**Energy storages**

**Pumped Hydro Storage (PHS):**

* **Principle:** PHS involves pumping water uphill to a higher reservoir during off-peak hours when electricity is cheap. When electricity demand is high, the water is released from the upper reservoir to flow downhill, turning turbines and generating electricity.
* **Advantages:** PHS is a mature technology with high efficiency and long-term storage capabilities. It can also provide ancillary services like frequency regulation and voltage control.
* **Disadvantages:** Requires suitable geography with a suitable upper and lower reservoir, and can have environmental impacts.

**Battery Energy Storage Systems (BESS):**

* **Principle:** BESS use batteries to store electrical energy. When electricity is available, the batteries are charged, and when electricity is needed, the batteries are discharged to provide power.
* **Advantages:** BESS offer fast response times, high efficiency, and flexibility in terms of location and size. They are becoming increasingly cost-effective.
* **Disadvantages:** Batteries have a limited lifespan and may require regular maintenance. Some battery chemistries, such as lithium-ion, can pose environmental concerns.

**Compressed Air Energy Storage (CAES):**

* **Principle:** CAES involves compressing air into underground caverns during off-peak hours. When electricity is needed, the compressed air is released to drive turbines and generate electricity.
* **Advantages:** CAES can store large amounts of energy for extended periods. It is a relatively low-cost option and can be located near existing power plants.
* **Disadvantages:** Requires suitable geological formations for underground storage and can have environmental impacts, such as noise pollution and land use changes.

**Thermal Energy Storage (TES):**

* **Principle:** TES stores excess energy in the form of heat. This heat can be stored in various materials, such as molten salt, rocks, or water. When electricity is needed, the stored heat is used to drive turbines and generate electricity.
* **Advantages:** TES can provide long-term storage and can be integrated with various renewable energy sources, such as solar thermal and geothermal.
* **Disadvantages:** Requires significant infrastructure and can have high upfront costs.

**Flywheel Energy Storage:**

* **Principle:** Flywheel energy storage involves storing energy in the kinetic energy of a rotating flywheel. When electricity is needed, the flywheel is slowed down, generating electricity.
* **Advantages:** Flywheels offer fast response times, high efficiency, and low maintenance requirements.
* **Disadvantages:** Limited storage capacity compared to other methods, and can be sensitive to vibrations and temperature changes.