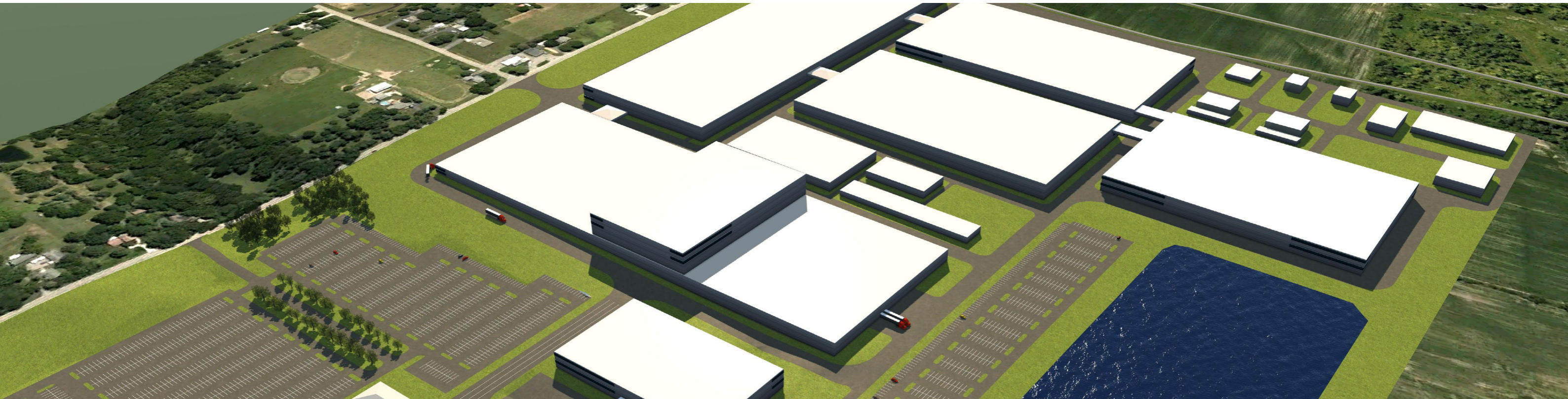
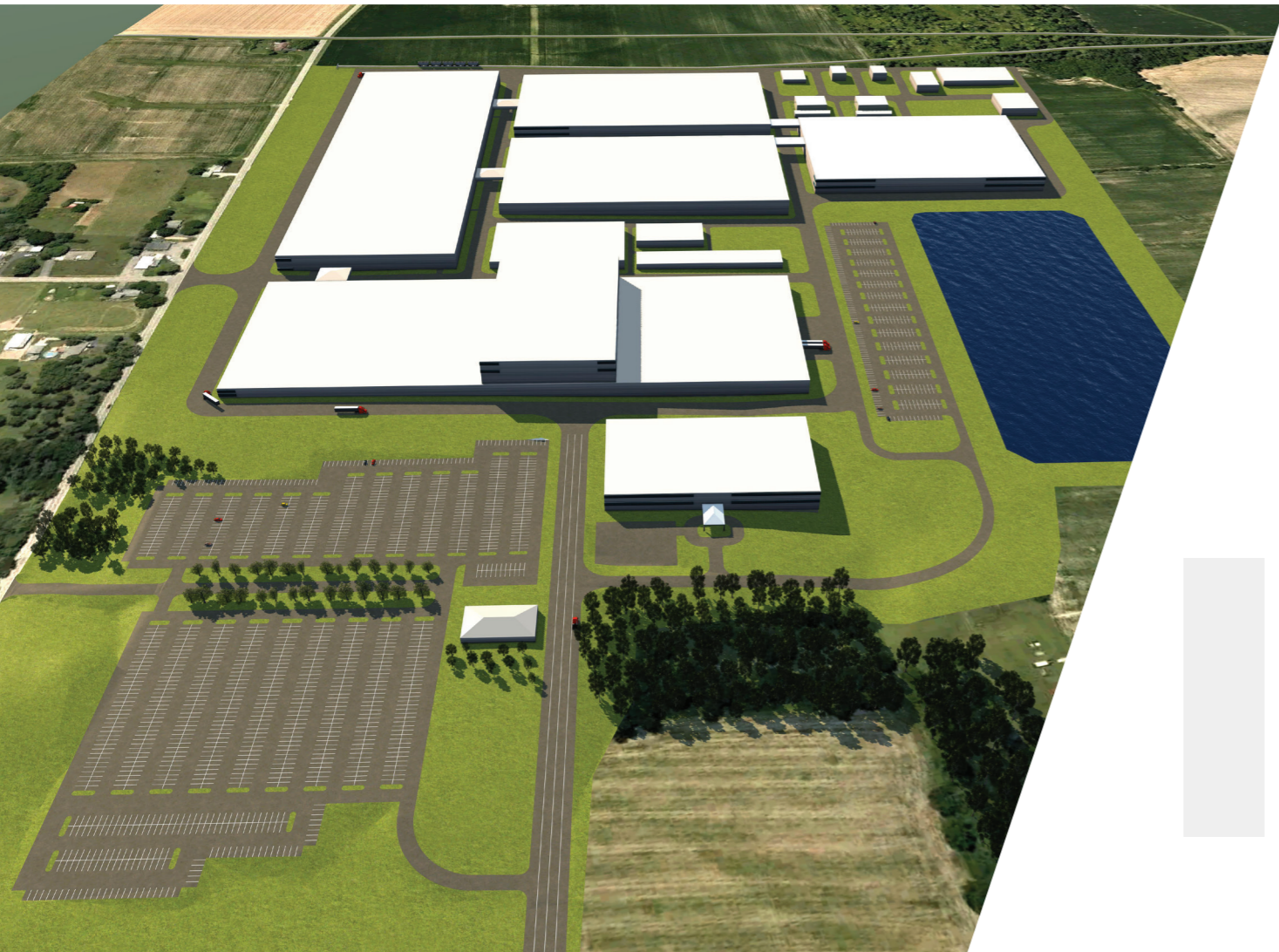




Planning your U.S. Battery Manufacturing Plant:

How to Avoid Costly Pitfalls and Achieve Success





SSOE is here to resolve the complex issues involved in the successful development of a battery manufacturing plant.

You may be a battery manufacturer, or perhaps you're a site selection consultant, general contractor, or state economic development agency official. We've gathered our technical expertise to create a road map of what's ahead during the project development process, from site planning to battery production and delivery. Whatever your role, this guide will walk you through three challenges that could affect your project: choosing the right location, starting up production on time, and optimizing both the project delivery process and ultimately your production.

Introduction

Lay the Groundwork – Site Suitability, Validation, and Permitting

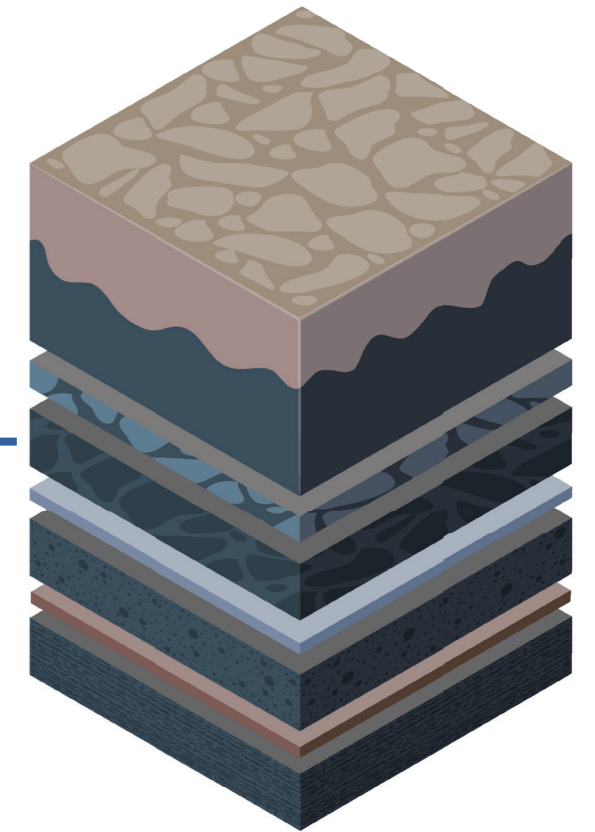
Set your project up for success before groundbreaking. In addition to the more traditional elements considered by a site selection consultant, we've found owners want to have a clear understanding of the characteristics that make a site suitable for a lithium-ion battery manufacturing plant.

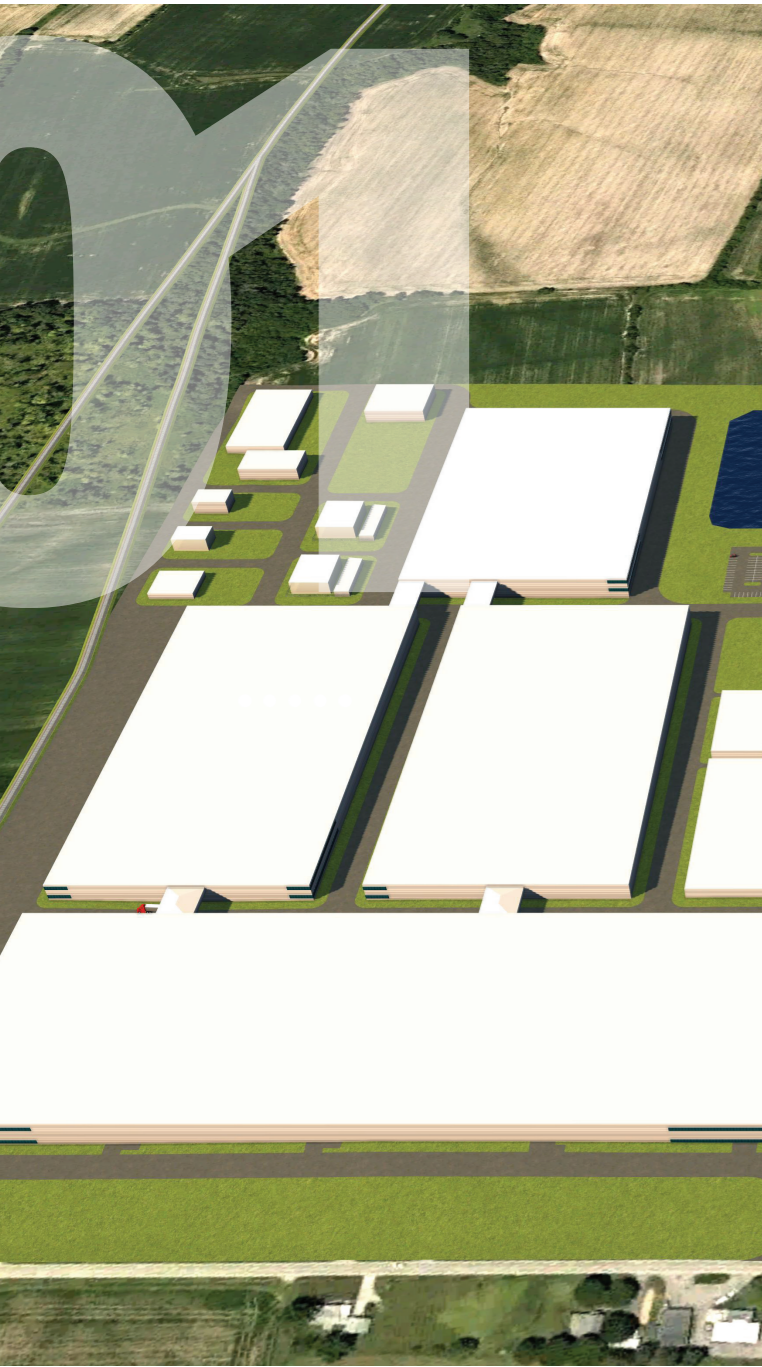
Site selection consultants are excellent at what they do and will ensure a site maximizes your incentives and has the workforce required to meet your needs. However, both greenfield sites and reuse of existing facilities pose unique challenges for battery manufacturers; but these are challenges that can be avoided by having your site evaluated by the technical experts who will design your facility. They will want to review soil conditions and grading, suitability of utilities, and permitting requirements. Before you agree to a site location, make sure the property will meet your technical needs and won't create any unexpected costs or schedule delays.

Physical Aspects of a Site

Everything needs a strong foundation. The physical aspects of a location are critical to success. Soil type can impact the suitability of a site, as can site grading. Suppose you have 50 feet (~15.25 m) of elevation difference across the site. In that case, you may need to make a significant investment to level the property before construction. That expense could be a deal-breaker.

Sometimes these expenses are hidden behind what looks like a good deal. For example, a community offered free property to a foreign investor for a manufacturing facility. The site would have required extensive modifications to be build-ready, including building expensive retaining walls. After learning about these issues, the investor abandoned their plans to build on the site.





Adequacy of Available Utilities

Sometimes sites advertised as shovel-ready may not meet the intense utility needs of a battery manufacturing facility. What happens if a gas company needs to build a six-mile (10 km) gas line to your plant? Who will pay for that expense, and how long will it take to install?

Utility companies may plan bring power to a site, but it can take them two or three years. For battery manufacturers who need to ramp up production as quickly as possible, that timeline doesn't work.

Before purchasing a site, you'll want a technical resource to partner with your traditional site selection consultant to identify potential problems before you spend too much time on an unacceptable location. Some design challenges are not obvious.

Early Focus on Chemical Storage

When designing a battery manufacturing plant, a key project component will be chemical storage. As an owner, you need to know what you're bringing on-site, how you will store it, and how to dispose of waste. The types of chemicals will affect how your building is classified.

Your design team needs extensive knowledge about chemical classification and reporting requirements. The heavy metals used in battery manufacturing require special considerations, which can vary depending on local code and environmental requirements. Owners without proper documentation and compliance could be fined heavily.

Buying and refitting an existing facility poses its own challenges, particularly in the amount of code analysis required for a successful project. Extensive changes to an existing facility may be necessary, and should be considered before final site selection and purchase.



SSOE Tip:
Conduct a code analysis before purchasing an existing facility for a new use.



Permitting May Impact Site Suitability and Project Schedule

Permitting requirements can have a huge impact on a project; it's critical to know what permits your project requires before construction begins. As a battery manufacturer, you'll need to comply with many regulations and obtain the necessary permits from a variety of Authorities Having Jurisdiction (AHJs). Permitting surprises are a common, and avoidable, cause of project delays.

SSOE Tip: Know what permits your project requires before construction begins.

To avoid these delays, it is critical to understand what permits you'll need for your specific site and their necessary time frames. Acquiring these permits will dictate when you can begin the development of your facilities. Necessary permits vary by state and region, down to site-specific environmental factors.

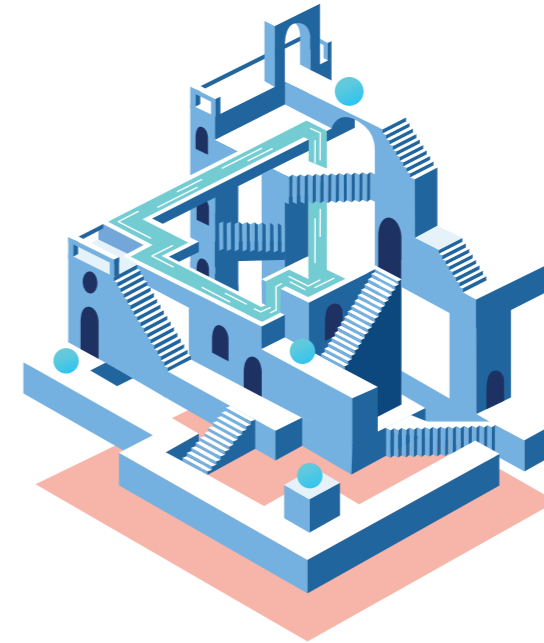
Many systems require some form of permitting, and responsibility for complying with all applicable government rules falls on the battery manufacturer. Beyond the construction process itself, a manufacturer often must follow strict governmental rules. For example, it's necessary to document what kind of exhaust chemicals a piece of equipment produces. In order to ensure that your facility and your manufacturing process meet these sometimes complex requirements, it helps to have an expert partner who understands permitting needs and how they may vary from site to site.

Consider these typical scenarios:

1. For a greenfield site, states may offer a fast-track permitting process as part of an incentive package, but some permits will require an established timeline such as Stormwater Management, Title V Clean Air Act Permits, Water Use Permits, and Groundwater and Mitigation documentation (to name a few).
2. For reuse of an existing facility, you must also consider how it was initially permitted. The new process for this facility will likely require new permits. Will these changes allow you to operate the way you expect? Here are some examples to think about:
 - Possible H-occupancy permitting.
 - Special permitting for unconventional construction in battery manufacturing areas.
 - Expanded fire sprinkler coverage may be required to receive permitting.
 - Additional fire-rated occupancy separation walls may be required. These walls can complicate movement of personnel and material from one area to another.

Have Confidence in Your Schedule

We know that schedule is a top priority for owners considering battery manufacturing facilities. The demand for lithium-ion batteries has never been higher, and with the increasing adoption of electric vehicle this will only increase. We understand that as a result, any delay in production start up could mean a significant revenue loss for you. Conversely, any schedule acceleration could create a competitive advantage as EV manufacturers look to award lucrative contracts with partners ready to produce.



SSOE Tip:
Multi-discipline teams provide efficient project delivery and can identify potential risks.

Selecting the Right Technical Team

When making your selection, look for a team of multi-discipline professionals who have experience with both facilities and the complex processes they house. You'll want your team to have on-site field experience and be led by a project managers with a technical background. They'll understand the critical nature of design transparency and how to communicate with owners about the status of their projects. Good technical leaders will start the project off with a collaborative pull planning session to identify important project milestones, critical path items, and areas for potential risk.

Streamline Projects Through Phasing

For expedited construction, break the design process into phased packages. We recommend starting with an expedited site preparation package, and a foundation slab package for the facility. This gets your structure up as soon as possible so you can start installing equipment. Other packages you may look to expedite include the steel mill order, concrete pre-cast order, HVAC equipment, high-voltage switchyard, primary power distribution gear, building foundations, and civil utilities.

Confirm any Existing Plans

Reinventing the wheel is never an efficient use of anyone's time, which is why many facility owners look for ways to replicate the layout of existing facilities with their new builds. As an owner, you'll want your technical advisors to review the existing plans and identify code issues that crop up when you build in a new region. This is especially important if the model facility was built outside the U.S., as code requirements can vary greatly between countries. Your technical advisors should also look at how the site might impact the layout of the facility itself. Confirming your existing site's layout will work in your new location early on is one way to avoid delays once you enter the design phase.

Keep an Eye out for Schedule Optimization Strategies

SSOE is always looking for opportunities to expedite the schedule. We find these strategies early in the planning process by first identifying your Conditions of Satisfaction (CoS). On day one we collaborate with the owner and the General Contractor if on board. We look at each project individually, but some of the common strategies we consider include:

- Project delivery models that allow early collaboration between design and general contractor.
 - Use of a single design model for the fabrication of process piping, which avoids duplicating modeling efforts and avoids additional submittal cycles.
 - Commitment-based visual planning with design, GC, Owner, and key trades.
- Negotiating permit variances by applying experience with local AHJs.
- Advanced reality capture (laser scanning) to assess existing conditions of brownfield facilities.
- Automated cross-discipline clash coordination to avoid last minute changes and delays in the field.
- Use of pre-engineered metal buildings for less complex structures (CUB, CWP and waste buildings).
- Pre-fabrication, modularization, and standardization strategies:
 - Cleanroom pre-fabrication and assembly.
 - Standardization of structural elements and optimization of the sizes and shapes used to simplify order, align with mill run, and simplify installation.
 - Modular pre-fabrication of process and utility systems and distribution.

Ask yourself: What are the potential risks that could affect your schedule?

Ensure Optimized Project Delivery and Production

Battery manufacturing facilities require a unique design skillset, combining an understanding of large-scale manufacturing with a technical mastery of controlled environments and process engineering. You want a design team that can bring the right level of detail to the right areas of the facility without burdening the large-scale general manufacturing spaces with that same cost. Look for partners like us who bring expertise in diverse markets and who know how to collaborate with partners and vendors to ensure a cohesive project and high-performing production facility.

Design Centered on Client Success

What are the business objectives driving your project? No one makes batteries like you do, which is why the key to our design process is establishing your formal Conditions of Satisfaction (CoS). Part of our commitment to lean project delivery, CoS define what a successful project looks like, and focuses the design team's efforts to maximize results while clarifying what can be sacrificed to prioritize your goals.

Regardless of how you define success, we take our Value Promise of "making clients successful by saving clients time, trouble, and money" very seriously. We have a database

detailing more than \$1.5 billion in savings for our clients resulting from our involvement in their project. Maybe we eliminate some scope, or suggest a different equipment layout to reduce overall square footage. Sometimes these savings involve alternate materials, construction methods, or project flows. We're always looking for ways to save our clients money, and on many of our projects, the savings we find more than pay for our design fees. By first understanding your CoS, we ensure these savings never come at the expense of your success criteria.

**SSOE's Billion Dollar
Value Promise:
We make clients
successful by saving them
time, trouble, and money.**



Project Delivery

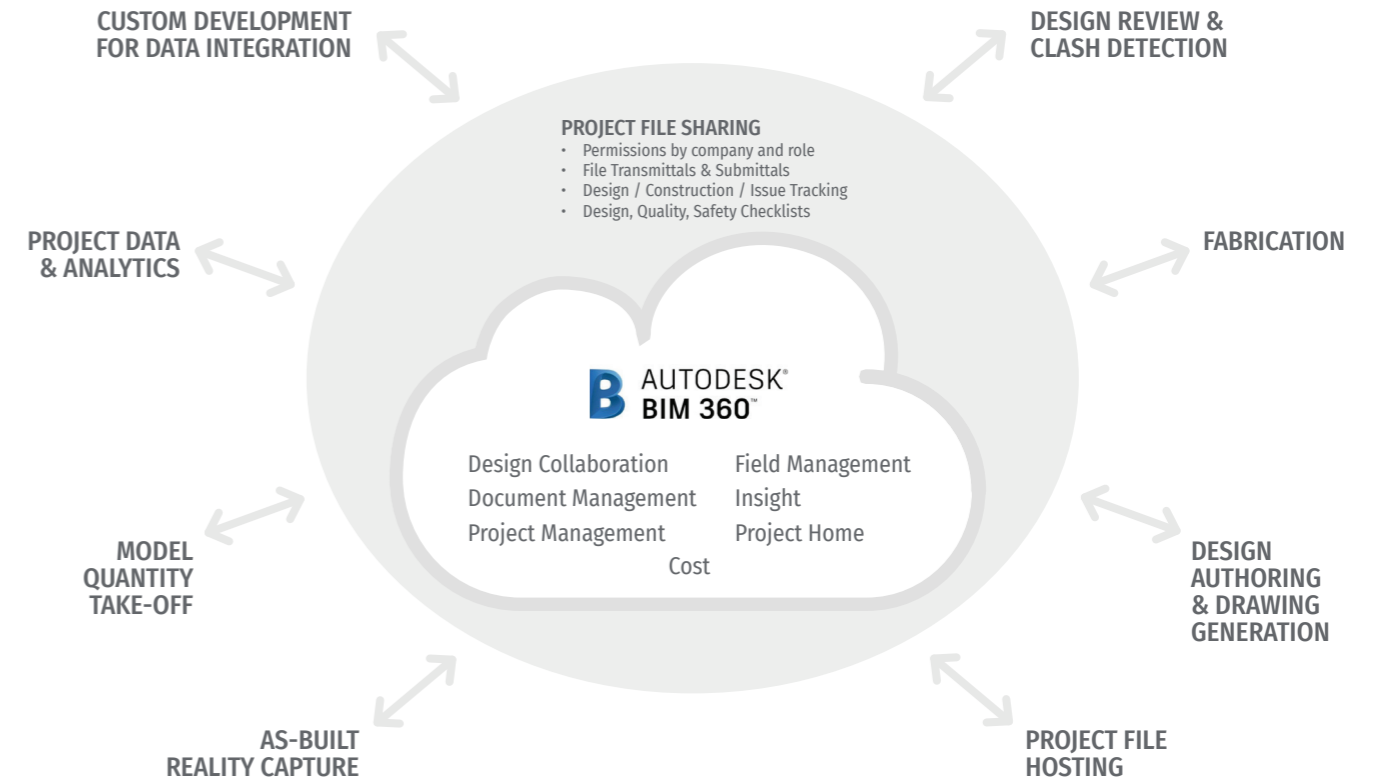
Each client's unique CoS are best addressed by a particular type of project delivery, from the highly collaborative Integrated Project Delivery (IPD) or Design/Build to the more traditional Design Bid Build (DBB), or any other number of approaches. Be sure to consider what method best supports your project drivers and make sure your design partner has experience with your preferred form of project delivery.

No matter the project delivery method, SSOE collaborates with all parties involved to ensure our designs are friendly to both the end-users and construction trades. Early discussions between SSOE's and our client's process experts ensure a design optimized for long-term production needs. Likewise, when the delivery method allows, early collaboration with general contractors and trade partners lets us leverage their domain expertise. This can improve budget certainty, ensure availability and cost-effectiveness of materials,

and can often identify areas to reduce design scope. For example, leveraging the expertise of a trade partner with strong domain knowledge rather than over-designing a system. By working closely with fabricators, SSOE has also developed the ability to provide them with fabrication-ready models—avoiding detailing rework and significantly compressing the schedule. Even on a project where the GC is not on board during the design phase, SSOE's architects and engineers can work side-by-side with our in-house construction managers as advisors to ensure the design's constructability. This saves the GC time and the owner headaches by avoiding preventable issues in the field. Leveraging our diverse in-house resources, our client's stakeholders, and the expertise of construction professionals enhances your project experience and allows us to deliver innovative solutions to complex problems.

Technology Enhances Efficiency and Collaboration

SSOE's investment in our technical tools provides direct benefits to our clients. We have a set goal to execute projects 50% more efficiently by 2025. Currently, we are leveraging advanced use of Building Information Modeling (BIM), including cloud-based collaboration and integration of models, and automation of tasks. Clients looking to adapt existing facilities will further benefit from SSOE's advanced use of laser scanning.



Our collaborative culture extends into the way we innovate and engage with technology. With Autodesk as a partner, we have access to the latest industry programs and tools, including BIM 360.

Procurement Support

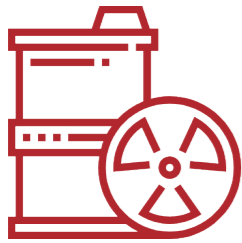
Equipment selection is an essential element of any battery manufacturing project. SSOE is well-acquainted with the vendors used in battery manufacturing facilities and can help you analyze options and select vendors who meet your needs. Taking the time to reach out to these vendors during design avoids surprises, but it's not something every design partner considers part of their scope. Because of our experience, we know the right questions to ask to save you money and to provide a seamless integration of your chosen equipment into the finished facility. A quick conversation can save millions of dollars or weeks of project delays and ensure your facility is designed to support this equipment.

Sustainability

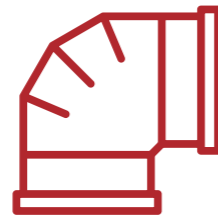
As a battery manufacturer, your mission is to revolutionize the way the world is powered. Your facility should reflect this commitment. SSOE performs environmentally-friendly design that saves resources; as part of our best practices, we focus on renewable energy sources, but also energy recovery and reuse. We reclaim heat from systems and reuse it in other areas. Dry air is expensive, and we find ways to reuse it so our clients enjoy cost savings without impacting delicate environmental conditions. Clients sometimes request information about the LEED (Leadership in Energy and Environmental Design) green building rating system. We can design to LEED specifications but find that clients are generally more focused on the positive impact of the design concepts vs. spending the additional funds required to achieve this certification.

How SSOE Excels

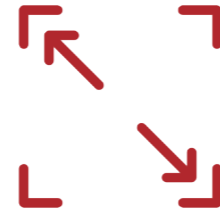
SSOE provides an unparalleled perspective to designing lithium-ion battery manufacturing facilities. We understand the importance of establishing and maintaining the proper environmental conditions for:



Hazardous material handling



Controlled environments including dry rooms and cleanroom-type manufacturing environments



Spatial needs for assembly and production

SSOE's diversity and breadth of talent give our clients a business advantage. Our top-notch experience with semiconductor, automotive, and chemical plant design positions our teams to handle the various aspects of industrial battery manufacturing.

Top 5

Semiconductor Design Firm for the past 9 years (ENR)

Top 5

Automotive Plant Design Firm for 2 years (ENR)

Top 10

Chemical Plant Design Firm for 2 years (ENR)

SSOE Manufacturing Expertise

- Battery assembly, packing, and storage
- Chemical storage
- Chemical mixing
- Chemical reclamation
- Cleanrooms
- Coatings
- Controlled environments
- Dry rooms
- Hazardous material handling
- Waste collection and treatment

[Learn more about our Billion Dollar Value Promise here](#)

Project Experience

Client	Project	Description	Project Statistics
Confidential Client	Greenfield EV and Li-Ion Battery Manufacturing Plant – Phase One	<p>SSOE performed the design scope for phase one of the client-managed greenfield project—a joint venture between an EV and battery manufacturer co-located in the same manufacturing facility. SSOE designed the layout and integration for equipment and infrastructure in collaboration with Owner for mixing, cathode, anode coating and drying, splitting, aging, rolling, canning, and packing processes. A dedicated team of engineers designed the infrastructure and equipment to meet Owner needs and distribution systems for the facility, completing layout and pipe stress analysis. SSOE's scope included:</p> <ul style="list-style-type: none"> • Process integration • Process chemical • Utilities • Mechanical / HVAC • Electrical • QA/QC • Arc Flash Analysis • Project management / design management support 	<ul style="list-style-type: none"> • 20 GWh/year • 6 million SF • 1 million SF of manufacturing space • \$5 million of savings • Powered by solar energy with an ultimate goal of net zero energy
Confidential Client	Li-Ion Battery Plant Upgrades and Integration	<p>Execution of design, services during construction, and ongoing design upgrades to enable tool and equipment integration. Team members were integrated into the owner's facility team for ongoing operations and variation.</p>	<ul style="list-style-type: none"> • 24 GWh/year • 1 million SF total; made up of individual buildings but designed to appear as one contiguous building • \$20,000,000 of savings; recognized by CEO

Client	Project	Description	Project Statistics
Confidential Client	Greenfield EV and Li-Ion Battery Manufacturing Plant – Phase Two	<p>The second phase of the aforementioned project involved the installation of additional battery production lines and associated utility system upgrades. This project was uniquely challenging. Merging the battery manufacturing client's improved technology with the vehicle manufacturer's ongoing production capacity increase in one shared facility created a need for simultaneous site and equipment upgrades. SSOE's cross-functional team assisted with planning all aspects of the expansion, virtually eliminating the risk of design gaps. Using this cross-functional team dramatically improved the holistic design and minimized issues in the field.</p> <ul style="list-style-type: none"> • Battery production line installation • Utility system upgrades • Chemical process analysis, permitting, and certification • Structural engineering and design • Cross-functional project team • Construction and trade bid support 	<ul style="list-style-type: none"> • Additional 3.4 GWh/yr • Additional 160,000 SF of manufacturing expansion • SSOE identified an opportunity to reduce overall equipment costs by one-third for Phase II—translating to nearly \$1.5 million in savings for the Owner.
Confidential Client	Greenfield EV and Li-Ion Battery Manufacturing Plant	<p>SSOE was selected to provide structural engineering and design, fire protection, code review, and permitting for the assembly and paint shop areas of the EV portion of this extremely fast-tracked facility. Based on our successful performance, the client later added structural design for the warehouse and architectural scope for the cathode production facility.</p>	<ul style="list-style-type: none"> • 8 million SF total made up of individual buildings but designed to appear as one contiguous building. • 500,000 SF multi-level assembly plant • 400,000 SF paint shop • 30,000 SF cathode production facility • Energy from renewable sources including a solar roof.

SSOE's experience extends throughout the battery lifecycle, from raw materials to recycling and includes work at some of the world's largest battery manufacturing facilities.



Client	Project	Description	Project Statistics
Confidential Client	Li-Ion Battery Recycling Plant – Pilot Production Line	<p>SSOE was selected to provide full multi-discipline services for the design of a pilot recycling plant within an existing facility. This required infrastructure and utility upgrades as well as extensive equipment installation. The facility will salvage high-quality raw materials for the battery supply chain from expired Li-Ion batteries. The project is considered a technology development design as the process is still dynamic.</p>	<ul style="list-style-type: none"> • 20,000 SF
Confidential Client	Li-Ion Battery Plant Upgrades and Integration	<p>SSOE was selected to provide chemical and process engineering support to update and unify projects as integrated team members at multiple sites. Throughout the independent projects, SSOE team members have designed, upgraded, and advised on:</p> <ul style="list-style-type: none"> • Electrolyte thermal safety regulation and delivery systems • High purity chemical delivery systems • Compressed dry air high volume generation and delivery systems • Solvent waste storage, management, and recycling systems • Dust hazard analysis • Hazardous material inventory and assessments • Alternate means and methods for chemical documentation for permitting 	<ul style="list-style-type: none"> • Saved the Owner \$150,000 on individual supply chain • Resolved persistent system issues for testing tools



Develop your Battery Manufacturing Plant with Confidence

Let's design a plan together to address your critical issues and manufacturing site needs.



ssoe.com

