

ELECTROVAYA, INC.
(OTCMKTS:EFLVF TSX: EFL)

Powering Ahead With Lithium-Ion Batteries For
Material Handling and Electric Vehicles

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KEY POINTS

- Lithium-ion batteries (LIBs) are gaining increased importance due to higher energy efficiency, longer life span, and higher density. As a result, LIBs are finding growing applications in industrial vehicles like forklifts, lift trucks, ground support applications, electric vehicles, stationary energy storage, and consumer electronics, among others, with Electrovaya well positioned to leverage this megatrend.
- Electrovaya, a research-intensive company, has over two decades of experience. Management believes it has a unique, differentiating technology that delivers greater safety and greater longevity, without compromising energy and power, than other batteries commercially available today. The company has an IP portfolio of over 100 patents.
- Safety is now the key performance parameter in LIBs. For example, two major auto companies had multibillion-dollar recalls last year due to battery safety. UL safety test data shows unique safety for Electrovaya's proprietary batteries and the pristine safety record of Daimler's e-Smart cars with Electrovaya ceramic components. Safety in commercial vehicles is even more important, whether they are material handling vehicles operating inside buildings, or e-buses or e-trucks carrying many passengers and valuables.
- The company believes their battery is a 'million-mile' item needed for e-vehicles that work long hours from 12-16 or even 24 hours a day. Data from Walmart and Raymond/Toyota indicate the extreme longevity of these batteries. Energy storage also requires batteries which can last over 15-20 years.
- Currently, the company's primary target market is the commercial industry, with a target market size of ~two million e-lift trucks in the U.S. By 2026, Electrovaya targets a ~10% market share of the new electric forklift segment, equating to 20,000 forklift batteries and an additional 500 e-bus and e-truck batteries. The price of a lift truck battery is usually \$12,000 to \$35,000

KEY STATISTICS

Price*	\$0.68
52-Week Range	\$0.63 - \$2.10
Avg. Daily Vol. (30 day)	58,375
Shares Out (MM)	145.9
Market Cap (\$MM)	\$99.24
Enterprise Value (\$MM)	\$101.39
Revenue TTM (\$MM)	\$9.78
Fiscal Year-End	September

Source: YCharts, *As of January 19, 2022

OUR INSIGHTS

The Opportunities

Electrovaya is uniquely positioned to leverage the rapid growth in lithium-ion battery demand. Management believes it has one of the best-performing commercially available batteries available on the market. However the company remains relatively undiscovered by most investors outside of Canada. Demonstrating the company's progress and technology are its strategic relationships with major OEMs, including Raymond and Toyota. In addition, Electrovaya batteries are starting to be used by major materials-handling customers, including Walmart, Mars, Home Depot, and a large online retailer. There is also a robust opportunity to retrofit existing lithium-ion units from lead-acid batteries. The company also believes it has exceptional opportunities in buses and Class 3 trucks, and recently inked a supply agreement with Vicinity Motors. Solid-state batteries present the second stage of growth and are a sea change technology under development, with 2023 targeted for launch.

The Obstacles

The company is in the initial stages of its pivot from e-passenger cars (Daimler) to higher-value e-commercial vehicles. However, the execution risk is minimized. The company has been delivering repeat orders for multiple distribution centers at Walmart and Mars, multiple stores at Home Depot, and a large e-retailer. Over 2,000 e-forklift trucks are now operating powered by Electrovaya.

COMPANY OVERVIEW

Electrovaya is a leading manufacturer of safe and long-lasting lithium-ion batteries with differentiated performance and safety attributes, according to the company. The company has two primary battery platforms: Infinity and Solid State. The Infinity battery platform targets commercial vehicles, including lithium-ion e-forklift, e-bus, and e-trucks. This product has been launched commercially through global partners, including Toyota, Raymond, and Walmart. To date, Infinity sales have been primarily to the material handling industry, where lithium-ion batteries are replacing lead-acid batteries and, to some degree, fuel cells. The company's batteries can also be used in larger grid-scale energy storage. The Solid State platform (SSB) is under development and targeted to launch in 2023, focusing on creating the lowest initial \$/energy (kWh) and highest energy density. The target market for SSB will be e-passenger cars where a low initial cost (sticker price) is required. Electrovaya sells its battery solutions through two primary channels: OEM strategic supply agreements and a direct sales force. It primarily utilizes strategic partners for battery sales into new equipment or vehicle production, and its direct sales force for the retrofit market. In addition to the two battery platforms, Electrovaya also develops cells, modules, battery management systems, software, and firmware necessary to deliver the systems. Electrovaya has substantial intellectual property in the lithium-ion battery sector and continues to carry out research and development activities in lithium-ion batteries, with over 100 patents in their portfolio. In June 2021, a new operating division named [Electrovaya Labs](#) was formed to focus on the R&D and commercialization of other disruptive technologies, including next-gen solid-state cells and a unique patented electrode processing technology. Electrovaya Inc. was founded in 1996 and is headquartered in Mississauga, Canada.

The Technology

Infinity Battery Platform: According to Grand View Research, the global lithium-ion battery market was valued at \$53.6 billion in 2020 and is expected to cross \$216.5 billion by 2028, representing a CAGR of 19%. The Infinity lithium batteries are based on proprietary ceramic technologies, allowing for improved safety and longevity without compromising energy and power. The EV-44 is Electrovaya's primary lithium-ion ceramic cell and meets the most stringent standards of safety, energy density, cycle life, and performance. In addition, Electrovaya's battery systems are designed to be scaled through a modular approach, which provides flexibility for an application's specific capacity requirements.

Solid State Platform: According to Grand View Research, the global solid-state battery market was valued at \$590.9 million in 2020 and is expected to cross \$5.3 billion by 2028, representing a CAGR of 36%. Electrovaya believes it is well-positioned for this next-generation battery technology. Its division, Electrovaya Labs, focuses on developing solid-state battery technology, among others, and has targeted 2023 for the debut of its solid-state battery platform.

Battery Management Systems: Electrovaya's 5th Generation BMS provides the highest levels of cell balancing, IoT functionality, and safety. Reviewed and certified by UL to UL991 and UL1998 for specific applications, it is available for both low voltage and high voltage battery systems. Electrovaya's hardware and firmware engineering team keep advancing and improving this technology to keep up with the increasing demands of the e-mobility industry. Electrovaya has launched a cloud-based battery analytics system for recurring revenues with a subscription model. The system monitors battery health, utilization, and charging to provide customers with optimized fleet and charging management. Furthermore, the system improves the capability and efficiency of troubleshooting and maintenance. Several customers have started using this analytics system.

The Markets

Material Handling: The material handling industry is undergoing a massive sea change from lead-acid batteries to alternative power sources, including lithium-ion and fuel cells. Electrovaya is having notable success in penetrating the material handling market as management believes it has arguably the highest performing battery solution in the market today. In addition, the company's customers have proven meaningful RIOs in material handling when compared to lead-acid, showing paybacks as short as a month, opening a significant opportunity for new units sold, as well as retrofits.

E-Mobility: In October, 2021, Electrovaya announced a strategic supply agreement with e-bus and e-truck manufacturer [Vicinity Motor Corp.](#) for EV buses and fully electric VMC 1200 Class 3 trucks. Management believes this is opening a new market for their batteries, and it is targeting further development and commercialization in this market. The company's solid-state battery platform will also target this market, with an expected launch date in 2023.

Key Drivers

- Management believes it is gaining market share across the material handling sector with batteries for retrofit and new equipment production. It uses both direct and OEM channels for this emerging market. Major repeat customers include Walmart, Home Depot, Mars, and a large online retailer.
- Electrovaya is targeting to increase sales through OEM channels. It has entered into strategic alliances with Raymond Corp, a Toyota subsidiary and North America's largest forklift manufacturer, and Vicinity Motor Corp, a leading electric bus and e-truck supplier in North America.
- In January 2022 the company received two orders totaling \$6.0 million for two distribution centers owned by a large e-commerce company, delivered by March 2022. These new purchase orders followed an initial order for \$2 million from the same company in June 2021. This e-commerce company has indicated its demand in 2022 for several greenfield and brownfield sites and, if that materializes, it will become the largest user of Electrovaya products in 2022.
- Electrovaya has launched a cloud-based battery analytics system for recurring revenues with a subscription model. The system monitors battery health, utilization, and charging to provide customers with optimized fleet and charging management. Furthermore, the system improves the capability and efficiency of troubleshooting and maintenance.
- The company expects 2022 will be a pivotal year for new commercial-scale orders and new business development. Revenue in 2022 is expected to be about \$27 million, with a positive EBITDA. The market risk to reach this target is reduced, as the emerging market to replace lead-acid batteries and diesel is gaining momentum. Furthermore, the Raymond/Toyota Material Handling group has a minimum annual purchase requirement of \$15 million to keep its exclusivity with Electrovaya, starting January 2022.
- The company has a working capital line of \$7 million, which should be adequate for it to meet the \$27 million revenue projection in 2022 and operate with a positive EBITDA. Additionally, the company has a base shelf for \$100 million if further growth funds are needed.
- The company's present Infinity battery line meets critical performance parameters of safety and longevity. This is demonstrated by the fact that the largest global OEM in its space, Raymond/Toyota, teamed with Electrovaya after intense validation of the technology, which took some 18 months, and Walmart started deploying the technology in multiple distribution centers. Safety is the critical performance indicator in lithium-ion batteries.
- Electrovaya is gaining value-added market share and pulling away from the global competition with its Infinity line. The company is also developing two patented next-generation disruptive technologies. The solid-state battery (SSB) initiative presents a tremendous opportunity. The SSB development is progressing, and patents have been filed with excellent initial performance data from coin cells. It is early to predict how the industry's technology and competition in SSB will develop relative to Electrovaya's SSB technology. The company has lengthy and unique experience scaling up lithium-ion batteries and SSBs. Its second disruptive technology, the non-toxic electrode production scale-up, would also be another important technology in the lithium-ion battery space. The massive use of toxic chemicals in lithium-ion electrode production creates extraordinary costs in environmentally sensitive jurisdictions like North America and the USA.

RECENT HISTORY AND KEY MILESTONES

Date	Description
1996	<ul style="list-style-type: none"> Founded by Dr. Sankar Das Gupta and Dr. Jim Jacobs focusing on lithium-ion technology
29-Apr-15	<ul style="list-style-type: none"> Announced completion of the acquisition of Evonik Litarion and licensing of SEPARION™ (“Separion”) intellectual property from Evonik
2015	<ul style="list-style-type: none"> Purchased Evonik’s 700 MWh/year battery factory in Europe in 2015 for producing batteries for Daimler’s Smart electric drive car from 2015-2018
22-Jul-16	<ul style="list-style-type: none"> Received approval for trading on OTCQX Best Market in the U.S. under the symbol “EFLVF”
25-Aug-16	<ul style="list-style-type: none"> Introduced LC-44, a new 44 Ah lithium-ion cell with higher energy density
18-Jul-17	<ul style="list-style-type: none"> First demonstration battery order for e-forklifts. Delivered 36V 960 Ah lithium-ion ceramic batteries and associated chargers to Mondelez International in an order worth \$634,000
2017	<ul style="list-style-type: none"> Delivered and installed 1.5MWh battery Energy Storage system in Toronto
25-Jul-18	<ul style="list-style-type: none"> Completed delivery and commissioning of Electrovaya batteries purchase order worth \$4.3 million received in September 2017 at a Walmart distribution center in Canada
26-Mar-19	<ul style="list-style-type: none"> Partnered with Jabil to provide battery solutions for their autonomous guided vehicles (AGVS)
9-May-19	<ul style="list-style-type: none"> Signed sales agreement with Raymond Corp allowing its sales and service network to sell Electrovaya battery systems to clients having the select compatible Raymond lift trucks; Raymond intensive validation of Electrovaya’s technology performance in respect of longevity, safety, power, and energy took over 18 months
9-Jul-19	<ul style="list-style-type: none"> Announced the addition of advanced features to its EV44 cell, including higher energy density and lower cobalt content. The cells have over 44Ah of capacity and an average output voltage of 3.7V, improved temperature tolerance and cycle life
4-Feb-20	<ul style="list-style-type: none"> Announced acquisition of 30 key ceramic separator patents for lithium-ion batteries earlier owned by Litarion GmbH
19-Nov-20	<ul style="list-style-type: none"> Received UL2580 certification for 24V and 36V line of forklift batteries. Also received UL991 and UL1998 certifications for its 5th generation proprietary battery management system
23-Feb-21	<ul style="list-style-type: none"> The company announces its intent to list on the Nasdaq to enhance investor profile, attract institutional & retail investors, further M&A opportunities and increase shareholder value
18-Mar-21	<ul style="list-style-type: none"> Announced commercial launch of electric bus battery systems with the delivery of a 700V, 300kWh battery marking its entry into the growing electric bus market
16-Jun-21	<ul style="list-style-type: none"> Announced mutual settlement of all potential claims, part of Litarion’s insolvency proceeding termination. Electrovaya to pay € 221,000 as full and final payment in installments over nine months
23-Jun-21	<ul style="list-style-type: none"> Established a new operating division ‘Electrovaya Labs’ focusing on R&D and commercialization of some of the fundamental technologies and intellectual property at Electrovaya
13-Oct-21	<ul style="list-style-type: none"> Signed strategic supply agreement with Vicinity Motor for lithium battery systems for Vicinity Lightning™ EV buses and fully electric VMC I200 Class 3 trucks
Jan 2022	<ul style="list-style-type: none"> Received \$6 million order from a large e-commerce user for two sites. This was a repeat order from the user.

COMPANY STRATEGY – TWO BATTERY PLATFORMS

Electrovaya operates through two battery platforms (i.e.) the ‘infinity platform’ and the ‘solid-state platform.’

Infinity Platform

This platform comprises established battery products for commercial vehicles, e-bus, e-forklift, and e-trucks. The lithium batteries offered have higher energy and power efficiency than lead-acid batteries, and industry trends are likely to continue to favor Li in new platforms across the modern motive sector. The initial focus of the company has been on material handling. According to Materials Handling magazine, the total addressable market stands at ~2.6 million lift trucks in the U.S. Electrovaya has installed its battery packs in over 67 locations across North America with customers including Raymond/Toyota, Walmart, Mars, BMW, Maple Leaf, Pafco, Michelin, Mondelez, Lowes, Home Depot, and Unilever, among others.

Solid-State Platform







This segment comprises the development of solid-state battery technology. The company has established a new research division, Electrovaya Labs, to unbottle the technology and develop it commercially. These batteries are expected to have the highest energy density and are more cost-efficient and safer than the existing lithium-ion batteries with liquid electrolytes. The application in electric passenger vehicles is likely to be at the core of solid-state battery technology development, requiring higher battery run time at lower costs. The company is also developing a non-toxic, low-cost method of electrode production, another disruptive technology in this industry. The company’s data claims much improved and homogeneous microstructure in this new process compared to the conventional process. This is in addition to not using toxic chemicals, such as n-methyl-pyrrolidone, and further capability in improving the microstructure of the electrode, which increases cell energy density and cell performance.

Products and End-Market Applications

Material Handling—Electrovaya’s Largest Short-Term Target Market

Based on the Infinity battery platform, Electrovaya believes it provides a wide range of proven, powerful, safe, maintenance-free, and cost-efficient battery systems for application in varied material handling electric vehicles, including forklifts, electric lift trucks, etc. The battery systems are U.L. certified, OEM-approved, and drop-in ready for existing and new Class 1, Class 2, and Class 3 electric truck fleets. The company provides batteries for newly manufactured electric trucks and replacement batteries for existing fleets powered by lead-acid batteries. The batteries come in different models with power ratings of 24V, 36V, 48V, and 80V for a potential market of ~2 million lift trucks in the U.S. Currently, the company’s batteries are used in e-forklift systems in over 67 locations. According to the company, some of the key advantages include:

- Offer industry-leading cycle-life and safety without compromising energy and power performance
- Have higher productivity due to longer drive time between duty cycles and lesser battery swapping
- Can be recharged up to 100% in an hour using the UberCharge
- Provide cost reductions vs. competing power technologies (lead-acid, fuel cell, propane, diesel)
- Are UL2580-certified and provide a drop-in replacement for lead-acid batteries

Feature	Description
 <p>Power</p>	<ul style="list-style-type: none"> The batteries are designed to operate even in three-shift, heavy-duty applications with one battery per truck
 <p>Maintenance Free</p>	<ul style="list-style-type: none"> Do not require watering or any other maintenance
 <p>Safety</p>	<ul style="list-style-type: none"> The batteries are protected using proprietary lithium-ion ceramic technology These are possibly the only commercially available UL Listed NMC batteries
 <p>Savings</p>	<ul style="list-style-type: none"> The batteries offer the longest cycle-life and lowest cost of ownership, providing more than 30% energy savings over lead-acid batteries
 <p>Rapid Charge</p>	<ul style="list-style-type: none"> Electrovaya's batteries have the highest U.L. rated charge rates compared to any lithium-ion battery in the market The batteries can be charged rapidly using existing infrastructure or Electrovaya's UberCharge systems
 <p>Plug and Play</p>	<ul style="list-style-type: none"> The batteries can be fitted into new or existing setups without the need for any additional infrastructure The company's BMS is a cloud-based battery analytics system with a subscription model, hence a potential source of recurring revenues The system monitors battery health, utilization, and charging to provide customers with optimized fleet and charging management. Furthermore, the system improves the capability and efficiency of troubleshooting and maintenance. Several customers have started using this analytics system.

E-Mobility

Electric Buses & Commercial Vehicles

Electrovaya has developed specialized heavy-duty vehicle battery systems ideal for all electric buses and commercial vehicles. Key product highlights include:

- Parallel battery pack design enabling a large range in overall capacity
- High-voltage architecture for applications up to 1,000V
- Optional liquid cooling for high rate applications
- Systems enabled with Electrovaya's overall system controller for vehicle integration
- Include CANBus communication to charger and vehicle systems

Electric Passenger Vehicles



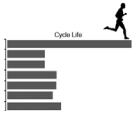

Electrovaya is currently working on a solid state battery (SSB) platform expected to be launched in late 2023. Through the recently formed Electrovaya Labs, the company continues to advance its work in SSB and EV solutions.

- The company’s SSB platform focuses on creating the lowest initial \$/energy (kWh) and highest energy density. The target market will be e-passenger cars where a low initial cost (sticker price) is required.
- Solid-state batteries can substantially increase energy density and improve other battery characteristics with applications in the energy storage and electric transportation sector.
- Electrovaya has filed for multiple patents on this technology and expects the production of larger pouch cells by 1Q CY2022.
- Electrovaya plans to scale up and commercialize solid-state battery technology for e-passenger cars and other markets

Automated Guided Vehicles (AGVs)

AGVs can run continuously for 24 hours, hence they require a long-lasting, reliable, and durable power system. Electrovaya has powered over 1,000 AGVs for Badger Technologies, a Jabil company. Some of the salient features of the AGV batteries include:

- Modular design with 2.3kWh building blocks and are available in 48V configuration
- Designed for automated charging and withstand 24/7 operations
- CANBus communication to charger and vehicle systems and are available in customizable specifications

Feature	Description
 <p>Powerful</p>	<ul style="list-style-type: none"> • The batteries are designed to operate even in three-shift, heavy-duty applications with one battery per AGV truck
 <p>Safety</p>	<ul style="list-style-type: none"> • The batteries are protected using proprietary lithium-ion ceramic technology. These are possibly the only commercially available UL Listed NMC batteries
 <p>Energy Density & Range</p>	<ul style="list-style-type: none"> • The batteries use NMC Ceramic technology and provide high energy density. This results in longer range and better performance
 <p>Low Cost of Ownership</p>	<ul style="list-style-type: none"> • Battery systems are designed to match the lifespan of the vehicle, offering the longest cycle-life and lowest cost of ownership

Energy Storage

Electrovaya offers energy storage solutions for industrial and commercial applications. The company provides customized energy storage products with long cycle life as per the clients/application requirement. It has installed storage systems in busy urban centers in Canada and U.K.

Figure I: Energy Storage Solutions Delivered to Customers



Energy Storage System installed in the UK with Scottish and Southern Energy



Energy Storage System installed at Ryerson University in Downtown Toronto

Source: [Company Website](#)

UberChargers

Electrovaya offers intelligent lithium-ion battery chargers under the brand name UberCharge which can fully charge batteries within an hour. These chargers have a built-in anti-arcing circuitry protection technology to prevent arcing from loose connection or hot disconnects. These chargers are highly efficient (>90%), requiring low maintenance with easy-to-replace parts.

Charger Specifications

Models	500V	320V	250V
No. of Phases	3		
Frequency	50/60 Hz		
AC Voltage	230, 400, 440, 480, 600 V		
AC Amp	48/42 V	29/23 V	12/9 V
DC Voltage Nominal	24-48 V	24-48 V	24 V
Max Current Output	500 A	320 A	250 A
Dimensions (L x W x H)	36V: 522 x 625 x 1057 mm 48V: 550 x 650 x 1400 mm	522 x 625 x 1055 mm	505 x 442 x 901 mm
Weight	36V: 225 kg 48V: 314 kg	213 kg	132 kg
Communication	CANBus		

Source: [Company Website](#)

Why Companies Are Making the Move to Electrovaya's Lithium-Ion Batteries (Energy Essentials from Raymond)

According to Raymond, lithium can reduce utility bills from higher energy efficiency and better regenerative acceptance, enhance life cycle management capabilities with industry-leading data integration, and provide increased pallet positions due to smaller battery compartment size while decreasing carbon emissions and electricity costs. [Raymond provides an ROI calculator](#) for companies considering the switch, with the table below showing the concluding ROI.

Figure 2: Lithium-ion ROI Illustration

	Operation Costs	
	Lead-Acid	Lithium-ion
Battery Maintenance (Hours/Month/Battery)	2.5	0.08
Battery Maintenance (Hours/Month/Truck)	7.50	0.08
Maintenance Costs per Hour	\$30	\$30
Battery Maintenance Costs per Year	\$2,700	\$29
Total Cost per Day	\$53.44	\$0.09
Annual Operating Costs per Truck	\$17,100.80	\$28.80

	Return on Investment	
Initial Investment	\$30,000	\$34,250
Annual Total Cost of Ownership	\$22,650.80	\$6,128.80
Annualized Productivity Improvement (Hours)		936
Annualized Productivity Improvement (Dollars)		\$28,080
Annualized Energy Cost Savings (Dollars)		\$491.23
Lithium Annual Investment (over Lead Acid)		-\$16,522
Annual Savings		\$45,093.23
Annual ROI		736%
Year 1 ROI		1,073%
Break Even Month		1

Source: [Raymond Corp Website](#)

Key Customers

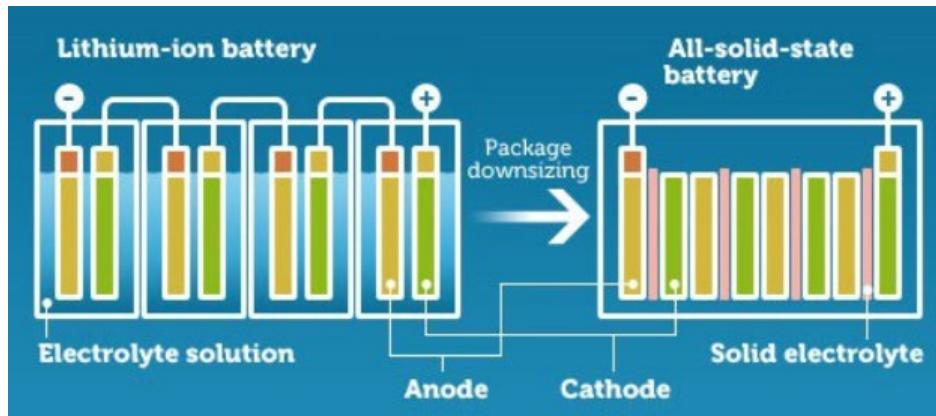
Some of the key companies already using ElectroVaya’s lithium-ion battery solutions include these Fortune 500 clients



Solid-State Batteries

Electrovaya set up a new division, ElectroVaya Labs, in June 2021 to continue its focus on the research and development of new technologies. The division is working on developing a proprietary solid-state battery (NMC cathode/lithium metal anode). Li-ion batteries today use a liquid electrolyte which exposes them to a risk of battery damage like swelling caused by temperature change or leakage caused by an external force. On the other hand, solid-state batteries use a solid electrolyte which improves the battery stability with a solid structure and increases safety as it maintains the form even if the electrolyte is damaged. The solid electrolyte plays the role of the separator as well.

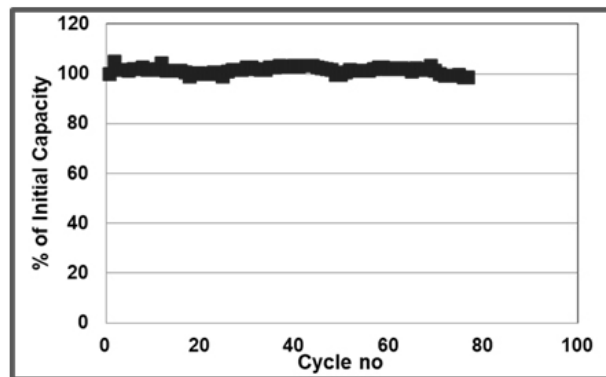
Figure 3: Solid State Battery



Source: [AutoIQ](#)

In October 2021 the company announced preliminary results highlighting promising developments. For example, the initial results have demonstrated minimal capacity fade. Also, multiple tests have shown performance repeatability with coin cells at room temperature.

Figure 4: Cycling Results of ElectroVaya Coin Cell using its Proprietary Technology



Source: [Electrovaya Press Release](#)

Solid-state batteries can substantially increase energy density and improve other battery characteristics with applications in the energy storage and electric transportation sector. The company has also filed for the patent on this technology and expects the production of larger pouch cells by 1Q CY2022. Going forward, Electrovaya plans to scale up and commercialize solid-state battery technology.

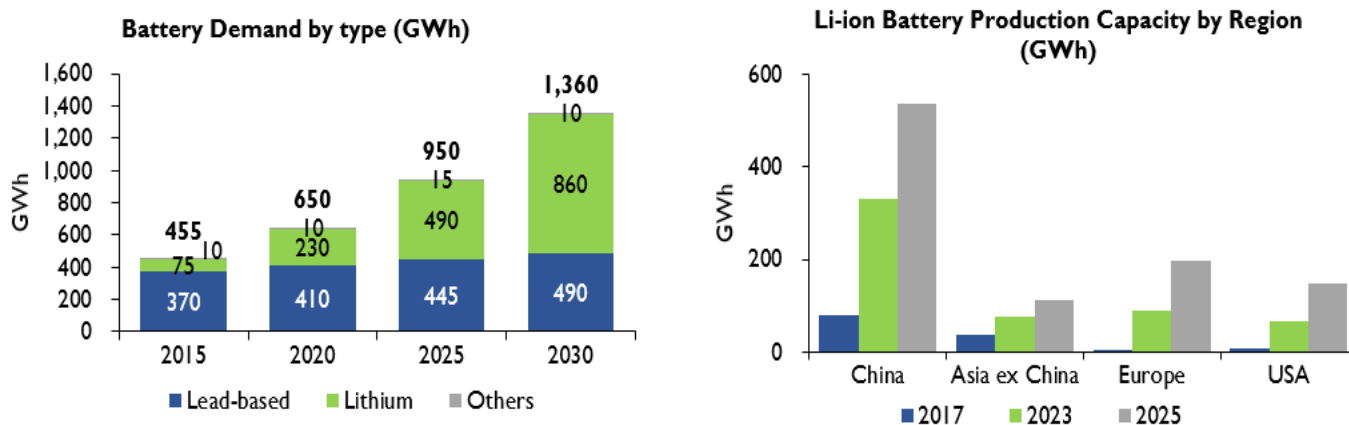
INDUSTRY OVERVIEW

Lithium-ion batteries find applications in almost all electric devices surrounding us. They are ubiquitous in consumer electronics, electricity storage systems, and defense applications. Current and projected demand is expected to be dominated by electric vehicles (EVs). As per Bloomberg, worldwide sales of passenger EVs will reach approximately 56 million units in 2040, and the deployment of lithium batteries in grid storage is likely to cross 1,095GW by 2040 against 9GW in 2018.

According to Grand View Research, the global lithium-ion battery market was valued at \$53.6 billion in 2020 and is expected to cross \$216.5 billion by 2028, representing a CAGR of 19%. The growth is expected to be driven by a surge in EV sales, a growing number of photovoltaic installations, nuclear power plants, the beginning of wind energy projects, and the increasing usage of lithium-ion batteries in medical equipment.

Increasing off-grid installations in the U.S., China, India, and Germany, coupled with rising acceptance, long life span, reduction in battery prices, and high energy density of lithium-ion batteries, are likely to propel the market over the forecast period.

Figure 5: Global Li-ion Battery Demand and Production Capacity



Source: [Avicenne Energy Presentation](#)

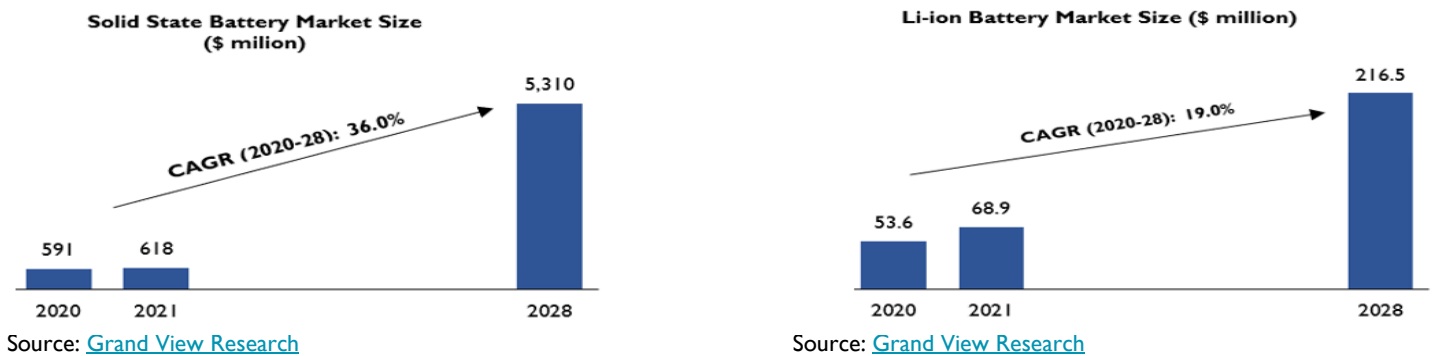
Solid-State Lithium-Ion Batteries

According to Grand View Research, the global solid-state battery market size was valued at \$590.9 million in 2020 and is expected to cross \$5,310 million by 2028, representing a CAGR of 36%. China dominates the market with bulk manufacturing facilities. Vehicle manufacturers like Nio, Enovate, and Weltmeister are working to commercialize SSBs for transport applications. The Chinese government is also pumping huge investments into battery production projects, further driving the market.

Solid-state lithium-ion batteries have a higher energy density than li-ion batteries which uses liquid electrolytes. As a result, SSBs do not risk explosion or fire; hence, they need fewer or no safety components. This also enables more active materials to increase the battery capacity, making them perfect for the EV battery system, which requires high capacity.

Solid-state battery developers have received and continue to garner investment and media attention. Still, despite the tremendous amount of money flowing into the research, the developers have yet to solve the complexities and challenges of using a solid electrolyte. In addition, the developers are still to prove if these SSBs can be used at a commercial scale.

Figure 6: Solid Vs. Liquid State Market Size Forecast

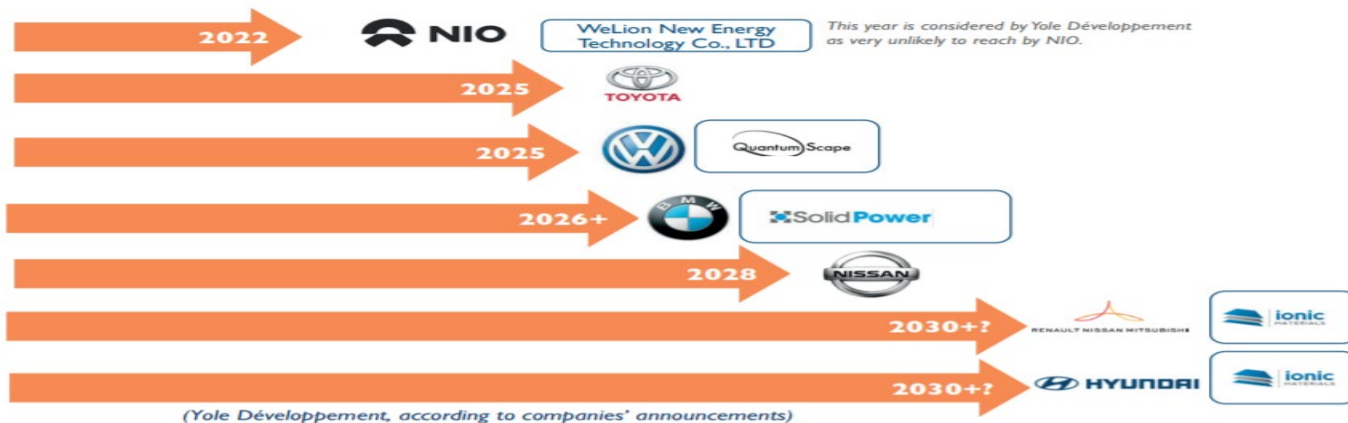


Solid-State Batteries to be a Game-Changer for Electric Vehicles

Range and battery charging time are the biggest concerns for customers looking to buy EVs. SSBs are expected to address this concern as they have more energy density, offer more energy, take less time to charge, and are more compact than traditional liquid electrolyte batteries. As per Volkswagen, the SSBs will offer ~30% more range and be charged to ~80% within 12 minutes (less than half the time required to charge the fastest li-ion cell now available). Globally, the EV companies are investing heavily in SSB technology development to differentiate their offerings from competitors. EV makers are likely to have high-volume battery requirements, i.e., they will need a lot of battery cells per vehicle for a lot of vehicles every year. Many companies partner with SSB developers and are planning to launch EVs with SSBs in the coming years. Some of the key partnerships include:

Company	Description
Toyota	Developing SSBs inhouse with an internal research team and in JV (Prime Planet Energy & Solutions, Inc.) with Panasonic
Volkswagen	Invested in Quantum Scape Corp, which intends to introduce SSBs by 2024 for Volkswagen's EV and after that for other carmakers
Stellantis	Has a venture with Total Energies called Automotive Cells Co and partnership with China's Amperex Technology Co. Ltd. for developing solid-state batteries. The company intends to launch the battery packs by 2026
BMW AG	In partnership with Ford, has invested in a startup, Solid Power. The company claims to have technology with 50% more energy density than liquid state batteries and will launch batteries by the mid-2020s.
Hyundai	Plans to start mass production of SSBs by 2030 through its Solid Energy Systems
Samsung SDI Co Ltd	Is an affiliate of Samsung Electronics and is working on developing SSBs

Figure 7: EV Manufacturers Racing Towards Solid-State Batteries



Source: [Yole Development, April 2021](#)

Electrovaya's SSB Solution

Many years ago, Electrovaya personnel assisted Hydro-Quebec in developing a solid-state battery. The battery worked; however, the lithium ion-conducting polymer had low conductivity at room temperatures. Since then, there have been many attempts to develop an SSB without any major commercial success.

Electrovaya's focus has been on the interfaces. In all electrochemical systems, the interface is where difficulties arise. Much of the improvement in the Infinity battery platform has been due to improved interfaces.

The company believes that it has developed a breakthrough technology in the SSB battery interface, and initial data shows excellent coin cell results. The company is now carrying out further development work and hopes to communicate more performance data.

The advantages of an SSB are well known—lower cost, higher energy density, lower cathode complexities, smaller volume, improved safety.

With the company's non-toxic electrode process, Electrovaya can further improve energy density through engineering the anode micro-structure.

Solid-State Battery Market Segmentation

By Application

According to Grand View Research, consumer and portable electronics were the most prominent segments in 2020, with a 33.6% share of the total market. Increasing urbanization and growing discretionary spending have increased spending on consumer electronics like smartphones, laptops, media players, etc. Other vital segments included electric vehicles (EVs), energy harvesting, wearable & medical devices, and others. EVs are predicted to become a dominant category by 2028, owing to their widespread worldwide deployment.

By Geography

In 2020, APAC accounted for a 51.2% share of the total global solid-state market, followed by Europe and North America (20.7%), according to Grand View Research. Across APAC, China, India, Japan, and South Korea are expected to enhance the demand growth in the coming years, driven by government regulations for lowering carbon emissions, the push for EVs, and a growing population supporting demand for consumer electronics in the region.

By Type

Based on battery type, the batteries are classified as thin-film and portable batteries. According to Grand View Research, the thin-film battery segment is expected to grow at a CAGR of 36.3% up to 2027, given their wide range of applications in IoT and wearable devices like fitness bands, smart clothing, and smartwatches (due to efficient recharging rate and compact design). In addition, low maintenance and higher energy density of SSBs will also support their growing application in consumer electronics.

By Capacity

Based on battery type, the batteries are segmented as 'below 20mAh', '20mAh-500mAh', and 'above 500mAh'. According to Grand View Research, batteries in the 'below 20mAh' segment are expected to grow at a CAGR of ~42% during the 2020-27 period. The batteries in this segment are primarily the thin film batteries catering to cosmetics, medical, wireless sensors, packaging, and other consumer applications. On the other hand, the 'above 500mAh' segment accounted for a 19.6% market share in 2019, driven by the increased usage of SSBs in EVs. In addition, the growing demand for battery energy storage systems in industrial and commercial sectors is further expected to augment this segment's growth.

Battery Market in North America for Commercial MHEVs.

Currently, ~90% of the material handling electric vehicles (MHEVs) in North America use non-lithium batteries for energy storage. There are two reasons for it.

1. MHEVs mainly work indoors, inside manufacturing or distribution centers, and it would have been catastrophic if there was a safety incident inside a warehouse. Safety incidents in lithium-ion batteries are ubiquitous, with a long history of unsafe batteries from most manufacturers, and sometimes billion-dollar recalls.
2. MHEVs work hard, often multi-shift and seven days a week. Typically these vehicles need million-mile batteries, which the standard NMC high-energy LIBs cannot provide. Hence NMC LIBs are focused on e-passenger cars where 150,000 miles is a good lifetime warranty. In MHEVs, the vehicle would exceed 200,000 miles in a year.

With its unique combination of safety and longevity without compromising energy and power, Electrovaya's battery is a fresh approach in this industrial sector, leading to its strategic supply agreement with Raymond/Toyota, the largest material handling OEM.

MHEVs would present a huge market opportunity for lithium battery suppliers. This market is estimated at ~1.5 million electric forklifts (mainly powered by lead-acid batteries) and, at an average price of \$15,000, would be an addressable market of over \$20 billion.

COMPETITION

The lithium-ion battery industry is highly competitive and geographically concentrated. The top 10 battery producers (all from Asia) account for more than 90% of the overall market share, with China leading the way with two of the world's largest manufacturers, CATL and BYD. The sector comprises several small and large-scale industry players in countries like the U.S., China, Japan, and India. As a result, companies are undertaking strategies like setting up JVs and doing M&As to increase their market share and presence. Organically, the companies aim to increase profitability through R&D activities and product innovation. Some of the key Lithium-ion battery and SSB developers are as follows:

Lithium-Ion

Contemporary Amperex Technology Limited (CATL)

Incorporated in 2011, CATL is the world's largest battery manufacturer with a one-third share of the global electric car battery market and the most OEM ties, including Tesla, BMW, Daimler, Geely, Great Wall, Honda, Hyundai, Volkswagen, and NEVS. Based in China's coastal city of Ningde, CATL has risen to become the world's largest battery business in less than 10 years. Outside China, CATL faces stiff competition from established players like LG and Panasonic. CATL specializes in manufacturing lithium-ion batteries for EVs and energy storage systems, and battery management systems (BMS).

CATL relies heavily on its partnership with Tesla. The two companies agreed in February 2020 to produce batteries for EVs built at Tesla's second battery mega factory, Giga Shanghai. Tesla is now producing Model 3s at a rate of 250,000 EVs per year. The Model 3 is China's lowest-priced premium mid-sized vehicle, owing to CATL's cobalt-free lithium iron phosphate (LFP) batteries and local procurement. For now, CATL is building a vast factory more than three times the size of Tesla and Panasonic's electric car battery gigafactory in the Nevada desert.

LG Chem / LG Energy Solution

Based in South Korea, LG is the world's second-largest producer of EV batteries and a major supplier of lithium-ion batteries to automakers like Audi, Mercedes-Benz, and their respective parent companies, Volkswagen Group and Daimler. LG Chem's battery division, LG Energy Solution, was officially spun off in December 2020. The new company will increase the production of battery cells for Tesla, which will include Giga Berlin in Germany. Management anticipates LG Energy Solution will overtake CATL as the top manufacturer of lithium-ion batteries in 2022, owing to its more diversified business globally, a significant order backlog totaling ~\$217 billion, and overall stronger intellectual assets. It is on its way to becoming the third-largest publicly traded firm in the country after its initial public offering in January 2022.

LG Chem is South Korea's largest cathode material manufacturer. It intends to increase its production capacity from 80,000 tonnes to 260,000 tonnes by 2026 to lead the worldwide market in the field of cathode materials. A cobalt-free cathode material that does not require costly cobalt, and a single crystal cathode material for solid state batteries, are also being developed. Cathode materials account for 40% of battery manufacturing costs. These advancements will allow LG Energy Solution to get lower-cost raw materials from LG Chem to produce battery packs.

Panasonic

Panasonic, with over 100 years of experience, is the world's third-largest provider of EV batteries. According to Benchmark Mineral's categorization criteria, the company is a Tier I lithium-ion battery maker. The accreditation indicates that the company manufactures the highest-quality lithium-ion batteries for automotive applications. Panasonic's efforts in the EV supply chain are widely known, owing to its partnership with Tesla. Panasonic and Tesla collaborated in 2014 to create Giga Nevada, the world's biggest lithium-ion battery facility. Panasonic will soon launch its prototype production line on Tesla's featured battery cell, known as the 4680. The new structure is projected to hold more energy and have a simpler production process, which is critical to further lowering battery prices. It has five times the capacity of the cells Tesla currently uses. Panasonic intends to start test production of the new cells at a plant in Japan in March 2022. Currently, the battery accounts for around 29% of the overall cost of an EV.

Panasonic is Tesla's exclusive supplier of lithium-ion batteries for EVs made in the United States and plans to grow its EV battery client base outside Tesla. The company has announced a collaboration with Toyota to establish a lithium-ion facility in Japan that would provide 500,000 EVs beginning in 2022.

BYD

BYD is the second-largest lithium-ion battery supplier in China after CATL. Starting in 1995, the initial growth came from strong sales of batteries for mobile phone handsets, followed by the creation of BYD Auto after the purchase of Qinchuan Machinery Works in 2002 (Qinchuan had been manufacturing cars since 1987). The company manufactures lithium-ion battery cells for passenger and commercial vehicles, energy storage systems, and consumer electronics. BYD Auto, the company's automotive manufacturing subsidiary, builds a range of battery-electric, hybrid-electric, and combustion-powered passenger cars, commercial vehicles, trucks, and buses.

BYD's current annual manufacturing capacity is projected to be around 60GWh. It had earlier announced an ambition to boost this amount to roughly 100GWh for 2020; however, as a result of the coronavirus pandemic, battery demand suffered a major short-term reduction throughout 2020. BYD's product line includes both large electric vehicles such as buses and trucks and small vehicles such as battery-powered city cars.

In 2008, US investment company Berkshire Hathaway fronted by Warren Buffett made a \$230 million investment in BYD in return for a 10% stake in the company; The investment recognized the strength of BYD in electric vehicles and would be the first step in exporting them from China to other markets, potentially including North America. BYD has several joint ventures in the electric vehicle market space with Toyota, Hino, Chang'an, Daimler, and Alexander Dennis.

Samsung SDI

Samsung SDI is a battery and electronic materials manufacturer based in South Korea. It operates in the energy solutions and electronic materials segments. The energy solutions segment manufactures rechargeable batteries used for IT device, automotive, and energy storage system (ESS) applications, and the electronic materials segment produces materials for semiconductors and displays. Samsung SDI has developed a complete battery cell platform portfolio and is capable of mass-producing various advanced automotive battery cells.

In January 2022, Samsung SDI announced the launch of its new battery brand, PRiMX, which will be applied to all Samsung SDI batteries, creating a new standard rather than an additional brand on top of the current lineup. According to the company, the PRiMX batteries will be high-performance, with high nickel (low cobalt) cathode, and silicon anode, and very high reliability and safety. One of the advantages will also be "the super-fast charging technology"—the reduced internal resistance of the cells is promised to translate into shorter charging times.

EnerDel

Founded in 2004, EnerDel was the first company in the U.S. to set up commercial-scale production of large format, prismatic, lithium-ion battery packs. The company designs and manufactures lithium-ion energy storage solutions and battery systems primarily catering to heavy-duty transportation, on- and off-grid electrical, mass transit, and specific task-oriented applications. The company is headquartered in Indianapolis, U.S., and has manufacturing facilities in Indianapolis, U.S., and South Korea.

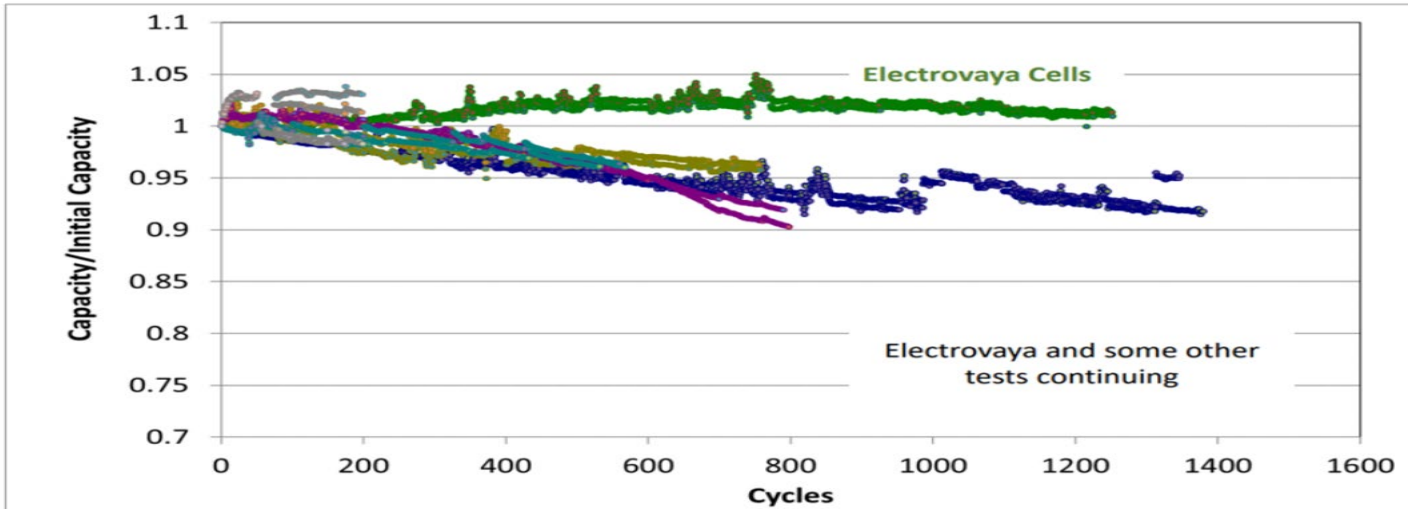
QuantumScape

QuantumScape is developing next-generation battery technology for electric vehicles ("EVs") and other applications. Over the last eight years, the company has developed a strong partnership with Volkswagen Group of America Investments and certain of its affiliates. Volkswagen has invested, and committed to investing assuming certain closing conditions are met, a total of more than \$300 million in QuantumScape, and has established a 50-50 joint venture to enable an industrial level of production of solid-state batteries. Volkswagen has successfully tested multiple generations of the company's single-layer, laboratory cells at industry-accepted automotive power rates. QuantumScape states that no other lithium-metal battery technology has demonstrated the same ability to achieve automotive power rates with acceptable battery life. The company expects Volkswagen to be the first to commercialize vehicles using its battery technology. Over the next few years, QuantumScape focuses on an initial pre-pilot manufacturing facility and its IGWh pilot facility and intends to work closely with other automotive original equipment manufacturers.

Electrovaya Cycle-Life a ~100-300% Potential Improvement Versus Competitors

Figure 8: Results of 3rd Party Laboratory Testing provided by Raymond/Toyota

Conditions: 22°C ambient, 0.5C charge rate, 4.0V end-point
6 cell types, tested in duplicate



Source: Electrosvaya

SUMMARY FINANCIALS

FYE: September ('000 US\$)	FY'18	FY'19	FY'20	FY'21
Revenue	5,633	4,891	14,525	11,584
Growth, %	147.6%	(13.2%)	197.0%	(20.2%)
Gross profit	1,764	1,942	4,933	3,924
Margin, %	31.3%	39.7%	34.0%	33.9%
EBITDA	(6,143)	(3,707)	(447)	(3,749)
Margin, %	(109.1%)	(75.8%)	(3.1%)	(32.4%)
EBIT	(6,451)	(3,816)	(656)	(4,068)
Margin, %	(114.5%)	(78.0%)	(4.5%)	(35.1%)
PAT	(22,657)	(2,837)	1,112	(7,534)
Margin, %	(402.2%)	(58.0%)	7.7%	(65.0%)
Total Assets	15,830	2,088	10,642	14,977
Gross Debt	26,814	12,822	9,960	8,642
Cash	126	333	1,124	4,202
Net Debt	26,688	12,489	8,836	4,440
Total Liabilities	29,588	16,353	19,357	16,673
Total Equity	(13,758)	(14,265)	(8,715)	(1,696)

Revenue

Revenue decreased to \$11.6 million in the year ended September 30, 2021 compared to \$14.5 million in 2020, a decrease of \$2.9 million or 20%. The 20% decrease in y/y revenue was due to reduced order volume resulting from a transition to the OEM strategic supply agreement with Raymond/Toyota, which was signed in December 2020. This OEM agreement brought a new corporate sales team focused on large corporations, which required time to become familiar with lithium-ion battery solutions and the sales cycle. Uncertainty on the part of customers due to concerns over global component shortages and continued supply chain disruptions caused a delay in orders.

It appears that these delays have been reduced as the company has received indications of significant new orders for delivery in 2022, with the majority of the new orders generated through its OEM sales channel but also with a significant new order from the direct sales channel. These orders included both repeat customers and new customers. In December 2021, a key customer indicated that they would be placing orders valued at approximately \$9 million in 2022, with deliveries beginning in the first quarter of the calendar year.

The company anticipates revenue of approximately \$27 million for the fiscal year ending September 30, 2022 (FY2022), more than double revenue of \$11.6 million in FY2021. The revenue is anticipated to be generated from two primary sources: direct sales and sales through the company's OEM partner dealer network.

The revenue forecast considers the OEM strategic supply agreement, pursuant to which Raymond/Toyota must make a minimum annual purchase of \$15 million to maintain exclusivity. This annual period commenced on January 1, 2022. While there is no assurance that the OEM will make more than \$15 million of purchases in 2022, given the sales initiatives underway with the OEM, management anticipates achieving or even possibly exceeding this minimum purchase level. Accordingly, it has included it in the revenue forecast of \$27 million for FY2022.

Working Capital & Capital Resources

The company ended FY2021 with \$4.2 million of cash and had drawn \$3.3 million of a working capital facility with maximum availability of \$5.6 million, leaving a further \$2.3 million available for drawing. The company believes this available liquidity of \$6.5 million (cash of \$4.2 million plus available line of \$2.3 million) is adequate working capital to support its operating activities at the anticipated sales level for the 12 months ending September 30, 2022.

In December 2021 the promissory note, which was due to mature on December 31, 2021, was amended to mature on July 1, 2022. All other terms and conditions were unchanged. In December 2021, the working capital facility was amended to extend the maturity from December 31, 2021 to December 31, 2022.

On December 7, 2021 the company filed a final base shelf prospectus with the securities regulatory authorities in Canada's provinces and territories. The base shelf prospectus is valid for 25 months. During this time, the company may offer and issue, from time to time, common shares, warrants, units, subscription receipts, and debt securities, or any combination thereof, having an aggregate offering price of up to \$100 million.

Given the company's strengthened financial position, available cash and operating facility, extended maturity of promissory notes, good relations with its supportive financial lender, strong relationship with its OEM partner, strong sales pipeline, and availability of \$100 million shelf prospectus, it appears well-positioned to reach its FY2022 revenue target of \$27 million.

RISK ASSESSMENT

Business Environment Uncertainty

Electrovaya is an essential business and has operated without major interruption during the COVID-19 pandemic to date. The company's customers include large global firms in grocery, logistics, and e-commerce that continue to provide critical services during this difficult period. The crisis has highlighted Electrovaya's important role in helping its customers execute mission-critical applications under highly challenging conditions. COVID-19 disturbed the company's supply chain from many of its global vendors, with resultant delays in the delivery of its products to its customers and associated cost increases.

The ongoing global COVID-19 pandemic has created many risks in Electrovaya's business, not all of which may be quantifiable or immediately identifiable. To date, the company believes the impact of the virus on the company's operations and workforce has been mitigated as the company was exempt from government lockdown orders, as manufacturing has generally been deemed an essential service in Ontario. The company has continued to operate throughout the pandemic.

Revenue Concentration

While the company does not disclose revenue by sales channel for commercial competitive reasons, the company strives to balance the two sales channels of approximately 40% direct and 60% OEM. The forecasted sales include the assumption this balance will be maintained in 2022. However, actual sales may vary materially from this based on actual purchase orders received.

Fulfilling orders through the company's OEM sales channel under the Raymond/Toyota strategic supply agreement is not expected to affect the ability to make sales and fulfill orders under the direct sales channel. The direct sales channel is for replacement batteries and has historically been focused on the Canadian market and non-OEM partner forklifts. The OEM partner sales channel is focused on the US market and historically OEM's new forklift sales. While the OEM partner can sell replacement batteries, it is generally for corporate accounts with no overlap with direct sales customers.

Competitive Industry Dynamics

Electrovaya operates in a highly competitive industry with much larger, well-capitalized competitors. The companies offer a similar kind of product with not much product differentiation. R&D investments develop more technologically advanced products, and extensive sales efforts, will have to be put in place to gain market share.

MANAGEMENT OVERVIEW

Dr. Sankar Das Gupta, Co-Founder, Chief Executive Officer and Director

Dr. Sankar Das Gupta is an award-winning scientist, having over 50 U.S. patents to his name. He co-founded Electrovaya in 1996 and has been serving as the CEO since then. He has been a member of several committees, including the White House Committee on Energy & Environment, headed by then Vice-President Al Gore. Recently he was appointed as the advisor on Climate Change and Energy Transformation to the Prime Minister of India. He is also a founding charter member of TIE-Toronto and is an honored speaker at global universities and conferences. He also serves as an adjunct professor at the University of Toronto. He graduated from Presidency College in Calcutta, India, and completed his doctorate from Imperial College, London.

Richard Halka, Executive Vice President and Chief Financial Officer

Richard Halka specializes in steering companies through the rapid growth phase. He joined Electrovaya in 2015 and previously served as President & CEO of Private Investment Group of Companies from September 2006 to June 2015, EVP & CFO of Iridium from June 2004 to June 2006, and EVP & CFO Stratos Global from April 2001 to May 2004. Before these, he served as the acting CFO and European Finance Director at Euronet Worldwide from January 1999 to March 2001, Treasurer and Controller at Hungarian Telephone and Cable Corporation from January 1995 to December 1998, and Partner in charge of Management Consulting at KPMG from January 1993 to December 1995. He graduated from Wilfrid Laurier University, Ontario, in 1982 and earned his Chartered Accountant designation from the Canadian Institute of Chartered Accountants in 1985. In 2012, he completed Chartered Professional Accountant from The Institute of Chartered Accountants of Ontario.

Dr. Rajshekar Das Gupta, Chief Operating Officer

Dr. Rajshekar Das Gupta was appointed as the Chief Operating Officer in April 2021. He joined Electrovaya in January 2009 as Director Research. He led the research activities from the front, and since then, he has been associated with almost every aspect of the company's operation. He is currently responsible for managing overall operations, including engineering, manufacturing, and R&D activities. Raj had studied at Imperial College, London, MIT, and Cambridge University, receiving his doctorate in Material Science in 2008.

ABOUT THE ANALYST



Shawn Severson

President & Co-Founder

Head of ClimateTech &
Sustainable Investing
Research

Shawn Severson is President & Co-Founder of Water Tower Research and is a member of the Board of Managers. Prior to co-founding Water Tower Research and previously founding predecessor firm alphaDIRECT Advisors, Shawn spent over 20 years as a senior equity research analyst covering the Technology and ClimateTech sectors, including senior positions at JMP Securities, ThinkEquity, Robert W. Baird (London), and Raymond James.

Shawn started his career as an Equity Research Associate at Kemper Securities. Shawn was frequently ranked as a top research analyst, including one of the Wall Street Journal's "Best on the Street" stock pickers and a StarMine Analyst Awards Top 3 stock picker. Shawn holds a B.A. in Finance and Economics from Augustana College.

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