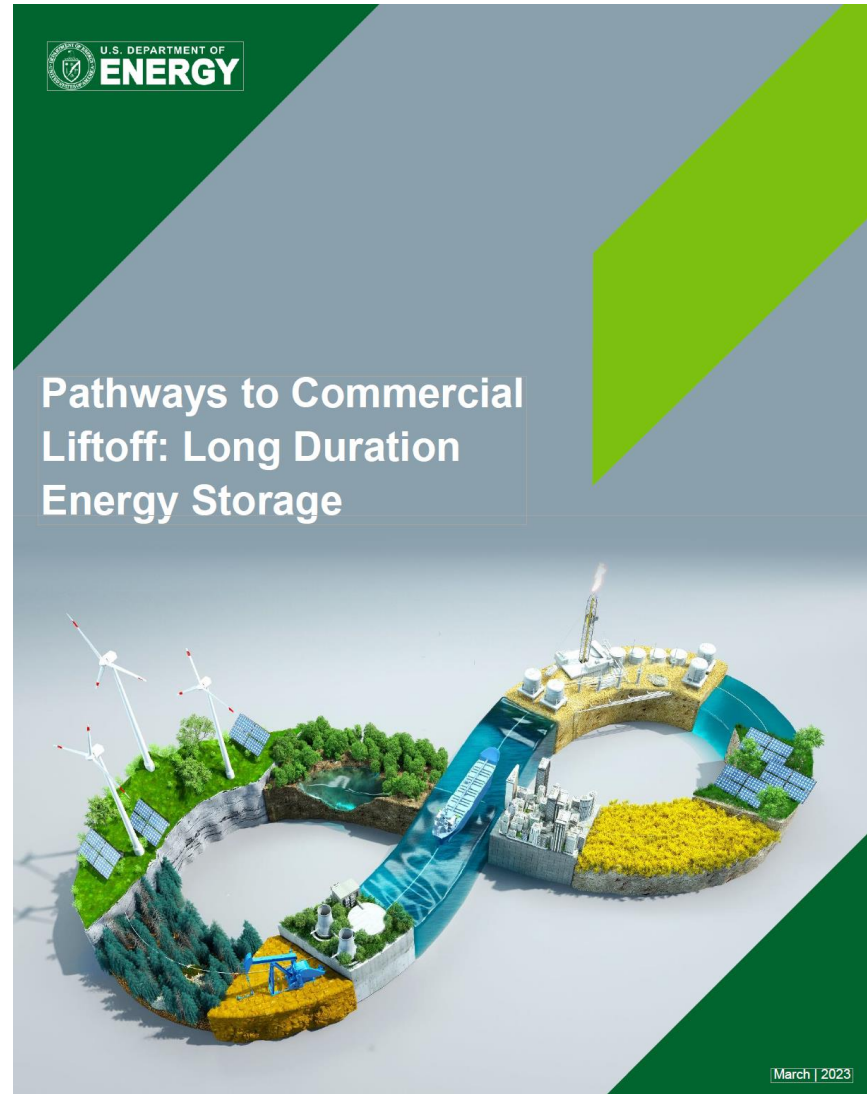


What does Safety and Grid Security Mean for LDES?



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Safety for Long Duration Energy Storage

Category	Description
Thermal Management and Fire Safety	<ul style="list-style-type: none">• Significant heat during operation or failure• Robust thermal management (overheating, fires)• Flow batteries vs. lithium ion
Pressure and Chemical Hazards	<ul style="list-style-type: none">• Storage of gases at high pressure• Hydrogen; compressed air energy storage• Leaks, explosions, mechanical failures
Environmental Impact	<ul style="list-style-type: none">• Dam failures (pumped hydro)• Hydrogen storage or other ocean based technologies• Ecological impacts



Grid Security for Long Duration Energy Storage

Category	Description
Resilience to Grid Disruptions	<ul style="list-style-type: none">• LDES systems can buffer against interruptions in energy supply• Wind and solar are intermittent• Reduce reliance on fossil fuel-based peaking plants
Frequency Regulation	<ul style="list-style-type: none">• Ancillary services such as frequency regulation, voltage support, and load balancing.• Flywheels or batteries: milliseconds response time.
Decentralization and Black Start Capability	<ul style="list-style-type: none">• Decentralized LDES systems• Reduce impact of local outages on broader grid• Black start capabilities: pumped hydro, batteries, hydrogen

Ten LDES Systems

- Pumped Hydro Storage
- Compressed Air Energy Storage
- Liquid Air Energy Storage
- Redox Flow Batteries
- Sodium-Sulfur Batteries
- Solid-State Batteries
- Thermal Energy Storage
- Hydrogen Energy Storage
- Gravity-Based Energy Storage
- Supercapacitors

+?