What is Happening Now in the Flow Battery Space?

A Growing Demand for Long-duration Energy Storage, and the Rise of New Players

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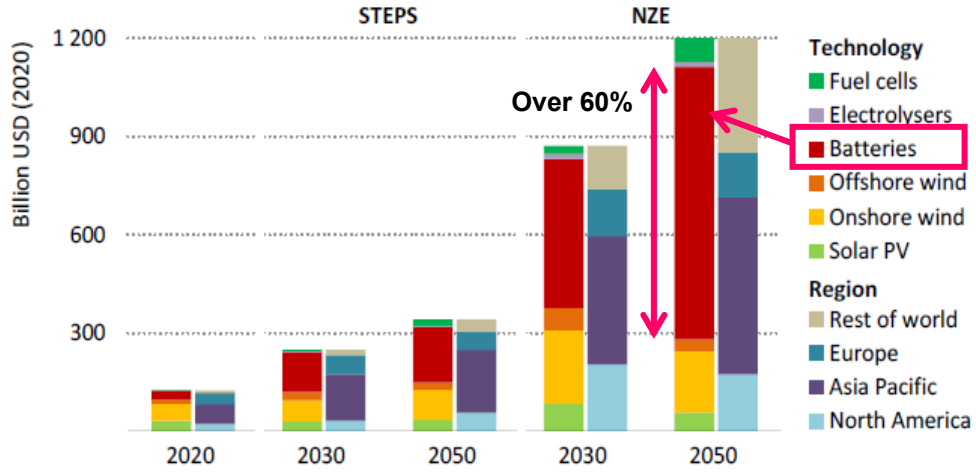
Introduction

Published in an April 2021 IEEJ publication[1], this paper looks at the technical characteristics, costs, global market size, and role at Japanese companies of vanadium redox flow batteries (VRFBs), which are seeing commercial use in power grids worldwide. It also explores cases of commercial applications and presents issues requiring resolution if the market is to see further proliferation and growth. Recent years have seen unprecedented changes happen in the flow battery space as it matures into a business domain. This paper provides an overview of characteristic changes taking place with respect to flow batteries, and examines the implications and impact of these changes.

1. Expanding investment in batteries as a clean energy technology

To begin, we will look at the amounts being invested in the clean energy technologies needed to achieve greenhouse gas neutrality by 2050, as well as the role of batteries in this endeavor. As part of the Net Zero Emissions by 2050 Scenario in its World Energy Outlook 2021, the International Energy Agency (IEA) estimates that 4 trillion dollars of annual clean energy technology investment will be needed by 2030. It further estimates that a total investment of 27 trillion dollars will be needed by 2050, more than 60% of which will be in batteries, and sees three terawatt hours of battery capacity being deployed worldwide by 2050 (including automotive batteries, **Fig. 1-1**)[2].



(Note) Stated Policy Scenario (STEPS): A scenario that accounts for all publicized policies and targets

(Source) IEA, *World Energy Outlook 2021* (October 2021)

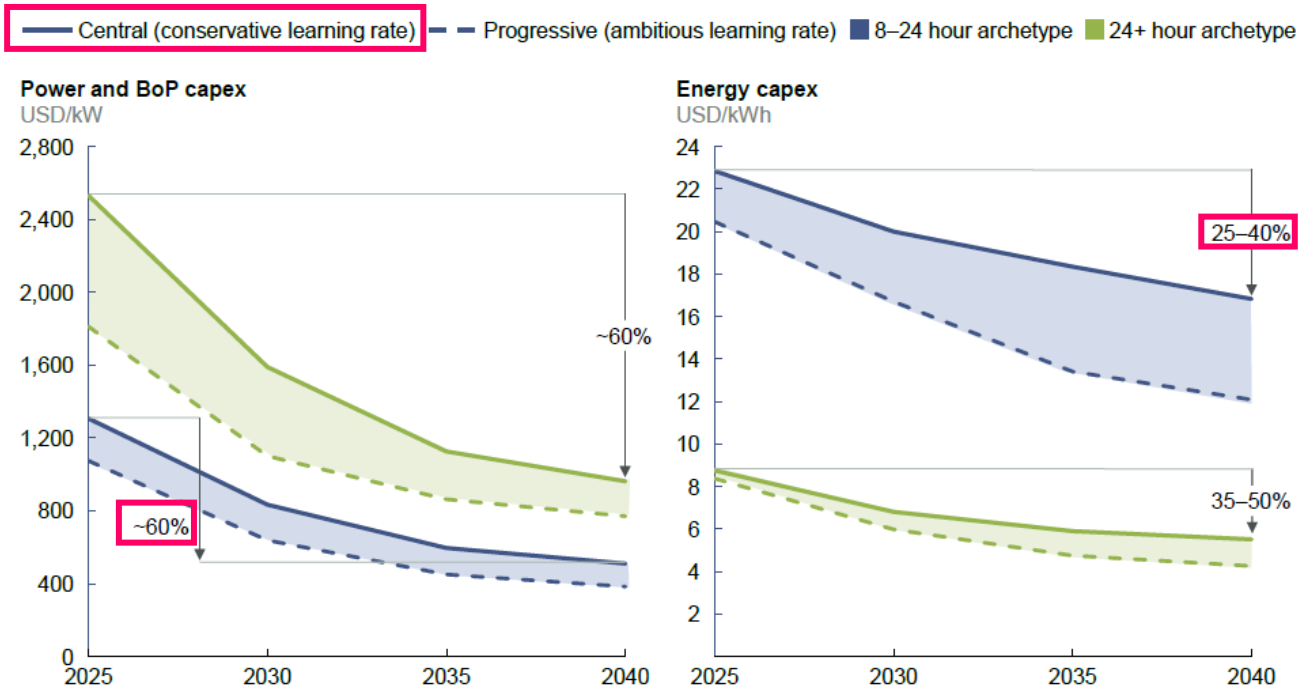
Fig. 1-1 Clean energy investment market size (by technology and region, 2020-2050)

[1] Yoshida (April 2021), *What Would Be the Most Suitable Battery for Utility-scale Energy Storage?- Redox Flow Battery Has Great Potential* -, Institute of Energy Economics, Japan

[2] IEA (October 2021), *World Energy Outlook 2021*, International Energy Agency, p.30.

The Announced Pledges Scenario, announced by the IEA at WEO2021, continues to diverge significantly from the Net Zero Emissions by 2050 Scenario and points to a need to fill gaps by prioritizing the reduction of emissions in the electricity sector, improvement of energy efficiency, reduction of methane emissions, and investment in hydrogen fuels and other low-carbon fuels, along with clean energy technologies. Low-carbon power[3] accounted for roughly 28% of global emissions as of December 31, 2020. Citing a need to increase this to 61% by 2030 and 88% by 2050, the Net Zero Emissions Scenario predicts that **batteries for the power grids needed to achieve that goal will, by 2030, grow to 18 times the 2020 level under the Announced Pledges Scenario and to 30 times that level under the Zero Emissions Scenario**[4].

A sharp decline in the costs of solar PV and wind power generation over the last 10 years has driven this increased deployment worldwide. Similarly, costs are expected to drop considerably for long-duration (8-24 hours) energy storage technologies. **Assuming a conservative learning curve, the equipment costs for long-duration energy storage technologies are predicted to conceivably decline by up to 60% per unit output ($/kW) and up to 40% per unit energy ($/kWh) over the 15-year period beginning in 2025 (Fig. 1-2)**.



(Source) LEDS Council (November 2021)[5]

Fig. 1-2 Outlook on long-duration energy storage technology costs (2025-2040)

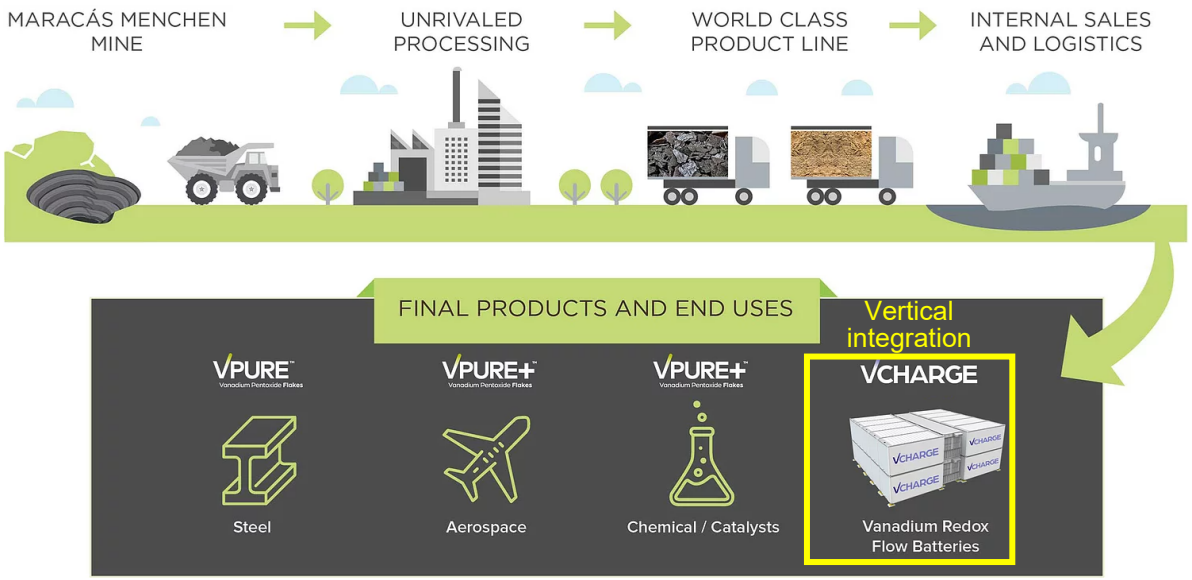
[3] Refers to zero-carbon energy or extremely low-GHG energy
[4] IEA (October 2021), *op.cit*., pp.37-40
[5] LDES Council (November 2021), *Net-Zero Power Long Duration Energy Storage for a Renewable Grid*, Long Duration Energy Storage Council, p.27

2. Mature sectors — Characteristic changes in the vanadium redox flow battery space

This section will look at characteristic trends and changes happening in the vanadium redox flow battery space, which is making advances both in terms of technology and the market.

(1) Largo Resources — Vanadium product manufacturers getting into VRFB production and sales through vertical integration

Largo Resources (Canada) supplies customers in the steel, aviation, and chemicals industries with highly purified vanadium products. In December 2020, the company announced that it would establish Largo Clean Energy and acquire from VionX Energy a group of patents related to vanadium redox flow batteries[6]. This enabled Largo Clean Energy to sell VRFBs under the VCHARGE +/- brand. Meanwhile, Largo Clean Energy hired core members from VionX Energy's technical team and succeeded in self-developing the kind of VRFB expertise and core technologies that took VionX Energy many years to achieve. Along with VRFB technologies that have been proven commercially viable, this deal has also seen the groundwork laid for scaling up in the future, including VionX Energy's investment of over 150 million dollars toward optimizing operations. These deals have led to the advent of vertically-integrated VRFB companies by major vanadium industry players. **(Fig. 2-1)**



(Source) Prepared by the author based on data from Largo Clean Energy[7]

Fig. 2-1 Entry into the VRFB manufacturing industry by Largo Resources (vertical integration)

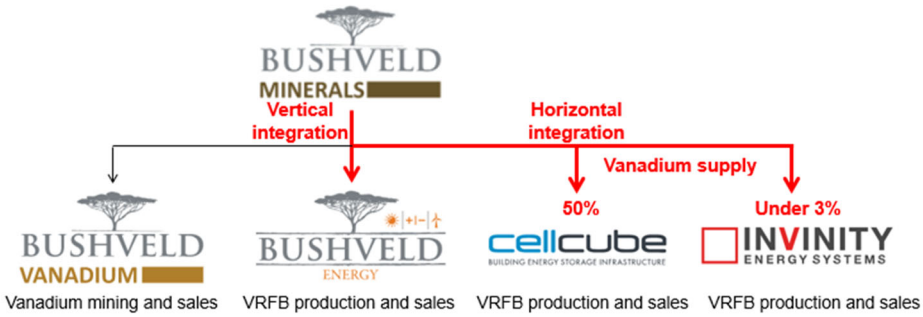
Largo Resources' vertically-integrated approach, which consists of a combination of using patented VRFB electrolyte processing technologies and industry-leading flow battery stack technologies, and supplying the highly-purified vanadium needed for vanadium electrolyte production, is a competitive one that will enable the company to reduce VRFB production costs by up to 40%. In July 2021, it was agreed that Largo Resources would supply its

[6] Largo Clean Energy (December 10, 2021), "Largo Resources Launches Largo Clean Energy," https://www.largocleanenergy.com/post/manage-your-blog-from-your-live-site
[7] Largo Clean Energy, "About Us," https://www.largocleanenergy.com/about

first-ever VRFB system (5 hours, 6.1 MWh) to a Spain-based subsidiary of Italy-based Enel, with operations to commence in 4Q 2022[8]. Largo Resources is planning to boost its VRFB production to 180 MW / 1,400 MWh by 2025 by fully leveraging the strengths of its vertically-integrated approach.

(2) Bushveld Minerals — A vanadium mining company that produces and sells VRFB through a combination of horizontal and vertical integration

Bushveld Minerals (South Africa) is a major miner, exporter, and supplier of vanadium. It had been indirectly involved in vanadium supply as well as VRFB production and supply through horizontal investments in Austria-based Enerox GmbH (50% stake), a producer of VRFB and supplier of VRFB under the CellCube brand, and UK-based Invinity Energy Systems (less than 3% stake), a major manufacturer and supplier of VRFB. In 2016, however, **it became directly engaged in the VRFB production and sales industries with the establishment of Bushveld Energy (vertically integrated)** (**Fig. 2-2**).



(Source) Prepared based on data from Bushveld Energy's website[9] and various other data[10][11]

Fig. 2-2 Bushveld Minerals' expansion of the vanadium business domain (horizontal-vertical integration)

Bushveld Energy is starting by opening the vanadium market in South Africa. Working with the Industrial Development Corporation of South Africa Ltd (IDC) Bushveld Energy is supplying VRFB systems (120 kW, peak energy 450 kWh) to state-owned power utility Eskom, and is currently conducting a proof of concept for the systems Furthermore, at its vanadium mines, the company is building mini-grids consisting of both solar PV (3 MWp) and VRFB systems (1 MW, 4 MWh) with the goal of reducing power costs and peak usage (**Fig. 2-3**).

[8] Largo Clean Energy (July 21, 2021), "Largo Enters into its First Battery Sales Contract with Enel Green Power España for VCHARGE± System," https://www.largocleanenergy.com/post/largo-enters-into-its-first-battery-sales-contract-with-enel-green-power-espa%C3%B1a-for-vcharge-system
[9] Bushveld Energy, https://www.bushveldminerals.com/bushveld-energy-3/
[10] Mining Weekly (November 13, 2019), "Bushveld group advances vanadium redox flow battery plans through Enerox deal," https://www.miningweekly.com/article/bushveld-group-advances-vanadium-redox-flow-battery-plans-through-enerox-deal-2019-11-13/
[11] Energy Storage News (April 6, 2021), "Vanadium producer Bushveld invests in scale up of Enerox flow battery manufacturing," https://www.energy-storage.news/vanadium-producer-bushveld-invests-in-scale-up-of-enerox-flow-battery-manufacturing/

(Source) Bushveld Energy's website[12]

Fig. 2-3　VRFB project by Bushveld Energy (Vametco Hybrid-Mini-Grid)

3. Maturing sectors —Paving the way for more venture companies with new technologies and possibilities of early scaling up

In the previous section, we looked at characteristic trends and changes happening with vanadium flow batteries, a technically mature space and rapidly expanding market. This section will summarize trends and changes happening in the flow battery space due to new and technically immature technologies.

(1) U.S.-based ESS Inc. — A specialized venture company that deals in iron flow batteries and that has the attention of even Bill Gates

ESS Inc.[13] was listed on the New York Stock Exchange through a SPAC[14] merger. Shockingly, despite having no revenues, the company was valued at ¥110 billion at the time of its listing. As an indication of the considerable expectations investors had for its growth, its stock price went up 70% on the first day of trading.

ESS Inc. is a venture company that specializes in iron flow batteries (Is). What exactly are IFBs and why is so much attention being given to ESS' IFBs, despite their immaturity as a technology?

Fig. 3-1 shows the principle of operation for ESS' IFBs, while **Fig. 3-2** shows their cell unit and power module. ESS' IFBs have a carbon substrate with carbon material used for the positive electrode and carbon composite substrate with polypropylene spacer for the negative electrode. A pump injects electrolytes (in aqueous solution containing iron chloride ($FeCl_2$), and charging and discharging occur from the resulting oxidation-reduction reactions. According to ESS, as with VRFBs, IFBs can charge and discharge without limit as they suffer no degradation, even from over-discharging[15]. Furthermore, since they are made primarily from iron, salt, and water, they are a non-toxic, highly-safe battery with zero fire risk.

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[12] Bushveld Energy, “Projects - Vametco Hybrid-Mini-Grid,” https://www.bushveldenergy.com/company/projects/
[13] Its ticker symbol is "GWH" (gigawatt hours)
[14] A special purpose acquisition company (SPAC) is a publicly traded company created in order to merge with an existing company in the future. Many SPACs have been listed in the U.S. because of the relatively simpler procedures and shorter time frame involved in getting listed relative to the conventional listing process.
[15]Refers to an extremely low-voltage state in which discharge continues even after the voltage falls below the discharge cut-off voltage (the lowest discharge voltage at which discharge can still be safely done)

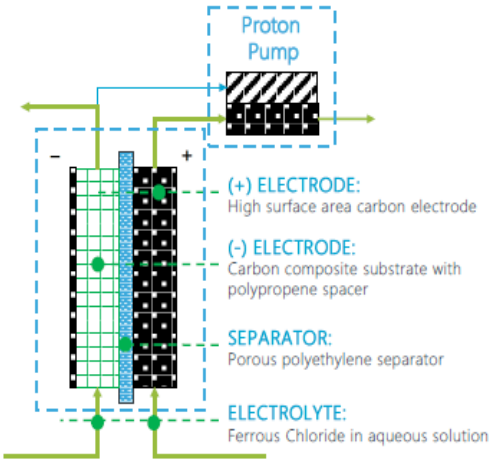
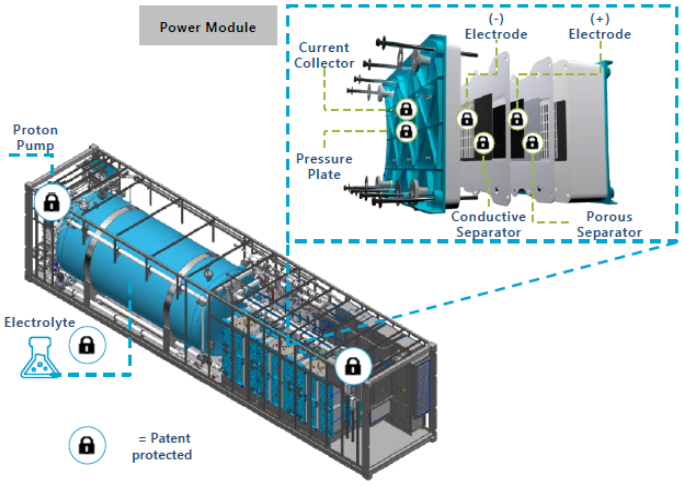


Fig. 3-1 Principle of operation for IFBs



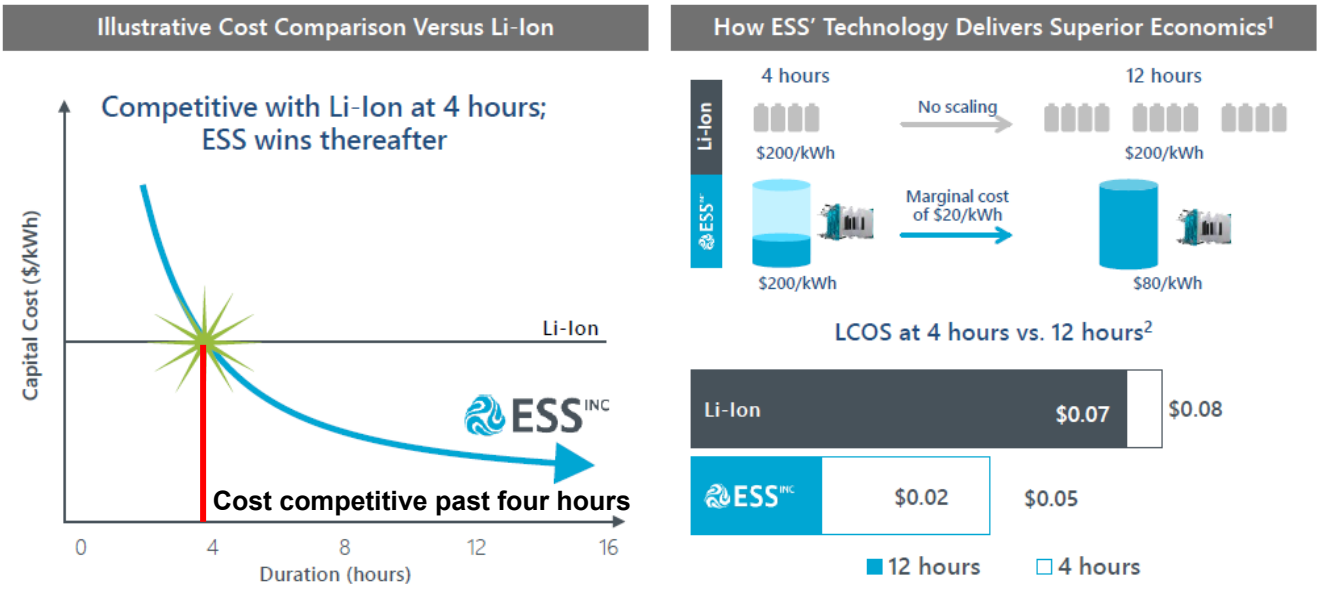
(Source) ESS Inc.[16]

Fig. 3-2 Cell unit and power module

The most groundbreaking thing about ESS' IFBs is their cost. ESS is targeting the market for power grids and other such large-scale markets that require long-duration energy storage of four to twelve hours, which is something for which lithium-ion batteries (LiBs) are ill-suited. LiBs lead the market and have found widespread adoption, primarily in automotive and household applications, due to their high energy density, small size, and light weight[17]. However, they are not well-suited to a larger form factor as the rising cost of the lithium inside them would compromise their cost competitiveness. Moreover, they can only charge and discharge for up to about four hours. In general, VRFBs are said to be more cost competitive than LiBs when their charge and discharge time exceeds eight hours. On the other hand, **IFBs are said to be cost competitive versus LiBs in systems where charge and discharge time exceeds four hours** (see **Fig. 3-3**). Electrolyte costs account for around 40% of the cost of producing VRFBs (this cost rises as a percentage of total battery cost as charge and discharge time increases), and the cost of vanadium, which is the primary component of electrolytes, accounts for about 45% of electrolyte costs. This makes reducing electrolyte costs key to reducing overall VRFB system costs. Unlike lithium, where resources are unevenly distributed, vanadium are ubiquitous worldwide. However, vanadium, the primary component of VRFB electrolytes, exists only in low concentrations in ore due to the many byproducts of mining activities such as phosphate rock, magnetite, and uranium that are produced when it is mined. Furthermore, the export market for vanadium is oligopolistic, with three countries — China (60%), Russia (17%), and South Africa (7%) — accounting for roughly 85% of all vanadium production. Furthermore, vanadium prices are rising[18] in the international commodities market due to rising demand for long-duration energy storage as a means to achieve net zero GHG emissions by 2050. Vanadium producers therefore face two risks: resource constraints and rising procurement costs. In contrast to VRFBs, IFBs suffer from no resource constraints as they are made from iron, salt, and water — all widely available and readily usable resources. Being relatively more stable in price and easier to procure

[16] ESS Inc., "Long Duration Energy Storage Systems for a Cleaner Future," https://essinc.com/wp-content/uploads/2021/08/ESS_Analyst-Day-Presentation-8-30-21.pdf
[17] Ibid., Yoshida (April 2021), Institute of Energy Economics, Japan
[18] https://www.investing.com/commodities/ferro-vanadium-80-min-europe-futures-streaming-chart

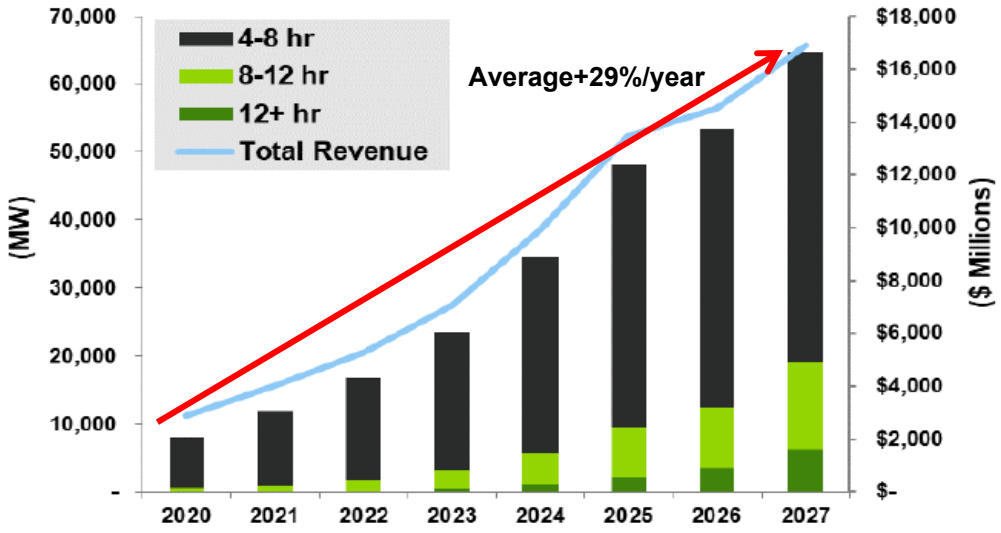
gives them a significant advantage. **By scaling up, it is said that they could be capable of achieving a lifecycle cost of storage (LCOS) of 0.02 $/KWh in 12-plus-hour systems (Fig. 3-3)**.



(Source) ESS Inc.

Fig. 3-3 Iron flow battery cost competitiveness (compared to LiBs)

Using the 300 million dollars it has raised through its listing, ESS plans to rapidly scale up its business. Specifically, it will bring the production capacity of its IFB manufacturing facility in Oregon, which is currently at 250 MWh, to 2 GWh by the end of 2022 and 6 GWh by the end of 2023, achieving a 24x increase over the next two years. Moreover, in addition to expanding its facility in the U.S., the company is currently thinking about making the most of the aforementioned lack of resource constraints and building new IFB production facilities in Asia and Europe.



(Source) Guidehouse[19]

Fig. 3-4 Deployed nameplate capacity and market size of long-duration energy storage batteries (2020-2027)

[19] Guidehouse (October 20, 2021), "White Paper: Energy Storage for the Decarbonizing Grid," https://guidehouse.com/-/media/www/site/insights/energy/2020/gh_eos_whitepaper_decarbstoragelongduration_2020.pdf?la=en

ESS' haste to scale up is to meet rapidly growing market demand. In recent years, California has been conducting large-scale planned power outages in order to prevent major forest fires caused by aridness and strong winds. Texas saw cold snaps in 2021 that far exceeded expectations and led to a power failure that lasted several days. These frequent outages and power failures caused by frequent natural disasters, themselves partly the product of global warming, have shaken the world's confidence in the United States' power grids, creating an urgent need to deploy long-duration energy storage technologies for use in backup applications. California estimates that it will need to deploy up to 11 GW of batteries capable of four-plus hours of charge and discharge time by 2030, and to deploy you can also get on up to 55 GW by 2045 to achieve climate change mitigation targets[20]. The increasing magnitude of natural disasters is a growing concern around the world. Consequently, **demand for batteries with a four-plus hour charge and discharge time is expected to increase at an annual average rate of more than 29% over the next seven years (Fig. 3-4)**.

Based on the above, ESS estimates that the market for long-duration batteries could grow to 700 billion dollars by 2027. ESS signed numerous large sales contracts in 2021, indicating that expectations are indeed high for the company's IFBs. SoftBank subsidiary SB Energy signed a contract with ESS to purchase up to two gigawatts of IFBs through 2026[21]. Similarly, Italy-based Enel concluded an agreement to buy 17 Energy Warehouse systems (a consumer-side battery system; ESS will also supply Energy Center as a front-of-the-meter product; **Fig. 3-5**) through a renewables subsidiary in Spain[22]. Taking advantage of a technical characteristic of IFBs whereby they do not degrade after repeated charges and discharges, ESS will work with Munich Re, the world's largest reinsurance company, to provide quality assurance for 10 years. Developments such as these illustrate the visionary and convenient sales methods being implemented[23].

[20] California Energy Storage Alliance (December 8, 2020, press release), “New research finds California alone will need deploy 2-11 GW of long duration energy storage by 2030, and up to 55 GW by 2045,” https://www.storagealliance.org/pr_long-duration
[21] ESS (September 30, 2021, press release), “ESS and SB Energy Sign Agreement to Deploy Two Gigawatt-hours of Long-Duration Storage,” https://essinc.com/ess-and-sb-energy-sign-agreement-to-deploy-two-gigawatt-hours-of-long-duration-storage/
[22] ESS (September 23, 2021, press release), “ESS Inc. Contracts With Enel Green Power España to Deliver 17 Energy Warehouse™ Long-Duration Iron Flow Battery Systems,” https://essinc.com/ess-inc-contracts-with-enel-green-power-espana-to-deliver-17-energy-warehouse-long-duration-iron-flow-battery-systems/
[23] S&P Global (October 13, 2021), “ESS seeks to expand energy storage universe after stock market blastoff,” https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/ess-seeks-to-expand-energy-storage-universe-after-stock-market-blastoff-67058674

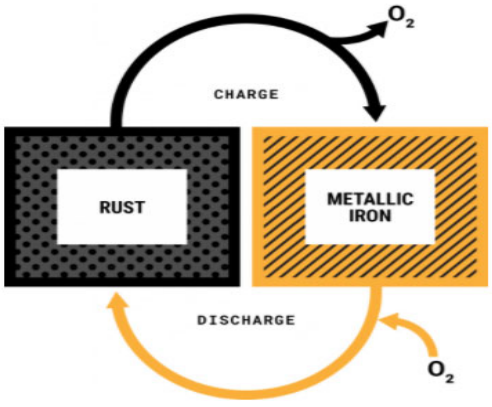
(Source) ESS Inc.

Fig. 3-5　ESS' iron flow battery product lineup

(2)　Form Energy — A venture company specializing in "iron-air batteries" led by a former Tesla executive

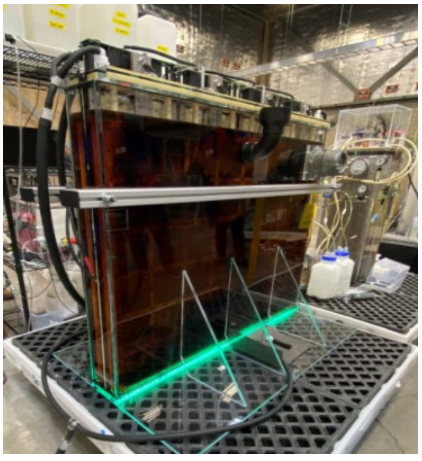
U.S.-based Form Energy is a venture company specializing in iron-air batteries (IAB) and was launched by a former head of the stationary energy storage business for Teslaa. Since Form Energy has been taking a passive stance on disclosing information, no information important to assessing the technological characteristics of IABs have been released. Despite this, the company has captured the interest of many investors with its IAB technologies, and succeeded in procuring 240 million dollars in the latest funding round[24].

The principle of operation for IABs is a simple one: it can reverse the chemical process whereby iron oxidizes and rusts. More specifically, when discharging they take in oxygen from the air, oxidize it, and convert it to rust. When charging, they apply an electrical current to turn rust back into iron and release oxygen in the process (**Fig. 3-6 and 3-7**)[25].



(Source) Form Energy

Fig. 3-6　Principle of operation of iron-air batteries



(Source) Form Energy

Fig. 3-7　Form Energy's iron-air batteries

[24] Energy Storage News (August 25, 2021), "Iron-air long-duration battery startup Form Energy closes US$240 million funding round," https://www.energy-storage.news/iron-air-long-duration-battery-startup-form-energy-closes-us240-million-funding-round/
[25] Form Energy, "Technology –The Battery Cycle-,"https://formenergy.com/technology/battery-technology/

According to Form Energy, IAB's greatest technical advantage lies in its use of iron, water, and air, which are low cost and exist in abundance all over the world, and it aims to get the production cost to 20 $/KWh. With such non-flammable and safe components, IABs can be used even in urban areas. Along with not degrading with repeated charging and discharging, IABs are well-suited to scaling up as the lack of resource constraints involved enables them to be produced anywhere in the world. Form Energy's IABs can also be used in long cycles of 100-plus hours. As such, the technologies to compete with IABs are not LiBs but rather hydrogen and other long-duration energy storage technologies.

As previously discussed, despite the technical immaturity of IABs, expectations are high among users looking for a low-cost, long-duration energy storage technology. In the state of Minnesota, Form Energy is working with Great River Energy, a cooperative of electricity producing, transmitting, and distributing companies to prepare for the launch of a pilot project in 2023 that will see the installation of a 1 MW module at a natural gas-fired power plant **(Fig. 3-8)**. In the winter of 2019, temperatures in Minnesota dropped to -10°C. This caused wind turbines to shut down, resulting in the shutdown of wind farms in the Upper Mid West as well as coal and natural gas plants in the area. Preparing for these sorts of tragedies is the goal of the pilot project and, if Great River Energy obtains conclusive technical proof, it is thinking about expanding its IAB systems to 300 MW. Form Energy's pilot project using IABs is that the results could lead to advancing IAB technology and stimulating market growth, thereby spurring development of Minnesota's steel industry[26].

(Source) Form Energy

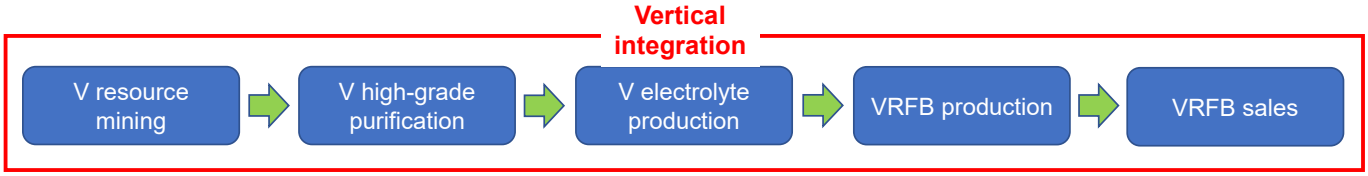
Fig. 3-8 Pilot plant operated in conjunction with Great River Energy (1 MW module)

[26] Renewable Energy World (September 3, 2021), “Minnesota utility co-op sees big battery as piece of grid reliability puzzle,” https://www.renewableenergyworld.com/storage/minnesota-utility-co-op-sees-big-battery-as-piece-of-grid-reliability-puzzle/

IAB's technologies are not especially new, and have a simple principle of operation. Furthermore, they are seen as commercially viable from the perspective of raw material costs. However, due to the fact that Form Energy is refusing to release performance data, many doubt the feasibility of it achieving its target production cost of 20 $/KWh[27].

4. Characteristic changes taking place in the flow battery space — An examination of implications and impact

(1) Mature sectors — Those with access to core resources will stake their survival on vertical integration

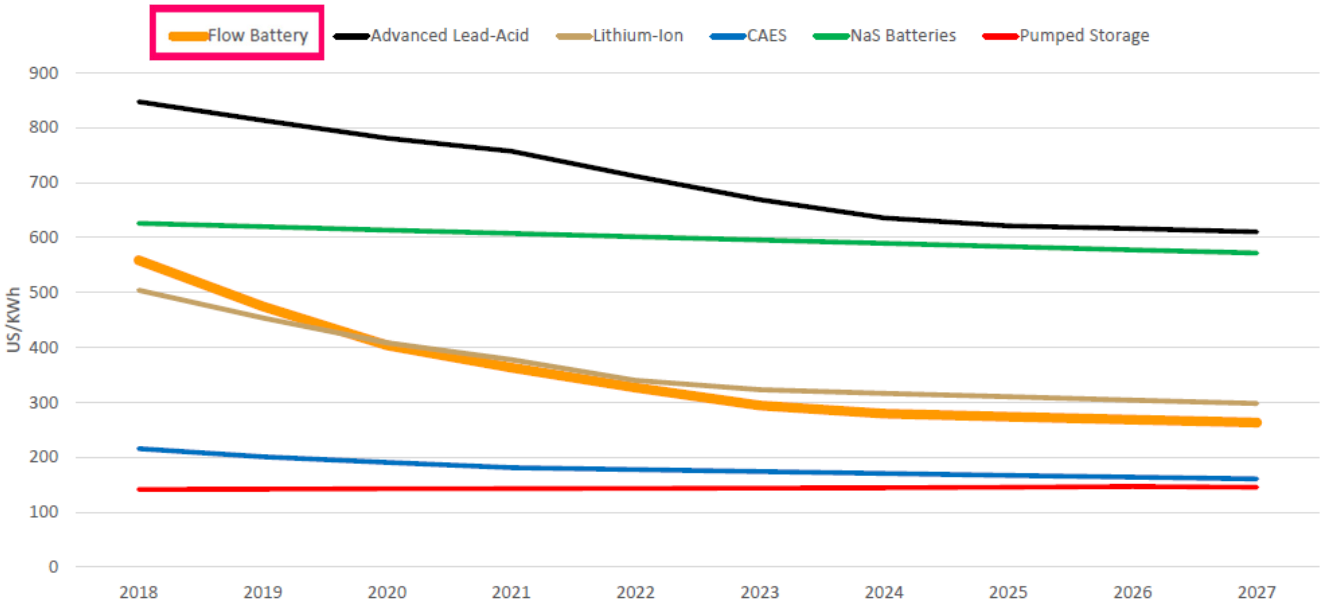


(Note) Prepared by the author

Fig. 4-1 Example of vertical integration in the mature sector of the flow battery space

VRFBs are what represent the mature sector for flow batteries. As discussed above, in this space, industry players with access to core resources and technologies in the form of vanadium mines and production technologies are strengthening their control in the market by expanding their business domains through vertical integration (**Fig. 4-1**). Their aim here is the pursuit of a strategy centered on cutting costs in order to survive amid fierce competition. VRFBs have seen dramatic cost decreases over the last several years. This trend is expected to continue, and should galvanize further VRFB proliferation (**Fig. 4-2**). The commercial use of VRFBs is expanding around the world, a trend that is likely to only accelerate. This will make it easy for those who have access to core resources, particularly vanadium, to establish an advantageous position relative to those who do not. As renewables deployment grows around the world, demand for the long-duration energy storage technologies that support them (especially batteries) is expected to rise even further, just as has been seen with LiBs for electric vehicles. With demand predicted to grow for VRFBs as a viable and mature technology, companies with access to the vanadium that goes into them and the core technologies to process vanadium are taking the initiative to cut costs by reducing middlemen margins in order to survive amid market competition that is likely to intensify. Vertical integration is one traditional means of prevailing in mature market competition.

[27] CNBC (August 25, 2021), "Stealthy battery company backed by Bill Gates, Jeff Bezos has a lot to prove," https://www.cnbc.com/2021/08/25/form-energy-raises-240-million-on-iron-air-battery-promise.html

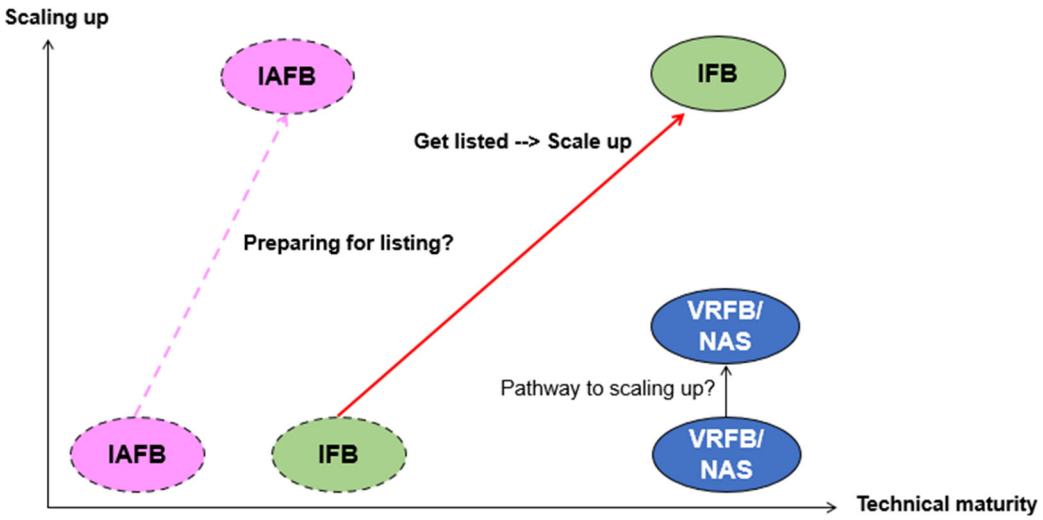


(Source) Guidehouse

Fig. 4-2　Projected energy storage technology equipment costs (2018-2027)

(2) Maturing sectors — A bid to scale up over the shortest possible time horizons by those with core technologies

This section provides an outline of the characteristic changes happening at specialized venture companies with IFBs and IAFBs in maturing industries. Keywords that apply to both are "core technologies" and "scaling up over shortest time horizons."

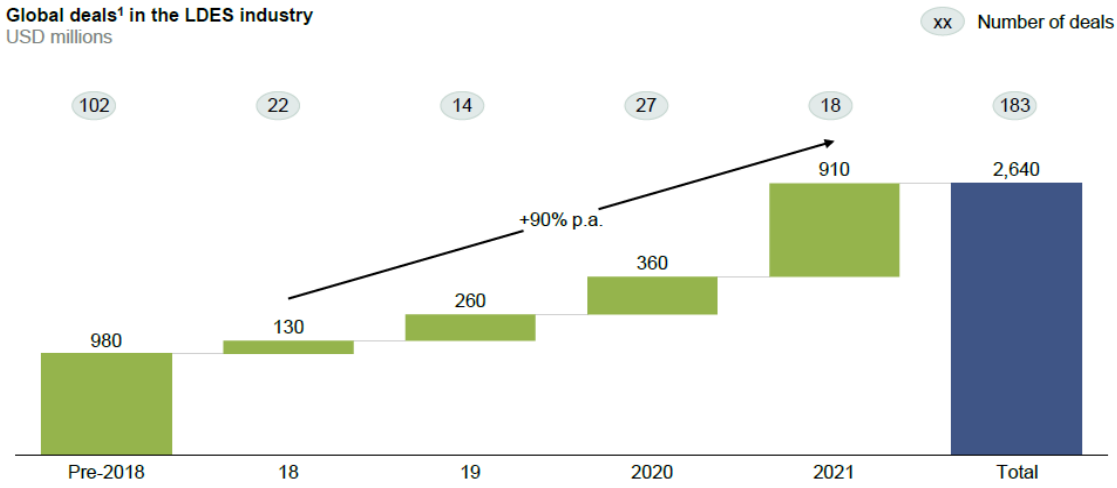


(Source) Prepared by the author

Fig. 4-3　Positioning of new players in the flow battery space

With the Y axis showing scaling and X axis indicating technical maturity, **Fig. 4-3** presents a comparison of changes brought by new flow battery players to NAS batteries and to VRFBs, a grid-scale battery. Technically, ESS' IFBs are

arguably immature. However, by scaling up over the shortest possible time horizon using funds procured through the stock market, the company is attempting to jump straight to full technical maturity. Sumitomo Electric Industries and NGK Insulators have been developing VFRB and NAS technologies, respectively, for many years, and while pilot projects and other accomplishments they have made around the world have put them in a better position than their competitors, they have no clear path for scaling up. One could say that ESS and Form Energy are taking a completely different approach from Sumitomo Electric Industries and NGK Insulators.



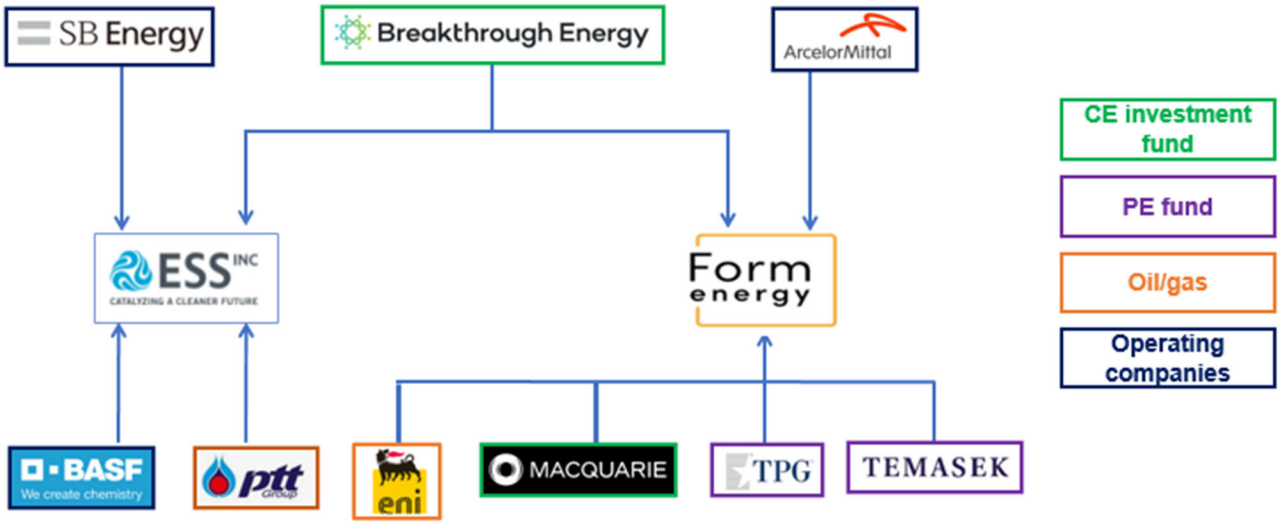
(Note) Applies to heat, mechanical, chemical, and electrochemical energy storage technologies with durations beyond eight hours

Source: LDES Council[28]

Fig. 4-4　Number and total amount of investments in long-duration energy storage technologies

ESS has been focused on the global market since its founding, with green energy investors and the venture development ecosystem pushing the company's vision along. According to the LDES Council, investments in the long-duration energy storage technologies grew having nearly tripled in the last four years over the four-year period from 2018 to 2021, from 980 million dollars to 2.6 billion dollars (**Fig. 4-4**). Along with Breakthrough Energy, a clean energy investment fund being supported by Microsoft founder Bill Gates and Amazon founder Jeff Bezos, SoftBank subsidiary SB Energy and Germany-based BASF are also investing in ESS (Breakthrough Energy has also made investments in Form Energy). Italy-based ENI and Thailand-based PTT are also investing in flow batteries in the oil and gas industries, while BASF is investing as a diversified chemicals industry player. Such investments illustrate a broadening of venture investment and the scope of development ecosystems to now cover batteries for use in long-duration energy storage. They also make clear that conditions are coming together for a considerable scaling up of these technologies (**Fig. 4-5**).

[28] LDES Council (November 2021), *op.cit*., pp.11-12



(Source) Prepared by the author based on various data

Fig. 4-5　New venture investment and development ecosystem in the flow battery space

Conclusion

This paper has presented an overview of characteristic changes happening in the flow battery space based on technical maturity levels, and has examined the implications and impact of these changes. We have seen that mature sector players who have access to resources are taking the initiative and vertically integrating in order to further strengthen their positions, while those in immature industries are focusing on the global market from the start and laying ambitious groundwork for scaling up in the future. This seems to foreshadow interest growing even further for flow battery space.

In Japan, mass adoption of electric vehicles, the renewal of expired solar FIT agreements, a great enthusiasm among companies to conclude corporate PPA, and other such developments indicate that demand is only going up for renewables aimed at decarbonization. Meanwhile, further development of the IoT and IoE is spurring explosive growth in data volume and driving tremendous demand for data centers. Data security problems are prompting businesses to bring their data centers back into the country from overseas, but they are faced with the need to use clean energy in their operations. With the battle over renewables already underway, we can expect to see an acceleration in the deployment of the long-duration energy storage technologies that will support the fight. Despite the flow battery space being an area in which Japanese companies excel, it would seem that there is yet no pathway to scaling up. As the global market for flow batteries expands on the back of rising demand, survival amid international competition will require that public and private sectors work together to build and strengthen supply chains while working to scale up business.

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