Trends in renewable energy and storage

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1. Summary

This short narrative is a readable overview of next steps that can be taken to improve the cost and performance of renewable electricity technologies, a modernized electric grid, and energy storage.

2. Solar

Chinese manufacturing policy has created a global glut of solar panels. There is a production capacity of 60GW while the global market can only support ~35GW. Local markets, say in California, can absorb some of this over-supply because there are government mandates for grid-level PV. But this is a false economic position in the long-haul to support renewable energy. *The long-haul opportunity is in the "balance-of-systems" cost reductions driven by companies that invest in "design-for assembly*." Recent evidence indicates that the these latter costs vary considerably – for example in the US the module installation cost is 5 cents per watt whereas in Europe it might be half this amount. Opportunities exist for investing in design-for-assembly methods and manufacturing technologies that will close such cost-gaps.

3. Wind

The U.S. wind industry is also too vulnerable to uncertain government policies. Once the federal tax-credits ran out in 2013 the market declined precipitously, only to bounce back with last minute re-instatement of the credits. With the long-term outlook for wind tax incentives so uncertain, industry will need to cut costs in order to maintain current rates of growth. One exciting opportunity area is investing in computer-aided-design, computer-aided-manufacturing, planning, simulation, and analysis tools. These give a 30% reduction both in overall production cost and time to market; 25% savings in plant and facility layout; 30% cost saving in labor utilization; 35% cost savings in optimized material flow; 15% savings in improved quality from validation of processes prior to production. In a related product-line, Boeing designed the 787 aircraft through extensive use of such software. Software codes were used to replace extensive wind tunnel testing of physical models. Only once the codes produced an optimized design, a physical model was built and tested. The resulting design is very fuel efficient (fuel savings of up to 30% are expected) because of the lighter-weight carbon-fiber construction. Other impacts are the reduced design time and the energy and cost savings that result from fewer wind tunnels and other physical testing. *In summary, the investment opportunity is to obtain long-haul efficiency and cost gains (ideally greater than the 2.3cent/kWh from the federal-government tax credit) from the use of computer-aided-design, computer-aided-manufacturing, planning, simulation, and analysis tools.*

4. Grid and renewables and analytics

The U.S. electric power infrastructure is undergoing a dramatic change from a load-following architecture to one that requires improved control and monitoring of both energy-supply and energy-demand. Integration of intermittent renewable resources requires new technology products and services to leverage supply-side intermittency (such as new designs of synchrophasors). Demand Response (DR) initiatives, as well as other load shedding efforts, are being implemented throughout the country to allow some control of the aggregate electric loads to reduce peak demand. Enhanced sensing and monitoring at the individual load level are then needed to allow further control and to defer non-essential loads during a DR-event.

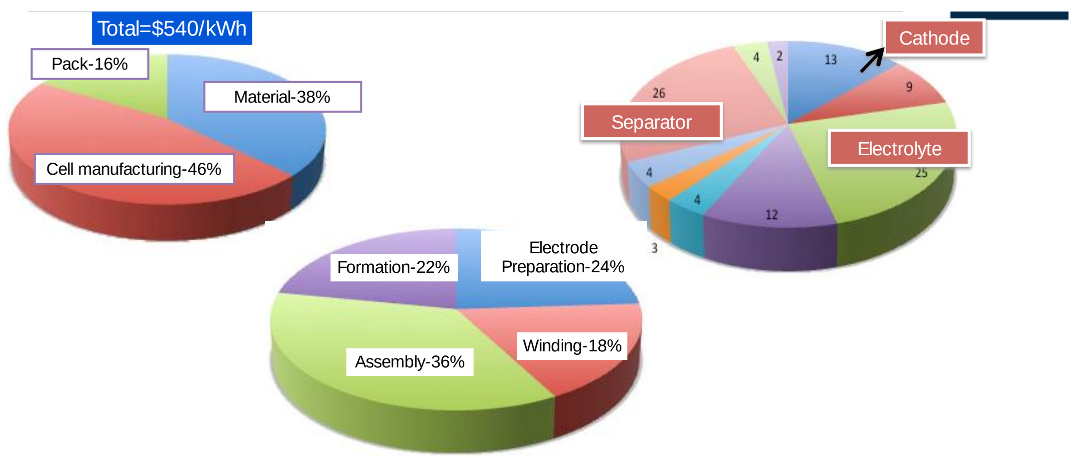
IT investments to orchestrate these new supply-side and demand-side scenarios offer one of the most exciting business opportunities for economic growth. Also these IT-based systems can be applied to other resources such as natural gas. The vast acceleration in the volume of sensor data also creates many new investment opportunities in companies that develop algorithms and methods for learning from data, including on-line monitoring, estimation of trends, and information aggregation.

5. Lithium supply: not likely a bottleneck for today's battery technology

The dominant technology for electric car batteries today relies on lithium. This has raised some concerns about the scalability of battery technologies. In 2013/4, lithium supply security is, in fact, not a concern in North America. *Two 'U.S./E.U. friendly' countries dominate world production: Chile and Australia.* Also the largest Australian lithium hard-rock ore miner doubled its production capacity in 2012 to 110,000 tons. Out of a world mine production and global use of ~35,000 tons, Chile supplies over one-third at ~13,500 tons, and Australia over one-third at ~13,000 tons [with Argentina (~3,000 tons) and Zimbabwe (~1,100 tons) playing a role]. China, at only ~4,000 tons, has a greater concern about its own future needs for lithium and is expanding as fast as possible. For example, a new Australian lithium chemical producer opened a plant in China to convert Australian lithium concentrate to battery-grade lithium carbonate. North American concerns can also be less because estimated world reserves are large at ~13 million tons with again Chile and Australia accounting for well over half. *Industry analysts report a ~6% annual increase in lithium consumption but costs are flat due to expanded mining.*

6. Lower cost batteries

Figure 1 shows data for a lithium-ion battery with a base cost of $540/kWh. Concerns over the cost and availability of lithium itself are only one aspect of the 38% material allocation. The lithium is dispersed in the cathode and electrolyte, but there can be cost savings overall from the other materials. A singular focus on material costs is misleading however, as the greatest costs are in cell manufacturing and packaging. New electrochemistry might become available and it's worth watching companies spinning out from universities and national labs. *Meanwhile, a 30% reduction to a cost of ~$400/kWh– anticipated by Tesla - can more likely be obtained by standard manufacturing tools that include design-for-assembly, computer-aided-manufacturing, statistical process control and data analytics.* Such tools can be used to establish the necessary "economies of scale."



• Both material cost and manufacturing costs are important
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• It is not obvious that simply finding lower cost materials or finding new ways to assembling batteries will be enough

Figure 1. Top-left: Relative costs of packaging (16%), materials (38%), and cell manufacturing (46%) for $540/kWh cost for lithium-ion batteries. Top-right: the Material costs broken down into the separator, cathode, electrolyte and other materials. Bottom: the cell manufacturing costs broken down into cell formation, electrode preparation, windings and cell assembly (courtesy LBNL).