Mixed Sources and Storage

Solar and wind electricity combined complement each other. Wind tends to peak in winter and at night. Solar energy tends to peak in the summer and during the day. Absolute still windless weather tends to be sunny. Heavy clouds tend to produce more wind. With a mixed grid of mainly solar thermal electricity (with thermal storage) and wind connected by long distance transmission lines, ten hours storage compared to average use will go even further. As with wind solar plants average only a small percentage of their peak output; so we can translate that ten hours average into three hours of peak for solar as well. (That is actually conservative. Solar electricity plants average more like 20% of peak than 30%.)

The least expensive way we know to store electricity is pumped storage - much less per kWh of capacity than flow batteries or flywheels. In a pumped storage plant, a reservoir is maintained at a significant elevation above a water source such as a lake or river. When excess power is available, water is pumped up to that reservoir. To recover that power, the water is simply dropped through a pipe into a hydroelectric generator then dumped back into that water source.

Conventional pumped storage is ecologically extremely damaging; in some cases it can dwarf even conventional hydro for in the destruction it causes. In North America the best conventional pumped storage sites are in use in any case. A more recent technique called modular pumped storage is both less ecologically harmful, and can be placed where conventional pumped storage can't. Modular pumped storage creates two artificial reservoirs an upper and a lower one. The lower reservoir is charged only once. Water is pumped between the two in a closed cycle. Operating water is only needed on a small scale to replace leakage and evaporation. Since such a system is not continuously draining rivers or lakes, it does not need to be near a major water source. You can place it anywhere you have sufficient differences in elevation, even in the desert. The price should be at high end of the Electricity Storage Association's estimate for a pumped storage cost range -- ~$150 per kWh of capacity[282].

So you would need about $450 worth of pumped storage per KW of peak wind and sun electricity. Those capital costs could add as much as 2 cents to each kWh, depending on how it was used in practice. O&M (excluding electricity costs) adds another quarter cent. In addition, you lose about 25% to 30% of each kWh you put into storage to friction, evaporation, and leakage. One third of power would go to base load without passing through storage. If you balanced amounts of wind and solar sources cleverly, a significant amount would also go directly into the grid to meet some peaking and load following needs. Also smart-grid technology would allow some of the load to follow production rather than requiring all of production to follow the load. If we had substantial all-electric and electric plug-in hybrid vehicles, a substantial portion of the power they used could probably be accepted on an as-available basis. Still, between half and 60% of production would probably need to come from storage. If we take the high figures (30% of 60%), that means we would lose 18% of our 5 cents per kWh electricity. We can round up to another 1 cent per kWh. So, total costs from storage would be around 3.25 cents per kWh.

End Notes

[282] Electricity Storage Association, *Electricity Storage Association - Technology Comparisons - Capital Cost*. 27-Oct 2005, Electricity Storage Association, 20-Jan-2008 <http://electricitystorage.org/tech/technologies_comparisons_capitalcost.htm>.