



Energy storage

50% – increase in energy stored in Lithium-ion batteries

\$5 billion – cost of the Tesla ‘Giga Factory’

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Storage, and particularly electricity storage, is the missing piece in the renewables jigsaw. If solved, it can enable truly distributed solar energy as well as accelerate the electrification of the transport industry.

After years of rising prices and increasing demand, there is change in the air for energy supply, with many seeking to accelerate the shift to renewables. Although there are short-term factors in matching current supply and demand in varied regions, most agree that long-term we will move to a renewables-based energy system. At the moment solar energy is playing a small role, contributing around 0.6% of the world's energy mix, but is expected to increase to between 5% and 20% by 2020 (depending on whose view you believe). The key variable is around cost. Today in some regions solar is already comparable with the cost of electricity from natural gas, in others government subsidies are used to make it competitive.

Successful transformation of the energy system is increasingly being linked with development and scaling of storage solutions. There is much optimism that substantial improvements in energy storage will be achieved over the next decade. There are though several misconceptions around energy storage – in particular that, by itself, it will not transform the energy system overnight as it will take many years or even decades to shift from fossil fuels to renewables. The existing energy system is not designed for renewable energy – rather it is focused around fossil fuels which simply hold their energy until ignited.

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Controlling how and when energy is provided is implicitly linked to our ability to store it, especially so in locations where energy demand is not in sync with supply – whether that be from solar, wind or wave renewables or a wider energy mix. People have been looking forward to the advent of smart energy grids for some time and having two-way transmission of electricity between supplier and consumer is a core element of this. Today the main options for large-scale energy storage are pumped hydro-storage and batteries. California's Inland Empire Utilities Agency uses spare energy capacity at periods of low demand to pump water up mountains so that it can be released at peak demand and turned back into electricity using conventional hydroelectric turbines.

Meanwhile, though, the role that batteries can play in displacing other energy solutions, even with incremental change, can be significant. Battery costs are falling steadily – they have halved in the last five years. In the past, batteries have been made from materials such as lead-acid and nickel-cadmium. Highly toxic, some of these ingredients are also bulky and heavy. The rechargeable lithium-ion battery helped slim them down and these batteries now power not just smartphones and laptops but also power tools, electric cars and drones. Lithium-ion batteries have been steadily getting better and, with improved chemistry and production techniques, the energy stored in them has increased by 50%.

Interconnected systems



For some applications, such as electric cars, a better battery would be transformative. Until recently the battery for an electric car could cost \$400-\$500 per kilowatt-hour, perhaps 30% or so of the overall cost of the vehicle. General Motors (itself involved in about a dozen battery storage projects) expects the battery in its latest Chevy Bolt electric car to cost around \$145 per kilowatt-hour; once costs come down to around \$100 per kilowatt-hour, electric vehicles will become mainstream because they will be able to compete with petrol cars of all sizes without subsidy.

Other organisations are looking at a more radical change in the technology. Sakti3 focuses on a lithium-ion battery with a solid electrolyte that offers about double the energy density; Dyson, the British inventor of the bag-less vacuum cleaner, recently bought the company. As Dyson expands into domestic robotics, expect to see solid-state batteries in the mix. And, with further engineering, maybe in electric cars and grid storage too; in large volumes, such solid-state batteries should cost around the target \$100 per kilowatt-hour.

Many research groups around the world are hoping for battery breakthroughs. 24M, a Massachusetts start-up, is using nanotechnology to develop a cost-effective “semi-solid” lithium-ion battery, while over in Cambridge, UK, there is much expectation from a new lithium-air cell that has overtaken current lithium-ion batteries in the amount of energy stored per kg. A spin-off of Carnegie Mellon University, Aquion Energy’s nontoxic, saltwater-based batteries are designed to deliver high-performance storage while avoiding the expensive maintenance of competing chemistries such as lead-acid. South Korea’s LG Chem is building on its experience supplying lithium-ion batteries for electric cars to provide residential, commercial and industrial stationary batteries. Alongside LG Chem, numerous other big lithium-ion battery producers, such as BYD, Johnson Controls, Panasonic, Samsung and Sony, are partnering solar installers, inverter manufacturers and innovative product integrators.

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Perhaps most significantly however, SolarCity, the largest residential PV installer in the U.S., is rolling out storage systems relying on lithium-ion batteries supplied by electric carmaker Tesla — whose CEO and founder, Elon Musk, is also SolarCity's chairman. The duo's entry into stationary energy storage is significant. SolarCity hopes to offer its solution to enable residential customers to take advantage of time-of-use rates, ancillary services and PV system interaction. It is spearheading a 200-kilowatt project to store energy from rooftop solar arrays at Tesla's factory in Fremont, with the aim of helping Tesla offset millions of dollars in demand charges.

Tesla (with its Japanese battery supplier, Panasonic) is building a \$5 billion lithium-ion battery factory in Nevada - the 'Giga Factory'. A new Tesla battery, Powerwall, can be used to store solar electricity generated at home, as well as lower electric car costs. Some see Tesla as much as an energy storage company as a manufacturer of electric cars.

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Some solar industry leaders see that within the next couple of years consumers will no longer be buying solar systems on their own, but rather a complete energy system, consisting of generation, storage, load-management and an app - all leveraged through big data analytics in the cloud. Each consumer will take more responsibility for storage, generation and usage, but do it in such a way that is less expensive than pure utility energy while the utility has access to what it needs to, to make sure that it plays well on the grid.

Tesla's Elon Musk highlights the possible network benefits of "system-wide implementation" of energy storage, including flattening peaks of electricity demand which could lead to far less conventional generation power plants being required – "you can basically, in principle, shut down half of the world's power plants if you had stationary storage, independent of renewable energy."

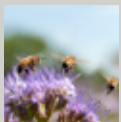
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Air quality



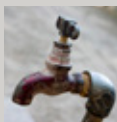
Rising air pollution in many cities is killing people and becomes a visible catalyst for changing mind-sets and policies across health, energy, transportation and urban design.

Full cost



Increasing transparency of society's reliance on nature, intensify requirements for business to pay the true cost of the resources provided by 'natural capital' and so compensate for their negative impact on society.

Key resource constraints



Economic, physical and political shortages of key resources increase and drive increasing tension between and within countries. As we exceed the Earth's natural thresholds, food and water receive as much focus as oil and gas.

Speed to scale



Greater global connectivity, growing consumer wealth and broader reach all combine to accelerate the time to 1bn customers and a \$10bn valuation for start-ups and new corporate ventures alike.