Energizing American Battery Storage Manufacturing

U.S. Solar Manufacturing Whitepaper Series

November 2023

Image courtesy of Nexamp

Solar Energy Industries Association®

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Introduction

The U.S. solar and energy storage industry has faced a variety of supply chain and policy challenges in recent years, some of which significantly reduced deployment. While our country can overcome these challenges, we must keep two important lessons in mind. One, the United States will continue to face barriers in meeting its full solar and energy storage potential without a robust domestic manufacturing base. And two, the country's overreliance on imports is an economic and national security vulnerability.

It is essential to the nation's continued economic health, global competitiveness and energy security to quickly address our overdependence on solar and energy storage component imports and lay the foundation for a robust solar and energy storage manufacturing base here in America.

As the White House recognized in 2021, energy storage "offer[s] an important and growing market that can support the creation of American jobs, help meet our national security needs, and bring ambitious climate targets within reach." In order to realize this potential, the United States must significantly invest in domestic clean energy manufacturing, including support for energy storage supply chains from raw material production to end use product manufacturing.

Achieving these goals, however, will require a balanced manufacturing and trade policy. History shows that tariffs in general have not had the desired effect of adding U.S. manufacturing capacity. In the case of tariffs on photovoltaic modules and cells, they have limited U.S. solar deployment, which has reduced the likelihood of investments in domestic manufacturing. Tariffs can also blunt domestic manufacturing. For example, the Section 301 tariffs cover most products coming from China, including manufacturing equipment and various inputs that cannot be readily sourced outside of the country.

[1]See Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth, page 86 (published June 2021), available at https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf

[2]See report at page 86

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Introduction

It is well documented that federal industrial policies can launch massive private sector investments. In referencing multiple research studies, the U.S. Department of Energy (DOE) has concluded that:[3]

> *policies and practices such as heavily subsidizing manufacturing and associated supply chains; streamlining siting and permitting; investing in necessary infrastructure; creating workforce education and training programs; and ensuring procurement with environmental conditions that preference their own domestic manufacturers have encouraged the development of in situ manufacturing needed to support the energy sector.*[4]

Historically, federal policy has focused on incentivizing solar and energy storage deployment. However, with passage of the Inflation Reduction Act (IRA), the United States broadened its federal incentive program to include domestic manufacturing through new tax credits, grants, low-cost loans, government procurement, research and development support, and public-private partnerships.

The IRA has the potential to greatly expand solar and energy storage manufacturing in the United States. For energy storage, the IRA offers incentives to produce electrode active materials, battery cells, and battery modules.

While the IRA can make domestically produced batteries cost competitive with Chinese products, one cannot overlook the importance of manufacturing experience, access to raw materials, partnerships with allies, and workforce in ensuring the success of domestic manufacturing.

[3]See page 13, America's Strategy to Secure the Supply Chain for a Robust Clean Energy Transition (published February 24, 2022), U.S. Department of Energy, available at https://www.energy.gov/policy/articles/americas-strategy-secure-supply-chain-robust-clean-energy-transition

[4]Secure the Supply Chain for a Robust Clean Energy Transition, U.S. Department of Energy Response to Executive Order 14017, America's Supply Chains (published Feb. 22, 2022).

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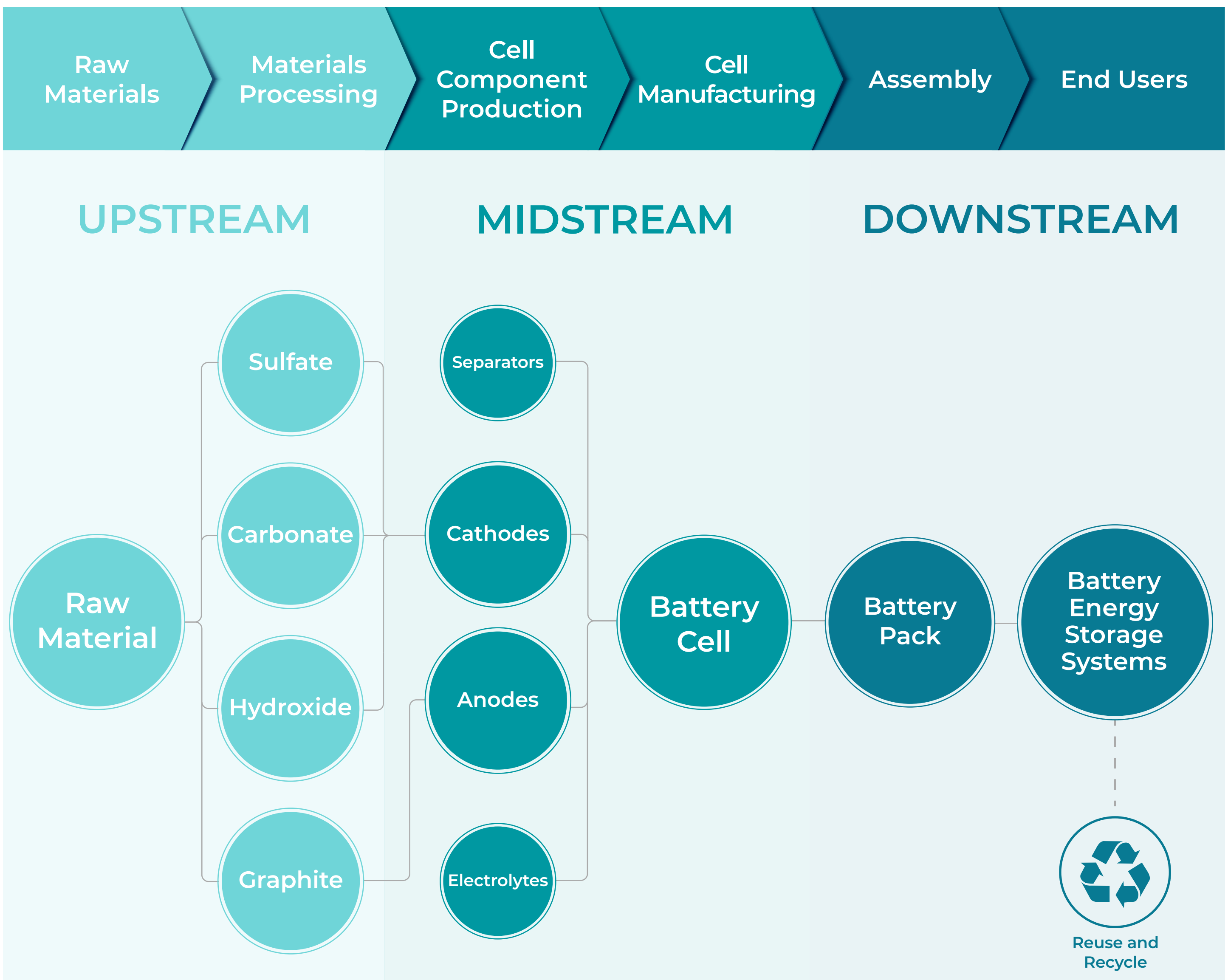
Overview of Battery Manufacturing

The key components in a lithium-ion battery cell are the cathode, anode, separator, and electrolyte. Cathode raw materials – lithium plus varying combinations of typically nickel, cobalt, manganese, phosphorus, and iron – are extracted from the ground, processed into metal chemicals (e.g., nickel sulfate) and then combined to make the cathode active material (CAM). Anodes are made primarily of graphite, which is either produced from naturally occurring mined graphite, or from forms of petroleum coke derived from oil by-products. The CAM is combined with additives and binders, then deposited on an aluminium foil; the anode material is similarly deposited on a copper foil. Within the cell these electrodes are kept apart by a separator; the cell is flooded with a liquid electrolyte. Individual LIB cells are combined to form a battery pack for use in an EV, BESS, or other battery application.

Figure 1: Overview of the Battery Storage Supply Chain



Growth in Energy Storage Demand

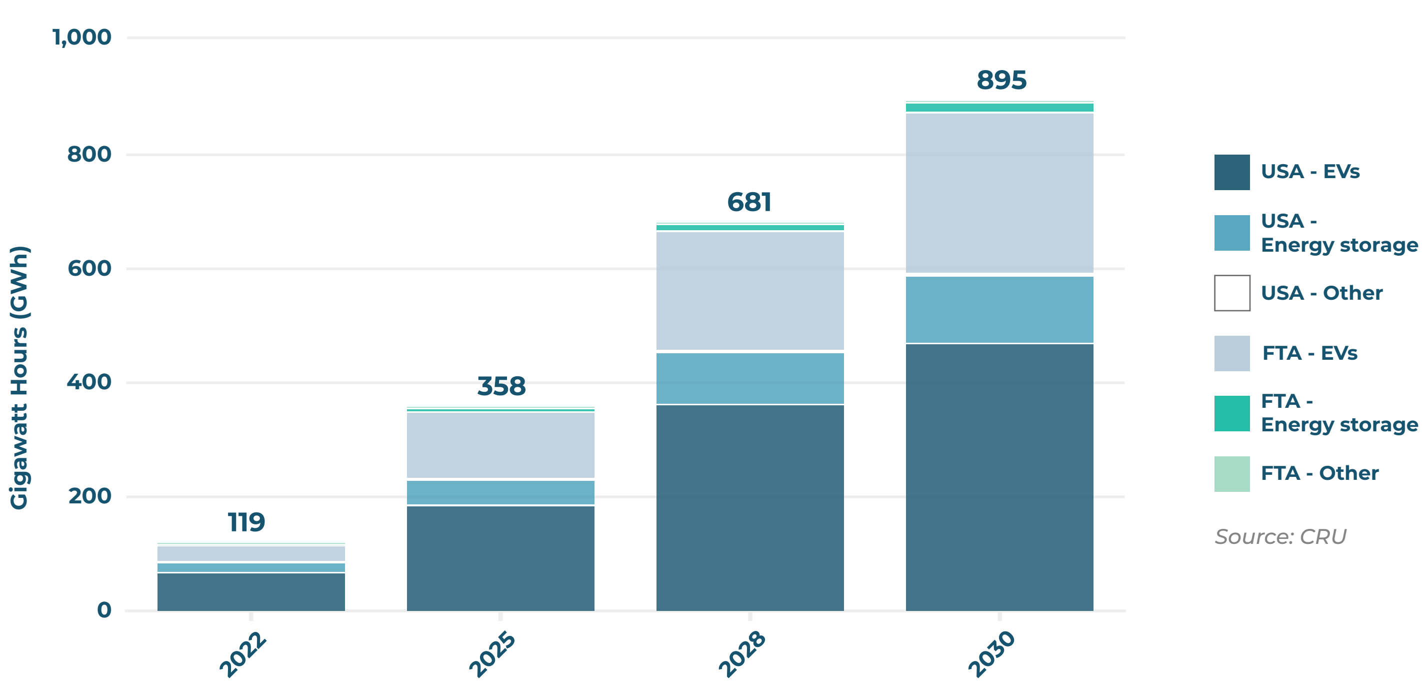
Before committing to new manufacturing investments, companies need reasonable assurances that there will be sufficient demand for their products.

Energy storage can bolster grid reliability and resilience. Energy storage can smooth electricity prices through arbitrage, manage evening energy ramps, mitigate the risk of curtailment, provide black start capability, provide backup power, and more. These benefits have attracted attention from developers looking to add new revenue streams. State governments are increasingly incentivizing the pairing of energy storage with solar. And the IRA provides tax credits for installing solar-plus-storage systems and standalone energy storage systems.

The main form of energy storage for renewable energy is the lithium-ion battery. Over the last few years, the rise in electric vehicles (EVs) helped drive down the costs of batteries as manufacturers scaled up to meet demand. The combination of benefits, incentives, and improving costs of energy storage have quickly made it integral to solar deployment in all segments.

Globally, total demand for batteries in all applications will grow from roughly 670 GWh in 2022 to over 4,000 GWh by 2030. Of that, global demand for battery energy storage systems (BESS), which are primarily used in renewable energy projects, is forecasted to increase from 60 GWh in 2022 to approximately 840 GWh by 2030. And US demand for BESS could increase over six-fold from 18 GWh to 119 GWh during the same time frame.

Figure 2: USA + FTA Battery Demand Forecast by Battery Application, 2022-2030



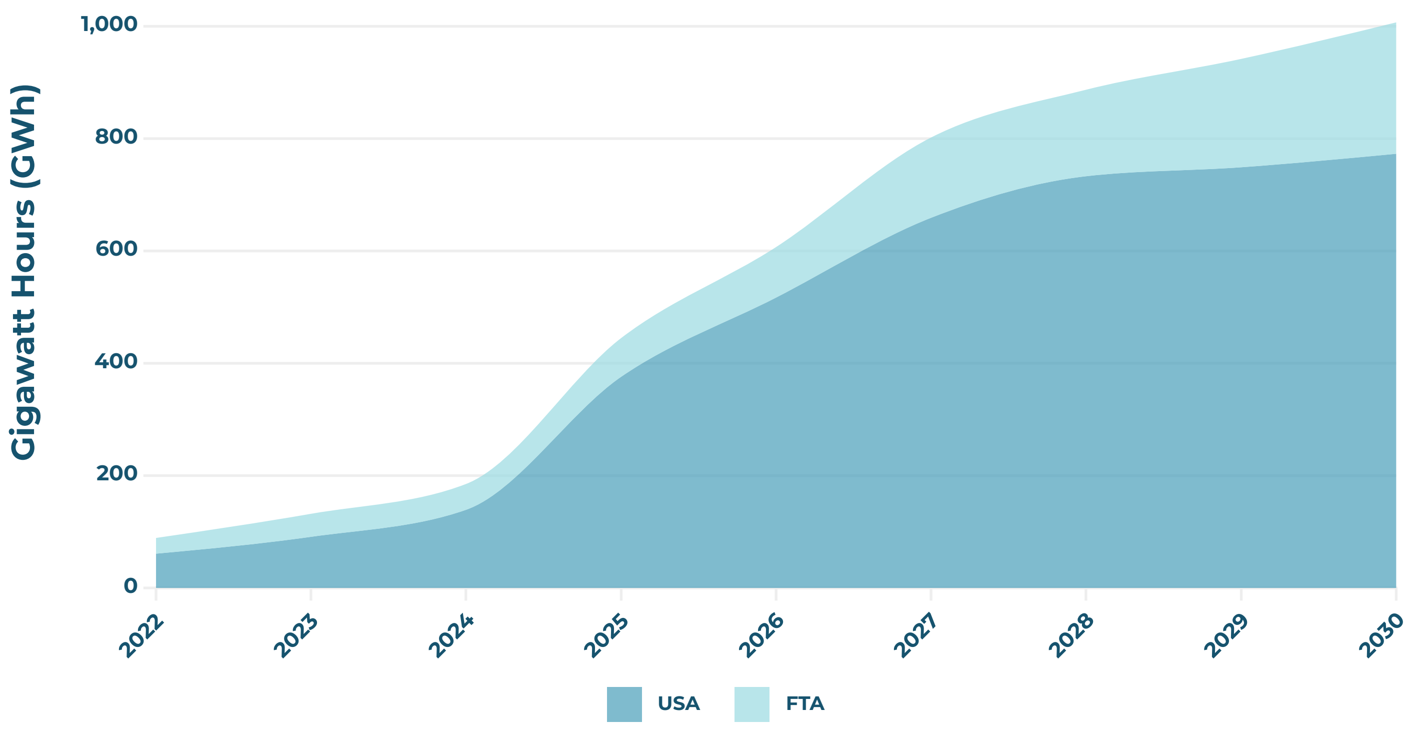
Domestic Manufacturing Capacity

U.S. manufacturing capacity for lithium-ion batteries is currently at 60 GWh; however, new factories are forecasted to increase domestic capacity to over 630 GWh over the next five years. When accounting for Free-Trade Agreement (FTA) countries,[5] we could see total capacity reach 1,400 GWh if every announcement comes through. However, not every announcement will materialize due to factors such as manufacturing experience, workforce, technology, and financials.

On a risk adjusted basis, US and FTA battery cell categories are expected to exceed 1,000 GWh.

Moreover, most of this capacity will be dedicated to the EV sector. Only ten percent is known to be dedicated to non-automotive applications which is primarily, but not exclusively, BESS. However, there is some upside because over 25% of the new factories have not publicly stated which markets they will serve and may dedicate parts of their capacity to BESS.

Figure 3: USA and FTA Countries Gigafactory Capacity Pipeline*



Source: CRU

[5]The U.S. has free trade agreements with 20 countries such as Mexico, Canada, Australia, and South Korea. A list of FTA countries can be found at https://ustr.gov/trade-agreements/free-trade-agreements

Cost Competitiveness

U.S. manufacturers must be able to offer in-demand products, sell at a competitive price and deliver consistently high-quality goods in sufficient quantities on time. Factors that affect the ultimate success of these factories include technical expertise, federal incentives, and the cost of raw materials.

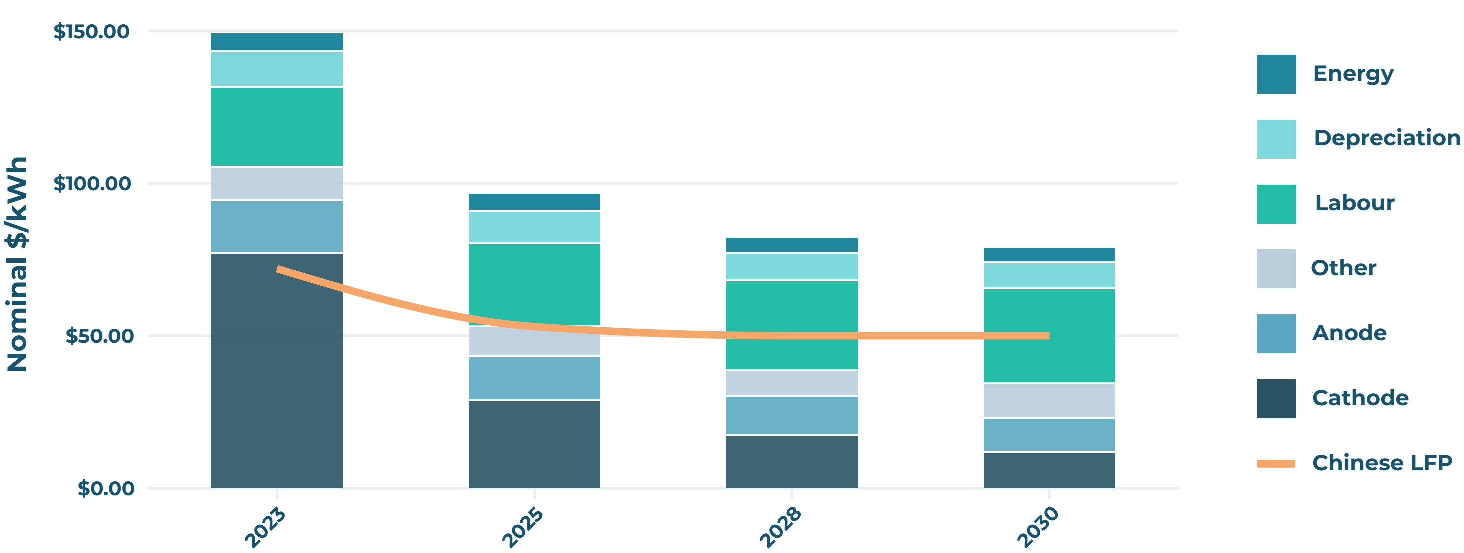
Initial production yields for new battery cell lines can be as low as 50%. New entrants are typically slower to improve their yields versus experienced manufacturers. In contrast, Chinese cell lines can have yields around 98% due to substantial experience in battery production. As a result, partnerships with experienced manufacturers are critical to improving yields and, ultimately, cost competitiveness of domestic batteries.

Costs of materials play a dual role in the cost-competitiveness of domestic batteries.

First, large scale battery plants' highest costs are materials, as the most expensive of which are those used to produce cathode active material (CAM). Between 2020 and 2022, the cost of battery grade lithium carbonate has swung from $6/kg to as high as $70/kg. To put this in perspective, a $30/kg increase in lithium carbonate and lithium hydroxide can increase the price of battery cells by 25%. Purchasing these materials at scale will play a critical role in reducing the cost of raw materials.

Second, the IRA's production incentives for battery cells could reduce costs by over 40%. These incentives, however, are tied to domestic content and recycling requirements which grow more stringent each year. The availability of domestic raw materials and recycling facilities materially impacts the cost-competitiveness of domestic batteries, especially in later years. If factories can access raw materials at reasonable costs and improve their yields to 90%, the IRA could reduce battery costs to the point that they are cost comparable with Chinese products.

Figure 4: Manufacturing COGS Forecast for U.S. and Chinese LFP Pouch Cell, 2023-2030



Source: CRU. Battery cost based on 35 Ah pouch cells produced by US and Chinese battery manufacturers at a final output of 10 GWh per year. Produced using CRU's proprietary Battery Cost Model. Material pricing based on Chinese manufacturer prices. "Other" denotes a combination of the electrolyte, separator and casing component costs.

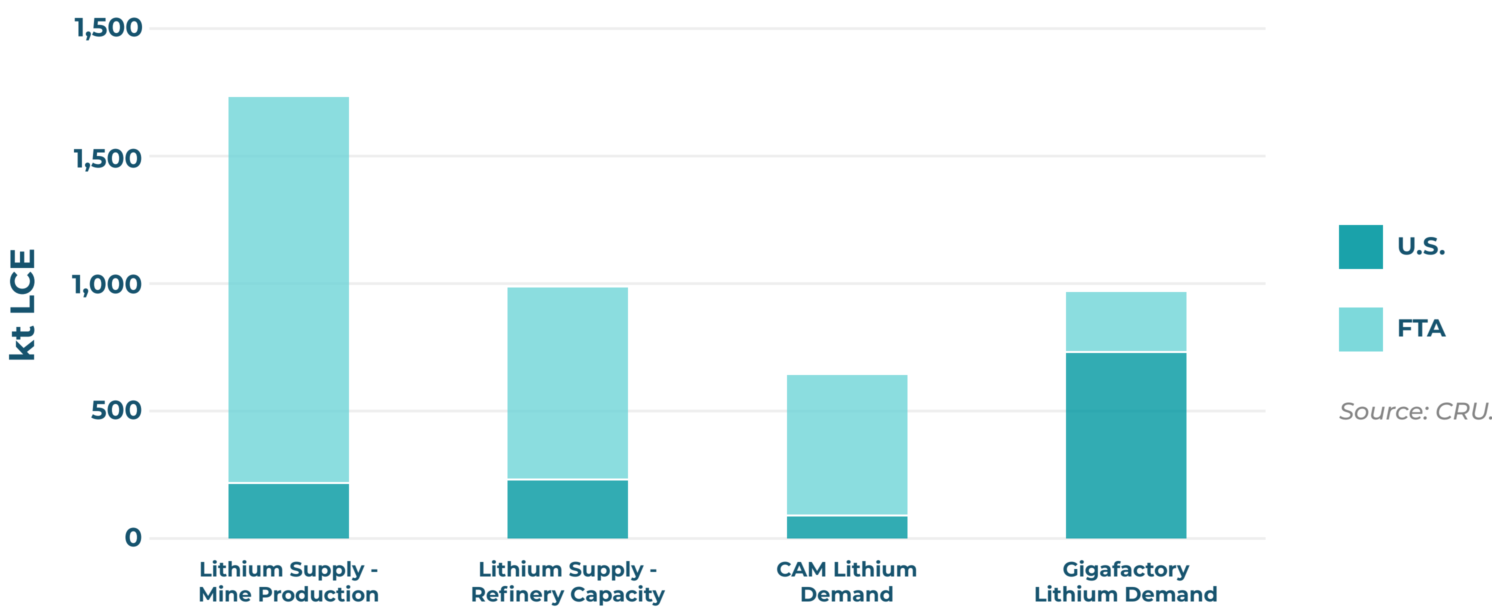
Access to Raw and Processed Materials

Raw Materials

Key materials used to produce lithium-ion batteries include lithium, phosphorous, and graphite. These materials are processed into cathode active materials and anode active materials which are then used to manufacture battery cells.

According to CRU, domestic and FTA sources of lithium bearing ore or brine and phosphorous should be developed enough by 2030 to supply domestic batteries needs. Most of these raw materials will be found outside of the US, and domestic manufacturers must compete with foreign battery manufacturers. For instance, a significant portion of lithium from FTA countries is destined for the Chinese market.

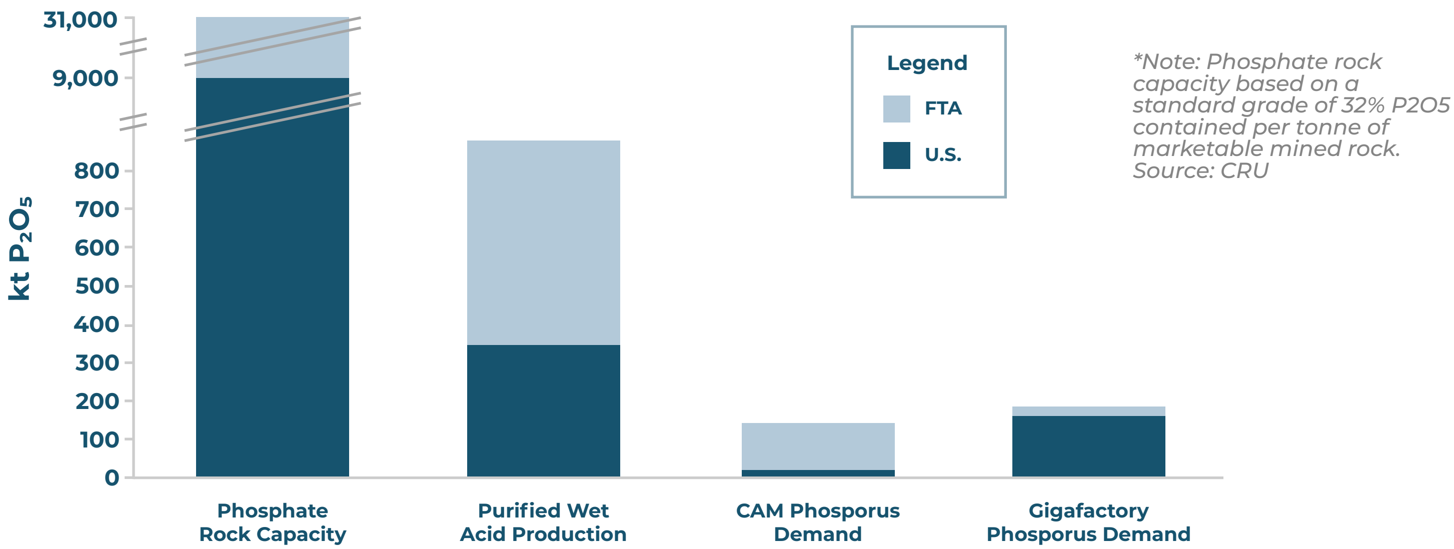
Figure 5: Lithium Supply Chain Balance in U.S. and FTA, 2030



Source: CRU.

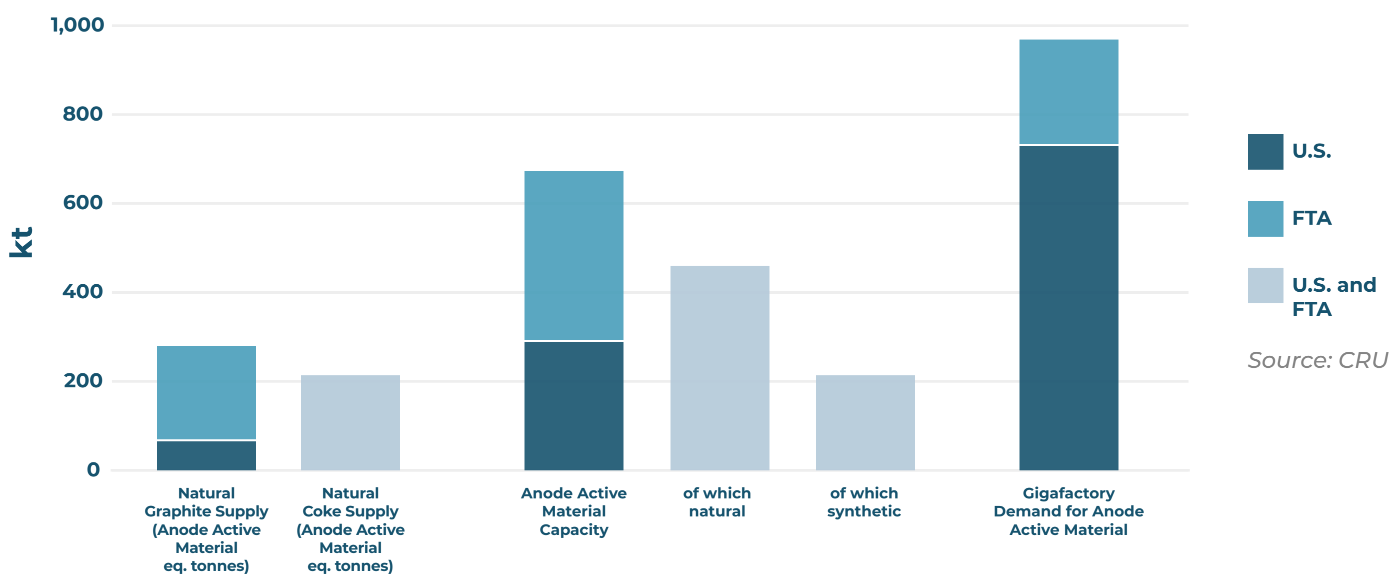
Phosphorus from the US and FTA countries is available in sufficient quantities to meet domestic manufacturers' needs, but over 70% of the world's reserves are found in Morocco. US manufacturers will not only compete with foreign battery manufacturers, but other industries as well. One competing industry is agriculture where phosphorous is a critical component for fertilizers.

Figure 6: Phosphorus Raw Material Balance in U.S. and FTA, 2030



Graphite supply is one potential chokepoint for the U.S. battery industry. Over the last five years, more than 60% of natural graphite mining has occurred in China. While there are no current natural graphite production sites in the U.S., Canadian and Australian sources could supply a large portion of the current demand for the U.S. if the various projects under development were to come on stream. However, these sources of natural graphite will not be sufficient to meet 2030 U.S. demand. As a result, the U.S. will likely need to explore sources for synthetic carbon products, foreign sources for natural graphite, and importing anodes.

Figure 7: Graphite Raw Material Balance in U.S. and FTA, 2030



Processed Materials

Demand for cathode active materials and anode active materials could exceed supply from U.S. and FTA countries starting in 2025. Without significant new investments in midstream capacity, the U.S. will need to turn to non-FTA countries to fulfill this need.

Timelines for New Capacity Additions

There are practical timelines for siting, permitting, constructing and commissioning new factories that influence how quickly domestic manufacturing can scale.

Companies new to the manufacturing space or those looking to establish new manufacturing processes will likely require longer development times for vetting equipment suppliers, engineering factories and demonstrating their ability to perform. These new entrants will also require time to commission, calibrate and refine their new manufacturing processes. As discussed above, new entrants can have yield rates as low as 50% versus 98% for experienced manufacturers.

Additionally, given its current reliance on imports for nearly all elements of the energy storage supply chain, U.S. facilities will initially have longer lead times versus facilities in other countries where supply chains are more established. And the build times will also affect a manufacturer's ability to tap into the IRA's production incentives because the requirements grow more stringent each year.

Workforce Development

Successful energy storage manufacturing industry depends on a well-trained workforce. For example, yields for new battery cell plants can start at 50% and increase as manufacturers imẢ prove their processes. It will be critical for manufacturers to train workers to understand and execute these process improvements.

Manufacturing not only brings opportunities for permanent and high wage jobs, but also the ability to help offset job losses in traditional energy and manufacturing communities and bring opportunities to historically underserved and marginalized communities. And many jobs do not require college degrees.

To meet this need, the industry must work as hard to recruit, train, and retain its workforce as it does on building new factories. Roles critical to energy storage supply chains include machine operators, production technicians, and mining, chemical, and electrical engineers.

In the short term, commissioning new factories and training U.S. workers will require collaboration with foreign-based experts to help the U.S. create cutting-edge technologies. Longer term, growing the manufacturing workforce depends on collaboration between manufacturers, government agencies, education institutions (including secondary schools), and other stakeholders. Providing workers with the necessary technical skills may require a combination of classroom and on-the-job training. Apprenticeships may also offer a useful pathway for training the next generation of manufacturing workers.

Diversity, Equity, Inclusion, and Justice

Developing tomorrow's manufacturing workforce provides an opportunity to build a more inclusive and just energy economy. Utilizing existing tools, such as supplier diversity databases, can ensure that the solar and energy storage industry draws from a wide talent pool and engages all communities in the benefits of solar. The industry should develop and advance scholarship, curriculum and internship programs with Black-, Latino- and Indigenous-serving institutions and other organizations focused on DEIJ to create a diverse talent pipeline. Similar programs already exist within the solar installation segment, and must be expanded to include manufacturing.

The industry should also seek partnerships with unions and community groups to ensure equitable access to apprenticeships and other quality, skill-building programs. In addition, workforce development should address the gender imbalance in the solar industry. These efforts are particularly important for traditionally male dominated manufacturing and engineering roles. Environmental justice is another critical consideration. The industry must minimize negative externalities in communities where manufacturing facilities are located. Manufacturers must ensure local communities are engaged, and have a say in facility siting and development. Further, environmental responsibility should be incorporated in all aspects of the product lifecycle, from raw materials to end of life Sustainability goals should be measured annually through environmental, social and governance reporting. Advancing carbon reduction strategies, pursuing technological diversity and reducing the use of critical minerals in the solar supply chain are also important objectives.

Incorporating DEIJ principles into manufacturing benefits all stakeholders and helps garner support from external stakeholders. Acting now will help move the country towards a diverse and equitable solar and energy storage industry which lives up to its full potential.

State Economic Development

State economic development offices provide critical incentive packages, reducing upfront costs, expedite timelines. Engaging with State economic development offices also offers tie-in opportunities for other goals such as workforce development. The three main incentives categories are: (i) tax incentives; (ii) workforce development; and (iii) siting and permitting support. State-level industrial policy provides critical early-stage support for the supply chain buildout from mining and refining to factories and R&D activities. Partnering with economic development offices generates mutual benefits for all involved.

Image courtesy of Nexamp

Conclusion

Building a domestic energy storage base is imperative. The rise in demand and the transformative suite of federal investments in energy storage are already generating results.

However, additional investment is required across the supply chain. We must recognize that building out a U.S energy storage value chain will take time, strategic investments, partnerships with experienced manufacturers, and collaboration with allies. Congress and the Biden administration provided valuable policy tools to build a globally competitive U.S. energy storage industrial base, making thoughtful implementation of these policies a top priority.

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