Storing Electrical Energy

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INTRODUCTION

- The electric power grid operates based on balance between supply (generation) and demand (consumer use).
- One way to help balance fluctuations in electricity supply and demand is to store electricity in relatively high production and low demand and release it back to the electric power grid in lower production or higher demand.
- Electricity storage could help the utility grid operate more efficiently.
- Electricity storage will permit greater system flexibility and help variable renewables resources to be built and used.

- Electric energy storage can make it easier to serve customers during high-demand periods without increasing electricity production capacity.
- Electric energy storage can also increase the predictability of integrating renewables like wind and solar onto the power grid.
- Currently, global storage capacity is less than 2 percent of the total electric power production capacity.
- Costs for batteries have decreased significantly in the past few years and are expected to continue to decline. Electric energy storage can also help reduce costs by potentially deferring the need to build new transmission or generation.

STORAGE METHODS

- Battery
- Flywheel
- Water(Pumped Hydroelectric)
- Compressed Air
- Thermal Energy Storage

Battery

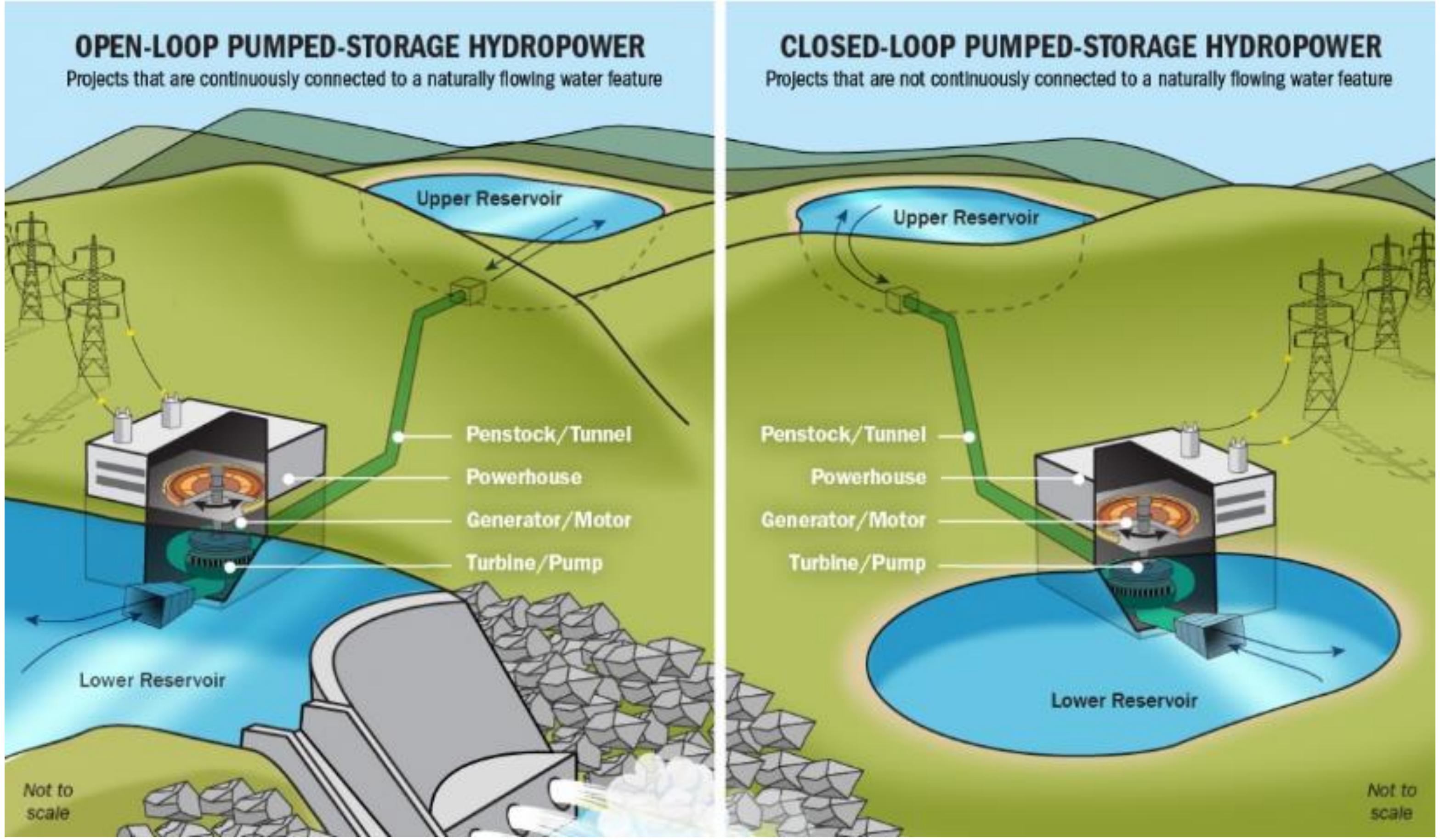
- Similar to most of common rechargeable batteries, large batteries can store a large amount of electricity until it is needed.
- Batteries where the energy is stored directly in the electrolyte solution for longer cycle life, and quick response times.
- These storage systems can use lithium ion, lead acid, lithium iron or other battery technologies.
- Battery storage is entering a dynamic and uncertain period. The sources of value will depend on four factors: how quickly storage costs fall; how utilities adapt by improving services, incorporating new distributed energy alternatives, and reducing grid-system cost; how nimble third parties are; and whether regulators can strike the right balance between encouraging a healthy market for storage (and solar) and ensuring sustainable economics for the utilities.
- Electricity batteries help you make the most of renewable electricity from a solar PV system or wind or hydro turbine. (e.g. solar PV system will generate electricity during the day when you’re out at work, and this can be stored in your electricity battery for you to use in the evening.)

Flywheel

- 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.
- A flywheel is able to capture energy from intermittent energy sources over time, and deliver a continuous supply of uninterrupted power to the grid.
- Modern flywheels are made of carbon fiber materials, stored in vacuums to reduce drag, and employ magnetic bearings, enabling them to revolve at speeds up to 60,000 RPM.

Water(Pumped Hydroelectric)

- Electricity is used to pump water up to a reservoir. When water is released from the reservoir, it flows down through a turbine to generate electricity.
- Pumped-storage hydropower (PSH) is a type of hydroelectric energy storage. It is a configuration of two water reservoirs at different elevations that can generate power (discharge) as water moves down through a turbine; this draws power as it pumps water (recharge) to the upper reservoir.
- 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.

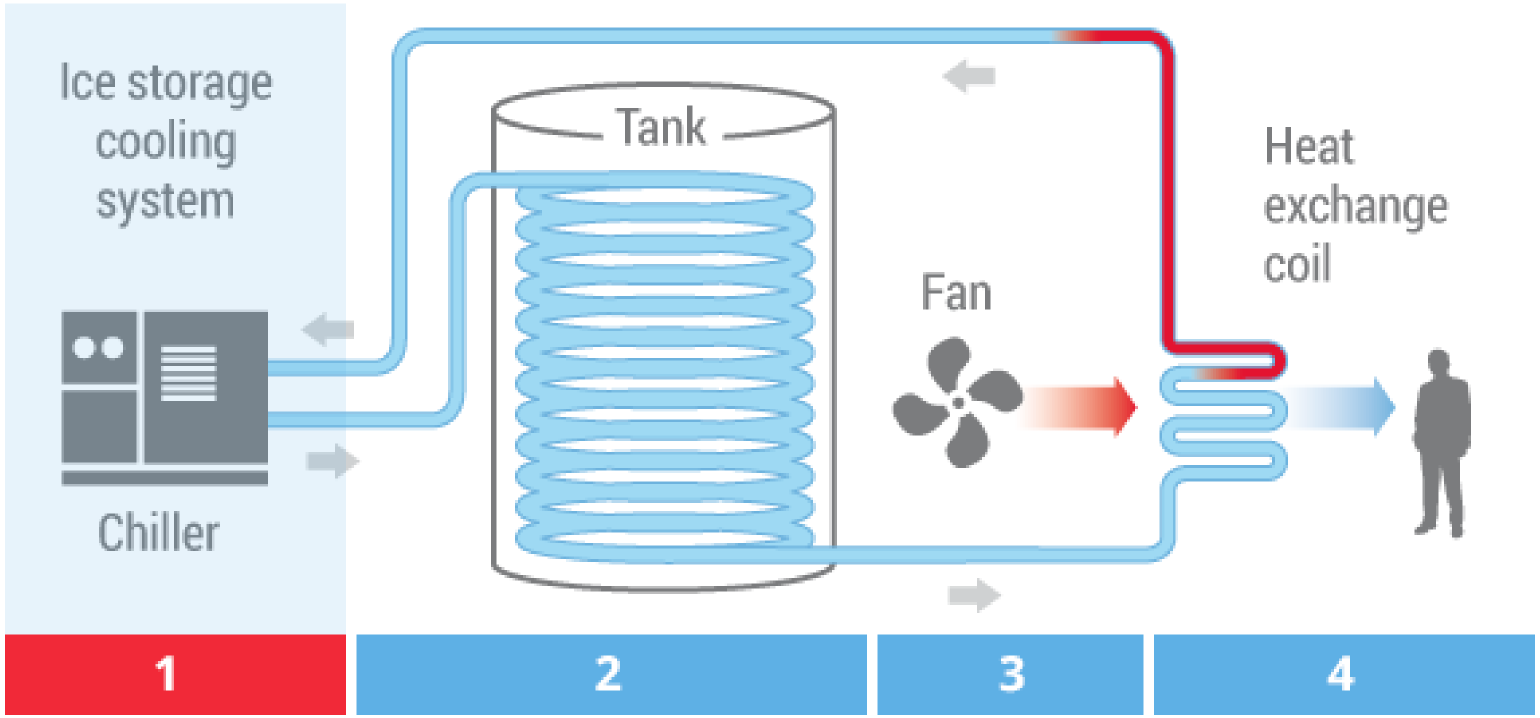

OPEN-LOOP PUMPED-STORAGE HYDROPOWER
Projects that are continuously connected to a naturally flowing water feature
Upper Reservoir
Penstock/Tunnel
Powerhouse
Generator/Motor
Turbine/Pump
Lower Reservoir
Not to scale
CLOSED-LOOP PUMPED-STORAGE HYDROPOWER
Projects that are not continuously connected to a naturally flowing water feature
Upper Reservoir
Penstock/Tunnel
Powerhouse
Generator/Motor
Turbine/Pump
Lower Reservoir
Not to scale

Compressed Air

- Electricity is used to compress air at up to 1,000 pounds per square inch and store it, often in underground caverns. When electricity demand is high, the pressurized air is released to generate electricity through an expansion turbine generator.
- Compressed Air Energy Storage (CAES) is a promising energy storage technology that can lower costs for customers and reduce greenhouse gas emissions through a greater integration of renewable energy sources. PG&E is engaged in a project to explore the use of CAES to power generators during peak periods when the energy is needed most.
- In a Compressed Air Energy Storage (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.

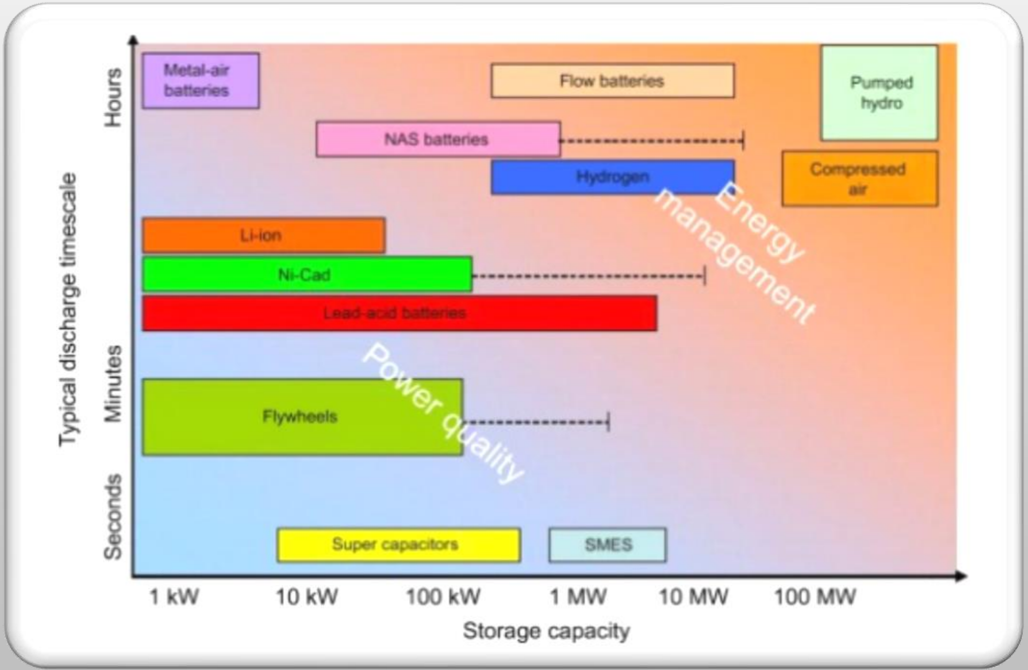
Thermal Energy Storage

- Electricity can be used to produce thermal energy, which can be stored until it is needed. For example, electricity can be used to produce chilled water or ice during times of low demand and later used for cooling during periods of peak electricity consumption.
- Thermal energy storage is like a battery for a building's air-conditioning system. It uses standard cooling equipment, plus an energy storage tank to shift all of a building's cooling needs to off-peak, night time hours. During off-peak hours, ice is made and stored inside Ice-Bank energy storage tanks. The stored ice is then used to cool the building occupants the next day.


Ice storage
cooling
system
Chiller
Tank
Fan
Heat
exchange
coil
1
2
3
4

Other Types of Storage Methods

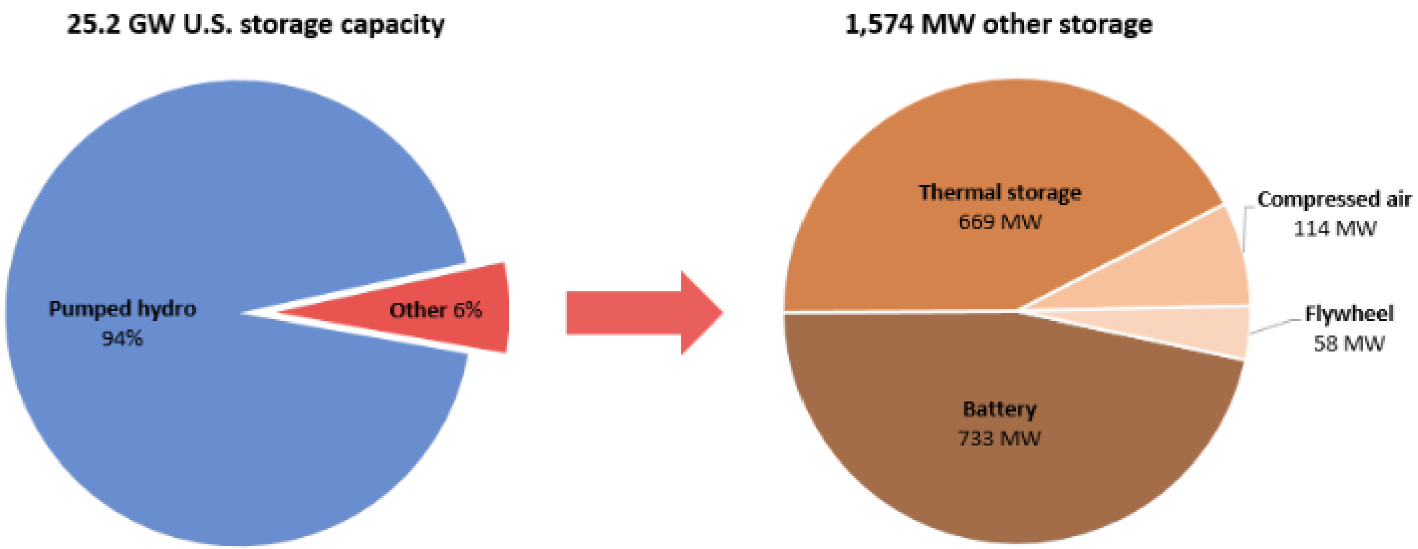
- In addition to these technologies, new technologies are currently under development, such as **flow batteries**, **supercapacitors**, and **superconducting magnetic energy storage**.



Electricity Storage in the United States

According to the U.S. Department of Energy, the United States had more than 25 gigawatts of electrical energy storage capacity as of March 2018. Of that total, 94 percent was in the form of pumped hydroelectric storage, and most of that pumped hydroelectric capacity was installed in the 1970s. The six percent of other storage capacity is in the form of battery, thermal storage, compressed air, and flywheel, as shown in the following graph:

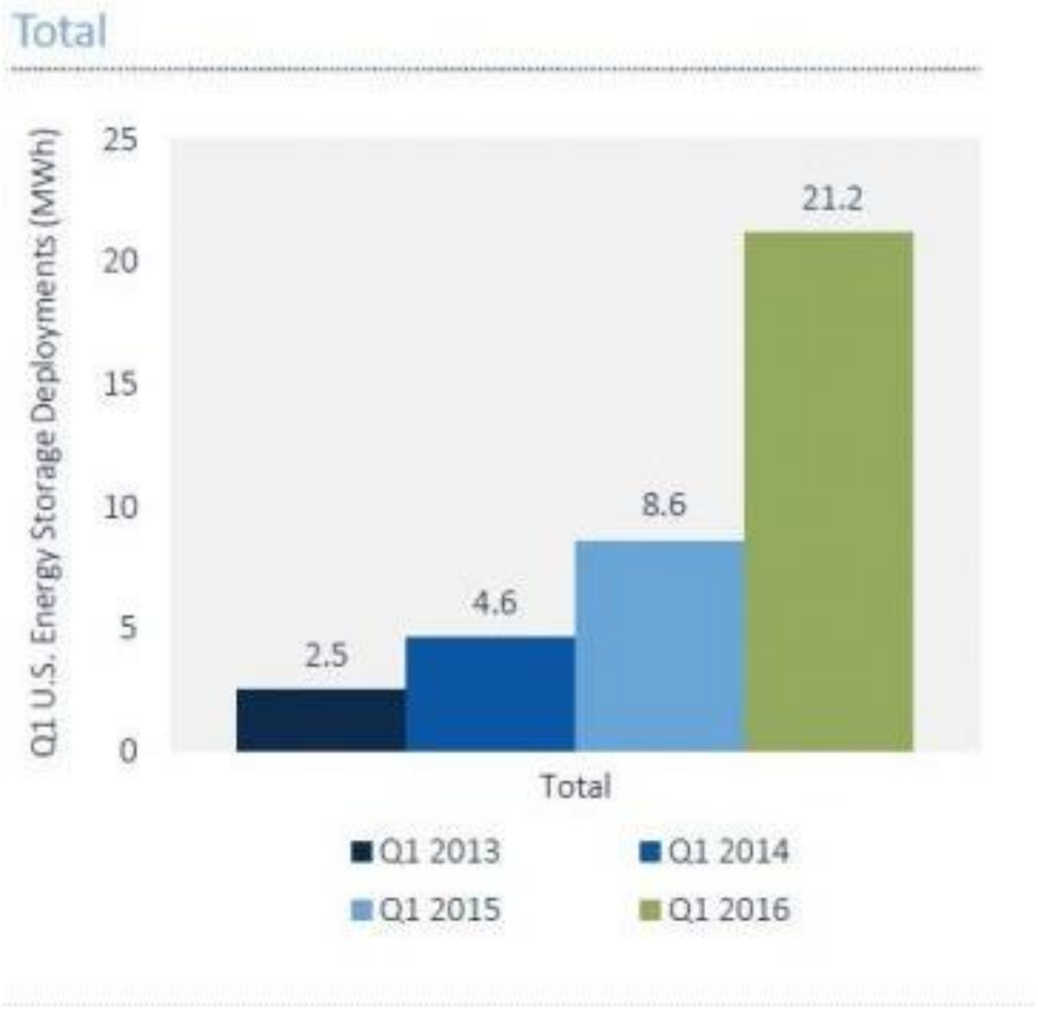
Electricity Storage Capacity in the United States, by Type of Storage Technology



Source: U.S. Department of Energy Global Energy Storage Database (accessed March 1, 2018).

U.S. Energy Storage Monitor

Delivered quarterly, the U.S. Energy Storage Monitor provides the industry's only comprehensive research on energy storage markets, deployments, policies, regulations and financing in the U.S. These in-depth reports provide energy industry professionals, policymakers, government agencies and financiers with consistent, actionable insight into the burgeoning U.S. energy storage market:



Total
Q1 U.S. Energy Storage Deployments (MWh)
25
20
15
10
5
0
21.2
8.6
4.6
2.5
Total
Q1 2013
Q1 2014
Q1 2015
Q1 2016

Environmental Impacts of Electricity Storage

- Storing electricity can provide indirect environmental benefits. For example, electricity storage can be used to help integrate more renewable energy into the electricity grid. Electricity storage can also help generation facilities operate at optimal levels, and reduce use of less efficient generating units that would otherwise run only at peak times. Further, the added capacity provided by electricity storage can delay or avoid the need to build additional power plants or transmission and distribution infrastructure.
- Potential negative impacts of electricity storage will depend on the type and efficiency of storage technology. For example, batteries use raw materials such as lithium and lead, and they can present environmental hazards if they are not disposed of or recycled properly. In addition, some electricity is wasted during the storage process.

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