



# Ohio Battery Supply Chain Opportunities

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## Executive Summary

As global automotive OEMs shift their investment away from internal combustion engine (ICE) vehicles, the entire global automotive supply chain is facing disruptive forces. Those jurisdictions who attract electric vehicle (EV) related investment, namely in lithium-ion battery manufacturing, are poised to lead as the automotive industry transforms itself in the upcoming decade.

Ohio is a premier automotive supply chain jurisdiction. Greater than 90% of the state's exports go to the ICE supply chain. Ohio faces a significant risk to its economic future unless investments are made to shift away from the ICE supply chain. As such, Ohio has a unique opportunity to lead in building a supply chain that capitalizes on the fast growth in electric vehicles.

Benchmark Mineral Intelligence (BMI), with support from the Natural Resources Defense Council (NRDC) and JobsOhio, prepared this report to equip the State of Ohio with the information and contacts needed to accomplish 3 major goals:

1. Reduce transportation sector emissions
2. Understand Ohio's key advantages when competing for investment
3. Understand the role of policy and governments in attracting investment

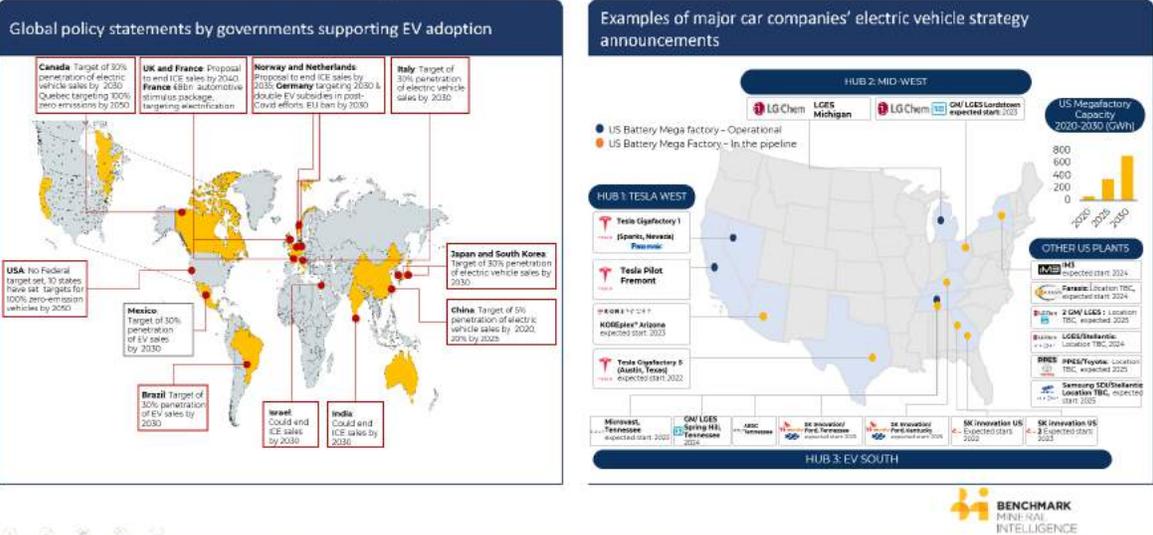
Ohio has again been identified as one of the most attractive states for new economic development projects. It should be no wonder as a result that the state is one of the most important jurisdictions for the US automotive supply chain. In the electric vehicle supply chain, building upon the state's success in attracting the GM-LG Chem Lordstown investment, **Benchmark's recommended next step to Ohio is to attract an investment in cathode active materials (CAM), one of the main components of a lithium-ion battery.** This investment would provide the largest jobs and taxable revenue opportunity for the state, and would lead to the establishment of the first lithium-ion battery supply chain hub in the USA.

This report overviews the global context and Ohio-specific conclusions for a robust EV battery supply chain strategy.

# Global Context

The automotive industry is shifting away from ICE vehicles and towards EVs due to customer preference, increasing standards globally, and a desire to reduce the transportation sector’s contribution to global greenhouse gas emissions (GHG) and air pollution. Governmental policy initiatives designed to attract local investment and job growth while pursuing climate-related goals are expediting this transition. While each jurisdiction varies in its approach and implementation of its policies, the implication is clear, **ICE vehicles are losing market share to demand for EVs.**

Policy statements and public opinion have seen major automakers commit over USD\$600B towards battery electric vehicles



**Figure 1. Examples of EV program announcements from governments and OEMs**

Drivers around the world are demanding the cleaner, quieter, more enjoyable driving experience offered by EVs. Following this evolving consumer demand and a growing desire to lower transportation sector emissions, automakers have committed more than \$600B in funding towards launching new electric vehicle models. This investment shift comes from both legacy automakers (ex. GM, VW, BMW, Ford etc.) and newer upstarts (ex. Rivian, Lucid, Proterra, Rimac etc.).

While ICE and EVs share many parts (ex. tires, steering wheels, paint etc.), they fundamentally differ in their **powertrain systems**. EVs and their electric drive train are powered by **lithium-ion batteries (LiB)**, which account for 25-

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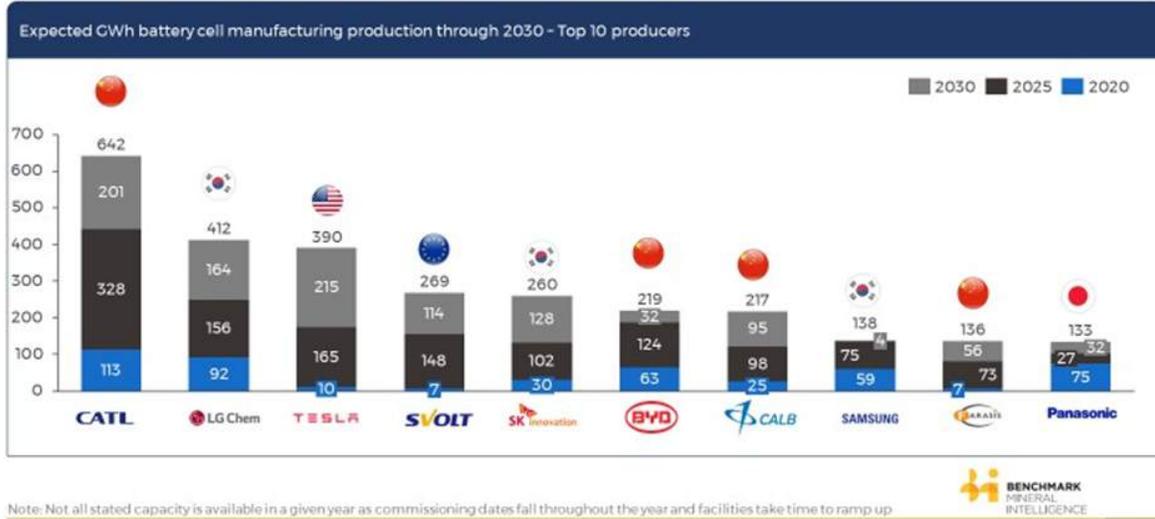
40% of the bill of materials (BOM) of an EV. LiB's importance to the EV revolution cannot be understated. The technology has seen decades of innovation and 30 years of commercialization success to date beginning initially with consumer electronics applications in the early 1990s.

**Over the last decade, LiB manufacturing costs declined nearly 90% and is expected to reach a low enough cost to facilitate EV's cost parity with ICE by 2023 for some passenger vehicle segments.** There is no other energy storage technology that could be used for automotive applications that has reached the level of penetration and maturity of the LiB, and **LiBs are expected to be the platform technology of choice for passenger and fleet EVs for at least the next decade if not more.**

In recognition of the growing demand from Auto OEMs for LiB, leading and new upstart battery manufacturers are ramping up capacity at a feverish pace. In early 2017, there were projected to be 17 LiB "gigafactories" (plants capable of producing greater than 1GWh yearly production). That number has grown to 261 plants in Q4 2021. The United States' share has increased from 3 in 2017 to having merely 18 battery megafactories in various stages of development today, most of which have been announced in the last 6 months. Of these 18, only 4 are active; one more than in 2017. As Benchmark Managing Director, Simon Moores stated in his June 2020 testimony to the US Senate, **"In more stark terms: China is building the equivalent of one battery megafactory a week, the USA one every four months."**

With bipartisan support from elected officials and leadership from organizations like JobsOhio, Ohio recognizes the scale of this opportunity and has successfully attracted the \$2.3B General Motors /LG Chem joint venture (Ultium Cells) to manufacture EV batteries in the state. By being one of the first states to successfully attract battery manufacturing to complement their already rich history in the automotive supply chain, Ohio now has the potential to become a major regional hub for battery manufacturing in the USA.

Today, lithium-ion manufacturers are ramping up >4.9TWh capacity from 261 battery "megafactories" by 2030

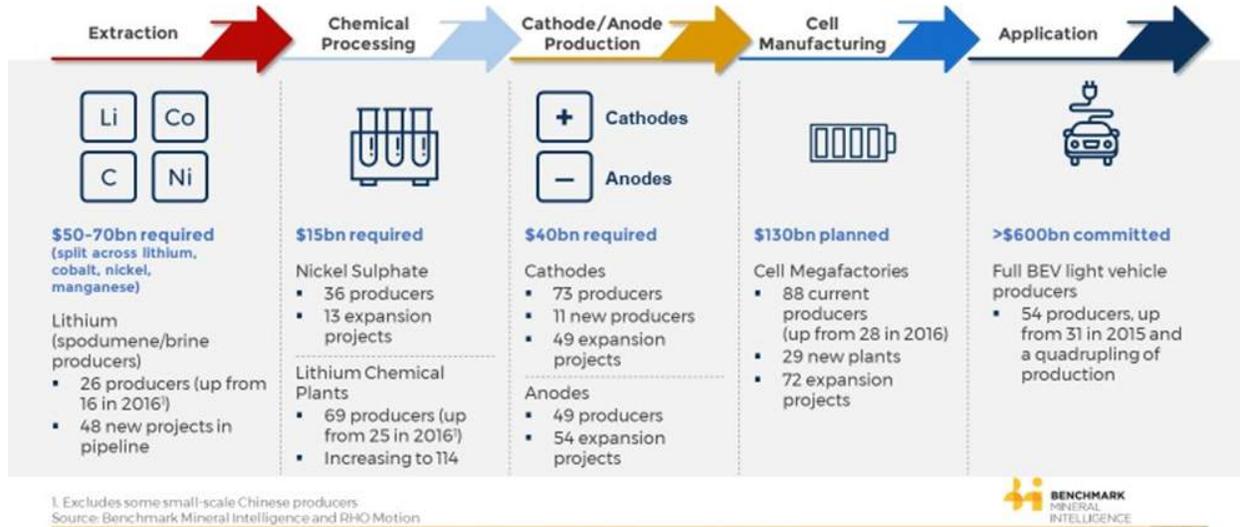


**Figure 2. Battery megafactory build-out projections based on announced capacity investments**

While this segment of the supply chain has attracted robust financing, there is a more complicated supply chain that underlies LiB manufacturing that will need to be built in parallel to avoid supply bottlenecks.

## EV supply chains are complicated and need billions in investment

Investment in clean tech can also include processing, components, R&D and new technologies



**Figure 3. Major steps of the LiB supply chain that lead to EVs (“application”)**

Each of these supply chain steps has its own set of incumbent producers who are attracting financing to keep up with the fast growth in the downstream industry. But today’s supply chain is spread sporadically across the world, leaving too many opportunities for bottlenecks or break points. The next evolutionary step in this supply chain buildout is to find opportunities not only to finance the growth of the upstream industry, but also to create “supply chain hubs” that co-locate as many of the processing and assembly steps as closely as possible within one geographic region. Building supply chain hubs will help to reduce manufacturing cost and risk for industry participants, but also creates significant pressure to attract this major job growth and tax revenue opportunity to the United States before it locates elsewhere.

## Market growth is allowing regional hubs to be developed and more and more individual assets are required

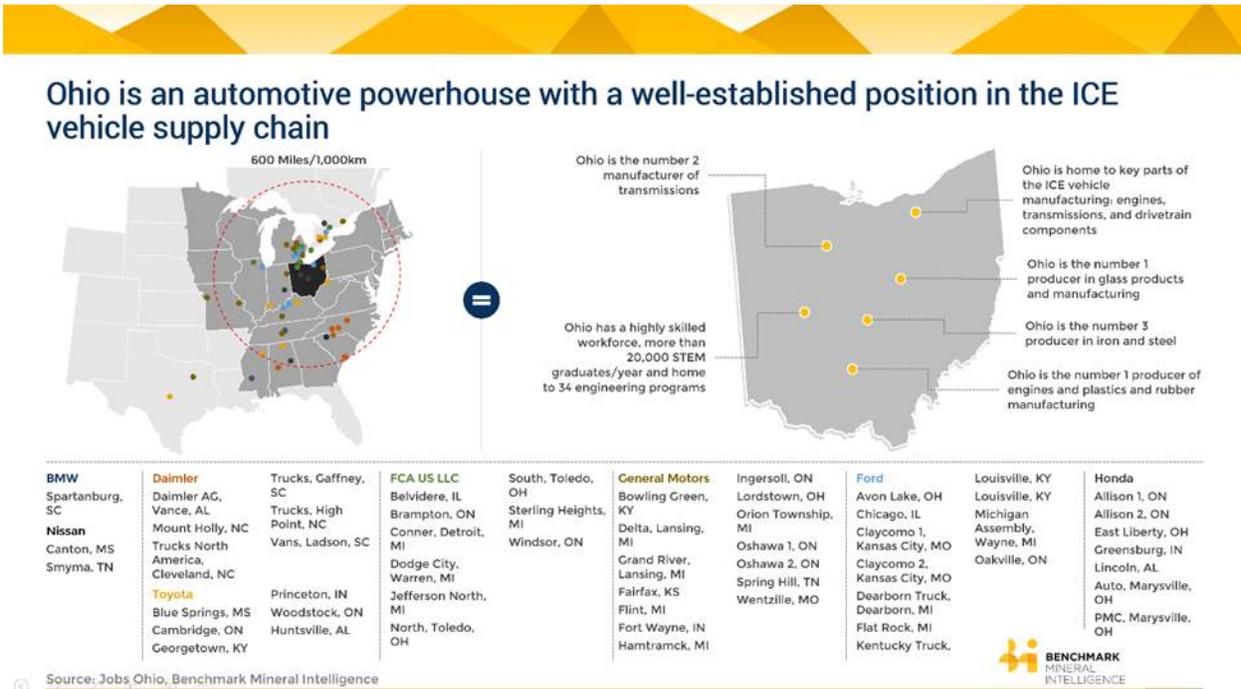
Huge pressure to build out European and North American Supply Chain to reduce costs and create jobs. Many governments and commercial banks are directing funding to this sector while reducing hydrocarbon investments.



**Figure 4. Illustrative example of supply chain hub formation to reduce logistics steps and concentrate value-creation within specific geographic regions**

# Ohio's Battery Supply Chain Opportunity

Ohio has a number of key advantages specific to the EV manufacturing supply chain when compared to other US States. First, Ohio is an automotive powerhouse with a well-established position in the ICE supply chain. 90% of Ohio's exports are related directly or indirectly to the automotive industry, and multiple leading global Auto OEMs have operations in Ohio, resulting in the 2<sup>nd</sup> largest Auto workforce in the USA. Ohio is also ranked as a top state for solar development in the Midwest over the next 5 years. Ohio currently has more than 8,400MW of utility scale solar projects either operating, approved for construction, or pending before the Ohio Power Siting Board for approval. **The growing solar presence in the state can serve as a key investment attraction asset as the automotive industry seeks to decarbonize its supply chain through local renewable energy purchases.**



**Figure 5. OEM operations located in Ohio and located within 600 miles of Ohio**

One of the lead dominoes for **Ohio's advantageous position in attracting a battery supply chain hub** however is the **GM-LG Chem Lordstown** investment (Ultium Cells) that will bring 30 GWh of EV-grade LiB production to the state. Other than Tesla's upcoming Austin factory, this is the only factory complex thus far in the USA where LiB and EVs will be produced in tandem at the same location, a key advantage for Ohio.

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As Ohio now seeks to build out its battery supply chain, there are multiple goals and criteria the state should prioritize to position itself for continued growth. These include:

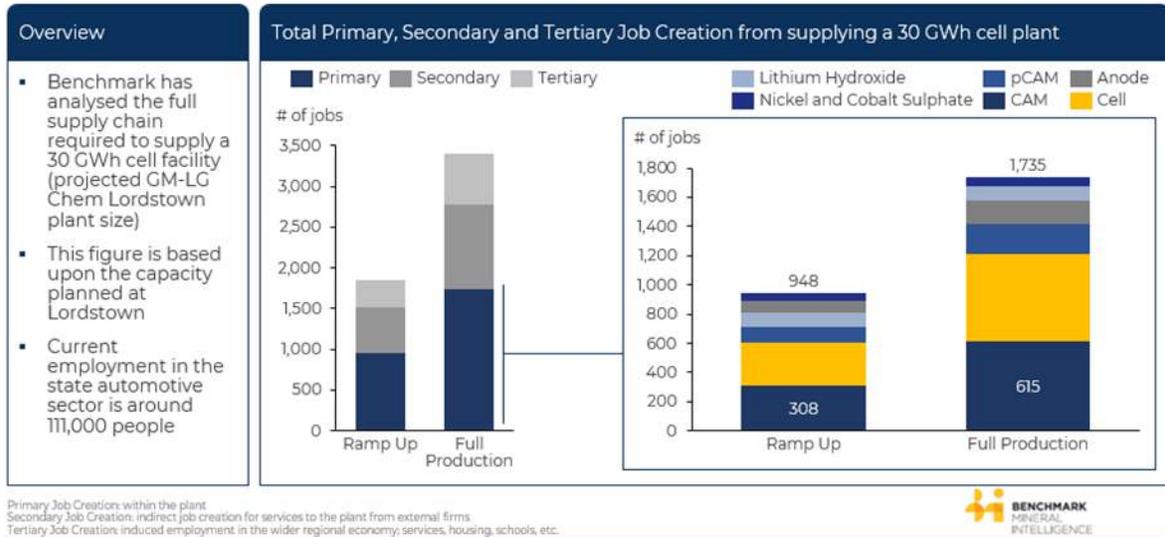
- Long-term tax revenue potential
- Job creation across multiple labor classes
- GHG emission reduction potential
- Network effects for future investment attraction
- Economic value multipliers

**Based on these goals and criteria, Benchmark recommends that the next battery supply chain investment area that Ohio should target is cathode active materials (CAM)**, the chemicals used to make one of the two electrodes (cathode and anode) within the battery cell. The movement of lithium between the two electrodes and chemical reactions within the batteries is what generates electricity externally. There is currently no large-scale CAM manufacturing production in the United States.

To attract this investment, Ohio can leverage the GM-LG Chem relationship and growing Ohio solar industry as companies in this supply chain place premium value on access to renewable energy as an effective means for lowering their cost and carbon footprint. Successfully attracting investments in CAM manufacturing will additionally realize multiple benefits tying into Ohio economic development goals, including:

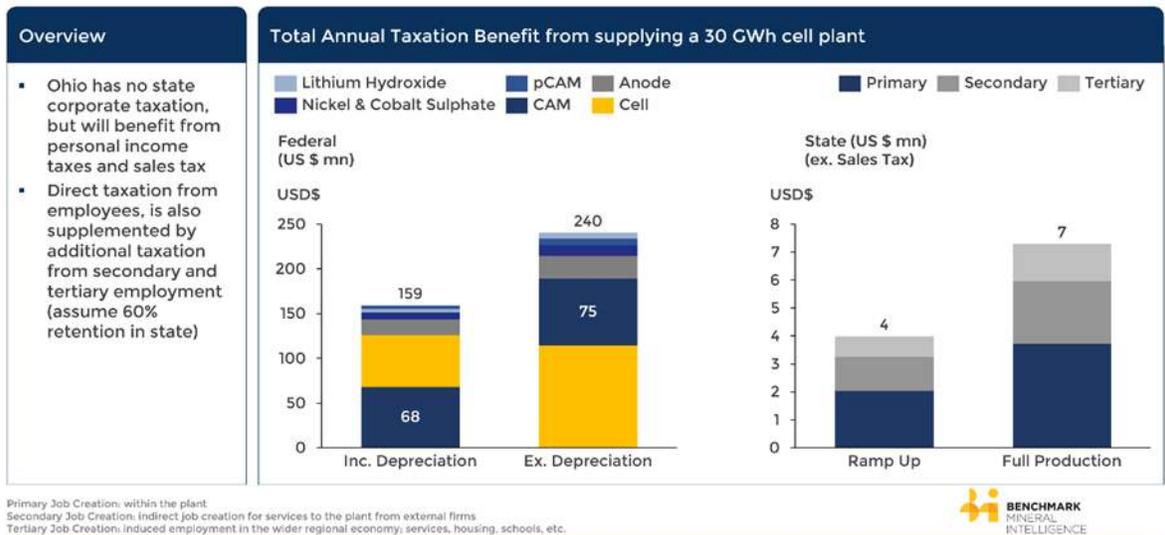
- **Long-term tax revenue potential** - Strong long-term potential due to cathode active materials being a specialty chemicals industry with high margins and a high intellectual property barrier to entry
- **Job creation across multiple labor classes** - Process engineers, chemists, equipment operators, and administrative/management headcount will all need to be hired
- **GHG emission reduction potential** - Local EV manufacturing can help to increase EV adoption, lowering transportation sector emissions. This will also create demand for local renewable energy generation which will lower the carbon footprint for manufacturing

## CAM offers the best job creation opportunity in Ohio beyond cell manufacturing



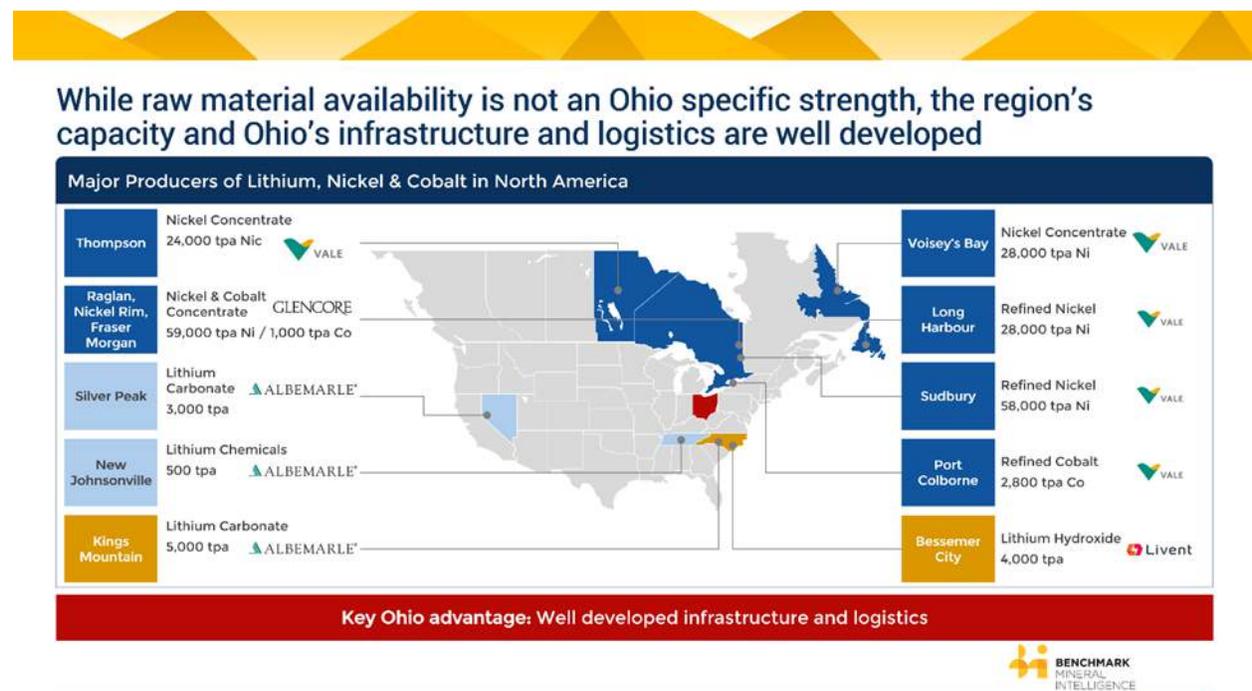
**Figure 6.** A CAM investment could be responsible for ~1/3 of all potential jobs that could be created from any upstream supply brought into Ohio

## CAM brings the highest direct and indirect tax revenues beyond cell investments



**Figure 7.** Beyond battery cell investments (ex. LG Chem Lordstown factory), CAM brings the highest direct and indirect tax revenues

Once a CAM investment is attracted to the state, Ohio will have created a positive feedback loop with the larger EV industry. Once successful, Ohio will become the prime US state for further upstream investments in specialty chemicals processing, which can be fed into CAM manufacturing facilities. The US already has robust lithium specialty chemicals industries in North Carolina and Nevada. Canada is also eyeing the development of nickel and cobalt industries due to the region's strong mined materials production. However, while raw material availability is not an Ohio specific strength, the region's capacity and Ohio's infrastructure and logistics are well developed. **Ohio has a key advantage in being centrally located as this allows the state to import and process the specialty chemicals used for CAM manufacturing.**

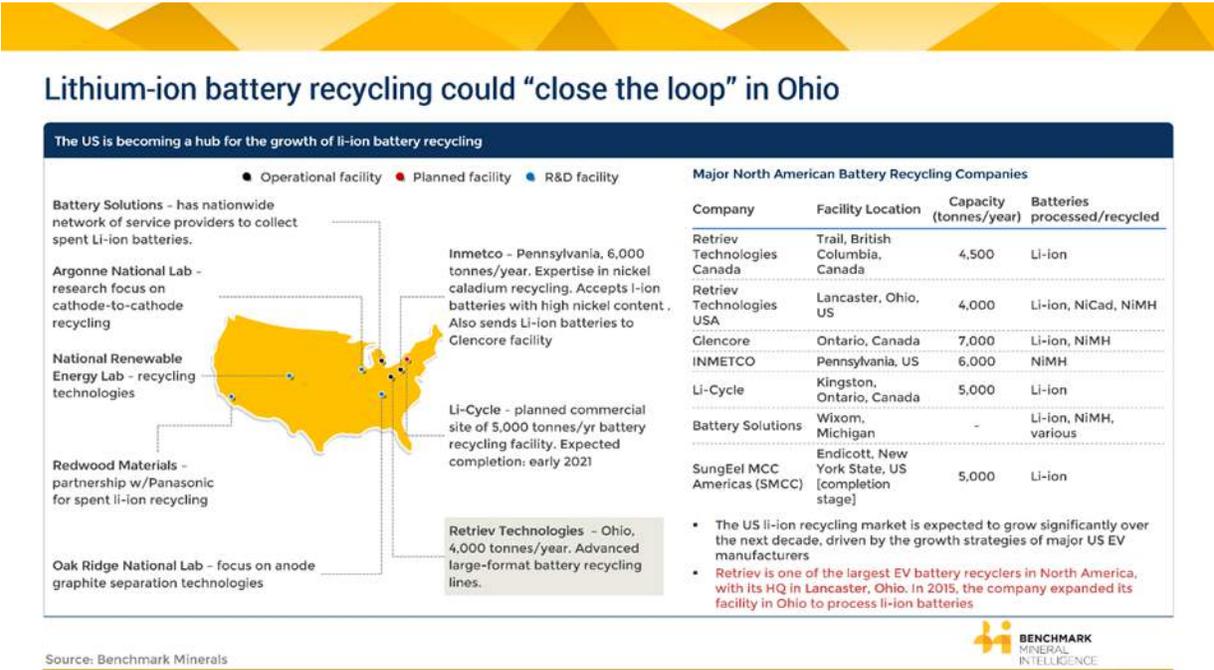


**Figure 8.** Ohio is centrally located with well-developed infrastructure and logistics

Lack of raw material availability however does not preclude Ohio’s ability to close the full loop on the supply chain by attracting battery recyclers to invest in state-based capacity. Battery recycling functions as an “urban mine” – instead of traditional mining practices that are environmentally harmful and face steep costs, recycling spent batteries could provide a source of the chemical feedstocks needed for new battery manufacturing. Several companies have recently announced investments in battery recycling research and development and capacity-building, including one in Ohio (Retriev Technologies).

However, recycling investment currently faces serious headwinds that could be solved through directive policy efforts:

- Ensuring that LiBs have a plan for end-of-life must occur at the moment of the battery’s commissioning, and not at the point of its retirement when it could be easy to dispose in a traditional landfill
- Standardized policies aimed at increasing battery collection rates across all states would be beneficial. Auto OEMs will struggle to collect and reuse spent batteries if each state has its own policy around collection procedures



**Figure 9.** Examples of recycling companies throughout the USA

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## OEM Environmental Considerations

Auto OEMs have been public about shifting their energy consumption towards renewable energy. But they are not simply demanding more, **they are increasingly wanting renewable energy sooner and closer to their operations.** The pace of Auto OEM announcements on this topic has accelerated following the general trend of corporate net-zero announcements since the 2017 Paris Agreement. This interest in renewable energy is driven by a desire to decrease energy costs and lower the carbon footprint of vehicle manufacturing. Although the lifetime carbon cost of driving an EV is lower than ICE, Auto OEMs desire a carbon free EV at the point of sale. To reach this goal:

1. OEMs require renewables penetration growth to occur as close to their operations as possible
2. OEMs will require that their suppliers tap into renewable energy supply to reduce carbon emissions embedded in their supply chains

With the 7<sup>th</sup> largest US solar labor force and a rapidly growing penetration of solar energy, Ohio is already on the right track to help Auto OEMs realize both of these goals. Promoting Ohio's renewable energy presence in parallel to battery supply chain investment attraction efforts will lead to **network effects for future investment attraction.** CAM manufacturers will see Ohio as an investible state as they will have access to critical renewable energy supply. This supply will allow them to push down their operating cost, and will fulfill their obligations to Auto OEMs' requests for decreasing dependence on traditional fuel sources.

# Investment Attraction

Ohio has several key advantages to spur upstream EV supply chain investment



**Figure 10.** Ohio has several key advantages to spur upstream EV supply chain investment

Ohio has a well-defined playbook for investment attraction that could be used to attract this CAM investment. The key step is to pair that playbook with demand-side policies and incentives that address the needs of investors in the battery supply chain as they evaluate their next jurisdiction for investment.

Demand-side policies to incentivize more EV uptake have been deployed with great success in the two largest EV markets in the world: China and the European Union. These countries saw an opportunity to pair increasing EV sales with more domestic EV manufacturing, and as such have implemented supply chain growth incentive packages as well. While some could argue whether supply and demand side incentives are a “chicken or egg” problem, the fact remains: the United States is behind in implementing these types of policies when compared to these other geographies, and has a critical need to implement incentives for both supply and demand of EVs. Ohio has an opportunity to play the leading role out of all US states:

- By investing in charging infrastructure and other EV incentive programs, Ohio can signal its friendliness to this growing industry
- These policies will lead to more EVs being driven in Ohio, thus reducing transportation sector emissions while serving as an effective investment attraction tool
- Then, as investments are secured and Ohio manufactures more EV pieces and parts in-state, a positive feedback loop will lead to yet more EVs on Ohio roads
- The cycle continues to repeat



**Major Consideration:** Demand side policies have a domino effect on domestic supply chain growth

	Global EV market	Government Policy				Manufacturing Market Share	
		Demand-side Incentives	Demand-side Requirements	Supply-side Incentives	Supply-side Protections	Chemical Processing (%)	Cell Manufacturing
China	43%	Strong. Phase out plan discarded post-COVID.	Strong	Strong and continuing	Strong and continuing	Nickel 68 Cobalt 70 Graphite 100 Lithium 56	75%
Europe Union	25%	Strong and expanding.	Strong	Strong and expanding	Still being formulated	Nickel 13 Cobalt 18 Graphite 0 Lithium 0	7%
United States	20%	Initially strong but phasing out.	Strong and expanding	\$6 billion in loan & grants to advance processing	10-year plan to develop a domestic LIB supply chain	Nickel 2 Cobalt 0 Graphite 0 Lithium 1	8%

**Key Ohio advantage:** Can quickly take a leadership position among US states for implementing both upstream and downstream policies

Source: Benchmark Mineral Intelligence; Rho Motion; Benchmark Forecasts



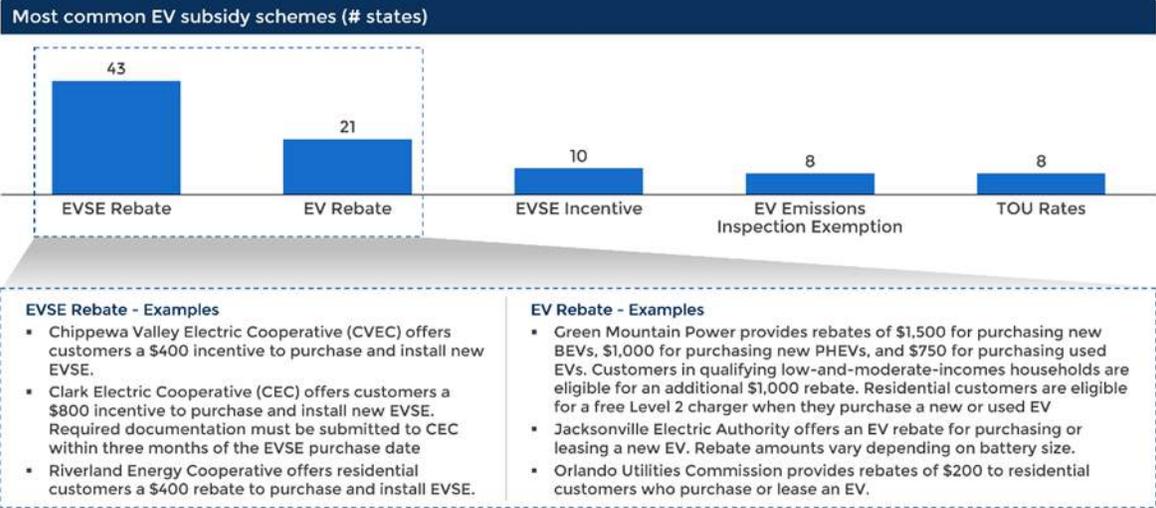
**Figure 11. Demand side policies have a domino effect on domestic supply chain growth**

Implementing demand-side policies will not immediately attract the supply chain to invest, but does signal to the broader market that **Ohio intends to position itself as an EV-friendly state**. Both demand-side and supply-side incentives and protections correlate closely with global supply chain manufacturing market share as shown in Figure 11. Some examples of demand-side incentives that have been implemented frequently across multiple US states are shown in Figure 12.

While it will be critical for Ohio to take proactive steps on its own, the tailwind of expected federal-level stimulus and other programs targeting the growth of this supply chain could benefit the state as well. President Biden’s administration has been vocal about its goals regarding transportation electrification, and it is expected that multiple actions will quickly be taken:

- Setting targets for number of charging stations to be constructed throughout the nation
- National security-related subsidies for the build-up of a domestic supply chain
- Department of Energy loan program guarantees to allow supply chain investors to access a lower cost of capital to finance their operations

**For EV subsidies, certain tax schemes are more prevalent than others**

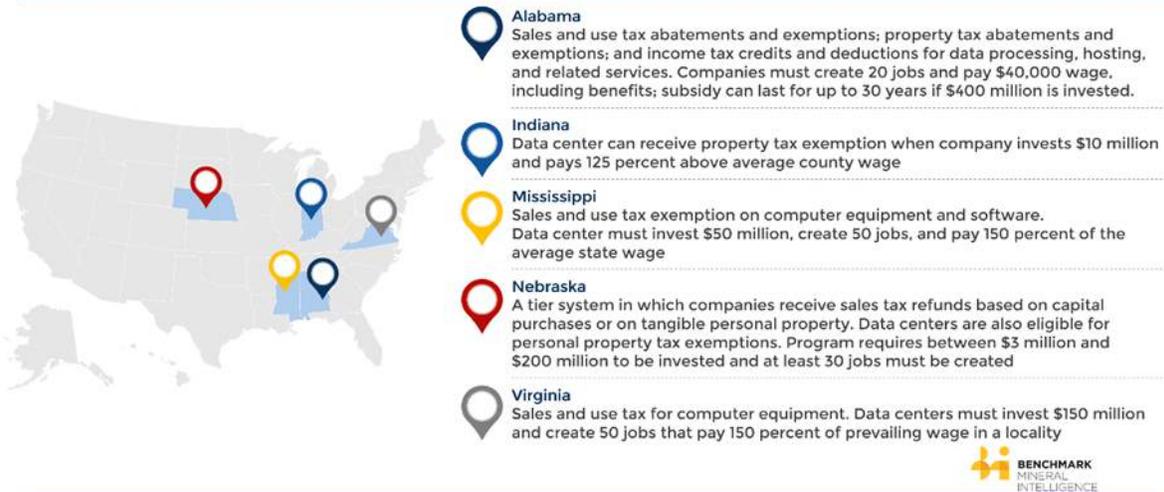


**Figure 12.** Types of commonly-used EV subsidy schemes

Due to efforts from regulated electric utilities and state public utility commissions, EV charging infrastructure investments and incentives are just beginning to take shape nationwide. Ohio already has taken the right steps in this direction. For example, American Electric Power (AEP) Ohio offers commercial customers incentives for installing Level 2 and DC fast-charging stations at workplaces and multi-unit housing. While EV charging incentives are just now being rolled out at large scale across the country, data center subsidies could provide an example of a desired end state. Data centers are also a form of infrastructure to power the nation’s informatics infrastructure, and as explored in Figure 13, their subsidies offer a strong comparable because they tend to emphasize job and wage growth as well.

## Data center subsidies generally more targeted towards job/wage growth, could be replicated to promote EV charging infrastructure deployment

### Examples of data center subsidies that encourage job growth



**Figure 13.** Types of commonly-used data center subsidy schemes that could be replicated for EV charging infrastructure

## Stakeholder Feedback

Throughout this research project, Benchmark's team interviewed industry leaders to gain insight on key motivators when making their investment decisions. Based on this industry feedback, categories of incentives preferred by the EV and battery supply chain include:

### Power infrastructure, availability, and cost

- Large power capacity (>100 MW) will be required to serve new load and electricity costs will have a large effect on overall operating costs. Investors will be interested in strategies for decreasing these costs and securing fixed, long-term electricity prices
- Investors would also welcome assistance in increasing the proportion of their energy consumption that is derived from renewable energy projects to help meet emissions reductions goals while achieving lower average power costs
  - Explain renewable energy purchase strategies
  - Provide access to renewable energy providers
  - Consider incentives to install more solar energy capacity
  - Assist in the renewable energy development process to ensure low-cost and available supply

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- Auto OEMs in particular prefer an increasing percentage of their energy supply to come from renewable energy sources. Ohio's growing solar industry can be promoted as an attractive asset as explained in the Environmental Considerations section

### **Labor**

- Investors will need assistance in identifying the skilled labor needed to run their operations. Working closely with organized labor to generate worker-friendly programs is critical
- Skills development and workforce training programs will be needed as well. Ohio can leverage its existing universities, apprenticeships and other worker training programs to meet this need

### **Logistics**

- Potential investors will need direct interstate access to OEM customers, including the freedom to use existing rail lines to move goods to/from east coast ports. Ohio is well-positioned to provide this as explained previously
- Related to this, Ohio's proximity to airports with international routes to Asia are viewed as an advantage as well

### **Land Suitability**

- Companies in the EV and battery materials supply chain would prefer access to and assistance with accelerated environmental permitting, subsidized land pricing, and financial assistance with infrastructure build up at/near a selected land site

### **Financing**

- Financing support is another topic raised frequently by potential investors. Cash incentives are preferred to help reduce CAPEX burdens. Tax holidays and deferrals are also of interest

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## Ohio's Key Advantages

In summary, Ohio has a number of key advantages that can be emphasized in the investment attraction process. The most important key advantages that Ohio should emphasize in accordance with Benchmark's internal analysis and stakeholder outreach are as follows:

1. The \$2.3B investment in the GM/LG Chem joint venture (Ultium Cells)
2. Extensive history in the US automotive supply chain industries
3. Proximity to resources, manufacturers, and end markets
4. Proven logistics and infrastructure
5. Increasing solar energy penetration
6. Highly-skilled workforce
7. Strong government-led mandate on new economy jobs growth

There are a few areas where Ohio can aim to improve its attractiveness to potential investors in the rapidly growing EV and battery materials supply chains. This includes strategies for better promoting its growing solar energy economy and taking care to signal its friendliness to the growing electric vehicle industry through demand and supply-side policy implementation and other regulatory structures.

If Ohio can successfully highlight these key advantages, the state can position itself as a positive feedback loop for significant growth in the EV supply chain and protect its automotive heritage. By targeting CAM manufacturers as an immediate next step to build off the Ultium Cells facility in Lordstown, Ohio can become the undisputed leader in the domestic EV supply chain industry.

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**About Benchmark Mineral Intelligence:**

Benchmark Mineral Intelligence (Benchmark) is the world's leading IOSCO-regulated price reporting agency (PRA), proprietary data provider, and market intelligence publisher for the lithium ion battery to electric vehicle (EV) supply chain. Our granular and expert focus on the entire supply chain makes us unique: from lithium and cobalt mining through to the manufacturing of cathode and anode functional materials, to battery cell and EV production. At Benchmark, we set the lithium industry's reference and benchmark pricing. Our series of price assessment and data methodologies allow us to collect our proprietary data from the source, creating data that is relied upon by the industry to make multi-billion dollar investment decisions that accelerates the energy storage revolution. Benchmark's tireless and methodical data collection coupled with in-house expert analysis makes us entirely unique in the 21<sup>st</sup> century publishing space and the world's most trusted service. As a result, our services are relied upon by major actors in the EV supply chain, we have testified to the US Senate multiple times, advised The White House, The Pentagon, and government agencies around the world. Visit us at [www.benchmarkminerals.com](http://www.benchmarkminerals.com).

**About NRDC:**

The Natural Resources Defense Council is an international environmental organization with more than 3 million members and online activists. Since 1970, our lawyers, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC has offices in New York City, Washington, D.C., Los Angeles, San Francisco, Chicago, Montana, and Beijing. Visit us at [www.nrdc.org](http://www.nrdc.org).

**About JobsOhio:**

JobsOhio is a 501(c)(4) private nonprofit corporation designed to drive job creation and new capital investment in Ohio through business attraction, retention and expansion efforts. JobsOhio works with six regional partners across Ohio: Ohio Southeast, One Columbus, Dayton Development Coalition, REDI Cincinnati, Regional Growth Partnership and Team NEO. Learn more at [www.JobsOhio.com](http://www.JobsOhio.com). Follow us on LinkedIn, Twitter and Facebook.

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