GreenSpace Tech
by Deloitte

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Long-duration energy storage

A decarbonization technology of growing importance

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Long-duration energy storage (LDES) will play a crucial role in the clean energy transition. Often defined as a system that can provide at least 10 hours of stored energy, LDES will be needed primarily to enhance reliability in power grids as they integrate growing amounts of intermittent renewable energy resources such as solar and wind.[1,2] When charged from clean sources, LDES can also enable clean heat for industrial processes. And it can provide clean backup power for remote and off-grid mines, data centers, buildings, and farms, among other applications. For some entities, now may be an excellent time to evaluate and pilot LDES. Indeed, a growing number are already doing so.

The electric power sector is leading demand

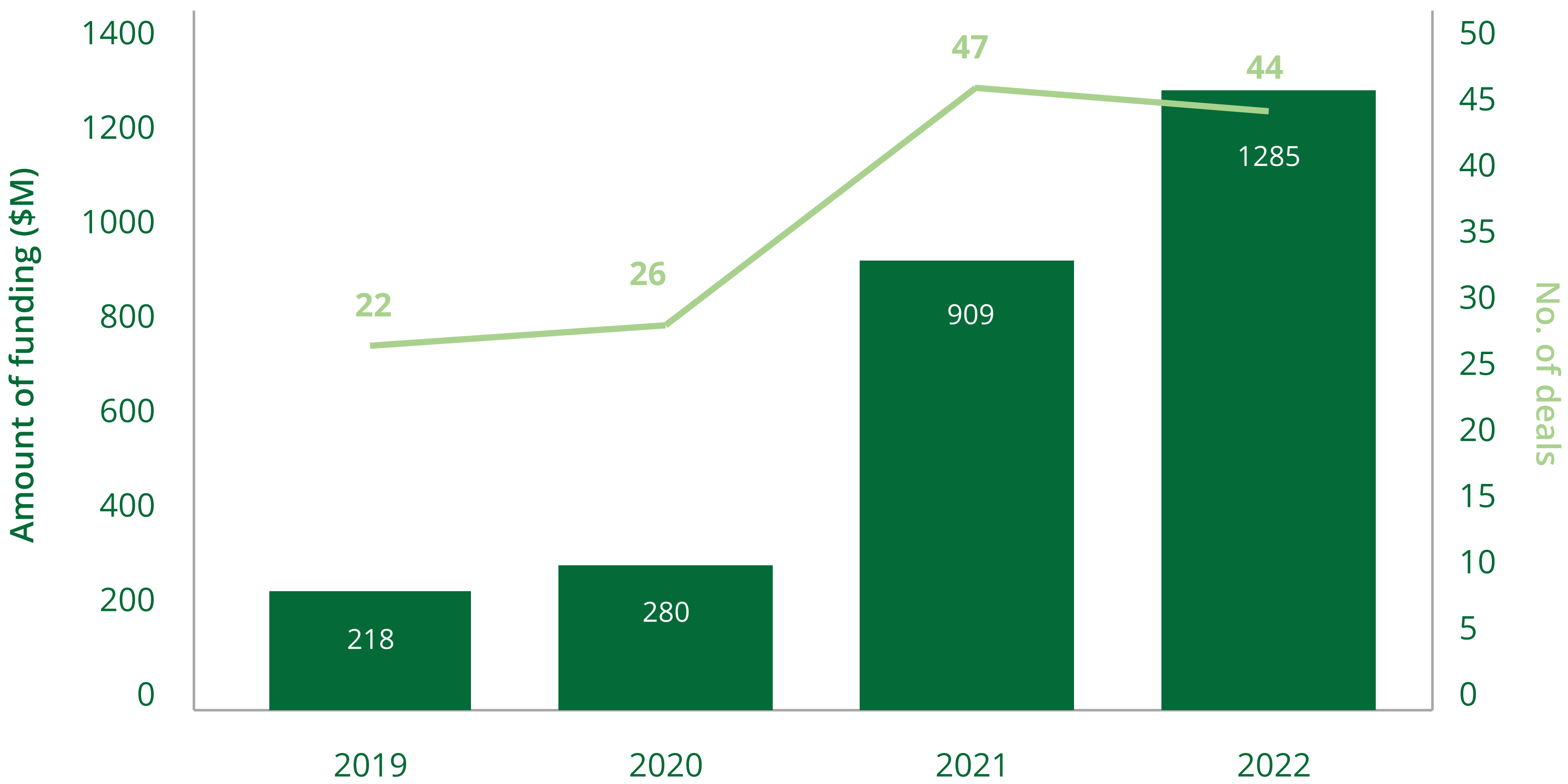
Spurred by the accelerating adoption of renewable energy, the electric power sector is expected to be the largest buyer of LDES.[3] The U.S. Department of Energy says the 2035 clean power goal could require from 100 to 680 GW of LDES capacity, massive growth compared to the less than 9 GW of grid-scale battery capacity installed to date.[4,5]

Government incentives and private investment (1/2)

The Biden administration has targeted 100% clean electricity by 2035, provided an investment tax credit for standalone energy storage in the U.S. Inflation Reduction Act[6], and announced $350 million in funding for LDES demonstration projects[7].

Private capital, recognizing this opportunity, has poured into LDES startups, surging from $218 million in 2019 to $1.2 billion in 2022 (Figure 1).

Figure 1: VC Investments in LDES startups

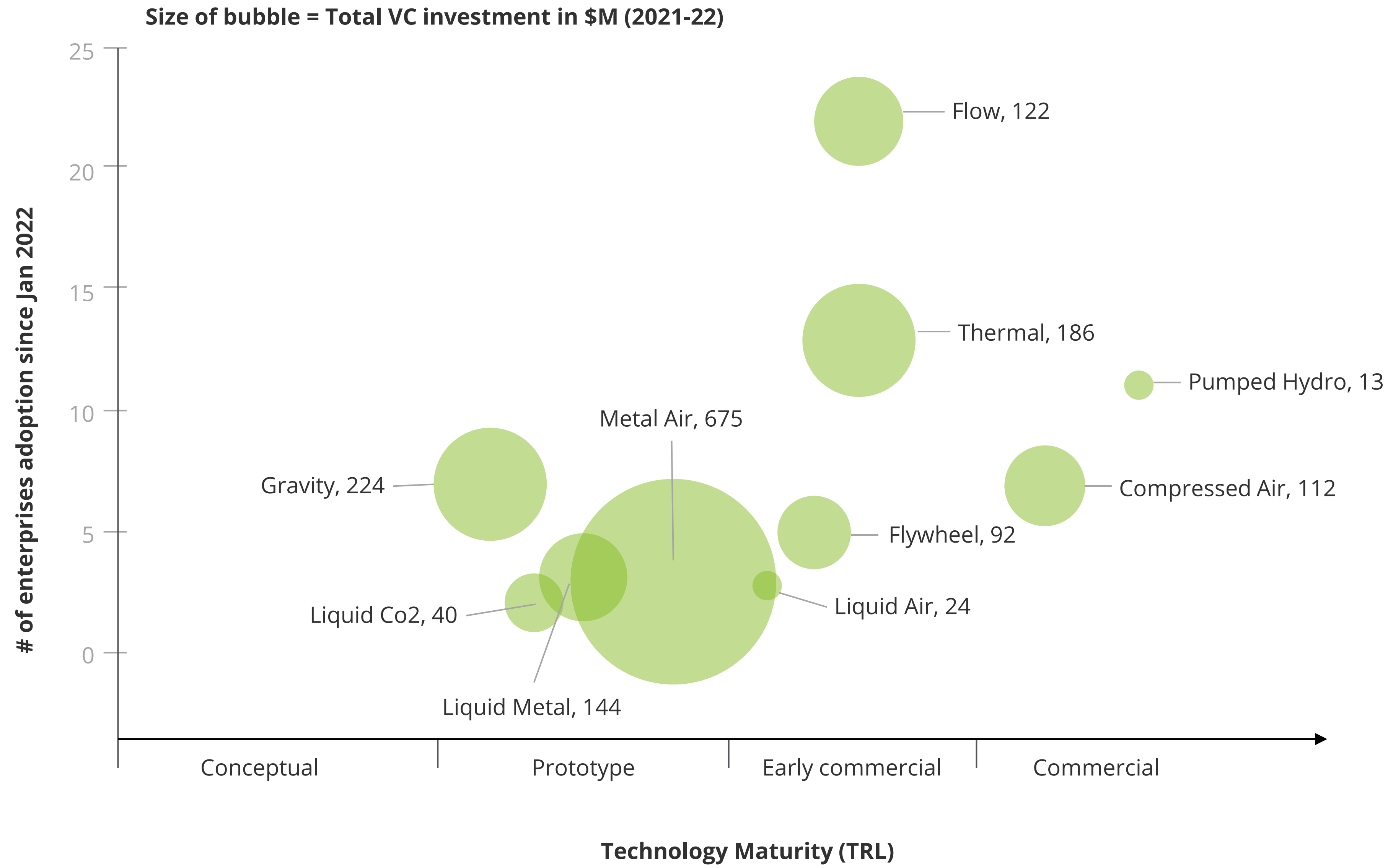


Source: CBInsights, accessed Jan. 27, 2023

Government incentives and private investment (2/2)

Venture capital investors have allocated funds to a wide range of LDES technologies, with startups focused on metal-air batteries receiving the most funding over the last two years (Figure 2). A startup using relatively inexpensive iron-air technology received $650 million of the total.[8,9] It claims to provide cheap bulk energy storage (more than 100 hours at a cost of $20/kWh)[10], an appealing proposition for the decarbonization needs of the electric power sector.

Figure 2: LDES funding and adoption by technology



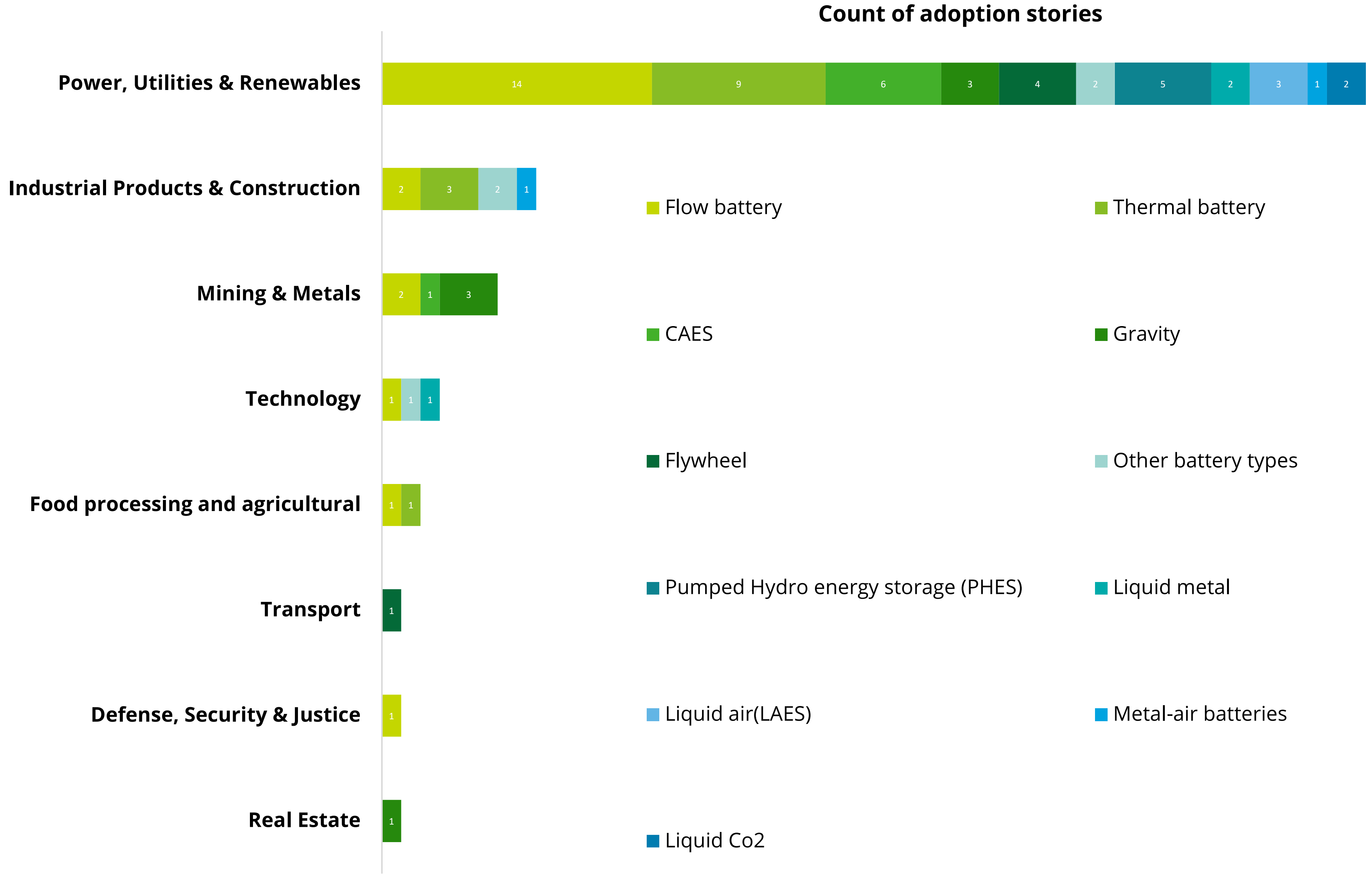
Source: CBInsights, accessed Jan. 27, 2023; Factiva, LDES adoption stories published between Jan. 1, 2022– Jan. 31, 2023

Diverse storage technologies being adopted (1/2)

Media accounts of LDES adoption over the last year confirm that the power sector is the most active and focuses on relatively mature technologies such as flow, thermal, and compressed-air batteries (see Figure 3). With their modular architecture, flow batteries enable low-cost capacity scaling through expandable electrolyte storage tanks, enabling electric power companies to deploy LDES on pace with growing renewable installations.[11] In this category, vanadium redox flow and iron-flow technologies are relatively mature and more widely adopted.[12]

Other LDES technologies are being adopted in the power sector and beyond. Thermal LDES, coupled with excess renewable output from the grid, is replacing fossil-fuel boilers at some power plants.[13]

Figure 3: LDES technology adoption stories published between Jan. 1, 2022 – Jan. 31, 2023, segregated by sector

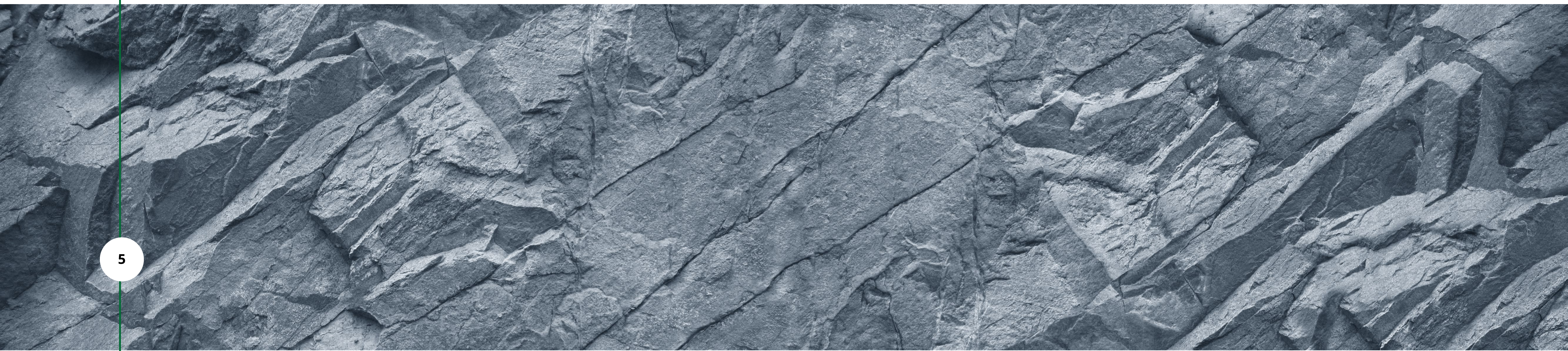


Source: Factiva, LDES adoption stories published between 1 Jan '22 – 31 Jan '23

Diverse storage technologies being adopted (2/2)

Compressed air energy storage (CAES) stores compressed air in large underground caverns[14] and can provide large-scale clean backup energy when paired with renewable energy at a low cost.[15]

The industrial sector leverages thermal LDES to decarbonize industrial processes using clean dispatchable heat, typically stored in molten salts, which are heated using captured waste factory heat or renewable sources.[16] Mining companies are testing gravity LDES in decommissioned mines using mining waste as weights for gravity-based batteries.[17] A Deloitte client in the mining sector is piloting gravity LDES, among other technologies, following an LDES technology scan undertaken by the GreenSpace Tech team.



Costs and business models remain challenging

Although the drive to decarbonize power grids and heavy industry are creating demand for LDES, the market is constrained by the cost of the systems, which generally remain many times higher than what researchers such as analysts at Sandia National Labs say will be necessary for LDES to attain wide adoption: about $20/kWh (Figure 4).[18,19]

In addition, while business models for short-duration storage on the grid are fairly well developed, a market for the services that LDES can uniquely provide has yet to take shape, complicating the investment case for some developers.

Figure 4: Performance, cost, and challenges associated with popular LDES tech

Category	Technology	Duration(Hrs)	Tech readiness	Energy capacity cost in 2021 ($/kWh)	Challenges
Mechanical	Gravity	2-24	Prototype	190-731	Infrastructure constraints
	Liquid Co2	4-24	Prototype	~200	Unproven, safety risk
	Liquid air	4 - 4 weeks	Early commercial	400-500	Complex design, high capex
	Flywheel	<4	Early Commercial	200-250	Commercial for only short duration
	Compressed air	6-12+	Commercial	16-295	Lower round-trip efficiency
	Pumped hydro	6-20+	Commercial	220-511	Geographical constraints
Thermal	Sensible heat	4-18	Early Commercial	130-600	Poor electric efficiency
Electrochemical	Metal-air	8-100	Prototype	~20 (Iron Air)	Large size, unproven
	Flow	2-15	Early Commercial	356-835	High footprint, high capex

Sources: Pacific Northwest National Lab "2022 Grid Energy Storage Technology Cost and Performance Assessment, August 2022; Massachusetts Institute of Technology, The Future of Energy Storage, June 3, 2022; IEA, ETP clean technology guide, Sep 21, 2022; Deloitte analysis)

Still, various studies forecast a downward trend in LDES costs, driven by regulatory support,[20] investments,[21] and technological developments,[22], similar to the lithium-ion battery price trend over the last decade.[23] Based on these developments, LDES technologies are forecasted to see accelerated adoption post-2030.[24] Enterprises should take note and start evaluating technologies and use cases most relevant to their respective sectors.

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Together, we will connect climate technology innovation with industry to accelerate the solutions of the future.

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