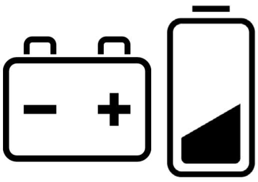
BACKING UP THE PLANET - WORLD BATTERY STORAGE

If the future demand for storage is met by batteries, how large is the challenge to provide grid-scale backup to the electricity supply?

Global demand for new technology battery storage is increasing, driven in part by growing numbers of electric vehicles. Demand for stationary battery storage, whether at residential or grid scale, is also expected to see strong growth.

23,537 TWh

In 2014, the total world demand for electricity was 23,537 TWh, or 0.045 TWh per minute. If we took the world's entire battery production capacity in the year 2014 we could store 11 minutes and 27 seconds of global electricity demand. Lead-acid batteries (the typical 12 volt accessory battery in most motor vehicles) would contribute the majority of this capacity, providing 10 minutes and 41 seconds of electricity, while lithium-ion batteries would contribute 46 seconds.



$11\frac{1}{2}$ minutes

Future grid-scale storage is likely to be based on technologies other than lead-acid.[1] To get an idea of the scale needed for lithium-ion batteries (representative of future battery storage technologies) to contribute significantly to grid-scale backup, consider the planned Tesla lithium-ion production facility, the 'Gigafactory'.

184 Gigafactories

The first Gigafactory will commence battery production in 2017. When full production capacity is reached[2] its annual output will add 47 seconds to global electricity storage capacity (at present demand) and double the entire 2014 production output.

Imagine a global blackout of grid-scale electricity supply. How many Gigafactories would it take to store enough electricity for an entire day? Assuming an in-service battery life of ten years[3], by aggregating ten years of world battery production:

184 Gigafactories would be required to produce sufficient lithium-ion batteries to power the world for one day. For a 5-day global backup, 920 Gigafactories would be needed.

These figures indicate the scale of the future battery demand for grid storage. In practice, the number of Gigafactories required is likely to be less than shown here. This is because other storage technologies such as hydrogen and pumped hydro will supplement backup power generation. Highly efficient long-distance transmission will also reduce the impact of geographic power variability.

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CALCULATION NOTES AND ASSUMPTIONS

In 2014, world battery production was dominated by lead-acid batteries for the automotive industry. It was estimated that global lead-acid production[4] in 2014 was 478 million kVAh (0.478 TWh).[5]

The total world production of lithium-ion batteries in 2014 was 0.034 TWh.[6]

In 2014 the total world demand for electricity was 23,537 TWh, or 0.045 TWh per minute. The minutes of battery storage then comes to:

$$\text{Minutes of storage} = \frac{0.478 \times 10^{12} + 0.034 \times 10^{12}}{0.045 \times 10^{12}} = 11.44 \text{ minutes}$$

At full production capacity, the Tesla Gigafactory is expected to produce 0.035 TWh per annum, or a doubling of the entire 2014 lithium-ion battery production.

If we assume that lithium-ion battery technology is scaled up and lead-acid growth remains stagnant, with time we can ignore the contribution of lead-acid[7]. We also assume that a typical battery has an in-service life of 10 years, and production output is cumulative over 10 years. How many Gigafactories do we need to achieve one full day of electricity storage?

$$n_{gigafactory} = \frac{\text{minutes in day}}{10 \times \text{minutes for 1 gigafactory}} = \frac{1440}{10 \times 0.78} = 184$$

Future production of lithium-ion batteries at this scale would greatly exceed present lead-acid battery output.

Scaling to *n* days is now just a factor of *n* x 184 Gigafactories. So for a 5-day global backup, 920 Gigafactories would be needed.

1 Most lead-acid batteries are used in vehicles and are not designed for deep cycle energy storage.
2 Estimated to be by 2020.
3 Current lithium-ion batteries can be cycled around 1000 times before serious degradation, or failure. Grid backup will not require deep cycling every day of the year.
4 Source (June 2016): http://www.reportlinker.com/p03548160-summary/Global-and-China-Lead-acid-Battery-Industry-Report.html
5 We have assumed the storage capacity from other battery technologies (Ni-Cd, Ni-MH, flow) is insignificant. Ni-MH are still widely used for electric vehicles with an estimated annual production of 0.002 TWh per annum Source (June 2016): http://insideevs.com/toyota-to-increase-nimh-production-capacity-to-1-4-million-packs-for-hybrids/
6 This represents all applications for lithium-ion batteries.
Source (June 2016): https://www.teslamotors.com/sites/default/files/blog_attachments/gigafactory.pdf
Source (June 2016): http://www.visualcapitalist.com/the-lithium-ion-megafactories-are-coming-chart/
7 Growth in lead-acid battery production is expected to stagnate, as lithium-ion batteries are substituted. Source (June 2016): http://www.reportlinker.com/p03548160-summary/Global-and-China-Lead-acid-Battery-Industry-Report.html