Singapore Battery Consortium

Q1 Newsletter

SINGAPORE BATTERY CONSORTIUM Understanding curation of recent industry developments and technology news

Recent industry developments and technology news are specifically curated based on the relevance to the progression of the industry. Each news event is categorized based on importance and area of focus (see below for description for both).



SK Innovation will build its second U.S. factory in Georgia, from which it intends to ship another 9.8 GWh to VW in Tennessee. Its total production goal of 100 GWh by 2025 outpaces its publicly known manufacturing projects, so expansions near already-planned facilities will likely be a forthcoming trend. In the Southeast U.S., automotive manufa 2 ers are nearby: VW is in Tennessee, Daimler has factories in South Carolina and Alabama, where Hyundai also is, and Volvo, BMW, and Kia are located in Georgia. Clients should expect SK Innovation to ramp up production near customers and keep chipping away at its 2025 goal.

1 Link: Hyperlink to original news article. Note some news articles may be behind paywall.

2 Analysis: Writeup of the news event as it relates to industry development and recommendations for action.

potential importance of the event from "Truly Disruptive" to "Ignore"

Importance: Take on the

Area of Focus: Category of the news event based on the to the topic.

Importance	Description	
Truly Disruptive	A game-changing, landmark development	
Very Important	Significant news that will have strong implications	
Average Importance	Worth noting, but not likely to be too important or disruptive	
Low Importance	An over-hyped development, which is not worth monitoring closely	
Ignore	Misleading or irrelevant development, worth being cautious about	

Area of Focus	Description	
Built environment energy use	Hardware and software technologies for commercial and residential energy consumption	
Business models and regulations	Novel business models for energy production, consumption, and distribution, as well as policies with transformational impact on new energy technology development	
Energy for mobility	Energy sources for powering road, rail, aviation, and marine – includes movement of goods and people	
Energy storage	Development and commercialization of various forms of electrochemical energy storage	
Stationary storage	Utility-scale and long-duration energy storage for grid services, renewables integration and backup, and microgrid support	

RECENT INDUSTRY DEVELOPMENTS AND TECHNOLOGY NEWS China and South Korea continue to dominate global Li-ion manufacturing capacity

<u>ефската и ракова</u>	13 January 2020 <u>China signals it may not cut</u> <u>electric vehicle subsidies in</u> <u>2020</u> Business models and regulations	China's aggressive subsidy cut in June 2019 resulted in a surprising decline in electric vehicle sales in the second half of the year. Although China has publicly sought to reduce reliance on subsidies and require automakers to produce electric vehicles, it also does not want to lose its position of leadership in the growing industry. Clients should expect China to see growth once again in China's electric vehicle industry in 2020 and view this as good news for all companies across the supply chain in China. Startups will stand to benefit the most, as Xpeng and Nio have significantly fewer resources to endure another challenging year of stagnant electric vehicle sales.
Very Important	15 January 2020 <u>SK Innovation announces</u> <u>10 GWh expansion of</u> <u>factory in U.S.</u> Energy storage	SK Innovation will build its second U.S. factory in Georgia, from which it intends to ship another 9.8 GWh to VW in Tennessee. Its total production goal of 100 GWh by 2025 outpaces its publicly known manufacturing projects, so expansions near already-planned facilities will likely be a forthcoming trend. In the Southeast U.S., automotive manufacturers are nearby: VW is in Tennessee, Daimler has factories in South Carolina and Alabama, where Hyundai also is, and Volvo, BMW, and Kia are located in Georgia. Clients should expect SK Innovation to ramp up production near customers and keep chipping away at its 2025 goal.
Average Importa	4 February 2020 Xcel Energy and Electric Power Research Institute use modeling to optimize T&D upgrade scenarios Built environment energy use	Entering distribution planning regulatory proceedings in Colorado and Minnesota, Xcel and EPRI modeled five scenarios for section of the grid: a conventional, wires-based upgrade and four scenarios with different combinations of demand-side management (DSM) and energy storage. The wires approach required adding a new substation transformer base by 2021, at a cost of about \$10 million. DSM only was most cost-effective and deferred the upgrade until 2025 or 2026, depending on the DSM capacity. While adding storage would cost more, Xcel could defer at least until 2027 and still achieve a net cost benefit. With utility grid modernization plans running into skepticism, modeling can both find optimal cost savings and help win over regulators.

RECENT INDUSTRY DEVELOPMENTS AND TECHNOLOGY NEWS Electric vehicles remain the demand driver for Li-ion batteries for the next 15 years



RECENT INDUSTRY DEVELOPMENTS AND TECHNOLOGY NEWS Energy storage will be a key component of oil and gas energy diversification strategy



Very Important Stationary storage

20 February 2020



UK

24 February 2020 Tesla opts for LFP over NCA in the Chinese market

Shell signs offtake deal with

100 MW storage facility in

Very Important Energy for mobility

This project consists of two 50 MW lithium battery units and is slated to become Europe's largest battery storage facility upon completion this year. Through this agreement, Shell has agreed to a multiyear off-take deal for the project. The oil major did confirm that the batteries will be used for grid balancing and frequency response and that Shell's subsidiary Limejump – acquired in March 2019 – will optimize battery usage through its virtual power plant platform. This deal means another step forward for Shell, which is rapidly consolidating its distributed energy resource (DER) aggregation capabilities.

The round was led by Breakthrough Energy Ventures, with other investments from The Engine, Lowercarbon Capital, and The Grantham Foundation. While the influx of fresh capital is certainly positive for Lilac, the company's decision to source funding from venture capital firms rather than strategic industry players is interesting. Investments from strategics are usually harbingers for pilot project or co-development opportunities, as with Livent's partnership with E3 Metals. Lilac's choice to go elsewhere for capital may speak to its technology's early stage of development, the lithium industry's strong risk aversion, or both.

It is highly unlikely that this choice was influenced by cobalt costs, as Tesla's NCA cathodes use a relatively small amount of cobalt compared to most NMC formulations. Instead, there are several other factors likely driving Tesla's LFP decision. First, doing so will help insulate Tesla against a nickel feedstock shortage, which is an increasingly concerning scenario given rapidly increasing demand. Second, the Chinese BEV market is the largest and most competitive in the world, with dozens of automakers (including a staggering number of Tesla copycats) competing with a diverse array of solutions. Lastly, even with reduced energy density, Tesla expects that its drivetrain efficiency will still allow it to qualify for range subsidies.

RECENT INDUSTRY DEVELOPMENTS AND TECHNOLOGY NEWS China's vertically integrated Li-ion value chain may prevent other countries aiming to commercialize new battery tech



PHILLIPS 66 2 March 2020 <u>Chinese scientist pleads</u> <u>guilty to stealing battery</u> <u>trade secrets from employer</u> <u>Phillips 66</u>

rtance Energy storage



Low Importance

Energy storage

Ganfeng will take 51% ownership in jointly owned Minera Exar, a jointly owned company operating the lithium project, and Lithium Americas will receive \$40 million in interest-free loans and 49% ownership. The Cauchari-Olaroz project is projected to begin in 2021 with an annual production capacity of 40,000 tons per annum using conventional brine evaporation pools. The extra cash will likely help Lithium Americas in its \$400 million clay mining operation at Thacker Pass, Nevada. Ganfeng's majority ownership will open opportunities of state support from China and further enhance its global lithium portfolio.

Chinese national Hongjin Tan pleaded guilty to intentionally copying and downloading battery research materials without proper authorization. According to Reuters, the FBI also found an employment agreement from a Chinese Li-ion battery company on his laptop, yet SCMP asserts that there is no evidence that Tan actually sent any trade secrets to the company. P66 claims the IP in question is worth \$1 billion; we strongly suspect this research is related to synthetic graphite production and/or use. The incident is a striking note in the ongoing trade war; clients should expect current political tensions to restrict the commercialization of U.S. battery startup technologies.

The investment will support Highview Power as it seeks to commercialize its liquefied air energy storage system globally. Sumitomo has demonstrated a strong interest in long-duration energy storage, though its bet on cryogenic energy storage is misguided. Non-electrochemical long-duration stationary storage faces many issues that can't be fixed with big investments. It has much lower efficiency compared to batteries, and the technology is more difficult to control, making it less able to participate in value stacking. Clients interested in opportunities to get involved with stationary storage should ignore companies like Highview Power and be mindful that the value proposition of energy storage is contingent on renewables penetration.

RECENT INDUSTRY DEVELOPMENTS AND TECHNOLOGY NEWS Leading next-generation battery startups begin ramping up commercialization efforts



Client confidential. Not for redistribution.

RECENT INDUSTRY DEVELOPMENTS AND TECHNOLOGY NEWS Non-road electrification begins to gain traction, but still far from reaching the momentum of passenger vehicles



12 March 2020 **Rolls-Royce expects 100 passenger hybrid-electric planes to be flying by 2029**

Average Importance Energy for mobility







Average Importance

Energy for mobility

The key issue is not the existence of hybrid-electric commercial airliners but the level of hybridization and the length of the flight. In these regards, Rolls-Royce failed to add any specifics, saying only that the routes would be restricted to regional flights and that fully electric planes carrying 150 to 200 passengers would not be possible before 2030. These views are well-aligned with Lux's expectations for the electric aviation market. Today, even mild hybridization is inhibited by the size and weight of the required power electronics systems. Clients should expect that the hybrid-electric planes of 2030 will use lighter, smaller power converters and solid-state batteries for improved safety.

Ahead of a citywide policy banning diesel engines in Amsterdam's canals by 2025, companies that operate commercial vessels are converting their fleets to electric power. Rederij Kooij, a company that offers boat tours, said that replacing diesel with electric power costs \$56,000, while building an all-new electric boat would cost \$1.1 million. At smaller scales, a newly built hybrid survey ship is conducting seabed scans in France, and Stockholm Transport is using a retrofitted hybrid boat. Clients should expect this trend to continue for short-range vessels, especially motor conversions of existing fleets.

BMW's eDrive system operates similar to Ford's PHEV system, which allows for automatic switching to pure electric driving modes in certain cities with low emission zones. Unlike Ford, which is aiming to communicate this information with local officials, BMW is introducing a points system in which drivers are rewarded for driving more electric miles, which can be redeemed on services like EV charging. Clients should note this approach will become more popular as more cities enact low-emission zones – or introduce reduced congestion charges for low-emission vehicles – although BMW's program cannot currently communicate which drive mode the vehicle is in to local authorities, which the Ford program is explicitly focused on.

STATIONARY ENERGY STORAGE The Nuts and Bolts of Application Stacking

Application stacking has long been a goal of the energy storage industry, as it helps address the single largest concern about stationary storage: it is too expense. Application stacking inverts the problem, not by reducing costs, but by securing multiple streams of revenue through various services stationary storage can provide. Once multiple value streams can be tapped, the economics tip in favor of stationary storage.

* 🕻 LUX TAKE

On paper, application stacking typically pencils out economically, but regulations and business case development have presented challenges. Understanding the specific needs of different utility markets and quantifying grid service revenue will help build value stacking business opportunities today.



STATIONARY ENERGY STORAGE Energy storage can provide a wide range of services

The local on- or off-grid greatly influences the value and use case for energy storage systems. There are three grid domains where an energy storage system can be sited – transmissions, distribution, and behind-the-meter.

- **Transmission**: Transportation of electricity from centralize plants to local substation at high voltage. Transmission connected systems are typically much larger in format (>10 MW), and as such the system is likely to be communicated with grid operator and utility.
- **Distribution**: Delivery of electricity from substations to end substations to end customers at low to medium voltage. Distributed connected systems are likely between 10MW and 100 kW in scale, and are likely to be controlled by the grid operator or utility.
- **Behind-the-meter**: Device connected to a home or business, which is located on the customer side of the electricity meter. Behind-the-meter systems are smaller than 1MW and are likely to be controlled by the customer or a third-party operator through a software platform.



STATIONARY ENERGY STORAGE The implementation of application has not been smooth, thanks to inconsistent rulemaking and market regulation

Regulation has long been a barrier, due to two primary factors:

- Degree of electricity market deregulation and availability of revenue streams
- Business model challenge of transferring value across different stakeholders

This has forced energy storage developers to cobble together viable projects through a variety of partners, much like the solar industry had to do years ago. Each stakeholder may gain some value from an energy storage asset, but not enough in isolation to merit the installation of that asset. Bundling those values together through an agreement or contract where revenue is commensurate with risk for each stakeholder has been the challenge and barrier to scale.



STATIONARY ENERGY STORAGE Even in a complicated regulatory landscape, stationary storage is expected to grow significantly

Not every region has access to these market-based models: most of the world still operates in a fully regulated environment. It will take years for countries to revamped their electricity markets to adopt market-based electricity pricing models, but that hasn't stopped countries from deploying energy storage and distributed resources already. Indeed, most countries have installed energy storage that provides multiple services without deregulating their power sector. Typically, these are infrastructure deferral or upgrade projects.

The global stationary energy storage market is set to grow 15-fold through 2035, with 214 GWh of demand that equates to approximately \$112 billion in annual revenue. Regions such as China, Europe, North America, Japan, and Korea is expected to lead the charge globally. **Global Stationary Energy Storage Market** Energy storage demand (GWh)





STATIONARY ENERGY STORAGE Economics behind energy storage projects

Energy storage projects today are highly complex, involving developers, utilities, technology providers, and site owners, all of whom have to agree on a business model that allocates value and risk adequately across multiple shareholders. Often those shareholders are reluctant to share details of project finances, but Lux Research interviewed multiples shareholders with each project and conducted its own analysis to reverse engineer specific financial operations.

- **Marcus Garvey Apartments**: A microgrid project featuring a 1.2 MWh battery for a 625-unit affordable housing complex in Brooklyn, New York
- **Glassenbury**: A 40 MW distribution-level storage asset in Glassenbury, UK that provides both grid and customer services.
- **sonnenCommunity**: A 22 MW virtual power plant comprising 6,000 solar- and storage-equipped homes throughout Germany.

CASE STUDY Glassenbury: A need for fast frequency response in the UK

In July 2016, National Grid opened a tender for 200 MW of enhanced frequency response (EFR) to manage sub-second fluctuations in frequency. VLC Energy big a 40 MW/27.65 MWh system provided by NEC Energy Solutions.

Altogether, VLC Energy won a contract to provide three services at fixed cost: EFR, capacity, and triad peak shaving. Total lifetime revenue is expected to be \$20.8 million with EFR providing 61% of lifetime revenue for the system with peak shaving and capacity providing 20% and 19%, respectively.

The Glassenbury installation cost \$16.3 million, and with \$20.8 million in present-value revenue, the project realizes a 28% return on investment with just the first four-year EFR/triad contract. Should that be renewed, even at much lower rates, the ROI would improve still.

Glassenbury Investment/Lifetime Revenue Comparison

Net present value (\$US millions)



CASE STUDY

Marcus Garvey Apartments: A dire need for reducing demand in Brooklyn

In July 2017, the Marcus Garvey Apartments microgrid was brought online. The project included a 400 kW solar array, a 400 kW fuel cell, and a 300 kW/1,200 kWh energy storage system. Each component was financed separately by project owner L+M, Bloom Energy, NYC Energy Efficiency Corporation, and Enel X.

The project participated in Con Edison's demand management program. Total lifetime revenue is expected to be \$1.4 million with demand response providing 50% of lifetime revenue for the system with distribution deferral and peak shaving providing 38% and 12%, respectively.

The total cost of the project was \$1.32 million and yields an ROI of 7% over the 10-year financing round. Even with significantly higher demand response prices, high costs from permitting and installation in NYC make it difficult to justify a energy storage system in this case.

Marcus Garvey Apartments Investment/Lifetime Revenue Comparison Net present value (\$US millions) \$1.6 \$1.4 **ROI: 7%** – \$1.2 \$1.0 \$0.8 \$0.6 \$0.4 \$0.2 \$-

Battery cost Distribution Demand Peak Lifetime deferral response shaving revenue

CASE STUDY sonnenCommunity: A retail model for virtual power plants

sonnenCommunity is a Germany-wide virtual power plant established by Sonnen (acquired by Shell). Approximately 6,000 residential solar-plus-storage systems enable homeowners to provide grid services or shift energy regionally through coordinated charging and discharging.

Instead of selling electricity to the grid via feed-intariffs, homeowners pay Sonnen a monthly fee of \$34/month to manage its battery systems. In return, Sonnen uses the battery to provide frequency regulation at \$2,780/MW-week.

Sonnen provides value to two stakeholders: the homeowner and Sonnen. The consumer battery cost is \$5,948 and yields an ROI of 5%. Sonnen's cost of covering the homeowners electricity bill is \$5,624 and yields an ROI of 40% from its service charge and frequency regulation with the grid.

sonnenCommunity Investment/Lifetime Revenue Comparison

Net present value (\$US thousands)



STATIONARY ENERGY STORAGE By design, there are few shared characteristics among the storage projects, but two key commonalities emerged

The energy storage projects selected vary by position along the electricity value chain, by battery chemistry type, and even by revenue source. Despite these differences, two important features were share across all projects.

- **Regulation**: All projects take place in deregulated markets. Identifying separate value streams and building business cases is much easier where generation, T&D, and grid services are all decoupled from one another. Projects can and indeed do take place in regulated markets, but it's more difficult to identify revenue streams.
- Share of main revenue source: The main revenue source constitutes at least 50% of total revenue. Developers identified a primary revenue source in each market and then built a business case out of complementary value streams depending on project specifics.

	Glassenbury	Marcus Garvey	sonnenCommunity
Regulation	Deregulated	Deregulated	Deregulated
Position	Front-of-meter	Behind-the-meter	Behind-the-meter
Battery type	LFP	NMC	LFP
Revenue model	Contracted bid	Shared savings	Virtual power plant
Main revenue	Frequency regulation	Demand response	Avoided costs
ROI	28%	7%	40%



STATIONARY ENERGY STORAGE The winning formula for stationary storage

In the right markets and with the right applications, stationary energy storage is hardly a losing proposition. The analysis shows that application stacking is crucial to making energy storage economics work out favorably. These projects identified a value stream necessary in each market and bundled together additional services to bolster finances.

Different regions and utility markets will have different needs, but it will be some combination of grid services, infrastructure deferral, and energy cost reduction that will add up to successful energy storage deployment. Application stacking presents both near- and long-term opportunities and challenges that technology innovation must address.

In the near-term success relies on software, and a large market means software and data providers could benefit beyond just offering intelligent controls and optimization, but also the data behind it. In the long-term success depend on cheaper battery systems as grid services prices fall.

INNOVATE SMARTER & GROW FASTER

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