Long Duration Energy Systems (LDES)

Tech for Net Zero Knowledge Poster #3

TECH FOR NET ZERO

In Today's World We Need LDES Technologies

We are currently facing **three major challenges**:

- balancing electricity & demand
- a change in transmission flow patterns
- decrease in system stability

With LDES, we can **increase the flexibility** of the power system.

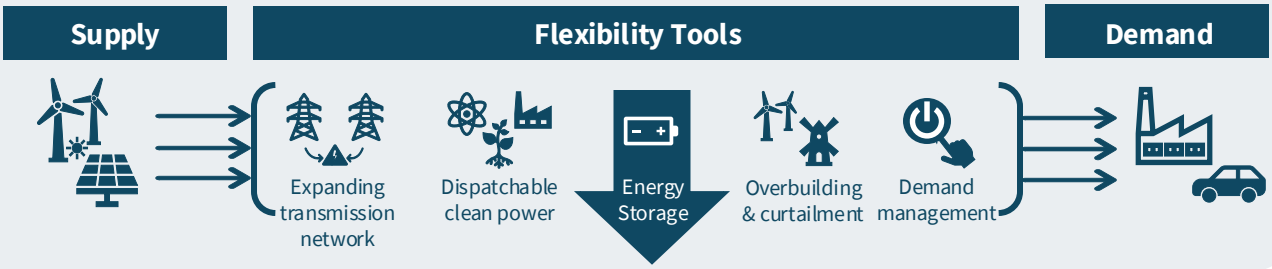
To accomplish this, LDES must be drastically scaled up within the next 20 years.

We can unlock LDES Technologies, through:

- *long-term system planning*
- *support for first deployment and scaling up*
- *market creation*

Unlocking LDES Technologies

To keep the electricity supply stable when using solar and wind power (which don't always produce energy), we need tools like batteries, better power lines, and smart ways to use or save energy.



Source: Future Cleantech Architects, 2023

Overview of LDES Categories

Thermal

- **Turns electricity into heat or cold,** which is stored and later turned back into electricity

Storage: heat stored in tanks
Examples: molten salt, liquid air storage
Duration: intra- to multi-day

Key Use: helps flexible renewable integration

Mechanical

- uses **movement, weight or air pressure** to store and release energy

Storage: water or air moved and released
Examples: pumped hydro (water lifted and released), compressed air
Duration: intra- to multi-day

Key Use: supports grid stability for large-scale needs

Chemical

- **converts electricity into chemical energy** via electrolysis and stores it as fuels

Storage: hydrogen and fuels made from electricity
Examples: green hydrogen, ammonia, iron power
(emerging approaches include "Zinc Zwischenschritt Electrolysis" – ZZE)
Duration: seasonal

Key Use: ensures long-term energy security

Electrochemical

- Electrical energy is stored in chemical form **within batteries**

Storage: rechargeable batteries
Examples: lithium-ion, flow batteries
Duration: intra-day

Key Use: daily renewable balancing

Deploying a **combination of LDES solutions** will allow for more renewable energy on the grid, enhance energy security, and reduce long-term system costs.

Further publication in cooperation with the SPRIN-D: *The First Principles Playbook: How new Energy Storage Technologies can unlock low-cost and resilient Energy for Germany*

Policy Recommendations

1. A **unified, storage-led energy shift** through the funding of pilot projects and coordinating investment across federal agencies must be driven.
2. Parliament should **prioritize low-cost, high-efficiency infrastructure** through cost-based benchmarks and **reformed capacity markets**.
3. Federal states must **streamline permits and incentivize municipalities** to host storage integrated with industry and district energy.

Immediate Actions
2025 - 2030

- **Fund 10 GW of LDES pilots by 2027**
  with BMWE, KfW, and SPRIND.
- **Reform capacity markets**
  with a mechanism that rewards flexibility over fossil fuel usage.
- **Pause support for new fossil fuel or gas technologies**
  except for emergency cases.

Medium-Term Actions
2030 - 2050

- **Scale LDES to fully replace fossil peakers**
  by installing 30–50 GW of dispatchable storage capacity.
- **Complete EU grid integration and co-storage markets**
  to maximize resilience and efficiency.
- **Develop a national LDES scaling roadmap**
  to guide long-term market evolution.

LDES Experts in the Tech for Net Zero Network

Cylib specializes in next-generation battery recycling, offering a holistic, water-based process to recover critical materials like lithium, graphite, nickel, cobalt, and manganese from end-of-life lithium-ion batteries. Their method boasts a 90% recycling efficiency and reduces CO_2 emissions by 80% compared to primary raw material extraction.

Ore Energy is developing long-duration energy storage solutions using iron, water, and air—abundant and recyclable materials. Their iron-air battery technology aims to provide cost-effective, scalable storage capable of lasting up to 100 hours, addressing the intermittency of renewables.

Based in Berlin, ***Scale Energy*** is building Europe's largest decentralized battery energy storage network by utilizing underused industrial grid connections. They offer fully financed lithium-ion battery storage to industrial clients, enabling grid participation and electricity cost reduction without upfront investments.

Unbound Potential is pioneering membrane-less flow batteries that use water-based electrolytes, eliminating the need for critical mined materials. Their design offers higher energy efficiency, and a lower carbon footprint compared to traditional redox flow batteries. They plan to deploy their first containerized storage system by mid-2026.

Voltfang focuses on sustainable battery storage solutions by repurposing second-life EV batteries for industrial and commercial use. Their systems support dynamic pricing and energy management, contributing to grid resilience and CO_2 reduction. They've raised €15 million in Series B funding to scale across Europe.

Reverion builds high-efficiency, reversible solid oxide systems that generate electricity from biogas or hydrogen—and can reverse to store energy. Their modular units reach up to 80% efficiency and enable flexible, carbon-negative, decentralized power.