# Our answer on long duration energy storage

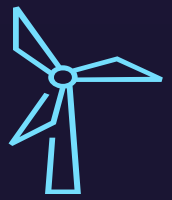
Customer Event Steam Turbine and Generators 2023



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# Compressed Air Energy Storage
# Kernaussagen



## Renewables need storage (to avoid fossil peakers)

The more variable renewable energy we add, the more urgent energy storage will become in order to avoid future deployment of fossil peaker plants



## Long term storage needs other solution than batteries

Batteries are a common solution for energy storage up to 4 hours. However mid to long term storage (up to 72 hours) will be needed to backup longer periods without wind & sun and to provide dynamic inertia and other ancillary services to the grid



## SE can provide the solution: CAES

Based on our mature & reliable compressors and turbines, transformers & switchyards as well as plant-wide control systems, SE can provide a turnkey solution for the Compressed Air Energy Storage surface plant


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# Pathways to decarbonization and energy efficiency

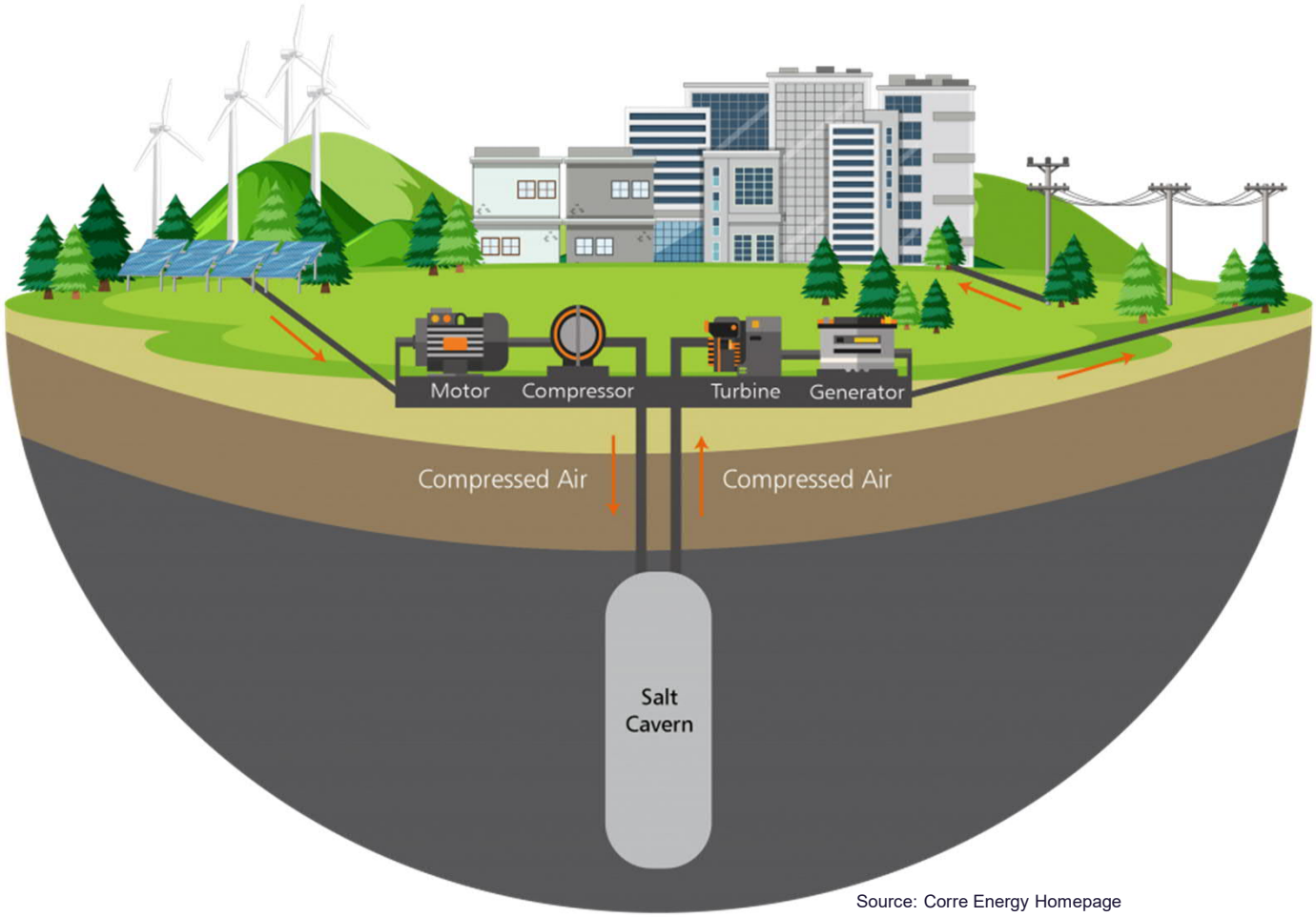
Long Duration Energy Storage by
Compressed Air Energy Storage (CAES)



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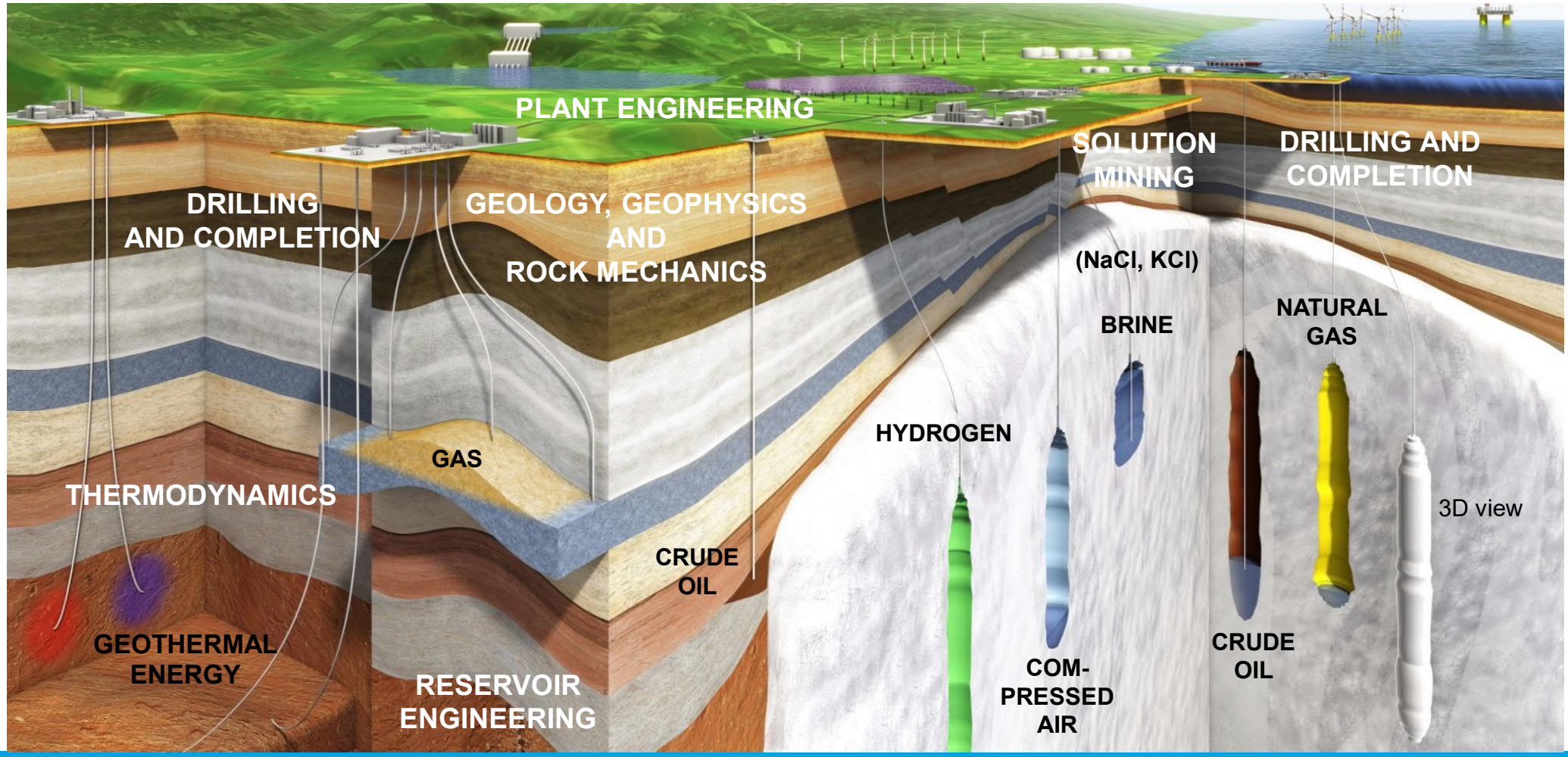
# Compressed Air Energy Storage (CAES)
## How does it work?




Source: Corre Energy Homepage


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# Underground Storage, Brine Production and Renewable Energies



# Compressed Air Energy Storage Plants in Operation
## Western Hemisphere

### Anlage in Huntorf (Deutschland, Niedersachsen)
1. Druckluftspeicherkraftwerk weltweit




| | |
|---|---|
| Inbetriebnahme | 1978 |
| Ertüchtigung | 2006 |
| Leistung | 290 MW für 2 h |
| Retrofit-Leistung | 321 MW für 3 h |
| Kavernenvolumen | 2 x 150.000 m³ |
| Kavernendruck | 43 bis 70 bar |
| Ladedauer | 6 h mit 60 MW |
| Wirkungsgrad | 42 % |

### Anlage in McIntosh (USA, Alabama)
2. Druckluftspeicherkraftwerk weltweit




| | |
|---|---|
| Inbetriebnahme | 1991 |
| Leistung | 110 MW für 26 h |
| Kavernenvolumen | 540.000 m³ |
| Kavernendruck | 52 bis 80 bar |
| Ladedauer | 42 h mit 50 MW |
| Wirkungsgrad | 54 % *) |

*) mit Rekuperator ausgeführt


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# Compressed Air Energy Storage (CAES)
## Surface plant variants




**Diabatic CAES**
- Compression Train
- Expander Train:
  - Steam Turbine as HP-IP Air Expander
  - and SXT-800 as LP Air Expander
- Recuperator as heat exchanger
- Natural Gas or Hydrogen ($H_2$) as additional fuel




**Adiabatic CAES**
- Compression Train
- Expander Train:
  - Steam Turbines as HP-IP-LP Air Expander
- Regular heat exchangers
- Heat Storage (hot, pressurized water tanks)

*A **diabatic process** involves the gain or loss of heat (and thus a change in entropy) while an **adiabatic process** occurs without gain or loss of heat (and thus with no change in entropy)*

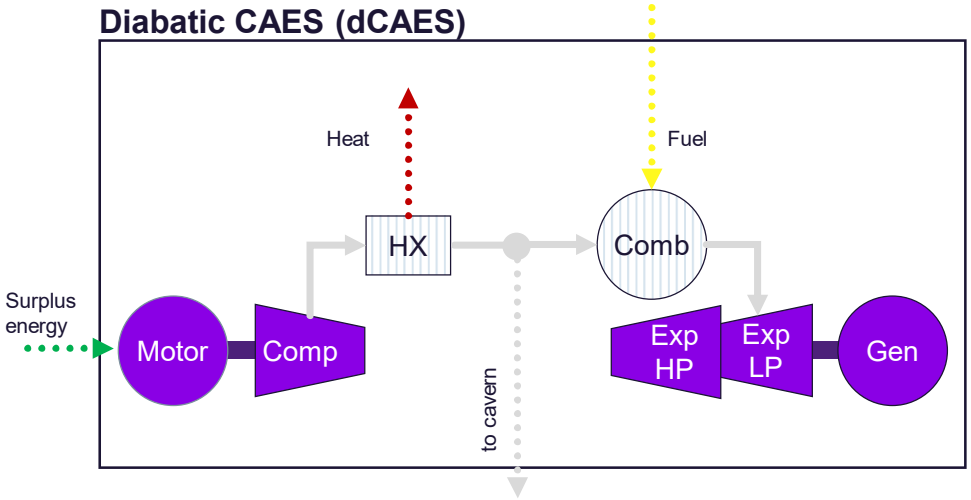

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# A-CAES vs. D-CAES

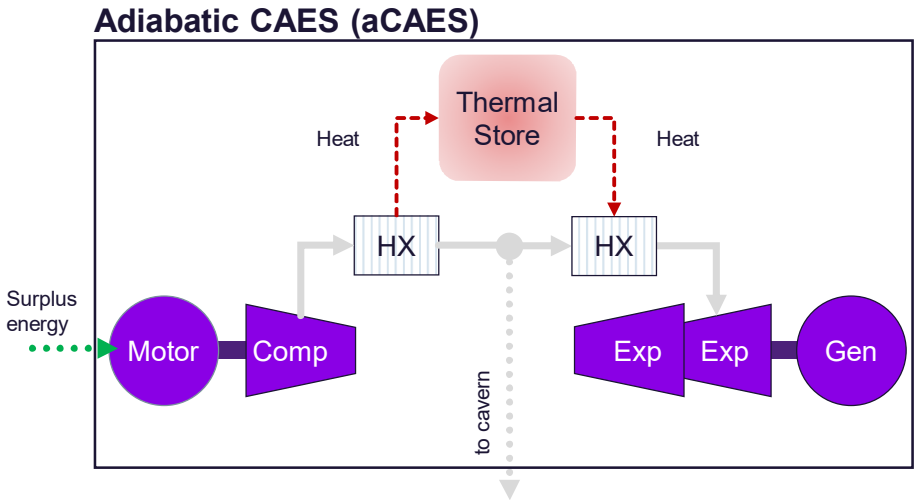
## Both CAES-variants have its justification

SIEMENS energy

### Diabatic CAES (dCAES)




### Adiabatic CAES (aCAES)




| | Diabatic CAES (dCAES) | Adiabatic CAES (aCAES) |
|---|---|---|
| Target Applications | **More than 24 hours discharge time possible** | **Ideally less than 16 hours discharge time** |
| | **Low $CO_2$, NOx emissions** ($H_2$ Ready – No $CO_2$) | **Zero emissions** |
| G-t-M | **Customer who require >24 hrs discharge-time & with fuel-access and acceptance for low emissions** | **Customers who require <16 hrs discharge-time & looking for Zero $CO_2$ and $NO_X$ emissions. Large flexibility for cavern-pressure and power** |


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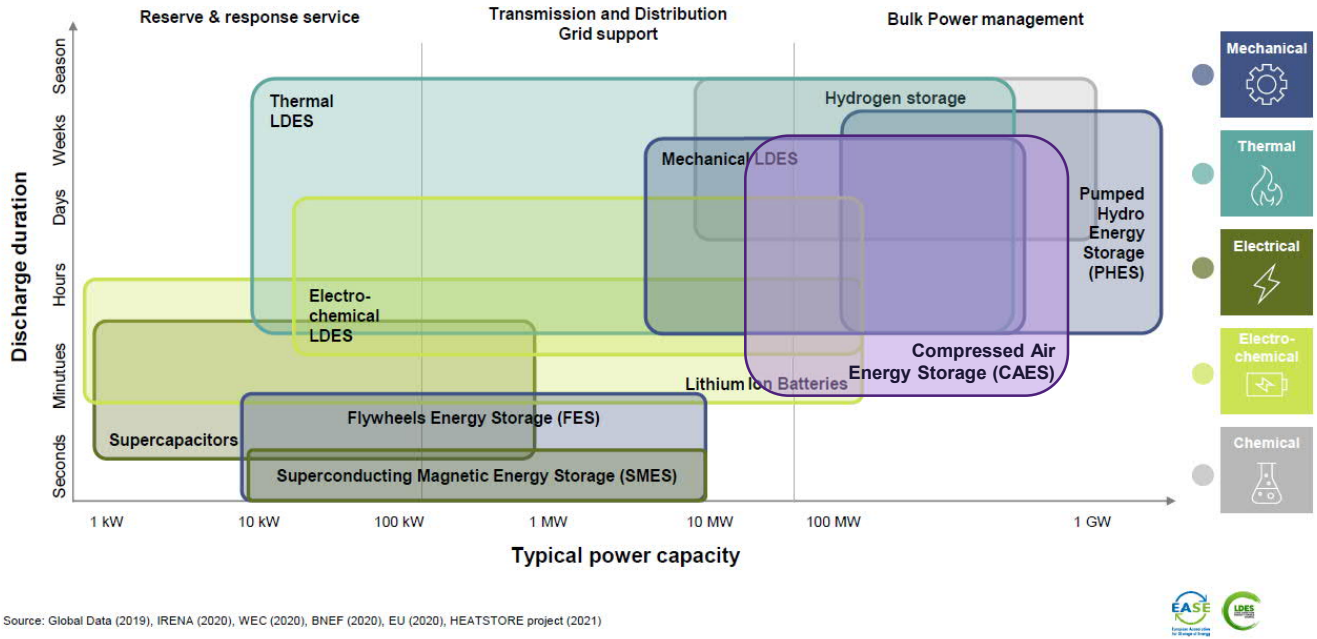
# Selected Projects

| Project | Loc. | FID | Comments |
|---|---|---|---|
| Netherlands | NL | 2024 | Turnkey, D-CAES (2x 160MW), H2 (future) |
| Netherlands | NL | 2024 | Power Island, A-CAES (1x 50MW), Pipeline Storage |
| Netherlands | NL | 2024 | Power Island, A-CAES (1x 50MW), Pipeline Storage |
| United Kingdom | UK | 2024 | Turbo Eq. only, A-CAES (1x 100MW), cavern existing |
| USA | US | 2024 | Turnkey, D-CAES (2x 160MW), H2 ready |
| Denmark | DK | 2024 | Turnkey, D-CAES (2x 160MW), Distr. Heating, H2 |
| Germany | DE | 2025 | Power Island, D-CAES (2x 160MW), extended ops |
| Germany | DE | 2025 | Turnkey, Hybrid (D/A), District Heating |
| Canada | CA | 2025 | Power Island, BoP, D-CAES (2x 160MW). H2 (future) |
| USA | US | 2025 | Turbo Eq. only, A-CAES (2x 235MW) |
| Canada | CA | 2025 | Power Island, A-CAES (1x 235MW) |
| USA | US | 2025 | Power Island, A-CAES (1x 100MW) |
| USA | US | 2026 | Power Island, BoP, D-CAES, H2 (future) |

Loc… Location
FID… Financial Investment Decision

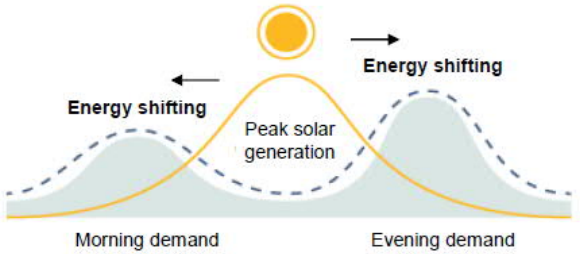

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# Storage Market




Source: Global Data (2019), IRENA (2020), WEC (2020), BNEF (2020), EU (2020), HEATSTORE project (2021)

## LDES unlock many different use cases



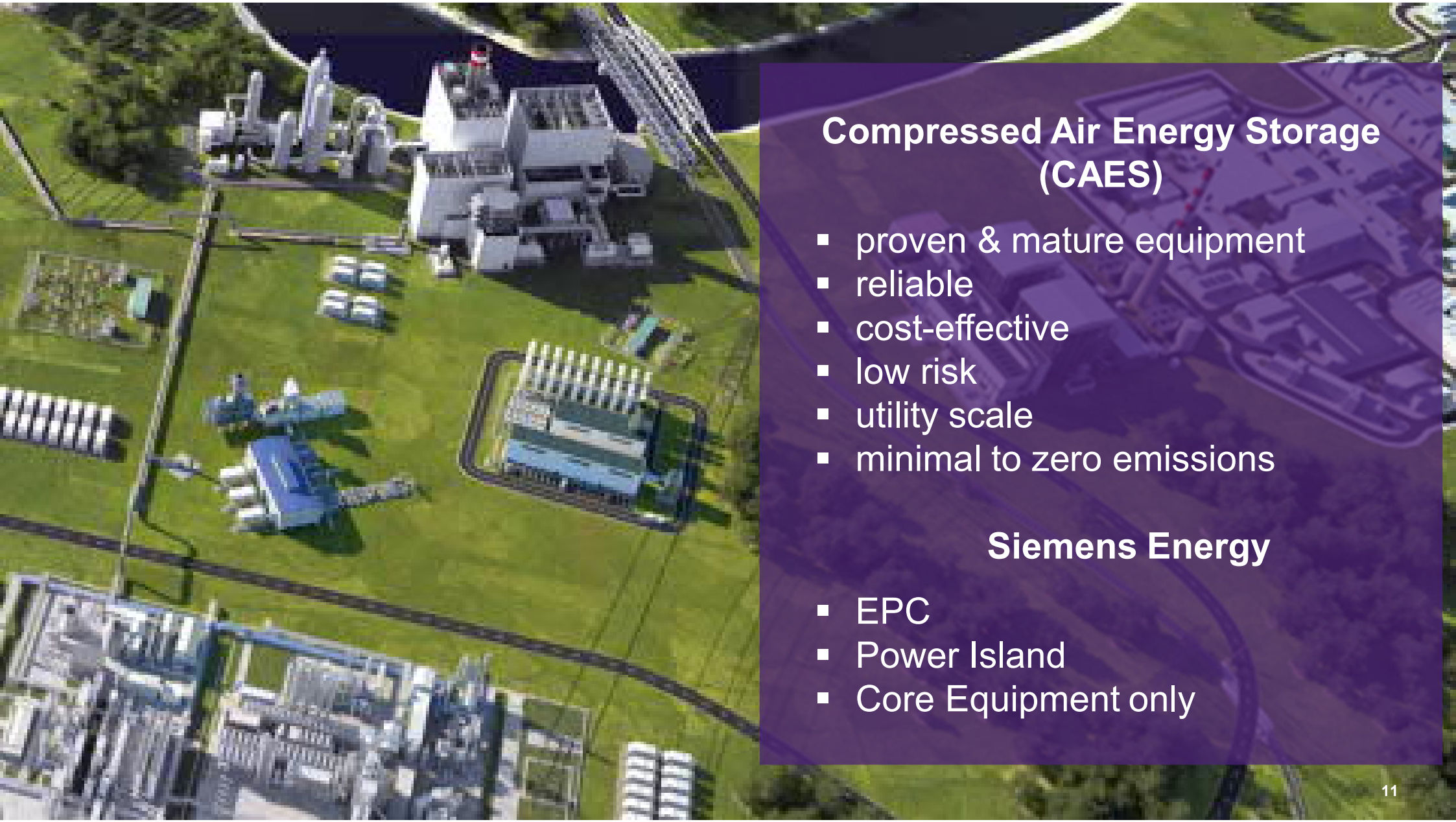

**Energy shifting**

+

**Grid services**


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## Compressed Air Energy Storage (CAES)

- proven & mature equipment
- reliable
- cost-effective
- low risk
- utility scale
- minimal to zero emissions

## Siemens Energy

- EPC
- Power Island
- Core Equipment only

Contact

# Compressed Air Energy Storage (CAES)

***Zero Emission Load Following Ressources to enable the Energy Transition***



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