The Tesla Battery—An Electricity Storage Technology with Potentially "Disruptive" Implications

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By David Von Hippel and Peter Hayes

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I. Introduction

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II. Policy Forum by David Von Hippel and Peter Hayes

The Tesla Battery—An Electricity Storage Technology with Potentially "Disruptive" Implications

Although "energy storage" made it only to #8 in terms of estimated year 2025 economic impact on a list of "disruptive technologies" published by McKinsey and Company[1], the high-capacity, relatively low-cost battery for home and business use recently announcement by internet, electric vehicle, and space flight mogul Elon Musk[2] has the potential to drastically affect the future of the electric power industry and beyond. Combined with rapidly falling costs for generating power from wind, and particularly, solar energy, advances in the efficiency of lighting and other electricity end uses, "smart grid" technologies, and other considerations, the availability of cheap bulk electricity storage has the potential to drastically change choices for power provision in Northeast Asia and the rest of the world. How the impact of the Tesla battery and related energy storage developments play out for traditional sources of power—including coal-fired and nuclear plants—will be fascinating to observe, and may force some hard choices and harder changes on the part of electric utilities.

Disruptive technologies have the potential to transform the way that people live and work, and to change how business is done in one or more industries, including, sometimes, upsetting the established order of an industry.[3] The electric utility industry is quite often one of the most conventional and stable (or alternatively, inflexible) in any nation, traditionally focusing almost entirely on using large central-station power plants to meet customers' electricity requirements. In the last few decades, this pattern has begun to change in some countries, first with the advent of integrated resource planning, with its emphasis on long-range planning, incorporation of environmental impacts, and consideration of non-traditional ways of serving customers, such as through demand-side management programs and renewable power sources. More recently, the introduction of “smart grid” concepts and technologies, facilitating communication between supply- and demand-side technologies, allowing resources and infrastructure to be used more efficiently, and more tightly binding the activities of the utility to that of its customers, has pushed the utility industry—in some places, at least—further into previously uncharted territory.

The Tesla Powerwall battery, to be built at Tesla’s “Gigafactory” in Nevada, in the western United States, and designed for home and small business, has the potential to demand further change of the utility industry, perhaps in some places shifting electricity provision to an entirely different business model. The Powerwall system measures 0.9 x 1.2 meters, and is designed to be wall-mounted, sticking out about 18 cm. Two versions of the battery have rated capacities of 7 and 10 kilowatt-hours (kWh) of electricity. The 7 kWh model could store the average daily electricity output from a one kilowatt (kW) solar photovoltaic array in a sunny place, or the output from a two-kW array in a not-so-sunny place (such as Seoul or New York). One 7 kWh system would not be sufficient to power an electric space or water heating system in a home, except for a short time, or run an air conditioner for very long, but could comfortably support the lights (assuming efficient lighting, such as light-emitting diode—LED—bulbs), electronics, and other appliances in a modest-sized modern home. Powerwall units can be added together to store more electricity and serve larger loads. At about $3000 per unit, these large batteries are not inexpensive, but as has been the case with solar PV systems, the price is slated to fall as production ramps up.[4]

The Powerwall system, and the inevitable battery technology competitors and imitators that will follow (and indeed are in many cases already on the way), offer disruptive possibilities across the spectrum of electricity supply models. For remote places in the developed or developing world, these batteries offer the possibility of off-grid power systems using renewable generation (wind, solar, or mini/micro-hydro) at costs lower than the costs of extending the grid. A 7 kWh battery system, coupled with one or more kW of solar power, could provide an evening’s electricity for lighting, communications, and entertainment, and perhaps a shared refrigerator, for a village of maybe 10 households in a developing country, again at a cost far less than that of grid extension, and scalable to provide for a larger village power system. For villages now depending on fuel-based lighting, the savings in kerosene costs, and the reduction of indoor pollutant emissions, are additional reasons why a battery/renewable-power system would be attractive.[5]

On existing distribution grids, coupled with smart-grid technologies, utilities could arrange to control their customers’ batteries (and/or battery arrays of their own) to provide peak power when needed, reducing the need to own and run expensive (usually gas- or oil-fired) peaking capacity.[6] With the wide availability of large-capacity batteries, tests as to the efficacy of using storage batteries to address peak power needs could be run quickly and cheaply. The widespread availability of batteries on the grid can also help to overcome the intermittency of grid-connected (distributed and central-station) renewable power sources, allowing renewables to play a larger role in supplying grid power without (or with less) reliance on expensive fossil-fueled backup power. In East Asia, this could include storing in batteries for use at peak times electricity imported from sunny or windy places far away, such are Mongolia or Australia, thus further reducing reliance on fossil-fueled generation.[7]

In sunny (and, in some cases, not-so-sunny) places, particularly where electricity costs are high, as battery availability and convenience increases, and battery and PV prices decline, many homes may in fact choose to leave the power grid, retaining (or not) the grid as a back-up system only. Widespread grid defection, unless it is adjusted to by the utilities in a timely manner, may leave increasingly smaller pools of consumer paying for large fixed costs (power plants and transmission and distribution infrastructure), requiring increases in rates (perhaps driving more customers to go off-grid) and/or increased government subsidies for the power sector. Another not-insignificant early adopter of battery power systems is likely to be the militaries of the world, especially those (like the US Armed Forces) with missions across the globe. In military applications the costs of portable power systems are much less of an issue than for typical consumers, and freedom from the need for fuel resupply is a major advantage.[8] Also not to be overlooked are the benefits of battery electricity storage in emergency situations, such as when grid power is lost due to technical malfunctions, extreme weather events (including, for example, those linked to a changing climate), and other natural disasters, such as earthquakes. Here, in addition to batteries stockpiled specifically to provide humanitarian relief in times of crisis, batteries used on a routine basis will also serve in times of crisis.   Studies have shown that the value of emergency electricity under such circumstances—to maintain communications, keep businesses open, to run key processes such as waste-treatment, water pumping, and industrial processes, and to keep households functioning, for example—can be up to 100 times its average retail price. In this case, storage technologies would build upon the disaster-resilience of the renewable power systems, including distributed renewable systems, that will likely increasingly be coupled with them.[9]

Perhaps the first places to experience widespread grid defection will be places like Hawaii in the US, with excellent solar resources and very high retail electricity costs, or like Japan, with high electricity costs (though a modest solar resource), and a populace with the wherewithal and drive (post-Fukushima) to seek alternative power sources. It is also interesting to consider what might happen if dramatically lower prices for renewable power sources and batteries, perhaps 5 – 10 years from now, coincide with an agreement between the international community and the Democratic People's Republic of Korea (DPRK) in which the latter agrees to phase out its nuclear weapons program in exchange for energy sector and other economic aid. Could the badly-needed refurbishment/replacement of the DPRK transmission and distribution grid be at least partially avoided, and its cost and complexity reduced, by installing battery/renewable power micro and mini-grids, particularly in rural areas, leaving only bigger cities to be powered by central-station generation plants? The DPRK would thus "leapfrog" past the central station utility model for some of the country. This hybrid rural/urban approach might be the quickest way to bring substantial re-electrification to most of the country.

A fascinating process to watch regarding electricity storage is its effect on the nuclear power industry. On one hand, one could see potential synergies between nuclear power and battery storage, with batteries storing nighttime generation from nuclear units for use at peak times, thus allowing peak loads to be met substantially fossil-free. But with less fossil resources on the grid, arrangements would have to be made to provide grid support for nuclear power units, particularly in smaller, less connected national grids. Presumably, with enough batteries controlled by the utility—they could be owned by either the utility or consumers—and a smart grid in place, sufficient grid support and power back-up could be provided for continued safe operation of reactors. But that scenario requires further investigation. On the other hand, it is more than possible that falling prices for batteries and renewable electricity generation could make the huge and often risky investments in new nuclear power plants even less attractive, particularly with the issues associated with nuclear spent fuel and waste management still substantially unresolved in all but a small handful of countries. The United States, Japan, Taiwan, and the Republic of Korea (for example) are all certainly in the "unresolved" camp. A recent article[10] reporting on a debate over the future of nuclear power quoted one of the participants, nuclear critic Arnie Gundersen, responding to his nuclear advocate opponent, as saying "We all know that the wind doesn't blow consistently and the sun doesn't shine every day, but the nuclear industry would have you believe that humankind is smart enough to develop techniques to store nuclear waste for a quarter of a million years, but at the same time human kind is so dumb we can't figure out a way to store solar electricity overnight.

To me that doesn't make sense." Others have suggested that coal-fired generation, already under pressure as the US and other nations seek to reduce emissions of greenhouse gases and other air pollutants, could similarly be imperiled by advanced low-cost electricity storage technologies.[11]

If past experience with other new electricity technologies (and, for that matter, policies related to the electric sector) are any guide, some utilities will seek to slow or block the spread of the use of storage batteries and related technologies through simple neglect and/or technical interconnection rules that make adoption of the technology difficult for consumers. Some utilities may simply be bowled over by the technology, and require some form of government/consumer bail-out or protection as their customer base wanes. Some utilities will embrace the new technologies, adopt new business models, develop new expertise, and thrive. How the combination of the new electricity storage technologies, grid extension/redevelopment in some nations, nuclear power issues, and a host of other evolving considerations manifest themselves with regard to the utility industry will be different from country to country, but should be intriguing to observe.

Image source: Reuters

III. References

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[3] See, for example, Peter Hayes (2010), "Transformative Technology for a Sustainable Future", *Global Asia*, Volume 4, No. 4.

[4] In addition to falling prices, the continued appeal of battery systems will also depend on demonstration that battery units can be built sustainably with regard to resources needed to produce them and with regard to the environmental impacts of battery production.

[5] Displacing low-efficiency, polluting fuel-based lighting in developing countries with LED bulb/solar PV/battery systems has been the focus of Lawrence Berkeley National Laboratory's Lumina project—see http://light.lbl.gov/.

[6] Plug-in battery-powered electric vehicles could similarly be used, via a smart grid, to provide peaking power when the vehicles are parked.

[7] A number of articles in recent issues of the Center for Energy, Governance and Security *Monitor* have touched upon pan-Asian opportunities for trade in renewable electricity between countries. See, for example, "Opportunities beyond the Australian Energy White Paper", by Samantha Mella and Geoff James (Volume 3, #4, April, 2015), "Mongolia's Future Energy and Economic

Development: Today's Complex Choices Will Have Long-term Ramifications", by David Von Hippel ,Chogdon Oyunchimeg, Jargal Dorjpurev, and Tsegmid Sukhbaatar (Volume 3, #3, March, 2015), and "Does Australia Energy Export Future Lie with the Asian Supergrid?", by Samantha Mella (Volume 3, #2, February, 2015).

[8] See, for example, Patrick Tucker (2015), "Here's What the New Tesla Battery Means for the Military", *Defense One*, May 5, 2015, available as http://www.defenseone.com/technology/2015/05/heres-what-new-tesla-battery-means-national-security/111928/.

[9] Distributed renewable generation, as well as (for example) building energy efficiency measures and solar thermal measures, contribute to disaster resilience because their distributed nature makes widespread outages in the event of an emergency unlikely. See, for example, Bill Young (2013), "Renewable Energy to the Rescue", *Solar Today*, March 21, 2013, available as http://solartoday.org/2013/03/renewable-energy-to-the-rescue/.

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