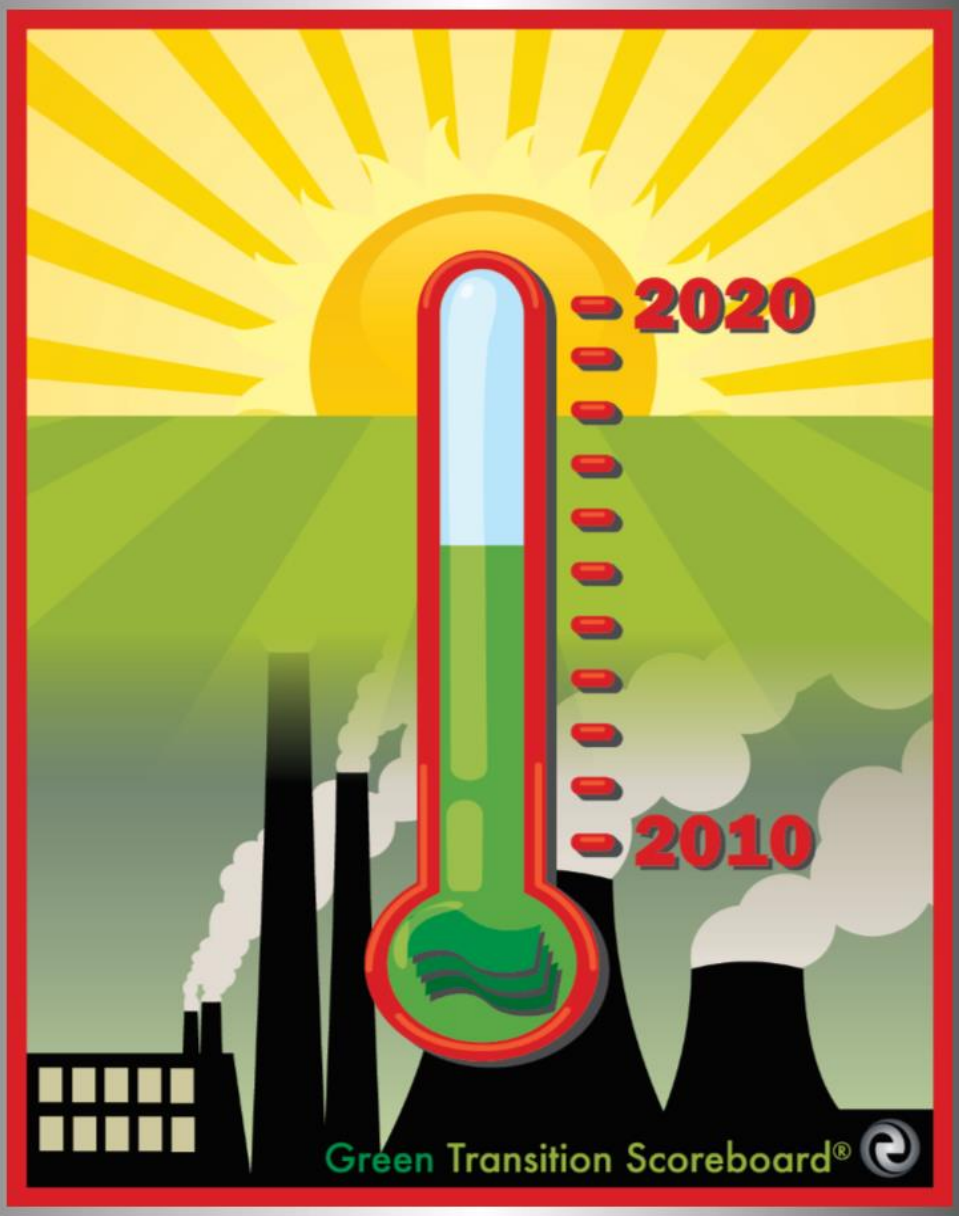
Batteries and Storage Charging the Green Transition



Green Transition Scoreboard®
2015 Fall Update

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Introduction

The Green Transition Scoreboard® tracks private investment in five sectors: Renewable Energy, Energy Efficiency, Life Systems, Green Construction and Corporate R&D. Each sector covers an area of substantial capital investment in technologies which Hazel Henderson's years of research as a science advisor and which the Ethical Markets Advisory Board expertise indicate are continuing to contribute to the growing green economy. Building on the upward trend in investments reported since 2007 and focusing on the institutional level, we recommend investing at least 10% of institutional portfolios directly in companies driving the global Green Transition both as opportunity and as risk mitigation. The current shifting from fossilized sectors includes increasingly stranded assets as low-carbon regulations are implemented and oil and coal reserves become harder and more expensive to exploit. This transition strategy will come to rely on technologies which maximize energy efficiency from renewable sources, increasingly requiring batteries and storage for full optimization.

Reporting on batteries and storage can be tricky from the green perspective given much of the manufacturing process and components are toxic. Our definition of 'green' is quite strict, omitting clearly unsustainable sectors as well as certain technologies having unsubstantiated claims, negative EROI or unexplored or untested consequences. This is a major consideration when addressing the shift in focus to technologies such as batteries and storage which have long existed but upon which we were less dependent on a macro level. With growing need, we must be vigilant in monitoring those companies taking short cuts, exploiting workers or polluting the environment.

This update focuses on investments in batteries and storage as enhancing and optimizing the use of renewable energy and efficiency. It also highlights best practices and the emerging breakthroughs which are directing batteries and storage to become an important sub-sector of green technologies tracked by the Green Transition Scoreboard®.

Batteries and Storage in a Systems Approach to Energy

By Hazel Henderson

2015 saw concerns in the USA and other energy-gulping societies focus on storage and the R&D efforts to develop better batteries. We have been covering this race for better, cheaper batteries for applications for our consumer electronics and devices, electric cars, home storage as well as those for aircraft and system-wide electricity generation. Storage helps to integrate intermittent renewable sources solar and wind into an aging fleet of centralized power plants linked by leaking transmission lines, regional and national grids. In our GTS 2013 report, we focused on new materials beyond legacy lead-acid and today's lithium-ion, to flow batteries, flywheels, super-capacitors as well as macro-storage in compressed air, reservoirs and pumped water storage. Long-discussed tidal estuary schemes possible in the Bay of Fundy in Labrador are now taking shape, such as that in the UK's Severn River estuary with its daily high to low tides of almost 20 feet.

While observing and analyzing all this flurry of activity, let's take a moment to pull back and look at a systemic wide shot at the US energy system and why we generate so much energy, 80% of which is lost in bad design, pollution and waste heat. Such systemic analysis is that of our energy advisor Dr. John "Skip" Laitner, whose "exergy" research is changing the energy paradigm in many countries. How did industrial economies develop without regard to efficiency criteria while heroically digging in the earth for ever greater supplies – even to Shell Oil's current efforts to drill in perilous Arctic waters and the rush of drillers to the North Pole? In our GTS reports, we pinpointed huge government subsidies to fossil fuels and nuclear, as well as to consumers, in many countries. A benefit of lower oil prices now is giving governments opportunities to remove these annual $500 billion subsidies and divert them to education and other life sectors. Yet the main reason for perverse funding of fossilized sectors is the pervasive "externalizing" of the social and environmental costs they impose. Carbon taxes considered optimal by most in business, government and academia still await political will[1], even though thirteen major corporations recently called for imposing carbon taxes and many others factor them into their future budgeting plans.

In my *Politics of the Solar Age* (1981, 1988), I pointed out the errors of economists for two centuries whose models of factors of production: land, labor and capital ignored energy as basic to all three. I quoted Nobelist chemist Frederick Soddy who tried to correct these economists' errors in his "Cartesian Economics" lecture to Britain's Royal Society in

[1] "Puffs of Hope," *The Economist*, Aug. 1, 2015, p. 12-15.

1921, pointing out that the steam locomotive was not powered by capital, technology or the labor that produced or drove it but by coal: "past sunshine stored by plants"![2]

State of Technology 2015

Fast forward to 2015, and we still see very few systemic plans for increasing the efficiency of that 20% of energy that actually drives our production and distribution systems! Instead, trillions of mal-investments are still planned by energy companies in trying to extract more fossil fuels which will continue to disrupt our planet's climate. Will such systemic questions prevail at COP21 in Paris, November/December 2015? Or will ignorant financial investments continue to dominate? Could we see new bubbles in the energy storage sector as we did in ethanol and other unsustainable biofuels? Markets regularly overshoot due to the now well-researched problem of herd behavior. The rush to exploit lithium (Li) already worries lawyer Tam Hunt in her forthcoming *Solar Singularity* questioning the focus on individual electric cars rather than public transport and better urban design. The US Department of Energy's CEMAC Center notes the current lithium-ion battery auto market at $9 billion and expects it to reach $14.3 billion by 2020.

Energy storage must be seen in this larger context of over-supply of fossil and nuclear energy due to inefficient use, unsustainable finance, herd behavior, regulatory capture, excessive subsidies to 19th-20th century technologies and incumbent fossilized sectors. Firstly, let's shift these wasteful financial models toward investing in efficiency and the cleanest, greenest, knowledge-richest technologies and companies in developing countries, as we reported in GTS 2014 and GTS 2015. The Clean Energy Leadership Council's Chris Marshall describes the new auction-based procurement model for renewable energy now powering South Africa.[3] These can leapfrog obsolete infrastructure, transport, urban design and buildings in the older industrial countries. Off-grid solar and wind power can serve millions in rural areas in India, China, Latin America and Africa, while cellphone based financial systems such as in Kenya[4] can bypass old Wall Street, London and EU economic gatekeepers. The resource-intensive GDP-growth model now fading worldwide is gradually transitioning to the new model embodied in the UN's Sustainable Development Goals (SDGs). Until the financial models catch up with this shift of development strategies, emerging economies will continue to look weaker than they are, overlooking their young populations and opportunities to leapfrog obsolete infrastructure and fossilized industrial sectors. The UN Inquiry into the Design of a Sustainable Financial System for release in October 2015 will clarify this picture and point the way toward

[2] Henderson, H. *Politics of the Solar Age*, Doubleday, 1981; Knowledge Systems, 1988.

[3] Marshall, C. "Procuring Clean Energy in the Developing World," The Energy Collective, June 10, 2015.

[4] "A new East Africa campaign," *The Economist*, July 11, 2015, p. 57.

revaluations of natural resources, ecosystem services, intellectual capital, human and social capital assets.

Emerging Opportunities

Keeping our eyes on the main prize: overall system efficiency and innovation, reveals a Dutch company, Eneco with 2 million customers, installing computer servers in five homes to see whether the heat they create can provide warmth. These "e-radiator" alternatives are the brainchild of Nerdalize, a Dutch start-up. These computers will also be used by the Leiden University Medical Center for their research calculations. In 2013, the French company Qarnot Computing started experimenting channeling heat from its servers to heat Parisian homes as reported by Aimee Chanthadarong in ZDNet.[5] *New Scientist* reports on how energy generated from Wi-Fi could be used to power electrical gadgets, where six households in Seattle with Wi-Fi providing their internet access also powered many of their electric devices over 24 hours. The Wi-Fi radio waves were converted into DC current voltage with a "rectifier". WiTricity of Watertown, MA, uses electromagnetic induction to remotely charge car batteries, which the company says Toyota will offer to Prius owners in 2016.[6]

Science Daily reports that billions of kilograms of CO2 could be saved by scrapping DVDs and switching to streaming video content, however the tradeoff comes as high-definition content streaming also increases energy consumption and carbon emissions. This research by Lawrence-Berkeley Labs concluded wisely that the focus should be on efficiency improvements of end-user devices and network transmission energy use as video streaming increases.[7] As we reported in GTS 2014, Boeing and the UAW's Masdar Institute are making superior aviation fuel out of algae grown on seawater and sunlight. Airbus flew

[5] Chanthadavong, A. "Dutch company to trial computers to heat homes," ZDNet, March 25, 2015.

[6] Baraniuk, C. "Power from Wi-Fi," *New Scientist*, June 6, 2015.

[7] Institute of Physics. "Billions of kg of CO2 could be saved by scrapping DVDS, research suggests." ScienceDaily, May, 28, 2014.

its E-fan battery-powered plane across the English Channel in July 2015.[8] Meanwhile, three startups, Carbon Engineering, Global Thermostat and ClimeWorks, are progressing toward directly removing carbon from the air. Climeworks in April, 2015, captured CO2 from the air and supplied it to German firm Sunfire, which then recycled it into a zero-carbon diesel fuel.[9,10]

Less than 0.01% of electricity is stored.[11] Types of storage of electricity include 1) chemical storage, such as batteries and fuel cells which reverse the chemical reaction which produces electricity; 2) thermal storage such as using molten salts to store heat from solar power plants as well as potential energy stored by compressing air or pumping water uphill to run down through turbines later; 3) kinetic storage, which stores energy in motion like regenerative braking in hybrid and electric vehicles or in flywheels now being upgraded beyond current use in grid load-balancing, such as Quantum Energy Storage's 100 kilowatt-hour steel design flywheel and those from Temporal Power and Beacon Power which run at more than 10,000 RPM. Flywheels can replace back-up diesel generators and many new applications are forecast in GTM Research's North American Microgrids, 2015 Advancing Beyond Local Energy Optimizations.[12] Overviewing the energy storage field is the goal of the US Energy Storage Summit, Dec. 8-9, 2015, in San Francisco, CA, as well as that of the Institute for Local Self-Reliance (ILSR) in their report by John Farrell, Energy Storage: The Next Change for Distributed Energy (March 2014). The value of solar plus storage is confirmed using a new methodology which validates strategies in Hawaii. This new analytic tool from IREC can unlock the value of solar PV plus storage models.[13] Other important tools access the full potentials of Renewable Portfolio Standards (RPS) in California by Energy and Environmental Economics, Inc. (www.ethree.com).

Reforming of the Financial System

As mentioned, financial systems need overhauling, as reported in the UN Inquiry into the Design of a Sustainable Financial System such as China's Green Financial Reform, where we see the world's underlying energy realities and the green transition we track. Beyond economists' false focus on money as wealth (rather than its role as a unit of account), these errors have been revealed. They are seen in the trials of the euro,

[8] "Volting Ambition," *The Economist*, July 18, 2015, p. 67.

[9] Gunther, M. "Startups have figured out how to remove carbon from the air. Will anyone pay them to do it?" *The Guardian*, July 14, 2015.

[10] Disclaimer: the CEO of Global Thermostat, Prof. Graciela Chichilnisky, serves on Ethical Markets Advisory Board.

[11] "Charge of the Lithium Brigade," *The Economist*, May 30, 2015, p. 17.

[12] Tweed, K. "Quantum Energy Storage Redesigns the Flywheel for Microgrids," Greentech Media, Aug. 10, 2015.

[13] Norris, B. (2015). Valuation of Solar + Storage in Hawaii: Methodology. Interstate Renewable Energy Council.

currency wars and the miseries imposed on real citizens in Greece, Spain, Ireland, Portugal and other peripheral EU member countries by ill-informed economists imposing "austerity" to shore up their over-leveraged, debt-ridden banking systems. These obsolete models are mis-managing the transition to sustainability in emerging economies by devaluing their real assets, such as in Brazil with its foreign-dominated banks and export focused on commodities to China,[14] just as the Chinese are shifting away from this obsolete model. Meanwhile, in the real energy world, genuine new thinking and innovation proliferates in the report of the GreenTouch consortium of Alcatel-Lucent, France Telecom, Fujitsu, Huawei, NTT, Vodafone, that energy efficiency of mobile networks could be increased by 10,000 times.[15]

So, GTS takes this wider focus of redeploying finance from the unsustainable fossilized past to the efficient future of renewables as our context for exploring how much and what kinds of energy storage and new technologies are needed. Looking at the global rush to lithium and other materials in the Periodic Table, 40% of the world's lithium is found in Chile and Bolivia, where President Evo Morales wants his country's lithium to remain a national asset, with additional large reserves found in China, Australia, Argentina and the USA. Lithium-ion batteries are now a $15 billion business, even though they can overheat and have caused fires. Tesla is betting on them with its Nevada-based "gigafactory" (subsidized by taxpayers) to produce enough batteries for 500,000 electric cars and its Powerwalls for homes at a targeted 30% price reduction.[16] Those batteries used in Tesla vehicles are made by Panasonic.

Changing Roles of Electric Utilities and Grids

California's 2014 law requires energy companies to bring 1.3 gigawatts of storage to the grid by 2022, enough to cover 1/40th of the state average power needs. Virginia-based AES Energy Storage is commissioned to build a lithium-ion battery array, the largest ever built, enough to supply 80,000 average US homes. Rather than this scaling up, startup Sakti3, headed by University of Michigan Prof. Ann Marie Sastry, has developed a much more efficient lithium-ion battery with solid state, systemic design for one-fifth the cost.[17]

Electric utilities are now accepting, rather than continuing their resistance toward renewables and learning to adapt to their intermittent nature with new load-balancing

[14] Dowbor, L. (2015). "How the financial system drains the Brazilian economy: overview. Ethical Markets. Retrieved from http://tinyurl.com/phfpdc6

[15] Tweed, K."10,000-fold Energy Efficiency Increase In Mobile Networks Is Possible," Greentech Media, June 22, 2015.

[16] Hodson, H. "Power to the People," *New Scientist*, July 25, 2015.

[17] Dumaine, B. "Will This Battery Change Everything?" *Fortune*, Oct. 6, 2014.

approaches. Many, including Florida Power and Light, still are lobbying state legislators to prevent their customers from installing rooftop solar panels and levying charges on them or cancelling net metering. The older electric utilities are taking advice from their trade association EPRI to stay relevant and prevent losing the market to local micro grids, homeowners and business rooftops. They are urged to shift all their vehicle fleets to electrics. This will be a disaster for climate unless all those new vehicles use solar and wind-generated electricity.

New Materials Search

Global lithium demand by 2025 will reach 499,000 tons of lithium carbonate for: portable electronic devices, grid storage, hybrid and electric vehicles and other applications.[18] Thus, the race is on for other materials, and this GTS update is a snapshot of current R&D on other materials including vanadium, nickel, cobalt, graphite and graphene, and other methods including flow batteries, which generate electricity when a charged liquid electrolyte is pumped through them, such as Imergy's ESP4 vanadium flow battery with many applications.[19] Primus Power has raised $25 million to bring flow batteries to Kazakhstan.[20] Hydrogen fuel cells are promoted by Japanese companies Panasonic, Toshiba and Tokyo Gas as "ene-farms" generating electricity in 100,000 Japanese homes.[21] In our 2004 TV show Green Building and Design, we explored Canadian investor/entrepreneur Geoffrey Ballard's scenario: electric vehicles as the preferred mobile storage batteries for homeowners and grid operators.

The current rush to scale some technologies, notably lithium-ion batteries, in order to lower costs, will run into inevitable resource limits which will drive prices back upward. The obsession with scaling production and cost-reduction is less efficient than the biomimicry approaches we advocate in our *Principles of Ethical Biomimicry Finance*® now available to asset managers on license. Similarly, economic models of substitution possibilities ignore herd-behavior where a rush for a new target material creates its own scarcity. These are all the reasons we at GTS favor systemic views of overall efficiencies as our starting point.

[18] Hodson, H. "Power to the People," *New Scientist*, July 25, 2015.

[19] Burger, A. "Flow Batteries Installed at Slovenian Alps Restaurant Renowned for Its Donuts and Renewable Energy," Renewable Energy World, Jan. 24, 2015.

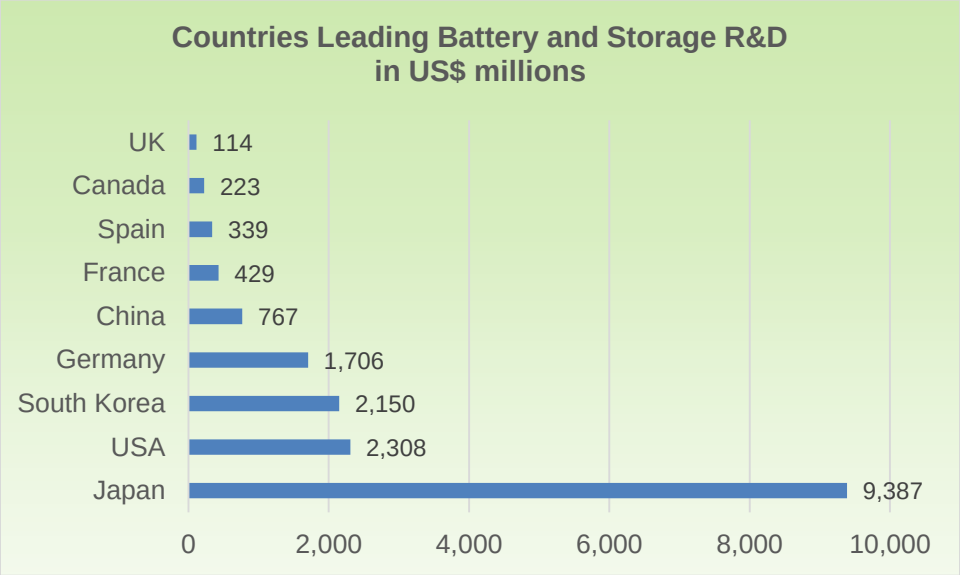
[20] St. John, J. (2015, September 9). Primus Power Raises $25M to Bring Flow Batteries to Kazakhstan. Greentech Grid. Retrieved from http://tinyurl.com/nabg7zs

[21] Watanabe, C. "Powering Your Home with a Box of Hydrogen," Bloomberg Businessweek, Jan. 15, 2015.

Exploring the Numbers

The GTS Fall Update focuses on battery and storage investments. Findings are compiled from 2007 to 2014 and include the top 30 technology producers. As of Q4 2014, there have been a total of $17.4 billion in private investments in R&D for battery and storage technologies.

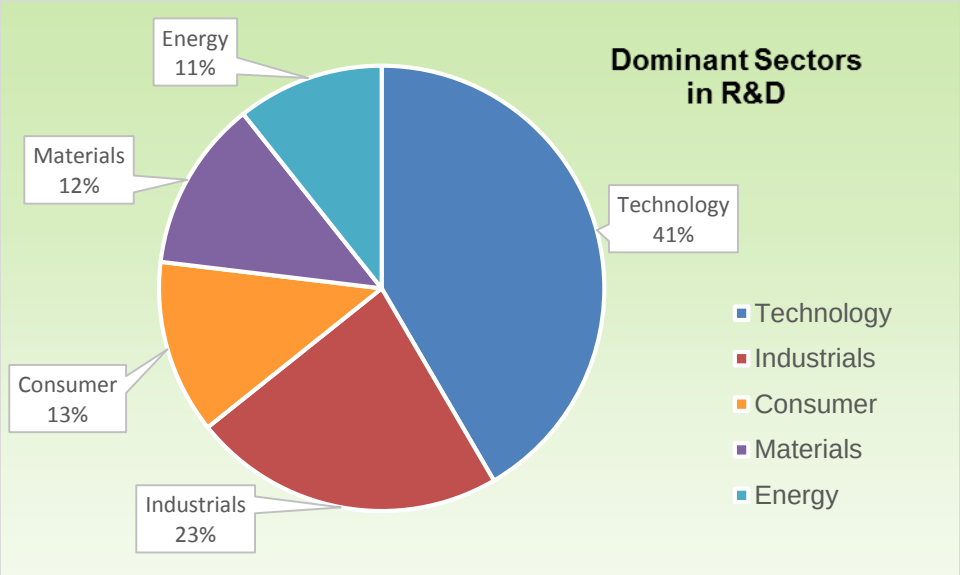
The countries with leading private investments in this sub-sector include: Canada, China, France, Germany, Japan, South Korea, Spain, UK and the USA. Japan's companies dominate by far with Panasonic and Toshiba close in investments and leading over NEC, Fujitsu, Hitachi, GS Yuasa and Kyocera combined. BASF based in Germany is the leader in Europe. There are only two major companies with R&D in batteries and storage in the USA: Johnson Controls and Energizer Holdings. While Japanese companies are leading the way, Spain's ACCIONA was the first in Europe to operate a grid-connected photovoltaic plant on an industrial scale with energy storage in batteries.[22]



[22] ACCIONA. (2012). "ACCIONA incorporates energy storage into a grid-connected PV solar plant for the first time in Europe [press release]. Retrieved from http://tinyurl.com/nte6zf8

Within the major sectors, the most heavily invested industries include: technology services which includes IT, $4.5 billion; electrical equipment, $3.6 billion; hardware, $2.7 billion; chemicals, $2.2 billion; renewable energy, $1.9 billion; and automotive, $1.8 billion. Sectors which have significant R&D in batteries and storage include:

- Consumer – which includes the automotive industry and consumer products
- Energy – predominately renewable energy sources
- Industrials – encompasses electrical equipment, engineering and machinery
- Materials – predominately the chemical industry
- Technology – predominately IT and hardware



There is a misperception that the automotive industry is leading the charge in batteries and storage. Yet the automotive industry doesn't even break into the top five. This is surprising given the hype around batteries for automotive use and the branding effort pushed by companies such as Tesla. In actuality, the automotive industry does not make batteries. Rather, as noted, it outsources as Tesla does to Panasonic which also supplies Subaru's hybrid-electric vehicles.[23]

One would think that the energy production–energy storage connection within a single company would manifest many times over as more and more homes and smaller

[23] Panasonic. (2013). Panasonic to Supply Nickel Metal Hydride Battery Systems for Subaru's First Hybrid Electric Vehicle [press release]. Retrieved from http://tinyurl.com/owtqbf8

businesses look for energy alternatives. However, SolarWorld based in Germany is the only solar company to sell their own solar+storage unit for homes. Instead, the production-storage technology integration is happening at the industrial level. GE, a player in the energy industry, dramatically downsized its sodium-ion storage unit division and is outsourcing for the lithium-ion batteries for contracts with Canada's Coachella Energy Storage Partners and with Con Edison in California.[24] Another example is the Alstom-Saft consortium in France using Alstom's converter and Saft's lithium-ion battery to release energy to the grid.[25]

Of the largest companies, only Saft Groupe is pure play and Johnson Controls has a dominant focus on batteries and storage. Of the rest, batteries and storage are a component of the many industries and sub-industries serviced by these largely diversified corporations.

Company	**Country**	**Sector**	**Industry**	**R&D**
Panasonic	Japan	Technology	Hardware	$2.55 billion
Toshiba	Japan	Industrials	Electrical Equipment	$2.26 billion
Samsung SDI	South Korea	Technology	Technology Services	$1.72 billion
BASF	Germany	Materials	Chemicals	$1.69 billion
Johnson Controls	USA	Consumer	Automotive	$1.53 billion
NEC	Japan	Technology	Technology Services	$1.40 billion
Fujitsu	Japan	Technology	Technology Services	$1.39 billion
Hitachi	Japan	Technology	Electrical Equipment	$1.23 billion
Saft Groupe SA	France	Energy	Renewable Energy	$429 million
LG Chem	South Korea	Materials	Chemicals	$421 million

Another prevalent partnership model is the agreement between Siemens and LG Chem, with Siemens supplying converters and controllers while LG Chem supplies batteries and management systems.[26] The Siemens/LG Chem system is being used at a steel mill in Germany, clearly an industrial application, rather than the "soft" or "green" applications commonly associated with battery storage. As regularly demonstrated in the GTS, there are sound economic motivations for these collaborations. The rapid rise of residential energy-storage is changing the game and the energy storage market is

[24] Krauskopf, L. (2015, July 26). "General Electric aims big in energy storage after battery step back." Reuters US Edition.

[25] Alstom. (2015). Alstom and Saft's innovative energy storage goes live at EDF's Concept Grid [press release]. Retrieved from http://tinyurl.com/necva7g

[26] Richardson, J. (2014, December 2). "Siemens & LG Chem to Collaborate More on Battery Storage." CleanTechnica.

expected to grow in the USA by 250% in 2015. California is leading with its three largest investor-owned utilities, followed by New York. As Markus Elsässer reports, Solar City, Sunrun and Sungevity are teaming up with Sonnenbatterie and Trina Solar to launch a residential battery along with SolarWatt, owned by a major BMW shareholder and the Quandt family in Germany.[27,28] Panasonic and Tesla will be competing for the residential market in Europe, starting in Germany.[29]

While many companies are dipping into their own coffers to develop systems and leveraging early payments for lucrative deals, YieldCo's are an important component of the finance picture, as well as private equity groups, including SunEdison founder Jigar Shah's Generate Capital.[30] SunEdison created TerraForm Power to bundle projects for public investors. TerraForm Power recently acquired Advanced Microgrid Solutions storage assets to add to its solar and wind holdings.[31]

Notes

- International investments are reported in US dollars, subject to fluctuating exchange rates. For the early quarters of 2014, currency changes dampened the update's totals, with the US dollar getting stronger against most global currencies (especially the Euro).

- Companies, organizations and the sources of financial data included in the GTS are screened by rigorous social, environment and ethical standards as well as the latest auditing standards for sustainability, including IIRC, SASB, ICAEW and others. Data is gathered from green and sustainability indexes, financial media, UN and other international studies, and the Climate Bonds Initiative. Government funded projects and initiatives are purposefully omitted. When government funding is part of a larger project, the research team removes, in as far as is transparent, the portion of investments from government funds.

[27] Elsässer, M. (2015). The Rapid Rise of Residential Energy Storage. RenewableEnergyWorld.com. Retrieved from http://tinyurl.com/qcsrqm4

[28] Disclaimer: Ethical Markets COO Sanquiche is an investor in Solar City.

[29] Thomson, A. (2015, September 4). Battery Frenemies Tesla and Panasonic Poised for a Fight in Europe. Bloomberg Business. Retrieved from http://tinyurl.com/nsnwl7b

[30] Disclaimer: Ethical Markets CEO Henderson is an investor in Generate Capital.

[31] Wesoff, E. and St. John, J. (2015, July 15). "SunEdison Joins With AMS to Develop and Finance 50MW of Energy Storage." Greentech Grid.

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