Wilson Center | Wahba Institute for Strategic Competition

Ten Steps to Achieve Resilient Cobalt Supply Chains

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I. Executive Summary

Upon commissioning this report on the cobalt supply chain, the Wahba Institute for Strategic Competition at the Wilson Center stressed the need for practical recommendations for US Government action that (a) would have a meaningful impact and (b) are well-within the realm of the possible. There is no shortage of policy reports stating, for example, "The preponderance of global cobalt is mined the Democratic Republic of Congo" and "Most global cobalt is 'processed'—however defined—in China." If these were the core takeaways from this work, then it would have failed.

Instead, cobalt is a tale of two markets: the "West" and the People's Republic of China. In the former, we find almost five decades of government and industry inertia, which has only recently begun to shift. In the latter, we find an industry-government dynamism deliberately aimed to leap-ahead of the incumbency advantages of the former. In short, cobalt is one chapter in this century's sharp-elbowed geopolitical marathon, in which the West and China are simultaneously supplier, customer, competitor, investor, innovator, and security challenge.

Some portions of this cobalt story are unlikely to change, such as the near-centennial dominance of cobalt production in the Democratic Republic of Congo and the prevalence of security themes in US Government cobalt policy—from 1970s-era regulations on superalloy production to more recent ones on "foreign entities of concern". In other areas, such as critical mineral diplomacy or investment program execution, the initiative rests exclusively with the US Government.

With that in mind, this work provides an overview of cobalt market, how and by whom it is produced as well as where and why it is consumed. This is followed by an evaluation of the role of industrial policy and price volatility in the cobalt market, highlighting China, Indonesia, and the United States. These data serve as the foundation for ten (10) recommendations, each of which has an Executive Branch component that may be implemented immediately, with follow-on supporting actions for the Congress in future authorization and appropriation cycles:

Recommendations

1. Maintain Long-Term Stability in Minerals Policy
2. Keep "National Defense" Broad to Achieve Genuine Resilience
3. Integrate Government Incentives towards Industrial Outcomes
4. Attract Highly Qualified Foreign Talent to "National Priority Projects"
5. Increase Cobalt Stockpiling to Ensure Emergency Access
6. Position the US Government on One Side of the Transaction
7. Leverage Trade Actions to Expand Access to Resilient Supply
8. Amend Reliable Sourcing Rules to Support Domestic Production
9. Embrace Joint Action with Allies
10. Explore a "Lease-to-Recycle" Model to Reduce EV Adoption Cost

II. Introduction–Consistency or Stasis?

In 1977 and again in 1978, the Congolese National Liberation Front (Fr: FLNC) crossed from neighboring Angola into today's Democratic Republic of the Congo (DRC), sparking the "Shaba I" and "Shaba II" conflicts. In the latter, the FLNC successfully captured the town of Kolwezi, a city founded by *Union Minière du Haut Katanga* in 1938 to serve as the company's headquarters for copper and cobalt mining operations in the country.

What followed in the US cobalt market was the largest spike in the commodity's modern history, from ~$32/lb. in 1976 to $104/lb. in 1978[1]. US customers saw a 30% supply allocation reduction due to disrupted shipments from the DRC. This shock to the cobalt market and to US consumers in the aerospace and industrial turbine engine sectors prompted an extraordinary shift in US government policy related to "critical minerals," with Congress attempting to reverse post-Korean War era drawdowns of the Defense National Stockpile Center[2] and the adoption of the first substantive overhaul to US stockpiling law[3] since 1939.

In 1983, the Senate Committee on Commerce, Science and Transportation commissioned the Congressional Budget Office (CBO) to analyze the challenges associated with "strategic and critical minerals" supply chains and to propose policy options for the Congress' consideration.[4] The CBO's recommendations included:

1. Increase the National Defense Stockpile;
2. Build "economic" stockpiles;
3. Subsidize domestic production through the *Defense Production Act of 1950* (DPA);
4. Diversify foreign sources through development finance;
5. Encourage mineral exploration and development on public lands;
6. Expand research and development funding for material substitution; and
7. Advance foreign policy initiatives (e.g., trade agreements, international development) to ensure security of supply.

For those engaged in the metals and mining sector for the past decade, as well as the casual observer and government policy planner, the narrative arc and its conclusions may sound eerily similar to the current state-of-play in Western critical minerals policy. Following the supply chain disruptions of the COVID-19 pandemic, the Biden administration charged the Department of Defense (DoD) to lead an inter-agency study of critical minerals supply chains.[5, 6] Perhaps even more striking, some of the recommendations by the CBO in 1983 and subsequent actions undertaken by the Biden administration are almost identical. Notable similarities include (1) the deployment of DPA Title III for cobalt projects; (2) reinvigorating critical minerals diplomacy through the Minerals Security Partnership; (3) economic stockpile development for battery minerals[7]; and (4) leveraging free trade agreements and sector-specific agreements to tie "reliable" foreign production to US battery supply chains under the *Inflation Reduction Act*.

What then should we make of US government policy toward critical minerals? Are we seeing a remarkably consistent approach that has withstood the test of time (albeit with variable implementation), or are we seeing an equally remarkable policy stasis that has yet to innovate beyond the early 1980s?

A deep dive into the cobalt supply chain offers perspective in answering these questions, in that cobalt has a place as a "critical mineral" for the US Geological Survey[8], a "critical material" in the Department of Energy's clean energy focus[9], and a "strategic and critical material" for the DoD's investment and stockpiling programs[10].

III. The Cobalt Market

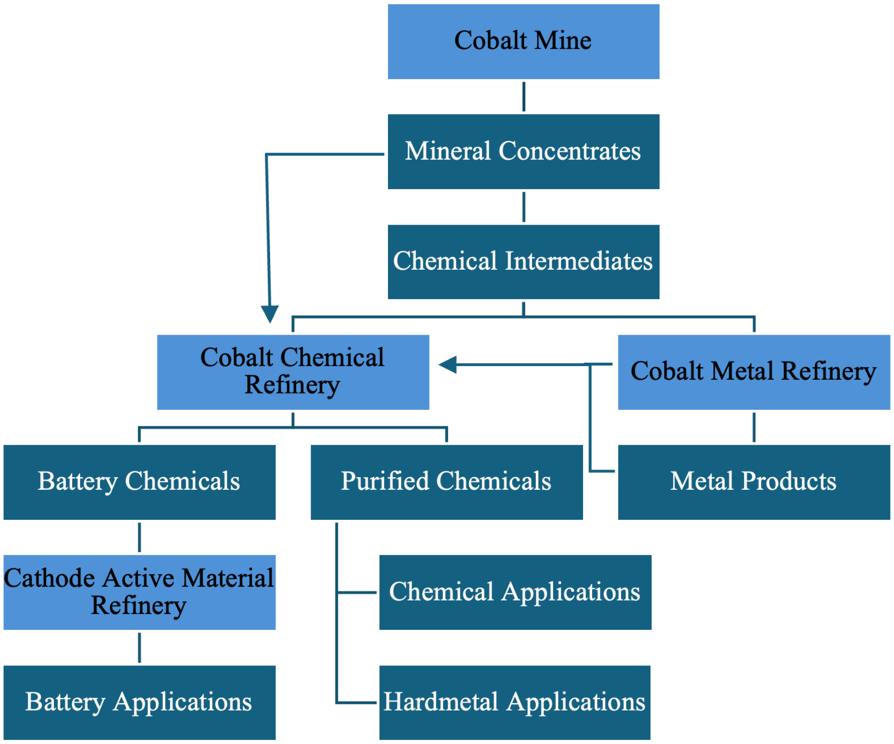
A. Market Dynamics and Production Process

Before initiating a policy review, some baseline information regarding cobalt production, consumption, and market dynamics is necessary. First and foremost, cobalt is a *by-product* market; namely, substantially all cobalt miners today produce the material as a result of their core business in the extraction of copper or nickel. Some industry observers may report cobalt as a *co-product* at select mines, but this distinction is largely moot, in that the difference rests on whether cobalt revenues are less than 50% (a by-product) or approximately 50% (a co-product). The essential factor is that market forces unrelated to cobalt often have an outsized influence on cobalt supply.

For example, copper demand is strongly correlated with the health of the global economy, given its distributed use in almost every sector of an industrialized nation. *Ceteris paribus*, higher copper prices may encourage greater copper production from existing mines. Given copper's co-mingling with cobalt, cobalt supply also may increase, irrespective of intrinsic cobalt demand. Similarly, stainless steel accounts for ~69% of total primary nickel demand.[11] Given successful Chinese manufacturing research into the conversion of nickel as used in stainless steels to nickel of sufficient quality for batteries, the technical gap between these markets is narrowing.[12] Thus, *ceteris paribus*, slumping demand for nickel in stainless steel may encourage supply cuts, which also may pull cobalt units from the market.

Regardless of ore source, all upstream cobalt-containing minerals must be converted into either a mineral concentrate (e.g., copper-cobalt, nickel-cobalt, cobalt-arsenic) or a chemical intermediate product (e.g., hydroxide, mixed hydroxide precipitate [MHP]) to be saleable. Assuming that cobalt units are extracted, and they are captured for subsequent conversion into a saleable product, the typical production process flows for cobalt are shown in **Figure 1**.

Figure 1: Cobalt Mineral Process Flows



The selected beneficiation method (i.e., separating cobalt mineral units from the balance of mineral products and waste rock) is customized to a given **cobalt mine**. However, the cobalt mineral beneficiation process, in general, consists of the following steps: (1) crushing and grinding the ore; (2) screening and, if necessary, re-grinding ore to ensure consistent flotation feed; and (3) a series of froth flotation and scavenger stages, in which cobalt-bearing ores are added to a water/chemical mixture, agitated, and then captured in rising air bubbles. The typical result of this production process is a "cobalt concentrate."

Although some mines may sell this cobalt concentrate, the next processing steps that may be integrated at a mine site are leaching and purification. In this series of production steps, cobalt concentrates are dissolved in an acidic solution (leaching), and the pH of the cobalt-loaded solution is modified by the addition of water (e.g., washing) or other chemicals (e.g., carbonates / hydroxides) to neutralize the pH of the solution and selectively precipitate-out deleterious elements and, finally, the desired cobalt hydroxide.

Either cobalt concentrate or cobalt hydroxide may be purchased by a **cobalt refinery** for the higher value-added conversion of cobalt units in higher-purity compounds, metals, or customer-bespoke chemical formulations of cobalt. However, the exact process operations executed at a cobalt refinery will vary from refinery to refinery, contingent on the products they intend to make and the input materials they procure.

Though a cobalt refinery may produce both metal products and chemical products, a metal refinery's output typically is sold as cut cathode, broken cathode, rounds, briquettes, and/or powders. These metal products ultimately serve downstream markets in aerospace and industrial turbine engines, medical implants, permanent magnets, and tool steels.

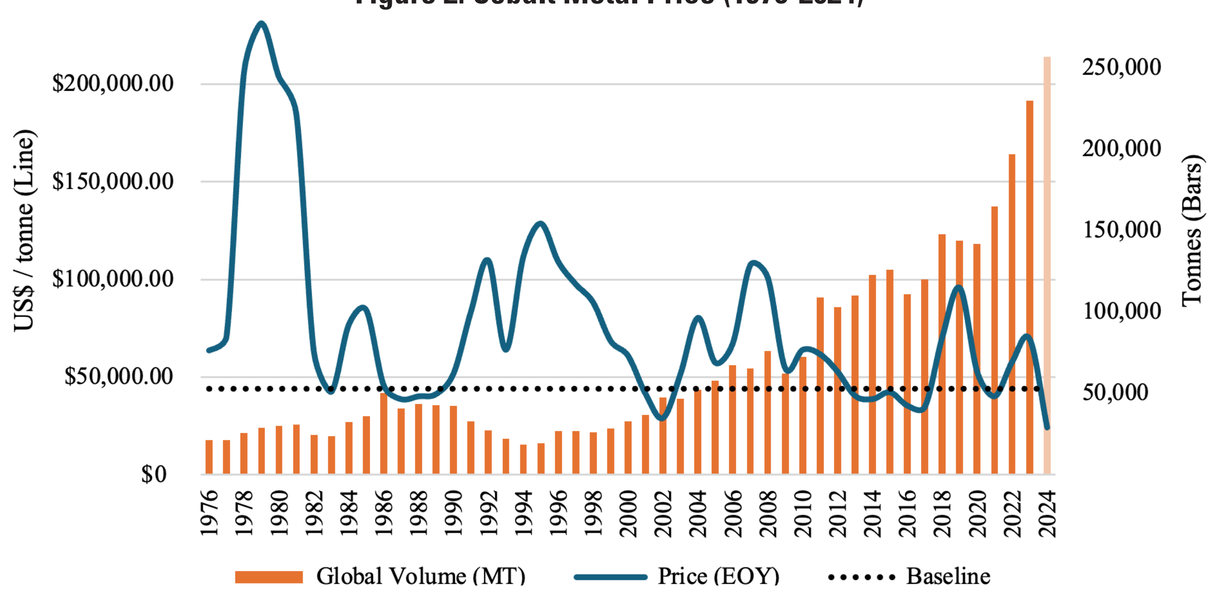
Cobalt chemical refinery output is incredibly diverse, ranging from "commodity-like" chemicals (e.g., cobalt sulfate) to battery chemicals engineered to a particular customer's specifications (e.g., precursor Cathode Active Materials [pCAM]). These chemical products support the lithium-ion battery sector (e.g., consumer electronics and electric vehicles [EVs]), traditional chemical applications (e.g., petroleum catalysts, glass coloring), and some powder products (e.g., tungsten carbide powders).

Whether pursuing a cobalt metal or cobalt chemical as the principal outputs of a given refinery, input cobalt concentrates and cobalt hydroxide units first undergo a solvent extraction process. Solvent extraction is a common hydrometallurgical approach used to (1) selectively extract impurity metals from a solution; and (2) recover the target element in specific concentrations and in specific product forms (e.g., sulfate, oxide). From this point, cobalt units separate into either an electrolytic process to produce metal, or variable processing techniques dependent on the product form to be achieved (e.g., crystallization, calcination, hydrogen reduction). On the other hand, some cobalt chemical refineries also can use cobalt metal as feed. In this circumstance, cobalt metal—whether externally-sourced or internally-generated—may be dissolved in sulfuric acid to generate a crude cobalt sulfate, whereupon the "regular" cobalt sulfate processing pathway may be undertaken.

B. Demand Drivers and Pricing

Global cobalt demand over the past nearly half-century is a tale of two markets. The first half, from 1976 to 2000, is characterized by relatively limited demand, concentrated in aerospace, defense, and industrial applications. Annual production averages 66.7 million lbs. per year (30,267 tonnes per annum [tpa]). The second half, from 2001 to the present, is characterized by significant year-over-year increases in global demand, fueled largely by the development of a whole new set of consumer electronics (e.g., cell phones, laptops, tablets, wearable electronics); and net-zero emission technologies in EVs. During this period, annual production jumped from 81.3 million lbs. per annum in 2001 to 566.5 million lbs. (est.) in 2024 (36,900 tpa to 256,960 tpa).

Figure 2: Cobalt Metal Price (1976-2024)

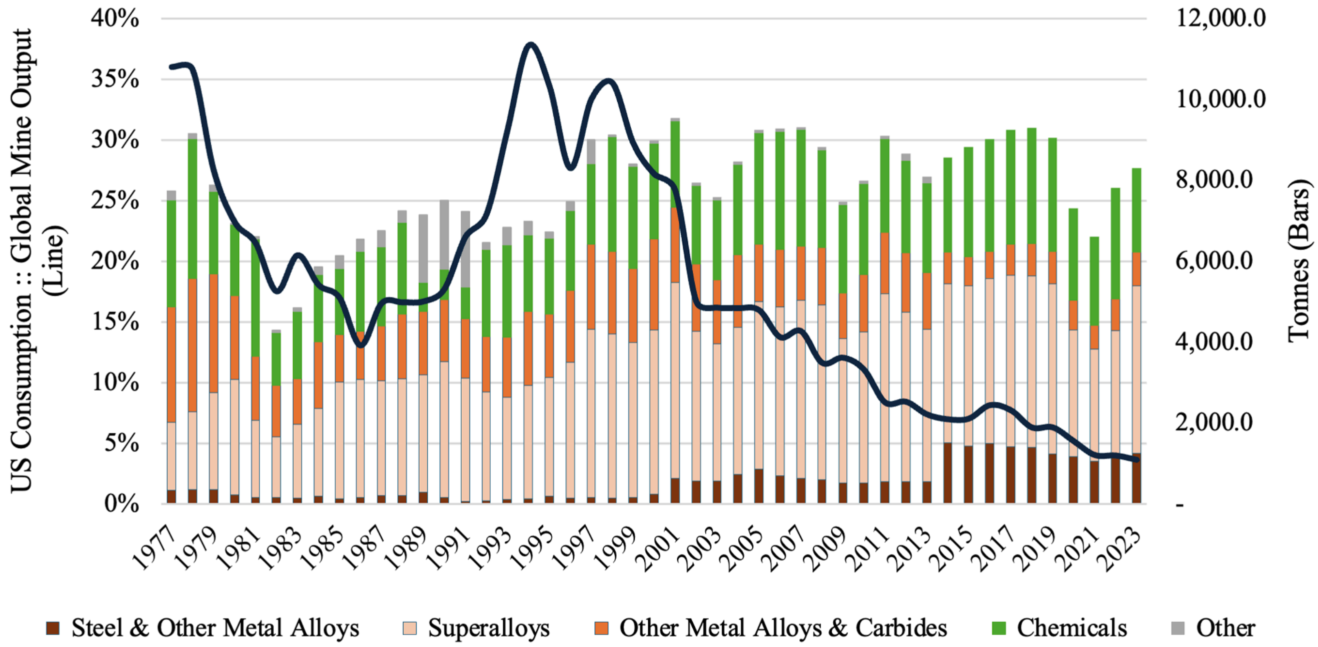


Industrial, Aerospace, and Defense

In many respects, today's US cobalt market is a microcosm of the 1977–2000 era global cobalt market. In brief, the US.' direct consumption of cobalt (i.e., US consumption of cobalt as "cobalt", as opposed to indirect consumption, which includes cobalt embedded in downstream goods, such as a cell phone) has remained almost entirely unchanged, by volume or by product distribution, from 1976 to today. The proportion of cobalt metal consumption, by volume, has remained largely flat at ~7,800 tpa, with cobalt metal's US market share also holding steady at ~69% per year.

Within the US cobalt metal market, the principal demand driver is super-alloys (~62%), which are incorporated into jet engines for aerospace and defense products and industrial gas turbines. The next most significant demand segment is metal carbides and permanent magnets[13] (~29%), respectively used in the manufacture of cutting implements, wear parts, and defense applications, as well as high-temperature motors and defense applications. The balance of US demand (~9%) is used in an array of steel products, including stainless steels, high-strength low-alloy (HSLA) steel, and tool steels.

Figure 3: US Cobalt Demand (Direct) by Product Segment[14]



Given the outsized demand from aerospace, defense, and industrial markets in the pre-2000 period, the global cobalt industry historically priced cobalt products with reference to the underlying cobalt metal price. For those cobalt products with lesser contained cobalt (e.g., concentrates), market participants have priced these products as a percentage payable, with the metal price as the baseline. Additionally, the convertibility of cobalt metal to cobalt chemicals further supports referencing to the underlying metal price.[15]

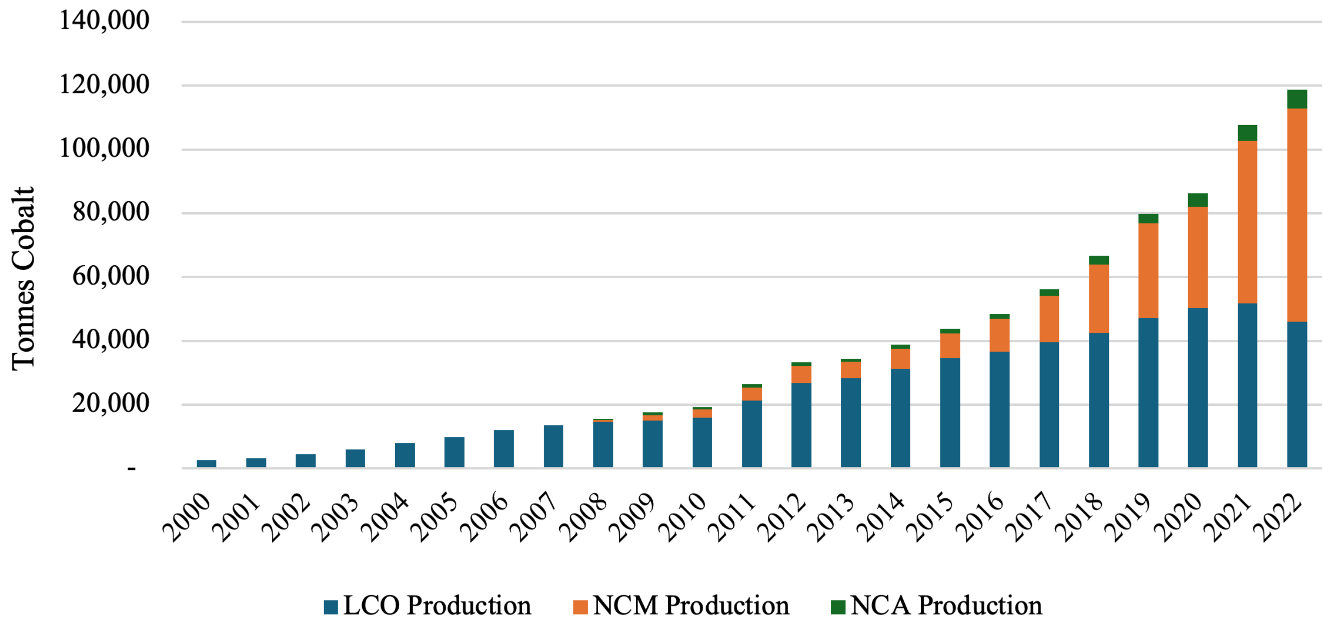
Lithium-Ion Batteries

Working in the shadow of the oil shock of the mid-1970s, the development of the lithium-ion battery can be traced to three separate research teams, led by Sir Michael Stanley Whittingham (Exxon Research & Engineering Company), John B. Goodenough (Oxford University), and Akira Yoshino (Asahi Chemical Industries). In 1977, Sir Whittingham patented the first rechargeable lithium metal battery, but given its use of titanium disulfide cathodes, the battery was not commercially viable. Dr. Goodenough improved upon what would become the lithium-ion battery in 1979, with the development of a cobalt oxide cathode. Dr. Yoshino made the next advance in 1985 when, in the pursuit of a lightweight power source for portable electronics, he observed the amenability of crystalline carbon-based materials for anodes. These three efforts combined formed the basis for the first commercial lithium-ion battery. All three researchers were honored with the Nobel Prize in Chemistry for their contributions to the discovery and commercialization of lithium-ion batteries.

The first mass production of lithium-ion batteries, using the lithium-cobalt-oxide (LCO) formula, began with Sony in 1991. As production scale increased and the cost per kilowatt hour (kwH) declined, lithium-ion batteries eventually replaced nickel cadmium batteries in consumer electronics. The ever-expanding pool of new consumer electronics products from 2000 to the present (e.g., cell phones, digital cameras, laptops, tablets/e-readers, and wearables), combined with aggregate global demand, buoyed robust cobalt consumption in lithium-cobalt-oxide batteries. Notwithstanding this commercial success, these batteries remained expensive through the 2000s, ranging from >$3,300 / kwH to ~$921 / khW. The first generation of plug-in hybrid-electric vehicles (PHEVs) and EVs benefited from some of the consumer electronics industry's scale, but these batteries also remained costly through the 2010s, ranging from ~$1,180 / khW to $156 / khW. [16]

The belief that EVs drove the cobalt market for batteries is a significant misperception regarding cobalt demand in batteries. However, for most of the past two decades, the comparatively higher cost of LCO and other "high cobalt" cathode chemistries (e.g., nickel-cobalt-manganese, "NCM") slowed adoption and encouraged industry and government research into the development and commercialization of alternative battery chemistries that either eliminated (e.g., lithium-iron-phosphate, "LFP") or economized cobalt use (e.g., nickel-cobalt-aluminum, "NCA"). Only in 2022 did battery chemistry demand for EVs and PHEVs exceed traditional consumer electronics demand for cobalt in batteries (see **Figure 4**).

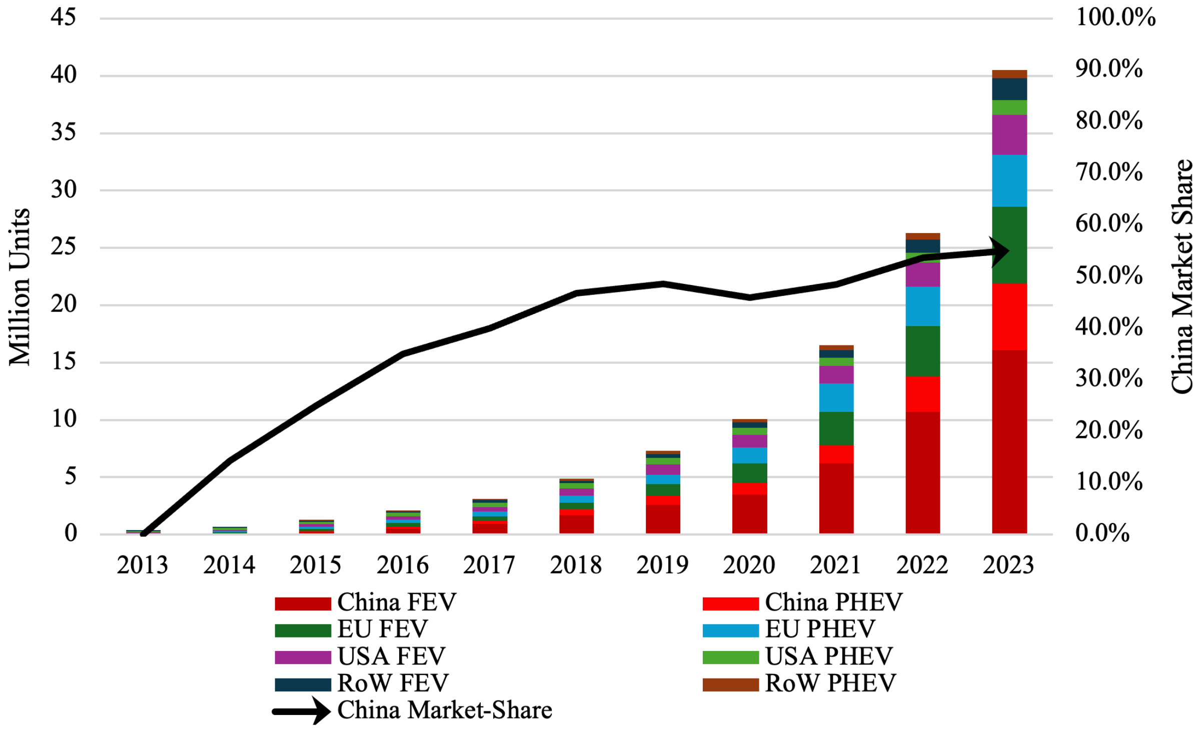
Figure 4: World Cobalt Cathode Production, Cobalt Contained[17]



Notwithstanding the successful substitution or thrifting of cobalt units in EVs and PHEVs, industry interviewees expressed skepticism that such efforts are immediately applicable to consumer electronics and, thus, to LCO consumption. Instead, industry interviewees have noted that the past four years of cobalt demand in consumer electronics is an aberration, featuring an artificial "boom" during the COVID-19 pandemic as office workers shifted to remote work and governments expanded consumer transfer payments to offset a recession. A return to normalcy (e.g., return-to-work policies) and tougher macroeconomic conditions (e.g., higher inflation) have brought a correction to cobalt demand in consumer electronics. On the other hand, industry interviewees expressed optimism that the integration of artificial intelligence into consumer electronics will place even greater demand on the battery pack. The integration will ensure that, until the development of a suitably more energy-dense substitute, cobalt demand in consumer electronics remains firm.

Within the EV and PHEV segment, the story of cobalt demand to date is a China-centered narrative: a rapid growth from the initial build-out of the Chinese EV and PHEV sector, followed by muted growth as broader EV adoption was countered by aggressive substitution effects.[18] In aggregate, global EV and PHEV demand has expanded from ~400,000 EVs and PHEVs in 2013 to ~40.5 million EVs and PHEVs in 2023. China's demand has accounted for approximately half the EV and PHEV market from 2019 onwards (see **Figure 5**).

Figure 5: Electric Vehicle and Plug-In Hybrid Electric Vehicle by Region, kwH Benchmark[19]



Cobalt-containing battery chemistries previously comprised substantially all of China's battery market. However, due to a combination of higher cost and reliance on an overseas supply chain, from the mid-2010s Chinese battery producers began shifting to low-cobalt (e.g., NCA) and no-cobalt battery chemistries (LFP). Notably, the LFP battery chemistry also was developed by Dr. Goodenough in the US. Though several companies sought to scale-up production of these batteries outside China, slow market adoption blunted these efforts. Some prospective US LFP producers formed joint ventures with Chinese companies or were acquired by them, notably A123 Systems.[20]

Today, LFP batteries are the dominant battery chemistry produced in China, comprising ~67% of the market.[21] The US market has been much slower to adopt no-cobalt battery chemistries, given range anxiety among US consumers. However, as a high-technology sector, material substitution and optimization trends in the battery sector remain dynamic. For example, the significant decrease in battery material prices (beyond cobalt, to include lithium and nickel) has diminished the near-term economic incentive to deploy new material solutions. Other material substitution or optimization options—such as the complete or partial integration of silicon into battery anodes[22], hybrid battery packs[23], and solid state or semi-solid state batteries[24], which feature a solid electrolyte for theoretically higher energy density—are nascent but highly promising.

Based on interviews with industry participants, the rapidly changing technology, materials, and manufacturing environment is injecting considerable uncertainty into investor perceptions of the longevity of cobalt in the automotive battery market.

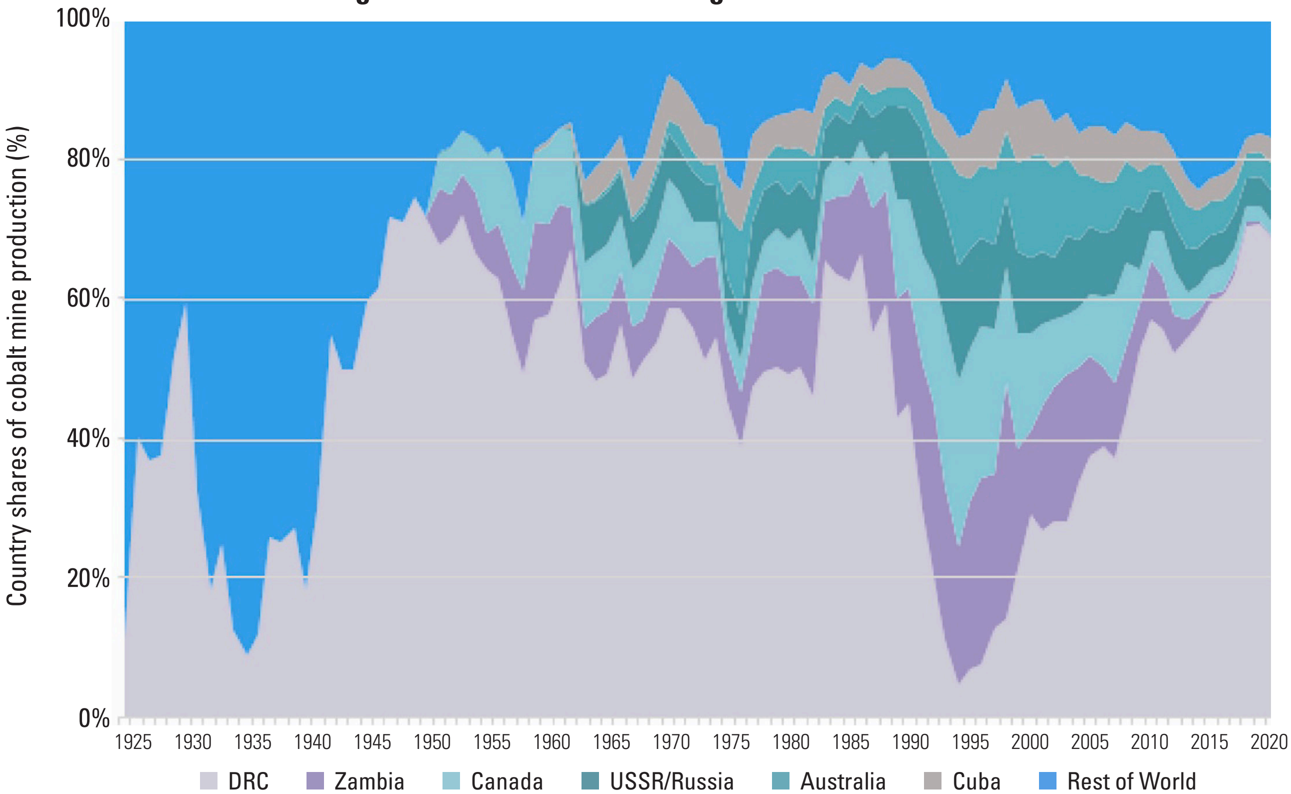
C. Global Production—Mining

As indicated in **Figure 1**, the cobalt production process may be broadly characterized by two key steps: (1) mining of concentrates, which often is co-located with the conversion of concentrates to hydroxides; and (2) customized refining of concentrates or hydroxides into an array of metal or higher-purity chemical products (e.g., sulfates, pCAM).

Democratic Republic of Congo

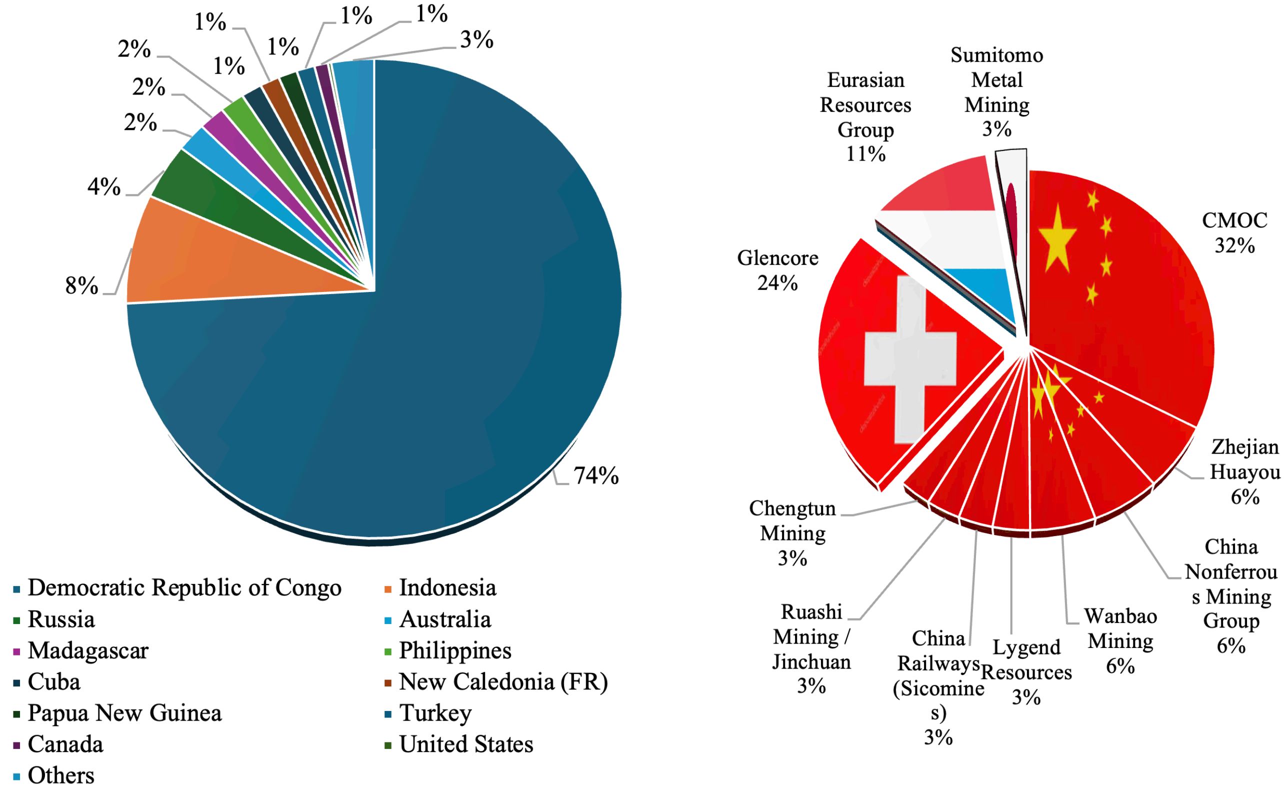
Within the first production step, the DRC (and the colonial and post-colonial governments that preceded it) has been the most significant global producer of cobalt products since World War II.[25] The only post-World War II departure from this longstanding trend is a brief period from 1990–94, due to a combination of underinvestment in national cobalt companies and political upheaval as the dictatorship of President Mobutu Sese Seko began to collapse.

Figure 6: Global Cobalt Mining Production Share[26]



Today, the DRC and Chinese-owned or operated mines, in particular, continue to mine the majority of global cobalt, at ~170,000 tpa. The first major foray for Chinese mining companies into the DRC was a $6 billion concession from the state-owned *La Générale des Carrières et des Mines* (Gécamines), in 2008, to a consortium of Chinese companies, including the China Railway Group, Sinohydro Corporation, and China Metallurgical Group Corporation (a subsidiary of China Minmetals Corporation). The transaction also included $3 billion in infrastructure investment commitments, of which one-third were provided by the China Export-Import Bank.[27] Perhaps the most significant cobalt mining transaction since this time was the 2020 acquisition of the Kisanfu mining project (now an operating mine) from Freeport-McMoran Inc. by a holding company beneficially-owned by China Molybdenum Corporation (CMOC) for $550 million.[28] CMOC subsequently invested ~$1.8 billion[29] in the development of the Kisanfu mine, whose production has surged 20% more than CMOC's production forecast. A summary of 2023 cobalt production in the DRC, comprising 98% of the country's output, and other sources is shown in **Figure 7**.

Figure 7: 2023 Global Cobalt Mining (L) / Top 10 Democratic Republic of Congo Miners (R)



Historically, artisanal cobalt mining (largely manual extraction as opposed to large-scale industrial mining) also has played a significant role in the cobalt supply chain. However, based on interviews with cobalt market participants and other non-industry cobalt market analysts, the scale of cobalt artisanal mining is strongly correlated with the prevailing cobalt price. As prices rise, artisanal mining tends to increase. As prices fall, artisanal miners cease mining activities or shift to other, more valuable commodities. Furthermore, as largely China-fueled investments in industrial mining enterprises have increased aggregate mine production in the DRC and elsewhere, the supply contribution of artisanal mining to the global cobalt market has decreased. Based on industry interviews, most market participants note that artisanal mining peaked at ~20% of mined cobalt in 2018, falling to <10% in 2023.[30]

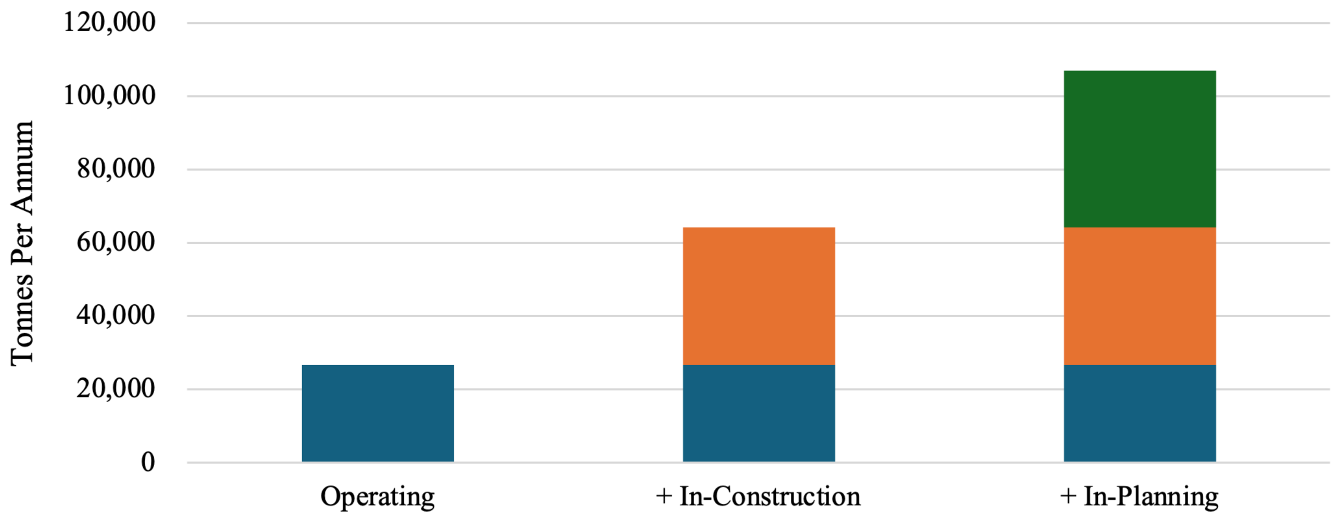
In a more detailed field study of the artisanal mining sector in the DRC, a joint study by the Bundesanstalt für Geowisseenshaften und Rohstoff (BGR)[31] and the DRC *Ministère de Mines*, researchers found that artisanal mining continues to operate in a legal grey area, nominally illegal yet broadly tolerated by civil authorities, law enforcement, and market participants. Furthermore, although the presence of legitimate civil authorities at mine sites (e.g., Mines Police and SAEMAPE[32]) has grown significantly in their year-over-year reporting cycle (2019-2020), artisanal mine sites also featured an outsized presence of the DRC internal security service[33] and a combination of the internal security service, the military, and police. In those circumstances where child labor was identified (16 cases) or mine accidents occurred (19 mines) during the field survey, a civil authority or security service was present at nearly all sites (14/16 child labor sites; 19/19 mine accident sites).

These minerals can flow into industrial mining operations within or outside the DRC through a series of convoluted supply chains, each of which may "skip" the nominally subsequent step and proceed to any follow-up step. These steps consist of (1) artisanal miners and cooperatives; (2) small-scale traders (*négociants*); (3) mineral depots; and (4) cobalt refineries. Of these supply-chain tiers, the most important is the mineral depot, in that the identity of the seller (and thus, information regarding the origin of the mined material) is reported at this tier. More specifically, it is common practice in the DRC that sellers present their voter identification cards (*carte d'electeur*) or other mining identification (e.g., *carte de creuseur* or *carte de négociant*) to the mineral depot manager. Although Chinese depot managers are known to have a well-publicized presence at the depot-level, no systematic study of the scale of this activity or of other nations has been identified in the course of this work.[34]

Indonesia

Outside the DRC, Indonesia is the most significant cobalt mining jurisdiction. Before 2019, Indonesia produced very little cobalt, perhaps a few hundred tonnes per year. From 2021 onward, Indonesian firms and Chinese joint ventures in Indonesia have rapidly grown the country's cobalt production to 17,000 tpa in 2023. Production capacity forecasts by Indonesia's Ministry of Maritime and Investment Affairs, presented at the *Cobalt Congress 2024*, anticipate additional cobalt supply growth, reaching as much as 107,000 tpa by 2030. The principal cobalt material produced in Indonesia is MHP, but Indonesia has expressed more expansive industrial policy goals, reaching toward local EV manufacturing.

Figure 8: Indonesia Cobalt Supply Growth Forecast (2030)[35]



Industrial policy and the rapid deployment of modified high-pressure acid leaching (HPAL) technology have enabled Indonesia's supply growth. Indonesian cobalt units occur within nickel laterite ores, and since 2014 (with a brief interlude from 2017-19) Indonesia has banned the export of nickel ores. This policy originally was enacted to encourage the downstream development of Indonesia's nickel industry, particularly in nickel matte and nickel pig-iron. However, the ban on nickel ore exports simultaneously prevented Indonesian cobalt units from leaving their domestic market. As the deployment of HPAL technology has proven successful (see below), Indonesia now has a stated goal of a complete lithium-ion battery supply chain, from mine to EV manufacture, aiming to produce 600,000 EVs annually by 2030.[36]

These trade and stated-policy actions are further supported by highly competitive economic and non-economic incentives, including the following[37]:

- Up to 100% corporate tax holiday for up to 20 years;
- Value-added tax (VAT) exemption for imported capital goods;
- VAT exemption for domestic procurement, if sited within a Special Economic Zone (SEZ);
- Import duty exemptions for capital goods and materials;
- 0% import duty for materials used in the production of a product with 40% domestic content;
- Between 50-100% local government tax reduction;
- Expedited permit applications; and
- Foreign-national employees; income is exempt from local taxation, and those employed within an SEZ have a five-year work permit.

Concurrent with these policy actions, Chinese companies began adapting HPAL production techniques at other mining projects for Indonesia's nickel resources. In the first case study, China's Lygend Resources partnered with another Chinese company, Enfi Engineering Corporation, to modify the latter's HPAL process in Papua, New Guinea, for a $1.05 billion nickel/cobalt project in Indonesia.[38] Subsequent Chinese enterprises have improved upon the HPAL flowsheet used by Lygend Resources, enabling subsequent operators to achieve nameplate capacity rapidly (e.g., within 12 months of mechanical completion) and at massively lower capital cost compared to their global peers ($55/annual tons nickel versus $30,000-$35,000/annual tons nickel at other Indonesian mines and ~$100,000/annual tons nickel at western-designed plants).[39] This engineering and commercial success has continued to fuel foreign investment in Indonesia, totaling ~$30 billion from 2020 to the first quarter of 2023.[40]

Rest of World Production

Cobalt production in the rest of the world has remained largely flat since 2019, at ~35,000 tpa, but the growth in cobalt production at the Kisanfu Mine in the DRC and, especially, at multiple Indonesian operations, has weighed heavily on global cobalt prices. As indicated in **Figure 2**, once adjusting for inflation, the current cobalt metal price is at its lowest point since 1979. This price decline has placed extraordinary pressure on both existing and nascent producers in the rest of the world.

In the US, Jervois Mining Ltd. ceased construction work on its Idaho Cobalt Operations in the first quarter of 2023. In Australia, BHP suspended operations at its Nickel West mine and West Musgrave projects in Western Australia. while First Quantum suspended mining at its Ravensthorpe nickel/cobalt mine. In New Caledonia, Prony Resources suspended operations at its nickel/cobalt operations, while Eramet suspended operations at its *Société Le Nickel* mine.

On the other hand, these rest of world mining suspension account for ~10% of the current cobalt market. Copper-cobalt miners have not come under as much pressure as nickel-cobalt miners due to comparatively more robust copper prices. *Ceteris paribus*, expanding nickel/cobalt supply in Indonesia and, to a lesser extent, cobalt production in the DRC, may continue to herald the end of more costly rest of world nickel/cobalt mining and refining operations.

D. Global Production–Refining

As indicated in "**Demand Drivers and Pricing,**" the cobalt market has undergone a fundamental change in consumption from 2000 onward, driven first by the ramp-up in global demand for lithium-ion batteries in consumer electronics and then in EVs. This shift is matched by an equally dramatic change in global refining capacity, underwritten by capital investments in China by Chinese enterprises.

In the more than two decades since the dawn of the 21st century, global ex-China production capacity for refined cobalt chemicals and cobalt metal has remained essentially flat, at ~34,700 tonnes cobalt chemicals and cobalt metal in 2000, versus 35,600 tonnes cobalt chemicals and cobalt metal in 2022.

People's Republic of China

China's first major policy foray into the lithium-ion battery sector began with the promulgation of the 10th Five Year Plan (2001-05), a key objective of which was the promotion of "new energy" systems, which included wind power technologies, battery systems, and geothermal energy, among others.[41] This, in turn, was translated into a new effort by China's technology development and industrial competitiveness program, the 863 Program,[42, 43] administered by the Ministry of Science & Technology (MOST), called "Major Science and Technology Special Project for Electric Vehicles." The effort aimed to boost China's industrial development of battery technologies, electric motors, and electric control systems, which would be deployed in fuel cells, PHEVs, and EVs. The effort was maintained through the 11th Five Year Plan (2006-10), with a renewed focus on lithium-ion batteries in particular, and powertrain components for EVs.

However, the selection of EVs and lithium-ion batteries as a state priority was as much a top-down decision as a bottom-up recommendation for the private sector. For example, Wan Gang—often called the "father" of China's EV industry—was serving as a Technical Manager for Audi Corporation's Production & Planning Department in Germany in 1999, when he drafted a letter to China's State Council, urging Chinese leaders to discontinue head-to-head competition with incumbent automobile manufacturers with internal combustion engine (ICE) vehicles. Instead, he recommended that Chinese industry pursue leap-ahead automotive technologies, with EVs as one such approach. Mr. Wan returned to China in late 2000, taking a position at Tongji University, where he also was appointed dean of the New Energy Automobile Engineering Center and chief scientist to the Project 863 effort on EVs.[44] In April 2007, after the conclusion of the 10th Five Year Plan in 2005, Mr. Wan was appointed as Minister for MOST.

With these early research and development investments beginning to bear fruit, MOST and several other Chinese government ministries began building the foundation for mass adoption of EVs. As minister, Mr. Wan was one of the key drivers behind the "Ten Cities and a Thousand Energy-Saving and New Energy Vehicles Demonstration and

Application Project." From 2009-12, it aimed to achieve 10% market-share for EVs in China's automotive market. As the project's name suggests, this would be accomplished by deploying at least 1,000 EVs in the public transportation systems (buoyed by financial subsidies) in at least 10 major metropolitan areas.

With the success of this demonstration, the Ministry of Industry & Information Technology (MIIT) served as the lead ministry—along with input from MOST and the National Development & Reform Commission, among other components—for the implementation of the *Energy Savings & New Energy Vehicle Industry Development Plan (2012-2020)*. Though the headline production capacity target of not less than 5 million EVs/PHEVs by 2020 is noteworthy, key aspects of this plan include the following[45]:

- Focusing on developing "battery industry clusters," with the goal of building two-to-three leading companies with a productive capacity of >10GWh;
- Promoting pilot adoption of EVs, to include consumer subsidies, charging infrastructure, and end-of-life recycling;
- Evaluating EV battery leasing and alternative business models, including battery swapping;
- Promoting charging infrastructure (slow- and fast-charging) with standardized construction approaches; and
- Cultivating the next generation of EV talent at universities and scientific research institutions, including foreign talent.

This comprehensive scientific, industrial, and fiscal program from 2000-12 was instrumental in setting the foundation for the significant growth in China's EV sector from 2015 to the present. The fruits of these efforts are best illustrated by the growth in NCM and NCA battery production in China since 2015. NCM grew from a zero-base in 2007 to 48,800 tonnes in 2022; NCA grew from a zero-base in 2015 to 500 tonnes in 2022. Unsurprisingly, this breakneck pace in EV and battery cathode material production had an outsized impact on the product mix for Chinese cobalt refinery expansions, with battery products growing from a zero-base in 2000 to 70% of Chinese refinery production in 2022.

Figure 9: Global Refined Cobalt/Cobalt Metal Capacity[46]

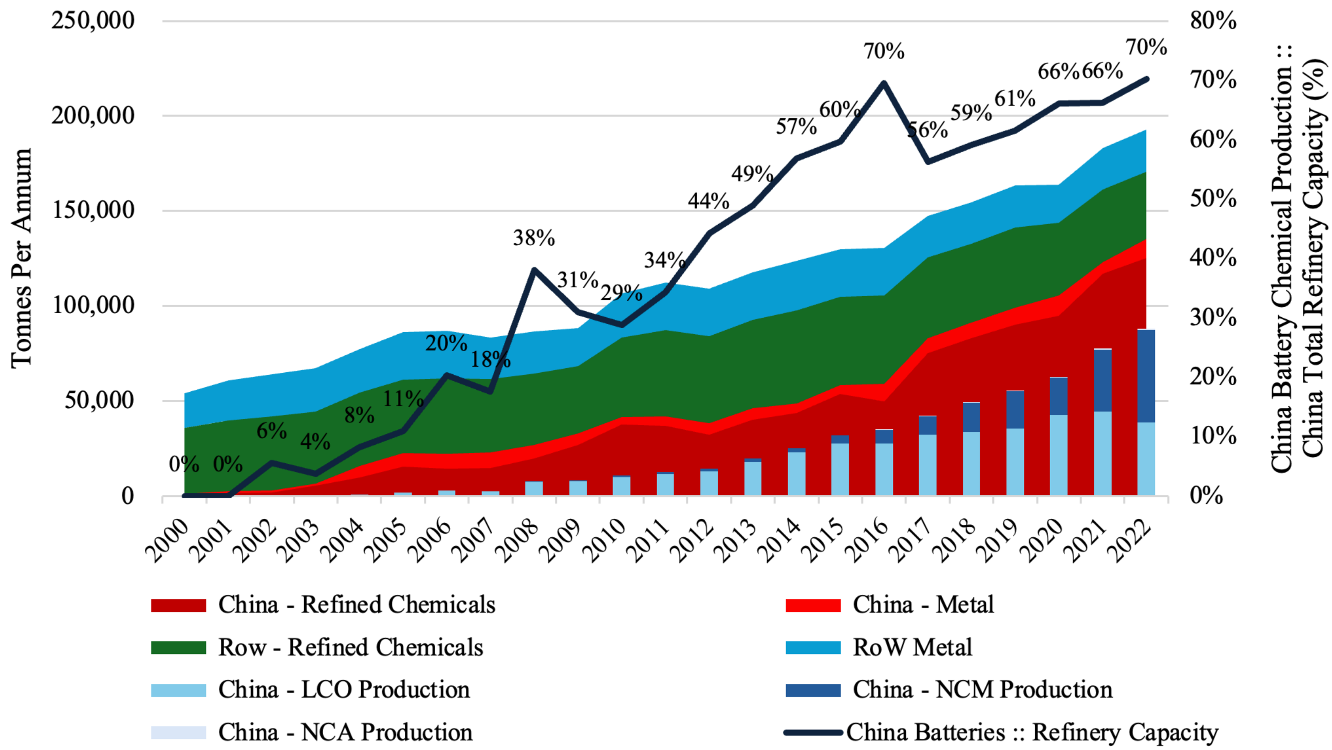
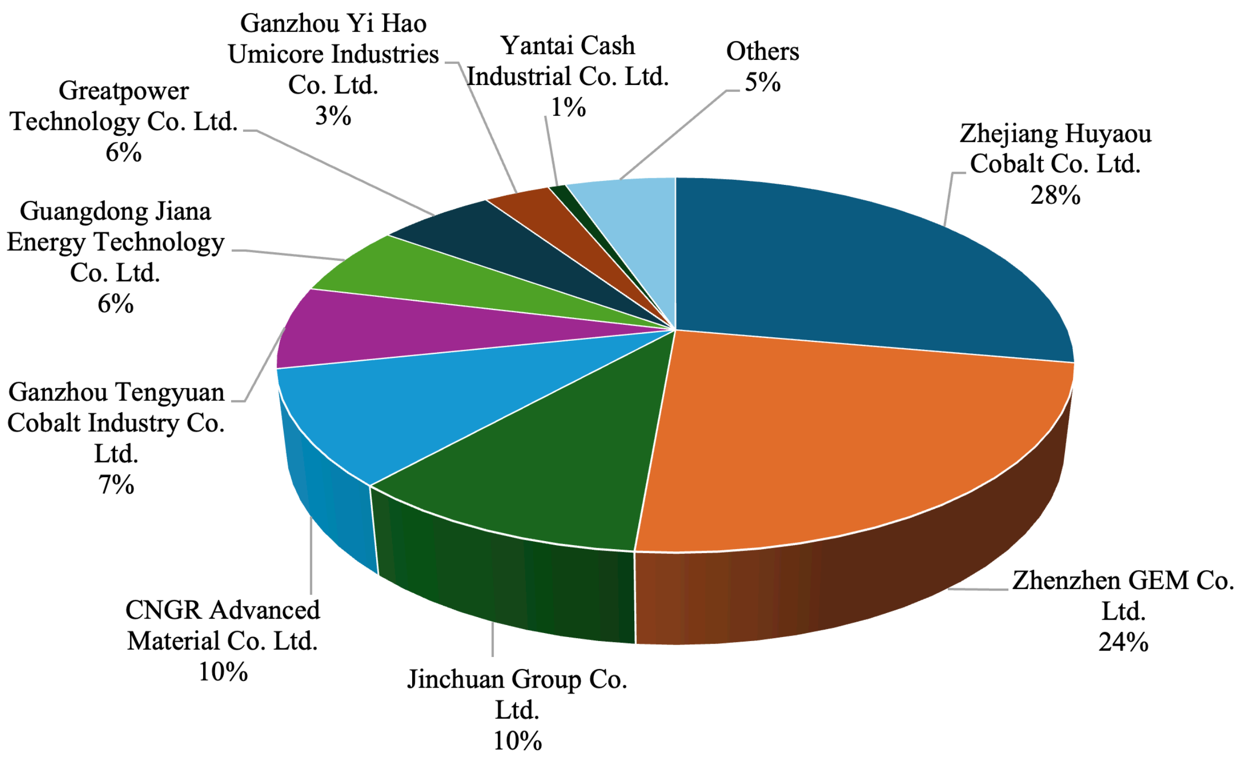


Figure 10: Major Chinese Cobalt Refineries, Refined Chemicals and Metal



Rest of World

Notwithstanding the significant change in the China's cobalt refining market—particularly in the cobalt refined chemical segment—the cobalt production at ex-China refineries, in all forms, has remained largely flat, at ~35,600 tpa in aggregate. Similarly, the market-share of ex-China cobalt metal production, relative to cobalt-refined chemical production, also has remained largely flat, with an average value of 56% and a range of 52%–64%.

Though cobalt metal production is widely distributed on a global basis at multiple small facilities, with a production generally not exceeding ~3,000 tpa,[47] this is not the case with cobalt-refined chemical production. First, only four facilities produce refined cobalt chemicals outside of China, and of these, the largest facility is the Kokkola Cobalt Refinery in Finland. Although the output from this facility is split between Jervois Global and Umicore,[48], it accounts for >70% of ex-China cobalt refined chemicals production today, a dominant position it has maintained for decades. Though Jervois Global initiated some work on the expansion of this facility, Jervois redirected those resources to support a cobalt refined chemical facility in the US (see **Figure 12**).[49]

Multiple firms have expressed an interest in developing cobalt-refined chemical production facilities in the US and Canada, at varying levels of project development, feasibility assessment, or construction. A summary of those projects that have been selected for US government assistance is described in the following section, "**Role of Industrial Policy**".

IV. Key Issues for the US Government

In the course of this assessment of the cobalt market, as well as in interviews with industry participants, two major themes emerged: first, the influence of "industrial policy"[50] on the cobalt market and second, price volatility.

Notwithstanding consistent inquiries with market participants, all Western participants noted that artisanal mining has a much-diminished impact on the cobalt market. All agreed that artisanal mining was a crucial source of income for many people in the DRC, and that recent efforts to formalize the artisanal mining sector (e.g., *Entreprise Generale du Cobalt* direct purchases of artisanal-mined cobalt) are a positive step toward reducing child labor and other dangerous and exploitative practices.[51] Although artisanal mined cobalt remains a significant reputational risk for all companies in the sector, interviewees cited the following factors driving this diminished role: (a) the growth in industrial cobalt mining operations in Indonesia and the DRC, (b) expanded purchasing of artisanal-mined cobalt for China-based cobalt refineries, and (c) Western customer and government requirements for rigorous supply chain due diligence with upstream suppliers.

A. Role of Industrial Policy

US Industrial Policy–National Defense

Though it is tempting to view recent Indonesian and Chinese behavior as a novel development, the cobalt market has been shaped by industrial policy for decades. In fact, the US government previously was an active participant in the cobalt market. Before the rapid growth from the lithium-ion battery sector, US demand for cobalt (in all forms) constituted one of the more significant global markets, with US apparent consumption covering ~25% of global mine supply from 1976-99; however, within the more static cobalt metal market, the US cobalt metal demand as a function of global cobalt metal production has maintained a relatively constant, at ~27%.[52] Given the close nexus between aerospace and defense requirements for cobalt metal, it has been the focus of historical security investments by the US government.

For example, to diversify wartime nickel supply, the US built the Nicaro nickel plant in Cuba in 1942. The General Services Administration (GSA) reactivated the facility with the outbreak of the Korean War. The plant remained in operation until 2012.[53] During the war, the GSA also entered into a purchase commitment and investment transaction, under the then-recent DPA Title III, with a predecessor company to today's Freeport-McMoran to acquire cobalt from a to-be-constructed US cobalt smelter, which would rely on the Cuban smelter for feed.[54] Some of these cobalt units ultimately may have been transferred to today's National Defense Stockpile, which, in 1982, held ~18,507 tons of cobalt metal, about two-and-a-half years of US demand.[55]

Similarly, from the enactment of the *Department of Defense Appropriations Act, 1973* to the present, the US Congress has restricted the procurement of "specialty metals" to domestic sources. The 1973 appropriations law enacted this restriction through a modification of the longstanding procurement rules on woven products (i.e., the "Berry Amendment"). Later, in the *John Warner National Defense Authorization Act for Fiscal Year 2007*, Congress enacted a stand-alone specialty metals clause at 10 USC. 4863.[56] This revised procurement restriction covers steel with more than 0.25% cobalt and all nickel- and cobalt-base alloys with more than 10% of other alloying metals (other than iron). Notably, this clause does not apply to the production of cobalt metal or any upstream forms of cobalt, simply the melting of alloys. This clause also includes exceptions to a strict domestic preference, allowing for the procurement of materials or components produced by US allies, for example.[57]

Congress has implemented a similar set of restrictions on procuring samarium-cobalt magnets at 10 USC. 4872, which prohibits the DoD and its contractors (at any tier) from procuring samarium-cobalt alloys and all downstream product forms from Russia, China, North Korea, and Iran. Effective January 1, 2027, this restriction will expand to the cover the complete supply chain, from mine to component.[58]

As noted previously, substantially all these restrictions are applicable to cobalt metal or cobalt alloy products. To date, Congress has not addressed US military procurement of batteries with the same rigor as legacy applications. However, this may be changing. In the *National Defense Authorization Act for Fiscal Year 2024*, Congress included a provision that prohibits the DoD from procuring batteries from six Chinese firms and their corporate successors.[59] Though a proposed rule has been drafted by the Department's Defense Pricing, Contracting, and Acquisition Policy office, an internal deadline for promulgating this rule has been extended to fall 2024.[60]

Figure 11: Prohibited Sources for Department of Defense Batteries

CATL	Contemporary Amperex Technology Co., Ltd. (CATL)
BYD	BYD Co., Ltd.
ENVISION	Envision Energy, Ltd.
EVE	EVE Energy Co., Ltd.
国轩高科 GOTION HIGH-TECH	Gotion High Tech Co., Ltd.
HTHIUM	Hithium Energy Storage Technology Co., Ltd.

Furthermore, in March 2022, President Biden issued a Determination under DPA Title III to support the development of critical minerals for the energy transition, including cobalt.[61] To date, the DoD has deployed ~$69 million in DPA resources to accelerate the development of cobalt mining and refining across North America. For those awards issued to projects where the principal place of performance is in Canada. Natural Resources Canada (NRCan) also has contributed funding toward these projects. Key awards to date include those indicated in **Figure 12**.

Figure 12: Defense Production Act (Title III) Awards, Cobalt

Company	Scope	Location	Amount (Million)
Jervois Global Ltd.[62]	Resource Development, Refinery Feasibility Study	North Fork, Idaho (USA)	$ 15.0
Talon Metals Corp.	Resource Development	Tamarack, Minnesota (USA)	$ 20.6
Fortune Minerals Ltd.	Feasibility Study	Yellowknife, Yukon Territory (Canada)	$ 6.4 $[63] 5.6
Doe Run Company[64]	Hydrometallurgical Plant Process Development	Herculaneum, Missouri (USA)	$ 7.0
Electra Battery Materials Corporation[65]	Refinery Construction	Temiskaming Shores, Ontario (Canada)	$ 20.0 $[66] 3.6
TOTAL			**$ 69.0** **$[67] 78.2**

US Industrial Policy–Economic Security

Aside from national defense-focused programs and activities, the US government has undergone a massive transformation in its willingness to intervene in private markets to achieve policy objectives. This transformation began during the Trump administration, and was aptly summed-up by the phrase "economic security is national security." It first appeared in the administration's *National Security Strategy68* and in regular remarks by Peter Navarro, Director of the Office of Trade & Manufacturing Policy and Defense Production Act policy coordinator to President Trump.[69] The key policy initiatives under this slogan included tax cuts, deregulation, modernizing US infrastructure, active trade defense, reciprocal free trade agreement negotiation, and rebuilding the US manufacturing base.

The most critical of these policies from the Trump administration was its trade defense and free trade agreement posture. Although rebuilding the US manufacturing base was a critical objective for the administration, deploying federal government funding toward that end was relatively muted, excluding the significant market interventions and investments by the US government during the COVID-19 pandemic. For example, President Trump issued five Determinations under DPA Title III to support the development of a domestic rare earth supply chain,[70] but only $51.5 million was awarded for such projects during the President's tenure—of the $458.5 million awarded to date.

Similarly, the Trump administration developed the US' first Federal Strategy on Critical Minerals under Executive Order 13817[71] and the first "Critical Minerals List." However, the Trump administration's ability to execute this scope of work was severely hampered by the COVID-19 pandemic. The DoD was particularly transparent about the impact of COVID-19 on its work plans in its *Fiscal Year 2020 Annual Industrial Capabilities Report to Congress*, indicating that substantial portions of its workforce assumed additional COVID-19 response duties, and core critical minerals tasks were cancelled or deferred (see **Figure 13**).[72] Notably, DoD participation in battery supply chain initiatives (such as inter-agency coordination on policy development) was reduced, and plans were delayed in conducting joint critical minerals projects with US allies (particularly under the Canada-US Joint Action Plan on Critical Minerals Collaboration).

Figure 13: COVID-19 Induced Reductions to Critical Minerals Activities

<table>
<tr><th>Cancelled Activities</th><th>Deferred Activities</th><th>Reduced Activities</th></tr>
<tr><td rowspan="4">Meeting of the Strategic Materials Protection Board (10 U.S.C. 187)</td><td>Time-Study for release of materials from the National Defense Stockpile under a simulated National Emergency</td><td>Meetings and reports to the Executive Office of the President under Executive Order 13817</td></tr>
<tr><td>Mobilization exercise for the release of National Defense Stockpile materials under a simulated national emergency</td><td>Meetings and reports for the Federal Consortium on Advanced Batteries</td></tr>
<tr><td rowspan="2">Joint research and development activities under joint critical minerals Action Plans</td><td>Meetings and collaboration with foreign allies under critical minerals Action Plans</td></tr>
<tr><td>Acquisition policy and legislative proposal development</td></tr>
</table>

Regarding international trade policy, the Trump administration pursued eight investigations under SEC. 232 of the *Trade Expansion Act of 1962*. Though none of these commodities directly impacted EV batteries, six of eight concerned critical minerals and metals (i.e., steel, aluminum, uranium, titanium sponge, grain-oriented electrical steel, and vanadium). The Trump administration also initiated multiple high-profile investigations under SEC. 301 of the *Trade Act of 1974*, the largest and most complex of which was the case entitled, "China's Forced Technology Transfer Policies and Practices." Most cobalt products were captured in "List 3," subjecting them to a 25% import duty.

Shortly after his inauguration in January 2021, President Biden initiated a wide-ranging review of US supply chains through Executive Order 14017, with critical minerals and large-capacity batteries two of the key supply chain reports due within 100 days (June 2020). In the policy blueprint that followed, the Executive Office of the President, the DoD, and Department of Energy established ambitious policy objectives, including deploying DPA Title III and other government financial incentives to onshore production, reconstituting US stockpile programs, and engaging US allies and partners to increase the reliability and sustainability of critical mineral supply chains.[73]

What stands apart in a review of these early policy documents from the Biden administration is not the spectacular similarity of programs that followed, important though that is. Instead, the core logic of "economic security is national security" remained fundamentally unchanged:

> The challenges and opportunities in strategic and critical material supply chains are emblematic of the intense geopolitical competition of the 21st century. Its complexity, global scope, and cross-cutting nature compel a whole-of-government approach by the United States, as well as close collaboration with our allies, partners, and the private and non-profit sectors.
>
> ——
>
> Even though the US Armed Forces have vital requirements for strategic and critical materials, the essential civilian sector would likely bear the most harm from a disruption event. This finding is consistent across every [National Defense Stockpile] modeling excursion by DoD since 2009.
>
> ——
>
> Overall, the essential civilian [neodymium-iron-boron, "NdFeB") shortfall and outsized reliance on embedded demand indicates that a civilian-centric mitigation approach is necessary. DoD and Federal Government activities can act as a catalyst, but absent collaboration with the private sector, government-driven mandates circumscribed to defense procurement will not be sufficient to close the gap between peacetime consumption and postulated national emergency shortfalls.[74]

In the one-year period following the release of this report, the Biden administration launched a sweeping peacetime legislative and administrative agenda to support critical minerals and lithium-ion batteries, much of which built-upon the foundations set during the preceding administration. For example, in September 2021 the Department of Commerce initiated a SEC. 232 investigation on neodymium-iron-boron rare earth permanent magnets,[75] and through spring and summer 2021, the administration worked with Congress to develop the *Infrastructure Investment and Jobs Act* (P.L. 117-58), which provided $51.4 billion, principally to the Department of Energy, to support clean energy industrial base and infrastructure programs.[76] Of these funds, ~$8 billion would be directed toward critical minerals and battery activities (see **Figure 14**).

Figure 14: Key Battery and Critical Minerals Funding Lines, Infrastructure Law

Agency	Program	Funding (US$ M)
Department of Energy	Battery Materials Processing Grants	$ 3,000.0
	Battery Manufacturing & Recycling Grants	$ 3,000.0
	Advanced Energy Manufacturing & Recycling Grants	$ 750.0
	Industrial Emission Demonstration Projects	$ 500.0
	Battery & Critical Mineral Recycling	$ 125.0
	Critical Material Supply Chain Research Facility	$ 75.0
	Lithium-Ion Recycling Prize	$ 10.0
Department of Interior	Earth Mapping Resources Initiative	$ 320.0
	Energy & Minerals Research Facility	$ 167.0
TOTAL		**$ 7,947.0**

Calendar year 2022 was a break out year for the Biden administration on critical minerals and battery initiatives, opening with the issuance of a Presidential Determination under DPA Title III for critical minerals necessary for the clean energy transition.[77] Notwithstanding the initial excitement around this Determination, no funding would become available to execute it until the adoption of the *Additional Ukraine Supplemental Appropriations Act, 2022* (P.L. 117-128) in May 2021 ($500 million) and then the *Inflation Reduction Act* (P.L. 117-169) ($250 million). Awards from these appropriations to cobalt projects are shown in **Figure 12**.

However, the far more significant change in US posture toward both critical minerals and batteries arrived with the rapid introduction and promulgation of the *Inflation Reduction Act* (P.L. 117-169) in August 2022. Though the direct outlay of funding for critical minerals and battery activities in the *Inflation Reduction Act* is only marginally greater than the *Infrastructure Investment and Jobs Act* (see **Figure 15**),[78] the most significant difference is the character of these funds. Funding provided under the *Infrastructure Investment and Jobs Act* largely consists of cash "grants," whereas the largest source of direct funding is provided as "credit subsidy" under to the Department of Energy's Loan Program Office.

Figure 15: Key Battery and Critical Minerals Funding Lines, Inflation Reduction Act

Agency	Program	Funding (US$ M)79
Department of Energy	Loan Program Office – Title 17 Program	$ 3,600.00
	Loan Program Office – Advanced Technology Vehicles Manufacturing Loan Program	$ 3,000.00
	Domestic Manufacturing Conversion Grants	$ 2,000.00
Department of Defense	Defense Production Act Purchases	$ 250.00
TOTAL		**$ 8,850.00**

In accordance with the *Federal Credit Reform Act of 1990* (P.L. 101-508) and for a direct loan, a credit subsidy is the "down payment" that an originating agency pays to the Department of Treasury to extend credit to a loan applicant. This "down payment" reflects the US Government's assessment of the net present value (NPV) of the cost of extending credit. This subsidy can be positive (indicating losses on an NPV basis) or negative (indicating gains on an NPV basis). Positive subsidies require the originating agency to transfer appropriated funds to the Treasury to cover anticipated loan losses, but under a negative subsidy scenario, the originating agency is not required to transfer any appropriated funds to extend credit. Multiple variables impact a positive or negative subsidy calculation, and select variables include borrower fees (e.g., fees on undisbursed funds, third-party consultant fees), cash-flow projections, repayment schedule (e.g., balloon payments, grace periods), credit spread (if any), deal structure (e.g., non-recourse subsidiary borrowing), loan recovery rate assessment, and probability of default.

In a review of *Infrastructure Investment and Jobs Act* and *Inflation Reduction Act* awards, the Department of Energy has not issued any funds for cobalt refining to date. However, the Department of Energy is indirectly supporting domestic production of cobalt through the recovery of cobalt units via recycling programs funded under both laws. Furthermore, both loans issued by the Department of Energy's Loan Program Office are conditional offers, subject to additional conditions precedent before close of these transactions. Both selectees likely will be required to make equity contributions as part of their loans, and assuming an 80::20 debt to equity ratio, these contributions may reflect the amounts shown in **Figure 16**.

Figure 16: Key Battery and Critical Minerals Funding Lines, Inflation Reduction Act

Program	Awardee	Government Funding (US$ M)	Awardee Match (US$ M)
(IRA) Loan Program Office – Advanced Technology Vehicles Manufacturing Loan Program	Li-Cycle	$ 375.0	$ 93.7*
	Redwood Materials	$ 2,000.0	$ 500.0*
(IIJA) Battery Materials Processing Grants (IIJA) Battery Manufacturing & Recycling Grants	Cirba Solutions	$ 74.9	$ 162.1
TOTAL	**$ 2,454.9**		**$ 755.8***

* Estimated

Grants and loans aside, the far more important impact of the *Inflation Reduction Act* are two perpetual tax credits for: (1) refining cobalt minerals ("Section 45X") and a two-part $7,500 tax credit for EVs based on (2a) the manufacture of assembly of the EV in North America and (2b) the critical mineral content of the battery pack from the US or a free trade agreement nation ("Section 30D").

Proposed rules issued by the International Revenue Service (IRS) for Section 45X confirm, as provided in the *Inflation Reduction Act*, that the 10% production cost tax credit for critical minerals, including cobalt, is perpetual under current law. In the case of cobalt, the proposed rules mirror the statute precisely, covering (1) the conversion of an upstream cobalt product to cobalt sulfate; and (2) the conversion of an upstream cobalt product form to elemental cobalt that is purified to 99.6% cobalt, by mass (e.g., metal).[80]

For the Section 30D tax credit, the IRS has issued a final rule for both portions of the tax credit, supported by the issuance of a final rule by the Department of Energy with respect to "foreign entities of concern."[81] The IRS rule also confirms the perpetual nature of the revised 30D tax credit under current law. Unlike the Section 45X tax credit, the Section 30D tax credit features a phase-in period for North American assembly, from 50% to 100% from 2024 to 2028, and contained critical minerals content, from 40% to 80% from 2024 to 2027.

For the first half of the tax credit (2a, North American assembly), the final rules establish a four-step process to determine whether an EV meets the Battery Component Requirement, adopting a "substantially all manufacturing or assembly" performance standard. This approach is common in "Buy America" type procurement requirements by the US government, but in this case, the geographic remit is expanded to the US-Mexico-Canada free trade Agreement (USMCA) area. Battery components are defined as active material components (e.g., anode electrodes, cathode electrodes) and non-active components (e.g., battery cells, modules).

For the second half of the tax credit (2b, critical minerals content), the IRS provides a three-step process, beginning with (1) supply chain due diligence to determine procurement chains; (2) identification of qualifying critical minerals; and (3) calculating qualifying critical mineral content. Step 2 is the most complicated, testing for (a) the jurisdiction in which the critical mineral (b) was mined, processed, or recycled (c) while calculating the incremental value-added at each step of the supply chain. Only the incremental value-add at a given production step, not the complete value chain, enables a given critical mineral to be determined as a "qualifying critical mineral."

With respect to the jurisdiction of qualifying critical mineral extraction and processing, the final rule establishes its geographic scope as those nations that have concluded a comprehensive free trade agreement with the US[82] and Japan. The IRS also noted it would expand the list of qualifying critical mineral countries under this final rule as or if future agreements are concluded.

Notably, this benefit for "free trade agreement nations" under the *Inflation Reduction Act* has provided a powerful economic incentive for critical minerals diplomacy by the Department of State and the Office of the US Trade Representative. The latter spearheaded the conclusion of a Critical Minerals Agreement with Japan in March 2023, which provided free trade agreement-like provisions to reduce trade barriers on critical minerals and share information on interventions by other governments in the critical minerals and EV battery sectors.[83] Other trading partners, such as Indonesia and the European Union, are seeking similar arrangements.[84] Crucially for the cobalt sector, the Department of State led the development of a Memorandum of Agreement with Zambia and the Democratic Republic of Congo on the development of local EV supply chains, including the development of co-financing opportunities.[85] This arrangement has already begun to bear fruit, with the US International Development Finance Corporation's Board of Directors approving a $553.0 million loan for the development of the Lobito Corridor, an alternative logistics route for export of Central African products.[86]

Notwithstanding the geographic jurisdiction of extraction, processing, or recycling, the presence of any material from a "foreign entity of concern" (FEOC) excludes a particular component or material from *Inflation Reduction Act* benefits.[87] Though other nations are included within the scope of an FEOC, the principal FEOC of concern for the purposes of critical minerals and EVs is China.

An FEOC consists of a "foreign entity" that is "owned by, controlled by, or subject to the jurisdiction or direction of a foreign government," in this instance, the People's Republic of China. Foreign entities consist of foreign governments, non-US citizens or permanent residents, and enterprises organized under the laws of or with a principal place of business outside the US. However, the Department of Energy's interpretive guidance also establishes that the US subsidiary of a foreign entity also qualifies as a "foreign entity." In turn, a foreign government includes national and subnational government entities, as well as senior political figures of a foreign government.

The most challenging portion of the FEOC rule pertains to "control" via ownership or technology licensing. Ownership "control" is achieved by the highest-level ownership in an entity's corporate structure, with a 25% threshold. For example, if a foreign entity holds a 30% equity position but only one of 10 seats on its board of directors (10%), ownership is 30%. These ownership ratios become multiplicative in the event of more complicated ownership structures (e.g., a pass-through entity). Technology licensing "control" also may be determined by the conclusion of a licensing arrangement or other agreement (e.g., a contract manufacturer) that enables another entity to exercise effective control over a production process.

Notwithstanding the prohibition on accepting FEOC components and critical minerals for the Section 30D tax credit, the US government also has recognized that, in the short term, Chinese companies and joint ventures remain the most significant global miners and processors of critical minerals for EVs. Thus, Section 30D tax credit rules provide an exemption for "impracticable-to-trace" battery materials, provided that a manufacturer engages in due diligence and tracking activities. However, this exemption only extends through 2026.

B. Price Volatility

In the course of this assessment, the author shared the cobalt metal price-to-mine production chart in **Figure 2** to elicit responses from market participants on their experience producing, buying, or selling cobalt products over multiple business cycles.

In general, market participants characterized the cobalt market as one with thin margins during short periods of market stability, which have been disrupted by geopolitical events (e.g., political instability in the DRC) or changes in technology (e.g., the initial rise of consumer electronics demand, followed by EVs). During the subsequent price spike, cobalt market participants gain "make-up margin" from previous down-cycles, while preparing for the next down-cycle. As prices rise, existing cobalt miners and refineries may run their facilities harder to produce more or to release inventory. Higher cost producers and "swing" producers (e.g., artisanal miners) may re-enter the market. Increase in supply, particularly from re-starts, often mis-times market need, contributing to a supply over-shoot that may endure for several years. The supply over-shoot also may spark a race among the now-expanded pool of miners and refiners to endure short-term losses until sufficient productive capacity exits the market. With supply receding, this cycle is primed to repeat.

Though some industry participants caution that recent industrial policy interventions and new low-cost production may render this historical pattern obsolete; other industry participants have cited a further one- to two-year period to work out current oversupply before the market comes back into equilibrium.[88] Notably, this two- to three-year timing for a cobalt recovery is the average duration of cobalt price "troughs" from 1976 to the present (see **Figure 2**).

Given current market conditions, some market participants suggested the US government should evaluate establishing a *de facto* price "floor" of $44,000/t to $50,000/t on a cobalt metal basis (~$20 / lb. to $22 / lb.) by adding to its stockpile whenever prices fell below this level. The rationale for this price floor is the observation that, once the cobalt metal price dips below this mark, selected Western cobalt refineries and miners also become at risk of facility closure. Timely intervention at this price benchmark could be offset by re-selling material into the cobalt market during severe price spikes. Further, such a price floor mechanism would give additional certainty to prospective investors in cobalt projects, that sufficient return on capital may be generated through boom-and-bust cycles.

Additional analysis on this approach is covered in "**Recommendation 3: Integrate**" related to stockpiling.

On the other hand, as production and trade in cobalt forms other than metal (e.g., MHP from Indonesia, sulfate in China) grow, cobalt metal may cease to be as dominant of a reference product for future pricing. Additionally, some industry participants observed that they have shifted to cost-plus contracting arrangements with their customers, which provides some insulation from price volatility. Others have introduced "price collars" into their contracts, which insulate the customer from the peak-pricing but guarantee a reasonable rate of return for the producer during a severe market correction; thus, in such an arrangement, the spot price reflected by a price reporting agency may not reflect the actual price transacted by market participants. On the other hand, multiple market participants noted challenges associated with customers claiming "price *majeure*", using a supply chain disruption to opportunistically depart from a higher-cost long-term contract to repurchase cheaper material on the spot market.[89]

V. US Government Policy Review–Consistency or Stasis?

This study in the cobalt market began with an overview of the disruption to the global supply in the late 1970s, which spurred considerable US government attention on the rejuvenation of US stockpiles and consideration (but not action) on investment in the domestic industrial base. Similar call-and-response activities appear from 2020 to today, with global supply chain disruptions from the COVID-19 pandemic seemingly spurring more interventionist policies in the US. Returning to the original question then, "What then should we make of US Government policy toward critical minerals? Are we seeing a remarkably consistent approach that has withstood the test of time, or are we seeing an equally remarkable policy stasis that has yet to innovate beyond the early 1980s?"

In this circumstance, pointing to COVID-19 pandemic supply chain disruptions is a classic *post hoc ergo propter hoc* fallacy; large-scale industrial base interventions by the Trump administration and the Biden administration in the critical minerals sector may have followed the COVID-19 pandemic, but that does not necessarily indicate causality. Instead, the evolution of US government policy toward the cobalt market is a microcosm of the acceleration of geopolitical competition.

The 21st century opened with a mid-air collision between a US Navy signals intelligence aircraft and Chinese interceptor aircraft, ultimately resulting in the death of a Chinese pilot, an emergency landing by the US Navy aircraft in China, and after apologies and compensation, the return of the aircraft to the US. Fast forward a decade, and a collision between a Chinese fishing boat and a Japanese Coast Guard vessel initiated an "embargo" on rare earth elements and litigation in the World Trade Organization regarding rare earths, tungsten, and several other commodities. In the years that followed, the US government and some US companies became increasingly active, respectively, in the prosecution and vocal accusations of cyber-intrusions and theft of intellectual property.[90] US perceptions of China's already large or (in the case of cobalt) rapidly growing market-share across extraction, refining, and production of critical minerals shifted from one of sharing the benefits from international trade to one of a potentially dangerous and costly over-reliance. The rapid growth in the Chinese economy was matched by equally impressive modernization of its armed forces.

Only at the end of this long sequence of events did the harmful impact of a supply disruption, once theoretical, became very real in medical facilities and grocery stores across the US.[91]

Geopolitical competition between two roughly even-matched actors, particularly ones as wealthy and powerful as the US and the People's Republic of China, invariably is highly complex. With that in mind, the programmatic tools deployed by the US government are not new (e.g., DPA Title III, stockpiling, international diplomacy, development finance, tax credits). However, the great innovations of the past eight years are (a) the acceleration in the speed of government action; and (b) the focus on mutually reinforcing solutions, cutting across agency lines, to address industrial and national defense challenges. In that sense, the various reports on the public health industrial base, the defense industrial base, semiconductors, and critical minerals under Executive Order 14017, Executive Order 13817, and Executive Order 13806 might be considered the "National Security Council Paper (NSC) Paper—68"[92] of our time—another inter-agency report which marked the decisive shift in US Government posture and resourcing toward long-term competition with the Soviet Union.

VI. Recommendations for US Government Action

RECOMMENDATION 1: Maintain Long-Term Stability in Minerals Policy

One of the most remarkable aspects of US government policy toward critical minerals has been the consistent and iterative approach adopted first by the Trump administration and then furthered by the Biden administration. Although many issues in US domestic politics exhibit two- to four-year swings, critical minerals—thus far—are a rare island of stability.

Figure 17: Trump and Biden Administration Minerals Initiatives, Compared

Policy Initiative	Trump Administration	Biden Administration
Non-Defense Engagement with US Allies and Partners	Energy Resources Governance Initiative	Minerals Security Partnership
		Partnership for Global Infrastructure & Investment
Joint US–Foreign Acquisition Programs	Planned with Canada but deferred by COVID-19	DPA Title III projects with Canada
		Expanded DPA "domestic sources" to Australia and the United Kingdom
DPA Title III Investment Scope	Rare Earth Elements	Battery minerals
		Other National Defense Stockpile shortfall materials
National Defense Stockpile policy	Going concern risk identified to Congress	New appropriations (>$253M)
	Inventory release exercise deferred by COVID-19	Inventory release authority delegated by Executive Order
Trade Defense	SEC. 232 investigations (multiple)	SEC. 232 investigation (NdFeB magnets)
	SEC. 301 (China) tariffs initiated	SEC. 301 (China) tariffs maintained and expanded
National Emergency Risk Potential	Declaration of a national emergency with respect to foreign dependence for critical minerals	Waiver of DPA Title III Determination requirement for National Defense Stockpile shortfall materials

The Trump administration built upon the human capital foundation established during the Obama administration, leveraging the inter-agency Critical Minerals Subcommittee of the National Science and Technology Council (NSTC) to develop the inaugural Federal Strategy on Critical Minerals.[93] With the promulgation of this strategy and, soon thereafter, the first "Critical Minerals List," the subcommittee became the focal point for establishing policy priorities, sharing information across agencies, implementing critical minerals policy, and providing regular progress reporting to the Executive Office of the President. The Biden administration, similarly, used this group to launch its review of critical mineral supply chains under Executive Order 14017 and coordinate domestic and international policy.[94]

This consistency of policy development is equally mirrored in implementation. Notably, President Trump issued five Determinations under DPA Title III to support the development of a domestic rare earth supply chain, including (1) light rare earth separation, (2) heavy rare earth separation, (3) metal and alloy making, (4) samarium-cobalt magnet manufacture, and (5) neodymium-iron-boron magnet manufacture.[95] President Biden followed suit with a similar DPA Title III Determination covering the "strategic and critical materials necessary for the clean energy transition."[96] Both administrations also recognized that the risks associated with "critical minerals" are broader than rare earth elements and the energy transition, translating into executive action to expand the delivery of loans/loan guarantees to domestic mining activities[97] and other critical mineral supply chains.[98] Additional examples abound, such as identification of going concern risk at the National Defense Stockpile program, followed by the deployment of new appropriations and stockpile reforms.[99]

Therefore, it is crucial that the next administration and the next Congress exhibit consistency of policy approach and resourcing. Developing, building, and operating cobalt mines, refineries, and recycling plant —like most other critical minerals projects—is a long-term undertaking; policy predictability is essential to maintain the forward momentum of the past eight years.

RECOMMENDATION 2: Keep "National Defense" Broad to Achieve Genuine Resilience

Since the DPA 's enactment, the US government has taken an expansive view of those materials, technologies, and sectors of the US economy that are necessary to support the national defense. The fundamental underpinning to this broad perspective was the World War II, Korean War, and immediate post-Korean War experience, in which the US deployed all elements of national power to win the immediate fight and to prepare for future conflicts or emergencies.

To support defense and non-defense industrial sectors critical to the war effort during the Korean War and in its immediate aftermath, the military services and non-defense agencies entered into an array of "voluntary agreements" under DPA Title VII[100] or the acquisition and investment programs under DPA Title III. For example, the Federal Reserve chartered a voluntary agreement to encourage the US financial sector to restrain issuing credit to industrial sectors unaffiliated with the war effort, while encouraging issuing loans to defense production and indirectly required goods and services.[101] The Air Force also established voluntary agreements for the production of the B-47 bomber and J-47 jet engines (for the B-47 and F-86 Sabre), to split large-scale production contracts among prime contractors, more rapidly integrate engineering changes across each production line simultaneously, and collaboratively manage sub-tier supplier constraints.[102] Additionally, the Department of Interior (DoI) managed an array of DPA Title III programs—Defense Minerals Administration, Defense Minerals Exploration Administration, and the Office of Mineral Exploration—to encourage the discovery and development of domestic "critical minerals."[103] This work was intended to be partially self-funded, with recipients obligated to repay the DoI through a 5% royalty on gross proceeds if the project entered production.[104]

This expansive view of national defense evolved in the post-Cold War era to include an array of non-military emergencies and national priority projects. For example, the Department of Commerce deployed its authorities under DPA Title I to expedite contracts executed by the US Architect of the Capital: to complete infrastructure upgrades to the Senate Legislative Garage and Federal Bureau of Investigation contracts for its Terrorist Explosive Device Analytical Center; the Federal Emergency Management Agency also regularly uses its authority under DPA Title I to expedite contracts and orders to house and feed disaster survivors and first responders (e.g., wildfires and hurricanes).[105] Perhaps the most widespread use all extant DPA authority occurred to respond to COVID-19 pandemic: expediting contracts, allocating scarce materials to domestic supply chains, prosecuting hoarding of scarce materials, expanding domestic production, and launching a new voluntary agreement.

However, some defense policy advocates have expressed varying degrees of concern related to the deployment of DPA authorities outside the traditional military sphere.[106] At the outside, some have cited that none of the DPA Title III funds from the *Inflation Reduction Act* and executed by the DoD have supported national defense needs.[107]

As a general rule, defense consumption of a critical mineral tends to be closely correlated with the percentage of a nation's gross domestic product (GDP) that it spends on defense.108 Put differently, civilian consumption for a given critical mineral is the principal demand driver in peacetime, and military consumption is the principal driver in wartime. However, this is the problem. Defense spending as a proportion of GDP rapidly increases in wartime, particularly if the conflict is protracted and involves two near-peer or peer adversaries, and this ramp-up in defense spending far outpaces the ability of all tiers of the industrial base to respond in the short-run. This disconnect between what can be economically sustained in peacetime and what was necessary in wartime is essential to the "preparedness" mission of the DPA.

Critical minerals industrial base solutions limited to steady-state defense requirements are unlikely to be of sufficient volume or value to sustain a production facility for a material period of time. Although the cobalt case study is more fortunate, in that the dominant material form in defense products (i.e., cobalt metal) is amenable to conversion into those forms necessary for commercial applications (e.g., cobalt sulfate for batteries), the DoD's history of defense-scoped minerals investment and acquisition programs is littered with examples of withdrawn production subsidies leading to plant closures.109 Therefore, the integration of critical minerals requirements for "defense" capabilities as a subset of "commercial" production facilities provides a more robust economic solution and preparedness posture for a national emergency.

RECOMMENDATION 3: Integrate Government Incentives towards Industrial Outcomes

(Executive Office of the President)

Shortly after the adoption of the *Infrastructure Investment and Jobs Act* (P.L. 117-58), the *CHIPS and Science Act* (P.L. 117-167), and the *Inflation Reduction Act* (P.L. 117-169), the Biden administration issued a fact sheet highlighting the development of an "American Battery Materials Initiative" (ABMI), which would herald a mineral-by-mineral approach to expanding domestic production of critical minerals for large-capacity batteries. Among other tasks for the ABMI was coordination of the slew of inter-agency initiatives supporting critical minerals development, including grant and loan programs, community engagement and permitting, and international diplomacy.[110]

Although there has been no shortage of grant, contract, and loan announcements since the roll-out of ABMI and the adoption of the aforementioned legislation, perhaps most striking is the absence of the phrase "mineral-by-mineral approach" since the release of this fact sheet or the 100-day report under Executive Order 14017. Similarly, executive branch agencies appear to be missing opportunities to provide agency-unique support across the US government.

For example, the DoD, Department of Energy, and Department of State announced a joint stockpiling initiative in February 2022, but no new information has been released since the initial announcement.[111] In addition, South32's Hermosa Project in Arizona received approval for the FAST-41 process to streamline permitting for its manganese project, which also received $20 million under DPA Title III.[112] Although Perpetua Resources' Stibnite-Gold Project has received acceptance to the FAST-41 process and DPA Title III funds, no other DPA Title III project—defense or non-defense, sponsored by DoD or any other US Government agency—has been placed on the FAST-41 dashboard.

Although each Executive Branch department and agency (individually) appears to be executing its funding and statutory authorities effectively, these actions appear to be the lesser of the sum of their parts. A more deliberate shift toward an "Integrated Approach" may deliver greater value and speedier decision-making. Thus, the Executive Office of the President should lead a process for (a) decomposing project delivery and industrial development goals into regular inter-agency tasks and (b) consolidating and eliminating the ad hoc **working groups that have sprung-up since 2020 and that do not add quantifiable value to project delivery.**

Further, the following recommendations (#4- #10) constitute some of the recurring "tasks" that the US Government should undertake. Some may require new legislation, but all would materially benefit the development of a US cobalt supply chain.

RECOMMENDATION 4: Attract Highly Qualified Foreign Talent to "National Priority Projects"

(Department of State / Department of Homeland Security)

The US already provides for a special immigrant visa class (i.e., H-1B2) for those foreign workers who support a defense cooperative research and development project or a coproduction project under a government-to-government agreement. However, no special sub-class exists for other national priority projects, such as those funded under the *CHIPS & Science Act* or the *Inflation Reduction Act*. Aggregate H-1B visa issuance is limited to not more than

65,000 visas annually, with recent applicant selection rates ranging from 46% to 27% of applicants.[113]

US government agencies have provided expedited access to key foreign talent in the past. For example, during the COVID-19 pandemic, the State Department coordinated with the Department of Homeland Security and other US government agencies to waive in-person interviews for multiple visa categories for foreign nationals who were supporting industrial base investment programs.[114] Based on the author's first-hand experience managing several such programs and requesting this support from both departments, these actions by the Department of State and the Department of Homeland Security were instrumental to ensuring the rapid scale-up of public health product manufacturing, as well as providing highly qualified foreign national engineering service support for defense programs.

Based on author interviews with industry participants, identifying qualified US citizens to support onshoring projects is a significant challenge, due to high demand. This demand-driven activity is exacerbated by labor supply constraints from an overall "greying" of the US mining workforce and decline in geoscience graduates, at all levels.[115]

Therefore, the Congress and the Executive Branch should evaluate the modification of a current visa class or creation of a new visa class to bring highly-qualified foreign talent to the US, as necessary or required, to execute "national priority projects." Such project may include those executed under DPA Title III, the Inflation Reduction Act**, the** Infrastructure Investment and Jobs Act**, the** CHIPS & Science Act**, projects on the FAST-41 dashboard, and future national priority project legislation. To the extent permissible within existing law, the Department of State and the Department of Homeland Security should provide administrative priority to processing visa applicants for those foreign workers supporting national priority projects.**

RECOMMENDATION 5: Increase Cobalt Stockpiling to Ensure Emergency Supply

(Department of Defense/Department of Energy/Department of State)

Stockpile programs are fundamentally two types: (a) "strategic" stockpiles to mitigate the harmful effects of a "black swan" or other national emergency event; and (b) "economic" stockpiles to stabilize market prices, support particular producers, or meet other industrial policy objectives. As is suggested by the potential harm these stockpiles are intended to mitigate, "strategic" stockpiles tend to be more conservative and insensitive to day-to-day commodity price fluctuations; "economic" stockpile programs tend to focus on short-term supply, demand, and price activities, with a much more interventionist posture. For example, the DoD's National Defense Stockpile program is a "strategic" stockpile, and the Department of Energy's Strategic Petroleum Reserve is an "economic" stockpile.

Before wading into the "economic" versus "strategic" stockpile debate, the DoD indirectly consumes cobalt metal and cobalt powders in steel, superalloys, and carbides embedded in jet engines and armor-piercing munitions, among other applications. US consumption of cobalt metal averaged ~5,900 tpa over the past decade, and notwithstanding the lack of growth in ex-China cobalt metal production over that period, ex-China production is distributed around the globe (~69%) and includes several US allies in Norway, Australia, Canada, and Japan. However, Chinese production capacity is double the nearest US ally, and if the defense industrial base were compelled to draw from the National Defense Stockpile, the inventory may be depleted in 19 days.[116] This level is clearly inadequate and should be increased.

The National Defense Stockpile, for its forthcoming *Strategic and Critical Materials 2025 Report on Stockpile Requirements* (January 2025), should assess the necessity of stockpiling cobalt metal, cobalt powders, or other relevant product forms. If this assessment cannot be undertaken before the delivery of this report to Congress, then the National Defense Stockpile should undertake this assessment as an off-cycle study, for internal completion during the first half of Fiscal Year (FY) 2025, to inform the FY 2026 or FY 2027 appropriations cycles.

Independent of the National Defense Stockpile and the DoD's need to mitigate potential vulnerabilities to defense-unique supply chains, several policymakers have raised the broader concern of the essential civilian industrial base's exposure to price and supply manipulation by foreign sources.[117] The Biden administration appears to have recognized this potential threat as well, with the announcement of a tripartite Memorandum of Agreement among the DoD, the Department of State, and the Department of Energy to stockpile critical minerals for defense and clean energy applications. The agreement is intended to undertake the following tasks (among others)[118]:

- Integrate extreme weather events (e.g., 2021 North American cold wave, US Gulf Coast hurricane, East Asia typhoon) in National Defense Stockpile planning as an alternative case scenario;
- Assess stockpile requirements for high-priority critical minerals for the energy transition and defense needs;
- Execute off-take agreements with domestic mining, refining, and recycling companies to meet acquisition needs, to include co-mingling stockpile purchases with other investment programs executed by the Department of Energy or under DPA Title III.

Since its initial announcement, none of the signatory departments have provided a material update on the memorandum or its implementation workstreams.

The evaluation of extreme weather events is well within the bounds of National Defense Stockpile planning requirements as an alternative peacetime disruption scenario. For example, in the 2011 and 2013 iterations of the *Strategic and Critical Materials Report to Congress,* the National Defense Stockpile assessed a series of peacetime supply disruptions, including: (a) an export cut off from China intended to coerce the US (or US allies), (b) an export cut-off by the Russian Federation, and (c) a deterioration of the South African economy and infrastructure. 119 The 2011 and 2013 assessments also served as test beds for evaluating the economic impact applying DPA Title I (e.g., allocating scarce supply for defense purposes at the expense of US civilian industry), which informed the US Government's COVID-19 response functions.

Extractive metallurgical enterprises and their customers may be particularly susceptible to extreme weather risk due to the industrial logic in siting these facilities. More specifically, value-added battery chemical refiners and battery manufacturers can generate significant operational synergies and reduced costs by co-locating. These operational and logistical benefits can be multiplied when located in industrial parks, with ready access to low-cost power, chemical reagents, and port/rail facilities (e.g., the US Gulf Coast, Bécancour Industrial Park).

The National Defense Stockpile should continue to integrate alternative peacetime disruption scenarios periodically, to test the validity of economic planning assumptions as well as industrial base investment and stockpile contingency planning.

RECOMMENDATION 6: Position US Government on One Side of Transaction

(Department of Defense / Department of Energy / Department of State)

With respect to the acquisition of battery materials for an "economic" stockpile, the author is concerned about the US government "sitting on both sides of a transaction" (e.g., the government providing capital support for project construction, while "repaying" that capital support with a purchase contract to a stockpile program). In effect, the US government would have two competing subsidies and may be ineffective. Namely, purchases or purchase commitment subsidies: (a) may be under-funded at the outset, given competition within annual budgets; and (b) may tie-up significant "obligated" but "unexpended" funding balances when used in a contingency-type contract (e.g., a right of first offer).[120] In addition, regularly adopting a position on both sides of a transaction also may (a) crowd-out private capital investment or commercial off-take and (b) increase moral hazard within the metals and mining sector, given an expectation of a US Government capital and purchasing support during market downturns or a crisis.

In light of these risk factors but acceding to the essential civilian risk potential, the DoD, Department of Energy, and Department of State should initiate a pilot program to develop the internal operating procedures, operating thesis, and technical aspects of broader battery minerals stockpiling activities. Of these, technical issues (e.g., material specifications, logistical requirements, audit, and security requirements) are the easiest to undertake. However, signatory agencies to the memorandum should devote significant time to a clear, written statement of the program's mission, its operating posture, risk tolerance, and other policy-subjective factors before initiating a full-scale program. These parameters also should be clearly expressed, in written form, to the relevant committees of Congress, so such a program may be appropriately resourced and authorized.

RECOMMENDATION 7: Leverage Trade Actions to Expand Access to Resilient Supplies

(Department of State/US Trade Representative)

Through the Trump administration and the Biden administration, the US government has adopted a more forward-leaning posture in the implementation of tariff barriers (e.g., SEC. 301 of the *Trade Act of 1974*), as well as the imposition of non-tariff barriers (e.g., the *Uyghur Forced Labor Prevention Act* (P.L. 117-78)) to respond to the theft of intellectual property and uphold US values related to the prevention of forced labor. Simultaneously, the Biden administration is leveraging the significant economic benefits associated with more recent investment legislation (e.g., *CHIPS and Science Act* and the *Inflation Reduction Act*) to strengthen its trade ties with close US allies and foreign direct investment.

Trade enforcement and policy tools are important mechanisms to level the playing field for US industry, particularly when its competitors have benefited or continue to benefit from state aid or, in some cases,

state-sponsored industrial espionage. Regardless of its benefits to US producers, an import tariff is a tax on consumers, and the imposition of tariff barriers should be calibrated to achieve a specific outcome.

On the other hand, an equitable lowering of tariff and non-tariff barriers as a component of US diplomacy has the potential to reap far more significant benefits. Building upon the initial success of the Memorandum of Agreement with Zambia and the DRC, the Congress and the Executive Branch should evaluate a modernization of the African Growth and Opportunity Act (AGOA) to provide "free trade agreement" benefits under the Inflation Reduction Act**, provided that such minerals are exported to the US or another free trade agreement nation. Integrating** Inflation Reduction Act **"free trade agreement" status into AGOA may provide African nations with a more viable alternative to Chinese investment, in that extant "foreign entity of concern" rules would provide a powerful incentive to seek alternative sources of capital.**

RECOMMENDATION 8: Amend Reliable Sourcing Rules to Support Domestic Production

(Department of Defense)

As previously discussed in this report, the DoD currently implements two—with a third related to batteries expected later in 2024—important procurement restrictions related to cobalt materials: (a) the "specialty metals" clause at 10 USC. 4863, covering steel and nickel- and cobalt-base alloys, and (b) the "sensitive materials" rule at 10 USC. 4872, covering samarium-cobalt magnets. In general, these rules have an opposing rule structure, in that 10 USC. 4863 establishes a positive rule for US and allied nation materials, where 10 USC. 4872 establishes a negative rule against China- and Russia-produced cobalt products. Notwithstanding the product overlap between these rules, the exceptions or waiver procedures vary widely (see **Figure 18**).

Figure 18: Specialty Metals and Sensitive Materials Compared

	10 U.S.C. 4863	10 U.S.C. 4872
Applies to...	Alloy Steel, Nickel alloys, Cobalt alloys, Zirconium	NdFeB magnets, SmCo magnets, Tungsten metal / heavy alloys, Tantalum metals / alloys
Coverage Point?	"Melted or Produced"	2019 – 2025: "Melted or Produced" > 2026: "Mined, refined, separated, melted, or produced"
Domestic Only?	Yes, or "Qualifying Country" components, or "Qualifying Country" materials	No, Do not source from "Covered Countries"
Commercial Exception?	Yes, complex	Yes, simple
Electronic Component Exception?	Yes	Yes

Non-Availability Exception?	Yes	Yes
Recycling Exception?	No	Yes, but only NdFeB magnets
De minimis *purchase Exception?*	Yes, but inapplicable to SmCo magnets	No
Market Basket Exception?	Yes	No
Commercial-Derivative Military Article Exception?	Yes	No

The robust exception structure to 10 USC. 4683 was developed over the course of fierce advocacy activities by domestic smelters and defense prime contractors from 2007 to 2017. Although specialty metals non-compliance is identified from time-to-time,[121] the current rule balances sufficient protection to domestic and allied specialty metal producers, while enabling defense prime contractors and major subcontractors to avoid establishing DoD-specific production lines for commercial-derivative products. On the other hand, very little of this flexibility has been passed to the restrictions in 10 USC. 4872, and reasonable modifications to this statute would provide significant compliance cost reductions to defense prime contractors and major subcontractors with little to no impact on current or nascent cobalt refineries.

Therefore, the Congress and the DoD should develop a legislative proposal to amend 10 USC. 4872 in two ways: (1) expanding the current exception for recycled feedstock to all covered products and (2) including a market-basket exception. In current statute, a defense contractor or subcontractor would not be able to accept a samarium-cobalt magnet recycled in the US, if the initial production of that magnet occurred in China. This is a nonsensical restriction that actively discourages the development of closed-loop supply chains for materials or components already in the US. Similarly, a market-basket exception would enable a defense prime contractor or major subcontractor to bulk-buy a fixed percentage or volume of its total cobalt requirements from a compliant source, then co-mingle compliant and non-compliant cobalt units on its production line. This exception incentivizes the industrial base activity that cobalt producers want (i.e., off-take agreements), while minimizing defense-unique requirements to defense primes and major subcontractors.

Pending the release of new rules regarding prohibitions on the procurement of various batteries produced by Chinese companies, Congress and the DoD also may wish to assess whether additional modifications to 10 USC. 4872, 10 USC. 4863, are other Defense Federal Acquisition Regulation Supplement (DFARS) rules are necessary. For example, expansion of 10 USC. 4863 to cobalt metal would have no appreciable impact on defense procurement, given its widespread availability from US allies, but such a modification may provide some price protection, in the event that the cobalt metal market comes under even greater pressure due to its "convertibility" use-case for lithium-ion batteries. Similarly, a prohibition on the procurement of batteries produced by Chinese companies is unlikely to have a significant impact on direct DoD procurement, but sub-tier compliance may be a significant challenge, dependent upon (1) the extent to which commercial item exceptions, if any, are incorporated and (2) the treatment of Chinese companies' ex-China joint ventures and subsidiaries.

RECOMMENDATION 9: Embrace Joint Action with Allies

(All Federal Agencies)

Since the authorization of significant appropriated funds through the *Infrastructure Investment and Jobs Act*, the *CHIPS and Science Act*, and the *Inflation Reduction Act*, the Executive Branch departments and agencies have been surprisingly successful in combining their efforts and, in the case of the DoD, aligning US government funding with host government funding to achieve a greater industrial base impact. The total value of co-mingled funds to date is up to ~$4,895.6 million, inclusive of conditional and non-binding loan commitments (see **Figure 19**).

Figure 19: Joint Critical Mineral Investment Projects (US$ M) (August 2024)[122]

Company	Department of Defense	Department of Energy	US Export-Import Bank	Canada
Electra Battery Material Corporation	$20.0	—	—	$3.6M
Lithium Nevada Corp.	$11.8	$2,260.0M (Conditional Loan)	—	—
Lomiko Metals Inc.	$8.3	—	—	$3.6M
Fortune Minerals Inc.	$6.3	—	—	$5.6M
6K Additive LLC	$23.3M	$50.0M	—	—
Albemarle U.S., Inc.	$89.9	$149.6M	—	—
Talon Nickel (USA) LLC	$20.6M	$114.8M	—	—
Graphite One (Alaska) Inc.	$37.3M	$201.0M* (Applied)[123]	—	—
Jervois Mining USA Limited	$15.0 M	—	* (Eligible)	—
Perpetua Resources Idaho Inc.	$59.2 (DPA Title III) $15.5M (US Army) $0.2M (DLA)	—	$1,800.0M (Letter of Interest)	—
Subtotal	**$307.4M**	**$2,774.8M***	**$1,800.0M***	**$12.8M**
GRAND TOTAL	**$4,895.4M**			

It is difficult to understate the difficulty in coordinating an inter-agency and international project. The US government often struggles to achieve effective coordination within single agencies, but this also has been demonstrated, for example with Perpetua Resources obtaining US Army funding to qualify the company's material for ammunition and DPA Title III funding to complete environmental and engineering studies to obtain multiple permits.

This coordinated investment approach within the US government and with US allies is extraordinarily *abnormal.* Typically, US Executive Branch departments and agencies—and often program offices within agencies—compete with one another in a zero-sum game for resources (e.g., personnel and funding) and

perceptions of policy prestige. Joint industrial base investment under DPA Title III, or its predecessor statues, has not occurred since World War II.124

US and Canadian government staff should be proud of the projects they have launched to date, but delivering these projects will remain an ongoing work-stream for years to come. In the meantime, the informal policies, procedures, and lines of communication (intra- and inter-agency, as well as international) that have coalesced to achieve these results should be documented and integrated into new employee and recurring staff training packages, to convert them to institutional memory. Where appropriate, these practices also should be deployed against other longstanding public procurement challenges (e.g., bridging the technology development "valley of death"),125 noting that most critical minerals awardees are "small businesses" and "non-traditional contractors."

Additionally, the DoD should consider collecting the documentation associated with its awards and others126, so they may be used as instructional case studies for industrial mobilization and critical minerals courses at the National Defense University (NDU)127 and US military educational institutions (e.g., US Army War College). Notably, the student body at NDU and US military educational institutions are principally mid-career of US military officers, but some are members of the US civil service, Congressional staff, or mid-career Foreign Military Officers. Teaching these case studies would provide a recent and relevant dataset to further innovate and distribute best practices, while building future "joint" project managers.

RECOMMENDATION 10: Explore a "Lease-to-Recycle" Model to Reduce EV Adoption Cost

(Department of Energy)

One of the material differences between the purchase of an ICE vehicle and an EV is the commodity-price burden of the driving vehicle. When purchasing an ICE, the consumer has no ability to forecast the price of gasoline or diesel, but crucially, the consumer does not pay for the cost of fuel at the time of sale of the vehicle. Instead, this fuel cost is amortized over its lifetime. It is the opposite with an EV; namely, the consumer immediately pays for 12–15 years' worth of an EV's "fuel," regardless of the driver's intent to own the car for one year or 15 years. According to the Department of Energy, a typical US ICE car consumes ~443 gallons of gasoline per year; assuming an average annual gas price of $3 per gallon over an 8-year vehicle life, an equivalent impact to the initial purchase cost of an ICE would be ~$10,392.[128]

This buyer/seller challenge is not without precedent in other industry sectors, and one to consider is the aerospace sector. More specifically, when an airline, charter service, or private individual acquires an aircraft, they have the option to pursue an engine leasing arrangement with maintenance, repair, and overhaul (MRO) organizations. One of the significant benefits to engine leasing is that the purchaser avoids the total up-front cost of buying the engine, instead paying only the leasing fee for the use of the engine over a fixed period of time. Aircraft customers also avoid costly down-time or non-availability of their airframe, given regularly scheduled maintenance or inspections for engines and engine components. Some MRO organizations also allow for "engine swapping," with a replacement engine furnished to the purchaser while their engine undergoes maintenance. The MRO organization benefits from more predictable engine repair scheduling and, perhaps most important, consistent cashflows from leasing fees. Additionally, at the end of an engine's useful life, the MRO organizations or their toll-processors regularly disassemble and recycle the engine's high-value metals and metal coatings, such as rhenium-bearing superalloys and platinum group metals.

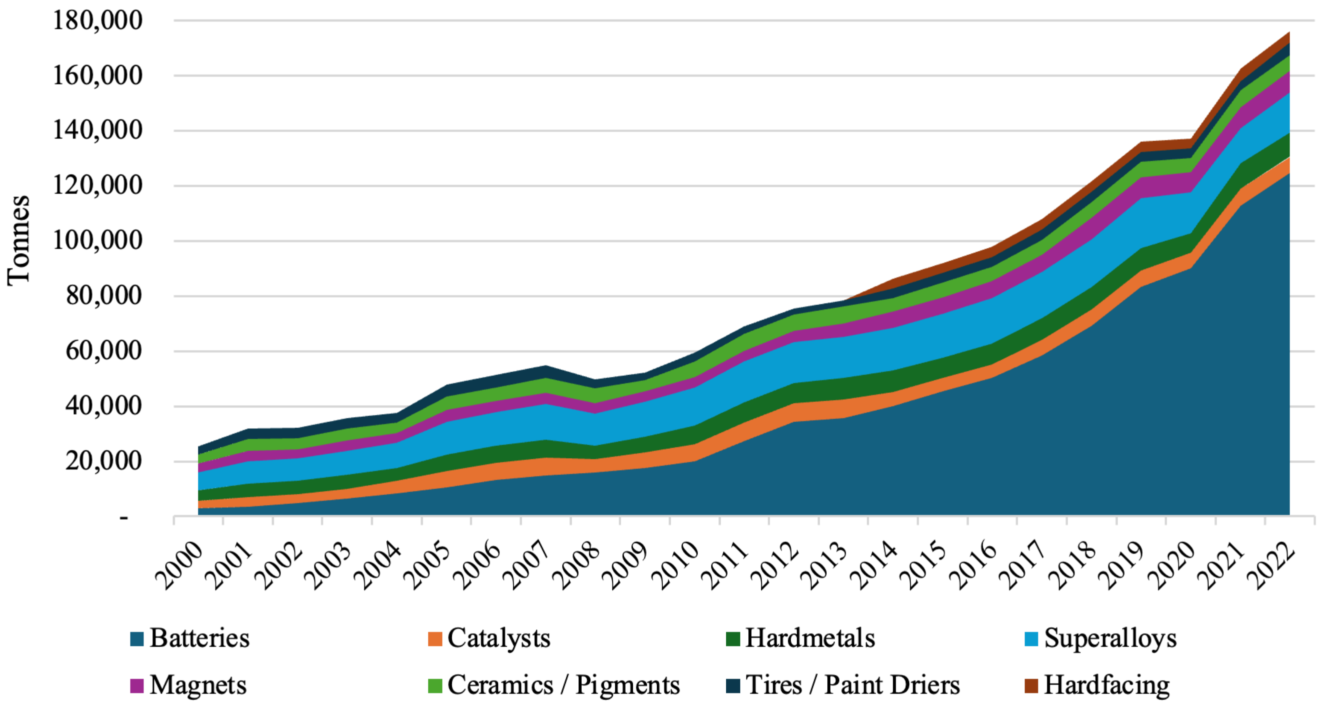
Therefore, the Department of Energy should evaluate a partnership with automotive financing organizations, battery manufacturers, and/or battery recyclers to evaluate the economic and technical feasibility of establishing "Lease-to-Recycle" programs for EV batteries. At minimum, a feasibility study should address two questions: (1) Are customers willing to pursue an alternative ownership option (i.e., no longer owned free-and-clear) in exchange for a lower initial purchase price? and; (2) To what extent should initial financial risk be mitigated? Other elements may include optionality for "battery swapping" to account for variable-range trips within a customer's lease period or battery upgrading, as well as integration with other economic incentives (e.g., transfer of tax credits under Section 30D).

With respect to the second question and controlling all other variables, few batteries likely would enter the recycle stream for the first several years of a "Lease-to-Recycle" program, since the batteries will be in use. Thus, vehicle financing organizations or other participants may require a US government loan guarantee or other financial assistance to bridge the "Lease-to-Recycle" program until such time as sufficient recycled feedstock is generated and cashflows (e.g., leasing fees, recycler toll fees) are proven to the market.

VII. Conclusion

This work has endeavored to provide a snapshot of the shifting trends in supply and demand within the cobalt supply chain, beginning as a relatively small-volume market focused on heavy industrial, aerospace, and defense customers. Over the past two decades, substantially all supply and demand growth has focused on a completely new market segment, consumer-oriented electronic products containing lithium-ion batteries (e.g., laptops, cell phones, and EVs). In sum, cobalt demand in lithium-ion batteries surpassed all other applications in 2016, and it has not looked back since that time.

Figure 20: Global Cobalt Demand by Application[129]



Though several Western research groups and manufacturers contributed to or, in some cases, led the initial technology development and production of lithium-ion batteries, this has not translated into material gains from widespread commercialization. Instead, the consistent application of fiscal and non-fiscal government incentives, supporting industry's desire to leap-ahead of incumbent manufacturers in the West, facilitated explosive cobalt demand from vehicle electrification in the People's Republic of China and, more recently, rapid supply increases from Indonesia. Though the US undertook some measures to shore up critical mineral supply chains other than cobalt (e.g., rare earth elements), a wholistic government approach was generally lacking—until now.

Notwithstanding the significant domestic and international policy differences between the Trump administration and the Biden administration, both effectively have the same approach to critical minerals: (1) securing those critical minerals necessary for the defense industrial base to support the full spectrum of contingency and deterrence operations and (2) leveraging all elements of national power—be it tariffs, grants, loans, or international diplomacy—to rebuild and grow the US manufacturing base with domestically- and ally-produced critical minerals. The only fundamental difference between them is the magnitude of fiscal resources deployed by the Biden administration, notably through the *Infrastructure Investment and Jobs Act*, the *Inflation Reduction Act*, and the *Ukraine Supplemental Appropriations Act, 2022*.

Each administration also has leveraged and innovated beyond the foundations provided by their predecessor. The Trump administration used the human capital base of the Obama administration's Critical Minerals Subcommittee of the National Science and Technology Council (NSTC) to develop the nation's first Federal Strategy on Critical Minerals. The Biden administration used this same group to develop their strategy towards critical minerals in Executive Order 14017, then mobilized them to execute and deliver critical minerals projects at a national scale.

This critical minerals policy "baton" has been passed between three very different administrations, giving significant grounds for optimism that what would otherwise appear to be a recent trend in critical minerals policy may, in fact, be a permanent fixture. To that end, the Ten Recommendations of this work also are not sweeping changes. Instead, the aim of these recommendations is to maintain the current strategic stability in critical minerals policy (Recommendation 1 and Recommendation 2), while offering a series of repeatable tasks (Recommendation 3 through Recommendation 10) that would benefit the development of a robust cobalt supply chain and, with appropriate modification, ensuring the resilience of other critical mineral supply chains and delivering national priority projects.

Recommendations

1. Maintain Long-Term Stability in Minerals Policy
2. Keep "National Defense" Broad to Achieve Genuine Resilience
3. Integrate Government Incentives towards Industrial Outcomes
4. Attract Highly Qualified Foreign Talent to "National Priority Projects"
5. Increase Cobalt Stockpiling to Ensure Emergency Access
6. Position the US Government on One Side of the Transaction
7. Leverage Trade Actions to Expand Access to Resilient Supply
8. Amend Reliable Sourcing Rules to Support Domestic Production
9. Embrace Joint Action with Allies
10. Explore a "Lease-to-Recycle" Model to Reduce EV Adoption Cost

Endnotes

1 Unless otherwise stated, price data throughout this report are reported as real 2023 US dollars

2 Today's "National Defense Stockpile Program" administered by the Defense Logistics Agency (DLA) Strategic Materials

3 The *Strategic and Critical Materials Stock Piling Revision Act of 1979* (Public Law 96-41)

4 Rivlin, "Strategic and Critical Nonfuel Minerals: Problems and Policy Alternatives," *Congressional Budget Office* (Washington, DC: August 1983)

5 See Executive Order 14017. *America's Supply Chains*

6 Executive Office of the President, *Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth* (June 2021)

7 Press Release "US Departments of Energy, State and Defense to Launch Effort to Enhance National Defense Stockpile with Critical Minerals for Clean Energy Technologies," *Department of Energy* (February 2022), https://www.energy.gov/ia/articles/us-departments-energy-state-and-defense-launch-effort-enhance-national-defense

8 US Geological Survey, "2022 Final List of Critical Minerals," *87 Federal Register 10381* (February 2022), https://www.federalregister.gov/documents/2022/02/24/2022-04027/2022-final-list-of-critical-minerals

9 Department of Energy, "Notice of Final Determination on 2023 DOE Critical Materials List," *88 Federal Register 51792* (August 2023), https://www.federalregister.gov/documents/2023/08/04/2023-16611/notice-of-final-determination-on-2023-doe-critical-materials-list

10 Executive Office of the President, "Presidential Determination Pursuant to Section 303 of the Defense Production Act of 1950, as Amended," *87 Federal Register 19775* (April 2022), https://www.federalregister.gov/documents/2022/04/06/2022-07421/presidential-determination-pursuant-to-section-303-of-the-defense-production-act-of-1950-as-amended

11 Ricardo Ferreira and Francisco Pinto, "The nickel market in 2023 and 2024—two years with surpluses," *Stainless Steel World*, https://stainless-steel-world.net/the-world-nickel-market-in-2023-and-2024-two-years-with-surpluses/

12 Dylan Duan, "Oversupply sets tone for China's nickel market | 2024 preview," *Fastmarkets* (January 2024), https://www.fastmarkets.com/insights/oversupply-sets-tone-for-chinas-nickel-market-2024-preview/

13 Though the most well-known cobalt-containing permanent magnet materials are samarium-cobalt and aluminum-nickel-cobalt magnets, some neodymium-iron-boron permanent magnet types also contain small amounts of cobalt to provide greater resistance to demagnetization at elevated temperatures.

14 Derived from US Bureau of Mines, *Minerals Yearbook* (1978-1993); US Geological Survey, *Minerals Yearbook* (1994-2019); and US Geological Survey, *Mineral Commodity Summaries* (2020-2023). Note data reported from 1977-1987 is converted from thousands of lbs. (cobalt) to tonnes (cobalt). Also note that the US Geological Survey changed its reporting of certain non-steel metal alloys (e.g., samarium-cobalt permanent magnets) as a "steel" product beginning in 2014.

15 Commodity Exchange Group, "CFTC Regulation 40.2(a) Certification. Initial Listing of the Lithium Hydroxide CIF CJK (Fastmarkets) Average Price Option and Cobalt Metal (Fastmarkets) Average Price Option Contracts," (November 2023), https://www.cftc.gov/sites/default/files/filings/ptc/23/11/ptc1122238918.pdf

16 Kittner et al. "Special Report on Clean Energy Innovation," *International Energy Agency* (2020), https://iea.blob.core.windows.net/assets/04dc5d08-4e45-447d-a0c1-d76b5ac43987/Energy_Technology_Perspectives_2020_-_Special_Report_on_Clean_Energy_Innovation.pdf

17 Derived from US Geological Survey, *Minerals Yearbook* (2005-2020), supplemented by Darton Commodities, *Cobalt Market Review* (2008-2021); Battery chemistries are shown in contained cobalt units

18 A more detailed discussion of the policies associated with China's EV, battery, and cobalt production growth is included in "Global Production—Mining" and "Global Production—Refining". Additional detail on US policy developments is described in Role of Industrial Policy.

19 EV and PHEV regional volumes from International Energy Agency, *Global EV Outlook 2024* (2024), https://www.iea.org/reports/global-ev-outlook-2024

20 Tom Hals, "Court OKs sale of US government-backed A123 to Chinese firm," *NBC News* (2012), https://www.nbcnews.com/business/business-news/court-oks-sale-u-s-government-backed-a123-chinese-firm-flna1c7561922; Tom Hals and Ben Klayman, "Chinese firm wins A123 despite US tech transfer fears," *Reuters* (2013), https://www.reuters.com/article/business/chinese-firm-wins-a123-despite-us-tech-transfer-fears-idUSBRE90S0JO/

21 International Energy Agency, *Global EV Outlook 2024* (2024)

22 Eric Walz, "Panasonic to develop advanced EV batteries with Sila Nanotechnologies," *Automotive Drive* (2023), https://www.automotivedive.com/news/panasonic-sila-nanotechnologies-agreement-batteries-graphite-silicon-anodes-evs/702927/

23 Christian Ruoff, "ONE's hybrid battery pack combines the best aspects of two chemistries to deliver 600 miles of EV range," *Charged* (2022), https://chargedevs.com/features/ones-hybrid-battery-pack-combines-the-best-aspects-of-two-chemistries-to-deliver-600-miles-of-ev-range/

24 Phate Zhang, "Nio starts to get cells from WeLion, as deliveries of 150-kWh batteries set to begin in July," *CNEVPost* (2023), https://cnevpost.com/2023/07/01/nio-gets-cells-from-welion-150-kwh-to-begin-july/

25 Andrew Gulley, "One hundred years of cobalt production in the Democratic Republic of the Congo," Resources Policy (Vol. 79) December 2022, https://www.sciencedirect.com/science/article/pii/S0301420722004500?via%3Dihub

26 Andrew Gulley, "One hundred years of cobalt production in the Democratic Republic of the Congo," Resources Policy (Vol. 79) December 2022, https://www.sciencedirect.com/science/article/pii/S0301420722004500?via%3Dihub (CC BY 4.0)

27 Stephen Burgess, "The Effect of China's Scramble for Resources and African Resource Nationalism on the Supply of Strategic Southern African Minerals; What Can the United States Do?", *US Air Force Academy* (2010), https://www.usafa.edu/app/uploads/Burgess-2011-China-and-South-African-Minerals.pdf ; of note, this transaction has since been renegotiated to provide greater investment by the Chinese consortium into the Democratic Republic of Congo ($7 billion) and additional royalty payments, Staff Writer, "Chinese companies to invest up to $7 billion in Congo mining infrastructure," *Reuters* (January 2024), https://www.reuters.com/markets/commodities/chinese-invest-up-7-bln-congo-mining-infrastructure-statement-2024-01-27/

28 Of note, in April 2021, Contemporary Amperex Technology (CATL) subsidiary Ningbo Brunp CATL New Energy purchased a 25% stake in the CMOC holding company. The beneficial ownership of this holding company is CMOC (71.25%), CATL (23.75%), and Democratic Republic of Congo (5%). Staff Writer, "China's CMOC plans $1.8bn investment in Congo copper-cobalt mine," *Mining Technology* (2022), https://www.mining-technology.com/news/cmoc-congo-copper/?cf-view

29 *Ibid.*

30 For example, see Andrew Gulley, "China, the Democratic Republic of the Congo, and artisanal cobalt mining from 2000 through 2020," *Proceedings of the National Academy of Sciences* (Vol. 120, No. 26), https://www.pnas.org/doi/10.1073/pnas.2212037120?doi=10.1073%2Fpnas.2212037120

31 Effectively, the US Geological Survey equivalent of the Federal Republic of Germany; unless otherwise stated, all citations in this section are derived from Sebastien Vetter and Philip Schütte, *Mining Conditions and Trading Networks in Artisanal Copper-Cobalt Supply Chains in the Democratic Republic of the Congo* (2021)

32 "*Service d'assistance et d'encadrement des mines artisanales et de petit echelle,*" the Democratic Republic of Congo government agency devoted to supporting artisanal mining activities

33 "*Agence Nationale de Renseignements*" (ANR)

34 For anecdotal accounts of the longstanding presence of Chinese depot organizations see the following: Staff Writer, "Chinese firms face new reality of Congo mining," *Reuters* (2007), https://www.reuters.com/article/world/chinese-firms-face-new-reality-of-congo-mining-idUSN07291889/; Jacob Kushner, "In Congo, Lure of Quick Cash Turns Farmers Into Miners," *NPR* (2013), https://www.npr.org/2013/03/28/175577518/in-congo-lure-of-quick-cash-turns-farmers-into-miners;

35 Presentation by Septian Hario Seto (Deputy of Investment & Mining Coordination to the Coordinating Minister for Maritime affairs and Investments, Republic of Indonesia) at the Cobalt Congress 2024 (May 2024)

36 Eri Silva, "Indonesia on track to create a local EV supply chain off nickel success," *S&P Global* (2024), https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/indonesia-on-track-to-create-a-local-ev-supply-chain-off-nickel-success-80363567

37 Seto, *op. cit.*

38 Tom Daly, Min Zhang, Mai Nguyen, "China's Lygend starts milestone nickel project in Indonesia," *Reuters* (2021), https://www.reuters.com/article/business/chinas-lygend-starts-milestone-nickel-project-in-indonesia-idUSL2N2N60XR/

39 Staff Writer, "The rise and rise of Indonesian HPAL—can it continue?", *Wood Mackenzie* (2023), https://www.woodmac.com/news/opinion/rise-of-indonesian-hpal/

40 Silva, *op. cit.*

41 International Energy Agency, "The 10th Five-Year Plan for Economic and Social Development of the People's Republic of China (2001-2005)," (2001), https://www.iea.org/policies/1736-the-10th-five-year-plan-for-economic-and-social-development-of-the-peoples-republic-of-china-2001-2005

42 Also known as the "State High-Tech Development Plan," operated under the Ministry of Science & Technology (MOST)

43 According to the US Intelligence Community, Project 863 is one of several government-supported efforts by the People's Republic of China to clandestinely acquire Western technology and sensitive economic information, see Office of the National Counterintelligence Executive, *Foreign Spies Stealing US Economic Secrets in Cyberspace, Report to Congress on Foreign Economic Collection and Industrial Espionage, 2009-2011*, (2011), https://www.dni.gov/files/documents/Newsroom/Reports%20and%20Pubs/20111103_report_fecie.pdf

44 World Economic Forum, "Wan Gang", retrieved 2024, https://www.weforum.org/people/wan-gang/; Staff Writer, "The World's Leading Electric-Car Visionary Isn't Elon Musk," *Bloomberg* (2018), https://www.bloomberg.com/news/features/2018-09-26/world-s-electric-car-visionary-isn-t-musk-it-s-china-s-wan-gang; Huiwen and Hansen, *op. cit.*

45 Ministry of Industry & Information Technology, "China Energy-Saving and New Energy Vehicles Industry Development Program(2012-2020)," Presentation at the *17th Automotive Dialogue (St. Petersburg, Russia)*, 2012, https://policy.thinkbluedata.com/sites/default/files/Energy-Saving%20and%20New%20Energy%20Automobile%20Industry%20Development%20Plan%20%282012-2020%29.pdf ; National Energy Agency, "The State Council issued the Energy-saving and New Energy Vehicle Industry Development Plan (2012-2020)," 2012, https://www.nea.gov.cn/2012-07/10/c_131705726.htm

46 Derived from US Geological Survey, *Minerals Yearbook* (2005-2020), supplemented by Darton Commodities, *Cobalt Market Review* (2008-2021); Battery chemistries are shown in contained cobalt units.

47 Key cobalt metal refineries are located in Norway, Australia, Finland, Japan, Canada, Madagascar, Morrocco, Russia, and Mexico.

48 Press Release, "Jervois to acquire Freeport Cobalt for US$160 million," *Jervois Global* (2021), https://www.thenewswire.com/press-releases/1kWVFDE9p-jervois-to-acquire-freeport-cobalt-for-us160-million.html

49 Staff Writer, "Jervois redirects BFS on Kokkola cobalt refinery expansion to US," *Mining Technology* (2023), https://www.mining-technology.com/news/jervois-refinery-expansion-bfs/?cf-view

50 For the purposes of this work, "industrial policy" is defined as a deliberate set of government policies (e.g., fiscal, monetary, trade, regulatory) intended to foster the development of a particular economic activity through support to particular industry sectors or companies.

51 Staff Writer, "Congo artisanal cobalt monopoly can launch in months, CEO says," Mining.com (2024), https://www.mining.com/web/congo-artisanal-cobalt-monopoly-can-launch-in-months-ceo-says/#:~:text=Congo%20founded%20EGC%20in%202019,cobalt%20prices%20due%20to%20oversupply.

52 See Figure 3 and Figure 8

53 Committee on Government Operations, "Cuba's Expropriation of US-owned Nickel Plant at Nicaro, Cuba," 87th Congress, 2nd Session (1962), https://www.govinfo.gov/content/pkg/SERIALSET-12441_00_00-002-1478-0000/pdf/SERIALSET-12441_00_00-002-1478-0000.pdf

54 Subcommittee of the Committee on Government Operations, "Nickel-Cobalt Contract Obligations of the United States (Moa Bay, Cuba, and Braithwaite, Louisiana)," 86th Congress, 1st Session (1959), https://search.worldcat.org/title/181335026; of note, this facility closed in 1959, following the Cuban Revolution

55 Rivlin, *op. cit.*. Of note, the National Defense Stockpile sold substantially of this inventory after the end of the Cold War; as of September 2022, the National Defense Stockpile holds ~302 tons of cobalt metal and ~3 tons of cobalt alloys recovered from US military scrap, and ~2 tons of lithium-cobalt-oxide cathode material, see US Geological Survey, "Cobalt," *2018 Minerals Yearbook* (2022), https://pubs.usgs.gov/myb/vol1/2018/myb1-2018-cobalt.pdf

56 See *Department of Defense Appropriations Act, 1973* (P.L. 92-570), https://www.govinfo.gov/content/pkg/STATUTE-86/pdf/STATUTE-86-Pg1184.pdf; see 10 USC. 4863, https://www.law.cornell.edu/uscode/text/10/4863

57 Including Finland, Australia, Japan, and most North Atlantic Treaty Organization (NATO) Members, see DFARS 252.225-7002, "Qualifying Country Sources as Subcontractors", https://www.acquisition.gov/dfars/252.225-7002-qualifying-country-sources-subcontractors.; see also Figure 20

58 See "Defense Federal Acquisition Regulation Supplement: Restriction on Certain Metal Products (DFARS Case 2021-D015)," *Federal Register* Vol. 89, No. 105, 46816-46821 (May 30, 2024), https://www.federalregister.gov/documents/2024/05/30/2024-11513/defense-federal-acquisition-regulation-supplement-restriction-on-certain-metal-products-dfars-case

59 *National Defense Authorization Act for Fiscal Year 2024* (P.L. 118-31), https://www.congress.gov/118/plaws/publ31/PLAW-118publ31.pdf

60 Defense Pricing, Contracting, and Acquisition Policy, "Open DFARS Cases" (August 2024), https://www.acq.osd.mil/dpap/dars/opencases/dfarscasenum/dfars.pdf

61 Executive Office of the President, "Memorandum on Presidential Determination Pursuant to Section 303 of the Defense Production Act of 1950, as amended," (2022), https://www.whitehouse.gov/briefing-room/presidential-actions/2022/03/31/memorandum-on-presidential-determination-pursuant-to-section-303-of-the-defense-production-act-of-1950-as-amended/

62 Throughout the author's research for this project, postulated use of DPA Title III funding in the 1970s and 1980s has highlighted the potential for exploiting cobalt resources (a) within the Idaho Cobalt Belt, including assets currently owned by Jervois Global, Electra Battery Materials, and Glencore, and (b) in Missouri, including assets currently owned by the Doe Run Company and U.S. Strategic Metals. See the following, for example, Rivlin, *op. cit.*

63 Supplemental funding contribution by Natural Resources Canada (NRCan)

64 See Footnote 39

65 See Footnote 39

66 Supplemental funding contribution by NRCan

67 Inclusive of funding contributions by NRCan

68 Executive Office of the President, *National Security Strategy of the United States of America* (2017), https://trumpwhitehouse.archives.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf

69 For example, see Peter Navarro, "Why Economic Security is National Security," (2018), https://trumpwhitehouse.archives.gov/articles/economic-security-national-security/ and Center for Strategic & International Studies, "Economic Security as National Security: A Discussion with Dr. Peter Navarro" (2018), https://www.csis.org/analysis/economic-security-national-security-discussion-dr-peter-navarro

70 Kip Keen, "Trump's rare earths materials, processing drive seen as boost to US sector," *S&P Global* (2019), https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/trump-s-rare-earths-materials-processing-drive-seen-as-boost-to-us-sector-53104101

71 Executive Office of the President, "A Federal Strategy To Ensure Secure and Reliable Supplies of Critical Minerals," *82 Federal Register 60835* (December 2017), https://www.govinfo.gov/content/pkg/FR-2017-12-26/pdf/2017-27899.pdf

72 Office of the Deputy Assistance Secretary of Defense for Industrial Policy, *Fiscal Year 2020 Industrial Capabilities Report to Congress* (2021), https://www.businessdefense.gov/docs/resources/USA002573-20_ICR_2020_Web.pdf

73 Executive Office of the President, "Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-based Growth," (2021), https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf

74 Executive Office of the President, "Building Resilient Supply Chains," (2021)

75 Department of Commerce, "US Department of Commerce Announces Section 232 Investigation into the Effect of Imports of Neodymium Magnets on US National Security," (2021), https://www.commerce.gov/news/press-releases/2021/09/us-department-commerce-announces-section-232-investigation-effect

76 Executive Office of the President, "A Guidebook to the Bipartisan Infrastructure Law for State, Local, and Tribal Governments, and Other Partners," (2022), https://www.whitehouse.gov/wp-content/uploads/2022/05/BUILDING-A-BETTER-AMERICA-V2.pdf

77 Executive Office of the President, "Memorandum on Presidential Determination Pursuant to Section 303 of the Defense Production Act of 1950, as amended," (2022), https://www.whitehouse.gov/briefing-room/presidential-actions/2022/03/31/memorandum-on-presidential-determination-pursuant-to-section-303-of-the-defense-production-act-of-1950-as-amended/

78 Executive Office of the President, "Inflation Reduction Act Guidebook," (2023), https://www.whitehouse.gov/cleanenergy/inflation-reduction-act-guidebook/

79 For Loan Program Office entries, the funds indicated in this table reflect the total resources for credit subsidies. Dependent on the credit subsidy ultimately calculated by the Department of Energy, with oversight by the Office of Management and Budget, the face value of such loans may be considerably greater. Assuming a positive subsidy of 10%, total Department of Energy lending authority may be as great as $66 billion.

80 Internal Revenue Service, "Section 45X Advanced Manufacturing Production Credit," *88 Federal Register 86844* (2023), https://www.federalregister.gov/documents/2023/12/15/2023-27498/section-45x-advanced-manufacturing-production-credit

81 Internal Revenue Service, "Clean Vehicle Credits Under Sections 25E and 30D; Transfer of Credits; Critical Minerals and Battery Components; Foreign Entities of Concern," *89 Federal Register 37706* (2024), https://www.federalregister.gov/documents/2024/05/06/2024-09094/clean-vehicle-credits-under-sections-25e-and-30d-transfer-of-credits-critical-minerals-and-battery; Office of Manufacturing & Energy Supply Chains, "Interpretation of Foreign Entity of Concern," *89 Federal Register* 37079 (2024), https://www.federalregister.gov/documents/2024/05/06/2024-08913/interpretation-of-foreign-entity-of-concern

82 These nations include Australia, Bahrain, Canada, Chile, Colombia, Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Israel, Jordan, Republic of Korea, Mexico, Morocco, Nicaragua, Oman, Panama, Peru, and Singapore.

83 Office of the US Trade Representative, "United States and Japan Sign Critical Minerals Agreement," (2023), https://ustr.gov/about-us/policy-offices/press-office/press-releases/2023/march/united-states-and-japan-sign-critical-minerals-agreement

84 Trevor Hunnicutt and Ernest Scheyder, "Exclusive: US, Indonesia to discuss potential for deal on EV minerals," *Reuters* (2023), https://www.reuters.com/markets/commodities/us-indonesia-discuss-potential-deal-ev-minerals-sources-2023-11-12/; Staff Writer, "EU, US seek broader reach on critical minerals as own deal stalls," *Reuters* (2023), https://www.reuters.com/markets/commodities/eu-us-seek-broader-reach-critical-minerals-own-deal-stalls-2024-04-03/

85 Memorandum of Understanding Among the United States of America, the Democratic Republic of the Congo, and the Republic of Zambia Concerning Support for the Development of a Value Chain in the Electric Vehicle Battery Sector, (2023), https://www.state.gov/wp-content/uploads/2023/01/2023.01.13-E-4-Release-MOU-USA-DRC-ZAMBIA-Tripartite-Agreement-Tab-1-MOU-for-U.S.-Assistance-to-Support-DRC-Zambia-EV-Value-Chain-Cooperation-Instrument.pdf

86 US International Development Finance Corporation, "DFC Announces New US Financing for Africa's Lobito Corridor" (2024), https://www.dfc.gov/media/press-releases/dfc-announces-new-us-financing-africas-lobito-corridor, https://www.dfc.gov/sites/default/files/media/documents/BDR%2824%2931%20Lobito%20Atlantic%20Railway%20S.A.pdf

87 Office of Manufacturing & Energy Supply Chains, *op. cit.*

88 William Clowes, "Glencore CEO Sees Cobalt Glut Lasting as Long as Two Years," *Bloomberg* (2024), https://www.bloomberg.com/news/articles/2024-08-07/glencore-ceo-sees-cobalt-glut-lasting-as-long-as-two-years

89 Jonathan Clyne and Monty Birley, "A Warning on Force Majeure Clauses, Covid-19, and 'Price Majeure'," *Jackson Parton Solicitors*, (2020), https://jacksonparton.com/news-and-articles/2020/4/16/a-warning-on-force-majeure-clauses-covid-19-and-price-majeure

90 Such as John W. Miller, "US Steel Accuses China of Hacking," *Wall Street Journal* (2016), https://www.wsj.com/articles/u-s-steel-accuses-china-of-hacking-1461859201

91 Economic Security Mission Center (Department of Homeland Security), "New Analytic Technique Indicates China Likely Hid Severity of COVID-19 from the International Community While it Stockpiled Medical Supplies," *Intelligence Enterprise* (May 1, 2020), https://www.dhs.gov/sites/default/files/publications/china_and_covid-19.pdf

92 "United States Objectives and Programs for National Security," (1950), https://history.state.gov/historicaldocuments/frus1950v01/d85

93 Executive Office of the President, "A Federal Strategy To Ensure Secure and Reliable Supplies of Critical Minerals," *82 Federal Register 60835* (December 2017), https://www.govinfo.gov/content/pkg/FR-2017-12-26/pdf/2017-27899.pdf

94 Executive Office of the President, "America's Supply Chains," *86 Federal Register 11849* (February 2021), https://www.govinfo.gov/content/pkg/FR-2021-03-01/pdf/2021-04280.pdf

95 Kip Keen, "Trump's rare earths materials, processing drive seen as boost to US sector," *S&P Global* (2019), https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/trump-s-rare-earths-materials-processing-drive-seen-as-boost-to-us-sector-53104101

96 Executive Office of the President, "Memorandum on Presidential Determination Pursuant to Section 303 of the Defense Production Act of 1950, as amended," (2022), https://www.whitehouse.gov/briefing-room/presidential-actions/2022/03/31/memorandum-on-presidential-determination-pursuant-to-section-303-of-the-defense-production-act-of-1950-as-amended/

97 See Executive Office of the President, "Addressing the Threat to the Domestic Supply Chain From Reliance on Critical Minerals From Foreign Adversaries and Supporting the Domestic Mining and Processing Industries," *85 Federal Register 62539* (2020), https://www.govinfo.gov/content/pkg/FR-2020-10-05/pdf/2020-22064.pdf; Department of Energy, "Loan guarantees for Clean Energy Projects," *88 Federal Register 34419* (2023), https://www.federalregister.gov/documents/2023/05/30/2023-11104/loan-guarantees-for-clean-energy-projects#footnote-18-p34420

98 For example, see Executive Office of the President, "Memorandum on Presidential Waiver of Statutory Requirements Pursuant to Section 303 of the Defense Production Act of 1950, as amended, on Department of Defense Supply Chains Resilience," (2023), https://www.whitehouse.gov/briefing-room/presidential-actions/2023/02/27/memorandum-on-presidential-waiver-of-statutory-requirements-pursuant-to-section-303-of-the-defense-production-act-of-1950-as-amended-on-department-of-defense-supply-chains-resilience/

99 Department of Defense, "Department of Defense Revolving Funds," *Fiscal Year 2020 President's Budget* (2019), pages 30-35, https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2020/budget_justification/pdfs/06_Defense_Working_Capital_Fund/Revolving_Funds_fy2020_PB.pdf ; see SEC. 1411 of *James M. Inhofe National Defense Authorization Act for Fiscal Year 2023* (P.L. 117-347), https://www.congress.gov/bill/117th-congress/house-bill/7776/text; Department of Defense, "Department of Defense Revolving Funds Justification / Overview," *Fiscal Year 2024 Budget Estimates* (2023), pages 51-56, https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2024/budget_justification/pdfs/06_Defense_Working_Capital_Fund/DoD_Revolving_Funds_J-Book_fy2024.pdf

100 See 50 USC. 4558, https://www.law.cornell.edu/uscode/text/50/4558

101 Committee on the Judiciary of the House of Representatives, "Hearings before the Subcommittee on the Study of Monopoly Power," 82nd Congress, 1st Session (1951), https://books.google.com/books?id=EmNFAQAAMAAJ

102 Committee on Banking and Currency of the Senate, "Report on Review of Voluntary Agreement Program under the Defense Production Act," 84th Congress, 2nd Session (1956), https://books.google.com/books?id=g_qebVkJeRMC

103 US Geological Survey, "Historical Files from Federal Government Mineral Exploration-Assistance Programs, 1950 to 1974," (2016, https://pubs.usgs.gov/ds/1004/ds1004_proginfo.htm

104 30 Code of Federal Regulations Part 229, "Regulations for Obtaining Federal Assistance in Financing Explorations for Mineral Reserves, Excluding Organic Fuels, in the United States, Its Territories, and Possessions," (1980), https://books.google.com/books?id=Y8r6u3FYubUC

105 Federal Emergency Management Agency, *The Defense Production Act Committee Report to Congress* (2021), https://www.fema.gov/sites/default/files/documents/fema_DPAC-report-Defense-production-act-committee_2020.pdf

106 Subcommittee on National Security, Illicit Finance, and International Financial Institutions, "Hearing entitled, Mission Critical: Restoring National Security as the Focus of Defense Production Act Reauthorization," (2024), https://financialservices.house.gov/calendar/eventsingle.aspx?EventID=409167

107 Roger Zakheim, "Testimony Before the House Financial Services Subcommittee on National Security, Illicit Finance, and International Financial Institutions," (2024), https://docs.house.gov/meetings/BA/BA10/20240312/116950/HMTG-118-BA10-Wstate-ZakheimR-20240312.pdf

108 For example, see J.D. Morgan, *Strategic Materials in World War II* (1983), https://www.cia.gov/readingroom/document/cia-rdp85-01156r000300390010-2

109 For example, before declining to find that US industry was harmed by imports of ferro-chrome and ferro-manganese in an investigation under SEC. 232 of the *Trade Expansion Act of 1962*, President Reagan authorized the National Defense Stockpile to upgrade its chrome and manganese ore stockpile to ferro-alloys (Department of Commerce, "Presidential Decision on Impact of Ferroalloy Imports on the National Security," *49 Federal Register 21391* (1984), https://www.bis.doc.gov/index.php/documents/section-232-investigations/1670-ferroalloys/file). The facilities used for ferroalloy upgrade work closed shortly after the conclusion of the Stockpile upgrade program and the released of excess ferrochrome stocks.

110 Executive Office of the President, "FACT SHEET: Biden- Harris Administration Announces Supply Chain Disruptions Task Force to Address Short-Term Supply Chain Discontinuities," (2022), https://www.whitehouse.gov/briefing-room/statements-releases/2022/10/19/fact-sheet-biden-harris-administration-driving-u-s-battery-manufacturing-and-good-paying-jobs/

111 Press Release, "US Departments of Energy, State and Defense to Launch Effort to Enhance National Defense Stockpile with Critical Minerals for Clean Energy Technologies," (2022), https://www.energy.gov/ia/articles/us-departments-energy-state-and-defense-launch-effort-enhance-national-defense

112 Press Release, "Hermosa confirmed as the first FAST-41 mining project," (2023), https://www.south32.net/news-media/latest-news/hermosa-confirmed-as-the-first-fast-41-mining-project; Press Release, "DOD Awards $20 Million to Enhance Domestic Manganese Supply Chain" (2024), https://www.defense.gov/News/Releases/Release/Article/3779115/dod-awards-20-million-to-enhance-domestic-manganese-supply-chain/

113 Stuart Anderson, "Immigration Service Likely to Change H-1B Visa Lottery," *Forbes* (2023), https://www.forbes.com/sites/stuartanderson/2023/05/01/immigration-service-likely-to-change-h-1b-visa-lottery/

114 Department of State, "Update on Worldwide Visa Services, 21 October 2022," reproduced by the *NAFSA: Association of International Educators* (2023), https://www.nafsa.org/regulatory-information/covid-19-restrictions-us-visas-and-entry#consular

115 American Geosciences Institute, *Status of Recent Geoscience Graduates 2021* (April 2022), https://www.americangeosciences.org/citations/status-recent-geoscience-graduates-2021

116 US annual demand of 5,900 tons divided by 305 tons, consisting of 302 tons cobalt metal and 3 tons cobalt superalloy scrap, see Footnote 50

117 For example, see George Datta, Ashley George, and Daleep Singh, "The US Needs More than a Critical Minerals Stockpile, It Needs Market Infrastructure," *Council on Foreign Relations* (2024), https://www.cfr.org/article/us-needs-more-critical-minerals-stockpile-it-needs-market-infrastructure

118 Department of Energy, *America's Strategy to Secure the Supply Chain for a Robust Clean Energy Transition*, (2022), https://www.energy.gov/sites/default/files/2022-02/America's%20Strategy%20to%20Secure%20the%20Supply%20Chain%20for%20a%20Robust%20Clean%20Energy%20Transition%20FINAL.docx_0.pdf

119 Under Secretary of Defense for Acquisition, Technology and Logistics, *Strategic and Critical Materials 2013 Report on Stockpile Requirements* (2013), https://mineralsmakelife.org/assets/images/content/resources/Strategic_and_Critical_Materials_2013_Report_on_Stockpile_Requirements.pdf

120 Driven by government-wide requirements under the *Antideficiency Act* (P.L. 97-258)

121 Stephen Losey, "Pentagon suspends F-35 deliveries over Chinese alloy in magnet," *Defense News* (2022), https://www.defensenews.com/air/2022/09/07/pentagon-suspends-f-35-deliveries-over-chinese-alloy-in-magnet/

122 Unless otherwise stated, all awards are DoD awards are under DPA Title III; awards pertaining to cobalt are highlighted

123 Rae Boyadjis, "Graphite One partners with Lucid Motors for US domestic advanced graphite supply chain," *Fastmarkets* (2024), link here

124 Alexander Panetta, "What's behind a historic, unusual US military cash transfer to Canadian mines," *CBC* (2024), https://www.cbc.ca/news/world/us-dpa-money-mines-canada-analysis-1.7214664

125 Joe Gould, "Tech startups still face Pentagon's 'valley of death'," *Defense News* (2020), https://www.defensenews.com/2020/01/30/tech-startups-still-face-the-pentagons-valley-of-death/

126 Such as those awarded under DPA Title III, the Industrial Base Fund (10 US C. 4817), the Rapid Innovation Fund, Small Business Innovation Research (SBIR) program, and National Defense Stockpile on rare earth elements

127 Such as the Eisenhower School for National Security & Resource Strategy

128 Department of Energy "Average Annual Fuel Use by Vehicle—May 2024," (2024), https://afdc.energy.gov/data/10308

129 See Footnote 46

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