Energy Storage Investigation at Groundwater Banks

This is a summary of the recently completed California Energy Commission (CEC) research project EPC 15-049 - the Investigation of the Potential to Add Energy Storage to Aquifer/Groundwater Storage Banks. This study investigated the feasibility and economics of adding energy storage (pumped storage) at groundwater banks. The Willow Springs Water Bank (WSWB) in Southern California was the facility chosen for the investigation.

Two different technologies were assessed. Aquifer Pumped Hydro (APH) involved using the aquifer as the lower storage reservoir and a surface storage reservoir as the upper reservoir. For APH groundwater wells will need to be retrofitted with reversible pump generators. Pumped Storage (PS) involved using a surface storage reservoir as the lower reservoir, an upper elevation reservoir as the upper reservoir, and pumps and hydroelectric generator to connect the two.

Due to the vagaries of the California hydrologic cycle, three different operating modes needed to be assessed. During Wet Years the Willow Springs Water Bank is recharging the aquifer and the projects were evaluated as a hydroelectric generator. During Idle Years the WSWB is neither recharging nor withdrawing water and the projects were evaluated as pumped storage. During Dry Years the WSWB is withdrawing water continuously and the projects were evaluated as demand response (curtailing pumping load in response to electrical system needs).

The results of the analysis are that, for both technologies, the ability to curtail/adjust pumping and participate in demand response was the most valuable resource, more valuable than the ability to generate electricity. This can be accomplished by adding a surface storage reservoir to balance out the water delivery needs when the pumps are curtailed and did not require the expenditure for generation components nor an additional higher elevation storage reservoir.

The Aquifer Pumped Hydro had a number of issues working against it. Not only are in-well reversible pump turbines significantly more expensive and less efficient than separate pumps and hydroelectric generators, but the aquifer transmissivity made the round-trip efficiency dismal. During withdrawal, a cone of depression develops in the aquifer, increasing the lift (and energy use) necessary to get the water to the surface reservoir. Conversely, during reinjection a mound develops in the aquifer, reducing the hydroelectric head for generation.

For Pumped Storage , the spread in California electricity market prices was not consistent enough to allow it to operate as pumped storage daily. The ability to participate in fast ramping and demand response was significantly more valuable than operating as a bulk energy supplier. But even the pumped storage option needed the Dry Year demand response to be cost effective.

Analysis templates and technical memos are available for review/download at:
http://www.waterandenergyconsulting.com/downloads.html