Fourth Wave Initiative
Phase 1 Assessment Report

November 2019

Sponsored by The Agency, Three Rivers Development and Team Tioga

Prepared by Susan Payne, Strategic Planning Consultant

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INTRODUCTION

Background

The world is witnessing a global race in the application of new battery technology in both the manufacture of products and the energy storage sector. It is evolving rapidly and forecast to be the next major global industrial wave. The sprint by businesses across the world to build a better battery and apply battery technology will impact products and operations ranging from electric busses, trucks and personal vehicles to forklifts and power grids with a focused effort to meet clean energy goals of the future.

Lithium ion batteries were created in the 1970's, long before smartphones, laptops or Tesla cars became mainstream. The importance of this technology was acknowledged by the Royal Swedish Academy of Sciences with award of the 2019 Nobel Prize in Chemistry to John B. Goodenough, Stanley Whittingham and Akira Yoshino for their development of the lithium-ion battery. Stanley Whittingham is a Distinguished Professor of Chemistry at Binghamton University and serves as director of both the Institute for Materials Research and the Materials Science and Engineering program. The Academy stated that "Lithium-ion batteries have reshaped the way we store energy, paving the way for a more portable, sustainably powered world."

The lithium ion battery market is growing at 33% per year and worth about $40B today. Lithium batteries are expected to represent more than 50% of all battery sales by 2023. By 2025, the worldwide market for new battery technology (other than acid-based) is expected to be at $5 Trillion and around 600 GWh per year compared to less than 200 GWh today.

This disruptive battery technology and global movement to clean energy is expected to generate trillions in economic value in the decade ahead. Global forecasts point to the largest growth being in electric busses and forklifts, followed by electric vehicles, aerospace, E-VTOL (Vertical Take-off and Landing), drones, military hand-held devices such as AVU's and large-scale energy storage for both domestic and military uses. The energy storage system (stationary) is small in comparison, but it is forecast to grow 28% per year during the next decade.

There are several dynamics on the global level that are impacting the advancement of battery technology and energy storage ranging from economic slowdowns in China and Europe to trade conflicts. Politicians are changing regulations and incentives to address climate change, while still threatening bans for lead batteries, and challenging lithium solutions after some high-profile fires at installations and landfills.

Regardless of the political dynamics in the world, battery technology has become an essential part of today's lifestyle and business operations. The future of this clean energy industry sector is dependent on making exponential improvements in battery technology and its application to address major issues such as the cost of high-volume manufacturing plants (for both batteries and pouches for cells), access to essential materials, cost of the battery, performance, weight, and concerns about safety and future recycling.

This means there's room to grow in the market. Competition will be tough with market prices decreasing continuously, so it will be important to remain on the cutting edge of innovative, commercialization of technologies, advanced manufacturing expansion and demand for a qualified supply chain.

Clean Energy: A New York State Priority

New York State Governor Andrew Cuomo's clean energy goals is a major economic development priority for New York State. The goals call for:

- Go from 26% renewable sources today to 70% by 2030 and 100% by 2040.
- Reduce greenhouse gas emissions by 85% from 1990 levels by 2050.
- Remaining 15% will have to be done through reforestation, restoring wetlands, carbon capturing or other green projects.
- 600 trillion Btu increase in statewide energy efficiency (at source).
- Support growth in Clean Energy Innovation.
- Build a more resilient energy system and improve energy infrastructure.
- Grow New York's energy efficiency.
- Support cleaner transportation.
- Create new jobs and business opportunities.

The Advanced Manufacturing Work Group of the Southern Tier Regional Economic Development Council recognized that with the global movement to clean energy and New York State's aggressive goals, combined with disruptive battery technology and a strong manufacturing base, meant the region had the potential to participate in the trillions of economic development value in the decade ahead.

In 2019 the Work Group named the need to strengthen and grow the manufacturing base and related supply chain of battery technology and energy storage sector as a top priority in order to increase the impact of new revenue and job growth.

Southern Tier REDC
Advanced Manufacturing Work Group

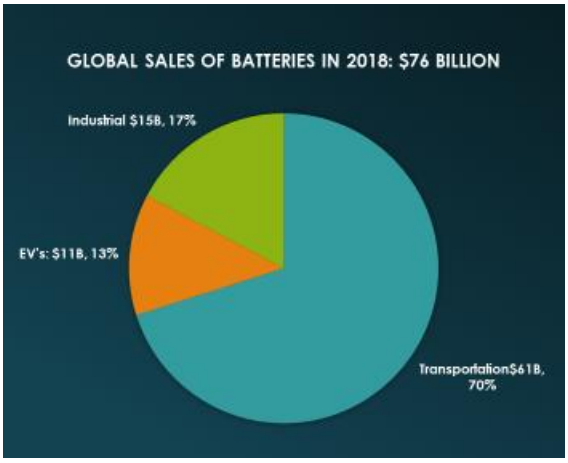
"***Focus on advanced manufacturing, with a particular focus on the growing transportation and clean energy*** *industry sectors, that will result in the Southern Tier being recognized as a destination for manufacturing business development, distinguished by its concentration of multi-national anchor companies, advanced infrastructure to support innovation and technology, rich education and research resources, specialized skilled workforce and vibrant communities."*

Fourth Wave Phase 1 Initiative

In early 2019, three of the Southern Tier Region's economic development agencies understood that the application of battery technology is the next major disruptive technology and driver of the next industry wave on a global scale. Demand for batteries is poised to surge in a wide range of markets ranging from autos, trucks, buses and helicopters to military applications, mobile products such as forklifts and stationary applications including wind and solar energy storage.

These economic development organizations included Team Tioga (Tioga County), The Agency (Broome County) and Three Rivers Development Corporation based in Corning, New York.

These agencies also recognized that the region has a well-established clean energy innovation ecosystem that is uniquely positioned to be a player in this global economic momentum of technology and innovation, expand its leadership role in advanced manufacturing, and advance Governor Cuomo's clean energy goals. The Southern Tier's particular concentration of advanced transportation manufacturing businesses and the burgeoning renewable energy storage industry are exceptional strengths that could be leveraged. In fact, the global transportation sector is driving demand for batteries, which is projected to reach $20B by 2023, with significant growth in manufacturing such as forklifts at $8.4B.



As part of their routine business retention and growth efforts, these agencies had begun to learn that businesses in their service areas were experiencing a wide range of issues in meeting demand in this expanding marketplace. Issues identified ranged from workforce to lack of supply chain; but it was recognized that the depth and breadth of the opportunities and challenges required further exploration.

These agencies were visionary about the Southern Tier's capacity to leverage its collective assets to become a player in this rapidly evolving field. In 2019, the Fourth Wave Phase 1 effort was undertaken with the overall objective of assessing the potential to grow the region's energy sector and capitalize on the potential for business investment and job creation, while simultaneously advancing Governor Cuomo's clean energy goals. Susan Payne, Strategic Planning Consultant, was engaged to conduct the Phase 1 Assessment.

The Fourth Wave Phase 1 was intended to conduct a more in-depth assessment of the potential to leverage the region's assets and opportunities for application of battery technology and growth of new and existing businesses. More specifically, the Phase 1 assessment was expected to evaluate the demand for value-added business development associated with clean energy product development, battery manufacturing, assembly of battery packets, base components of energy storage stationary equipment, system integration, and more.

To achieve this objective, a methodology was developed that involved one-on-one interviews and telephone interviews with the industry and R&D communities.

One-on-one Interviews with the Manufacturers, Developers and the R&D Community

One-on-one and group interviews were conducted with thirty-five representatives of the manufacturing sector, supply chain businesses, developers, innovation and incubator centers, and the region's leading academic institutions to assess opportunities to apply new technology, drive demand for battery applications, identify current and anticipated gaps and growth opportunities for supply chain development, and assess opportunities for commercialization of new technology.

- Amphenol AIO
- Amphenol IPC
- Assoc of Chemical Engineers
- BAE Systems
- Best Buy
- Binghamton University
- Borg-Warner
- C&D Fabricating
- Conamix, Inc.

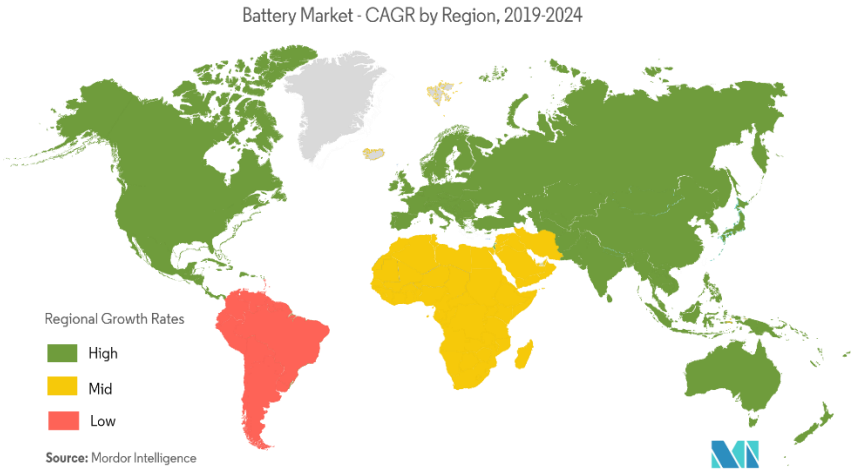
- Cornell University
- Corning Incorporated
- Crowley Fabricating
- Ensco
- Ethosgen
- Huron Campus
- Imperium3
- Incodema

- LaunchNY
- Lockheed Martin
- NY- Best
- NYSERDA
- NextEra
- RAPED (manufacturing institute)
- Raymond Corporation
- XNRGI

STATE OF THE GLOBAL CLEAN ENERGY INDUSTRY SECTOR

Rapid Growth of Battery Technology and Business Development on a Global Scale

Disruptive technologies such as IoT, renewable energy, advances in autonomous driving and others are expected to generate trillions in economic value in the next ten years.



Battery manufacturing and commercialization of battery technology are being driven by several factors:

- *The advancement of batteries in new product development is moving rapidly with new technologies such as lithium ion, sodium, solid-state and silicon wafer format options.*
- *The applications of batteries and battery systems is diverse across key industrial markets ranging from forklifts for materials handling to mass transportation, telecom, aerospace and renewable energy markets.*
- *Leaders from the public sector to private industry are investing in disruptive technologies to accelerate their economies, improve environmental sustainability, attract business investment, gain production efficiency, capture new consumer markets, and be recognized as global leaders in the economy and technology of the future.*
- *Asian countries and European governments such as France, Germany and Sweden are making significant investments in EV development with clean energy goals and mandates for consumer sales, consumer incentives, financing and subsidies for manufacturers.*
- *US states such as California and New York State have set aggressive clean energy goals and are investing in numerous energy storage projects.*
- *Battery manufacturing is dominated by Asian companies. Their success has been fueled by significant financial subsidies and consumer incentives provided by these countries.*
    - **China (57% market share)**: CATL, Hitachi, ShanShan Shenzhen BAK, Dongguan P Amperex, Shandong Goldencell, and more.
    - **Japan (19% market share)**: Sanyo-Panasonic (largest global production capacity), SONY, Samsung, Panasonic-Tesla.
    - **Korea (22% market share)**: LG Chem (NextEra is largest U.S. customer).
    - **India (11% market share)**: BYD.

- *There is a limited number of US-based battery manufacturing facilities; but that is slowly shifting with companies such as Tesla that are moving into battery cell manufacturing. It started with the acquisition of Maxwell's technology, a supercapacitor manufacturer with some battery cell technology. In September 2019 Tesla confirmed that it plans to manufacture its own battery cells and is building a new cell manufacturing line in Fremont, California.*
- *Companies world-wide are addressing battery pack technology, production and application issues.*
- *Although Asian (China with 57% of the global market) currently is the leader in manufacture of batteries and related clean energy products, the state of the global economy and growing domestic demand indicates the marketplace is poised to surge and there is a window of opportunity to capture a share of this market ranging from stationary to mobile products.*

Growth in the Mobile Sector

Global forecasts point to the largest growth being in electric busses and forklifts, followed by electric vehicles, aerospace, E-aircraft, E-VTOL (Vertical Take-off and Landing), drones.

Electric Vehicles

The electric vehicle (EV) market grew 65% from 2016 to 2018, with the largest growth in China due to consumer incentives. Bloomburg NEF forecasts sales of EV's will increase from 1.1M worldwide in 2017 to 11 M in 2025 and 30M in 2030. An estimated $300B will be invested by automakers by 2030, with the largest expenditures by Ford, VW, Daimler, Nissan, Toyota and VolksWagon.

The increase in EV production is being driven by government mandates, led by European and Scandanavian countries. For example, Norway has mandated 100% auto sales be EV or plug-in by 2025. The Netherlands will ban all petroleum cars in 2025. Britain will ban new gas-powered cars in 2040. Germany will ban gas powered cars in 2030. India will require 100% of all new vehicle sales to be electric by 2030.

Electric Buses

Urban e-buses are leading electric-vehicle growth, across China, Europe and the US. They constitute the fastest-growing part of the EV market, with a compound annual growth rate of more than 100 percent since 2013, compared with 60 percent for fully electric passenger cars.[1] This reflects the overall trend among cities to embrace electrification and new mobility business models and technologies, such as shared mobility and autonomous vehicles.

The leader is China, where e-buses accounted for 90% of new urban bus sales in 2017-2018. A study by Bloomberg New Energy Finance predicts that the sale of electric buses could reach up to 1.2 million by 2025, with China accounting for 99% of the world's electric buses by that time.[2]
In Europe, the number of electric city buses is expected to increase by 18% per year. Urban bus fleets in Europe are expected to transition to electric power by 2030, also supported by the proposed e-bus target of 75% of all buses sold in Europe by that year.[3]

In early 2019, the last diesel-burning Rapid Transit Series bus ceased operation in New York City. "One of the cleanest bus fleets in the world is now getting cleaner with the retirement of this model as we push on with the latest technologies, including zero-emission electric buses," said a NYC Transit official. New York is just one

[1] Fast Transit: Why Urban E-buses Lead Electric Vehicle Growth. McKinsey and Company. October 2018.
[2] Electric Buses Will Take Over Half the World Fleet by 2025. Bloomberg New Energy Finance Study. February 2018.
[3] Fast Transit: Why Urban E-buses Lead Electric Vehicle Growth. McKinsey and Company. October 2018.

among a growing number of cities, states and countries leading a shift to greener transit. In Texas and Georgia, there are moves to replace aging gas-powered fleets with electric vehicles, including electric compact utility vehicles. The California Air Resources Board voted to require that all new buses be carbon-free by 2029. Most US states offer incentives to make the move more appealing to fleet operators and drivers.

Forklifts

Demand is growing rapidly for forklifts ranging from walkie pallet trucks to heavy-duty very narrow aisle turret trucks to meet the rapidly growing needs of the warehouse and logistics industry that utilizes this equipment. Forklift manufacturers around the world utilize battery technology as an essential component of their product designs to achieve optimum performance in a highly competitive market. It is essential to offer light weight and fast-charging batteries together with opportunity-charging systems to meet customer demand.

Aerospace

There is Increasing demand for "light weight" batteries for commercial airplanes, vertical lift vehicles and helicopters. Companies such as AirBus and Boeing are actively pursuing research partnerships to meet this objective. Israeli startup Eviation has a development plan for its "Alice" all-electric regional aircraft and the battery-powered propulsion system at the heart of the design. RollsRoyce recently purchased the Siemens electronic propulsion business unit and it appears the company intends to make e-aircraft a target market. A Southern Tier business anchor, Lockheed Martin, is taking a leadership role in application of battery technology in the design and production in the broader aerospace sector.

E-VTOL (Vertical Take-off and Landing)**:**

Uber is aggressively seeking R&D partners and equity investors to pursue an electric vertical lift division. It's predicting the rise of VTOL vehicles offering on-demand flights in urban areas leveraging existing infrastructure (e.g. parking rooftops) as vertiports (airports for aircraft that can take-off and land vertically). Some of the challenges identified by Uber include battery technology.

Drones

Drones have gained popularity among recreational users and are rapidly becoming more and more affordable. The Amazon patent on the use of a flying warehouse shows where things are headed.

Growth in the Stationary Sector

In the U.S., 18% of all electricity produced in 2017 came from solar, wind, hydroelectric, or other renewable power sources, up from 15% in 2016. [4]

The rise of large wind and solar projects, individual smart grid technologies, distributed renewable resources and generation, and an industry focus on security and reliability have come together to bring about change. In addition to domestic use, there are important military uses as well. For example, there is need to improve the life, durability and capacity of batteries to support the stationary energy storage facilities that are critical to the operation of military operations in remote areas of the world.

[4] Business Council for Sustainable Energy and Bloomberg New Energy Finance. 2018

Thanks to advances in lithium ion battery technology and system integration capabilities, battery systems can effectively support large-scale grid storage solutions and enable the electric grid and energy storage assets to work in tandem.

The stationary storage market grew from $400M to $2B between 2017 and 2020. Wood MacKenzie Consultancy forecasts growth of energy storage through 2023 led by China and the US. They forecast that US battery use will expand 10X to over 4 GWhs by 2023, driven by large utility linked systems.[5]

China, India and the US will concentrate more than 50% of global solar PV installations to 2024, making both APAC and North America the most attractive regions within the solar O&M segment.

The US energy storage market is projected to reach $4.5 billion by 2023.[6] At the same time, annual solar plant operations and maintenance (O&M) costs will grow from nearly $4.5 billion in 2019 to just over $9 billion in 2024. This increase is due to future demand growth and current installed capacity. Unplanned repairs alone can cost owners up to $3,000/MW/year, based on an average-sized solar power system of 50MW, according to research from Wood Mackenzie Consultancy. Unplanned solar plant repairs will cost industry $16 billion over next 6 years.[7]

After a modest decline in 2018, the global solar market is expected to reach a new annual high of 114.5GW in 2019 – up 18% from the previous year. Annual installations will grow to 120-125 GW in the early 2020s as emerging markets begin to deliver results. Global cumulative solar PV installations are expected to grow from ~500GWdc in 2018 to 1,243 GWdc by 2024.

Just in the months of September and October 2019 the volume of investment and the merger and acquisition activities in the clean energy industry sector has surged. For example:

- D. E. Shaw Group, a successful global investment and technology development firm and pioneer in quantitative investing, has entered the renewables arena with sizeable investments. One of its subsidiaries, DESRI, has acquired several solar projects from First Solar in US. Linde (UK) recently merged with Praxair (Connecticut).

- 174 Power Global acquired OnForce Solar.

- Distributed Solar Development (DSD), a joint venture of GE & BlackRock Investment, announced that it had closed a $250 million fund financed by Morgan Stanley, Silicon Valley Bank and Fifth Third Bank to fund a portfolio of commercial and industrial (C&I) solar projects through 2020.

- Honda (auto maker) announced that the company will be purchasing 482,000 MWh/year from a 200 MW Texas solar facility. This purchase, in addition to the 530,000 MWh/year Honda will be buying from the 120 MW Boiling Springs Wind Farm in Oklahoma, will bring the company to 60% of its electricity needs being procured from renewable resources.

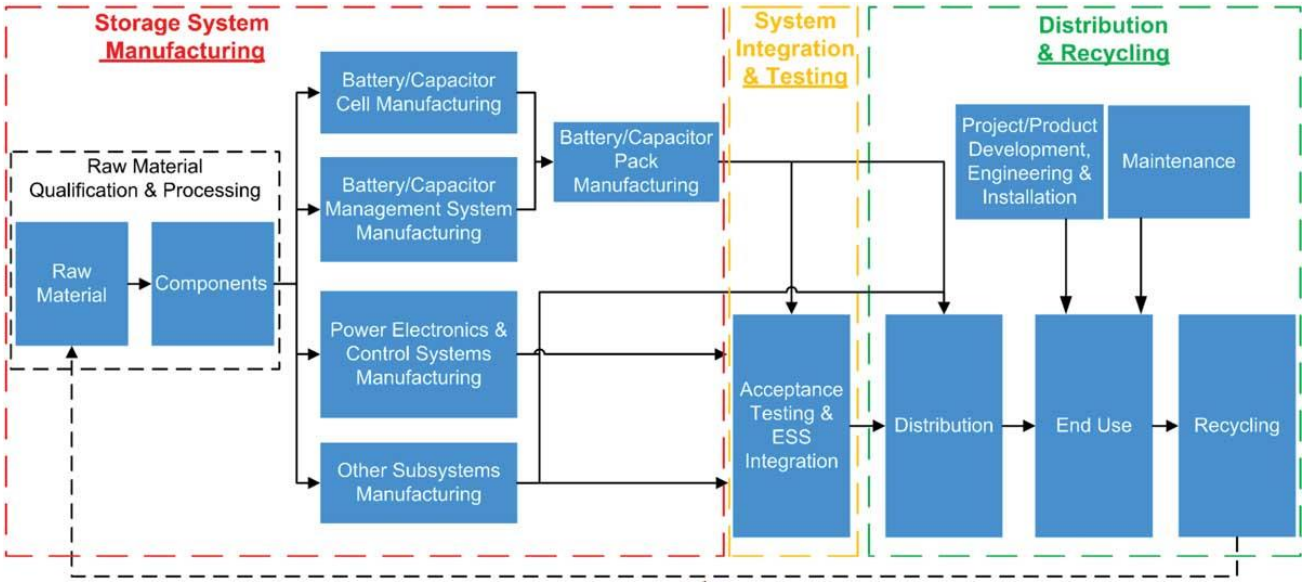
- Complete Solar, Inc. has expanded its partnerships across California, New Jersey, Massachusetts, New York, Connecticut, Utah, and Arizona. It also is expanding its product lines to include electric car chargers, battery back-up systems, electric heat pumps, roofing, and other home energy upgrades by cross promoting its partners' energy products.

[5] WoodMacKenzie Consultancy. October 2019.
[6] State of the US Energy Storage Industry: 2018 Year in Review.
[7] WoodMacKenzie Consultancy. October 2019.

- NextEra has long been the largest owner of US wind farms, but its solar business has grown rapidly. According to Wood Mackenzie, NextEra is now the world's largest owner of solar capacity outside China. In recent months NextEra has undertaken new renewables and storage projects that have grown its pipeline of projects past 12 gigawatts. These examples represent a small portion of the investment activity underway in 2019.

Who and what are driving demand for <u>stationary projects</u>: energy storage companies (purchase batteries, storage containers and assembly/integration of parts and military)?

Companies purchase batteries, containers and rack, and then sub-contract for the on-site preparation and assembly of battery packs and full system integration within the containers.



Global Industry Issues and Challenges

<u>Battery Supply</u>

The growing demand for high-performance, high-quality batteries is exceeding the available supply. Demand is so strong across sectors that it is expected to drive a 10x increase in global lithium-ion battery production over the next decade.

For many companies, the current imbalance between demand and supply has had negative consequences—in many instances exacerbating the challenges of selecting the right battery in the right timeframe. That means more suppliers to vet and more time required for testing and qualifying their batteries.

As The Atlantic reported in April 2019, many lithium-ion batteries are produced in China, where it can be difficult to monitor the materials and processes used in battery production.

This same issue applies to the stationary sector as well as the mobile sector with the manufacture of busses, trains and trollies, forklifts, avionics and more.

Automakers rapidly electrifying their passenger and commercial fleets are also facing challenges in assuring an adequate high-quality supply. Many automakers are entering into partnerships with battery vendors to secure sufficient volumes. For example, Volvo—whose goal is to see fully electric vehicles account for half of its sales by 2025—has entered into a multi-billion-dollar agreement with battery producers LG Chem and CATL.

In 2017 Panasonic opened the largest automotive lithium-ion factory in China. Toyota has announced a joint venture with Panasonic, beginning in 2020, to build batteries for electric vehicles with the goal of producing batteries with fifty times the capacity of today's hybrid-vehicle batteries.

Multiple automakers are investing in battery-related Centers of Excellence (CoE), including Volkswagen, which has placed all of its battery R&D and related competencies in a single facility and battery factory in Salzgitter, Germany. BMW plans to invest 200 million euros and create 200 new jobs in its Battery Cell Competence Centre in Munich, where experts will focus on cell chemistry and design, and look to improve battery performance, lifespan, safety, and cost.

Tesla currently buy cells from Panasonic made in Japan for its Model S and Model X, as well as, cells made by Panasonic at Tesla's Gigafactory 1 in Nevada for its Model 3. Tesla now is moving into a "new product line": battery cell manufacturing, and in September 2019 Tesla confirmed that it plans to manufacture its own battery cells and is building a new cell manufacturing line in Fremont, California.

A major challenge is the limited number of US-based battery manufacturers.

- LithiumWerks in Austin, Texas and Las Vegas, Nevada. Owned by Norwegian company. Owns patents developed in US by Valence and A123
- LG Chem plant in Holland, Michigan
- Panasonic-Tesla plant in Nevada
- Saft in Jacksonville, FL (owned by French company; however, layoffs are taking place)
- BMW (German) near Atlanta, Georgia
- Southwest Electronics Energy Group in Missouri, Texas
- EnerDel in Indianapolis, Indiana (owned by Korean firm)

<u>Battery Vendors and Distribution Supply Chain</u>

- Asia dominates the battery market (production and usage), but the supply base is heavily fragmented. Nearly 25% of US companies involved in purchasing batteries said in a recent survey that there are too many battery vendors to evaluate, while 21% said there were too many battery materials to evaluate.
- With heightened competition to lock in supply, particularly in the consumer electronics and electric vehicle sectors, Tier 1 battery vendors can be extremely selective when choosing their customers. As a result, many consumer electronics companies are working with Tier 2 or even Tier 3 vendors.
- Major US based battery manufacturers, such as ACDelco, DEKA and US Battery are getting into the lithium-ion battery distribution supply chain in collaboration with Asian companies such as Panasonic.
- An entity known as Energy Products has created the Battery Partner Program as a supply chain solution to advance the business of all Battery Specialists. The entity has created s single source mixed order supplier with thirty-six global partners.

Battery Pack Technology, Production and Application for Mobile Applications

Battery pack technology also is a major issue. Companies world-wide are addressing battery pack technology, production and application, but again, there is a limited number of US-based companies in this area.

- **Panasonic** (Tokyo): World's largest supplier of lithium-ion batteries. Operates Gigafactories in joint venture with Tesla.
- **Contemporary Amperex Technology (CATL)** (Ningde, China): Industry powerhouse and supplier to carmakers.
- **Shenzhen BAK** (China): Battery maker and manufacturer of battery packs.
- **Dyson** (Malmesbury, England): The appliance maker has lots of experience in batteries.
- **Cadenza** (Connecticut; affiliated with Duracell): Developing battery packs for EV's and large-scale energy storage projects.
- **Fisker** (Los Angeles): Developing solid-state batteries with faster recharge times.
- **Solid Power** (Colorado): Solid state battery maker.
- **QuantumScape** (San Jose, California): Recent to solid-state technology, and recently received a $100M investment from VW.
- **Romeo Power** (Los Angeles): Co-founded by a former SpaceX energy storage engineer, designing packaging that can achieve 25% more energy density than existing lithium-ion battery packs.

Limited Number of US Suppliers of Energy Pack for Energy Storage Projects

- SouthWest Electronic Energy Group (Missouri, TX): designs and assembles custom battery packs of primary lithium, large capacity lithium-ion, solar power, and other major chemistries for OEM, EOEM and MRO.
- Valence Technology, Inc. (Austin, TX): develops and manufactures lithium iron phosphate cathode material, as well as, lithium ion battery modules and packs.
- EnerDel (Indianapolis, IN): Builds compact lithium-ion-powered battery solutions for the transportation, utility grid and industrial electronics markets. Has manufacturing locations in the US and Korea.

Time-to-Market Issues

The battery industry will continue to be incremental, although the period of time between the major incremental changes is narrowing. Global demand is straining the market due to several competing factors.

- Design and assembly of energy packs for large-scale energy storage projects; specifically, lack of domestic companies that provide "system integration" in support of energy storage projects and manufacturers of products such as forklifts.
- Integrators suffer from lack of capital to buy the batteries.
- Limited access to essential materials; i.e., Nickel, Cobalt, Synthetic Graphite, Lithium, etc.; however, the US does have deposits of lithium in geo-thermal wells located in Utah and Arizona, as well as some deposits of Graphite. In addition, new R&D and battery development are addressing this issue.

Examples include Imperium3 (start-up in Endicott) that does not use Nickel and Conamix (start-up in Ithaca) that is focused on cobalt-free electrode materials for lithium-based batteries. Scientists at the University of California Riverside and a spin-off battery tech company called Silanano are focused on an alternative type of lithium-ion battery that uses silicon purified by using sand to achieve three times better performance than current graphite li-ion batteries. Silanano has received major investments from companies such as Daimler and BMW.

- Demand for a cost-effective battery with a longer life and capacity.
- Cost to build and operate high-volume manufacturing plants for both batteries and pouches for cells.
- Lack of production standards for the manufacture and application of batteries.
- Time to market issues due to the high cost of mass production and time to transport from Asian; compounded by concern about the impact of trade war and national security issues.
- Safety and environmental concerns related to transportation and the need for safe discharging and recycling.

Safety Concerns with Lithium Ion batteries

In lithium ion batteries, the ions move from one electrode to another across a liquid electrolyte. In solid state batteries, the liquid electrolyte is replaced by a solid compound, which allows lithium ions to migrate within it. The first huge advantage is a marked improvement in safety at cell and battery level: inorganic solid electrolytes are non-flammable when heated, unlike their liquid counterparts. There are many (costly) constraints and restrictions on Li-ion battery efficiency that are necessary to ensure their stability and safety. For this reason, there is a focus on development of solid-state batteries and other materials such as sodium.

Qualified Engineers

As battery-powered electrification shifts beyond consumer electronics to electric vehicles and energy storage, companies are struggling to hire engineers to electrify their products and meet their product goals.

Historically, engineering talent has been comprised of mechanical and electrical engineering expertise, designing the form and functionality of products and systems. However, as batteries are becoming a more essential product component companies need engineering talent to ensure batteries are performant, reliable, and safe.

Companies such as VW, LandRover, Audi, Volvo, BMW and Rolls Royce are aggressively seeking the best minds from around the world, including engineers and small start-up companies, to develop batteries and new car design.

Reuse and Recycling

As solar installations ramp up and electric vehicles have been on the market for a few years, automakers are starting to look for ways to get more life out of old electric-car batteries and repurposing them for stationary storage. Volvo, which builds trucks and buses in addition to cars, is experimenting with taking used batteries out of 14 of its old electric buses and using them to store energy at apartment complexes that have their own solar generation. Amphenol AIO (Endicott) suggests there are environmental reuses of eV of Batteries as their efficiency declines to move into energy storage such as Charge Station ESS.

Lack of Venture Capital for Commercialization of Technology

Battery technology eventually will supplant traditional internal combustion engines, and the R&D underway today will establish the platform for the next 40 years.

As the battery industry expands the R&D continues to address challenges such as access to natural materials and opportunities to replace them with chemicals, safety, weight, long-life and more.

There is significant R&D taking place at US-based academic institutions and spin-off companies are emerging throughout the country; however, there is lack of venture capital and state government investments in start-ups. Many small companies throughout the country with cutting-edge technology have failed due to lack of adequate capital. Examples include A123 (MIT) and Aquion Energy (Carnegie-Mellon).

A typical investment of $200M is needed to launch a technology into the early stages of production, and an additional $2-5 billion to turn the technology to manufacturing on a global scale. For this reason, many start-ups are attracted to the Boston and Silicon Valley regions where there is the "mature commercialization and capital investment ecosystem" that has the potential to dominate the battery technology sector in the long-term.

A123 and Aquion Energy: Case Studies in Foreign Acquisition of US-based R&D

It is not unusual for US start-ups that have successfully achieved commercialization of academic-based R&D to be acquired by large Asian companies.

A123 SYSTEMS

Today, A123 Systems, LLC is a wholly owned subsidiary of the Chinese Wanxiang Group. The company develops and manufactures lithium iron phosphate batteries and energy storage systems. Its original product technology was based upon materials initially developed at the Massachusetts Institute of Technology. The company was founded in 2001 by Yet-Ming Chiang, Bart Riley, and Ric Fulop. By 2009, it had about 2,500 employees globally and was headquartered in Waltham, Massachusetts.

In 2010, A123 received a US$249 million grant from the U.S. Department of Energy for building battery production facilities. Approximately $129 million of the grant was used to build a 550 MWh battery plant in Livonia and another in Romulus, Michigan. An untapped $120 million grant was abandoned by May 2012. The company laid off 125 workers in December 2011 as A123 issued a battery recall for all batteries in a car developed by Fisker. A123 Systems had more than 3000 employees as of December 2012. In August 2012, Chinese automotive components manufacturer Wanxiang Group agreed to invest up to $465 million to acquire as much as 80% of A123 Systems; but the acquisition was not completed before A123 filed for bankruptcy. In early October 2012, the A123 Systems' stock was trading for 27 cents per share, down from a 52-week high of $4.44 per share about a year beforehand. On October 16, 2012, A123 filed for bankruptcy protection under Chapter 11. On January 28, 2013, Wanxiang America purchased the preponderance of A123's assets out of bankruptcy for $256.6M and organized A123Systems, LLC.

Aquion Energy

The company was founded in 2008 by Jay F. Whitacre, a professor at Carnegie Mellon University, and Ted Wiley. They set up research and development offices in Lawrenceville, MA where it produced pilot-stage batteries. The company raised funds from Kleiner Perkins, Foundation Capital, Bill Gates, Nick and Jobey Pritzker, Bright Capital and Advanced Technology Ventures, among others. In 2011, an individual battery stack was promoted to store 1.5 kWh, a shipping container-sized unit 180 kWh. In October 2014 they announced a new generation with a single stack reaching 2.4 kWh and a multi-stack module holding 25.5 kWh. In 2015, the company announced it would supply batteries for a Hawaii microgrid to serve as backup for a 176-kilowatt solar panel array that would store 1,000 kilowatt-hours of electricity. In April 2015 they announced a headcount reduction. In September 2015, Whitacre won the Lemelson–MIT Prize. In March 2017, Aquion Energy filed for voluntary bankruptcy under Chapter 11. In June 2017, Juline-Titans LLC, an affiliate of the China Titans Energy Technology Group, won the bidding with an offer of $9.16 million - a small fraction of the reported $190 million in venture capital and debt the company had raised from investors including Bill Gates, Gentry Venture Partners, Kleiner Perkins Caufield & Byers, Foundation Capital, Bright Capital, Advanced Technology Ventures, Trinity Capital Investment and CapX Partners, Yung's Enterprise, and Nick and Joby Pritzker. In September 2017 the East Huntingdon Township facility was closed and production moved to China.

Trends in Addressing Challenges and Meeting Demand

Joint Ventures, Collaborations and Partnerships

Joint ventures, collaborations and partnerships area driving the industry in terms of both R&D and investment. For example:

- Panasonic and Tesla have multiple alliances.
- The European Battery Alliance was launched in 2018 to develop the next generation of lithium ion batteries and solid-state technology.
- Saft (France) launched an alliance with four large European companies that are experts in chemicals and materials, specializing in battery cell and module assembly equipment to develop large energy storage systems (including Siemens and Manz).
- The North American InnovationHub in Atlanta is an investment by Sonnen (German battery manufacturer) to bring its R&D and manufacturing together in one site to collaborate with Georgia Tech, with a focus on residential renewable energy storage.
- To guarantee supply, Volvo has entered into a multi-billion-dollar agreements with battery producers LG Chem and CATL.
- Effective in 2020, Toyota will have entered into a joint venture with Panasonic for its new EV fleet of cars.
- Several automakers are investing in battery-related Centers of Excellence such as VW in Salzgitter, Germany and BMW that plans to invest 200M Euros in its Battery Cell Competence Centre in Munich.
- The Energy Partner Program was created as a solution to the supply chain issues and serves as a single source mixed order supplier. There are 36 members from around the world ranging from Panasonic to ACDelco, Deka and US Battery.

Leading research institutions in the US have formed partnerships. For example, Battery500: Pacific Northwest National Laboratory is a partnership of academic institutions including **Binghamton University**, Brookhaven National Labs, Idaho National Lab, Binghamton University, Stanford, University of California San Diego, University of Texas at Austin and University of Washington

The Joint Center for Energy Storage Research (JCESR) ADOE Energy Innovation Hub group includes Argonne National Lab, Lawrence Berkley National Lab, Pacific Northwest National Lab, Sandia National Lab and SLAC National Accelerator Lab. University partners include **Cornell University**, University of Michigan, Northwestern University, University of Chicago, University of Illinois-Chicago, and University of Illinois-Urbana Champagne. Industry partners include Dow Chemical, Applied Materials, Johnson Controls and Clean Energy Trust.

On-going Investment in Innovation and Technology to Replace Acid Batteries

Investments are being made in the industry sector and academic institutions throughout the world in a wide range of materials and design of batteries to increase capacity, reduce weight, increase safety and address issues such as limited materials. A few examples include:

Gold Nanowire Batteries	Transparent Solar Chargers	Liquid Flow Batteries
Foam batteries	Aluminum-air Battery	Carbon-ion Batteries
Solid State Technology	Dual Carbon Battery Tech	Zinc-air Batteries
Paper-like Foldable Batteries	Sodium-ion batteries	Graphene Batteries

Tesla is leading the industry with commercialization of R&D technology. For example, in September 2019 Tesla announced that it has added a patent for a new longer-lasting battery cell with better performance and cheaper cost. The patent for Novel battery systems is based on two-additive electrolyte systems designed to increase energy density and durability, projected to last over 1 million miles in an electric vehicle. The technology was developed by Tesla's battery research group based in Halifax, Nova Scotia, Canada where they have established a lab in collaboration with leading scientists from Dalhousie University. The new patent filed by Tesla's battery research group mentions that the technology would be useful for both electric vehicles and grid- storage.

Another example is Tesla's collaboration with PepsiCo. It was announced in October 2019 that fifteen Tesla Semi electric trucks are replacing all of PepsiCo's existing diesel-powered freight equipment with "zero-emission and near-zero emission trucks and equipment at its Frito-Lay Modesto, California manufacturing site.

Issues and Challenges in the Stationary Sector

The US energy storage market is projected to reach $4.5 billion by 2023.[8] At the same time, the annual solar plant operations and maintenance (O&M) costs will grow from nearly $4.5 billion in 2019 to just over $9 billion in 2024. This increase is due to future demand growth and current installed capacity. Unplanned repairs alone can cost owners up to $3,000/MW/year, based on an average-sized solar power system of 50MW, according to research from Wood Mackenzie Consultancy. Unplanned solar plant repairs to cost industry $16 billion over next 6 years.[9]

According to Wood MacKenzie Consultancy, solar installations nearing inverter end of life will reach 21GW by the end of 2019, representing 3.4% of the global market. This increases to more than 14% of the total cumulative capacity over the following five years. By 2024, Wood Mackenzie expects the solar industry to have 176GW of projects with inverters older than ten years.

Given this tremendous growth, the business growth in the stationary sector continues to face challenges.

- Need for application of new technology to address issues such as keeping the cells cool.

- Need to fill gaps in the supply chain for the manufacture and assembly of integrated systems used in the construction of solar and wind energy storage systems.
  - Manufacturers of the large containers used in the energy storage projects (only one in NYS)
  - Battery pack assembly/integration companies.
  - Manufacturer of racks and modules that hold the battery packs.

- Shared challenges with the manufacturing sector, including
  - Increased demand for batteries and system integration.
  - High cost of batteries and pouches for cells due to Asia being the primary source.
  - Gap between buying battery cells and packaging due to the limited number of US-based battery manufacturers and suppliers of energy packs, which is contributing to the time-to-market challenge.

[8] State of the US Energy Storage Industry: 2018 Year in Review.
[9] Wood MacKenzie Consultancy. October 2019.

NEW YORK'S SOUTHERN TIER IN THE GLOBAL MARKET PLACE

Clean Energy Ecosystem

The Fourth Wave Initiative: Phase 1 assessment was conducted to evaluate the strength of the assumption that the region's collective assets form an innovation ecosystem and are sufficient for it to become a leader in the clean energy sector.

A major strength in the Southern Tier's Clean Energy Ecosystem lies in the commercialization of clean energy technology among its existing manufacturing and supply chain businesses. The application of batteries and battery systems is diverse across key industrial markets in the Southern Tier region ranging from forklifts for materials handling to mass transportation, avionics and the large-scale renewable energy markets. And, the next largest energy technology growth sector is expected to be at 15% growths and annual sales of $2.6B in Energy Storage applications across the electricity grids, followed by electric vehicles (EV's).

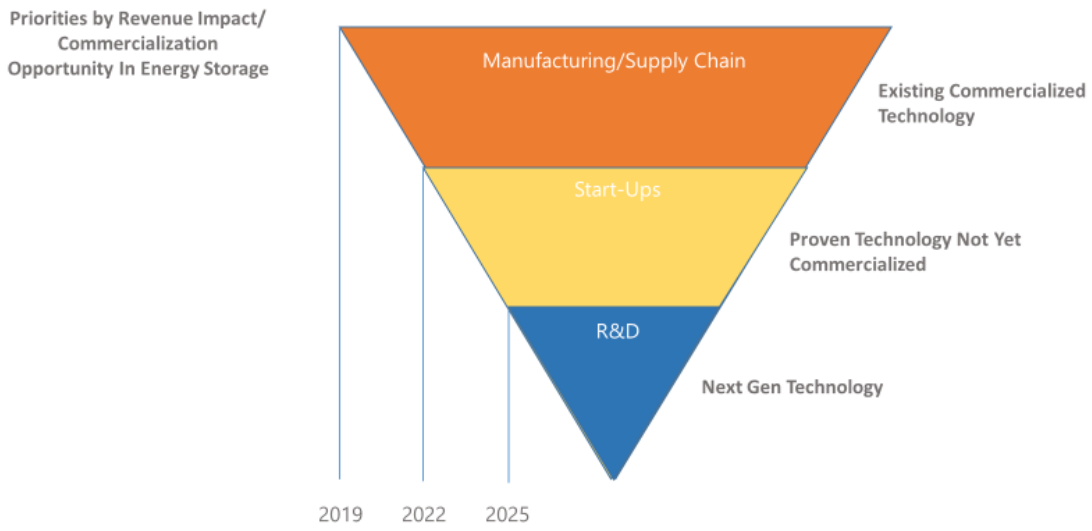
Although Asian-based companies lead in manufacture of batteries and related clean energy products, the global economy and growing domestic demand indicate that the marketplace is poised to surge and the major growth among US-based manufacturing companies will be in "avionics and transportation" … exactly where the Southern Tier excels. The transportation segment alone is projected to be the fastest growing of all in the clean energy sector, at a rate of 18% per year; and electric buses and forklifts are projected to be the top two growth products areas for the next 10 years.

The Southern Tier has assets that have the potential to influence its future role in the battery technology and energy storage marketplace.

- An abundance of manufacturing expertise that is commercializing existing technology.
- Development of large-scale renewable energy projects.
- Business assets and innovation to attract and grow business involved in the application and commercialization of battery technology.
- A burgeoning industry sector supply chain.
- Proven technologies in early stages of commercialization among start-up companies and spin-offs.
- Cutting edge next generation technology being developed at both the industry and academic levels.

Clean Energy Ecosystem

The findings point to the conclusion that the Southern Tier has a clean energy innovation ecosystem that is uniquely positioned to be a player in the global economic momentum of technology and innovation, expanding its leadership role in manufacturing, and advancing Governor Cuomo's clean energy goals.



Demand-driven Perfect Storm

The results of the Phase 1 assessment reveal that a major strength in the Southern Tier's Clean Energy Ecosystem lies in the commercialization of clean energy technology among its existing manufacturing and supply chain businesses. Further, the assessment revealed there is demand for value-added business development associated with energy storage, as well as, the need to fill gaps in the supply chain for products ranging from clean energy product development, to battery manufacturing, assembly of battery packets, base components of energy storage stationary equipment and systems integration in order to successfully position the Southern Tier to be a leader in this next great industrial wave.

There are five significant and simultaneous factors that together are creating a "perfect storm" for growth of a robust business development initiative centered around the battery technology and energy storage industry in the Southern Tier.

Private Industry Demand-driven Perfect Storm
Positioning the Southern Tier to be a Leader in the Next Major Global Industrial Wave

Industry and Innovation Strengths

The Southern Tier has established a clean energy innovation ecosystem that is poised to grow and be an economic driver in New York State.

The application of batteries and battery systems is diverse across key industrial markets ranging from forklifts for materials handling to mass transportation, telecom and renewable energy markets. Industry leaders and economists forecast that the major growth among US-based manufacturing companies will be in "avionics and urban transportation," exactly where the Southern Tier excels.

In this growing market, the transportation sector (not including electric vehicles) currently represents 62% of the battery technology and clean energy manufacturing market, valued in 2018 at $61 billion. The transportation segment alone is expected to be the fastest growing of all in the clean energy sector, at a rate of 18% per year. Electric buses and forklifts are projected to be the top two growth products areas for the next 10 years. The global industrial share for forklifts alone is projected to be the largest growth sector at $8.4B by 2023.

Several of the Southern Tier's manufacturers are involved in the design and manufacturer of battery powered products that are being sold in the global marketplace. They are active in the battery market ranging from R&D and new product design and development to making battery packs, manufacturing components, packaging components, and systems integration.

These companies have the expertise to both drive and respond to demand. For example:

- BAE Systems is the largest manufacturer of battery packs in New York State (buys cells from Samsung) and a world leader in electric buses.
- Raymond Corporation is a world-leader in manufacture of forklifts and has developed a system that allows the user to schedule charge times and it monitors charging and usage to prevent overcharging and discharging events.
- Amphenol AIO makes components for batteries manufactured in China.
- Amphenol Aerospace and Lockheed Martin are leaders in avionics and application to military sector needs.
- Amphenol IPC makes bus bars that are used by Uber, avionics and mass transportation.
- Corning Incorporated is a leader in optical sensing.
- Lockheed Martin is a global leader in the application of technology and product development ranging from mobile and stationary equipment to military aircraft and devices.

Other Southern Tier companies make components and are part of the supply chain in this growth sector. Companies such as Amphenol AIO, Amphenol IPC and Borg-Warner's new affiliation with Romeo are part of the supply chain for the US military, Toyota, Uber, Tesla, Airbus, Cummins, Pylon Tech, Nokia, Wan Viang, LG Chem, Panasonic, and auto manufacturers such as Ford, Chrysler, General Motors, Volkswagen and Volvo.

These companies have identified the lack of an adequate supply chain and battery manufacturers located in close proximity as among their major challenges. In order to gain a competitive advantage and compete for the growing number of contracts being let, they are being forced to compensate for lack of an adequate supply chain by building more in-house battery-related expertise and capabilities including battery manufacturing, as well as, executing the testing and review required. However, they continue to point to the need for a competent supply chain and battery manufacturing companies that are satellites of the major global producers.

There also is an opportunity for the Southern Tier to be a leader in addressing the major challenge of "time-to-market" if a business attraction strategy can be executed that fills product and supply chain gaps. Time-to-market has been determined to be one of the largest challenges that is straining the companies in the Southern Tier to respond to demand. These time-to-market challenges include the design and assembly of energy packs for large-scale energy storage projects, the time to transport batteries from Asian, which is now compounded by the impact of trade wars and national security issues, as well as, the lack of battery manufacturers in the US.

Global trends also point to the significant growth in energy storage applications including solar and wind across electricity grids where the Southern Tier also has taken a leadership role in investments. Global forecasts point to a renewables market reaching $2.6B by 2023. Wood Mackenzie predicts that significant growth of energy storage through 2023 will be led by China and the US. With the current rate of investment the US is expected to be the global leader within the next 5-8 years.

New York State is among the leaders in the US in terms of setting renewable energy goals. It has been successful in attracting leaders in renewable energy products such as Next ERA, Invenergy and Innology. These companies have indicated that as battery storage systems become more prevalent, operators of grid and energy storage systems will need rapid access to battery data to accelerate product development and system integration, and also to optimize field use. One of the major challenges identified by energy storage companies is the translation matrix for grid scale generation and storage. This rate of growth in the Southern Tier will create an increasing demand for battery production and systems integration.

Alignment with New York State Clean Energy Goals

Reforming the Energy Vision (REC) is Governor Cuomo's comprehensive energy strategy for New York State. REV is intended to help consumers make more informed energy choices, develop new energy products and services, and protect the environment while creating new jobs and economic opportunity. This clean energy initiative is a major economic development priority for New York State. The goals call for:

- Go from 26% renewable sources today to 70% by 2030 and 100% by 2040.
- Reduce greenhouse gas emissions by 85% from 1990 levels by 2050.
- Remaining 15% will have to be done through reforestation, restoring wetlands, carbon capturing or other green projects.
- 600 trillion Btu increase in statewide energy efficiency (at source).
- Support growth in Clean Energy Innovation.
- Build a more resilient energy system and improve energy infrastructure.
- Grow New York's energy efficiency.
- Support cleaner transportation.
- Create new jobs and business opportunities.

The Advanced Manufacturing Work Group of the Southern Tier Regional Economic Development Council recognized that global movement to clean energy and New York State's aggressive goals combined with disruptive battery technology and a strong manufacturing base had the potential participate in the trillions in economic value in the decade ahead. Therefore, in 2019 the Work Group named the need to strengthen and grow the manufacturing base and related supply chain of this sector as a top priority in order to increase the impact of new revenue and job growth.

Potential to Grow: Challenges and Opportunities

Regardless of the geographic area of the world, there are common challenges being faced by businesses in both the mobile and stationary sectors that are involved in the commercialization of battery technology and energy storage. These same factors were identified by companies conducting business in the Southern Tier.

Phase 1 documented the opportunities and the major challenges impacting manufacturers in the mobile sector, businesses and development companies in the stationary energy storage sector, and the emerging recycling sector in the Southern Tier region and constraining their ability to take advantage of the Perfect Storm.

Common Challenges in the Mobile and Stationary Sectors

- Rapid evolution of battery technology.
- Cost of high-volume manufacturing plants: for both batteries and pouches for cells.
- Lack of standards for the manufacture and application of batteries.
- Concerns about access to essential materials; i.e., Nickel, Cobalt, Synthetic Graphite, Lithium.
- Demand for a lighter, cost-effective battery with a longer life and capacity.
- Unmet charging requirements.
- Safety issues: opening and discharged in a safe environment, and safe transportation.
- Technology, investment and technical expertise required to design and assembly of energy packs for large-scale energy storage projects.
- Time-to-market because cost of battery mass production is high and mostly based in China, Japan and Korea.
- A fragmented and inadequate supply chain impacting time to market.
- Lack of a qualified US-based supply chain needed to successfully compete for government contracts.
- Lack of recycling and product standards.

Overall Opportunities

- Enhanced commercialization and application of technology among several existing Southern Tier companies involved in design and manufacture of mobile and stationary equipment, military aircraft and devices, drones, mass transportation, optical sensing and recycling.
- Forecast for rapid growth in application of battery technology in the mobile section; specifically, buses, forklifts and avionics where the Southern Tier already has a strong footprint. Avionics also is a major growth sector for both federal agencies and the private sector.
- Demand for supply chain businesses to support the region's advanced manufacturing ranging from manufacture of components to sourcing battery packs to recycling.
- New business spinoffs such as Imperium3 (CV4), Conamix, Inc. and Nohms.

- Incubator triangle in the Southern Tier region and the potential for start-up businesses that could evolve into members of the supply chain and potential new business leaders.
- Collaborations with Binghamton University and Cornell University, which are recognized globally as leaders in battery technology R&D.
- Investments in new business development via programs such as 76West that involve application of cutting-edge technology.

Overall Challenges

- Business growth is creating an increased demand for batteries and system integration.
- High cost of batteries and pouches for cells due to Asia being the primary source.
- Gap between buying battery cells and packaging due to the limited number of US-based battery manufacturers and suppliers of energy packs, which is contributing to the time-to-market challenge.
- Need to build in-house expertise and capabilities including "build our own" battery assembly and testing, evaluating battery vendors, undertaking battery pack technology and production, conducting system integration, and addressing safety issues.
- Engineering and design are conducted regionally, but some is done in countries such as China, France and Mexico … some manufactures recognize the opportunity to reduce costs by conducting it locally.
- Companies being forced to use resources to compensate for challenges by building more in-house battery-related capabilities ranging from battery assembly to testing.
- Need for significant financial investment in technology development, commercialization of technology, and expansion of research, design and production facilities.
- Attracting and retaining a skilled workforce; particularly the ability to attract and retain qualified engineers.
- Lack of capital to harness opportunities. Investment is needed for:
    - Commercialization of new technology at the manufacturing and supply chain levels.
    - Continued investment in R&D.
    - Transfer of technology for new product development and manufacturing.
    - Attraction of early stage clean energy firms that are spin-offs of both regional and US academic institutions that are attracted to the region because of the R&D assets and reputation of Binghamton University and Cornell University.
    - Battery manufacturing, assembly and packaging companies to locate in the region.

Opportunities and Challenges: Advanced Manufacturing

Opportunities

- Increasing investments by foreign governments and US agencies including federal, state and regional government in mass transportation, small utility vehicles, drones, aerospace, robots and on-site stationary energy storage.
- Enhanced commercialization and application of technology among several existing Southern Tier companies involved in design and manufacture of mobile and stationary equipment, military aircraft and devices, drones, mass transportation, optical sensing and recycling.
- Forecast for rapid growth in application of battery technology in the mobile section; specifically, buses, forklifts and avionics where the Southern Tier already has a strong footprint. Avionics also is a major growth sector for both federal agencies and the private sector.
- Demand for supply chain businesses to support the region's advanced manufacturing ranging from manufacture of components to sourcing battery packs to recycling.
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- Incubator triangle in the Southern Tier region and the potential for start-up businesses that could evolve into members of the supply chain and potential new business leaders.
- Collaborations with Binghamton University and Cornell University, which are recognized globally as leaders in battery technology R&D.

Challenges

- Business growth is creating an increased demand for batteries and system integration.
- High cost of batteries and pouches for cells due to Asia being the primary source.
- Profitability and time-to-market challenges due to the gap between buying battery cells and packaging due to the limited number of US-based battery manufacturers and suppliers of energy packs.
- Need to build in-house expertise and capabilities including "build our own" battery assembly and testing, evaluating battery vendors, undertaking battery pack technology and production, conducting system integration, and addressing safety issues.
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- Need for significant financial investment in technology development, commercialization of technology, and expansion of research, design and production facilities.
- Attracting and retaining a skilled workforce; particularly the ability to attract and retain qualified engineers.

Opportunities and Challenges: Stationary Energy Storage

Eighteen percent of all electricity produced in the US during 2017 came from solar, wind, hydroelectric, or other renewable power sources; up from 15% in 2016.[10] New York State's Governor Cuomo has determined that energy storage is essential to enabling renewable energy, and the energy grid market for storing renewable energy for residential and commercial uses is ramping up. The application of battery technology and energy storage by a growing business sector and accelerated time-to-market will be major factors contributing to New York State's success in reaching its goals.

Opportunities

- Both major and small energy storage companies are attracted to New York State and the Southern Tier.
- New York's Clean Energy Stand (CES) is the most comprehensive and ambitious clean energy goal in the State's history. It is designed to fight climate change, reduce harmful air pollution, and ensure a diverse and reliable low carbon energy supply.
- N**YSERDA** research and programs have been a stimulus to clean energy project, with a focus on:
  - Reducing energy use
  - Increasing energy efficiency
  - Creating jobs
  - Creating public-private partnerships to stimulate entrepreneurism
  - Preparing tomorrow's workforce for the clean energy economy
- **NY Green Bank** ("NYGB") – NYSERDA's investment division and a part of NYS's 10-year $5.3 billion Clean Energy Fund that has invested $1.96 billion in aggregate. Invests are made in projects that apply renewable energy technology, i.e., solar, wind, fuel cells, hydroelectric, biomass, biothermal energy, liquid biofuels, etc.

Challenges

- Need for application of new technology to address issues such as keeping the cells cool.
- Need to fill gaps in the supply chain for the manufacture and assembly of integrated systems used in the construction of solar and wind energy storage systems.
  - Manufacturers of the large containers used in the energy storage projects (only one in NYS)
  - Battery pack assembly/integration companies.
  - Manufacturer of racks and modules that hold the battery packs.
- Shared challenges with the manufacturing sector, including
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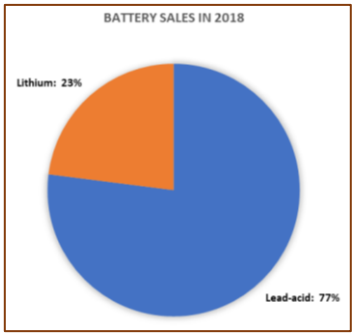
  - High cost of batteries and pouches for cells due to Asia being the primary source.
  - Gap between buying battery cells and packaging due to the limited number of US-based battery manufacturers and suppliers of energy packs, which is contributing to the time-to-market challenge.

[10] Business Council for Sustainable Energy and Bloomberg New Energy Finance.

Challenges: Logistics and Distribution Sector

Lithium batteries are expected to represent more than 50% of all battery sales by 2023. By 2025, the worldwide market for new battery technology (other than acid-based) is expected to be at $5 Trillion and around 600 GWh per year compared to less than 200 GWh today.



Globally, lithium batteries could be in 25% of new trucks by 2023. Though changing rapidly, lead-based batteries still represent 77% of the dollar value of this market.

Southern Tier companies involved in logistics and distribution such as Best Buy report they are struggling with the high cost of lithium batteries to replace the lead-acid batteries in their electric and hybrid vehicles. It is estimated that the cost to replace the lead-acid batteries with lithium ion batteries continues to be four to five times higher than continuing to operate with existing technology and investing in new government mandates for storage of batteries.

Some limited progress is being made in this sector to maximize battery range and reliability for every vehicle configuration from passenger vehicles to last-mile delivery trucks. For example, it was announced in October 2019 that fifteen Tesla Semi electric trucks are replacing all of PepsiCo's existing diesel-powered freight equipment with "zero-emission (ZE) and near-zero emission (NZE)" trucks and equipment at its Frito-Lay Modesto, California, manufacturing site.

However, the majority of businesses in this sector continue to be anxious about the cost of batteries and truck design necessary to meet clean emission goals while simultaneously maintaining a consistent level of profitability.

Opportunities and Challenges: Recycling

Due to the relative youth of the battery market, a well-organized recycling sector has not evolved. This sector of the overall battery technology evolution is facing significant barrier ranging from safety to profitability.

The waste presents a number of serious challenges including storing batteries before repurposing or final disposal, the manual testing and dismantling processes required for either, or in the chemical separation processes that recycling entails.

"Rapid growth in the market for electric vehicles is imperative, to meet global targets for reducing greenhouse gas emissions, to improve air quality in urban centers and to meet the needs of consumers, with whom electric vehicles are increasingly popular. However, growing numbers of electric vehicles present a serious waste-management challenge for recyclers at end-of-life. Nevertheless, spent batteries may also present an opportunity as manufacturers require access to strategic elements and critical materials for key components in electric-vehicle manufacture: recycled lithium-ion batteries from electric vehicles could provide a valuable secondary source of materials."

Recycling Lithium-Ion Batteries From Electric Vehicles
Nature | Vol 575 | 7 November 2019

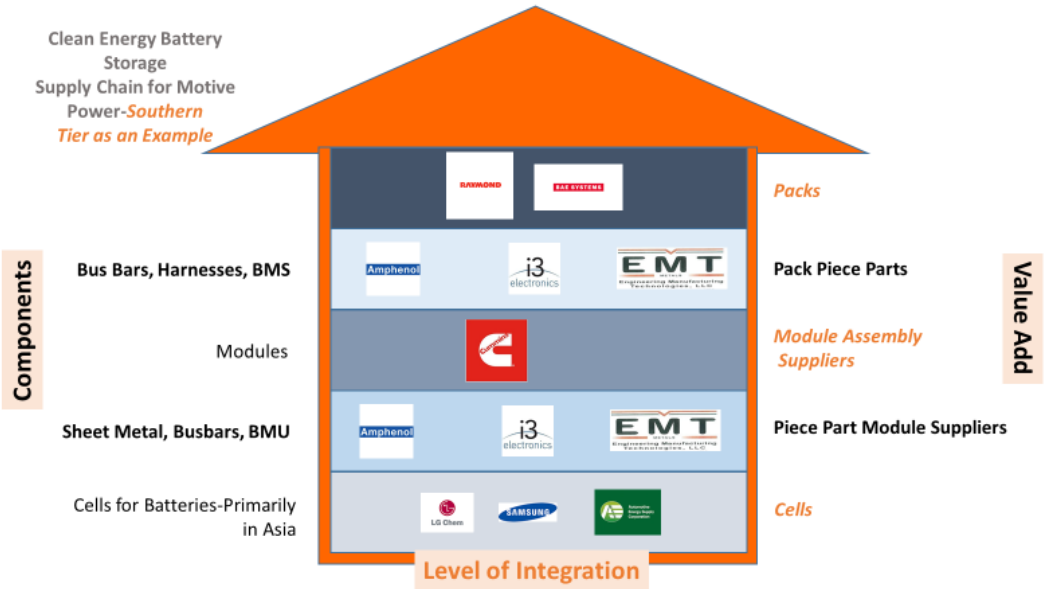
Industry Led Business Development

The Phase 1 assessment suggests there is potential for the Southern Tier to be New York's prominent region for commercialization of innovations in battery technology, growth of clean energy technology businesses, and large-scale renewable energy development.

Although the auto industry is considered the "Big Fish," demand is being driven by electric buses, forklifts, aerospace, robots, drones, small utility vehicles and energy storage systems.

Both the mobile and stationary sector companies in the Southern Tier region point to the need for additional capacity and resources together with a qualified supply chain to successfully ***respond to demand, gain a competitive edge, successfully compete for the increasing number of contracts being let, and capture an increased market share.***

Raymond Corporation provided this diagram to illustrate the clean energy battery storage component and value-added needs of regional manufacturers in motive power.



The opportunity for the Southern Tier to address these gaps and potentially capture a larger share of the growing global clean energy industry would require development and implementation of an industry-led and demand-driven business development strategy designed to strengthen and expand the existing manufacturing base, as well as, grow the critically important supply chain. Failure to position the Southern Tier to capture the increasing market share has the potential to result in that same demand being absorbed by state's other than New York.

Such a targeted business development and recruitment effort would require an accounting of key assets including those that support innovation and technology development, an inventory of existing businesses and their respective investment needs to meet demand and pursue opportunities for growth, listing of benefits and potential incentives, a qualified prospect list for supply chain recruitment, description of a specialized and skilled workforce and quality of life, a detailed case statement and recruitment strategy that states the opportunity for a business to achieve success, a statement of alignment with New York State Clean Energy goals and the economic development priorities of the Southern Tier, and recruitment collateral.

Ideally, such a strategy also would identify ways to coordinate recruitment efforts with NY-BEST, NYSERDA, Empire State Development, TEN, the incubators in the region and more.

In addition, it would be beneficial to closely monitor the activities of both foreign governments and the US government to maintain an understanding of the changing regulatory environment, clean energy goals, and targeted investments. For example, understanding the activities of the Committee on Foreign Investment (CFIUS), an inter-agency committee of the United States Government would be beneficial. It reviews the national security implications of foreign investments in US companies or operations and could be advantageous if the region seeks to actively pursue military funding for R&D and/or sale of products and services. Also, note that in 2018 President Trump signed the Foreign Investment Risk Review Modernization Act (FIRRMA), which gave CFIUS new powers over particular types of FDI that mainly concern Chinese investors. These include real estate investing, areas where minority investment through private equity provide access to US tech companies' business information, and US-Chinese joint ventures.

It is recommended that interested economic development agencies form an Industry Led Advisory Committee to guide the process to identify priorities for investment in local companies necessary to spur the commercialization and application of battery technology, opportunities for collaboration among the businesses and academic institutions, opportunities for battery innovation and commercialization, and development of target sectors and prospects for recruitment. Such advisory committees might include representatives of established businesses and supply chain involved in both the mobile and stationary sectors, academic and research institutions, and other stakeholder groups.

DEFINITIONS

- **Stationary:** Energy storage facilities, cell phones, tablets, etc.
- **Motion/Mobile:** Cars, buses, trucks, forklifts, etc.
- **EV:** Electric Vehicles
- **PL-EV:** Plug-in Electric Vehicles
- **SLI:** Starting-Lighting-Ignition battery is a lead-acid and rechargeable type of battery that is mainly used in vehicles and motorcycles.
- **Power Capacity**: The maximum instantaneous amount of power output. Measured in megawatts (1 MW= 1 one million watts)
- **Energy Capacity**: The total amount of energy that can be stored or discharged by the battery storage system. Measured in megawatt-hours (MWh)
- **Lithium-Ion (Li-Ion):** A type of rechargeable battery in which lithium-ions move from the negative electrode to the positive electrode during discharge and back when charging. Lithium-ion battery storage represents more than 80% of the installed power and energy capacity of large-scale battery storage in the United States. Since 2011, most large-scale battery storage installations have opted for lithium- ion batteries, including retrofits of older systems that initially relied on different chemistries.
- **Nickel-Based Battery:** NIMH

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