



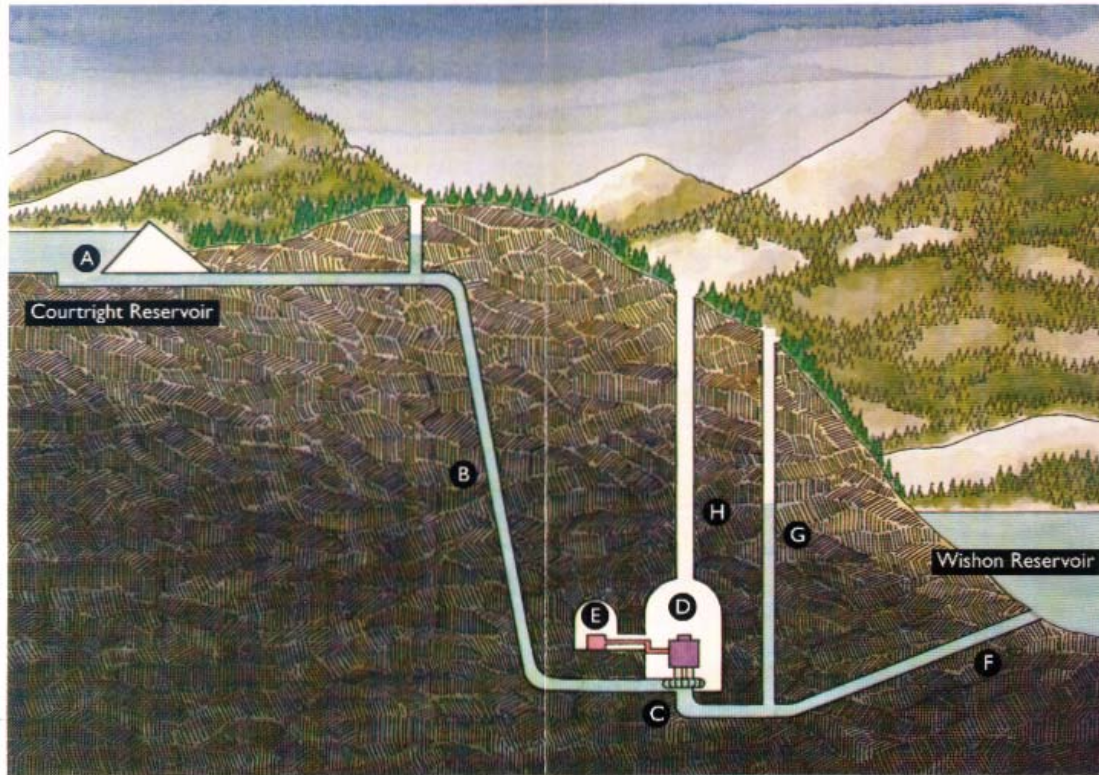
# Using Pumped Storage to Integrate Renewable Energy to the Grid

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PG&E Photo: Helms Pumped Storage Project

- Historically, Pumped Storage was used to **shape base load generation** to move bulk energy from periods of **low demand** to periods of **high demand**....We thought of it as a **Generation Resource**.
- Today, Pumped Storage looks more like a **Transmission Tool** as it **integrates new renewable** energy sources like wind and solar into the grid. This **facilitates** the addition even more renewables.
- Pumped Storage **complements** the **intermittent** nature of some renewables, **firming** these resources to ensure **stable grid operation** and reliable supply for the customer.
- Pumped Storage supports **reduction of GHG** emissions from fossil peaking or load following resources.

- **Pumped storage** is an established and widely deployed **bulk energy storage** alternative and can provide significant ancillary services functionality for **electric system stability and control**.
- **It takes time to develop, permit, license, and construct** pumped storage projects.
- There are **multiple storage technologies** in development. **Incentives** can help ongoing development of several technologies to maintain **optionality of storage solutions**.



A typical pumped-storage development is composed of two reservoirs ... situated to maximize the difference in their [water surface] levels. These reservoirs are connected by a system of waterways along which a pumping-generating station is located (see illustration). Under favorable geological conditions, the station will be located underground, otherwise it will be situated on [at] the lower reservoir. The principal equipment of the station is the pumping-generating unit. The machinery is reversible and is used for both pumping and generating; it is designed to function as a motor and pump in one direction of rotation and as a turbine and generator in opposite rotation.

PG&E illustration showing Helms Pumped Storage Project; and <http://www.answers.com/topic/pumped-storage?cat=technology>

Renewables like wind and solar may have one or more of the following characteristics:

1) Located distant from load centers

Possible solution: Expanded transmission

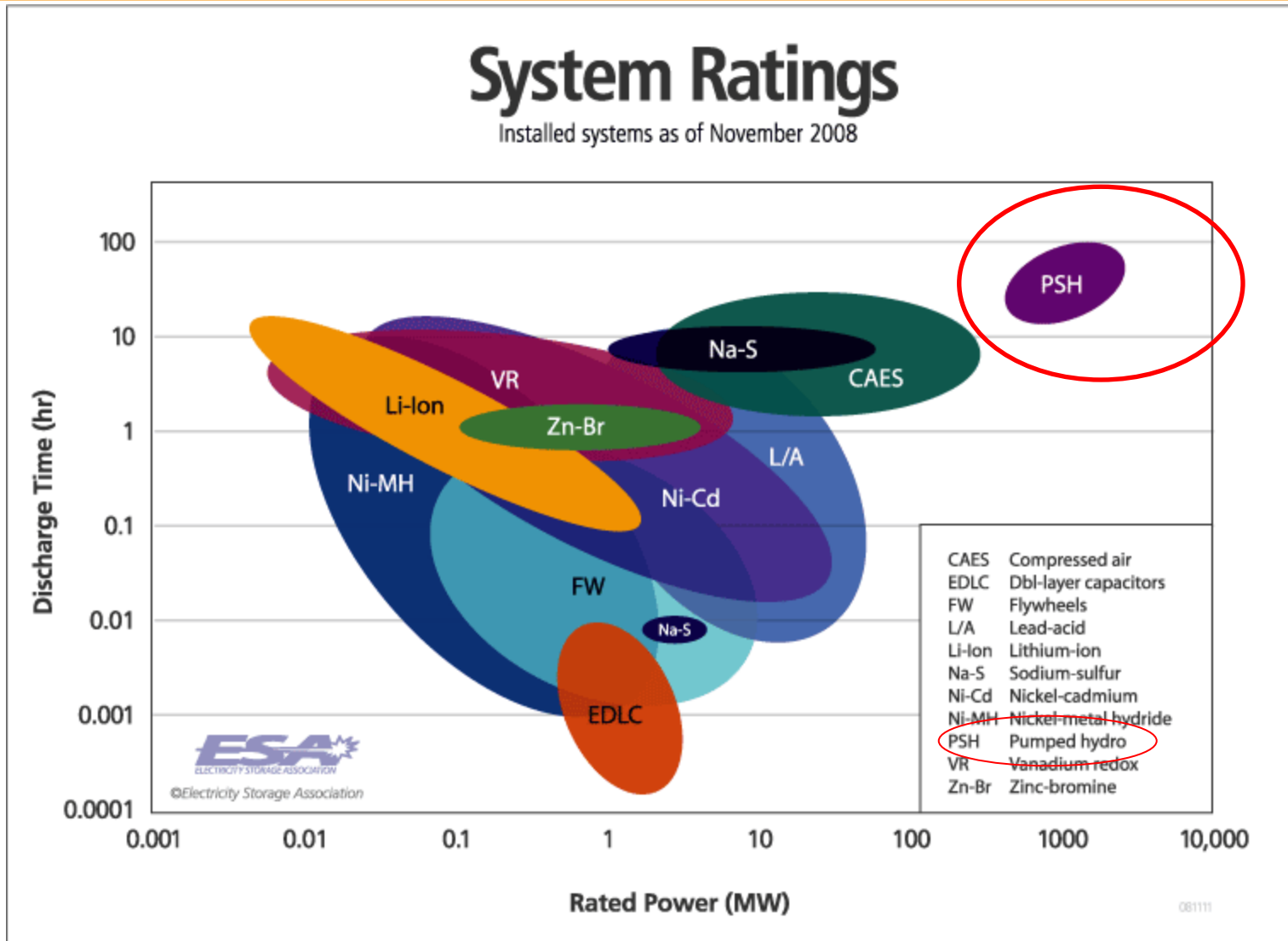
2) Peak production is not coincident with peak demand

Possible solutions: Smart Grid, **Energy Storage**, Additional Conventional peaking or shaping Generation (hydro or fossil)

3) Variable output:

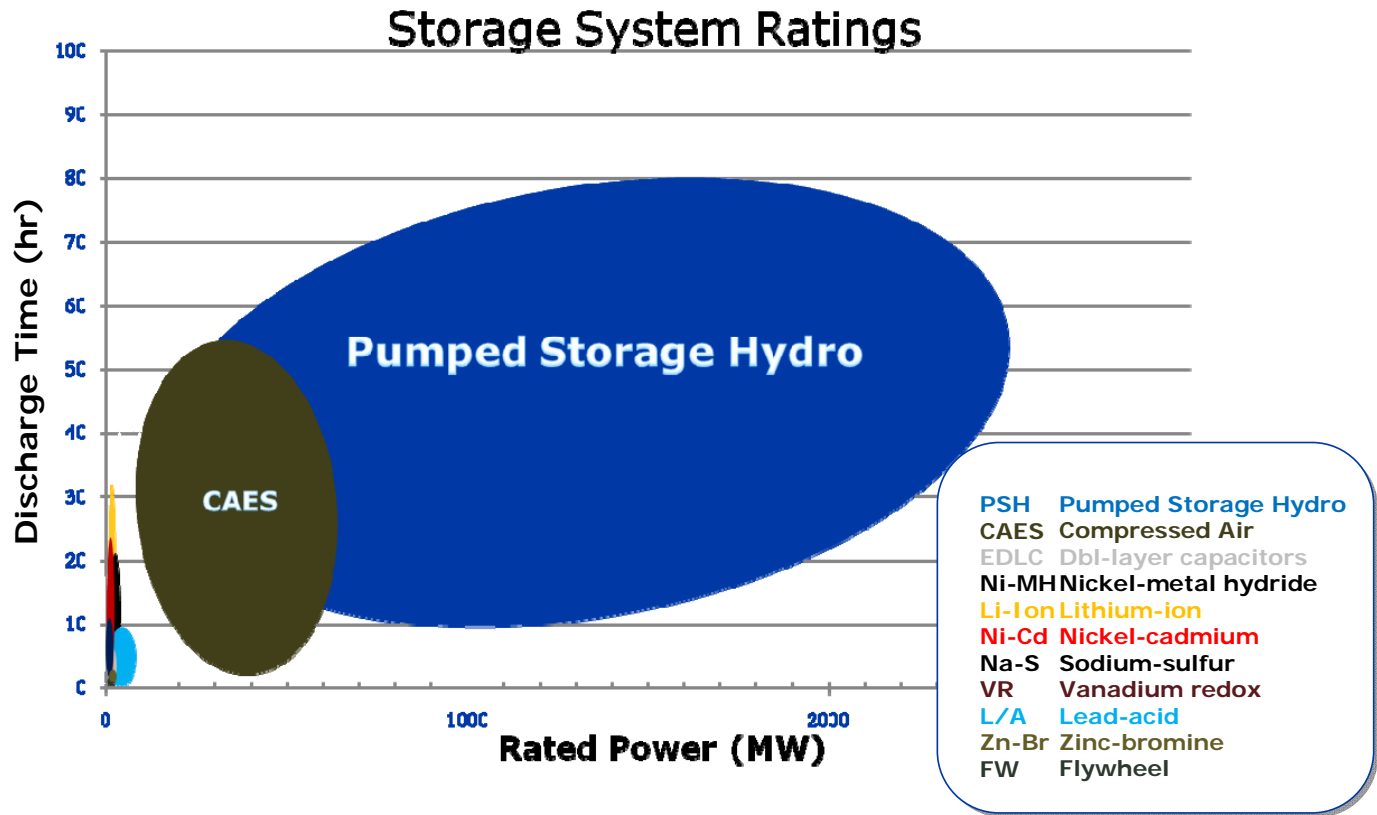
Possible Solutions: Smart Grid, **Energy Storage**, Additional Conventional peaking or shaping Generation (hydro or fossil)

# Different Storage Technologies Can Play Different Roles



[http://electricitystorage.org/tech/technologies\\_comparisons\\_ratings.htm](http://electricitystorage.org/tech/technologies_comparisons_ratings.htm) (logarithmic scale)

## Energy Storage Technologies



Same as prior graph by Electricity Storage Association (converted to normal scale by Rick Miller, HDR | DTA)



## How Does Pumped Storage Benefit Electric Customers?

- Storage of economy energy, (surplus energy) that is sometimes available at night for daily cycling or during Spring snowmelt runoff conditions for seasonal storage.
- A large amount of fast acting spinning reserve and electric system regulation capability, or generating capacity that is immediately available to meet fluctuations in electric demand and provide grid stability.
- Helps alleviate over-generation or minimum load condition by using excess energy to pump water into storage
- Reduces dependence on fossil fueled technologies and their associated greenhouse gas emissions otherwise needed to firm variable resources.
- Provides all of these functions with a very small footprint when compared to a similarly sized conventional hydro project.

## What is the Industry Doing Regarding Pumped Storage?

The FERC has recently issued **23 preliminary permits** for new pumped storage hydro projects, representing approximately 15 GW [**15,000 MW**] of new pumped storage capacity. **Another 15 applications** for preliminary permits pending before FERC could provide an additional 16 GW [**16,000 MW**] of capacity (FERC 2009a, 2009b). <sup>(1)</sup>

...these new developments are situated in key areas of the western United States, where new development of variable [**renewable**] generation sources, including wind and solar, is occurring at a rate that is challenging the capabilities of the existing transmission system to manage the variability of these resources. <sup>(1)</sup>

<sup>(1)</sup> Opportunities in Pumped Storage Hydropower: Supporting Attainment of Our Renewable Energy Goals. Rick Miller and Maureen Winters.

## What is PG&E Doing Regarding Pumped Storage?

PG&E has filed with FERC and **received preliminary permits** to investigate pumped storage opportunities at two of our existing hydro projects:

- 1) **Mokelumne**
- 2) **Kings River**

PG&E is also investigating pumped storage opportunities at our existing **Drum-Spaulding project**, which is now in the relicensing process. PG&E has notified FERC that it is including investigation of these opportunities, within the ongoing relicensing proceeding.

Handouts include:

- 1) State of California map that shows the location of PG&E's hydro assets
- 2) Mokelumne pumped storage project map showing various alternatives under evaluation.

## Licensing Cost Range:

up to \$15 to \$20 million per license over 4 to 5 years

## Installed Cost Range:

\$2,000 kW to \$3,000 kW (\$2 billion to \$3 billion for a 1,000 MW facility)  
– construction 4 to 5 years

## Benefits:

In addition to capturing the energy price difference between pump and generation modes (peak and off peak power prices), other factors being considered in valuing pumped storage are:

- **Capacity** (reliability) value
- **Ancillary services** value (ability to shift power output or demand)
- **Avoided carbon** costs

**Pumped Storage** is one of several types of storage technologies that will be important for **integrating renewable resources** to the grid which helps to **facilitate** the addition of **more renewable resources**.

**Pumped Storage** provides the MW **size** and **discharge duration** needed for large scale energy storage.

Pumped Storage development takes several years, so...**Now** is the time to step up efforts in order to deliver Pumped Storage technology as renewable supplies **are expanding—rather than waiting**.

**Waiting** could result in installing additional fossil peakers or result in a **shortfall** of important storage services that are critical to meet this integrating need.

**Taking Action** keeps Pumped Storage as a **viable option** as renewable resources expand.

Provide **incentives and other mechanisms** to encourage development of pumped storage.

Options include:

1. Investment Tax Credits
2. Staged Incentive Program – e.g. cost recovery for the development phase of projects
3. Recognize value of pumped storage in RES/RPS for firming renewable energy sources