Compressed-air energy storage (CAES)

February 20, 2021

What Is Compressed Air Energy Storage?

- Compressed air energy storage, or CAES, is a means of storing energy for later use in the form of compressed air.
- CAES can work in conjunction with the existing power grid and other sources of power to store excess energy for when it is needed most, such as during peak energy hours.
- Wind power is one example of how this works perfectly with other types of energy production. The wind turbines spin around to produce energy any time there is wind available, but the electricity it generates may not always be needed at the moment it is being produced, and thus, is wasted.

How Does Compressed Air Energy Storage Work?

- With compressed air energy, the electricity produced by other power sources, such as wind turbines, is converted into highly pressurized compressed air and stored for later use.
- When the energy is needed, this compressed air is then released into turbine generators so it can be used as electricity again.
- With compressed air energy storage, the energy can be stored – and later used – at any time of the day or year, regardless of weather or other conditions.
- Air compression creates excess heat, and the decompression process removes heat from the air.

There are three main ways of dealing with the compression and decompression process:

1. **Adiabatic:** In an adiabatic energy storage system, the heat produced during the air compression process is kept, and then released out into the air during the decompression of the stored air. The heat can be stored in solids like concrete, or fluids like oils or molten salt. Currently, adiabatic storage systems are more theoretical, and have no major utility-scale applications in place yet, although they are expected to have a very high-efficiency rating.
2. **Diabatic:** Instead of storing the heat during the compression process, adiabatic storage systems use intercoolers to dissipate the heat into the air as a waste product. As the heat is wasted, when the compressed air needs to be decompressed to release from storage, additional heat must be added. Natural gas is often used for the re-heating process and contributes to a lower efficiency of the power plant system overall. In a diabatic storage system, the air temperature can be used to gauge the volume of air remaining in storage. Although diabatic storage systems tend to be less efficient, they are the only type that has been implemented at a commercial or utility level so far.
3. **Isothermal:** An isothermal storage system is the ideal that other systems attempt to attain. Isothermal systems are mostly theoretical but can be applied in very small scale systems with highly efficient equipment. These systems achieve a perfect or near-perfect heat exchange with the surrounding environment, but as of yet, have not been in practice for large scale CAES systems, as a certain degree of heat loss is unavoidable.

There are two main types of storage that can be utilized in a CAES system:

- **Constant volume storage:** In a constant volume storage system, specific physical boundaries control the volume of the storage space, but the air pressure of the space

is variable. These systems need to maintain certain maximum pressure thresholds to avoid damage to the storage vessels. Examples of constant volume storage include natural options like abandoned mines, salt caves and old natural gas reservoirs, as well as man-made systems like above-ground pipelines.

- **Constant pressure storage:** A constant pressure storage system maintains constant air pressure, while the volume of the storage is variable. These systems generally utilize huge bags for the air to be stored in and are placed deep in the ocean, to make use of the ocean’s hydrostatic pressure. The constant air pressure allows for greater efficiency of the turbines and the power plant itself. These systems are more costly due to the placement of the storage units, but they also open up possible locations for CAES systems.