Partners Universal International Research Journal (PUIRJ)
Volume: 03 Issue: 01 | January – March 2024 | ISSN: 2583-5602 | www.puirj.com

Strategic Battery Autarky: Reducing Foreign Dependence in the Electric Vehicle Supply Chain

Dr.A.Shaji George

Independent Researcher, Chennai, Tamil Nadu, India.

Abstract – Over the past decade, China has emerged as a prominent player in worldwide electric vehicle battery supply chains by means of assertive financial commitments, astute acquisition of strategic mineral resources, manufacturing facilities, and technological expertise. Presently, China possesses more than fifty percent of the world's capacity to manufacture battery cells and high-nickel cathodes, which are indispensable for long-range electric vehicle batteries. Its market share for critical battery raw materials, such as lithium, cobalt, and graphite, is even more substantial, owing to its ownership of state-owned enterprises and acquisitions overseas. This degree of authority over numerous critical supply chain components grants Chinese battery behemoths such as CATL and BYD considerable sway over the pricing and availability of critical battery components. The reliance of nations on a solitary country for a critical emergent technology presents potential threats to the energy security and national security of countries aiming to convert their vehicle fleets to electric propulsion. On the contrary, countries that establish themselves as leaders in sophisticated battery technologies will gain significant economic benefits as the worldwide adoption of electric vehicles quickens. Therefore, reducing reliance on batteries manufactured in China becomes a critical strategic objective. Conversely, China's current preeminence has been methodically established throughout the previous decade, leaving limited alternatives in the immediate future. In all likelihood, the successful reconstruction of domestic battery supply chains by other nations will require five to ten years to complete. Enhanced subsidies or tax exemptions in conjunction with increased investments in domestic battery raw material refining or advanced cell/cathode manufacturing facilities are policy alternatives that can be utilized to reduce reliance on imports. Governments have the ability to ensure alternative foreign sources of critical inputs such as lithium or cobalt by establishing trade and investment partnerships with nations abundant in resources. Additionally, nations should make full use of trade remedies permitted by WTO regulations in order to combat unfair competition posed by Chinese firms that receive substantial state subsidies. In contrast, the abolition of dependence must be done so without inciting an unwarranted surge in economic nationalism. Extremely stringent regulations pertaining to battery components and materials run the risk of drastically impeding global decarbonization efforts. Over the course of the next decade, competition between China and other major economies to control the battery supply chains that are essential for the widespread adoption of electric vehicles is likely to intensify. Countries must implement policies that are proactive and consistent in order to mitigate their susceptibility to potential disruptions in supplies or fluctuations in prices. Inaction could result in China gaining permanent control over this vital emerging sector, which would have severe geopolitical and economic ramifications. Alternative options are limited, necessitating an immediate strategic effort to reestablish domestic or amicable foreign battery supply capacity.

Keywords: Batteries, Electric vehicles, Supply chains, Manufacturing, China, Dominance, Dependence, Alternatives, Policies, Competition.

1. INTRODUCTION

1.1 Importance of Batteries for Electric Vehicle Growth and Energy Security

Electric vehicles (EVs) are widely regarded as crucial for reducing emissions from the transportation sector, which accounts for nearly 30% of global energy-related carbon dioxide output. As countries around the world set ambitious decarbonization targets and consider banning sales of new internal combustion engine vehicles, policy support for EVs is accelerating rapidly. However, realizing a widespread transition to electric mobility hinges critically on continued innovation and cost reductions for lithium-ion batteries. Battery packs remain the most expensive component of EVs, accounting for over 30% of total vehicle costs on average. Bringing 200+ mile range EVs to cost parity with conventional vehicles requires cutting lithium-ion battery costs from an estimated $157/kWh today to under $100/kWh in the next few years.

Fortunately, lithium-ion battery prices have already declined nearly 90% over the past decade thanks to economies of scale and sustained manufacturing innovations. However, the raw materials, cell fabrication facilities and precision engineering required for advanced batteries also introduce vulnerabilities. In particular, the unprecedented growth expected for this still nascent industry raises serious energy security concerns about reliance on foreign supply chains dominated today by Chinese state-backed firms. China already controls an estimated 60% of global lithium-ion battery production capacity and over 70% of battery-quality lithium hydroxide supply chains. Left unchecked, China could monopolize access to a technology critical for catalyzing EV adoption across major automotive markets in North America, Europe and Asia.

While lithium reserves are geographically widespread, known deposits are highly concentrated. Chile, Australia and Argentina hold nearly 75% of the world's 9.2 million metric tons of identified resources. However, China dominates midstream chemical processing to convert raw lithium into battery-grade lithium hydroxide and carbonate. China also holds a commanding lead in advanced cell fabrication and essential component manufacturing like cathodes, anodes and separators. This control across multiple industry chokepoints means Chinese battery giants wield outsized influence on costs and availability for governments seeking secure future EV supply chains.

China's dominance is largely a product of Beijing's strategic efforts and subsidies over the past ten years aggregating intellectual property, mines and engineering expertise while exponentially expanding manufacturing capacity. With economies of scale driving down costs, Chinese battery makers like CATL and BYD have systematically squeezed out competitors to capture booming global EV markets. However, this level of supply chain centralization carries significant economic and national security risks. Realizing mass EV adoption without being beholden to a geopolitical rival will require alternative production centers in North America, Europe, Japan/Korea and India.

Governments aiming to secure future energy supplies have powerful incentives to invest in domestic battery manufacturing and raw material refining. However, rebuilding supply chains to reduce import reliance will take 5-10 years minimum. Policymakers thus face pressing decisions on how to manage China's existing centrality without sacrificing near-term carbon reduction goals dependent on accelerating EV sales. Any durable strategy must balance economic competitiveness, energy security and environmental sustainability. But despite the complex tradeoffs involved, establishing some measure of battery self-sufficiency is becoming an urgent priority for nations betting heavily on an electric mobility future.

1.2 China's Current Dominance of Global EV Battery Supply Chains

Over the past decade, China has systematically gained control over critical links in the global electric vehicle (EV) battery supply chain. Leveraging state-directed investment and integrating technical knowledge acquired from foreign partners, Chinese companies now dominate lithium processing, battery cell manufacturing, cathode and anode production - key steps in delivering finished batteries to automakers. This rapid ascent has relied heavily on government subsidies, below-market financing and consolidation of technical expertise within a few national champions like CATL and BYD.

As a result, China has captured over 70% of growing lithium-ion battery production capacity, establishing an outsized lead in what promises to be a trillion-dollar industry by 2030. Already, global capacity for lithium-ion battery manufacturing has leapt from just 33 GWh in 2015 to over 500 GWh today. Benchmark Mineral Intelligence forecasts capacity could reach up to 5,800 GWh by the end of this decade given automakers' EV expansion plans. Capturing this exponential growth has been a priority for Beijing, with battery manufacturing capacity in China expanding 130% in 2020 alone.

China recognized earlier than other nations the critical importance batteries would play in catalyzing EV adoption and dominating next-generation automotive propulsion technology. This first-mover policy focus has yielded major dividends. Just four Chinese companies - CATL, BYD, CALB and Eve Energy - account for over 50% of installed battery production capacity worldwide as of 2022. Europe and the United States by comparison have less than 10% each of global capacity. U.S. capacity is set to expand to over 200 GWh by 2030, but will still lag behind Chinese giants like CATL and BYD which are on pace to control over 2,000 GWh of capacity by that date.

Beijing's battery push is even more dominant on the raw materials and chemical refinement side. Chinese firms control an estimated 90% of the critical lithium iron phosphate (LFP) cathode market today. On lithium in particular - the basic feedstock for all lithium-ion chemistries - China holds sway over most global supply chains. Though South America and Australia together still produce over 75% of world lithium output, Chinese companies have strategically invested to control the midstream chemical processing converting raw lithium to battery-ready lithium carbonate or hydroxide. By 2025, over 60% of global lithium chemical supply is forecast to occur in China.

This level of control has raised supply disruption concerns as the world accelerates efforts to electrify road transport. Continued innovation to improve range, charging speed and cost depends on reliable access to specialized battery materials now concentrated in China. Beijing also wields significant leverage over battery prices critical to spurring mass EV adoption. Reducing risks of supply shocks or price manipulation will require other nations expedite efforts to rebuild domestic capacity across battery value chains. But displacing China anytime soon looks unlikely given the enormous capital outlays and technical hurdles still facing competitors in Europe, North America, Japan/Korea and India. Global EV supply chains look set to remain intensely China-centric for much of this decade.

2. CHINA'S SYSTEMATIC ACQUISITION OF MARKET POWER

2.1 Control of Raw Materials (Lithium Mining)

China does not yet control a majority share of lithium mining and extraction globally. However, Chinese companies have been engaged in a systematic effort over the past decade to dominate critical midstream links connecting lithium producers with battery manufacturers. By integrating chemical processing capacity and acquiring foreign lithium reserves, China now influences pricing and availability for over 60% of global lithium supply chains.

This outsized control stems from directed investment into chemical facilities converting lithium concentrates into purified lithium hydroxide or carbonate. These chemicals provide the high-purity feedstocks battery and cathode makers require. Until recently, most lithium production was geared toward lower-value applications like glass or aluminum manufacturing which could tolerate lower purity. But surging electric vehicle demand requires increasingly specialized lithium grades upwards of 99.5% purity levels. Building this complex and costly chemical processing capacity at scale has been a key enabler cementing China's battery supply chain advantages. Today, China holds over 800,000 metric tons per year of chemical capacity - including state-of-the-art conversion facilities tailored for battery applications. Chinese companies are on track to control over 1 million metric tons of capacity by 2025 based on projects currently underway. This dwarfs projected capacity for the next largest player, the United States, expected to reach just 85,000 metric tons by mid-decade.

Backing leading firms like Ganfeng and Tianqi, Beijing designated lithium an essential national resource as early as 2011-2012. Generous grants and subsidized credit fueled rapid capacity expansion to process not just domestic lithium, but growing imports from mineral-rich countries like Chile, Argentina and Australia. By 2020, over 90% of lithium imports entering China went straight to chemical processing facilities. Some analysts estimate Chinese lithium refining capacity could meet or even outpace global lithium resource production by 2025. These massive capacity investments have cemented key partnerships locking up substantial lithium reserves before they ever reach open markets. Chile's SQM - the second largest lithium producer globally - now sells nearly 60% of output directly to China on a long-term contracted basis rather than trading openly. China's Tianqi holds a 51% stake controlling Australia's Talison mine, one of the richest known lithium reserves still being actively tapped. Chinese firms also hold rights to develop major lithium brine complexes in Argentina's lithium triangle alongside domestic producers like Orocobre.

This integrated control spanning investments at mine sites to intermediate chemical facilities underpins efforts by Chinese battery champions to control product flows all the way through final cell fabrication. By 2025, Benchmark Mineral Intelligence forecasts only 4% of Chinese battery supply will rely on imported precursors, down from 24% today and nearly 100% just five years ago. Competitors lack integrated capacity of this scale, forcing continued reliance on supply chains centered within China for the foreseeable future. Reversing this dependency will require equally ambitious capital investment from other nations to unlock alternative lithium reserves and localized refining.

2.2 Massive Subsidies to Domestic Manufacturers

As part of a broader industrial strategy to dominate clean energy technology manufacturing, China has systematically subsidized and supported the rapid expansion of its domestic lithium-ion battery sector. Generous grants, low-interest loans and provincial government supports have catalyzed economies of scale for Chinese battery champions while allowing them to price goods below international competitors. The resulting market consolidation has established Chinese firms as the predominant global supplier across electric vehicle and stationary storage supply chains.

Detailed quantification of Chinese subsidies granted on a company-level basis remains scarce given limited transparency. However estimates suggest sizable government financial support has been crucial for fueling rapid capacity growth. Contemporary Amperex Technology Ltd. (CATL), now the world's largest battery maker, received an estimated $2.5 billion in low-interest loans and credit facilities from Chinese state banks alongside $1.4 billion in direct subsidies and tax breaks from the Ningde government since its founding. Provincial governments compete aggressively to attract promising high-tech manufacturers like battery makers, offering acres of cheap land, grants for factories and research centers along with preferential utility

rates and tax holidays. These incentives have allowed CATL and peers to radically accelerate production scale, driving costs down through manufacturing innovations and increased buying power over suppliers. In under a decade, CATL captured 34% of the global EV battery market share while scaling capacity from 0 to over 130 gigawatt-hours (GWh). CATL is now on pace to produce up to 630 GWh annually by 2025. For context, LG, Samsung, Panasonic and SK Innovation – CATL's next largest competitors – produce around 25-35 GWh per year each. This rapid growth trajectory far outstrips foreign firms, undercutting emerging rivals before substantive competition can develop.

Total subsidies supporting battery manufacturing more broadly are estimated between $5-20 billion based on China's announced government investment funds and additional provincial supports. Benchmark Mineral Intelligence estimates this has mobilized over $140 billion in commercial capital flows into China's battery supply chain over the past decade – a level of investment that outpaces the U.S. and E.U. combined. These funds actively target established Chinese EV battery leaders as well as emerging startups working on next-generation technologies like lithium metal anodes or ceramic separators. The result is an innovation ecosystem geared toward cementing China's first-mover advantages into enduring dominance across the full lithium-ion battery value chain.

While key details remain opaque, the strategic priority Beijing places on battery leadership is unambiguous. Subsidies and domestic supports are explicitly tied to export and production quotas designed to capture maximum market share abroad while reserving cutting-edge capacities for Chinese automakers. Some estimates suggest 80% of Chinese battery production is already destined for overseas end-users today. Absent countervailing policies, this mix of below-market capital and captive domestic demand creates enormous barriers for late-entering battery producers in Europe, North America or Asia to meaningfully compete.

2.3 Export Restrictions on Battery Components

Seeking to consolidate domestic control and influence global battery supply chains, China has selectively imposed export restrictions and quotas on materials and components critical to lithium-ion battery production. By limiting foreign access to processed battery metals, advanced cathodes and related technologies nurtured with extensive state support, these measures are accelerating China's dominance of the electric vehicle value chain. China's export restrictions encompass minerals like lithium and cobalt where domestic refining capacity now meets or exceeds domestic demand. China is the world's largest refiner of lithium, cobalt and other key battery metals, giving authorities significant discretion over allocation and end-users. In 2020, China imposed a 20% export duty on cobalt metal, a key ingredient for longevity-enhancing cathodes. Quotas and heightened customs inspections have further limited legal outflows. As the majority of global cobalt refining capacity now resides within China, these squeeze intermediate supply available to non-Chinese battery and cathode makers.

Similar export restrictions target rare earth mineral products since 2015, including sought-after magnet materials found in electric vehicle motors. The state-affiliated China Nonferrous Metals Industry Association provides approved export quotas to select companies. But quotas have fallen short of foreign demand, driving up international prices. The U.S. is just 6% dependent on imported rare earths from China today thanks to these policies catalyzing new mines and processing abroad. Lithium export restrictions are so far limited to waste products and scrap not battery-grade metals. But surging domestic lithium chemical capacity could enable controls on refined products in future. Chinese cathode firms are already shifting focus from exporting finished cathodes to just the processed component metals and chemicals foreign rivals require to produce

their own. Reducing access to these critical intermediate inputs allows China's integrated battery supply chain an enormous competitive advantage to dominate battery manufacturing and the EV sector. Advanced lithium-ion battery components and manufacturing equipment face particular scrutiny and restrictions given their national security sensitivities. Items listed as "dual use technologies" with military applications by Chinese authorities require special export licenses. Firms can face penalties for unauthorized exports or even theft of IP. As China's battery champions advance the frontier of lithium-ion, solid-state and future battery technologies, keeping sensitive techniques onshore bolsters their leadership.

Foreign companies also face local content requirements mandating battery materials, parts and manufacturing equipment support Chinese economic development before finished cells or packs can be sold into China's enormous auto market. Such policies pressure technology transfer to Chinese partners in exchange for market access. Once involuntary IP transfers are complete, Chinese national champions then leverage aggressive state financing and subsidies to overtake former partners in global competition. While facially non-discriminatory against foreign firms, China's export controls have a disproportionate impact enabling domestic battery dominance. By reserving domestic supply for favored national champions, they constrain international efforts to establish alternative supply chains and battery production centers abroad to challenge Chinese firms' economies of scale and cost advantages. With over 70% of global lithium-ion manufacturing capacity already in China, these export barriers help further concentrate production there for the foreseeable future.

3. POLICY OPTIONS FOR OTHER NATIONS

3.1 Invest in Domestic Battery Production and Manufacturing

With China dominating over 70% of global lithium-ion battery production capacity currently, establishing new regional production centers is a strategic priority for nations seeking to secure electric vehicle supply chains. While challenging China's scale advantages will take sustained investment over a decade or more, governments have powerful incentives to nurture domestic battery manufacturing.

Direct investment into cell production plants, cathode and anode factories, and lithium refinement infrastructure can help align domestic economic priorities with climate goals. Each gigawatt-hour of additional battery capacity supports thousands of technical jobs in high-value manufacturing. Workforce development programs at vocational schools and universities can funnel talent into emerging electrochemical engineering fields underpinning this growing sector. And anchoring integrated production locally avoids exporting the embedded value of refined battery materials, components and finished packs abroad.

In the United States, the Inflation Reduction Act passed in 2022 authorizes over $60 billion in advanced manufacturing tax credits for domestic producers across EV supply chains. Firms receiving support must meet minimum local content thresholds over time - for example 60% domestic value for battery components by 2026 rising to 100% by 2028. This aims to catalyze American production of key mineral inputs, chemical precursors, cathode/anode materials and cell fabrication. Several U.S. projects are underway to scale domestic lithium-ion manufacturing to over 30 gigawatt-hours annually by 2025. Factories under development by LG, Panasonic and Chinese firm Gotion would more than quadruple current American cell fabrication capacity. Expansions across cathode, anode and lithium hydroxide production are targeting similar 4-5 fold increases. While still lagging China's existing capacity, these investments can establish an alternative battery ecosystem nurturing further innovation.

In Europe, the European Battery Alliance provides government funding matched to private capital to build continental capacity across EV and energy storage supply chains. Supported "gigafactories" should scale the region's lithium-ion manufacturing from less than 15GWh presently to over 260GWh by 2025. German firm BASF for example will invest €400 million aided by €175 million in public funds to build out cathode material refining feeding regional cell production hubs.

India has similarly committed over $3 billion in production-linked incentives aimed at facilitating fully domestic end-to-end battery manufacturing at scale. By subsidizing capacity buildout of precursor materials, electrodes, cells and battery packs, India can nurture firms capable of capturing a larger share of the country's own rapidly electrifying automotive and grid storage markets. States like Gujarat with access to ports and renewable energy inputs highlight the local strengths India can leverage to develop globally competitive production and export hubs over time. While initial capital outlays to build domestic battery supply chains are substantial, the long-term economic and national security benefits warrant public co-investment to crowd in private funds. Establishing localized production buffers against potential supply disruptions or price spikes also aids countries' green electrification objectives. With supportive policies, advanced battery manufacturing can drive high-quality job creation while enabling sustainable transportation and grid decarbonization critical to combating climate change.

3.2 Secure Alternative Sources of Key Battery Inputs (E.g. Argentina Lithium)

Given China's dominance of intermediate supply chains converting raw lithium into refined battery-grade materials, securing alternative sources of this critical battery input is a growing strategic priority for major auto manufacturing economies. Countries recognize the risks of relying on a single geopolitical rival for the immense lithium volumes that will be required for global electric vehicle adoption rates to continue climbing.

Fortunately, lithium is geologically widespread with economically viable deposits distributed across several trading allies in the Americas. Chile holds over 20% of identified global lithium resources with substantial proven and inferred reserves still untapped. Argentina ranks second with over 17% of known reserves concentrated in lithium-rich salt flats in the northwest provinces of Jujuy, Salta and Catamarca. Australia, another key U.S. ally, accounts for 12% globally.

Direct government investment and public-private partnerships can help accelerate responsible build-out of lithium mining and processing in these alternative supply regions. The U.S. Department of Energy recently announced $2.8 billion in infrastructure funding targeting increased domestic lithium refining capacity and new regional partnerships by 2030. Additional policy tools like investment tax credits, purchasing guarantees or discounted battery storage can incentivize expedited mine development timelines to bring new volumes to market.

For example, Argentina's government has set explicit goals to capture 5% of the global lithium market share by 2025 from the current 2% today. This will require rapidly scaling extraction and processing to supply over 230,000 tonnes per year into the forecasted 2030 lithium market. Encouraging such expansion aligns with U.S. and European interests to nurture alternative supply chains and introduces healthy competition that moderates prices. Automakers and governments are actively building partnerships and co-investing to develop Argentine lithium in exchange for supply agreements.

Increased recycling of lithium-ion batteries once they reach end-of-life can further enhance domestic supplies of recycled metals to supplement mining. Installing safe, efficient battery collection infrastructure allows reclaiming vital elements like cobalt or nickel for low-impact reuse rather than sending to landfills. The

U.S. has set goals to recover over 90% of lithium-ion batteries by 2030. Responsible metals reclamation can satisfy up to 25% of total lithium demand in a mature market.

While geology limits how quickly new lithium production can ramp up compared to chemical processing investments, dedicated policies to expand allied supply chains help reduce Chinese dependence. Any single new lithium reserve outside China displaces further potential concentration of pricing influence or political leverage within Chinese borders. Integrating alternative resources through joint ventures or dedicated purchase agreements creates enduring partnerships around responsible battery materials production.

Such international collaboration will be essential to balance battery supply chain resilience and sustainability with keeping pace with soaring lithium demand trajectories. Global success electrifying transport for climate goals depends on new lithium volumes entering supply at unprecedented rates for another decade at least. Aligning national security priorities with decarbonization incentives by investing to diversify lithium's geographic sources serves both objectives.

3.3 Utilize Trade Remedies to Counter Unfair Competition

With evidence mounting that substantial Chinese government subsidies are catalyzing domestic firms to undercut international rivals, trading partners are increasingly deploying trade policy tools to counteract unfair price competition. Remedies like anti-dumping duties or countervailing tariffs authorized under WTO statutes offer policy options to offset injuries to competing industries from Chinese battery makers' below-market pricing.

In the United States, a recent Department of Commerce investigation formally found that Chinese lithium-ion power banks received countervailable subsidies of at least 5-10% on top of normal value-added tax rebates. These advantages allowed imported power banks as much as 88% below prevailing market prices in America. In response, the U.S. levied customs duties from 177-220% on leading Chinese manufacturers to offset the illegal subsidies identified by Commerce's inquiry. These penalties eliminated the injury to domestic producers by increasing costs to fair market prices. The European Union also launched its first anti-dumping investigation in April 2022 on imported Chinese lithium nickel cobalt manganese oxide (NMC) cathodes. Evidence indicates these critical EV battery components arriving from China undercut average E.U. producer prices by up to 53%. If unfair trading practices are established, Europe could impose remedial duties to avoid undercutting their own industrial strategy investments aimed at scaling domestic cathode materials production and broader battery manufacturing leadership.

India as well has repeatedly used trade remedies over the past half-decade to discourage dumped Chinese lithium-ion cells or modules from capturing market share as India nurtures its own nascent domestic producers. Most recently in April 2022, authorities hiked tariffs to 40% on Chinese module and cell imports valued over $85 per unit. Cheaper imports face duties of 21%. Without such actions, advanced Chinese lithium batteries could monopolize the Indian market given relatively uncompetitive domestic alternatives today. While China officially challenged U.S. methodologies justifying leveling punitive anti-dumping measures, WTO statutes permit governments to pursue their own investigations and take appropriate countervailing actions under domestic laws. However, remedies imposed should not unduly restrict international trade flows or technological diffusion still needed for global decarbonization goals.

Nations considering new trade policies should thus carefully assess that any litigated duties narrowly target established injuries from Chinese firms' unfair subsidies and pricing distortions. Broad import restrictions not elaborating evidence of harm risk hampering climate progress for political ends. But where consistent

evidence upholds allegations, enforcing penalties equivalent to the dumping margin can productively negate artificial competitive advantages from Chinese state largesse. All governments should continue pursuing constructive dialogue around reforming battery trade policies through bilateral consultations or multilateral negotiations. The ideal outcome implements disciplines and transparency measures validating that government supports spur technological innovation without permanently distorting international competition. Establishing standards around fair trade in critical climate technologies like lithium-ion batteries can help balance economic and decarbonization priorities.

4. MANAGING THE GEOPOLITICS OF BATTERIES

4.1 Responding to China's Protests Against Supply Chain Diversification

As major auto-producing nations implement policies aimed at localizing more electric vehicle battery production and reducing Chinese import dependence, Beijing unsurprisingly objects to supply chain shifts threatening its dominant position. China has filed formal complaints arguing diversification mandates unfairly discriminate against its firms. While recognizing China's protests, governments should reinforce that updating trade policies is essential to balance economic competitiveness with energy security.

Specifically, China appealed to the World Trade Organization challenging battery localization measures in US clean vehicle subsidies passed under the Inflation Reduction Act (IRA). Chinese authorities assert the IRA's bonus incentives for automakers using domestically manufactured batteries discriminate against foreign producers. However the actual IRA text applies uniformly to all firms regardless of nationality, requiring 50% domestic content across supply chains to receive full Federal tax credits. This threshold gradually rises to 100% North American content required by 2029, allowing time for multinational firms to adjust production patterns.

European Union officials have heard similar dissatisfaction from Beijing regarding the European Commission's Battery Regulation legislation currently under debate. This proposal mandates consent and sustainability criteria for importing battery cells or minerals into the EU market. Though facially neutral regarding country of origin, the standards risk disadvantaging lower-cost Chinese suppliers if EU verification processes excessively burden imports with red tape. In responding to China's objections, policymakers can reference longstanding WTO statutes permitting domestic content rules so long as they do not arbitrarily discriminate against foreign commercial interests. Global trade law has recognized that governments retain authority to set certain limitations around access to domestic subsidies or public procurement contracts provided the same transparent standards apply to all vendors regardless of nationality.

That said, the current scale and pace of China's battery industry expansion make requirements prioritizing local production inherently likely to currently favor non-Chinese firms in practice. Governments should thus take care not to implement deliberately obstructionist policies under false pretenses of security or sustainability that needlessly stoke economic nationalism. Overly restrictive battery rules risk hampering climate progress by kneecapping affordable EV adoption simply to undermine China's industry leadership position. Acknowledging Beijing's protests, trading partners can reaffirm their openness to fairly-traded battery imports through lower tariffs in exchange for reciprocal market access for value-added materials and precursors. Discussions establishing transparency around subsidies and investment incentives may identify acceptable boundaries for government supports not considered material distortions. Upholding free trade where possible remains in all nations' combined interest to accelerate the affordable battery innovation required for ubiquitous e-mobility. But with batteries so central to 21st century economic competitiveness and resilience, ensuring reliable access supersedes preserving any single country's privileged market status.

Governments have an obligation to secure sustainable supply chains, even when this requires difficult structural shifts.

4.2 Mitigating National Security Risks From Battery Dependence

With China controlling over 70% of global capacity to manufacture lithium-ion batteries currently, establishing alternative regional supply chains takes on new urgency as a national security imperative for nations aggressively transitioning vehicle fleets to electric propulsion. Lacking domestic fallback options in a crisis risks crippling auto industries and mobility systems given batteries' centrality to next-generation transport infrastructure. The urgency reflects batteries' profound dual-use potential both empowering sustainable mobility systems and in weapons applications from drones to precision-guided munitions. Volatility around Chinese relations with rival states like the U.S. and India makes military planners particularly wary of ceding control over capacity or raw materials essential for key defense systems. Losing access would necessitate painful, costly efforts to replace inventory dependent on high-performance lithium chemistry batteries.

Mitigating risks requires policy supporting redundant localized capacity across multiple links in battery supply chains. Governments should facilitate stand-alone domestic mineral refinement, component manufacturing and final cell production scaling to significant volumes - even at higher initial costs before economies of scale fully mature. Establishing strategic reserves of rare metals or essential chemicals adds resilience against potential supply cuts. Stockpiling critical defense-related finished cells produced nationally also provides immediate contingency capacity for military contractors if imports are disrupted. The U.S. National Defense Stockpile already began procuring high-nickel cathodes from domestic firms in 2022 after previously lacking any reserves. Expanding future purchases to fully assembled battery packs tailored for key weapons systems is advisable. Still, complete self-sufficiency in all raw materials required for lithium batteries remains unrealistic near-term for most countries given China's enormous existing capacity advantages. An alternative hedge would secure bilateral supply agreements with trusted mineral exporters like Australia or Chile to diversify import partners external to China. Aligning commercial incentives around shared interests in stable clean energy trade can produce mutually beneficial battery partnerships among friendly nations.

Overall the scale of battery technologies required for broad transportation electrification itself necessitates global supply chains. Seeking meaningful market share or cost parity inherently depends partly on accessing worldwide materials and innovations. Progress reducing risks stemming from China's dominance should therefore focus on diluting its current monopoly power by cultivating manufacturing capacity among major democratic economic allies with shared interests. With sound policies accelerating alternative production hubs across Asia, Europe and North America, no one state retains sole control over the full value chain essential for modern battery-powered mobility and defense systems. Distributed regional capacity across jurisdictions with strong rule-of-law safeguards delivers natural resilience. And encouraging trade based on transparency, reciprocity and competition - not extraction or coercion - ultimately fuels faster collective innovation benefiting all nations working to electrify key infrastructure in the face of shared climate challenges.

4.3 Avoiding Intensive Battery Nationalism or Protectionism

As nations push to re-shore more electric vehicle battery production capacity currently concentrated in China, policymakers must take care to avoid counterproductive measures that unwarrantly restrain international trade and innovation flows. While securing domestic energy resilience justifies some strategic

decoupling, any detachment from global battery supply chains must be carefully scoped or risk hampering climate progress. Achieving ubiquitous electric mobility likely requires terawatt-hours of annual battery production - scale only feasible through globally distributed manufacturing hubs. Erecting restrictive barriers around materials, components or knowledge flows risks handicapping the cost declines and technological leaps essential to displace internal combustion vehicle dominance in time to meet mid-century net zero targets. Yet governments focused on economic security vulnerabilities also cannot ignore the risks manifest from relying predominantly on Chinese battery supply chains. Beijing already demonstrated willingness to coercively suspend rare earth mineral exports over narrow political disputes. Entrusting the transition from oil-dependent transport to Chinese state-backed firms warrants prudent safeguards.

Reconciling these tensions requires policies expertly targeting specific pressure points to ease rather than exacerbate overall market concentration, while still expanding production outside China. Governments in the U.S., Europe, Japan and India should collaborate where possible to multiply non-Chinese capacity across respective strengths while harmonizing standards. For example, the U.S. excels in lithium extraction and refining innovation as well as advanced R&D around next-generation solid-state electrolytes. Europe hosts world-class cathode materials chemistry and precision engineering for prototyping novel battery cell architectures. India's information technology services and light manufacturing offer complementary advantages to scale up recycling infrastructure allowing reclaiming battery materials. Synergistic investments play to each region's relative capabilities while keeping global supply appropriately diversified across borders. But integration should avoid forcing dependence on any one external power, mitigating outside coercion risks while preventing closed-off customs unions. Mandating exclusionary bilateral trade pacts often backfires long-run by freezing out alternative suppliers and technologies. Reciprocal special access risks cronyism, not merit-based competition to drive down costs.

Well-calibrated interventions like targeted R&D funding, tax incentives around specific value chain gaps, and public co-investment helps attract substantial private capital flows into priority areas without picking narrow winners or choking off import availability. Setting performance standards, sustainability criteria and responsible sourcing requirements levels the playing field for all manufacturers rather than penalties targeting individual countries. Ultimately the enormous global scale-up in lithium battery capacity needed for decarbonization itself necessitates interdependent trade with diverse partners, precluding excessive protectionism. But active collaboration on pre-competitive technologies and coordinated policies to displace entrenched monopolies also offers a positive path to emerge from unhealthy dependency without provoking counterproductive economic nationalism.

5. CONCLUSION

5.1 Phasing Out Battery Dependence Will Take Over a Decade

With China dominating over 70% of global electric vehicle battery manufacturing capacity today, reducing over-reliance on Chinese champions like CATL and BYD will be a gradual years-long process for other nations. Achieving meaningful supply chain localization or reshoring of high-value activities requires sustained investment and policy support before realizing substantial market share shifts away from Chinese firms over the next decade. Constructing even a single new major battery factory from scratch can take 3-5 years accounting for planning, financing, procuring specialized equipment and staffing technical teams. Most economic projects anticipating positive returns on investment would target operating lives in excess of a decade, implying 2035 is the practical earliest horizon where alternative regional cell production hubs could decisively displace China's first-mover advantages.

Supply chains for critical battery components and materials face similar timelines reaching viability at scale outside China. Expanding cathode production, anode factories, lithium refining complexes or nickel and cobalt streams to feed gigafactories all run multiple years from initial permitting through facilities construction and process optimization. While select greenfield projects might come online faster with unprecedented capital allocations, a healthy competitive non-Chinese battery industry realistically remains over five years away.In the interim, global electric vehicle sales growth and sustainability targets depend significantly on access to affordably priced Chinese battery imports avoiding severe shortages. A faster pace of fleet electrification globally over the next half-decade offers greater cumulative gains reducing transportation emissions than delaying purchases indefinitely waiting on U.S., European or Indian manufacturing capacity to attempt playing catch up.

Bridging policies should thus focus on securing long-term contracts guaranteeing supply access from Chinese vendors at reasonable prices while avoiding a stillborn zero-sum race to reshore every link domestically. Until alternative regional refining and production centers outside China mature, importing finished cells or packs often remains the prudent near-term option to balance climate imperatives with economic security.Early government investments into research, workforce pipelines and some pilot commercial facilities can lay the groundwork for scaled battery manufacturing leadership later this decade. But aggressively mandating purchases only from fledgling domestic producers risks higher costs and inadequate volumes hampering mass EV adoption.

Once functioning local supply ecosystems demonstrate global cost and quality competitiveness, transitioning transportation manufacturers onto domestic or friendly foreign battery sources follows more organically without jeopardizing decarbonization timetables. Patience coupled with proactive financing of next-generation innovations safeguards energy security long-run while avoiding disruptive industrial policies just to swiftly eradicate China's current market dominance. Any realistic strategy to phase out Chinese battery dependencies requires credible milestones across at least 10 years. Shorter time horizons risk serious climate consequences from kneecapping EV availability, while resisting engagement with China jeopardizes hoped-for supply chain shifts in the first place. Sustained investments partnered with targeted trade policies can deliver resilient alternatives, but strategic patience remains essential.

5.2 Early Policy Action Essential to Reduce Long-Term Strategic Vulnerability

While immediately extricating from China's supply dominance across electric vehicle battery value chains proves infeasible, governments worldwide must still undertake deliberate early efforts to cultivate domestic manufacturing capacity, fund next-generation R&D, and align international partnerships. Sustained investments now, though unlikely to impact today's short-term cost or availability realities, remain essential to remedy intensifying long-run economic and national security risks from over-reliance on Chinese battery imports. Without proactive policies implemented before mid-decade locking in alternative supply projects, global automakers and national militaries will likely confront deepening vulnerabilities through 2030 as transport electrification accelerates. Failure to leverage still-open windows for action threatens a future beholden to Chinese industrial dominance for lack of viable scalable alternatives once foreign dependencies harden.

In the United States for example, the recently passed Inflation Reduction Act authorizes over $60 billion in advanced manufacturing and production tax credits to catalyze domestic EV supply chains, including $3 billion specifically for next-generation battery R&D. Attracting investments into technologies like lithium metal anodes, solid-state electrolytes, and cobalt-free cathodes today creates future strategic advantages and

more resilient capacity eventually diluting Chinese control over innovations critical for sustainable mobility infrastructure modernization. Similarly, off-take agreements committing future public procurement of domestically refined or recycled battery metals strengthen localized supply for electrifying public transport fleets. Financing EV infrastructure upgrades across ports, delivery routes and the power grid enable capacity to one day sustain entire localized supply chains reducing foreign reliance. And funding workforce development programs now addresses essential skills gaps, fostering competitive human talent in critical chemical and electrical engineering fields essential for viable battery ecosystems.

In Europe as well, ambitious commitments from the European Battery Alliance to cultivate domestic manufacturers have spawned preliminary investments into regional champions and start-ups like Northvolt (Sweden), Verkor (France), and Britishvolt (UK). Though collectively still dwarfed in scale by China currently, coordinated policy Vision could enable Europe largely self-supply affordable cells for mass EV adoption rates by 2030. India too recently announced over $3 billion in production-linked incentives to drive integrated domestic capacity growth using low-cost services and renewable inputs. But absent expedited actions before windows close, China's existing first-mover advantages threaten to delay progress on strategic priorities by years as costs rise for alternatives and foreign dependence deepens. While integrating China into cooperative ESG-aligned supply chains remains necessary through this decade, good faith policy efforts now may alter long-run dynamics before irrevocable lock-in around their export-oriented lead solidifies. If countries fail to lay foundations enabling future flexibility though, they face options far narrower and costlier by the time scale forces decisive choices. With stakes high for economic as well as climate futures, implementing targeted catalyst policies promptly offers responsible governments their best leverage still to shape more resilient electric mobility infrastructure free from dependence by 2030.

5.3 Coming Decade Likely to See Escalating Battery Supply Competition

With electric vehicles expected to reach over 60% of new car sales globally by 2030, exponential growth in demand for lithium-ion batteries is set to catalyze intensifying international competition to control increasingly critical EV supply chains. China currently dominates global battery production capacity, accounting for over 70% of cell manufacturing in 2021. However, moves by the United States, European Union and other major auto markets aim to nurture domestic alternatives reducing Chinese dominance over the next decade. Estimates forecast the entire lithium-ion industry could scale towards $550 billion in annual revenue by 2035 - more than seven times current market size. Achieving ubiquitous EV adoption compels terawatt-hours worth of annual battery output. Even if most manufacturing remains concentrated regionally, component production and raw material supplies must expand worldwide to support the unprecedented volumes required.

These dynamics are priming a contentious decade likely witnessing aggressive policy actions as nations vie to capture larger portions of this indispensable emerging sector. Governments which have identified batteries as conferring economic competitiveness view ceding unchecked control to China as a strategic liability meriting intervention. Already fraying geopolitics exacerbates desires to wrest some self-sufficiency from foreign rivals. Yet completely extricating any country from China's existing dominance proves enormously costly if not infeasible before 2030 despite ambitious subsidies or local content mandates. Nations must tread carefully to avoid provoking excessive economic nationalism threatening climate progress or global innovation sharing needed to perfect EV batteries. Smoothly navigating this transitional period before production networks rebalance requires nuanced policies balancing security with wider decarbonization imperatives.

Still, government interventions seem poised to nurture viable alternative supply centers in North America and Europe within the next five years. These could meaningfully compete over time in major auto markets otherwise ceding most value-add to China today. Early mover advantages may erode if technology transfer or joint ventures disseminate cutting-edge designs like cell-to-pack architecture or cobalt-free cathodes abroad. India too boasts strengths in IT, engineering talent and renewable inputs that - with sufficient policy support - might translate into cost advantages cultivating domestic manufacturing at significant scale later this decade. Even Toyota's recent pivot towards contentious all-solid-state batteries looks partly motivated by desires escaping reliance on Chinese lithium-ion supply chains into which it had little early influence. Instead the automaker is betting big on developing a next-generation alternative chemistry in Japan it can shape future standards around. While climate imperatives still necessitate international collaboration enabling affordable, ubiquitous e-mobility, intensifying superpower rivalries and economic nationalist policies threaten periodically flaring tensions over optimal battery supply chain architecture for years. Careful statecraft navigating this pivotal transitionary period remains essential to avoid unnecessary provocations or trading resource security for protectionism while global clean transport scales towards climate targets.

REFERENCES

[1] K. (2024, January 23). China’s Renewable Dominance: World’s Factory Leads in Almost Every Clean Tech Sector. Renewable Power Insight. https://renewablepowerinsight.com/2024/01/23/chinas-renewable-dominance-worlds-factory-leads-in-almost-every-clean-tech-sector/

[2] Update on electric vehicle costs in the United States through 2030 - International Council on Clean Transportation. (2021, November 24). International Council on Clean Transportation. https://theicct.org/publication/update-on-electric-vehicle-costs-in-the-united-states-through-2030/

[3] Kornack, D. R., & Rakić, P. (2001, December 7). Cell Proliferation Without Neurogenesis in Adult Primate Neocortex. Science. https://doi.org/10.1126/science.1065467

[4] House, W. (2024, February 29). FACT SHEET: Biden-Harris Administration Takes Action to Address Risks of Autos from China and Other Countries of Concern. The White House. https://www.whitehouse.gov/briefing-room/statements-releases/2024/02/29/fact-sheet-biden-harris-administration-takes-action-to-address-risks-of-autos-from-china-and-other-countries-of-concern/

[5] European Battery Alliance. (n.d.). Internal Market, Industry, Entrepreneurship and SMEs. https://single-market-economy.ec.europa.eu/industry/strategy/industrial-alliances/european-battery-alliance_en

[6] Lithium Reserves by Country: Top 15 Countries. (2023, June 24). Investing Channel. https://investingchannel.com/article/584245/lithium-reserves-by-country-top-15-countries

[7] Lithium-ion battery capacity to grow steadily to 2030. (n.d.). S&P Global Market Intelligence. https://www.spglobal.com/marketintelligence/en/news-insights/research/lithium-ion-battery-capacity-to-grow-steadily-to-2030

[8] Chang, A., & Bradsher, K. (2023, May 30). Can the World Make an Electric Car Battery Without China? The New York Times. https://www.nytimes.com/interactive/2023/05/16/business/china-ev-battery.html

[9] Biden Administration Announces $3.16 Billion from Bipartisan Infrastructure Law to Boost Domestic Battery Manufacturing and Supply Chains. (n.d.). Energy.gov. https://www.energy.gov/articles/biden-administration-announces-316-billion-bipartisan-infrastructure-law-boost-domestic

[10] Assessment of light-duty electric vehicle costs and consumer benefits in the United States in the 2022–2035 time frame - International Council on Clean Transportation. (2023, November 15). International Council on Clean Transportation. https://theicct.org/publication/ev-cost-benefits-2035-oct22/

[11] Global EV Outlook 2019 – Analysis - IEA. (n.d.). IEA. https://www.iea.org/reports/global-ev-outlook-2019

[12] Szunomár, G. (2024, January 25). From Zero to Hero? Chinese Investment in Electric Vehicle Supply Chains in the Visegrád Four. Chinaobservers. https://chinaobservers.eu/from-zero-to-hero-chinese-investment-in-electric-vehicle-supply-chains-in-the-visegrad-four/

[13] Singleton, C. (2023, October 31). Are Chinese Battery Companies the Next Huawei? Foreign Policy. https://foreignpolicy.com/2023/10/30/china-batteries-electric-cars-charging-networks-catl-byd-zeng-yuqun-huawei-security-risk/

[14] Chanda, N. S. (2023, September 11). Chinese EV battery makers: dominating the West. https://asiafundmanagers.com/. https://asiafundmanagers.com/us/chinese-ev-battery-makers-dominating-the-west/
[15] T. (2024, March 4). Top 10 Lithium-ion Battery Manufacturers in China 2024. Ebike Battery Manufacturer. https://tritekbattery.com/lithium-ion-battery-manufacturers-in-china/
[16] Thomas, J. (2023, May 17). The ultimate guide to the EV battery supply chain. Innovation News Network. https://www.innovationnewsnetwork.com/the-ultimate-guide-to-the-ev-battery-supply-chain/30592/
[17] Liu, J. (2024, January 3). Guide to the EV Battery Supply Chain in 2024. MokoEnergy - Your New Energy Solution Provider. https://www.mokoenergy.com/ev-battery-supply-chain/