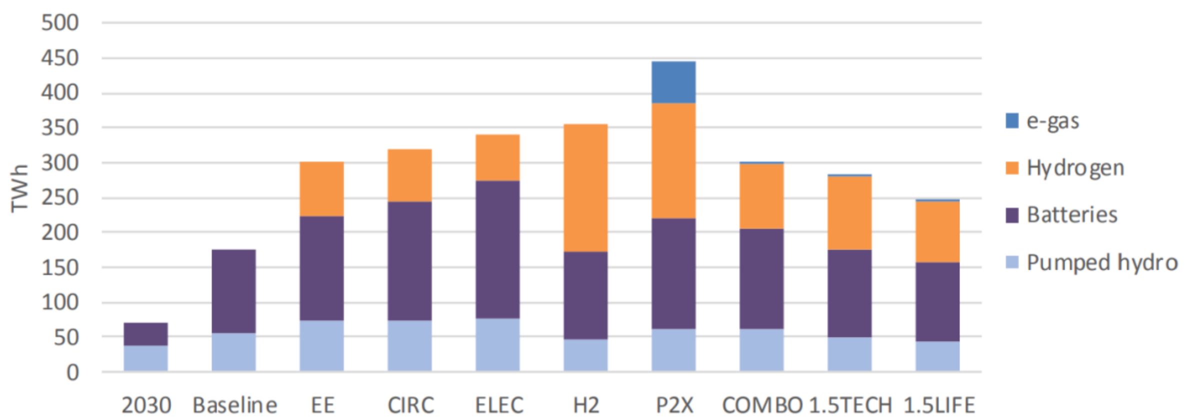
- Capacity mechanisms for energy storage facilities;
- Extension of already-existing subsidies for prosumers to include storage installations;
- Support schemes for off-grid solutions that incorporate storage;
- Adjustment of current financing schemes to new support mechanisms that can enable an efficient deployment of storage capacities;
- Clear remuneration framework for V2G owners;
- Incentivise circular economy initiatives, especially for battery technologies.

1. Introduction: EU policy context

The European Green Deal (European Commission 2019a) represents the EU's development strategy towards a climate neutral economy. Its flagship policy, the Climate Law, is set to enshrine the net-zero greenhouse gas (GHG) emissions by 2050 objective into law. This will create certainty about the EU's climate ambitions and will thus foster a competitive environment for providing the most cost-effective decarbonisation solutions.

Given its versatility as an energy carrier, the increased electrification of industry, transport, and buildings is a must for decarbonisation. Projections show a doubling or even tripling of the EU's current electrification level of final energy demand of 24% (European Parliament 2018, European Commission 2018a, Eurelectric 2018) Obviously, for electrification to provide a reduction of GHG emissions it must be produced from climate neutral sources, such as renewable energy sources (RES). Yet, the Commission's long-term strategy (European Commission 2018b) acknowledges that the further uptake and integration of wind and solar energy renewable energy necessitates flexibility of the rest of the system, which includes fast reacting generation sources on the supply side, storage and demand response. A more decentralised power system dominated by renewables also relies on smarter and more flexible energy infrastructure. Therefore, the Commission's decarbonisation scenarios indicate the need for deployment of up to ten times today's level of storage to deal with variability in the electricity sector. Figure 1 shows highlights the technologies that will provide the necessary storage, according to these scenarios.

Figure 1: European Commission's scenarios for electricity storage in 2050



Source: European Commission (2018)

The uptake of storage technologies, such as pumped hydropower, batteries of utility- and household-scale, electrolysers, as well as thermal storage, will receive added support through the EU's commitment to promote energy system integration (European Commission 2020a). Through sector coupling solutions, which will interconnect processes in sectors such as electricity, gas, industry, and transport, efficiency gains will be maximised, and the cost of transition reduced. For example, the smart charging of electric vehicles and vehicle-to-grid (V2G) solutions could provide flexibility for the power sector, assist in congestion management, and limit costly investments in additional grid capacity. Given its ability for long-term storage, but also for energy buffering, hydrogen will also be a vector for renewable energy storage (European Commission 2020b).

In anticipation of these future developments, concrete steps have already been taken at EU level to favour and accommodate an increase in storage capacity. As part of the Clean Energy Package, the Electricity Directive (European Commission 2019b) and Regulation (European Commission 2019c) that are the basis for a revamped EU electricity market design, set energy storage on an equal footing in the market with power generation. Article 2 of the Electricity Directive defines *energy storage* in electricity systems as 'deferring the final use of electricity to a moment later than when it was generated, or the conversion of electrical energy into a form of energy which can be stored, the storing of such energy, and the subsequent reconversion of such energy into electrical energy or use as another energy carrier'.

Moreover, these pieces of legislation stipulate that network tariffs should not discriminate against energy storage, electricity prices should reflect the need for energy storage double charging for storage should be avoided, and they clarify the issue of ownership of storage installation, which is not permitted for system operators, with a few notable exceptions. The Electricity Directive also contains provisions regarding smart charging and V2G services. The Commission will support the deployment of storage through the implementation of the Clean Energy Package, but also through the further review of existing legislative acts, such as the TEN-E Regulation. Other initiatives, such as the European Battery Alliance (EBA) also recognise the increasing need for storage technologies, seeking to create domestic strategic value chains for the manufacture of these installations (European Commission 2019d).

Based on the EU context and planning a significant uptake of renewable energy sources in its electricity mix over the following decades, Romania must also develop a strategy for the deployment of energy storage technologies. In this respect, the present report sets out to highlight Romania's need for flexibility, as well as evaluate the main options for increasing the national capacity for energy storage.

Without taking into account the flexibility options and in-depth analysis at regional, national and EU-level, one cannot accurately estimate the necessary storage capacity that would allow accommodating the new renewable capacities envisioned by the NECP.

2. NECPs and the 2030 outlook for storage

Increasing the use of renewable energy sources (RES) is among the pillars of the decarbonisation process embraced by the EU. However, an increased RES share translates into more variable capacity coming into the grid, a challenge that finds its answer, among others, in expanding the energy storage capacity of the system. Therefore, there should be a clear link between renewable sources (utility- or household level) and storage capacities envisaged in the NECPs submitted by the member states.

An assessment of the draft NECPs submitted at the end of 2018 reveals, though, that only 11 out of 28 member states included an evaluation of current and future shares of storage or plans to support the deployment of storage technologies through market design or support instruments. Following the EC's initial assessment, more member states have included in their final NECPs more specific targets and measures to encourage the uptake of storage capacities by 2030 (WindEurope, National Energy and Climate Plans).

One example is Romania's NECP, which at first did not address storage technology. The updated version of 2020 was marginally improved in this respect, listing 'developing storage capacities' as an instrument to improve energy security, but lacking detail on the storage capacity to be developed until 2030. In effect, the updated NECP quoted the assessment study of system adequacy by the TSO, Transelectrica SA, which mentions a minimum 400 MW of needed new storage capacity (Transelectrica 2018) A deployment calendar should also have been indicated. The NECP mentions the possibility that storage be covered by a contract-for-difference (CfD) scheme.

The Commission, through DG Energy, issued in 2020 a Study on energy storage – *Contribution to the security of the electricity supply in Europe*— highlighting that storage can make a significant contribution to the flexibility requirements and security of energy supply, and also offering a rough estimate of the required storage capacity by 2030 and 2050 to enable the current decarbonisation plans (European Commission 2020c). The study finds that 108 GW of stationary storage capacity will be needed at EU level by 2030, mainly batteries (67 GW) and pumped-hydro storage (mostly the current capacities).

Electrolysers are not expected to become by then competitive flexibility solutions, but if a large-scale deployment occurred on the heels of the new EU strategy and indirect electrification of end-uses in industry and heating, it would add to the system flexibility on all timescales. Thanks to a short deployment time, similar to wind and solar PV projects, batteries seem to be in pole position to take on the market for the next years. Accordingly, electrolyser manufacturers will have to ramp up production capabilities in order to meet the envisaged 2030 targets.

3. Energy storage: value-chains and technology ecosystems

As suggested, designing a proper legislative framework while also laying the foundation for a predictable investment environment will be critical to address climate-related challenges and restart the economy. To be able to invest in clean generation technologies, the Romanian energy sector must first address its network adequacy issues.

Several solutions ought to be considered, ranging from grid reinforcement and expansion, interconnections, storage, decentralised production, and software-based solutions — demand response, IoT, aggregators, etc. While most of these can be applied individually, their utilisation will be enhanced by coupling them with storage components. Indeed, storage technologies are important in solving network issues, while also unlocking technology ecosystems and creating synergies with other parts of the energy system. Investing in storage will enhance grid flexibility and create additional room for deployment of clean technologies. Energy storage facilities, regardless of technology, will bring, apart from the mentioned structural and operational advantages, economic and social advantages. In particular, utility-scale storage units (batteries, hydrogen storage, electric thermal energy storage, etc) reveal the range and complexity of manufacturing, installing and operating medium and large storage assets.

At household level, the relevance of prosumers – recently inserted in the Romanian legislation – is expected to significantly increase. By adding storage to their decentralised generation units, prosumers can extend their energy management capabilities, maximise aggregation, and increase efficient electricity use. Moreover, a different type of prosumer will emerge in the next years, through increased penetration of EVs. While the V2G technology (vehicle-to-grid) is still in early stages of development, the potential of having multiple 'batteries on wheels' – able not only of injecting electricity in the grid but also, more importantly, to stabilise the distribution grids in peak hours – represents an important opportunity for EV owners, business operators and the overall energy system.

For both utility-scale and small-scale solutions, numerous existing value-chains will benefit from deployment of storage technologies, while other new economic activities need to be created in the following years. Among the main economic activities positively impacted will be research and development (R&D), manufacturing, installation, operation and maintenance (O&M) (including software integration), decommissioning and recycling.

Additional jobs will be created or maintained for these purposes. A study by Lappeenranta University of Technology (LUT) of January 2020 — which cannot include the latest recovery initiatives designed by the Commission for the following years — estimates that, in the EU alone, energy storage could create 277,000 new jobs by 2050 (Ram, Aghahosseini and Breyer 2020). However, the figure must be put into perspective by also accounting for the number of jobs lost as a consequence of a growing energy storage sector, directly and indirectly. To maximise net job growth, it is crucial that the member states develop adequate industry and economic strategies, with substantial dimensions of just transition.

4. Current status in Romania

The Romanian energy system is currently highly dependent fossil fuels, centralised, and to a good extent technically obsolete, being in serious need of overhaul in order to sustain the upcoming energy transition. And yet, if there is a distinctive strength to it, next to its diversified energy mix, it is the substantial contribution of the hydroelectric power of 6,100 MW, about half of which comes from reservoir lakes, which have a key contribution to the balancing market.

According to the latest information from the national regulatory authority, ANRE, Romania has an installed power of 20,655 MW, with approximately 4,700 MW in coal power plants and 3,200 MW in gas-fired power plants, many of them inefficient and close to or even beyond their expected lifetime. In effect, whenever power demand peaks over 8,000 MW, absent significant RES production, Romania must import electricity from its neighbours. According to the NECP, quoting Transelectrica's ten-year development plan, Romania's goal is for its interconnectivity level to grow from about 10% at present to 12.3% by 2025 and 15.4% by 2030, increasing total import capacity from 1.4 GW to 3.5 GW.

With just 2 MW of battery storage installed, the flexibility of the energy system currently relies on the hydroelectric power plants and the conventional generation assets based on coal and natural gas. This, in turn, is reflected in the high degree of concentration on the balancing market, with RES having to pay some of the highest balancing costs in Europe (EWEA 2016). As anticipated, this has been accentuated with the implementation of the Clean Energy Package, which required a removal of the price cap on the balancing market — a measure implemented as of September 1, 2020. Without alternative flexibility options, such as storage and demand-side management, playing any significant role in the Romanian grid anytime soon, the accommodation of variable electricity generation was rendered even more expensive by the increasing prices on the balancing market.

Moreover, the following decade is expected to bring about significant developments, according to the NECP, with a massive deployment of new RES of more than 6 GW by 2030, on top of the existing 4.5 GW of wind and solar power, while a significant share of conventional capacity is expected to be phased-out. Unlocking the pathway to an ambitious renewable 2030 target relies on upgrading the grid and increasing its flexibility. At present, there is an ostensible mismatch between the share of renewables envisaged for 2030 and the TSO's grid development plan. However, the TSO is expected to correspondingly lift its commitments by means of its two-year revisions of its decadal development plans.

The Romanian NECP contains only minor details regarding the development of storage technologies, while the Energy Strategy envisages a significant role for large scale storage capacities after 2030, and particularly after 2040. However, there is little detail on how such capacities are to unfold, other than the mention of 1,000 MW of PHES by 2050. The 2050 long-term strategy that is currently in progress will very likely bring more clarity on the decarbonisation targets and the pathways to net-zero, which will help in developing a dedicated roadmap for storage technologies for 2030 and 2050 based on its decarbonisation scenarios.

Legislative, regulatory and institutional framework

Although the two most important laws for the Romanian energy sector were developed in 2008 (Law for renewable energy promotion) and 2012 (Energy law), respectively, it was in 2018 that storage technology, and batteries in particular, were first included in the regulatory framework. Beforehand, the Romanian power sector lacked any provisions related to storage projects, utility- or household-scale. For this reason, the steps ahead in this sector had been timid. Indeed, the sole utility-scale pilot project implemented in the country was EDP Renewables' battery storage facility at Cobadin (Constanța county) in September 2018 (EDP 2018). No incentive schemes or subsidies were developed for storage projects, and the regulatory framework lacked integration norms for storage technologies, as well as procedures for the participation of storage installations in competitive tenders for ancillary services.

In 2018, after several years of debate, the Romanian authorities defined the *prosumer* as 'the final customer who owns electricity generation installations [...], who consumes and who can **store** and sell electricity from renewable sources produced in his building, including a block of flats'. Thus, the notion of *storage* was indirectly introduced in the regulatory framework for on-grid decentralised production. Later on, in 2020, on the heels of EU Regulation 943, which clarifies the role of storage and its ownership status (Walstad 2020), the authorities transposed in Law 155/2020 (amending Law 123/2012) specific provisions related to new storage facilities and their management rules. Among the most significant is the government's new and clear responsibilities of developing plans and actions for energy storage, aligned with the NECP, European Green Deal, and Next Generation EU. In addition, the provisions related to the licenses issued by ANRE include references to storage capacities for energy producers.

Although it clarified some important notions, mostly in response to EU regulations, the current Romanian legislation fails to include details on future-proof systems and technologies, and there are insufficient provisions regarding the adoption of different types of storage and norms related to storage system integration.

Factors favouring to the development of the energy storage sector

With the EU emphasising renewables and energy efficiency as the main pillars of a green recovery in the wider context of the decarbonisation goals of the European Green Deal, momentum is building up for a significant deployment energy storage technology. Storage capacities are enablers of a massive uptake of RES in sectors such as utility and household energy systems, transport, heating and cooling, and even industry.

Over the last decade, technological progress led to significant cost reductions for energy storage technologies. Nonetheless, the key barrier for large scale deployment seems to be the lack of viable business cases, due to project costs and market rules that limit revenue streams. With the Clean Energy Package, the EU has made significant steps towards creating an enabling environment, as well as a level playing field for an accelerated development of the energy storage sector. In July 2020, two other important documents that are part of the European Green Deal were published: the Energy System Integration Strategy and the Hydrogen Strategy. Both outline profound reforms for the energy systems of today and create significant opportunities for storage technologies such as batteries and hydrogen to develop and create European industrial value chains.

In order to support the development of a competitive industry in Europe and to create a market based on industrial scale demand and supply, the Commission also launched two initiatives: the European Battery Alliance in 2017 and the European Clean Hydrogen alliance in 2020. These initiatives are aimed at bringing together the most relevant companies, R&D institutions, and public authorities to establish technological leadership in these sectors.

Besides, the new economic recovery instrument, Next Generation EU, brings vital financing pathways for the energy storage sector. The €750bn package (€500bn and in grants and the rest in loans) includes two essential instruments that cover energy storage: the Strategic Investment Facility (€150bn) dedicated to energy transition technologies including RES, batteries and other forms of energy storage, clean hydrogen and CCS; and Horizon Europe, expected to pool a €94bn total funding for research schemes in the green and digital transition, as well as other areas. The Multiannual Financial Framework (MFF) also offers opportunities for energy storage in the EU between 2021 and 2027. Likewise, the European Investment Bank (EIB) is expected to play a major role in the following years, as Europe's climate bank. EIB has recently updated its energy lending policy, highlighting that storage technologies are in line aligned with its priorities.

Romania is among the well-placed member states to benefit from the EU financial instruments for the clean energy transition: Apart from the above, it is a beneficiary member state of the Modernisation Fund and the Just Transition Mechanism. A brief overview reveals that energy storage can be developed in Romania through the following instruments:

- Modernisation Fund – with a total allocation for Romania of more than €6bn, depending on the EUA price;
- Just Transition Fund – more than €1bn for the energy transition in Romania's most carbon-dependent regions;
- Innovation Fund – a total of €10bn at EU level for innovative projects;
- NextGen EU – based on the National Recovery and Resilience Plan (NRRP); InvestEU (former Juncker fund) – leveraging public and private funds through the EIB;
- Cohesion Policy – especially through its policy objectives for a smarter Europe and a greener, low-carbon Europe:
    - European Regional Development Fund (ERDF) – 30% of which will be allocated to investments in a greener, low-carbon Europe;
    - Cohesion fund (CF) – can also be used to finance investments in a greener, low-carbon Europe by promoting clean and fair energy transition, green and blue investment, the circular economy, climate adaptation and risk prevention and management.

In addition, the Romanian authorities announced that they are considering a Contracts for Difference (CfD) scheme that will also cover storage technologies.

5. Assessment of potential energy storage in Romania

Based on its natural renewable potential and considering the national energy sector's characteristics – generation assets, regional interconnections, market design, regulatory landscape – Romania has both the need and the opportunity to assess and adopt storage technologies to address adequacy issues and system flexibility.

This section assesses the potential of some of the main energy storage technologies, underscoring their strong and weak points that influence the likelihood, scale and speed of investment.

<table>
<tr><th colspan="2">Utility-scale battery storage</th></tr>
<tr><td>Description</td><td>Utility-scale batteries are a relatively mature and future-proof alternative for enhancing grid adequacy and providing economically feasible alternative for power reserve capacity.</td></tr>
<tr><td>Costs[1]</td><td>• Lithium-ion cells: $200-900/KW
• Lead-acid cells: $300-700/KW
• Sodium-sulphur batteries: $350-3,000/KW</td></tr>
<tr><td>Utilisation</td><td>• Frequency control and short-term storage for balancing output from RES farms
• Stand-alone capacities for ancillary services and balancing market use
• DSO storage for grid losses</td></tr>
<tr><th>Strong Points</th><th>Weak Points</th></tr>
<tr><td>• For RES producers, battery installation reduces the need to sell/buy from the balancing market, thus optimising their hedging portfolio.
• Stand-alone capacities can contribute to balancing the power grid and redressing wholesale market faults.
• Battery storage could be an opportunity for distribution system operators, if allowed under EU law and provided the regulator allowed the inclusion of such investments in tariffs, as this will decrease the financial impact of commercial and technical losses.</td><td>• No functional regulatory framework in place for utility-scale deployment, including access to ancillary services and balancing market.
• No technical procedures in place for the integration and utilisation of battery storage.
• High upfront cost.</td></tr>
</table>

[1] Fundacji WWF Polska (2020).

Potential for the Romanian energy sector	• Romania must increase the power grid's adequacy level in order to accommodate future intermittent capacities. Utility-scale batteries can complement the new RES assets to be deployed by 2030. • The balancing market has been facing major challenges, as low competition has caused major crises in the past years. By opening the ancillary service market and by allowing battery operators to compete for secondary and even tertiary reserves, recurrent energy price spikes would be less probable. • The regulatory pressure on the distribution system operators to limit the financial impact of their commercial losses' in consumers bills may be reduced by allowing them to operate batteries – again, assuming this is admissible under EU law.

Pumped hydroelectric storage (PHS)		
Description	PHS is, by far, the most popular energy storage systems in the world (up to 95% of all active storage facilities worldwide). PHS pumps and stores water in an upstream dam whenever electricity demand is low, usually during night-time; the stored water is released to generate power when the demand is high. The 1,000 MW Tarnița-Lăpuștești PHS project of Cluj county is an old proposal that has turned into a common fixture of the Romanian energy establishment.	
Costs (CAPEX)	€630-3,600/kW[2]	
Utilisation	• Used for stable electricity generation during peak hours • Used for instantaneous balancing intermittent RES capacities	
Strong Points		**Weak Points**
• Supports RES projects by balancing intermittent RES power plants, thus avoiding deployment of fossil-fuel balancing capacities (e.g., coal, natural gas) • Long-term plant lifetime • High efficiency (although technically PHSs are net consumers, they are financially profitable as they sell electricity at peak demand, while the consumption takes place during off-peak hours)		• PHS requires favourable terrain conditions, which are difficult to meet. • Works needed for artificial reservoirs, with strongly impact on the natural environment (some of them are already protected areas, so installation is impossible). • Long construction time (including feasibility analysis and environmental clearance), ranging from 5-10 years.
Potential for the Romanian energy sector	• Romania's energy strategies have included a high-capacity PHS starting in the late 1970s. • The 1000 MW Tarnița-Lăpuștești PHS has been constantly considered as a solution to balance the grid, first as a solution for providing peak demand in	

[2] Fundacji WWF Polska (2020).

	conjunction with Cernavodă NPP's baseload generation (discussed as a mandatory solution for two additional nuclear units). It later turned into a favourite solution for balancing intermittent RES generation, too.
	• While the high production capacity and load factor would perfectly serve the needs of the Romanian grid, a project of this scale (1,000 MW) is difficult to develop, for environmental, social and financial reasons.
	  ○ While no real financial analysis has been provided, the figures ventured in the past years are not economical. Other storage facilities and flexibility solutions have more competitive costs than the Tarnița-Lăpuștești project.
	  ○ The deep environmental impact has always been considered a significant issue. Besides, the potential social impact needs to also be considered, especially considering the increased real estate investments in the region over the past two decades or so.

Hydrogen energy storage	
Description	Hydrogen as an alternative energy vector to store energy, particularly renewable, over long periods of time has become an important concept of the energy transition, given the variability of RES production, as well as resource-oriented localisation of production assets. The notion of hydrogen energy storage has become more complex than the mere re-electrification cycle (electrolysis + fuel cell), as hydrogen has potential uses in various fields and opens prospects of system integration.
Costs	• Electrolyser CAPEX: €500-1,000/kW (alkaline and PEM)[3] • Electrolyser OPEX: 2% of initial CAPEX/year (IRENA 2018) • Levelized cost of hydrogen: €2.5-5.5/kg H2 using renewable electricity (2018) (IEA 2019)
Utilisation	• Significant seasonal energy storage potential • Balancing RES power • Energy systems integration

Strong Points	**Weak Points**
• Allows storage of large amounts of energy over long periods • High storage capacity • Enables synergies with other parts of the energy system	• High upfront costs • Regulatory framework in early development phase • Steep learning curve is required

[3] Based on cost assessments from BloombergNEF, Hydrogen Europe, IEA.

	• Limited to availability of adequate geological formations

Potential for the Romanian energy sector	• Taking into account the potential of offshore wind developments in the Black Sea, combined with the high concentration of clean energy production in Southeast Romania (Dobrogea region) and limited grid capacity to evacuate this variable energy profile, there are clear prospects for hydrogen to become an alternative energy carrier in the region, also benefitting from the major role that the port of Constanța can play. • In the conventional power generation sector, there are plans for investments in at least 1.6 GW worth of gas-fired power plants in the next five years. Such costly assets, along with any new piece of gas infrastructure, should better be designed as 'future proof.' Making them able to run on hydrogen as well is a way of securing their economic lifetime, thus reducing their risk of becoming stranded assets. • One such initiative is the recently announced plan to build a gas-fired PP alongside wind and solar PV capacities to power the country's largest steel plant in Galați, a project that will transition to hydrogen use in a second phase. • Clean hydrogen is also expected to play a role in making H&C, transport and industrial processes more sustainable. • The currently available options for financing hydrogen technologies, as well as the unprecedented level of support for them at EU level, make it into one of the most attractive prospects for the Romanian energy sector in the next years.

Electric thermal energy storage (ETES)	
Description	ETES uses electricity from the grid to store it as thermal energy at high temperatures and reconvert it to electric energy using a steam turbine. It is a versatile concept that uses mostly off-the-shelf components and can function in various configurations.
Costs	• Although some projects have been already deployed,[4] ETES technologies are still in the demonstration/pilot phase, thus there is no real market price yet.
Utilisation	• Daily, up to weekly energy storage potential • Adds system flexibility • Multiple revenue streams
Strong Points	**Weak Points**

[4] Renewable Energy World (2019).

• Potential GWh scale • Potential to become cost-competitive • Versatility and scalability • High efficiency for storing direct heat	• Low efficiency in reconverting heat back to electricity • Low level of maturity, with only one larger-scale project so far[5]

Potential for the Romanian energy sector	• With only one ETES large-scale facility currently operating in Hamburg, Germany, there is significant potential for replication. Versatility and scalability make ETES a solution for increased flexibility in the Romanian energy sector. • Based on the parameters of the pilot plant in Germany, similar ETES facilities developed in Romania would be able to take up renewable energy and store it as thermal energy for up to a week and reconvert it into electricity using a turbine in 24 hours. • While to overall efficiency of the complete cycle is around 45%, the fact that this concept can be developed by the existing power plants make it an attractive prospect for added flexibility.

Small-scale battery storage	
Description	The prosumer eco-system has seen major developments in the past few years. As more fiscal or financial incentives were available to households and SMEs, the deployment of small-scale PV capacity grew significantly. A second step in the deployment of the eco-system is the installation of storage capacities, which are needed to unlock services such as demand-response, energy management etc.
Costs[6]	• Lithium-ion cells: \$200-900/KW • Lead-acid cells: \$300-700/KW
Utilisation	• Household/SME storage for small-scale decentralized production (mostly PVs)

Strong Points	**Weak Points**
• It reduces dependence on the distribution grid, while maximizing the usage of decentralised RES. • For off-grid consumers (houses, farms, etc) with off-grid generation systems, this type of batteries can expand the utilisation rate of decentralised electricity production.	• Relatively low utilisation time. • Relatively high upfront cost, although in most cases the use of electricity stored is more advantageous than consuming the grid electricity provided, as it includes distribution and transmission tariffs.

Potential for the Romanian energy sector	• While the past and current subsidies for prosumers do not include storage capacities, the business case for battery owners is positive, since consuming local production is better than buying electricity from suppliers (which includes

[5] ibid.

[6] Fundacji WWF Polska (2020).

	transportation and distribution tariffs, taxes and support schemes paid by all customers). • Some programmes implemented by the Environmental Fund Agency (AFM) for off-grid users address energy access issues. Additionally, the energy-water-food nexus can be tackled with off-grid solar PVs and batteries, as irrigation systems in remote areas require additional generation capacities. • Moreover, buildings are becoming energy micro-hubs and, considering the new building regulations and the EU Renovation Wave, small-scale storage capacities are expected to be integrated in both renovated and new buildings.

V2G technology	
Description	Electric vehicles are already used as ‘batteries on wheels,’ as more recent models have also the option of injecting electricity in the distribution grid. Business models are created to benefit all the parties – EV car owners, DSOs, suppliers and operators of EV chargers. Pilot projects have been developed and the results are promising, unlocking vast opportunities for EV users.
Costs	• Most of new EVs already have V2G technologies included. • Costs are related to the technical adaptation of distribution network and deployment of bidirectional EV chargers.
Utilisation	• Used by EV owners as storage/balancing capacity for household/SMEs solar generation. • Serves as a balancing capacity for local distribution grids.
Strong Points	**Weak Points**
• The V2G mode is becoming a general feature of EV manufacturers, so it comes at no additional cost for buyers. • V2G users can monetize battery availability in different commercial packages offered by their electricity providers. Car battery can also play the role of static batteries for PV systems. • Equally, the distribution operators can use EV batteries for local grid stabilization.	• Some studies show an accelerated depletion rate of batteries, due to the V2G mode usage (Bishop et al. 2013) • Need for significant and expensive upgrade of distribution networks need in order to become V2G-ready.
Potential for the Romanian energy sector	• On the back of a generous incentive schemes available in Romania for the past several years, the EV adoption rate has increased substantially. In fact, EV manufacturers are facing challenges in meeting local demand. • While not all car models available in Romania have the V2G option, more models with this option are upcoming.

	• The use of car batteries will be a important for DSOs, which are facing high urban congestions, especially during peak hours. Thus, V2G will increase the quality of the DSO service and lower distribution tariffs for all users. • However, technical challenges (some networks are not yet prepared to inject available EV power) and the lack of a regulatory framework for V2G users are significant barriers.

Other storage technologies, particularly those based on mechanical or kinetic energy, such as compressed air storage (CAES) and flywheels, will likely not play a major role in the Romanian energy sector in the short to medium-term and can, at most, be limited to niche applications requiring long-term storage. While the geological potential for CAES projects – large reservoirs such as salt caverns – are available in Romania, the technology still cannot generally compete in terms of costs. For their part, flywheels are suitable for short-term storage with very good response time, but only have low storage capacity. Thus, they can potentially be an option for very fast frequency control but must compete with batteries on this segment.

6. Optimal storage investment for Romania by 2030

Assessing the need for storage investments in the power sector is a complex process, encompassing multiple factors: generation capacities, projections of demand, import/export transmission lines and balances, market regulations, and expected technology changes, just to name a few. Absent complex modelling, only a qualitative assessment can be offered.

Table 1: Storage technologies and their utilization, based on response time

	Instant response (adequacy)			Reserve (flexibility response)		
	Seconds	Minutes	Hours	Days	Weeks	Seasons
Utility scale batteries	Suitable/indicated	Suitable/indicated	Suitable/indicated	Less suitable/indicated	Not suitable/indicated	Not suitable/indicated
Pumped Hydro	Not suitable/indicated	Suitable/indicated	Suitable/indicated	Not suitable/indicated	Not suitable/indicated	Not suitable/indicated
Big hydro (capacity reservoirs)	Less suitable/indicated	Suitable/indicated	Suitable/indicated	Suitable/indicated	Suitable/indicated	Suitable/indicated
Hydrogen	Less suitable/indicated	Less suitable/indicated	Less suitable/indicated	Suitable/indicated	Suitable/indicated	Suitable/indicated
Electric thermal energy storage (ETES)	Not suitable/indicated	Less suitable/indicated	Suitable/indicated	Suitable/indicated	Not suitable/indicated	Not suitable/indicated
Small-scale battery storage	Less suitable/indicated	Suitable/indicated	Suitable/indicated	Not suitable/indicated	Not suitable/indicated	Not suitable/indicated
V2G	Suitable/indicated	Suitable/indicated	Less suitable/indicated	Not suitable/indicated	Not suitable/indicated	Not suitable/indicated

Suitable/indicated Less suitable/indicated Not suitable/indicated

Energy storage technologies have various characteristics and offer different functions to the energy system, making them suitable for specific applications. For some applications, such as adequacy response, the power rating of a storage system may be the most relevant (MW). For flexibility response, the storage capacity would be the determinant parameter (MWh).

The power sector and power markets are highly dynamic at present, and an adequacy assessment which can estimate recommended capacities for the mentioned technologies can only be done at TSO level. To this effect, Transelectrica has issued some adequacy studies, the conclusions of which were included in the NECP. The TSO’s ambitious recommendation is for 400 MW of installed battery storage by 2025 in order to achieve the long-term adequacy target at national level (Transelectrica 2019):

> ‘’integration of battery energy storage systems (BESS) in the national energy system at a level of 400MW and more, especially to flatten the load curve and ensure added reserves usable as technical system services (TSS) for frequency stabilisation. This process of BESS integration must be correlated with an increase of installed power in distributed renewable power plants.”

Additionally, a significant adoption of decentralised production units, both at individual level and energy community level, will translate into higher demand for small-scale battery storage, an indispensable element in the development of future-proof and clean energy producing eco-systems. At the same time, EVs adoption rate is expected to continue its positive evolution and with it the V2G potential can be harnessed for both EV owners and DSOs’ operational objectives.

Clean hydrogen may also contribute to the flexibility of the power system in the 2025-2030 stage, benefiting from and at the same time supporting the system integration of RES. In particular, this may harness the potential for offshore wind power generation in the Black Sea.

As for the other storage technologies, pilot projects can be expected by 2030, their evolution being dependent on a favourable investment environment, available subsidy schemes, and a predictable and stable regulatory framework.

7. Policy recommendations

Taking into consideration both the current poor adequacy level of the Romanian power grids and the need to scale up renewable power generation in the years ahead, the energy sector needs to find technical and investment opportunities for storage capacities. To this end, a proper **regulatory framework** for different storage technology deployment, able to create a functional remuneration system for investors. Such a framework should include:

- Norms and procedures on technical integration of different storage technologies, both utility-scale and household level, including roles and responsibilities of participants by type of technology (producer, TSO, DSO, supplier, etc). Presently, batteries are treated as additional power capacities, so that small RES farms (less than 10 MW) face the challenge of exceeding their licensed output power and the regulated threshold – initial installed capacity + storage capacity – thus being mandated to request a switch to a higher voltage level, which comes with high fixed costs for the investors.
- Equal access to auctions for ancillary service for utility-scale storage facilities, in order to enhance effective competition on the balancing market. In this sense, the Commission Regulation (EU) 2017/2195 establishing a guideline on electricity balancing (EGBL) enjoins the implementation of EU-wide exchanges for balancing market services. To this purpose, the member states' TSOs are developing the following platforms (ENTSO-E 2018):
    - IGCC – International Grid Control Cooperation, for imbalance netting;
    - PICASSO – Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation, for frequency restoration reserves with automatic activation (aFRR);
    - MARI – Manually Activated Reserves Initiative, for frequency restoration reserves with manual activation (mFRR);
    - TERRE – Trans-European restoration Reserves Exchange, for replacement reserves (RR).
- Explore the legal possibility – i.e., compliance with Regulation 944/2019 and its exceptions – for DSO operators to use batteries to mitigate the financial impact of technical and commercial losses in the end consumers' bills. to be considered (Nouicier and Meeus 2019);
- Stable, predictable, and attractive framework for investment in storage capacities and services;
- Regulatory provisions for storage decommissioning (especially for batteries), to ensure the environmental control and protection;
- Regulatory framework for renewable Hybrid Power Plants (HPPs).

Most of the storage technologies still need support schemes, thus **financing opportunities and subsidies** need to be developed. Among them:

- Capacity mechanisms for energy storage technologies to provide fixed incomes for existing and future storage facilities in exchange for available capacity;
- Expanding the current subsidies for prosumers – households and SMEs – to storage projects;
- New support schemes for off-grid solutions with storage, for example in agriculture (irrigation or farms), off-grid residences, industry, etc;
- Adjust current financing schemes and design to new support mechanisms, in light of substantive contribution at energy system level. Some financing programs are scoring more highly project proposals containing storage components, which tends to create artificial incentives for such technical additions. Efficiency, technical and financial, is key for a sound deployment of storage capacities;
- A clear remuneration scheme for V2G owners, and incentivising the use of V2G by means of tax exemption for its adoption;
- Incentivise circular economy initiatives, such as second-life systems and services for batteries.

Finally, considering the vast potential of different storage technologies (especially batteries and hydrogen) domestically and abroad, the Romanian authorities should develop initiatives and long-term planning to **attract and create industrial value chains** domestically.

Abbreviations

AFM	Environmental Fund Agency
ANRE	National Authority for Energy Regulation
CCS	Carbon Capture Storage
CAPEX	Capital Expenditure
CfD	Contract-for-difference
EBA	European Battery Alliance
EIB	European Investment Bank
EPG	Energy Policy Group
ETES	Electric thermal energy storage
EUA	European Union Allowance
EV	Electric Vehicle
GHG	Greenhouse Gas
H&C	Heating and Cooling
HPP	Hybrid Power Plant
LUT	Lappeenranta University of Technology
MFF	Multiannual Financial Framework
NECP	National Energy-Climate Plan
NRRP	National Recovery and Resilience Plan
O&M	Operation and Maintenance
OPEX	Operating Expense
PHS	Pumped hydroelectric storage
PV	Photovoltaic
R&D	Research and Development
RES	Renewable Energy Sources
SME	Small and Medium-sized Enterprises
TEN-E	Trans-European Electricity Networks Regulation (EU) 347/2013
TSO	Transmission System Operator
V2G	Vehicle-to-grid

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