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# ATV - MEKANISK LAGRING

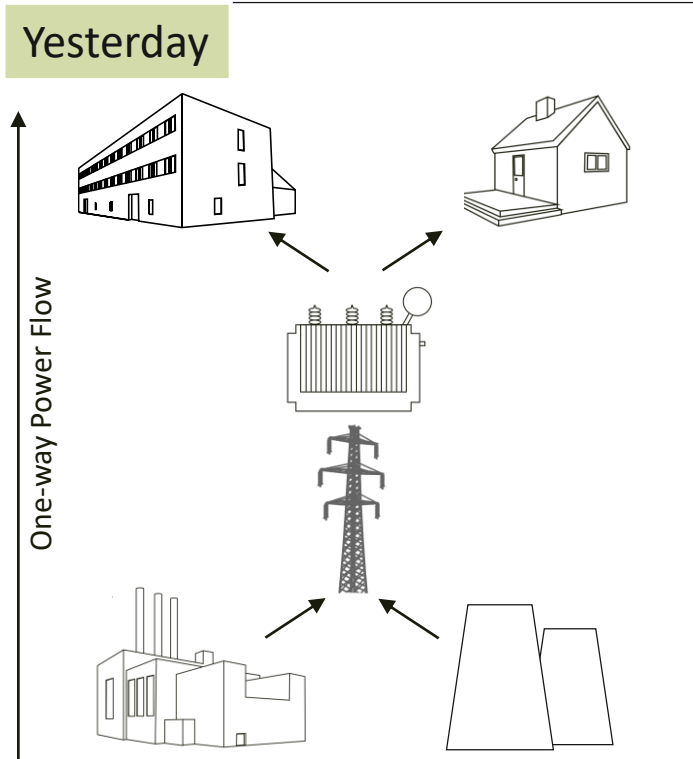
Martin Speiermann, CEO @ WattsUp Power A/S

# THE "TECTONIC" SHIFT WITHIN ENERGY

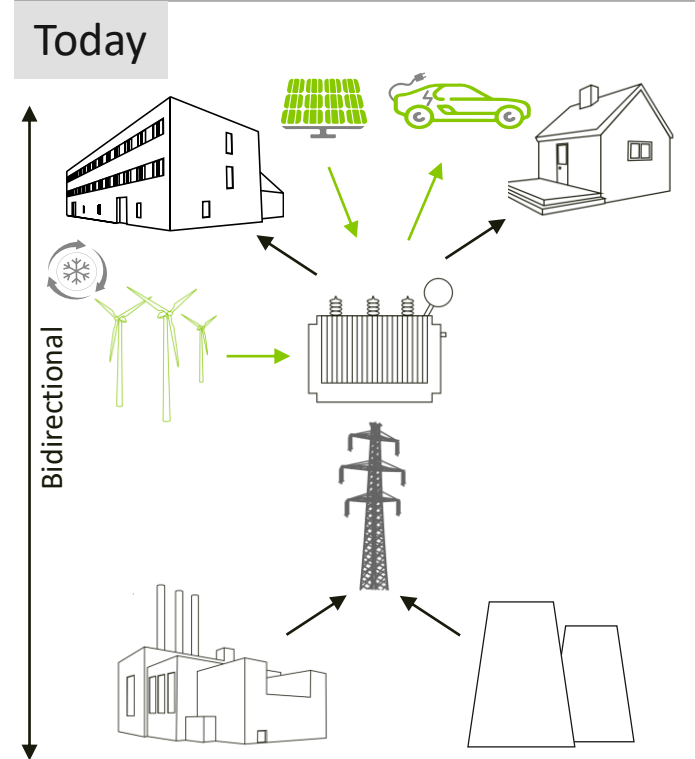
IS HAPPENING FAST AND CREATING CHALLENGES FOR THE DISTRIBUTED POWER GRID



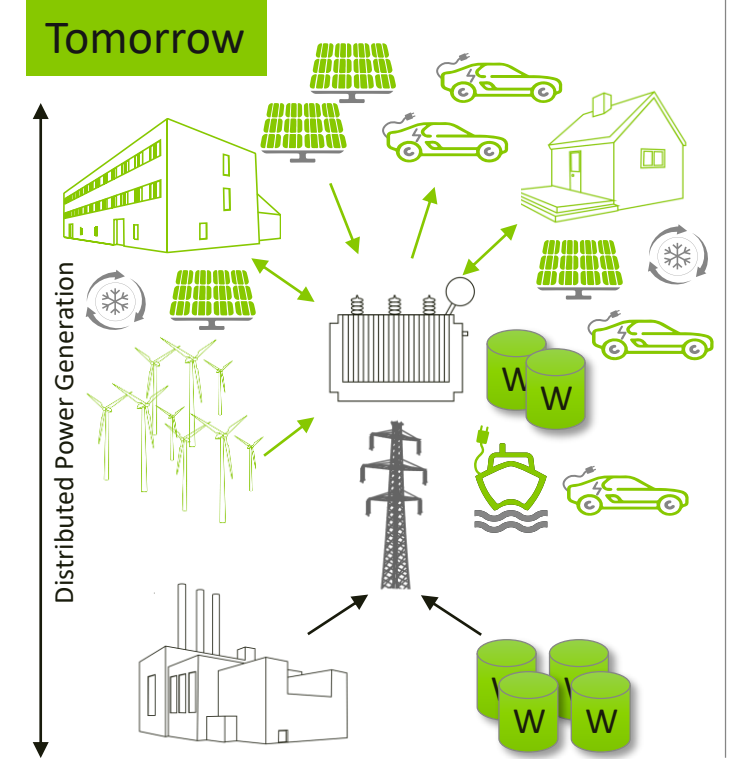
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Historically, the global power grid has been designed as a one-way power flow distribution from a central power production to the end user.



Today, the power grid is evolving, more and more distributed renewables are being added to the power grid which challenges a centralized power control.



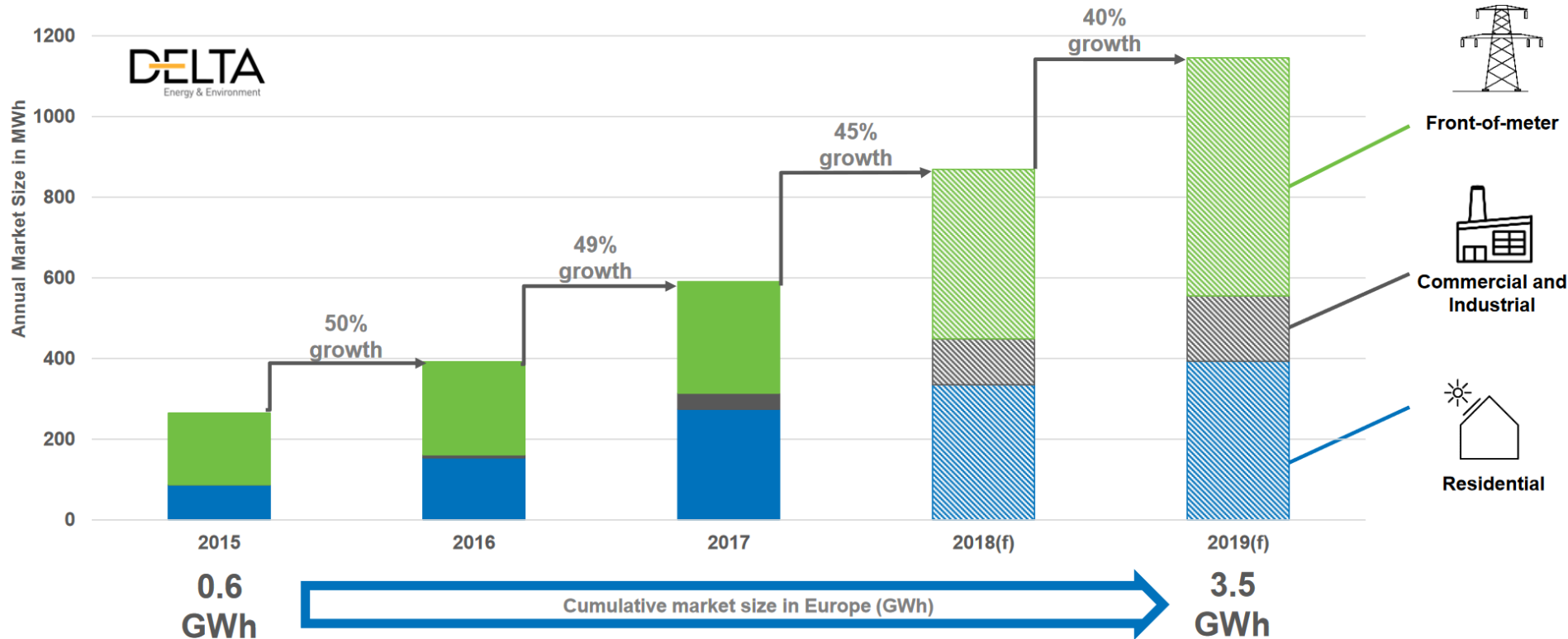
Distributed Power Generation – will allow the future power grid to be fully controlled and integrated with any form of renewable energy.

# EMMES 2.0\* Market figures and forecasts

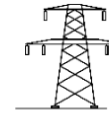
## Electrical Energy Storage

The analysis includes electrical, electrochemical and mechanical storage (with the exception of pumped hydro storage).

Electrical energy storage capacity annually installed (MWh)



DELTA  
Energy & Environment



Front-of-meter



Commercial and Industrial



Residential

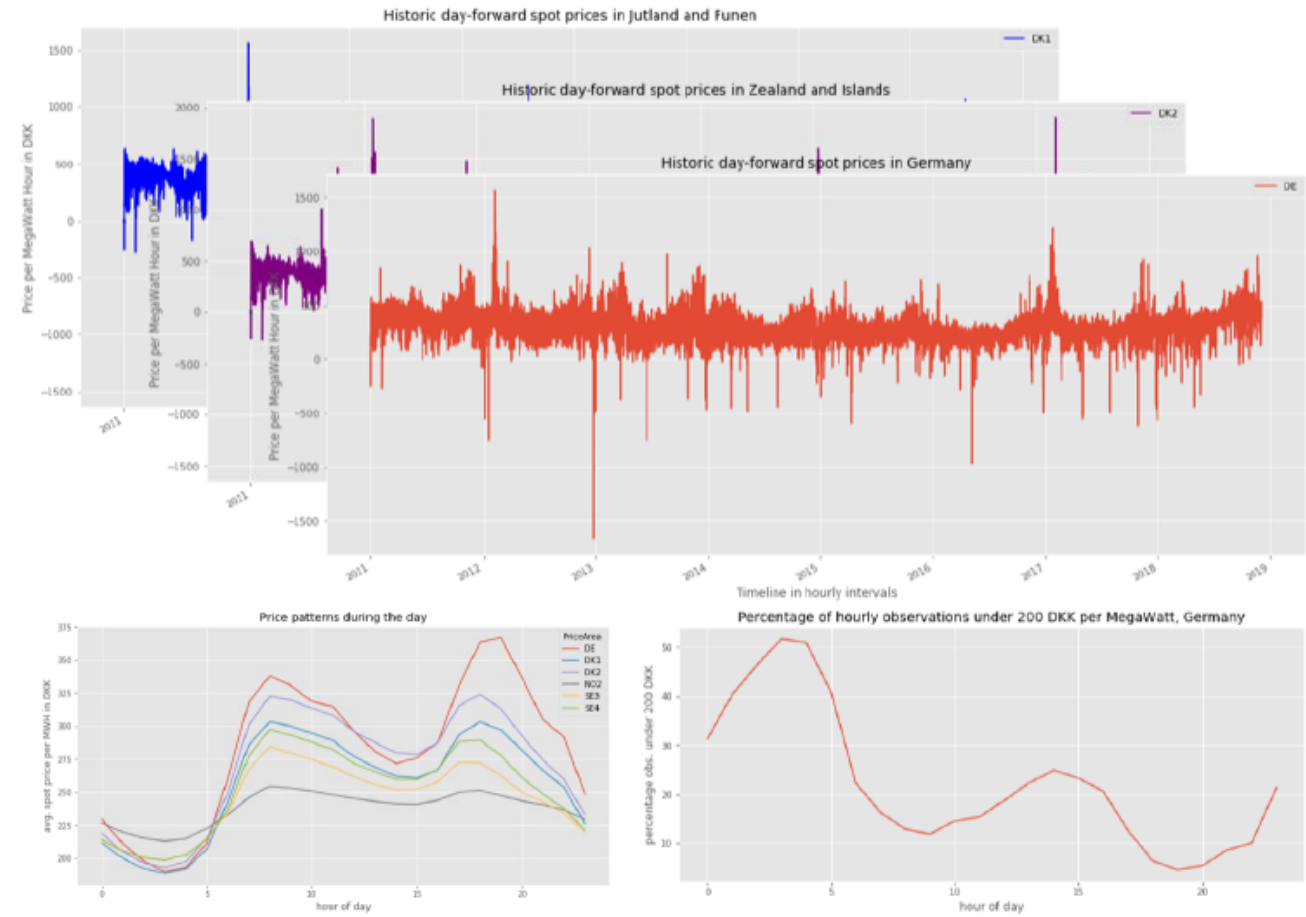
# FLUCTUATING PRICES

IS HAPPENING FAST AND CREATING CHALLENGES FOR THE DISTRIBUTED POWER GRID



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- We carefully studied the Scandinavia, German and Californian energy market and hourly prices since 2011. Fluctuations are becoming larger and larger. We see prices in Europe from 0 EUR to +150 EUR / MWh, and even larger fluctuations in California with peak prices of 275 USD / MWh. All numbers are ex. Tax. WUP can further conclude that prices are cheaper in the weekends and over a single day we observe 2 to 3 periods where prices are below index 10 compared to the average energy prices. In order to take benefit and make money from this knowledge we need two things – and we have both!
- One – An advanced database technology, unique machine learning and AI; The WattsUp **“Energy As A Service – Solution”** will be able to increase the energy value of locally produced energy and provide a significantly better power control – Enabling delivery of reliable and clean sustainable energy for everybody!
- Two - Access to **Highly Efficient Energy Storage** from WattsUp Power – Enables storing and delivering energy with up to 4 hours delay.

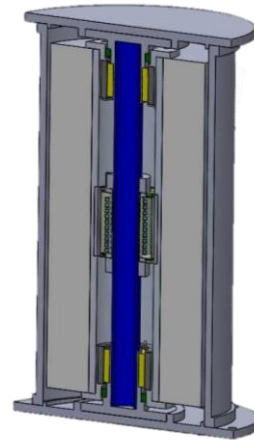


# ENERGY STORAGE TYPES

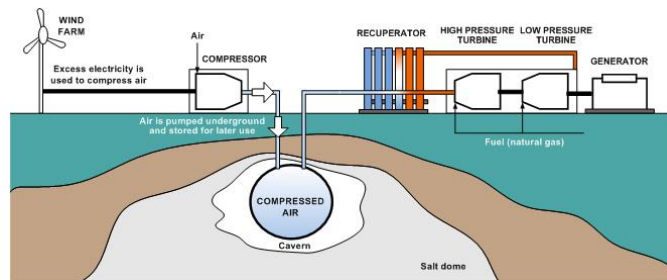
## ENERGY MANAGEMENT



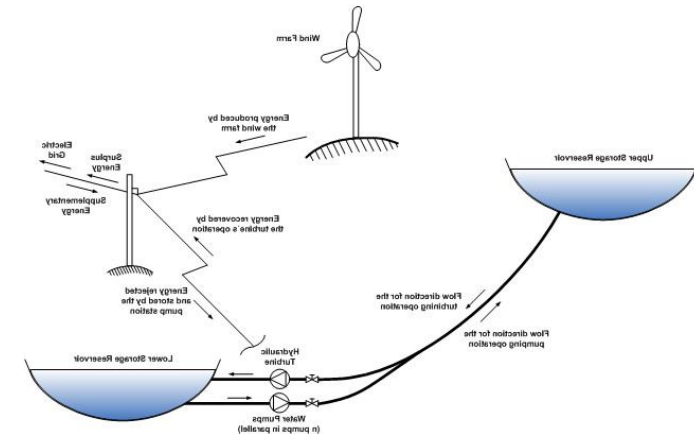
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1MW Flywheel



CAES, AA-CAES and Isothermal CAES



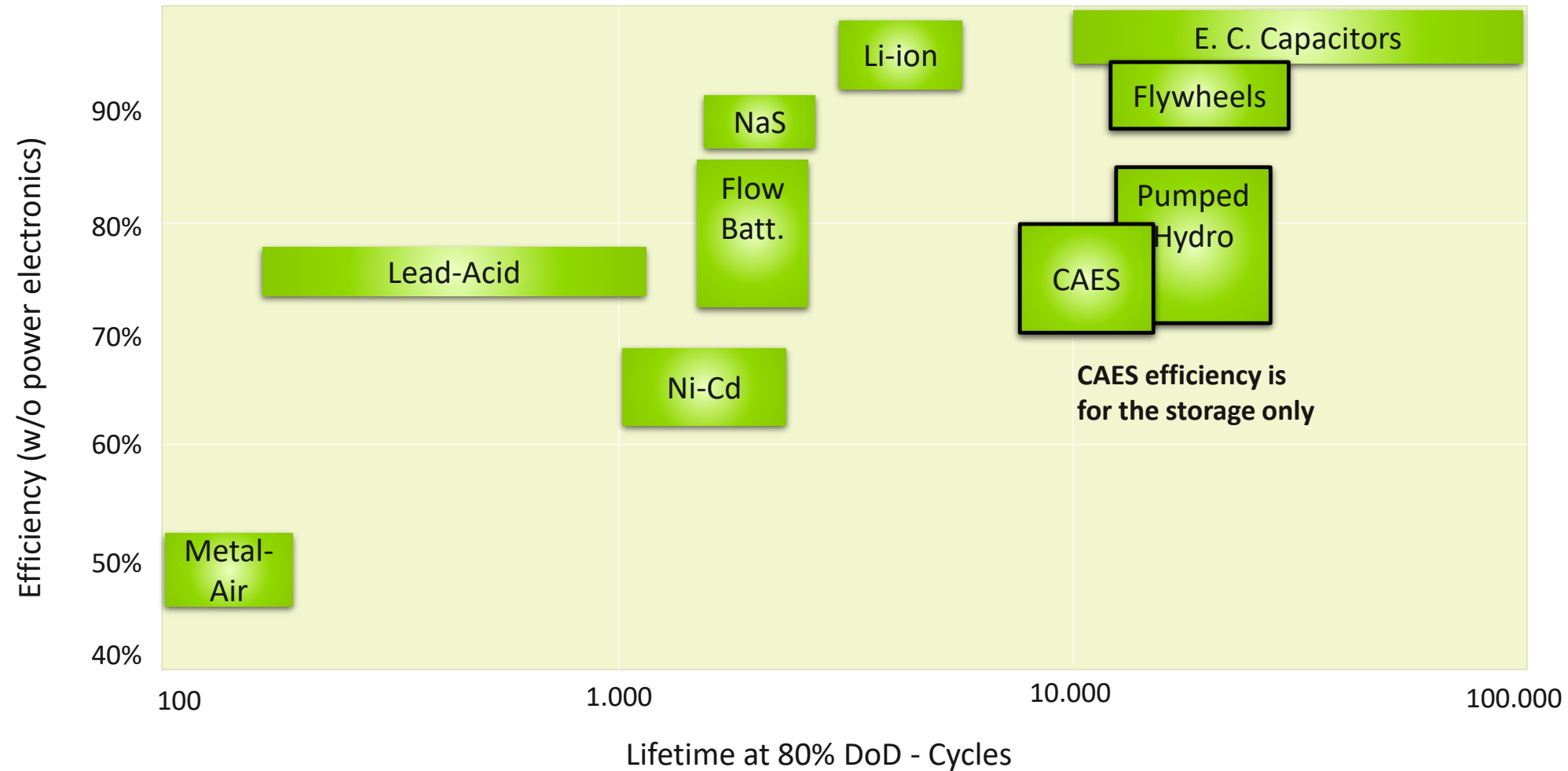
Pumped Hydro

[http://www.sc.ehu.es/sbweb/energias-renovables/temas/almacenamiento\\_1/almacenamiento\\_1.html](http://www.sc.ehu.es/sbweb/energias-renovables/temas/almacenamiento_1/almacenamiento_1.html)

# EFFICIENCY AND LIFETIME



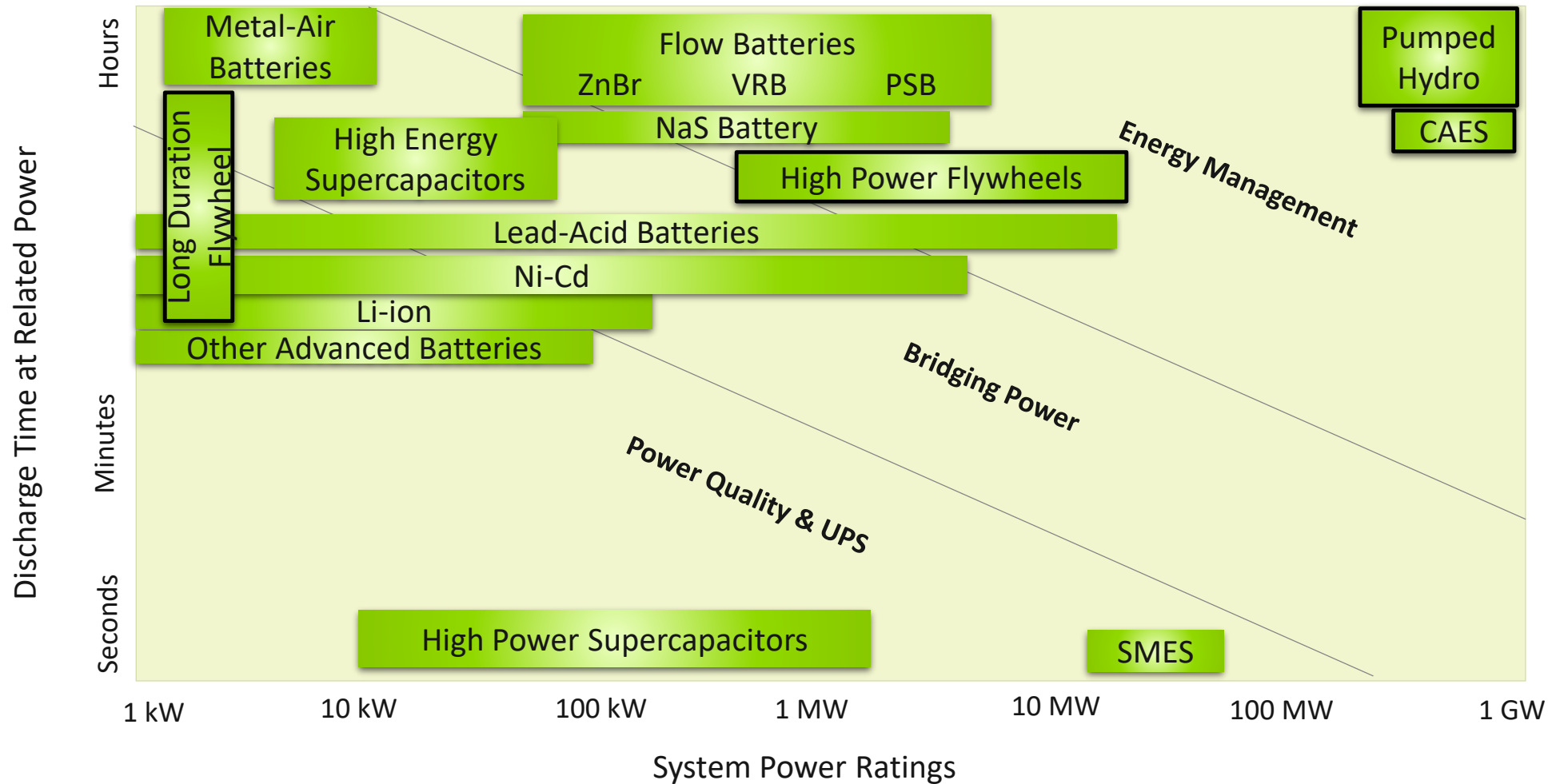
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# DISCHARGE TIME AND POWER RATINGS



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# Flywheel Energy Storage

## How it works

- A flywheel is a rotating mechanical device that is used to store rotational energy that can be called up instantaneously. At the most basic level, a flywheel contains a spinning mass in its center that is driven by a motor - and when energy is needed, the spinning force drives a device similar to a turbine to produce electricity, slowing the rate of rotation. A flywheel is recharged by using the motor to increase its rotational speed once again.
- Flywheel technology has many beneficial properties that enable us to improve our current electric grid. A flywheel is able to capture energy from intermittent energy sources over time, and deliver a continuous supply of uninterrupted power to the grid. Flywheels are able to respond to grid signals instantly, delivering frequency regulation and electricity quality improvements.



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**Unique Technology** – Energy Storage outperforming both existing battery technologies and competing flywheel technologies

- Exceptional High - System efficiency >98%
- Long performance life – Durability
- Adaptable Power Performance
- Non-Hazardous
- 100% Green



# Compressed Air Energy Storage

CAES, AA-CAES and Isothermal CAES



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Compressed air energy storage (CAES) is a way to store energy generated at one time for use at another time. At utility scale, energy generated during periods of low energy demand (off-peak) can be released to meet higher demand (peak load) periods.

Since the 1870's, CAES systems have been deployed to provide effective, on-demand energy for cities and industries. While many smaller applications exist, the first utility-scale CAES system was put in place in the 1970's with over 290 MW nameplate capacity. CAES offers the potential for small-scale, on-site energy storage solutions as well as larger installations that can provide immense energy reserves for the grid.

- Compressed Air Energy Storage (CAES)
- Advanced Adiabatic Compressed Air Energy Storage (AA-CAES)
- Isothermal CAES

Source: <http://energystorage.org/energy-storage/storage-technology-comparisons/caes>

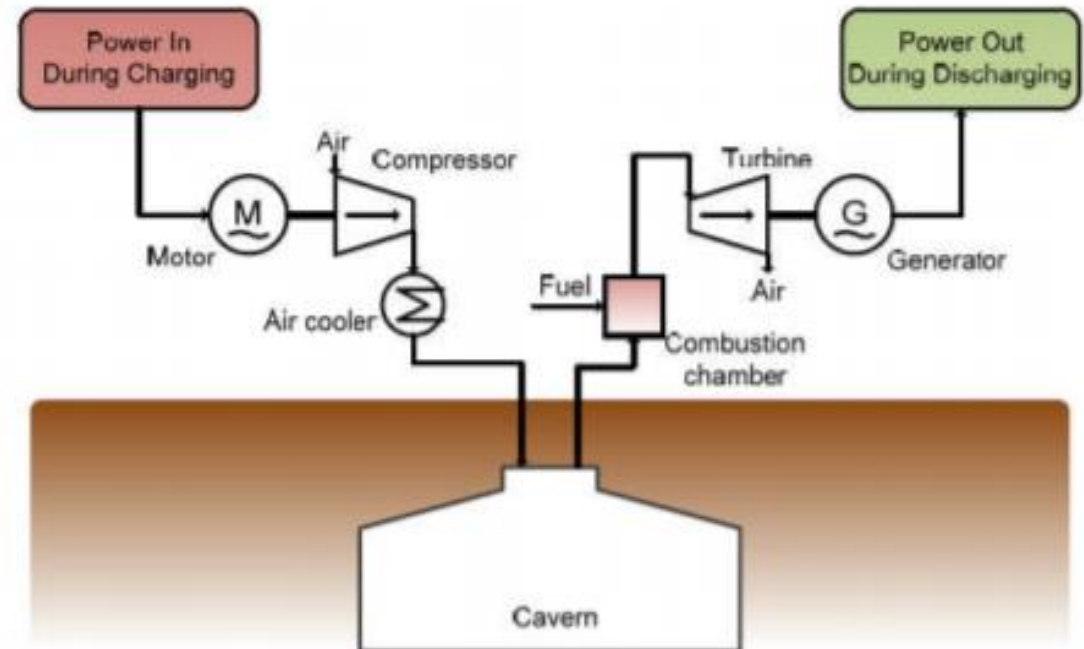
# Compressed Air Energy Storage (CAES)

## How it works

- Compressed Air Energy Storage (CAES) plants are largely equivalent to pumped-hydro Power plants in terms of their applications, output and storage capacity. But, instead of pumping water from a lower to an upper pond during periods of excess power, in a CAES plant, ambient air is compressed and stored under pressure in an underground cavern. When electricity is required, the pressurized air is heated and expanded in an expansion turbine driving a generator for power production.

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Source: <http://energystorage.org/compressed-air-energy-storage-caes>

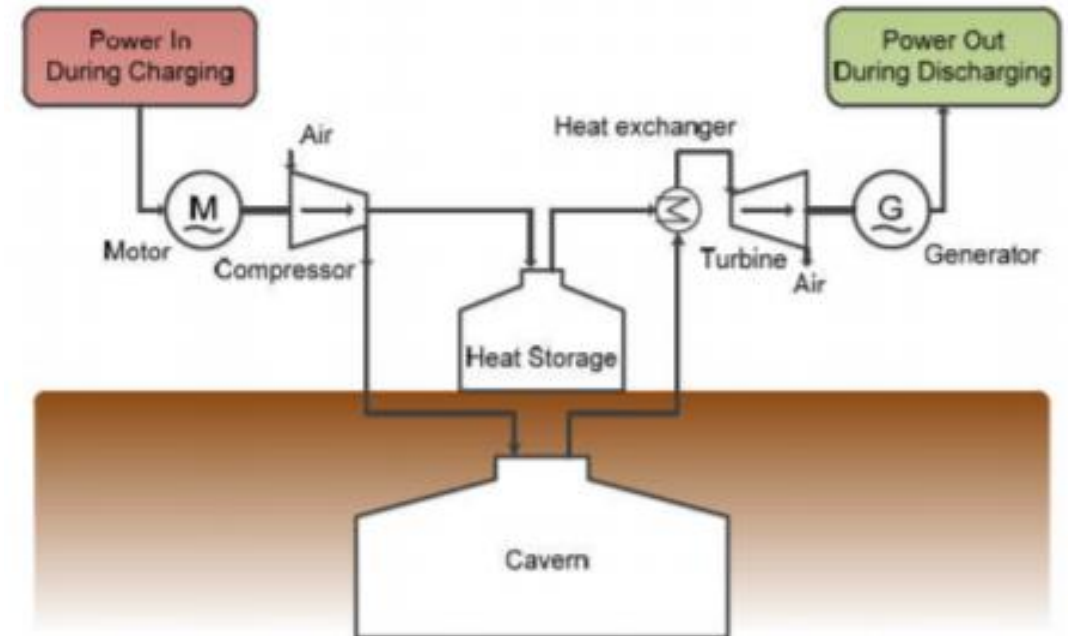
# Advanced Adiabatic Compressed Air Energy Storage (AA-CAES)

## How it works

- Advanced-adiabatic compressed air energy storage (AA-CAES) is an evolution of traditional CAES, designed to deliver higher efficiencies via a zero-carbon process. Operation is similar to traditional CAES in that energy is stored by compressing air with turbomachinery and storing in an underground cavern. The difference lies in the treatment of the heat of compression.



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Source: <http://energystorage.org/advanced-adiabatic-compressed-air-energy-storage-aa-caes>

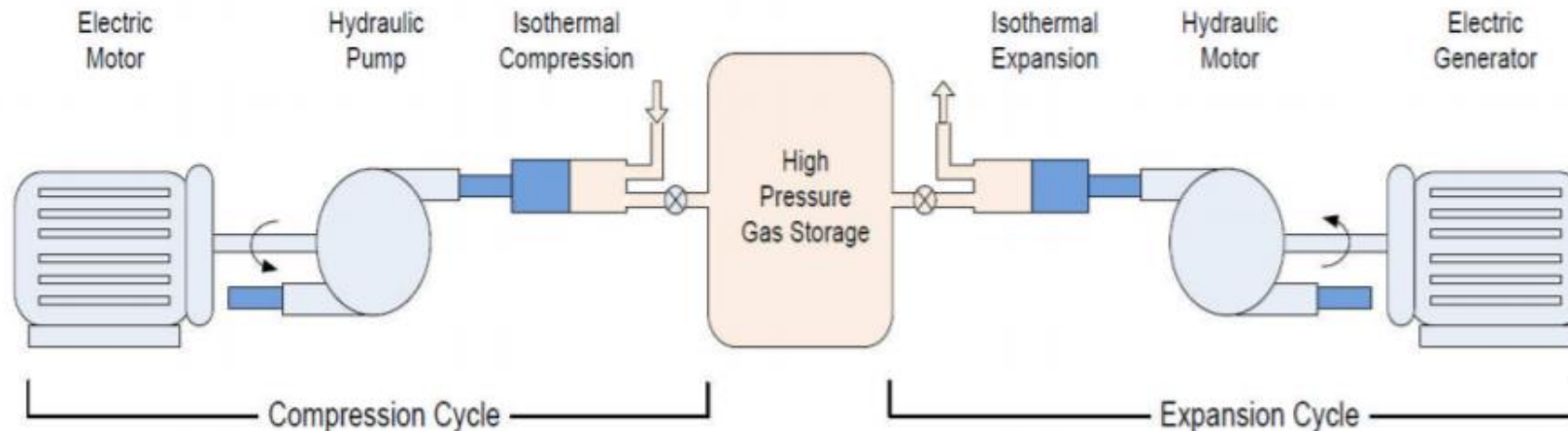
# Isothermal CAES

## How it works



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- Isothermal compressed air energy storage (CAES) is an emerging technology which attempts to overcome some of the limitations of traditional (diabatic or adiabatic) CAES. Traditional CAES uses turbomachinery to compress air to around 70 bar before storage. In the absence of intercooling the air would heat up to around 900K, making it impossible (or prohibitively expensive) to process and store the gas. Instead the air undergoes successive stages of compression and heat-exchange to achieve a lower final temperature close to ambient. In Advanced-Adiabatic CAES the heat of compression is stored separately and fed back into the compressed gas upon expansion, thereby removing the need to reheat with natural gas.



Source: <http://energystorage.org/energy-storage/technologies/isothermal-caes>

# Pumped Hydro-Power Storage

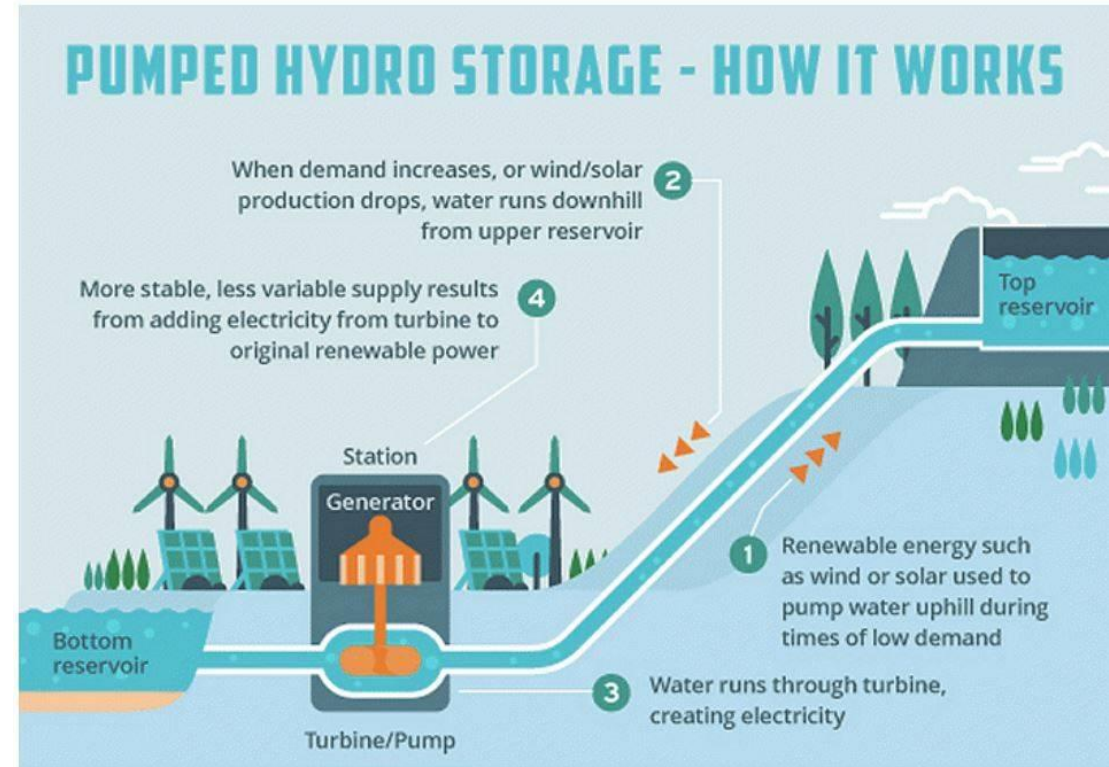
## How it works

- Gravity is a powerful, inescapable force that surrounds us at all times - and it also underpins one of the most established energy storage technologies, pumped hydro-power. Currently the most common type of energy storage is pumped hydroelectric facilities, and we have employed this utility-scale gravity storage technology for the better part of the last century in the United States and around the world.
- A hydroelectric dam relies on water cascading down through a turbine to create electricity to be used on the grid. In order to store energy for use at a later time, there are a number of different projects that use pumps to elevate water into a retained pool behind a dam - creating an on-demand energy source that can be unleashed rapidly. When more energy is needed on the grid, that pool is opened up to run through turbines and produce electricity.
- But the material that is raised to a higher elevation doesn't have to be water. Companies are currently creating gravitational systems that move gravel up the side of a hill and use the same underpinning principle - when energy is needed, the gravel is released and the weight drives a mechanical system that drives a turbine and generates electricity.

Source: <http://energystorage.org/energy-storage/energy-storage-technologies>



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