

Webinar Technology Watch, October 26, 2022

Sistemi di accumulo: tanti servizi al sistema, tante tecnologie

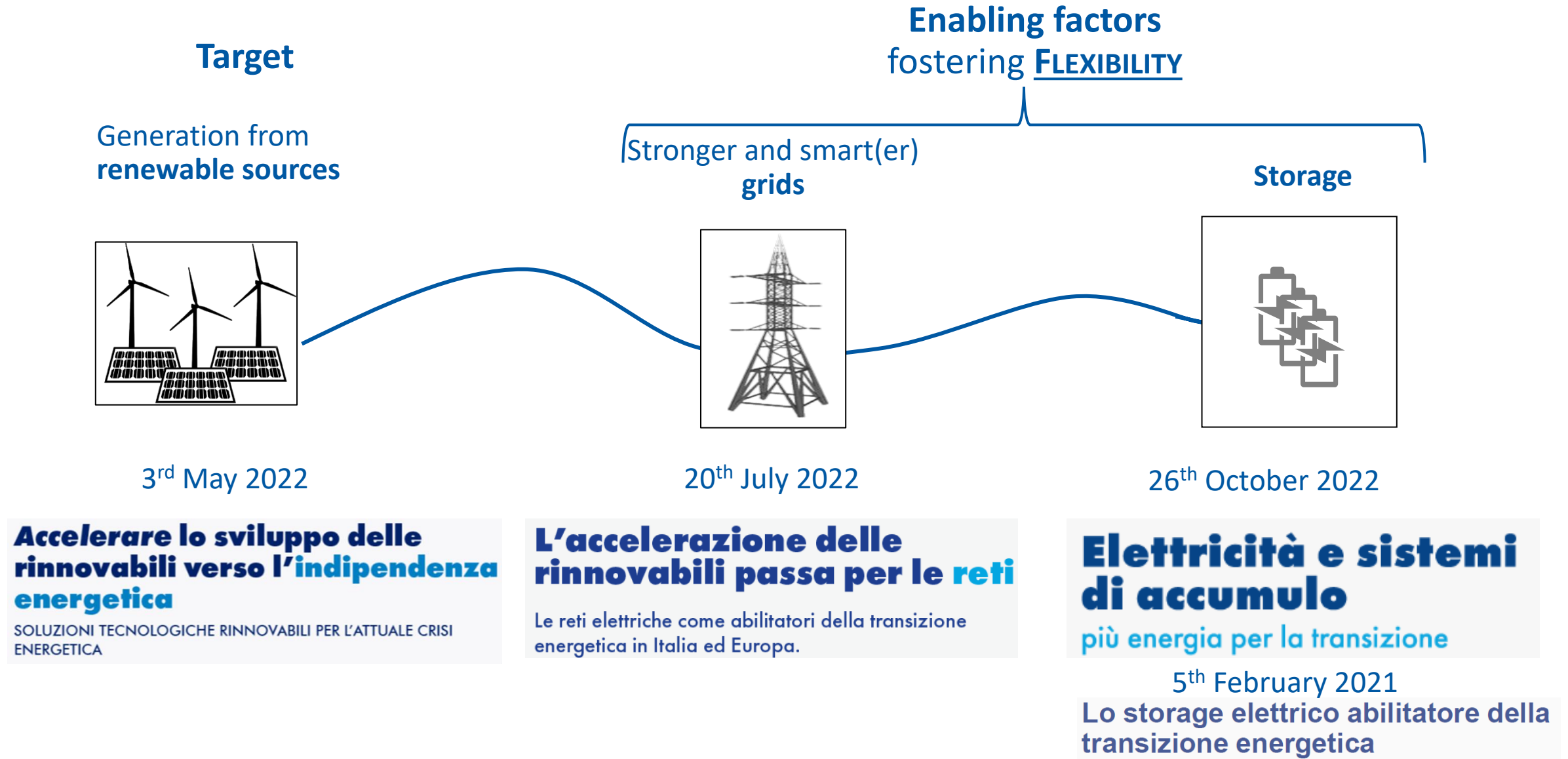
Bruno Cova

*Advisory Services & Studies Director
Consulting Division*

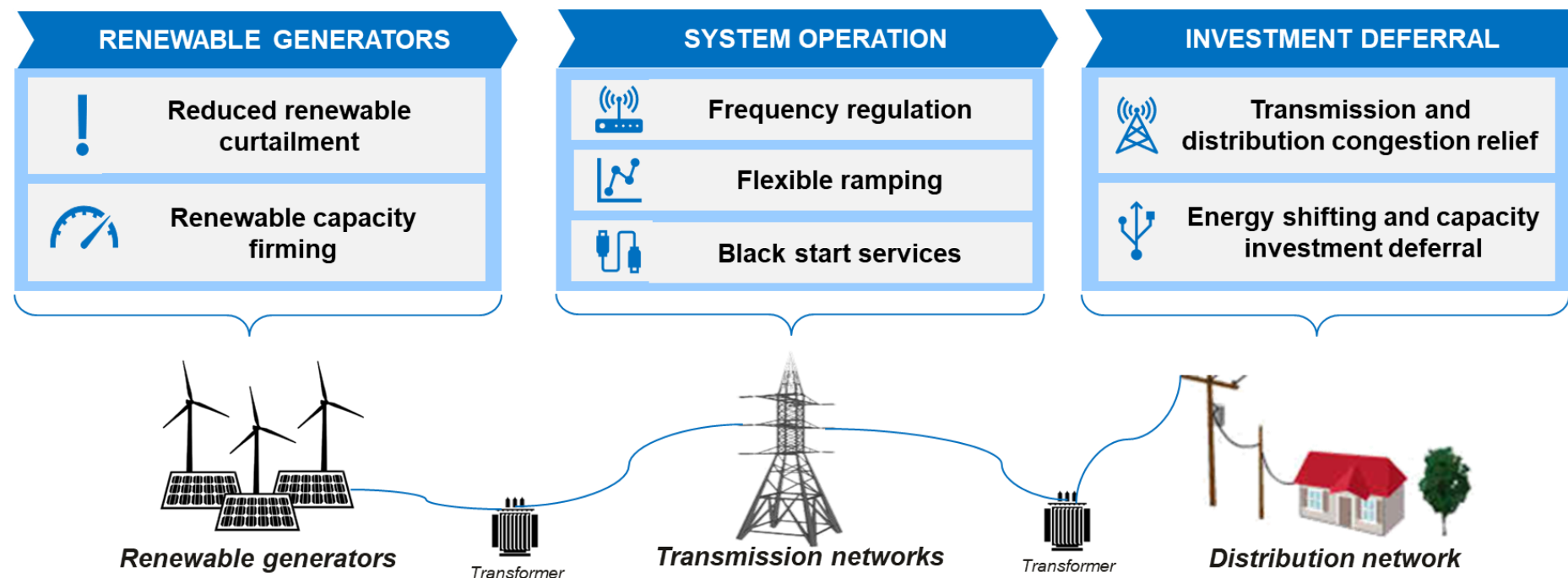
CESI SpA

**Elettricità e sistemi
di accumulo**
più energia per la transizione

Storage as one of the enabling factors towards carbon-free power systems



Storage: multiple services- multiple technologies

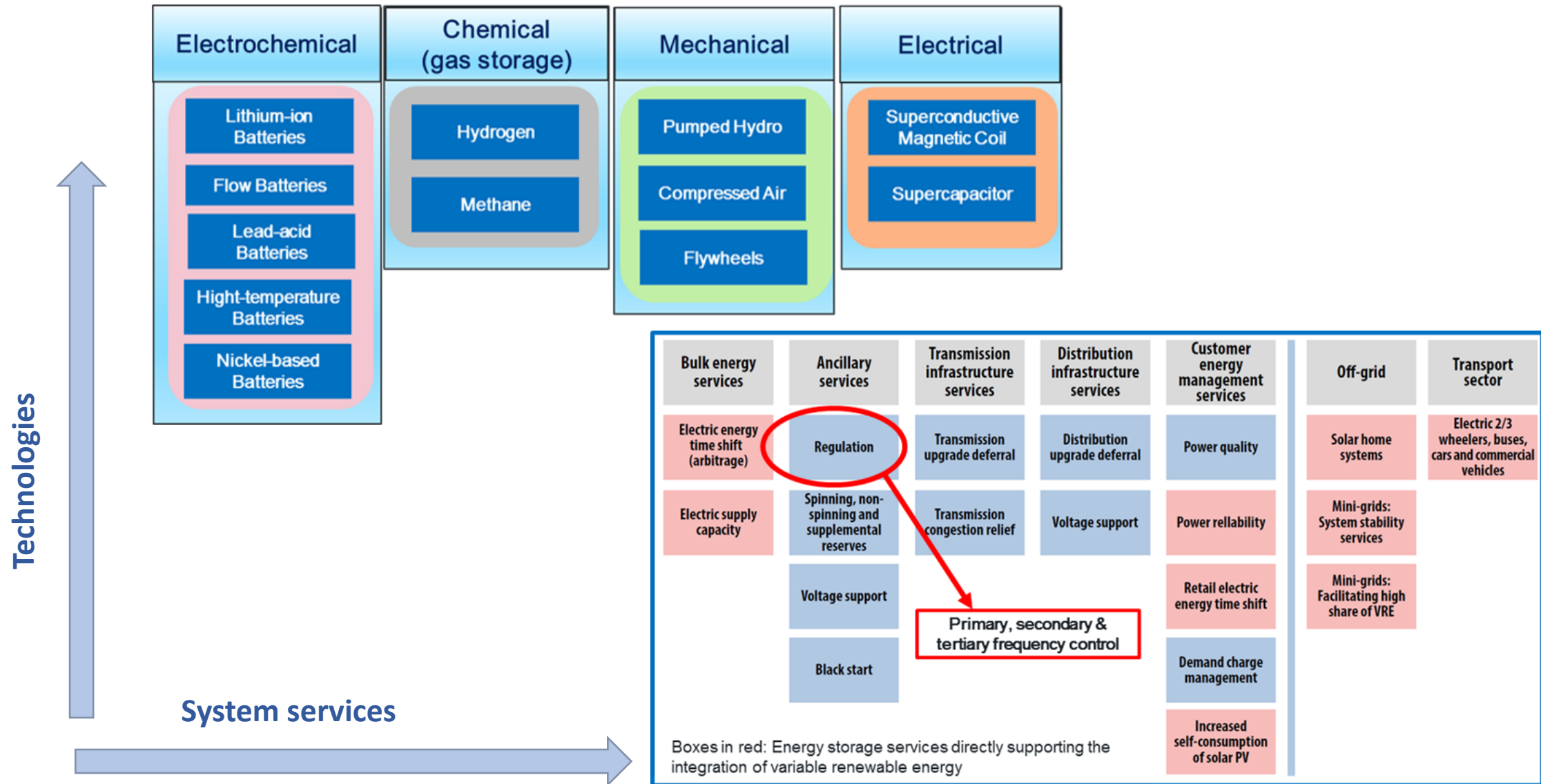


Utility-scale storage systems provide benefits across the generation, transmission, and distribution value chain

Need for Storage capacity to resort to:

- ✓ multiple technologies considering size, time interval for the various services, cycling&ageing
- ✓ non-conventional solutions: clusters of EV, CAES, LAES, coupling with other sectors (thermal energy storage, green hydrogen)

Electric storage: technologies and system services



Source: IRENA and EASE website

Storage: categories of technologies

Five main categories of storage technologies

	 Mechanical	 Thermal	 Electro-chemical	 Electrical	 Chemical
	 <i>Pumped Hydro Storage</i>	 <i>CSP with Thermal Storage</i>	 <i>Li-Ion Energy Storage</i>	 <i>Supercapacitor System</i>	 <i>Hydrogen Storage System</i>
	Uses elevation or motion to store energy in mechanical form	Converts electricity to heat that is then stored in a medium (e.g., molten salt)	Uses battery technology to store electricity	Stores electrical energy on 2 metal plates separated by a semiconductor	Uses electrolysis to separate natural elements and store energy in gas form
Global 2020 Capacity (GW)	159¹	2.5	3.3	~0	~0
CAGR (%) (2010-20)	2%	18%	34%	26%	80%²

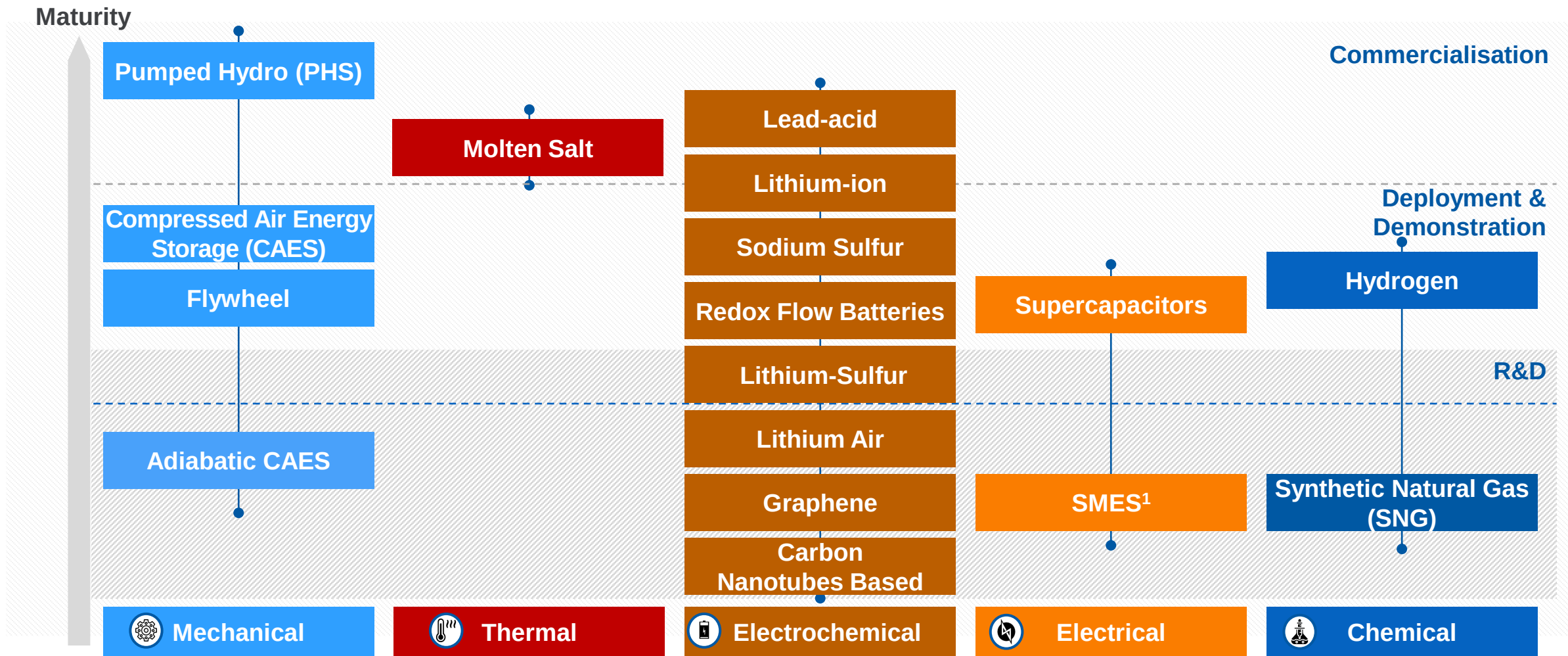
1) 1.3 GW excluding Pumped Hydro Storage

2) 2012-20 CAGR

Source: Strategy&/CESI analysis

Storage: categories of technologies and maturity stage

Key energy storage technologies



1) Superconducting Magnetic Energy Storage

Source: World Energy Council, IEA, Rocky Mountain Institute, Strategy&/CESI analysis

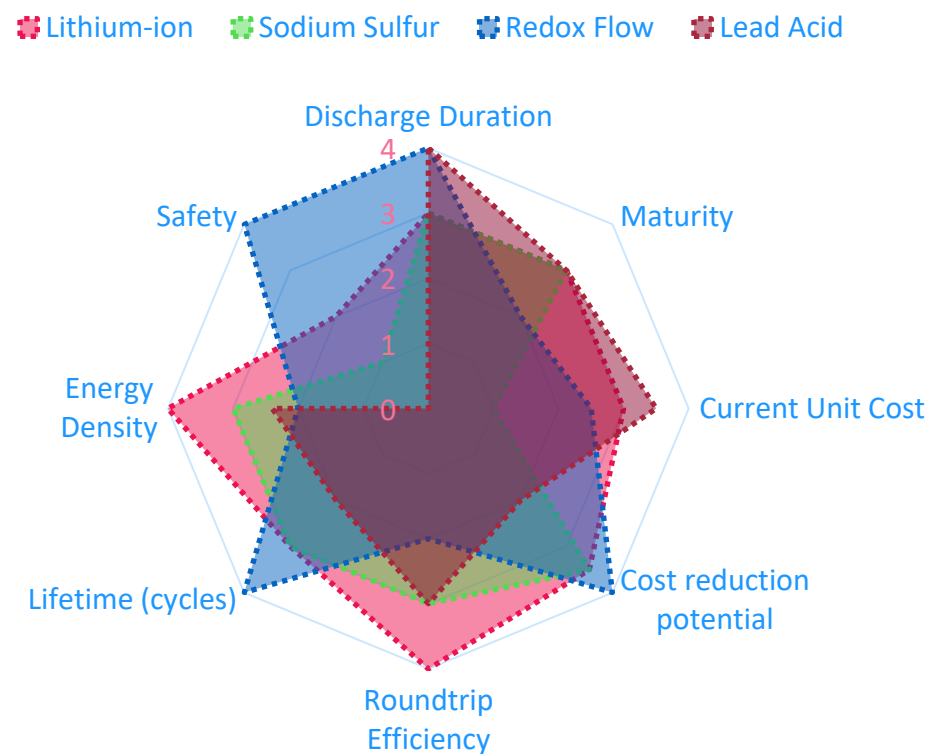
Key energy storage technologies by system type and maturity

Within electrochemical systems, **Li-ion** is currently the winning tech, yet **redox flow** is well positioned to compete in future

	Lithium-ion	Redox Flow	Sodium-Sulfur	Lead acid
Max. Discharge Time ¹	8h	10h	8h	10h
Maturity	4	2	3	4
Current Unit Cost (\$/kW)	175-4000	600-1500	1000-3000	120-700
Cost reduction potential	3	4	3	2
Roundtrip Efficiency (%)	85%-98%	60%-85%	70%-90%	75%-85%
Lifetime (cycles)	1,000-10,000	12,000-14,000	1,000-10,000	600-1,250
Energy Density ² (Wh/l)	200-620	15-70	140-300	50-100

1) The duration at which the energy from the battery is discharged

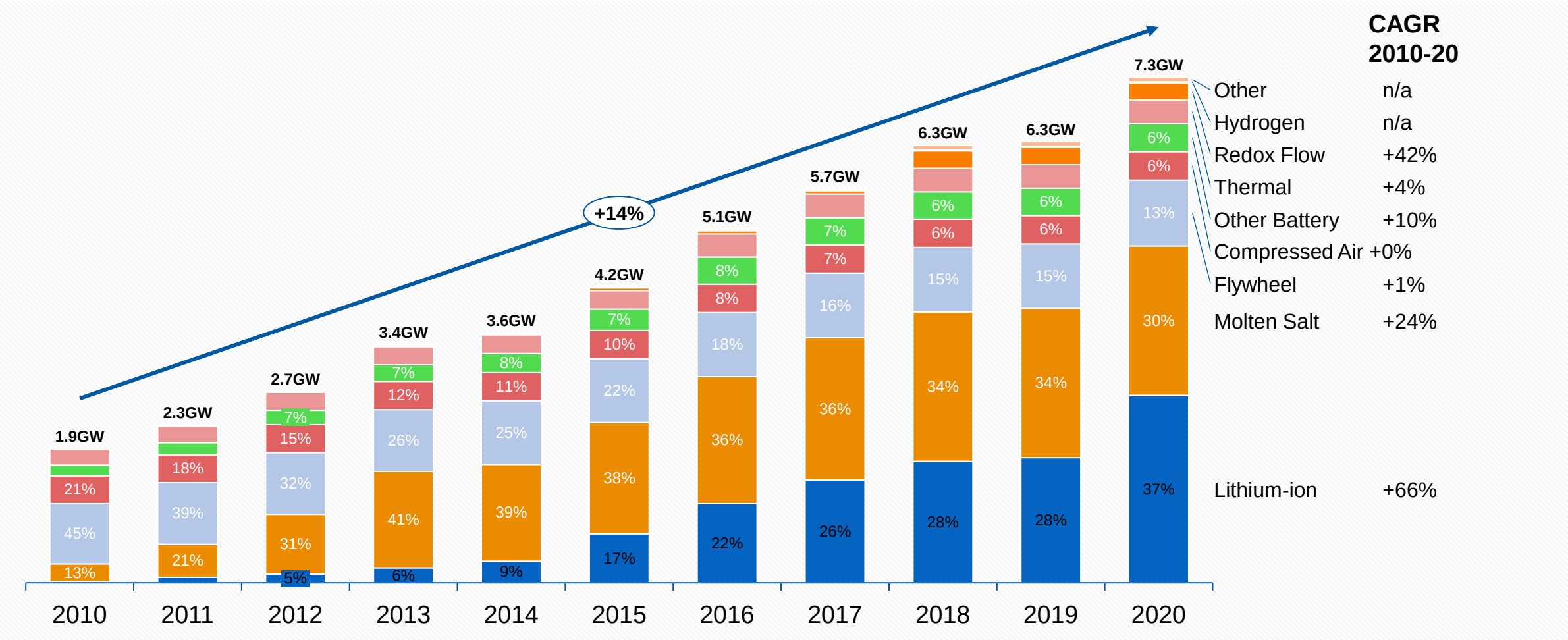
2) The amount of energy stored per unit volume



Source: EASE, AECOM, Fluidic, EOS, Lazard, Strategy&/CESI analysis

Cumulative energy storage capacity by technology (2010-20)

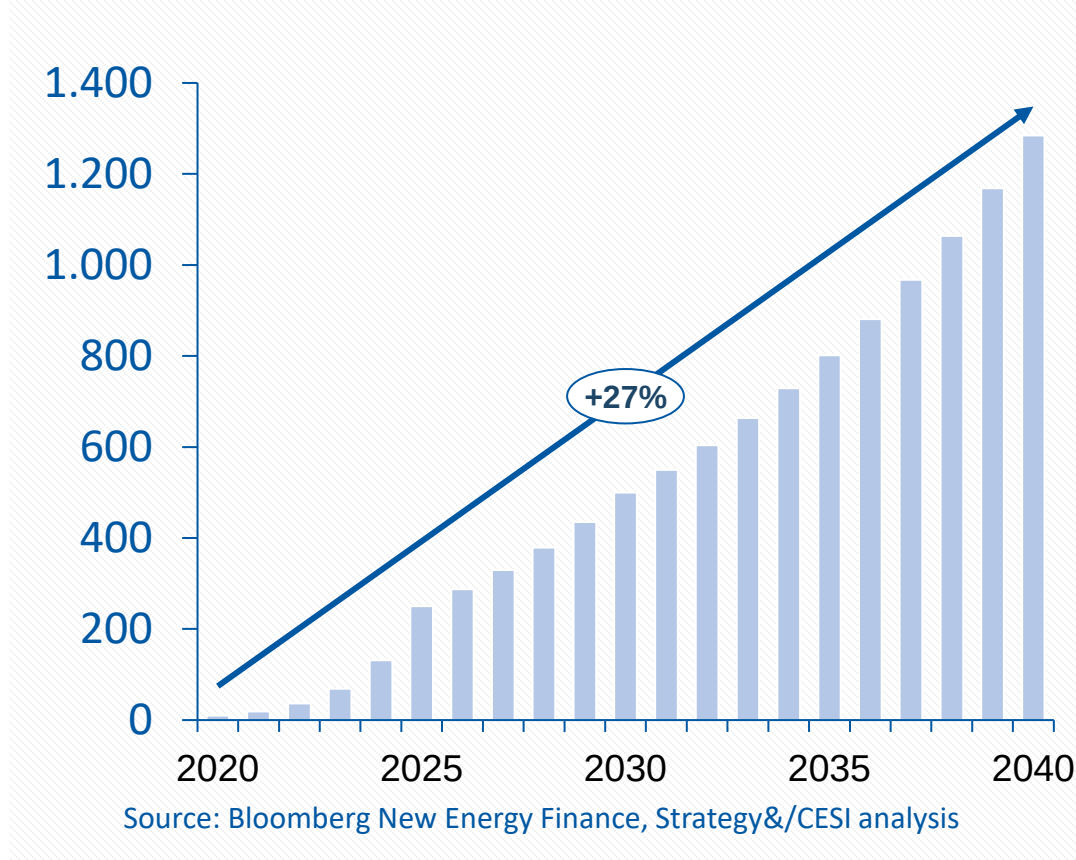
Global storage capacity grew by ~14% to ~7 GW over the last decade, mostly driven by **lithium-ion** & **molten salt** technologies



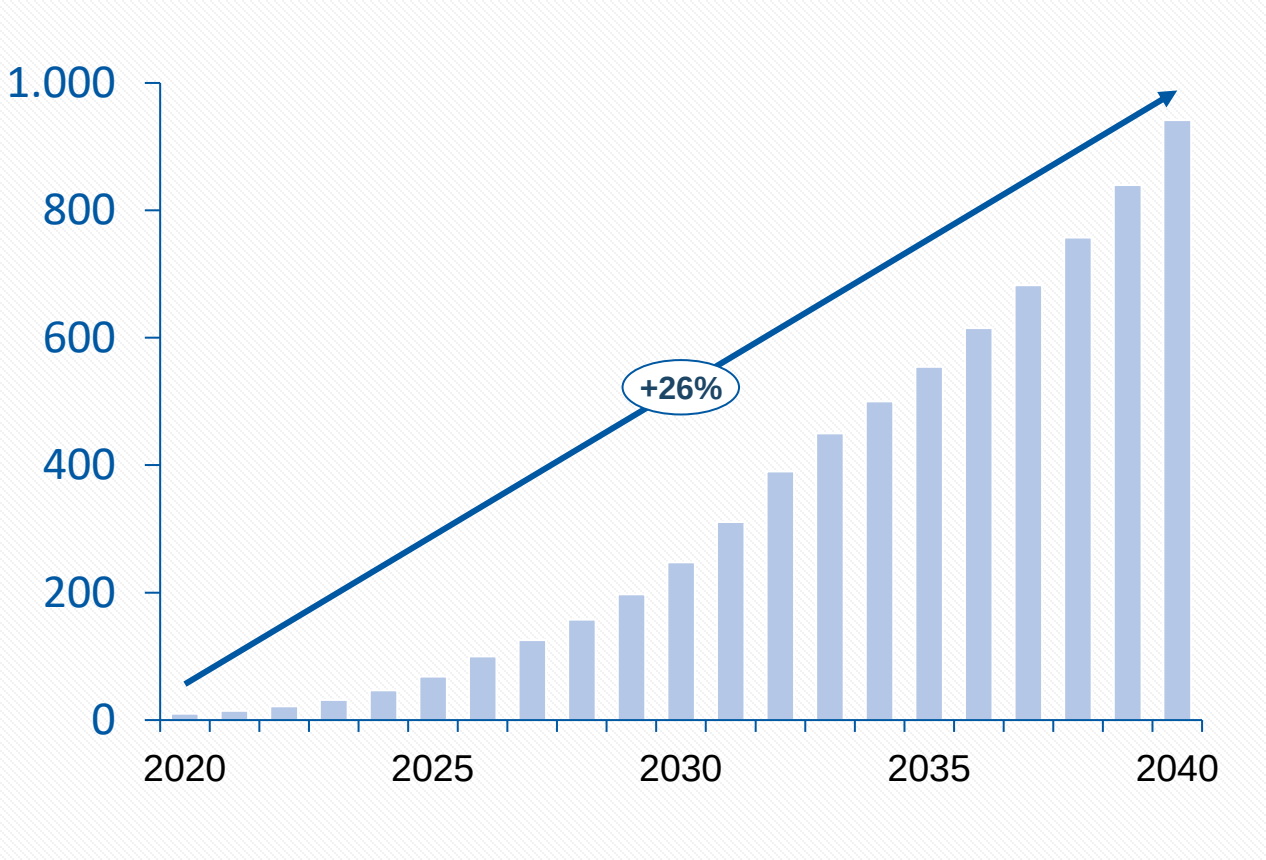
Source: DoE, Strategy&/CESI analysis

The installed capacity is expected to continue growing at a 25%+ CAGR to reach ~1,000 GW by 2040

Global Cumulative Utility Scale Battery Storage Capacity, GWh



Global Cumulative Energy Storage Deployments, GW

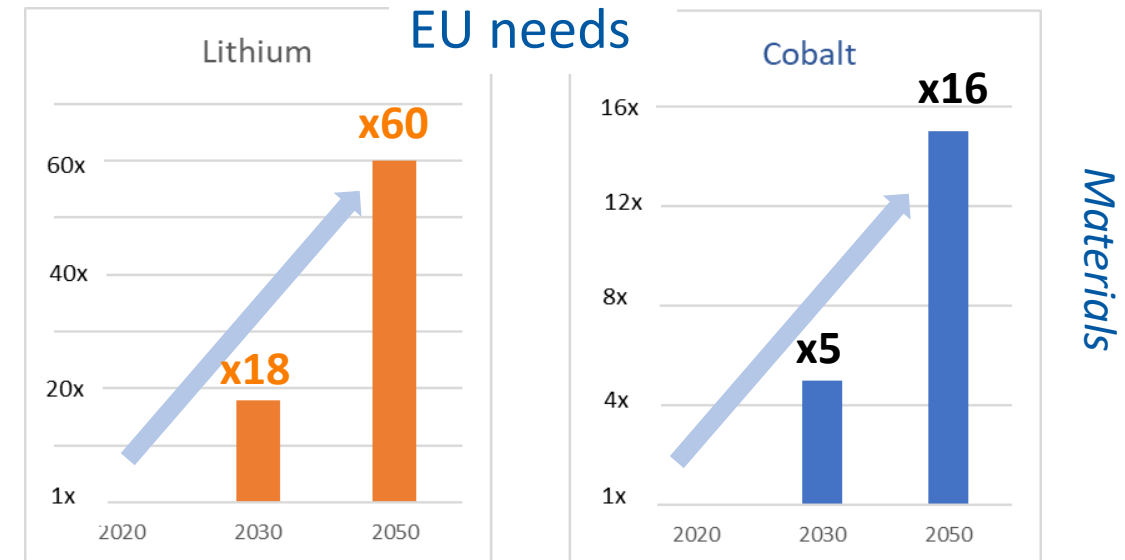


Italy needs 80 GWh of additional storage with daily cycling by 2030 to match REPowerEU targets ⁽¹⁾

⁽¹⁾ EF estimations

Storage technology evolution: main challenges

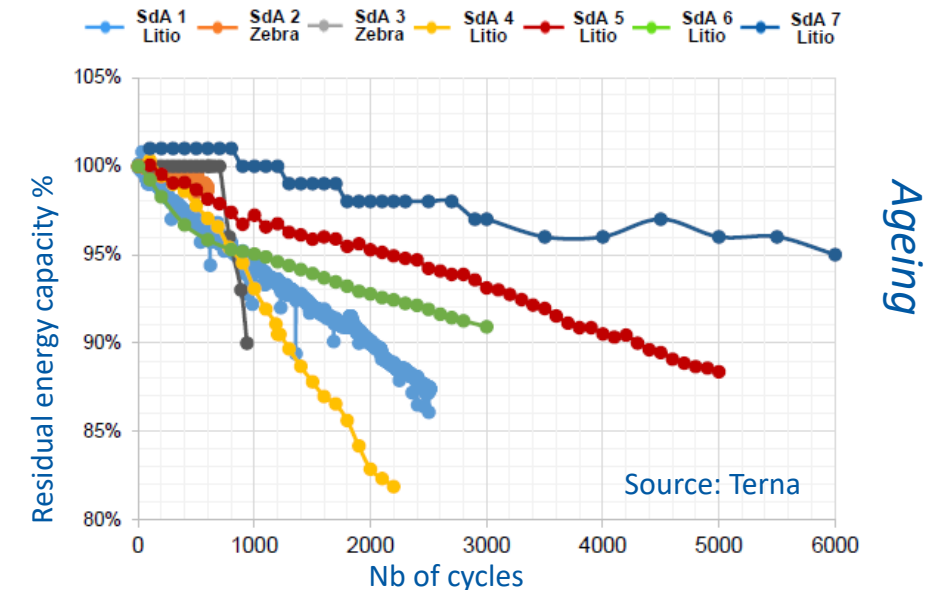
- Critical materials (issue of availability)
- Competition with other sectors (e.g.: Li for automotive, Co for super alloy, hard materials, ceramics, etc.)
- Ageing
- Energy density
- Long-term storage (weeks, seasonal)
- Costs (~40% additional cost reduction projected for Li-ion systems by 2030)



Works in progress on several fronts

5 May 2022 **Green&Blue**
 Mensile - Dir. Resp.: Riccardo Luna
 Tiratura: N.D. Diffusione: N.D. Lettori: 3889000 (0004135)
LA STORIA
 “Batterie,
 la soluzione
 è lo zolfo”
 di VITTORIO EMANUELE ORLANDO

10 Oct 2022 **QN ECONOMIA & LAVORO**
 Strade e batterie:
 il futuro è green
 grazie al grafene

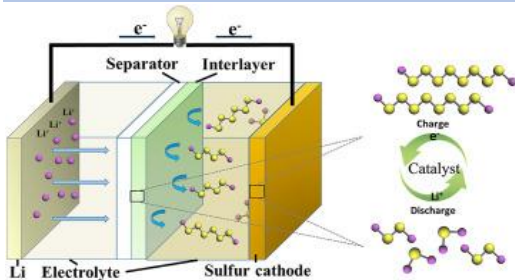


Disruptive storage technologies

Multiple other technologies with disruptive potential are currently under development

1

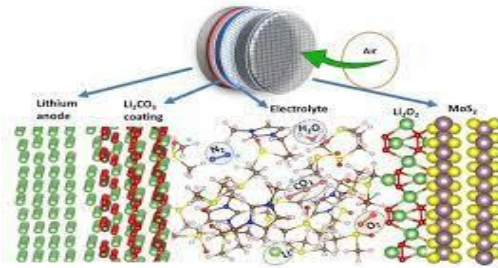
Lithium-Sulphur Batteries



- **Rechargeable energy storage system**
- Lithium Anode and Sulphur Cathode
- Sulphur abundantly available in earth crust and is environmentally friendly

2

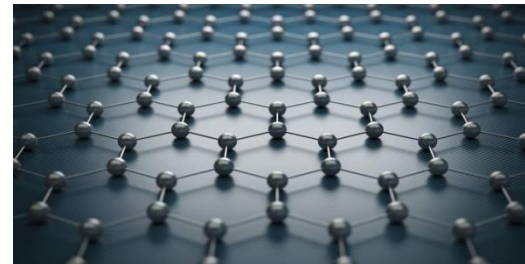
Lithium Air Batteries



- **Oxidation of Lithium at Anode and reduction of oxygen at Cathode to induce current flow**
- Practical power and life cycle need significant improvements for finding a market niche

3

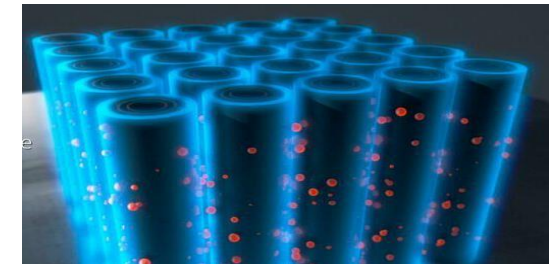
Graphene Batteries



- **Similar technological set-up as Li-Ion, however using graphene as electrolyte**
- Very promising technology and focus with major R&D efforts but with no commercial applications as of now

4

Carbon Nanotubes Based

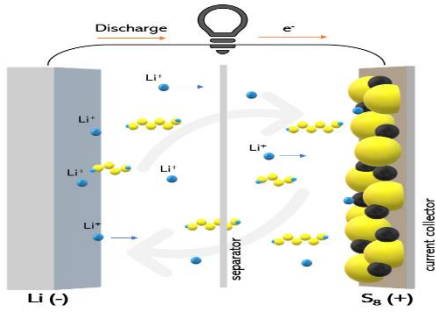
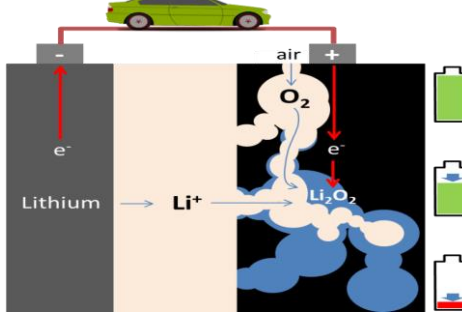
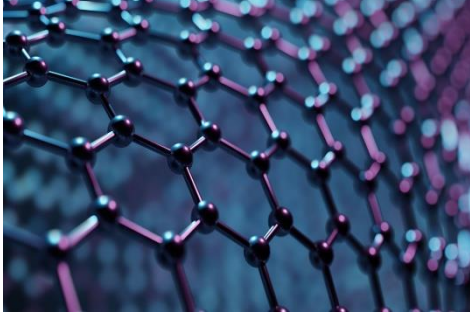
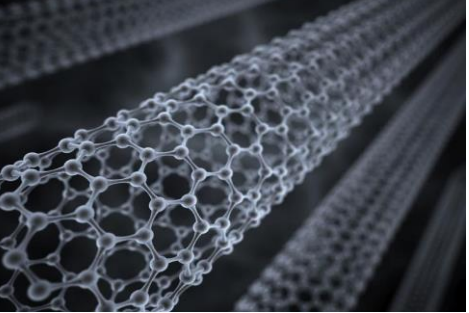


- **Using carbon nanotubes as electrodes in Lithium batteries**
- Superior conduction of ions and efficient storage of lithium on the surface of the tubes, however with no commercialization as of now

Source: IEEE Spectrum, CIC Energy Gune, MIT, IRENA, Strategy&/CESI analysis

Disrupters may have significant advantages over current technologies, but challenges exist before commercialization

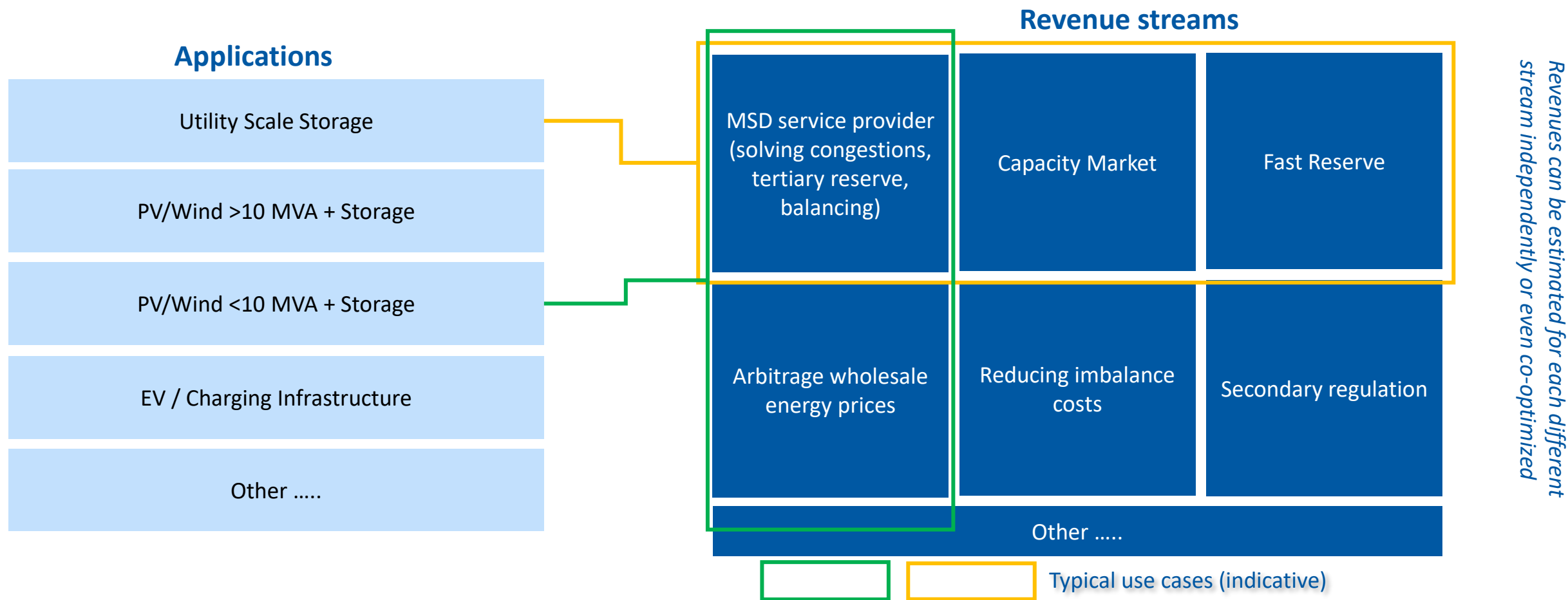
Assessment of upcoming technologies

	1 Lithium-Sulphur batteries	2 Lithium Air Batteries	3 Graphene Batteries	4 Carbon Nanotubes Based
Advantages	 + Double the Li-ion cell's energy density + Use of cheaper and sustainable material	 + Potentially has 5-15 times the Li-ion's specific energy + Not possible to over charge & damage	 + Lightweight + Faster charging + Up to 6x higher energy density than Li-Ion	 + Up to 10x higher power, capacity and lifecycle over Li-Ion + Faster charging
Challenges	- Electrolyte stability - Low life cycle	- Low cycle Lifetime - Blockage of porous carbon cathode with Li2O2	- Still in early R&D phase - Does not have a band gap – can't be switched off currently	- Still in early R&D phase - Performance significantly impacted by the spacing of tubes

Source: Powerelectronics news, Frontiers in energy research, MIT, IRENA, Strategy&/CESI analysis

Business models and Revenue stacking for storage systems + RES

Investments on storage facilities shall be market based (EU Directive 2019/944 - art. 54¹): important to identify business models for investors - Italy forerunner in the EU with forward markets (auctions on Capacity Markets and Fast Reserve)



Each case study has its own **specific features and business opportunities, with one or more predominant revenue stream**

Need to be familiar with relevant regulatory frameworks and pricing mechanisms of the specific revenue stream



Milan (IT) · Arnhem (NL) · Berlin (DE) · Mannheim (DE) · Prague (CZ) · Chalfont (US) · Knoxville (US) · Dubai (AE) · Santiago de Chile (CL) · Rio De Janeiro (BR) · Shanghai (CN)