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CO_2 Energy Storage

Creating a New Era of Long-Duration Energy Storage

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Content

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Challenges & Opportunities

Current Status and Pressing Issues

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Global Renewable Boom

- By mid-2025, renewables accounted for ~22.8% of global electricity generation.
- Total renewable capacity reached ~4.4-4.5 TW by end-2024, with record additions of ~585 GW in 2024 (Solar ~452 GW, Wind ~113 GW).

Renewables have moved from supplementary to mainstream, but major challenges remain.

Grid Absorption Challenges

- Global renewable energy curtailment on the rise, exceeding 5% in certain regions
- Most severe in resource-abundant areas with grid congestion

High System Regulation Pressure

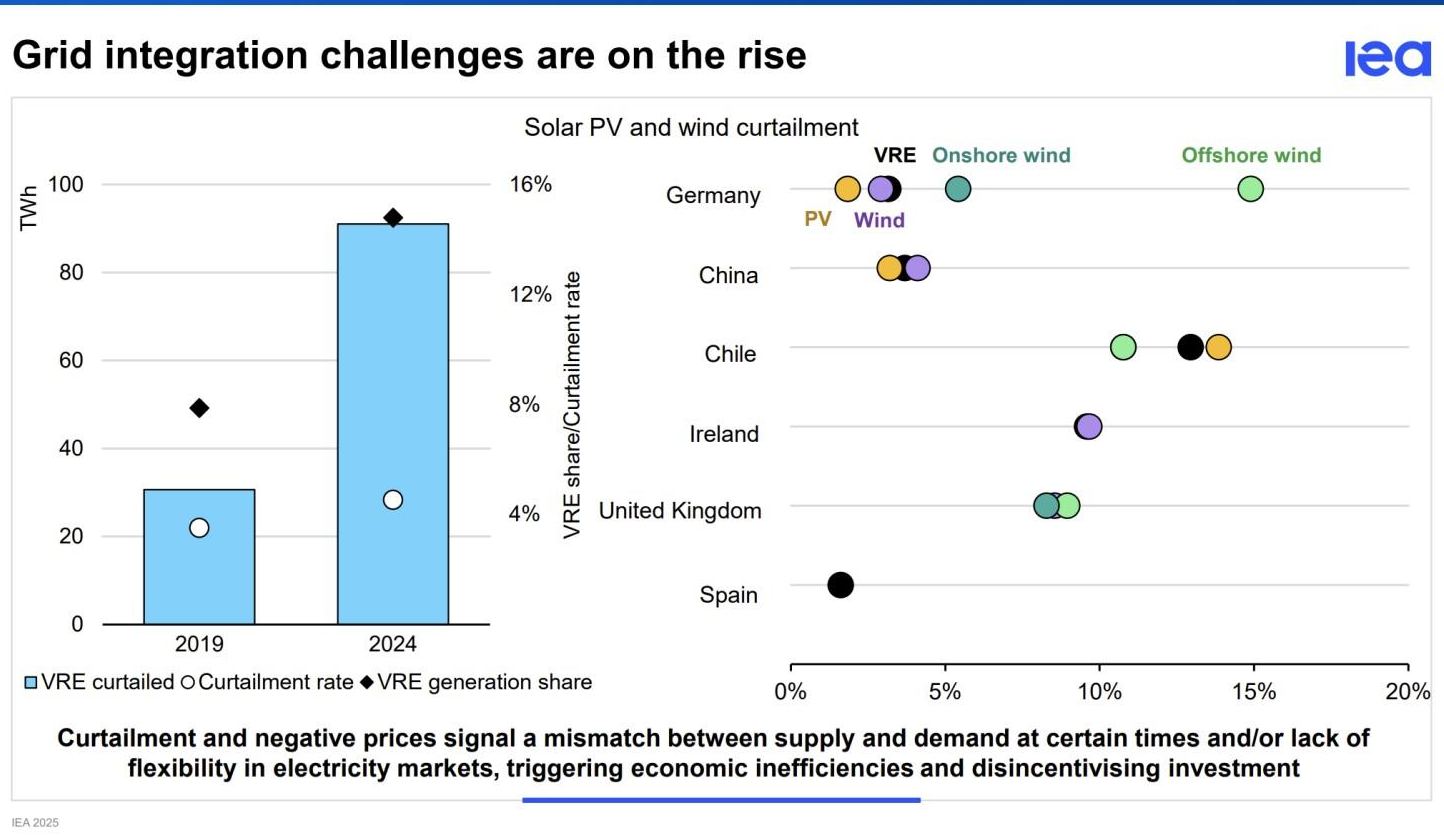
- Renewable energy volatility & intermittency raises pressure on grid safety and stable operation
- Drives continuous growth in system regulation costs

Surging Demand & Power Shortage

- AIDC, EVs & global electrification: 2025 global power demand up 4–5%
- Weakening fossil fuel backup + slow renewable scaling → rising power shortage risks

Data from: Ember Global Electricity Mid-Year Insights 2025; IRENA Renewable Energy Statistics 2025

IEA Warning: Grid Integration Challenges on the Rise



Source: IEA Renewables 2025

Global VRE Curtailment Volumes Soar

2019: ~30 TWh (Nearly 3x increase)

2024: ~90 TWh

Curtailment Rate Stable, but Absolute Waste Rises

Curtailment rate remains at around 4–5%;

But surging total generation drives a sharp increase in absolute waste.

Curtailment Rates in Selected Markets

Chile: With PV and wind curtailment rates both approaching 15%.

Ireland & UK: Constrained by island grid scale, wind curtailment rates remain high at 8%–12%.

Germany: Overall curtailment controlled at ~4%, but offshore wind ~15%.

The Inevitable Path to LDES

Supporting renewables as they evolve from supplementary power to primary power source.

Enhancing Autonomy

Ensure System Stability: It provides the power system with large-capacity, long-duration stable regulation capability.

Ensuring System Stability

Enables the transfer of energy across hours and days, reduces reliance on traditional thermal power peaking regulation and the bulk power grid.

Technical Requirements for LDES

Safety & Reliability	Safety Risks	Environmental Impact	Operational Requirements
Economic Feasibility	Construction Cost	Energy Efficiency	Cycle Life
Resource Accessibility	Geographical Constraints	Resource Supply	Recycling

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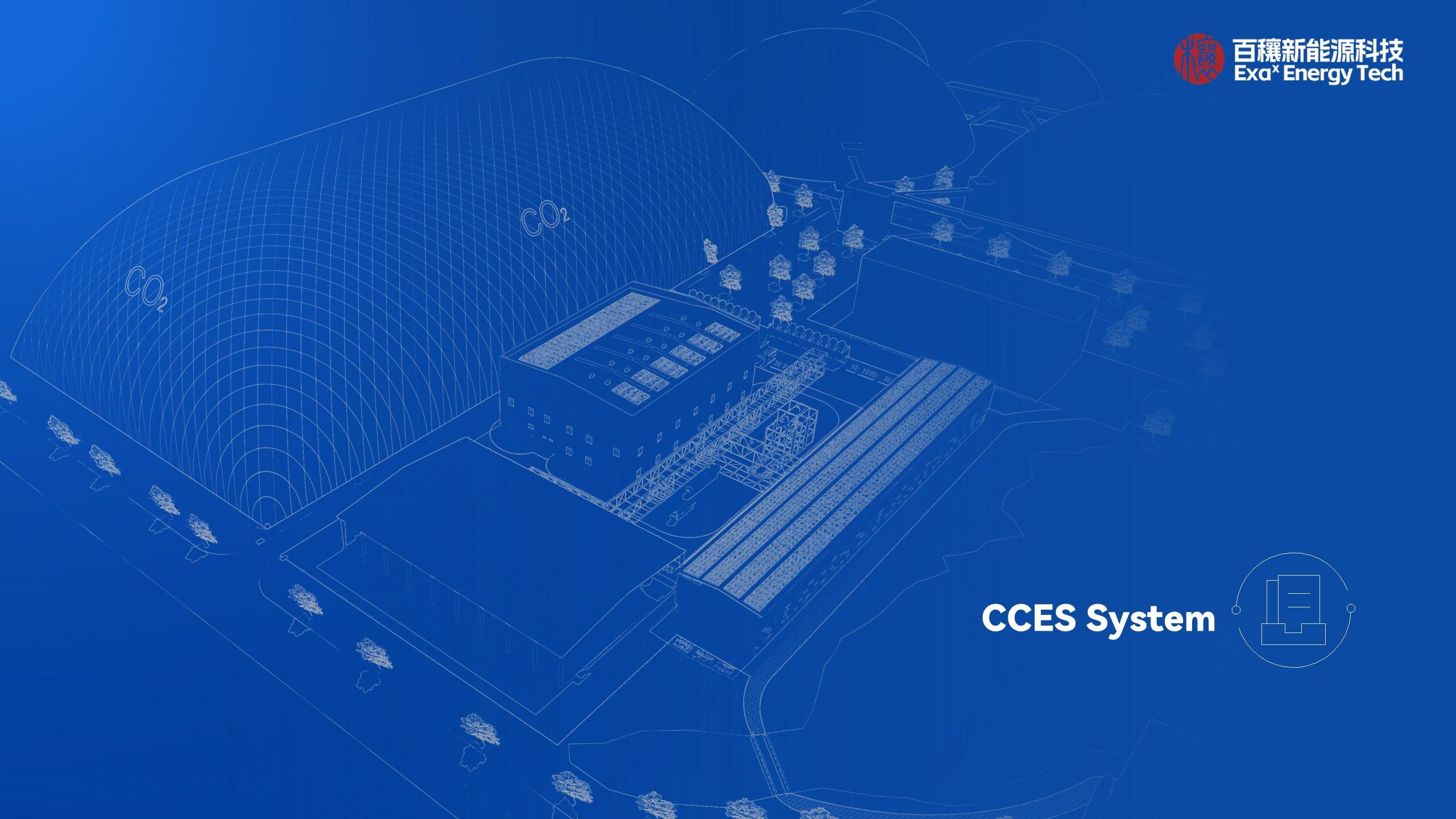

CCES System

Introduction to CCES System

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Full Independent Mastery of Core Design and Manufacturing

Exa's CCES is a **gas-liquid phase-change transition technology**, distinguished by its fully above-ground installation, high reliability, and cost-effectiveness.

Exa^x holds multiple globally original and groundbreaking patents in the field of innovative CO_2 energy storage.

Energy Storage

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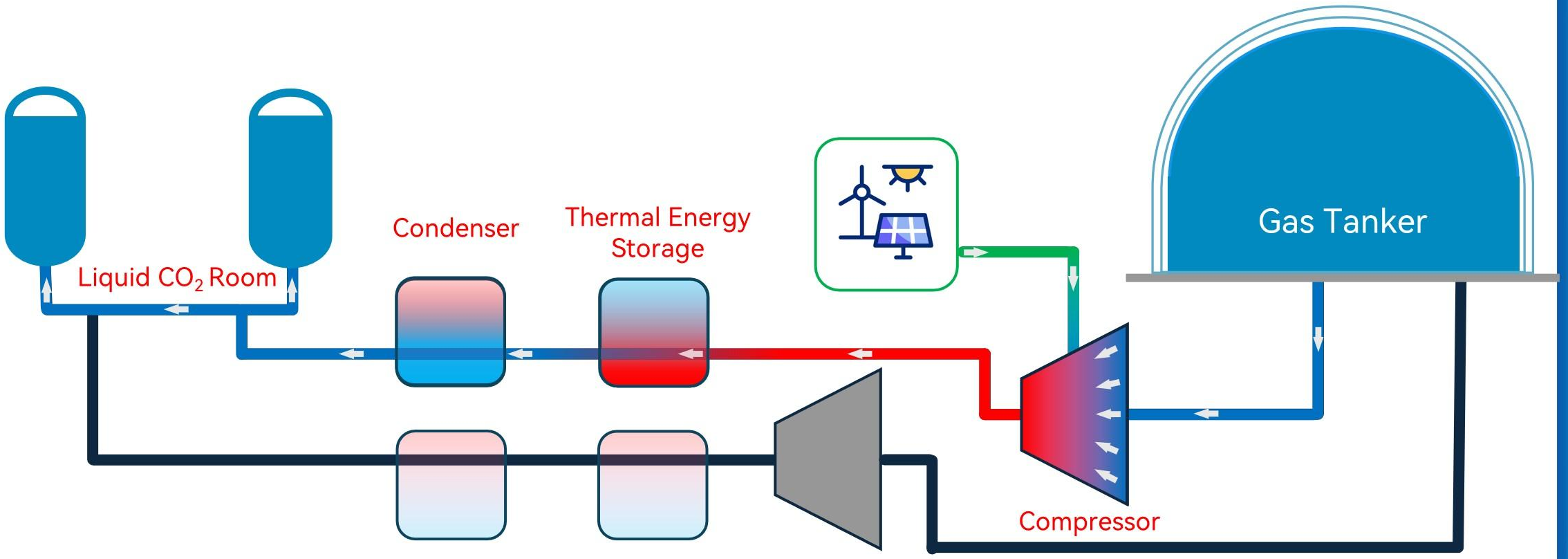
Energy Storage Phase: Surplus electricity drives the compressor to liquefy CO_2 through pressure and condensation, while the heat generated during compression is stored.



Energy Discharge

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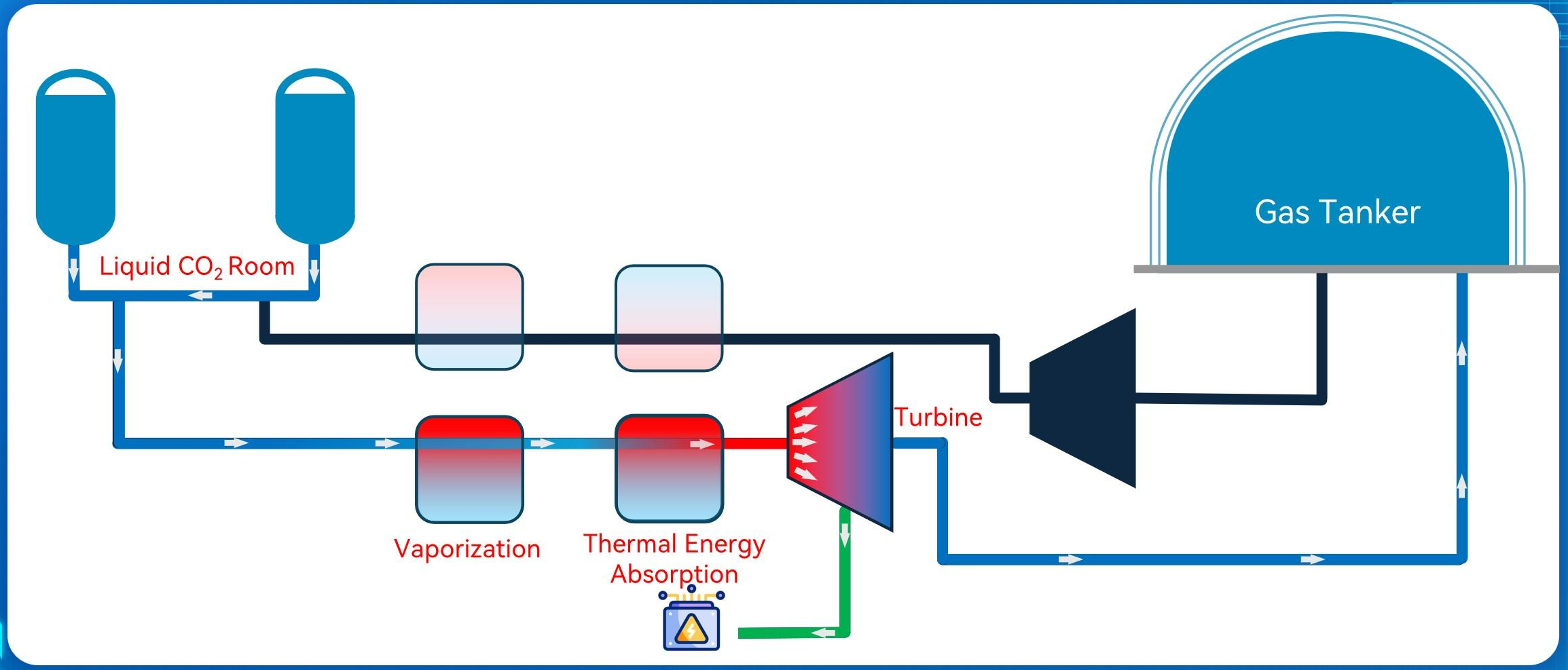
Energy Discharge Phase: During peak demand, the system uses stored thermal energy to vaporize the liquid CO_2, which drives the turbine to generate power.



System Advantages

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Zero-Carbon Carbon-Negative

- Zero Carbon at Source
- Carbon-Negative in operation
- Store up to 18,000 tons per GWh

24/7 Availability

- Simultaneous Charge/Discharge with 24/7 Power Generation

Safety

- Low Pressure and Temperature Levels
- No Risk of Combustion or Explosion
- Environmentally Friendly

Flexibility

- Unrestricted Climate
- Unrestricted Geography

Grid Friendly

- Rotational Inertia
- Auxiliary Services
- No Attenuation

LCOE

- Service life: 30 years
- LCOE: 0.02 - 0.04 USD /kWh

CCES Comparison Chart

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Items		CCES	Pumped Storage	Air Energy Storage System	Lithium Battery	Vanadium Flow Battery
Economical	Life Cycle Cost (China)	0.02 - 0.04 USD /kWh	0.03 - 0.13 USD /kWh	0.028–0.048 USD /kWh	0.05-0.08 USD/kWh	0.084~0.126 USD/kWh
Safety Risk	Explosion	None	None	None	Yes	None
	Pollution	None	Environmental Impact	None	Residue	Residue
Universality	Temperature requirements	None	Influence of Icebound	None	Influence of Low Temperature	0-45℃
	Geographical requirement	None	Terrain & Reservoir	Salt Caverns	No specific requirement	No specific requirement
Grid Friendliness	Capacity, Reliability	No attenuation	No attenuation	No attenuation	Degrade	Degrade
	Rotational Inertia	Yes	Yes	Yes	None	None
Durability	Lifespan	30 Years	30 - 50 Years	30 Years	5 -10 Years	20 Years

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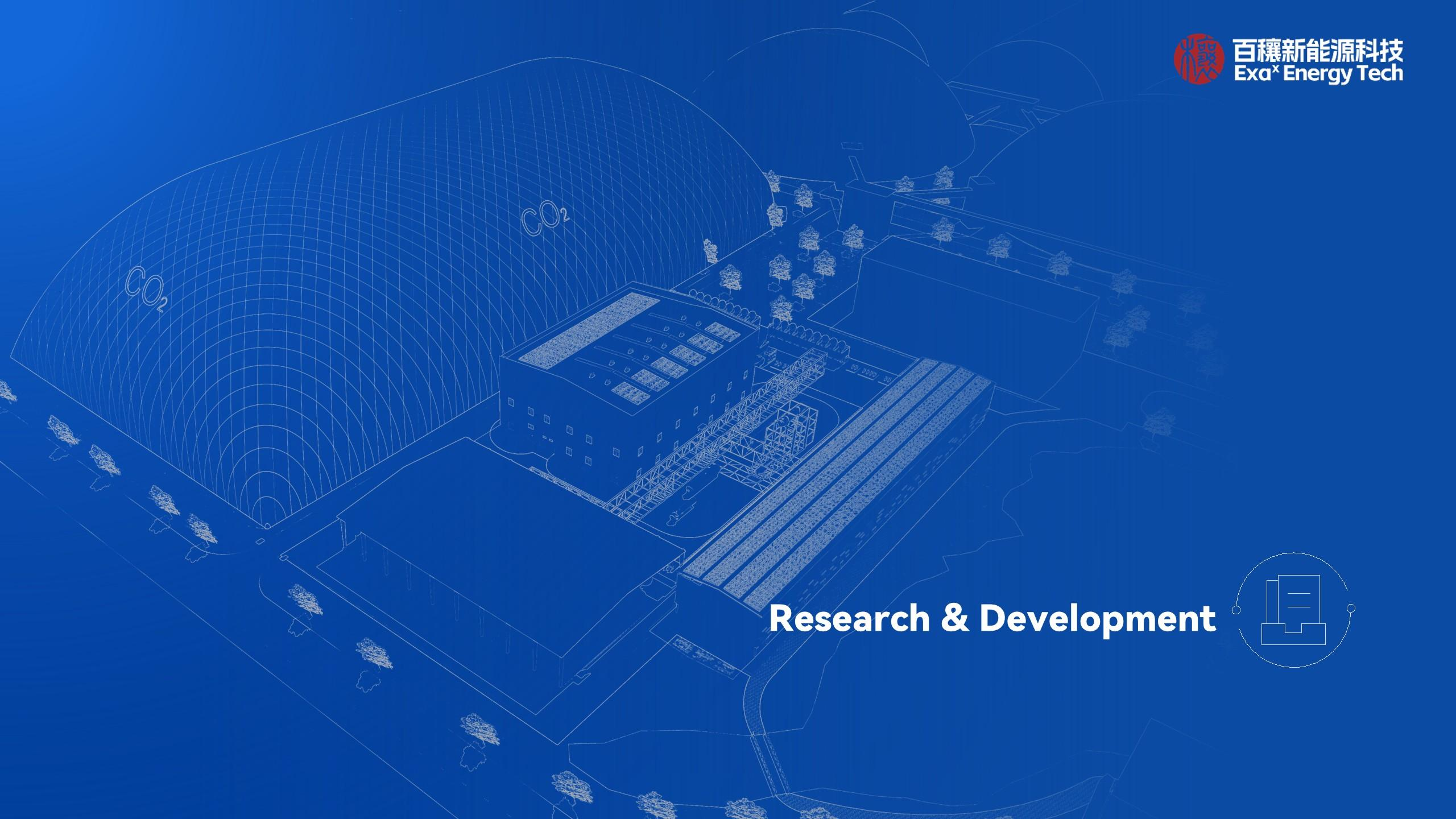

Research & Development

Research & Development

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R&D Personnel

High-caliber Talent Pool

Over 90% of the R&D team hold master's or doctoral degrees, serving as the core driver for technological innovation.

Core Technical Team

Sustained R&D Investment

R&D System

Technology-Driven Strategy

Adhering to a "Research-First" philosophy, Exa^{x} co-established the "Advanced Energy Storage System & Power Equipment Research Center" with Xi'an Jiaotong University.

In-depth University-Industry-Research Collaboration

西安交大—百穰新能源科技
先进储能系统动力设备研究中心
XJTU–Exa^{x} Energy Tech AESPE Research Center

Technical Achievements

World's First Commercial System

World's Largest Energy Storage Power Station

Patent

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Our global patent strengthens our leading position in the industry.

Number of Patents

Core Technology
Mastered **180+** Know-how

Patent Applications
Hundreds of domestic and international PCT patents are in progress

Patent Grants
Obtained **80+** domestic and international patent grants

Patent Coverage

System Design
Covers overall architecture and system solutions

Core Components
Protection for key components and core equipment

Control Strategy
Intelligent algorithms and optimized control logic

Advanced Thermal Energy Storage Test Platform

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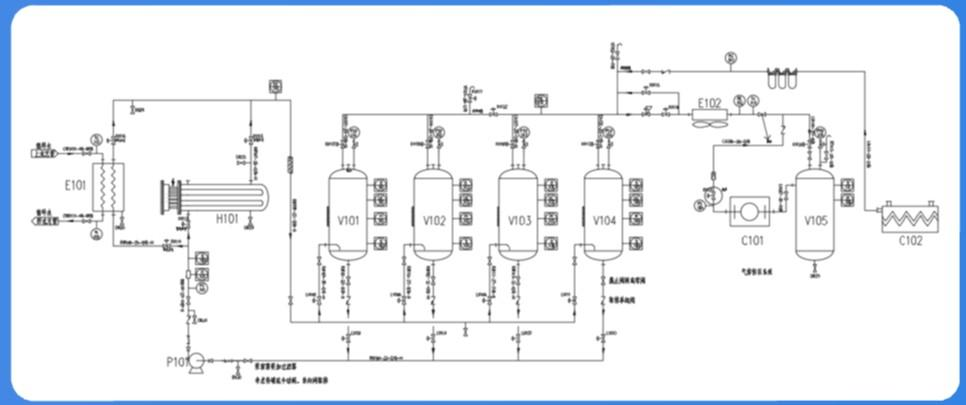
Independently developed advanced thermal energy storage test platform.

Core Functions

- Validate and optimize to ensure technical feasibility
- Enable efficient storage and flexible utilization to balance energy supply and demand
- Continuously iterate algorithms to improve system efficiency



Strategic Role

- Provide reliable and comprehensive experimental data for core technology R&D
- Accelerate transformation into commercial applications

Test Platform Capabilities:
Pressure: 0 ~ 5.0 MPa
Temperature: 0 ~ 350 ℃

CO_2 Tanker

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CO_2 Tanker: An intelligent storage unit featuring high efficiency, stability, and safety.

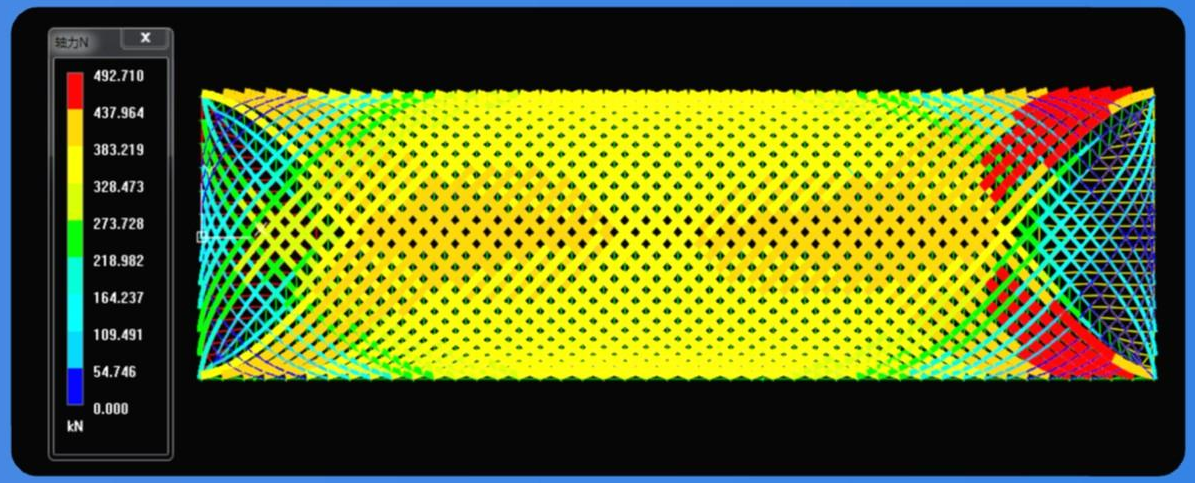
Technical Features

Ultra-Large Capacity Storage

Single-unit capacity of up to 1.6 million m^3

Innovative Double-Layer Structure

Outer layer for protection and pressure regulation, inner layer for storing CO_2 gas



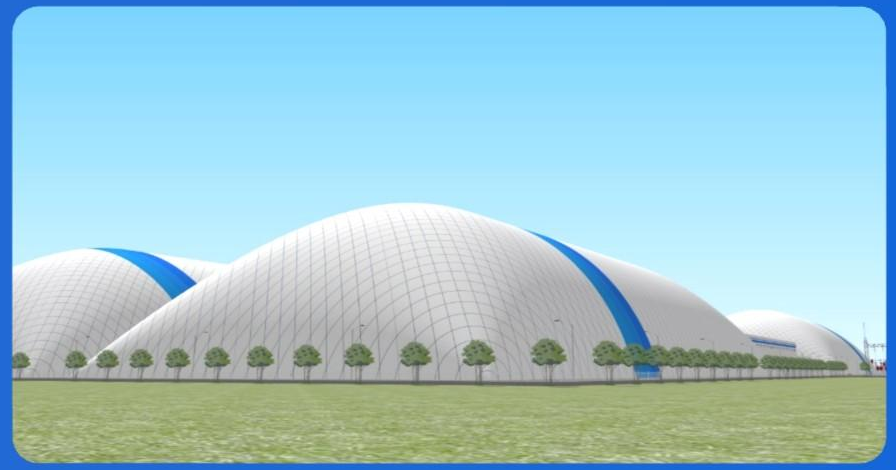
Core Advantages

Patented Composite Material

Validated through over a thousand material test

Proprietary Distributed Control Technology

A distributed control system with centralized data collection management, and decentralized control of EC fans



Liquid CO_2 Room

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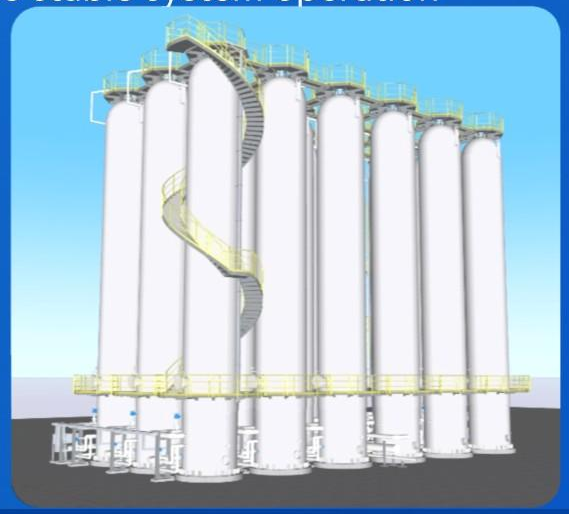
Liquid CO_2 Room: A modular, stable, and easily scalable pressure management solution

Technical Features

Modular Design
Adopts modular structure for rapid deployment and flexible configuration

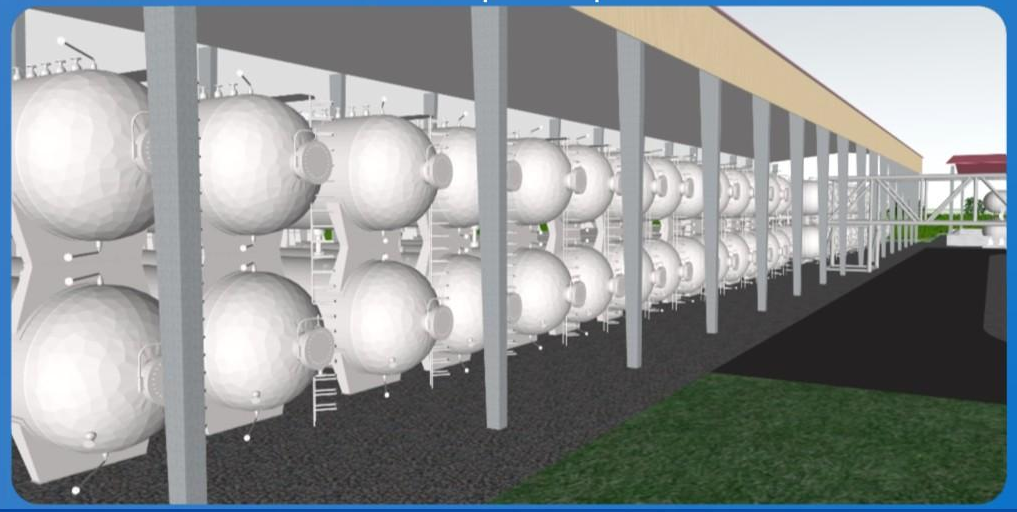
Pressure Self-Balancing Technology
Intelligently adjusts pressure across vessel groups to ensure stable system operation



Core Advantages

Easy Scalability & Maintenance
Facilitates future capacity expansion and routine maintenance

Stable & Reliable
Proven through field testing and design iterations to ensure 24/7 uninterrupted operation



Thermal Energy Storage

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Thermal Energy Storage: A modular, stable, and scalable thermal energy management solution

Technical Features

Layout

Reducing site planning constraints, and facilitating pipeline installation and construction

Stable Storage & Release

Enables stable storage and on-demand release with rapid response and minimal fluctuation

Core Advantages

Intelligent Zoned Management

Enabling efficient collaboration between modules in different temperature ranges

Independent Controllability

With a management unit intelligently regulating energy distribution for efficient energy transfer

Energy Exchange Technology

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Temperature

Optimal temperature differences and resistance characteristics across various operating conditions

Simulation

Equipped with computer simulation capabilities, featuring rational internal equipment structure

Medium

Water, conductive oil, and fused salt, covering temperatures from ambient up to 585℃

Design

Collaborates with universities and enterprises, leveraging specialized heat exchange software and in-house developed programs for calculations

Energy Exchange Technology

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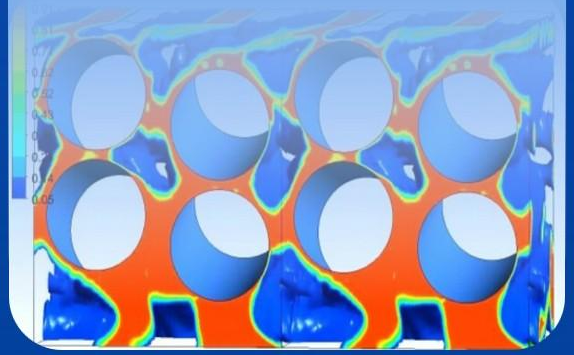
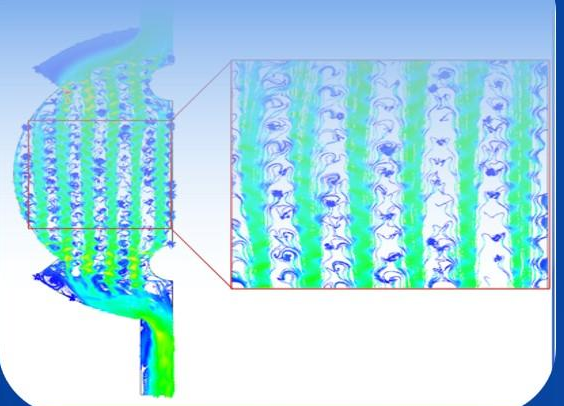
High Exchange Efficiency

The overall heat transfer coefficient for gas-liquid heat exchange is 30% higher than traditional heat exchangers.



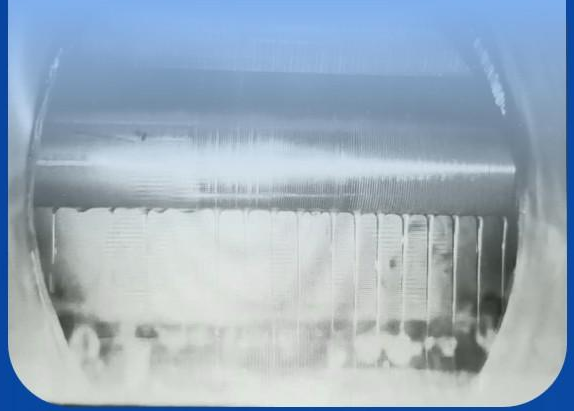
Optimal Distribution

Operates strictly in countercurrent, eliminating dead zones and ensuring stable medium outlet temperatures.



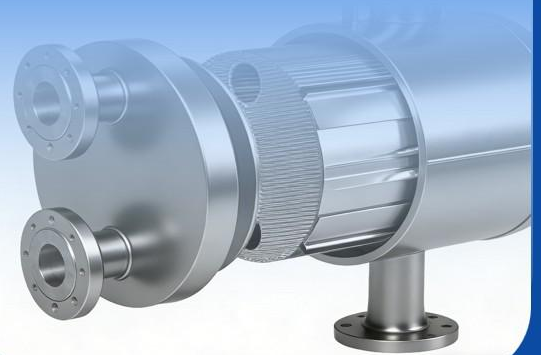
High Condensation Efficiency

Compared with other condensation technologies, condensation efficiency is improved by over 40%.



Minimal Temperature Approach

The temperature approach is as low as 2~8℃, maximizing energy storage efficiency



Compressor & Turbine

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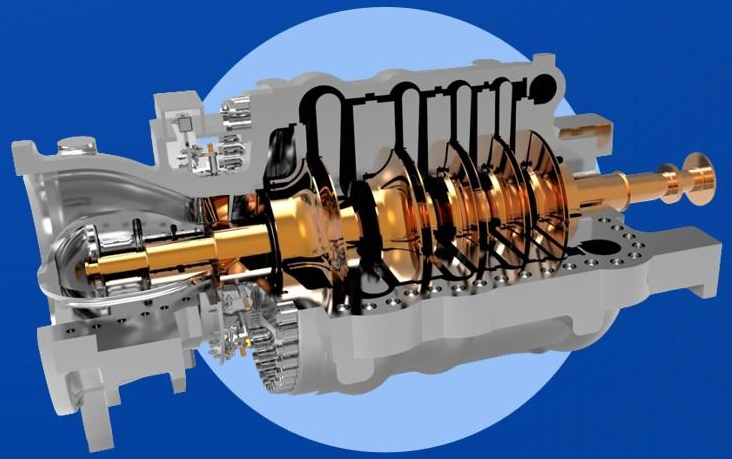
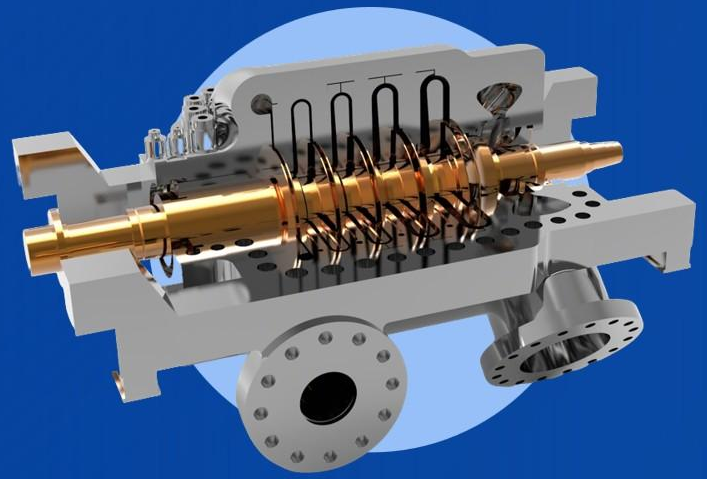
Building on years of research in CO_2 power generation by Xi'an Jiaotong University and China Eastern Electric, Exa^{x} Energy Tech has jointly developed high-efficiency compressor technology and advanced turbine technology, achieving full independent control over all equipment.

High-Efficiency Compressor: Leveraging aerodynamic design, it overcomes technical challenges such as high pressure ratio, high temperature, and high rotational speed, enabling efficient CO_2 compression.

Advanced Turbine: Achieves breakthroughs in high enthalpy drop and high expansion ratio, enabling efficient expansion power generation of CO_2.



Low-Pressure Compressor



High-Pressure Compressor

High-Low Pressure Integrated Turbine

R&D Goals

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Efficiency Improvement

Achieve a system efficiency of **75%** within 5 years

Cost Reduction

Target a **20%** reduction in system costs within 3 years

Standardization & Modularization

Establish system structure standards within **3** years, enabling on-site modular assembly

Develop Tiered Solutions

Combine millisecond- and minute-level response capabilities

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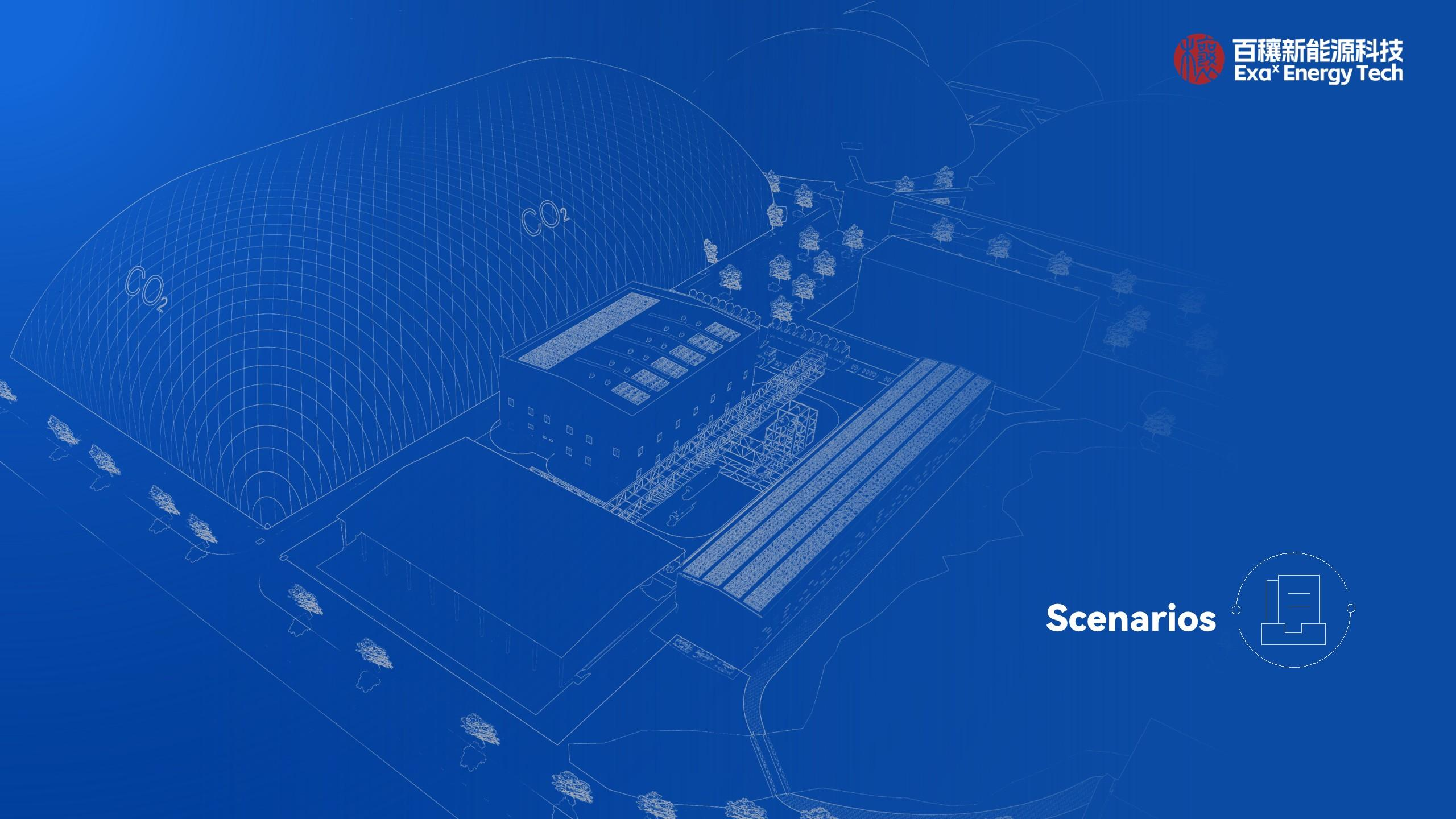

Scenarios

Scenario 1: Grid-Side Energy Storage

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(LCOE): $ 0.03 / kWh

Round-Trip Efficiency: 50%

Minimum Investment: $285 million

Construction Period: 5-10 years

Applicability: Site constrained

Scalability: Difficult to expand

(LCOE): $ 0.03 / kWh

Round-Trip Efficiency: 60%

Minimum Investment: $28 million

Construction Period: 10-12 months

Applicability: No geographical constraints

Scalability: Easy to expand

Scenario 2: Energy Storage for Renewable Power Plants

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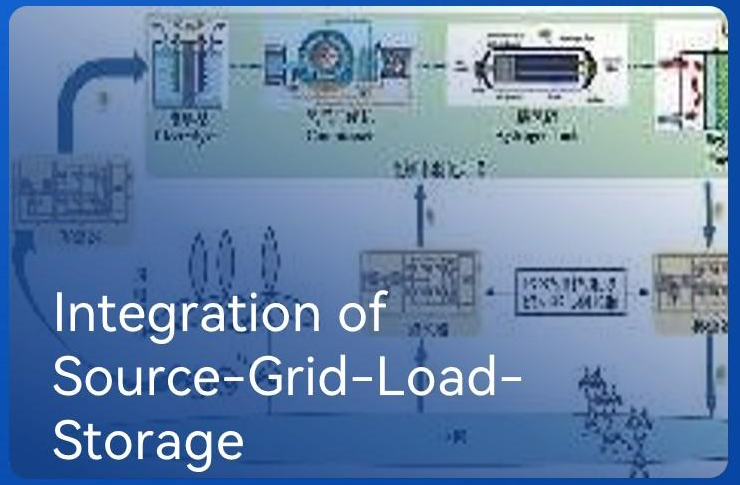
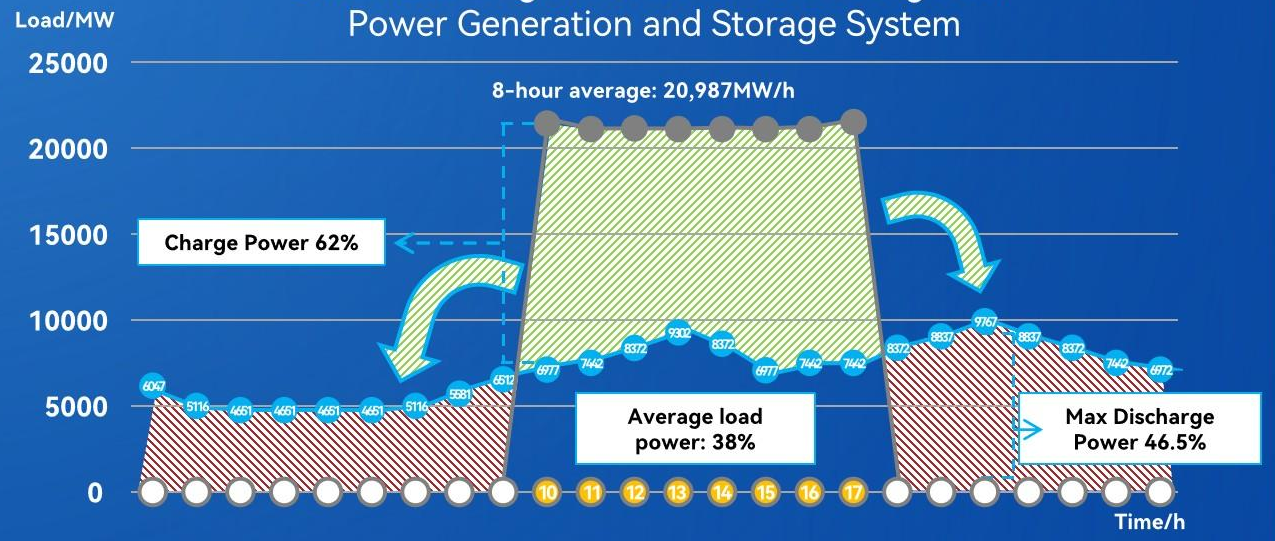
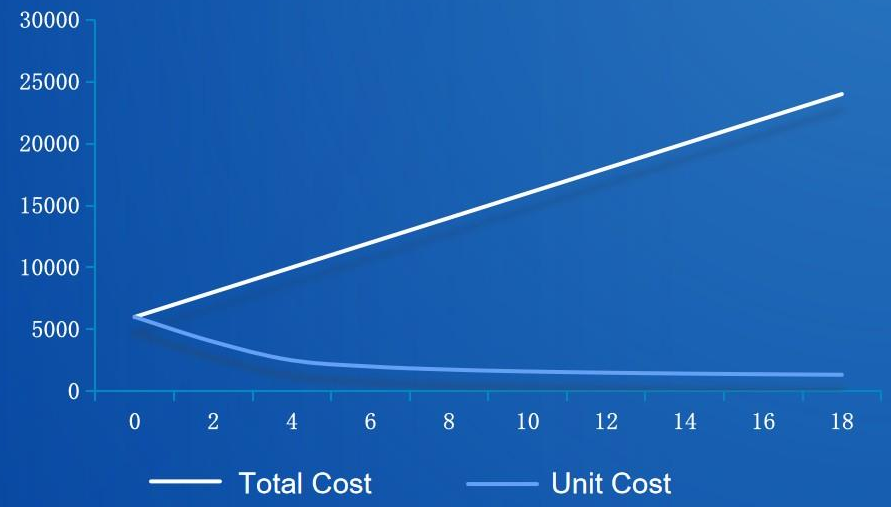


Schematic Diagram of a Self-Circulating Solar Power Generation and Storage System



Cost Structure Characteristics of CCES



Scenario 3: HCPS For Data Center

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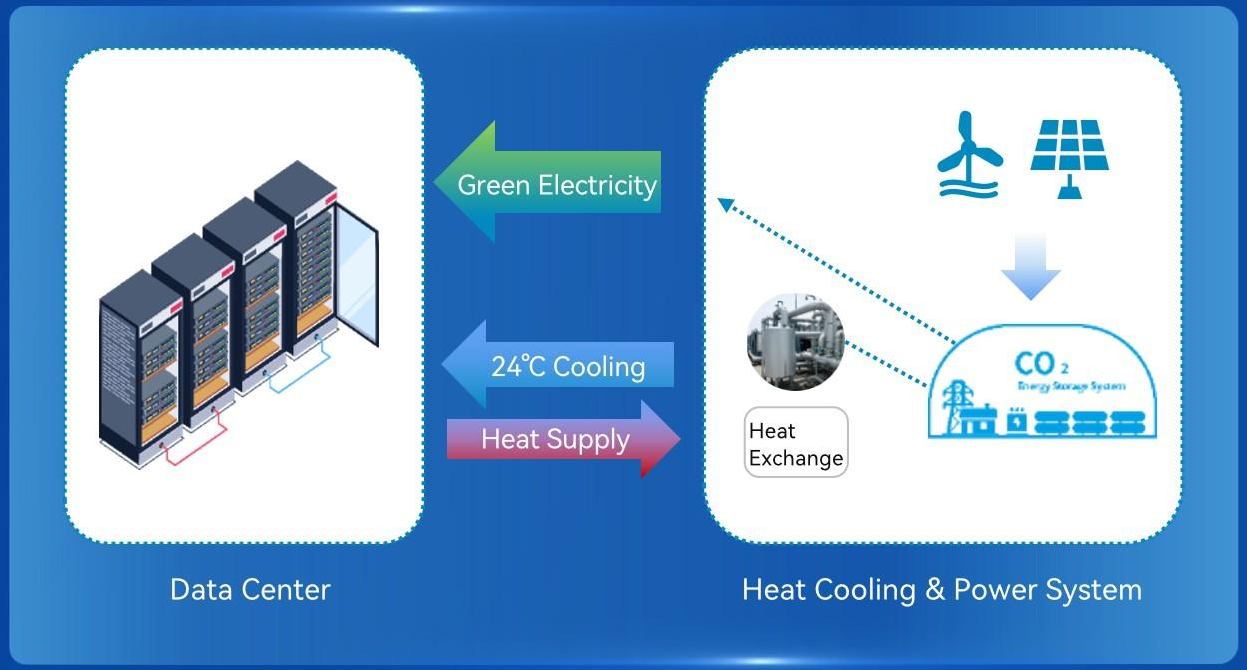
During the discharge phase, our CCES system intelligently captures and utilizes the waste heat generated by the data center to drive the CO_2 evaporation process.
At the completion of this evaporation cycle, a substantial amount of high-quality cooling is produced – which is then transferred directly back to the data center as a free, eco-friendly cooling source.



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Real-World Cases

The World's First Commercial CCES System

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Wuhu CONCH CO_2 Energy Storage Demonstration Project

NEA’s new energy storage pilot demonstration project

The first (set) major technical equipment supporting project of the NEA

The World's First Commercial CCES System

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CONCH Group (Fortune 500)

Wuhu City, Anhui Province, China

Covers an area of 39,950 m²

Connected to grid in December 2023

Charge: 18MW, 8h
Discharge: 10MW, 8h

Increase the proportion of green electricity used by CONCH and reduce their energy cost.

CO_2 Recycling

Integrate with the CCS line of cement to achieve a closed loop of CO_2 Capture, Utilization and Storage. (CCUS)

Waste Heat Utilization

Utilizing low-grade carbon-containing waste heat (50°C+) from cement production lines has resulted in an annual reduction of approximately 3,130 tons of standard coal.

The World's First 100 MW CCES System

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Huadian Corporation 100MW/1GWh CO_2 Energy Storage Power Plant

The First (Set) Major Equipment by the National Energy Administration of China

The World's First 100 MW CCES System

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China Huadian Corp

Covers an area of 400,000 m²

Begin in September 2024
Estimated Grid Connection in May 2026

Capacity: 100MW/1000MWh (1GWh)

Duration: 10 hours

600MW Wind Power +
400MW Solar PV

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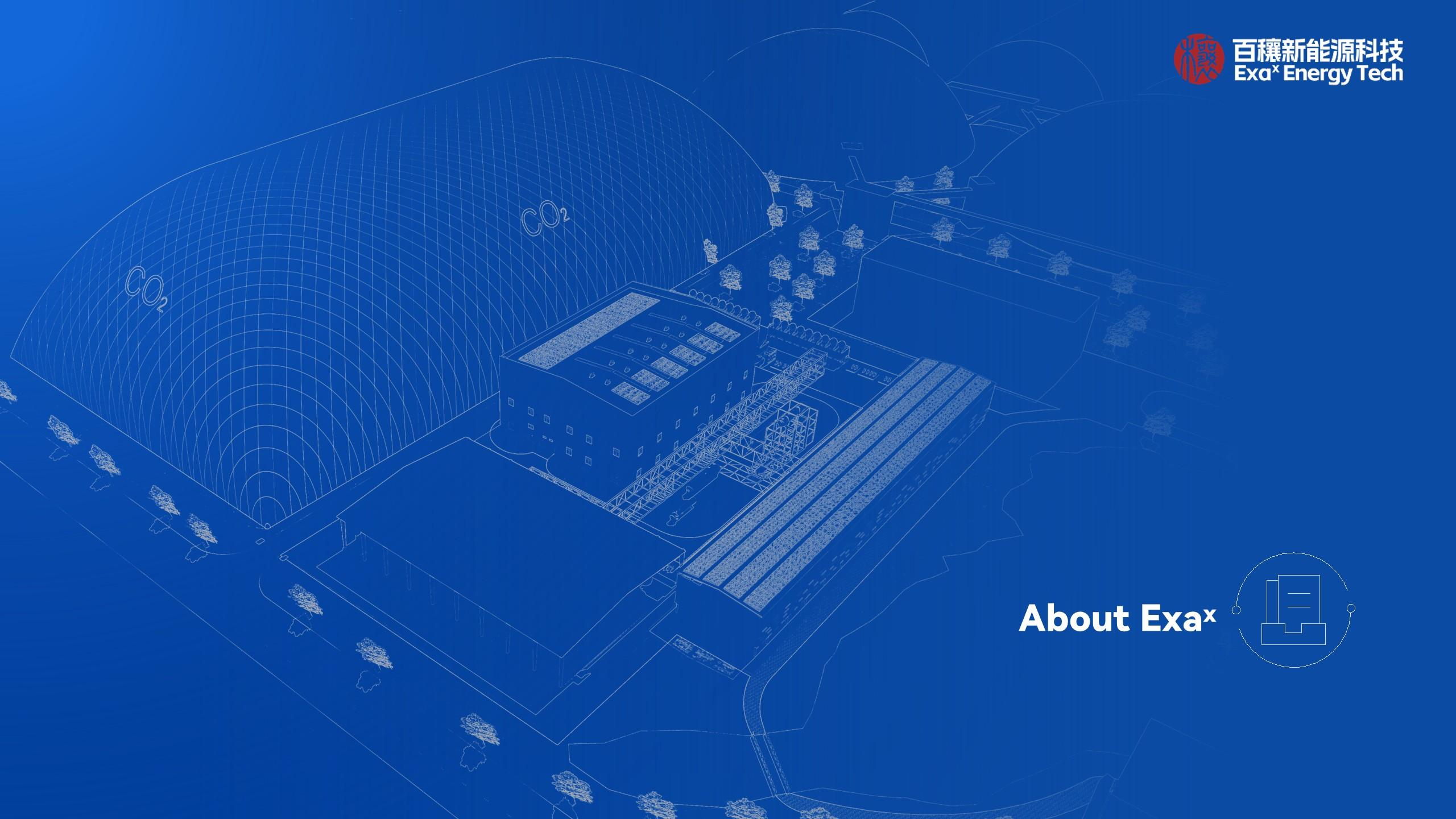

About Exa^{x}

Exa^{x} Energy Technology

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Exa^{x} Energy Tech, founded in September 2021, is an innovative technology enterprise specializing in compressed CO_2 energy storage. Foucused on CO_2 cutting-edge technology, we are dedicated to become the world's premier provider of zero-carbon energy solutions, accelerating the global energy transition and enabling a sustainable, low-carbon future.

Vison

Enabling Global Energy Transition

Core Value

Innovation Drives the Future

Exclusive
First-of-its-kind

180+
Know-how

80+
Patents

75%
R&D Professionals

Global Leader in Energy-Carbon Integration

Development Timeline

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National Certification

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The Demonstration Project of Renewable Energy Storage issued by NEA

In January 2024, Wuhu Conch 10MW/80MWh CO_2 energy storage demonstration project was successfully selected.

The First (Set) Major Equipment issued by NEA

In January 2025, "Large-capacity CCES based on Gas-Liquid Conversion Technology" was officially selected.

Main Low-Carbon Technology released by the Ministry of Ecology and Environment

In February 2025, CCES technology was selected as one of the main low-carbon technologies to be promoted by the state.

Main promoted technologies for Energy Conservation and Carbon Reduction in China's Industrial & Information Technology Sector

Included in the Recommended Catalog of Energy Conservation and Carbon Reduction Technologies and Equipment for China's IIT Sector in November 2025.

Certificates & Awards

- Enterprise Undertaking New-type Energy Storage Pilot and Demonstration Projects Approved by the NEA
- Enterprise Undertaking the The First (Set) Major Equipment Support Projects Approved by the NEA
- Enterprise Listed in the National Catalogue of Key Promoted Low-Carbon Technologies
- Enterprise Included in the National Recommended Catalogue of Energy-Saving and Carbon-Reduction Technologies & Equipment for Industry and Information Technology Sector
- National High-Tech Enterprise
- Top 100 Innovative Enterprises of "Innovation China" Initiative
- Best Long-Duration Energy Storage Technology Innovation Award in China's Energy Storage Industry
- Annual Influential Innovative Enterprise in Energy Storage Industry
- Annual Emerging Enterprise in Energy Storage Industry
- Vice Chairman Unit of the Zero-Carbon Park Professional Committee, China Association of Development Zones
- Member of the Carbon Neutrality Professional Committee, China Energy Conservation Association
- Member Unit of the Novel Energy Storage Industry Association
- Member Unit of the Zhongguancun Energy Storage Industry Alliance

80+
Patents

75%
R&D Staff

Core Strengths and R&D Roadmap

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Core Advantages

- **Global Uniqueness:** The only company in China with CO_2 energy storage system construction capability.
- **Technical Expertise:** Mastery of 180+ Know-Hows.
- **Innovation Leadership:** 80+ authorized patents, hundreds of domestic/PCT patent applications in the near future.
- **R&D Excellence:** Efficient CO_2 energy storage that is developed through dual-direction R&D.
- **Strategic Partnerships:** Collaboration with Xi'an Jiaotong University and DEC.
- **Supply Chain Synergy:** Close R&D partnerships with main suppliers for capacity expansion and cost reduction.

R&D Roadmap

- **Efficiency Improvement:** 75% efficiency within 5 years
- **Cost Reduction:** 20% cost reduction target within 3 years.
- **System Standardization & Modularization:** Establish standards for system structure within 3 years. On-site assembly will enhance engineering efficiency and shorten project timelines.
- **Multi-Level Energy Storage Solutions:** Combine millisecond and minute-level response systems.
- **Situational Energy Harvesting & Storage Solutions:** Develop complementary energy collection and storage systems.

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Accelerating the Era of Green and Clean Energy!