The Holy Grail of Battery Storage

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By Roger Andrews

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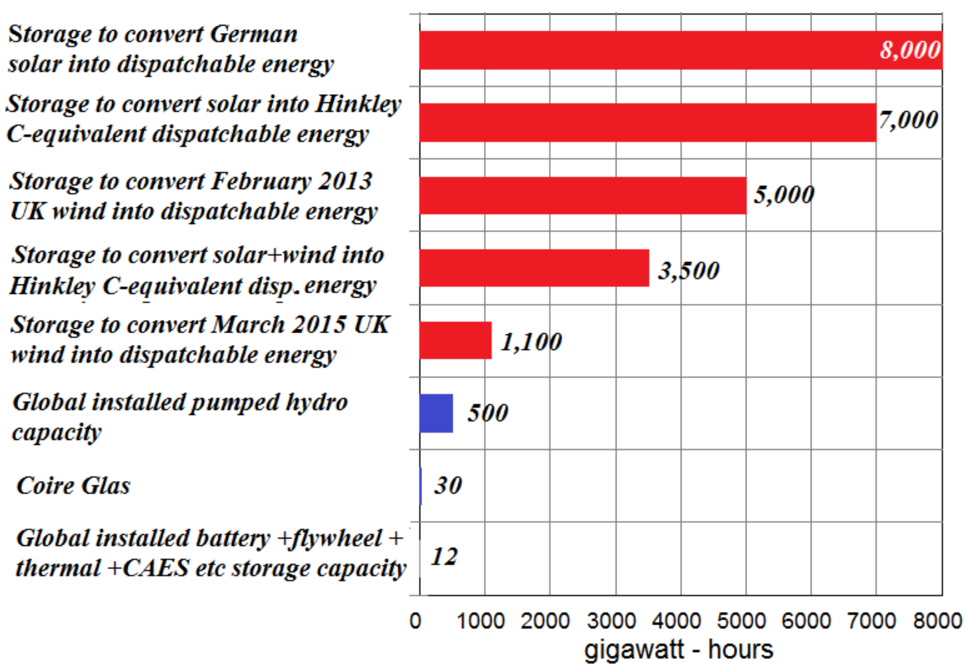
A recent Telegraph article claims that storage battery technology is now advancing so fast that “we may never again need to build 20th Century power plants in this country, let alone a nuclear white elephant such as Hinkley Point” and that the “Holy Grail of energy policy” that will make this solution economically feasible – a storage battery cost of $100/kWh – will be reached in “relatively short order”. This brief post shines the cold light of reality on these claims by calculating battery storage costs based on the storage requirements for specific cases estimated in previous Energy Matters posts. It is found that installing enough battery storage to convert intermittent wind/solar generation into long-term baseload generation increases total capital costs generally by factors of three or more for wind and by factors of ten or more for solar, even at $100/kWh. Clearly the Holy Grail of energy policy is still a long way off.

First a simple calculation. $100/kWh = $100,000/MWh = $100 million/GWh = $100 billion/TWh. If everyone is happy with this we can proceed. (Note that all the costs listed in this post are in US dollars unless otherwise specified).

In the Is large-scale energy storage dead? post I presented this graph:



The procedures used to estimate these storage requirements are described in these posts:

- Large scale grid integration of solar power – many problems, few solutions
- Hinkley Point C or solar, which is cheaper?
- Estimating storage requirements at high levels of wind penetration

Multiplying the storage capacities shown in the Figure by $100 billion/TWh gives the following battery installation costs. Wind and solar installed costs (both estimated at $2,000/kW) are from IRENA :

> Battery storage needed to convert Germany's 2013 solar generation to baseload: *$800 billion, about 13 times the $66 billion cost of installing the ~33GW of solar capacity involved.*
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> Battery storage needed to convert solar generation equal to a year of Hinkley nuclear generation to baseload: *$700 billion, about 28 times the ~$25 billion cost of the Hinkley plant.*
>
> Battery storage needed to convert solar + wind generation equal to a year of Hinkley nuclear generation to baseload: *$350 billion, about 14 times the cost of the Hinkley nuclear plant.*
>
> Battery storage required to convert one month of UK wind generation to baseload: *up to $500 billion, over twice the $200 billion cost of the ~100GW of wind capacity involved. (Note 1: storage requirements for a complete year would likely be significantly higher. Note 2: the lower-storage options discussed in the "estimating storage requirements" post are achieved by increasing wind capacity and curtailing large amounts of wind power.)*

I added a small project– Gorona Del Viento – to round the estimates off. During its first year of operation GdV generated only about half the wind energy needed to fill El Hierro annual demand, but had it generated 100% of it then 10GWh of storage would have been required to store the wind surpluses for re-use in windless periods. The cost of installing this much battery storage is $1 billion, approximately ten times the €82 million euro project capital cost.

And how good are my storage estimates? Well, the late Sir David Mackay, at the time DECC's Chief Scientific Adviser, confirmed some of them in a comment on the "estimating storage requirements" thread:

> Your calculations agree with my back-of-envelope estimates. In SEWTHA Ch 26 I said "imagine we had 33 GW of wind capacity, delivering on average 10 GW"; I reckoned that ballpark of 1000 GWh of storage would be needed ….

Mackay's estimate gives a ballpark battery cost of $100 billion, not quite twice the $66 billion cost of installing his 33MW of wind power but again well in excess of it.

Clearly large-scale battery storage will remain uneconomic even at the Holy Grail price of $100/kWh. So why do battery companies, research institutes and greens claim the opposite? Because they assume that the intermittency problem can be solved simply by installing enough storage to balance daily load fluctuations. A large amount of storage isn't necessary to do this, and $100/kWh batteries might indeed be able to supply it without breaking the bank. But they ignore the much larger amounts of storage that are needed to keep the electricity coming during extended windless periods and/or to flatten out seasonal variations in solar output. Why? I see two possible explanations. First, they are being carried along in a wave of visionary enthusiasm and haven't recognized it as a problem; second, they know about it but don't want to tell anyone because it might spell the death of large-scale storage battery research, and ultimately maybe the death of intermittent renewables too. I'll let the readership make up their minds as to which it is.