



# Long Duration Energy Storage (LDES) and CO2 Battery Storage Systems

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## Context:

The recent development of a **160MWh LDES plant**, installed in collaboration with **Triveni Turbine Ltd** and **Energy Dome** (Italy), marks a significant advancement in the field of **Long Duration Energy Storage (LDES)**. This system allows energy to be stored for extended periods, from **8 hours to days, weeks, or even seasons**, addressing a critical need for sustainable energy storage solutions.

## CO2 Battery Storage System

The **CO2 Battery Storage System** works by storing energy in the form of **compressed and liquefied CO2** during periods when energy supply exceeds demand (charging phase). When there is a need for energy, the stored CO2 is allowed to expand back into a gas to drive a turbine (discharging phase), generating electricity.

- **Functioning:** This system operates on the **Closed Brayton Thermodynamic Cycle**, manipulating **CO2's physical state** (from gas to liquid) to store and release energy. During the charging phase, the CO2 is compressed and liquefied, and during the discharging phase, it is expanded back into gas, which drives a turbine to produce power.
- **Comparison with Other Battery Energy Storage Systems (BESS):** Unlike **electrochemical BESS** (such as lithium-ion or sodium-ion batteries), CO2 storage systems operate using **electro-mechanical turbomachinery**, which leads to **minimal performance degradation** over time. This feature makes CO2 battery storage systems highly durable and efficient, offering advantages over traditional electrochemical systems.

## Energy Storage Systems Overview

**Energy Storage Systems (ESS)** are technologies used to store **excess energy** during times of low demand and release it when demand is high, ensuring the **stability** and **reliability** of the grid. These systems are vital for **balancing supply and demand** in power generation, particularly with the increasing use of **renewable energy sources** like wind and solar.

- **Significance:** ESS contribute to a **greener** and more **sustainable energy environment**, helping to **reduce reliance on fossil fuels** and improve **grid stability**.

## Major Types of Energy Storage Systems

### 1. Chemical Energy Storage Systems:

- These systems store energy in the form of **chemical energy** and convert it back into **electricity** using **electrochemical reactions**.
- **Examples:**
- **Lithium-Ion Batteries**

- **Sodium-Ion Batteries**
- These are the most common energy storage systems used in **consumer electronics** and **electric vehicles**.

#### 1. **Advanced Chemical Energy Storage Systems:**

- A new generation of chemical batteries that aim to be more **efficient, durable, and environmentally friendly** than traditional chemical systems.
- **Examples:**
- **CO2 Batteries**
- **Solid-State Batteries**
- These batteries offer **longer life spans** and **higher energy densities**, making them suitable for large-scale applications, including grid storage and electric vehicles.

#### 1. **Thermal Energy Storage Systems:**

- These systems store **thermal energy** (heat or cold) in a **storage medium** and release it when needed.
- **Examples:**
- **Electric Thermal Energy Storage:** Uses electrical energy to heat or cool materials that can store heat for later use.
- **Molten Salt Storage:** Used in solar thermal plants to store heat for use when sunlight is not available.

### **Conclusion**

The **CO2 Battery Storage System** represents a pioneering approach to energy storage, offering significant benefits over traditional electrochemical batteries, such as **minimal performance degradation** and a **longer lifespan**. As **Long Duration Energy Storage** continues to evolve, it promises to play a crucial role in ensuring grid stability, supporting the transition to **renewable energy**, and creating a more **sustainable energy future**. With ongoing advancements in **chemical** and **thermal energy storage technologies**, these systems are poised to revolutionize the way we manage and store energy.