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Precious and Few: Solving Renewable Energy's Critical Minerals Problem

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INTRODUCTION

According to some recent reports, global cobalt supplies are less than 10 years away from running out.[1] Demand for cobalt has surged in recent years due to rapid growth in battery production for electric vehicles and utility-scale energy storage.[2] Although it would technically be possible to replace cobalt with certain other minerals in most energy storage products, all known substitutes for the mineral would substantially reduce batteries' efficiency and would require that they be fitted with costly cooling systems.[3]

Unfortunately, cobalt is not the only mineral at risk of shortage as the demand for renewable energy and energy storage grows; market supplies of multiple other essential battery minerals such as lithium are at risk of depleting to troublingly low levels.[4] Critical minerals ("CM") serve important functions in a broad array of widely-used products, from smartphones to automobiles. The United States ("U.S.") federal government has expressly recognized cobalt and lithium as "critical

1. Nathanial Gronewold, *Deep-sea Miners See Tesla Growth as Signal to Pluck Cobalt,* E&E NEWS (Jan. 6, 2020), https://www.eenews.net/stories/1062004431 [https://perma.cc/3FB4-6W8D] (refers to the estimated current supply of terrestrial cobalt).

2. *Id.*

3. U.S. GEOLOGICAL SURVEY, MINERAL COMMODITY SUMMARIES 2019, at 51 (2019), https://prd-wret.s3-us-west-2.amazonaws.com/assets/palladium/production/atoms/files/mcs2019_all.pdf [https://perma.cc/DN72-DUBU] [hereinafter MINERAL COMMODITY SUMMARIES 2019].

4. Guy Burdick, *Battery Makers Face Looming Shortages of High-Quality Lithium*, UTILITYDIVE (June 25, 2020), https://www.utilitydive.com/news/battery-makers-face-looming-shortages-of-high-quality-lithium/580482/ [https://perma.cc/BV5C-V28R].

minerals" essential to national security and economic stability.[5] However, many CM are also crucial to the global decarbonization effort because they are essential inputs in wind turbines, solar panels, and grid-scale battery storage.

The growing demand for CM has driven dramatic increases in their mining and production in recent decades, and those trends are likely to continue in the coming years. Worldwide lithium production catapulted from around 6,200 tons annually in 1993 to 91,000 tons in 2019 due to increases in demand.[6] Currently, battery production makes up 65% of annual global lithium use.[7] Increasingly, these lithium-ion batteries are finding their way into the world's growing fleet of hybrid and electric vehicles. For instance, a modern Toyota Prius' electric battery contains more than 20 pounds of lithium—an enormous amount considering the rarity of the mineral.[8] Automakers sold 770,000 electric vehicles in China and 200,000 electric vehicles in the U.S. in 2017,[9] and Amazon alone placed an order for 100,000 electric vehicles in September 2019.[10] Lithium demand is projected to increase to 1.3 million metric tons by 2025, driven primarily by continued demand for batteries for uses like grid storage and electric cars.[11] In addition to lithium, other CM associated with battery and

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5. Exec. Order No. 13,817, 82 Fed. Reg. 60,835 (Dec. 26, 2017); *see also* Gronewold*, supra* note 1.

6. JOYCE A. OBER, U.S. DEP'T OF INTERIOR, U.S. GEOLOGICAL SURVEY, LITHIUM 4 (1994), https://s3-us-west-2.amazonaws.com/prd-wret/assets/palladium/production/mineral-pubs/lithium/450494.pdf [https://perma.cc/JWK3-22TW]; MINERAL COMMODITY SUMMARIES 2019, *supra* note 3, at 99.

7. U.S. GEOLOGICAL SURVEY, MINERAL COMMODITY SUMMARIES 2020, at 98 (2020), https://pubs.usgs.gov/periodicals/mcs2020/mcs2020.pdf [https://perma. cc/EH2G-93K4].

8. Andrew W. Eichner, *More Precious Than Gold: Limited Access to Rare Elements and Implications for Clean Energy in the United States*, 2012 U. ILL. J. L. TECH. & POL'Y 257, 262.

9. HJ Mai, *To Compete in the Global Battery Arms Race, the U.S. Must Spur its Domestic Market, Analysts Say*, UTILITYDIVE (June 24, 2019), https://www.utilitydive.com/news/creating-a-domestic-market-is-paramount-for-us-battery-industry-to-close-th/557339/ [https://perma.cc/9KLE-C3H9].

10. Ernest Scheyder*, Miners Push for U.S. Congress to Vote on Electric Vehicle Supply Chain Bills*, REUTERS (Sept. 23, 2019), https://www.reuters.com/article/us-usa-mining-strategicminerals/miners-push-for-u-s-congress-to-vote-on-electric-vehicle-supply-chain-bills-idU.S.KBN1W81ST [https://perma.cc/CS3C-6CCM].

11. James Ellsmoor, *Electric Vehicles Are Driving Demand for Lithium - With Environmental Consequences*, FORBES (June 10, 2019, 5:46 PM), https://www.forbes.com/sites/jamesellsmoor/2019/06/10/electric-vehicles-are-driving-

renewable energy production such as cobalt and certain rare-earth elements are likewise expected to experience skyrocketing demand that could potentially outstrip available supplies.

Meeting the global economy's burgeoning demand for CM is presenting ever-more significant challenges because of the tremendous scarcity of these minerals. For instance, lithium only makes up 0.002% of the Earth's crust, amounting to a global mineral reserve of 62 million tons.[12] Even if lithium demand plateaus at 1.3 million tons per year, less than a 60-year supply exists.[13] Known supplies of multiple other CM are likewise severely limited.[14]

Within U.S. borders, the rapidly increasing demand for CM is causing many mining companies to search for new ways to increase domestic CM mine production. For example, the Mountain Pass rare-earth mine in California became operational again in 2018 after several years of inactivity.[15] Unfortunately, that mine is capable of supplying only a small fraction of the U.S.'s CM requirements.[16] Piedmont Lithium Limited likewise recently applied for permits to reopen a lithium mine 25 miles outside of Charlotte, North Carolina.[17] However, the North Carolina mine possesses only a 13-year production supply at current demand rates, and that timetable is likely to only get shorter as domestic lithium demand increases.[18] Senators from coal mining regions have even been pushing for legislation to support the extraction of certain CM from coal, although the potential benefits of that strategy are also limited.[19]

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demand-for-lithium-with-environmental-consequences/#7a6f270862e2 [https://perma.cc/YRX2-7Z8L].

12. Carolyn Gramling, *The Search for New Geologic Sources of Lithium Could Power a Clean Future*, SCIENCENEWS (May 7, 2019), https://www.sciencenews.org/article/search-new-geologic-sources-lithium-could-power-clean-future [https://perma.cc/M497-Z6CA].

13. This number was derived from taking the estimated lithium reserve of 62 million tons from Gramling, *supra* note 12, and dividing it by the estimated lithium demand of 1.3 million tons/year from Scheyder, *supra* note 10.

14. Ellsmoor, *supra* note 11.

15. MINERAL COMMODITY SUMMARIES 2019, *supra* note 3, at 132.

16. *Id.*

17. Bruce Henderson, *NC was once a top source of lithium. Growing demand could lead to a mine near Charlotte*, CHARLOTTE OBSERVER (Apr. 2, 2019) https://www.charlotteobserver.com/news/business/article228475629.html [https://perma.cc/XV83-NWSX].

18. *Id.*

19. Rare Earth Element Advanced Coal Technologies Act, S. 1052, 116th Cong. (1st Sess. 2019); *see also* Scheyder, *supra* note 10.

Efforts to increase supplies of CM are hampered in part by concerns about the environmental risks and social costs of mining for these minerals.[20] Terrestrial mining of CM such as lithium, cobalt, and rare-earth elements tends to be relatively inexpensive but often threatens environmental and human health. For instance, lithium mining pollution in Tibet was recently blamed for causing fish and a yak in a local river to go belly up.[21] Lithium mining in Chile is depleting groundwater resources, depriving local communities of an essential resource.[22] Rare-earth element mines across China have stripped topsoil from valleys and pumped thousands of gallons of acid into streams.[23] California's Mountain Pass rare-earth element mine leaked radioactive fluid into neighboring land.[24] Furthermore, a recent investigation estimated that 35,000 children are working in cobalt mines in the Democratic Republic of the Congo.[25] In light of all of these problems, alternatives to terrestrial mining are needed to help minimize the societal costs of supplying these CM while still furthering the global transition to renewable energy.

This Article highlights the deficiencies in existing U.S. policies related to CM production and ultimately advocates for specific policy changes capable of helping the country usher in an era of responsible CM security. These policy changes, designed to more aggressively promote domestic CM production and research into CM-alternative technologies could do much to strengthen the nation's long-term national security, economic growth, and divestment from fossil fuels.

Part I of this Article describes CM and the key factors in their production, examines ongoing international trade issues involving them, and highlights the essential roles CM play in the renewable energy and energy storage industries. Part II reviews the U.S. Government's existing efforts to incentivize CM and identifies certain shortcomings of these approaches. Part III recommends specific policy strategies for

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20. Keith Bradsher, *After China's Rare Earth Embargo, a New Calculus*, N.Y. TIMES (Oct. 29, 2010), http://www.nytimes.com/2010/10/30/business/global/30rare.html [https://perma.cc/NR2D-LA7D].

21. Amit Katwala, *The spiraling environmental cost of our lithium battery addiction*, WIRED (Aug. 5, 2018) https://www.wired.co.uk/article/lithium-batteries-environment-impact [https://perma.cc/GN4Y-JE39].

22. *Id.*

23. Bradsher, *supra* note 20.

24. *Id.*

25. Siddharth Kara, *Is Your Phone Tainted by the Misery of the 35,000 Children in the Congo's Mines?*, THE GUARDIAN (Oct. 12, 2018) https://www.theguardian.com/global-development/2018/oct/12/phone-misery-children-congo-cobalt-mines-drc [https://perma.cc/F4QB-UAXQ].

incentivizing deep-sea mining, promoting greater investments in efficient CM recycling, and otherwise reducing dependence on importations of CM, and describes how adopting these strategies would address many of these challenges facing this important industry.

I. THE DIRT ON CRITICAL MINERALS

Today, the U.S. is heavily reliant on imports of at least 35 specific CM that are essential to the nation's economic stability and financial security.[26] While many of these minerals have been critical for decades, recent technological advancements and the growing demand for renewable energy generation have driven a subset of them to the forefront of concern.[27] The following are brief descriptions of these particular minerals and the reasons for their growing importance to the U.S. economy and to the transition to a sustainable energy system.

A. Critical Minerals

The federal government has defined critical minerals as "non-fuel mineral[s] or mineral material[s] essential to the economic and national security of the U.S. with a supply chain vulnerable to disruption" that "serve[] an essential function in manufacturing a product."[28] Examples of minerals falling within this definition include lithium, cobalt, and certain rare-earth elements.[29] As the language of a 2017 federal administrative order explains, the nation's dependency on importation of these minerals "creates a strategic vulnerability for both its economy and military to adverse foreign government action, natural disaster, and other events that can disrupt supply of these key minerals."[30]

Dozens of commonplace products and materials require CM for their production. For instance, aluminum, ceramics and glass, lubricating

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26. Final List of Critical Minerals 2018, 83 Fed. Reg. 23,295 (May 18, 2018).

27. *Id.*; *see* G. Kevin Jones, *United States Dependence on Imports of Four Strategic and Critical Minerals: Implications and Policy Alternatives*, 15 B.C. ENVTL. AFF. L. REV. 217, 218 (1988) ("minerals upon which the United States is dependent for foreign sources of supply, chromium, cobalt, manganese, and platinum group metals").

28. Exec. Order No. 13,817, 82 Fed. Reg. 60,835 (Dec. 26, 2017).

29. Final List of Critical Minerals 2018, 83 Fed. Reg. 23,295 (May 18, 2018) (the seventeen rare-earth elements are cerium, dysprosium, erbium, europium, gadolinium, holmium, lanthanum, lutetium, neodymium, praseodymium, promethium, samarium, scandium, terbium, thulium, ytterbium, and yttrium).

30. Exec. Order No. 13,817, 82 Fed. Reg. 60,835 (Dec. 26, 2017).

grease, and synthetic rubber production use lithium.[31] The production of superalloys for aircraft gas turbine engines requires cobalt.[32] Night vision goggles, glass polish, cellphones, video screens, lasers, and magnets also incorporate rare-earth elements.[33] Importantly, these minerals are also essential components for the transition to clean energy production because of their heavy use in renewable energy technologies such as batteries, solar panels, energy-efficient lighting, and wind turbines.[34]

B. The Renewables Boom

Renewable energy technologies such as batteries and solar panels currently depend primarily on supplies of CM produced from terrestrial mines.[35] In 1994, the U.S. Geological Survey predicted that the fate of the lithium battery market would largely depend on the success of electric vehicles and whether the best type of battery for powering them is ultimately a lithium battery.[36] This prediction has proven accurate over the past couple of decades, as annual world lithium production has soared from approximately 5,600 metric tons in 1994 to 85,000 metric tons in 2018—a 1400% increase.[37] Increased battery production has been the chief driver of this surge. Over half of the annual current world production of lithium is used in the manufacture of batteries.[38]

Similar trends of burgeoning demand are likewise affecting markets for cobalt and certain rare-earth elements due to the heavy use of these minerals in renewable energy and battery technologies. Annual world cobalt production has jumped from 19,000 metric tons in 1995 to 140,000 metric tons in 2018,[39] with 80% of that production flowing to the

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31. OBER, *supra* note 6, at 1.

32. U.S. GEOLOGICAL SURVEY, U.S. DEP'T OF INTERIOR, MINERAL COMMODITY SUMMARIES 1996, at 46 (1996) [hereinafter MINERAL COMMODITY SUMMARIES 1996].

33. Simon Webb, Lisa Shumaker & Jonathan Oatis, *U.S. Dependence on China's Rare Earth: Trade War Vulnerability*, REUTERS (June 27, 2019 3:33PM) https://www.reuters.com/article/us-usa-trade-china-rareearth-explainer/u-s-dependence-on-chinas-rare-earth-trade-war-vulnerability-idU.S.KCN1TS3AQ [https://perma.cc/3UCY-KLFE].

34. *Id.*

35. *Id.*

36. OBER, *supra* note 6, at 3.

37. *Id.* at 4 (citing MINERAL COMMODITY SUMMARIES 2019, *supra* note 3, at 98 (excludes U.S. production)).

38. MINERAL COMMODITY SUMMARIES 2019, *supra* note 3, at 98.

39. MINERAL COMMODITY SUMMARIES 1996, *supra* note 32, at 47; MINERAL COMMODITY SUMMARIES 2019, *supra* note 3, at 51.

manufacture of batteries.[40] Rare-earth elements production jumped from 72,000 metric tons in 1995 to 170,000 metric tons in 2018,[41] and catalyst and magnet products like those found in wind turbines account for 41% of today's rare-earth element use.[42] In short, the pace of the global transition to sustainable energy hinges on an available and secure supply of these minerals.

The importance of effective policy making for CM is magnified even more by the fact that CM-dependent industries in the U.S. are heavily reliant on importation from a relatively small number of countries. Norway, China, Japan, and Finland collectively supplied over 61% of the cobalt consumed domestically in 2018.[43] China supplies 80% of the nation's imported rare-earth elements.[44] And lithium imports from Argentina and Chile account for over 50% of the lithium consumption in the U.S.[45] Accordingly, continued access to the minerals critical to renewable energy depends on an uninterrupted international supply chain.

C. Trade War and Critical Mineral Security

The U.S.'s heavy reliance on importation of CM is concerning in part because it can sometimes enable foreign powers to leverage their influence over CM supplies against the U.S. in the foreign policy sphere. For example, as stated above, China controls 80% of the global supply of rare-earth elements.[46] This heavy reliance created significant fears within the U.S. when China reduced its annual tonnage of exports of rare-earth elements from 2006 to 2009 and then cut its allowed export amount in half in the second half of 2010.[47] China defended these disruptive supply cuts

40. MINERAL COMMODITY SUMMARIES 2019, *supra* note 3, at 51.

41. MINERAL COMMODITY SUMMARIES 1996, *supra* note 32, at 132; MINERAL COMMODITY SUMMARIES 2019, *supra* note 3, at 132.

42. *Rare Earth Elements Facts*, NATURAL RESOURCES CANADA, https://www.nrcan.gc.ca/our-natural-resources/minerals-mining/minerals-metals-facts/rare-earth-elements-facts/20522 [https://perma.cc/G865-58HP] (last visited Sept. 10, 2020).

43. *Id.* at 50.

44. Webb, Shumaker & Oatis, *supra* note 33.

45. MINERAL COMMODITY SUMMARIES 2019, *supra* note 3, at 98.

46. Mai, *supra* note 9; H. Sterling Burnett & Wesley Dwyer, *Will Green Energy Make the United States Less Secure?*, NAT'L CTR. FOR POL'Y ANALYSIS (Feb. 10, 2011), http://www.ncpathinktank.org/pub/ba739 [https://perma.cc/J9JR-EPJH].

47. Marvin L. Astrada, *Revisiting the WTO Rare Earths Dispute – Law, Trade, Sovereignty, & Environmental Security in a Networked World*, 46 SYRACUSE J. INT'L. L. & COM. 4 (2018).

on the grounds that, as an independent sovereign, it was entitled to restrict exports to regulate environmental protection, ensure sustainable production levels, and privilege Chinese interests over others.[48] However, China also temporarily discontinued supplying Japan, the U.S., and Europe with rare-earth elements during a diplomatic stand-off in 2010.[49] Although many importers responded to China's manipulation of rare-earth supplies with efforts aimed at reducing rare-earth consumption, China proved CM supplies can be wielded as a powerful sword in foreign policy.[50]

Having witnessed China's use of its CM market dominance as a foreign policy weapon, some other countries that export CM have signaled a willingness to mimic China's actions. This tactic was already implemented for the non-critical—but essential to battery production—mineral nickel. Indonesia, the world's largest producer of nickel, proposed to enact an export ban on nickel ore in 2019 that would eliminate nine percent of the market supply.[51] The Indonesian government floated the ban to force miners to invest in value-adding processing.[52] The government's actions led the European Union to file a complaint concerning the ban with the World Trade Organization in November 2019.[53] This dispute was yet another chapter in a trade war saga between the EU and Indonesia that began in early 2019 after the EU imposed stricter limits on the use of palm oil—an Indonesian export that can be used to produce biofuels.[54] Restrictions on exports of minerals like those used by China and Indonesia

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48. *Id.*

49. Jeremy Hsu, *Don't Panic About Rare Earth Elements*, SCIENTIFIC AMERICAN (May 31, 2019), https://www.scientificamerican.com/article/dont-panic-about-rare-earth-elements/ [https://perma.cc/S9A4-YW23]; Bradsher, *supra* note 20.

50. Webb, Shumaker & Oatis, *supra* note 33.

51. Tim Treadgol, *Nickel Surges Higher as a Supply Squeeze Looms, Leaving Gold Even Further Behind*, FORBES (Sept. 2, 2019 5:19AM), https://www.forbes.com/sites/timtreadgold/2019/09/02/nickel-surges-higher-as-a-supply-squeeze-looms-leaving-gold-even-further-behind/#4047df07190b [https://perma.cc/77HX-MXLT].

52. *Id.*

53. *EU-Indonesia Trade War: Nickel Ore Ban & Palm Oil Tariff Disputes Filed in WTO*, EUBULLETIN (Dec. 25, 2019), https://www.eubulletin.com/10499-eu-indonesia-trade-war-nickel-ore-ban-palm-oil-tariffs-disputes-filed-in-the-wto.html [https://perma.cc/92EX-T7TJ].

54. Ewa Krukowska, *Palm Oil Is at the Heart of the Next Trade War*, BLOOMBERG (Mar. 13, 2019, 9:59 AM), https://www.bloomberg.com/news/articles/2019-03-13/palm-oil-trade-war-looms-as-europe-sets-limits-on-use-in-biofuel [https://perma.cc/9WS6-9M59].

are unlikely to be isolated events. To the extent that the planet's economies rely more and more on reliable supplies of these minerals, the likelihood of CM supplies being leveraged in foreign policy will only increase.

Because imported CM are crucial to the continued functioning of the U.S. economy, unstable supplies of CM could impair various industries, national security, military defense, and the U.S. transition to renewable energy.[55] Former Secretary of the United States Department of Energy ("DOE"), Rick Perry, specifically suggested that dependence on foreign sources of CM is a threat to the U.S.[56] The U.S. imports 100% of 14 minerals essential to defense technologies, cell phones, and clean energy production.[57] Additionally, the U.S. relies on imports for at least 50% of 30 other minerals.[58] Missiles, smart bombs, and satellite communication would not function without these minerals.[59] Under the Obama Administration, the DOE noted CM were also essential to the transition to renewable energy technologies.[60] For all of these reasons, reducing dependence on foreign supplies of CM for energy and defense technologies could do much to secure these important industries.

Since the nation's heavy reliance on imported CM is an issue with significant foreign policy implications, responsibility to address it falls primarily on the federal government. In 2017, the federal government made some attempts to reduce its vulnerability to CM-related manipulation from other countries.[61] Among other things, President Trump issued an executive order ("EO") declaring a policy initiative aimed at reducing the nation's vulnerability to supply chain disruptions and identifying new supplies.[62] The EO encouraged greater investment in CM exploration, mining, concentration, separation, alloying, recycling, and reprocessing.[63] The EO also called for streamlining the leasing and

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55. *See* Nicholas Sanders, *A Response to Ryan P. Carpenter's "The Bottom of the Smart Weapon Production Chain: Securing the Supply of Rare Earth Elements for the U.S. Military"*, 41 PUB. CONT. L.J. 957, 958 (2012).

56. Mai, *supra* note 9.

57. Morgan D. Bazilian, *We Need to Get Serious About "Critical Materials"*, SCI. AM. (June 10, 2019), https://blogs.scientificamerican.com/observations/we-need-to-get-serious-about-critical-materials/ [https://perma.cc/L2U3-U5A8].

58. *Id.*

59. Sanders, *supra* note 55, at 958.

60. *Critical Materials Institute: An Energy Innovation Hub*, U.S. DEP'T OF ENERGY, https://www.energy.gov/eere/amo/critical-materials-institute-energy-innovation-hub [https://perma.cc/9RK9-54AC] (last visited Aug. 25, 2020).

61. Exec. Order No. 13,817, 82 Fed. Reg. 60,835 (Dec. 26, 2017).

62. *Id.*

63. *Id.*

permitting processes for mines and for improving access to topography, geological, and geophysical surveys to enable mining.[64] However, it neglected to address any international issues involving CM, to create actual incentives for increasing investment in CM recycling technologies, or to promote research in CM alternatives. As described below, aggressive policy actions in these three areas could do much to improve domestic CM security and ensure a steady transition toward a more sustainable energy system.

II. THE FEDERAL STRATEGIC PLAN FOR SECURING RELIABLE CRITICAL MINERAL SUPPLIES

Recently, the federal government outlined a set of specific strategies that, if adopted, could reduce risks associated with the nation's reliance on CM imports.[65] This comprehensive strategic plan acknowledges that increasing CM exploration, processing, and manufacturing base requires a government-wide effort.[66] The federal plan takes aim at securing CM supplies, focusing primarily on research, industry supply chains, international trade, understanding domestic CM, improving access to domestic CM, decreasing permitting timeframes for mines, and growing the CM workforce.[67]

Diversification of domestic CM sources and efficient use of these materials play a central role in the federal plan.[68] Under the federal plan, diversified sources include deep-sea mining, recycled CM, and alternative CM materials.[69] In addition to developing new sources, the federal government is promoting research into more efficient uses of CM through public-private partnerships.[70] To achieve these goals, federal officials have suggested offering tax incentives for private investments in new CM-related technologies and creating government purchase programs for products using domestic CM through DOE and Department of Defense ("DoD").[71]

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64. *Id.* at 60,836.

65. U.S. DEP'T OF COMMERCE, A FEDERAL STRATEGY TO ENSURE SECURE AND RELIABLE SUPPLIES OF CRITICAL MINERALS 4 (2019), https://www.commerce.gov/sites/default/files/2020-01/Critical_Minerals_ Strategy_Final.pdf [https://perma.cc/HUX5-BV3W] [hereinafter FEDERAL STRATEGY 2019].

66. *Id.* at 12.

67. *Id.* at 4–5.

68. *Id.* at 14–15.

69. *Id.*

70. *Id.* at 19–20.

71. *Id.* at 20–21.

In addition to new sources, the federal strategy identified a strengthened CM supply chain as essential.[72] The government proposes to study the CM supply chain and periodically assess market trends in order to recommend policies like investment in research, capacity expansion, and stockpiling to alleviate supply problems.[73] Deployment of investment tax credits, capital gains tax exemptions, loan guarantees, trade adjustment assistance, and small business procurement opportunities plus new federal legislation are expected to drive private investment to strengthen the supply chain.[74] Under the government's strategy, private industry plays an essential role in strengthening the CM supply.

International trade and cooperation compromise additional federal policies employed to stabilize CM supplies.[75] The federal plan expects to implement policies to improve trade relations and utilize trade agreements.[76] Specifically, by increasing international exchanges with partner nations, U.S. officials hope to identify new opportunities for CM trade and collaboration.[77] By monitoring and limiting foreign trade barriers, officials can help to prevent foreign CM trade practices from harming U.S. industries and broader interests.[78]

Staying attuned to CM market trends and investing more in exploration for potential domestic CM supplies are additional strategies described in the government's plan. Under the plan, the Department of the Interior must periodically update its list of CM and develop new, mineral-specific plans to counteract supply, demand, and production changes.[79] To boost domestic CM supplies, the federal plan emphasized development of maps useful to the mining industry plus promotion of the identification of new conventional, secondary and unconventional sources of CM.[80] According to the federal report, increasing the ability of private industry to locate new CM resources and understanding CM market behavior should ultimately lead to more stable CM supplies.

The federal plan likewise demands a greater focus on shortening federal permitting timeframes and increasing access to public lands containing CM as a means of increasing domestic CM supplies.[81] The

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72. *Id.* at 22.
73. *Id.* at 23.
74. *Id.* at 24–25.
75. *Id.* at 27.
76. *Id.*
77. *Id.* at 29.
78. *Id.*
79. *Id.* at 33.
80. *Id.* at 31, 33.
81. *Id.* at 37.

government acknowledges that any given mining project may require several types of permits.[82] Expediting the permitting processes for mining, under the federal plan, requires evaluating National Environmental Policy Act ("NEPA") and other regulations to improve timely processing of CM permit applications.[83] To improve access, the federal plan promotes new legislation that better facilitates deep-sea mining and incorporates terrestrial mineral projects as part of Title 41 of Fixing America's Surface Transportation ("FAST-41").[84] The government postulates efficient permitting and increased CM location access will create secure CM supplies.

Augmenting both the private and public CM workforces to help drive increases in CM security is yet another tenet of the federal government's strategic plan. The nation's current CM workforce is aging and shrinking.[85] To reverse this trend, the federal strategy advocates for policies aimed at bolstering educational opportunities and interest in mining engineering, geology, and other fields related to CM mining and manufacturing.[86] The federal strategy also identifies a need for the Bureau of Land Management and the U.S. Forest Service to improve recruitment and retention of staff who are familiar with mining.[87] To address these challenges, the federal plan calls for additional employee training focused on domestic CM development and increases in the number of field expert staff positions to hasten the permitting process.[88]

In short, the federal government identifies a wide array of potential policy strategies capable of helping the nation to develop more secure and reliable CM supplies. It highlights the need for a greater focus on research, the incentivizing of domestic mining and manufacturing, international trade, building increased knowledge about domestic CM supplies, and expediting permitting, and workforce augmentation.[89] As valuable of a start as this plan may be, it unfortunately only represents a subset of a broader menu of important strategies available to better secure CM supplies for the crucial transition to renewable energy. Moreover, a few of the approaches advocated in the plan suffer from deficiencies that will

82. *Id.* (The mining proponent must navigate State, Federal and Tribal regulations.)
83. *Id.* at 40.
84. *Id.* at 43.
85. *Id.* at 44.
86. *Id.* at 45.
87. *Id.* at 46.
88. *Id.*
89. *Id.* at 4-5.

likely limit their effectiveness. Accordingly, additional policies are still needed to fill these gaps.

III. DEVELOP, RECYCLE, AND REPLACE

As just described, the U.S. federal government's declared plans for confronting the nation's CM supply challenges are a useful start but are likely incapable of fully addressing these increasingly important problems. Among other things, the federal plan fails to articulate an adequate plan for utilizing international law and the purchasing power of the general public to help drive increases in CM supplies within the U.S. The federal government also neglects to sufficiently clarify the optimal structure of "tax incentives" for incentivizing important industry activities in this area. Although the federal strategy suggests that federal agencies can use their purchasing power to promote greater CM investments, it never describes how to promote such uses or if congressional legislative action should help to spur them. Fortunately, there are promising ways of addressing each of these deficiencies.

Many of the most promising strategies for addressing the nation's CM supply challenges involve the development of new CM mines or of technologies that rely on other mineral resources that are available in greater abundance. Large quantities of CM reside on the deep seafloor or in existing products that might otherwise end up in landfills, and alternative technologies using common substances such as sodium or carbon may also provide solutions to the global CM scarcity problem.[90] This Part describes the current science, regulation, and industry characteristics of deep-sea mining, CM recycling, and CM alternatives and argues for specific policy initiatives to more rapidly advance these

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90. Karen Uhlenhuth, *As World Chases Rare Metal for Batteries, Iowa Looks to Sodium for Storage Solution*, ENERGY NEWS (Oct. 4, 2019), https://energynews.us/2019/10/04/midwest/as-world-chases-rare-metal-for-batteries-iowa-looks-to-table-salt-for-storage-solution/ [https://perma.cc/RUB3-9TFA]; Max Langridge & Luke Edwards, *Future Batteries, Coming Soon: Charge in Seconds, Last Months and Power Over the Air*, POCKET-LINT (June 17, 2019), https://www.pocket-lint.com/gadgets/news/130380-future-batteries-coming-soon-charge-in-seconds-last-months-and-power-over-the-air [https://perma.cc/SP24-NDPP]; Melody Bomgardner, *Recycling Renewables*, CHEMICAL & ENGINEERING NEWS (Apr. 9, 2018), https://cen.acs.org/energy/renewables/Recycling-renewables/96/i15 [https://perma.cc/C73J-86FL]; *Global Ocean Mineral Resources*, U.S. GEOLOGICAL SURVEY, https://www.usgs.gov/centers/pcmsc/science/global-ocean-mineral-resources?qt-science_center_objects=0#qt-science_center_objects [https://perma.cc/SQL6-GZ3J#qt-science_center_objects](last visited August 25, 2020).

strategies. By promoting alternatives to foreign CM importation, the U.S. can develop new industries that contribute to the national economy, secure its CM supply, and ensure the transition to renewable energy continues unabated.

A. Deep-Sea Mining

Greater investment in deep-sea mining is arguably the most promising means of increasing the nation's supply of many CM—a supply that will be insufficient to support a full transition to renewable energy if confined solely to terrestrial sources.[91] However, new policy incentives are needed to allow for deep-sea mining to serve its optimal role in supplying CM. The most straightforward and promising means of doing that would be for the federal government to ratify the United Nations Convention on the Law of the Sea ("UNCLOS") and expedite permitting and licensing for deep-sea mining through the creation of a programmatic Environmental Impact Statement ("EIS"). Through these two actions, the U.S. federal government could spur significant new growth in this industry and ultimately shore up the nation's CM supplies while also allowing the public to provide input on deep-sea mining activities. The following subsections describe deep-sea mining and deposits and how the U.S. could better position itself to engage in deep-sea CM mining within its own exclusive economic zone ("EEZ") and beyond.

1. Deep-Sea Minerals

Vast deposits of important CM are already known to exist on the deep ocean floor.[92] Numerous CM such as lithium, cobalt, and rare-earth elements reside in ferromanganese crusts, polymetallic nodules and seafloor massive sulphides there.[93] Of course, most of these deposits are located at depths surpassing 500 meters.[94]

There are multiple potential benefits of diving to the ocean's floor for minerals rather than continuing to mine terrestrial resources. Among other

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91. PIETER VAN EXTER ET AL., DUTCH MINISTRY OF INFRASTRUCTURE & WATER MGMT., METAL DEMAND FOR RENEWABLE ELECTRICITY GENERATION IN THE NETHERLANDS 4 (2018); *see* Gronewold, *supra* note 1.

92. Olive Heffernan, *Seabed Mining is Coming – Bringing Mineral Riches and Fears of Epic Extinctions*, NATURE (July 24, 2019), https://www.nature.com/articles/d41586-019-02242-y [https://perma.cc/J7SB-3JQR].

93. MACROSOURCE MEDIA, COMMERCIAL DEEP-SEA MINING MARKET REPORT 9 (2019), https://perma.cc/73JC-4HYG.

94. *Id.*

things, deep-sea mining often yields higher grade mineral ores than those found on land because the best known land deposits have already been exploited.[95] For instance, the quality of copper ore (not a CM but an excellent example of the issue) from terrestrial mines fell by 25% in the last ten years.[96] According to the World Bank, one ton of land-based ore is valued at $50-180, while the price per ton of ore extracted from a polymetallic sulphide deposit is worth $500-1,500.[97] Such higher-grade ores are not only less expensive to process, they may also be more environmentally friendly in many instances because they tend to require less energy for processing.[98]

Deep-sea mining does pose some potential environmental threats, the full extent of which are admittedly unknown, but these threats can likely be adequately managed.[99] Oceans cover about 70% of the planet, and scientists have heretofore explored less than one-thousandth of its expanse.[100] Nautilus Minerals' Solwara 1 Project, the first deep-sea mining operation, anticipated loss of habitat, disturbance to the seafloor, sediment plumes, increased noise, and increased metals concentrations in the water column due to deep-sea mining activities.[101] What is known is that deep-sea mining requires disturbance of ocean floor sediments and crusts that take millions of years to reestablish.[102] Sediments disturbed during deep-sea mining experiments nearly three decades ago still show scars.[103] Still, although deep-sea mining will undoubtedly impact the environment, so long as those impacts are properly monitored and mitigated, the environmental benefits of additional CM supplies available through such mining in many instances seem likely to outweigh the costs.

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95. *Id.* at 13.

96. Martha Henriques, *Japan's Grand Plans to Mine Deep-Sea Vents*, BBC (Jan. 6, 2019), https://www.bbc.com/future/article/20181221-japans-grand-plans-to-mine-deap-sea-vents [https://perma.cc/T54D-K7RQ].

97. MACROSOURCE MEDIA, *supra* note 93, at 13.

98. *Id.*

99. Rahul Sharma & Samantha Smith, *Deep-Sea Mining and the Environment: An Introduction*, *in* ENVIRONMENTAL ISSUES OF DEEP-SEA MINING: IMPACTS, CONSEQUENCES, AND POLICY PERSPECTIVES 3, 12 (Rahul Sharma ed., 2019).

100. Antje Boetius & Matthias Haeckel, *Mind the Seafloor*, SCIENCE, Jan. 5, 2018, at 34, 34.

101. NAUTILUS MINERALS NIUGINI LIMITED, SOLWARA 1 PROJECT ENVIRONMENTAL IMPACT STATEMENT 26 (2008).

102. Boetius & Haeckel, *supra* note 100, at 35.

103. *Id.*

2. Regulating Deep-Sea Mining

The geographic location of a CM deposit greatly affects which set of laws regulates its extraction.[104] Some deposits are situated within the EEZs of individual countries, while others are found at remote depths in international waters.[105] Within EEZs, mining activities for these deposits are regulated by an individual country.[106] Outside of EEZs, international law generally governs extraction activities.[107] Accordingly, deep-sea mining activities are subject to either international law or the domestic law of a particular country depending on the specific location of the offshore mining operation.

a. International Regulations

As stated above, international law generally governs the mining of CM deposits situated beyond the limits of any national jurisdiction.[108] UNCLOS provides the primary international framework governing deep-sea mining for most deposits located in international waters.[109] UNCLOS declares the high seas to be the "common heritage of mankind" and generically labels these regions the "Area."[110] The treaty establishes the International Seabed Authority ("ISA") to regulate the "Area" and the Commission on the Limits of the Continental Shelf ("CLCS") to aid in determining the extent of the "Area."[111] Not surprisingly, extracting

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104. Besty Baker & Catherine Danely, *Resource Rights in the Continental Shelf and Beyond: Why the Law of the Sea Convention Matters to Mineral Law*, 64 ROCKY MT. MIN. L. INST 2-1 (2018).

105. *Id.*

106. Randy W. Tong, *It's Time to Get Off the Bench: The U.S. Needs to Ratify the Law of the Sea Treaty Before It's Too Late*, 48 U. OF PAC. L. REV. 317, 328 (2017).

107. *Id.*

108. United Nations Convention on the Law of the Sea, art. 1, Dec. 10, 1982, 1833 U.N.T.S. 397.

109. *Id.* at art. 137.

110. Leta Dickinson, *Clean Energy Requires Rare Metals. Should We Mine the Ocean Floor to Get Them?*, GRIST (June 25, 2019), https://grist.org/article/clean-energy-requires-rare-metals-should-we-mine-the-ocean-floor-to-get-them/ [https://perma.cc/P4WR-X7H9]; United Nations Convention on the Law of the Sea, *supra* note 108, at art. 136–37 (the "Area" is the deep-sea bed outside of the extended continental shelf where no state exercises sovereign rights).

111. United Nations Convention on the Law of the Sea, *supra* note 108, at annex II, art. 1.

resources from this "common heritage of mankind" involves additional responsibilities.

UNCLOS levies fees on all minerals retrieved from the international seafloor. Under the treaty, exploitation of deep-sea natural resources in the "Area" triggers obligations to make in-kind contributions payable to the States Parties to the Convention, to be shared based on the interests and needs of the developing States.[112] It also requires the ISA and States Parties to transfer "technology and scientific knowledge relating to activities in the Area so that the Enterprise and all States Parties may benefit."[113] Through these provisions, UNCLOS attempts to spread the economic benefits and intellectual property gleaned from deep-sea mining activities among its signatory members.

China, Germany, France and Russia are among the 168 countries across the world that are signatories to UNCLOS.[114] Since 2001, the ISA has granted 29 exploration contracts for over 1.3 million square miles of the deep sea.[115] China controls more mining exploration areas in international waters than any other country.[116] In contrast, the U.S. and American companies control zero contracts because the U.S. continues to resist ratifying the treaty.[117]

Not all deep-sea exploitations of mineral resources fall subject to the in-kind contribution requirements under UNCLOS. Deposits within the EEZs of individual countries are outside the regulation of UNCLOS.[118] However, UNCLOS signatory countries may petition to extend their EEZs past the traditional 200 nautical mile (nm) delineation through submissions to CLCS.[119] Such EEZ extensions are a potential way for countries to incur fewer UNCLOS fees.[120]

112. United Nations Convention on the Law of the Sea, *supra* note 108, at art. 82, paras. 1–2, 4.

113. *Id.* at art. 144.

114. MACROSOURCE MEDIA, *supra* note 93, at 20; Tong, *supra* note 106, at 318.

115. MACROSOURCE MEDIA, *supra* note 93, at 3.

116. *Id.* at 2.

117. Baker & Danely, *supra* note 104.

118. United Nations Convention on the Law of the Sea, *supra* note 108, at art. 77.

119. *Id.* at art. 76. The potential scope of these jurisdictional extensions is not limitless. *See id*. at art. 76, para. 5 (the shelf may not extend beyond 350 nm from the baselines which the breadth of the territorial sea is measured or 100 nm beyond the 2,500-meter isobaths).

120. Baker and Danely, *supra* note 104.

b. U.S. Regulations

Existing federal laws and regulations govern nearly every aspect of deep-sea mining within the EEZ of the U.S. The Deep Seabed Hard Mineral Resources Act ("DSHMRA") regulates deep-sea mining within the U.S.'s exclusive economic zone, which comprises all areas within 200 nautical miles of the nation's coastline.[121] Among other things, the Act establishes a licensing regime that ensures the protection of the marine environment, the safety of life and property at sea, the prevention of unreasonable interference with other uses of the seas, and conservation of mineral resources.[122] The National Oceanic and Atmospheric Administration ("NOAA") administers the DSHMRA.[123] To receive a DSHMRA exploration license, licensees must substantially comply with a long list of application requirements, including evidence of sufficient financial resources, technological capability, an exploration plan, a plan for the safety of life and property at sea, and a completed National Environmental Policy Act environmental impact statement.[124] Through this process, NOAA has issued four exploration licenses, including the Clarion-Clipperton Zone of the south Pacific Ocean, which is in international waters.[125]

3. Acceding to UNCLOS

Although a DSHMRA license grants its holder exclusive rights against other U.S. entities, it may not provide secure rights against those whose home countries have signed UNCLOS because the U.S. itself is not a signatory to that treaty.[126] Consequently, the U.S. could improve its capacity to engage in deep-sea mining for CM by acceding to UNCLOS. Unfortunately, the federal government's proposed strategic plan for

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121. Deep Seabed Hard Mineral Resources Act, 30 U.S.C. §§ 1401–1473 (2018).

122. *Deep Seabed Hard Mineral Resources Act Summary*, NAT'L OCEANIC & ATMOSPHERIC ADMIN., https://www.gc.noaa.gov/documents/gcil_dshmra_summary.pdf [https://perma.cc/U6FY-U7SU] (last visited Aug. 25, 2020).

123. 30 U.S.C. § 1413 (2018).

124. NOAA Deep Seabed Mining Regulations for Exploration Licenses, 15 C.F.R. § 970 (2019).

125. NAT'L OCEANIC & ATMOSPHERIC ADMIN., DEEP SEABED MINING, REPORT TO CONGRESS 9–10 (1987), https://www.gc.noaa.gov/documents/gcil_dsm_87_20110607084359.pdf [https://perma.cc/XLF7-48ZK].

126. Deep Seabed Mining: Approval of Exploration of License Extensions, 82 Fed. Reg. 42,327 (Sept. 7, 2017).

increasing domestic CM supplies makes little mention of the use of international diplomacy and treaty-making. Instead, the nation's proposed strategy relies heavily on international trade and cooperation.[127] This approach creates uncertainty for holders of deep-sea mining permits issued by NOAA in international waters and hinders U.S. private investment in such mining activities.

Joining UNCLOS would help the U.S. secure clearer CM-related property rights in multiple ways. Accession would compel a significant number of international states to recognize U.S. entities' real property claims to deep-sea mining areas.[128] It could also facilitate extension of the nation's current 200 nm EEZ, thereby providing stronger access rights to additional jurisdictional territory that potentially contains additional deep-sea mineral deposits.[129] Acceding to UNCLOS would likewise entitle the U.S. to share in the intellectual property developed by the ISA and State Parties and simultaneously protect the country's own deep-sea mining-related intellectual property.[130] By securing U.S. property rights on the world stage, signing and ratifying UNCLOS would arguably provide much greater legal certainty to private U.S. investors in deep-sea CM mining and thereby do much to strengthen this increasingly important industry.

a. Securing Real Property Rights

The U.S. can secure deep sea property rights beyond its EEZ only by acceding to UNCLOS. Negotiating bilateral international agreements, which comprise much of the federal government's current strategy for stabilizing CM supplies, is unfortunately incapable of providing reliable property rights in the deep sea. This problem was evident when the U.S. entered into a temporary agreement, the Provisional Understanding Regarding Deep Sea Mining ("Provisional Understanding"), with Belgium, France, Germany, Italy, Japan, the Netherlands, and the United Kingdom in the 1980s.[131] The Provisional Understanding purported to resolve potential deep-sea mining claims in international waters.[132] However, UNCLOS' Preparatory Commission declared the Provisional

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127. *See* FEDERAL STRATEGY 2019, *supra* note 65, at 27.

128. *See* Tong, *supra* note 106*,* at 319.

129. United Nations Convention on the Law of the Sea, *supra* note 108, at art. 76.

130. U.N. GAOR, 48th Sess., U.N. Doc. A/RES.48/263 (Nov. 16, 1994); United Nations Convention on the Law of the Sea, *supra* note 108, at annex III, art. 5; United Nations Convention on the Law of the Sea, *supra* note 108, at art. 302.

131. Tong, *supra* note 106, at 332–33.

132. *Id.* at 333.

Understanding wholly illegal and rejected any claims made by any party to it.[133] A deep-sea mining regime in conflict with any resolution of UNCLOS is not recognized by the 167 parties to the treaty.[134] Accordingly, the U.S. cannot secure seafloor property rights for CM mining without signing onto UNCLOS. Signing and ratifying the treaty is presently the only plausible way to maximize the nation's access to the planet's stores of deep-sea CM by ensuring more secure and reliable property rights.

More certain and secure property rights attainable through acceding to UNCLOS would finally help U.S. businesses to overcome the property rights uncertainty that currently stalls mining activities in international waters.[135] For example, in the 1970s Lockheed Martin invested $500 million into developing deep-sea diving technologies.[136] NOAA granted Lockheed Martin two deep-sea exploration permits: one in 1984 and the other in 1994 for the Clarion-Clipperton Zone.[137] However, Lockheed Martin has yet to undertake at-sea exploration pursuant to either of these licenses.[138] NOAA explicitly noted, in 2017, that Lockheed "continues to find that the market conditions and the lack of international tenure under UNCLOS prevent the company from moving forward with [the at-sea phase] of its exploration plan."[139]

Even worse, by not joining UNCLOS the U.S. has prompted some U.S. companies to use foreign subsidiaries for their deep-sea mining activities. For instance, the fact the U.S. has not acceded to UNCLOS has not kept Lockheed Martin out of the deep-sea mining game but has merely shifted many of the benefits of those activities to a different country. Lockheed Martin "wanted to join the race for undersea riches, but could not assume investment risks until it was clear that it would have legal title to its finding."[140] To mitigate its investment risk yet still participate in the race, Lockheed Martin moved its deep-sea mining research to a subsidiary

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133. *Id.*

134. *Id.*

135. Deep Seabed Mining: Approval of Exploration of License Extensions, 82 Fed. Reg. 42,327 (Sept. 7, 2017).

136. MACROSOURCE MEDIA, *supra* note 93, at 4.

137. Deep Seabed Mining: Approval of Exploration of License Extensions, 82 Fed. Reg. 42,327.

138. *Id.* at 42,329.

139. *Id.*

140. Stewart M. Patrick, *(Almost) Everyone Agrees: The U.S. Should Ratify the Law of the Sea Treaty*, THE ATLANTIC (June 10, 2012), https://www.theatlantic.com/international/archive/2012/06/-almost-everyone-agrees-the-us-should-ratify-the-law-of-the-sea-treaty/258301/ [https://perma.cc/8PBX-VJFD].

in the United Kingdom (a country party to UNCLOS), secured licenses from ISA, and invested around $16 million.[141] Joining UNCLOS would ensure other major players in deep-sea mining such as China, Russia, and the United Kingdom recognize the claims of the U.S., creating a viable way for U.S. companies to engage directly in deep-sea mining markets.

b. Securing Additional Resources

The U.S. federal government's signing of UNCLOS would also potentially allow for an extension of the country's conventional 200 nm exclusive economic zone. Under Part VI of UNCLOS, coastal sovereign nations receive ownership rights to the resources on the continental shelf.[142] The treaty also allows a coastal state with a broad continental margin to establish an EEZ beyond 200 nm.[143] EEZs are an appealing area for a country to embark in deep-sea mining activities: Mining within a nation's EEZ provides greater emergency response capabilities, greater worker safety, better understood marine environments, and typically lower total costs.[144] Moreover, the possibility of extending the EEZ is becoming even more important now because, as the climate changes, receding ice in the Arctic is opening up new seafloor that could ultimately include CM.[145] For instance, Norwegian researchers recently found new sulphide vent systems possessing CM in the Arctic.[146]

Unless it accedes to UNCLOS, the U.S. cannot assert solid property rights in areas beyond its 200 nm EEZ or protest foreign nation's EEZ extension petitions. Presently, Canada, Russia, Norway, Denmark, and even the U.S. are preparing submissions to CLCS to extend their EEZs in the Arctic.[147] However, unless the U.S. ratifies UNCLOS, it may have no representative on CLCS and no standing to challenge other States'

141. MACROSOURCE MEDIA, *supra* note 93, at 4.
142. United Nations Convention on the Law of the Sea, *supra* note 108, at art. 77.
143. *Id.*
144. Baker & Danely, *supra* note 104.
145. Roncevert Ganan Almond, *U.S. Ratification of the Law of the Sea Convention*, THE DIPLOMAT (May 24, 2017), https://thediplomat.com/2017/05/u-s-ratification-of-the-law-of-the-sea-convention/[https://perma.cc/L2DZ-C7G7].
146. Damian Carrington, *Is Deep Sea Mining Vital for a Greener Future – Even if it Destroys Ecosystems?*, THE GUARDIAN (Jun. 4, 2017 8:00 AM), https://www.theguardian.com/environment/2017/jun/04/is-deep-sea-mining-vital-for-greener-future-even-if-it-means-destroying-precious-ecosystems [https://perma.cc/J2GR-UY9U].
147. Almond, *supra* note 145.

claims.[148] For example, the U.S. once attempted to challenge China's overreaching jurisdictional claims in South China based upon UNCLOS but failed because of its lack of accession.[149] Further, as a non-party to the treaty, even if the U.S. makes a submission to the CLCS, it may not be legally recognizable—a potentially significant problem since the U.S. currently has overlapping claims to portions of the Arctic with Russia and Canada.[150] By acceding to UNCLOS, the U.S. would gain power to defend its property rights at a level recognized by other world powers.

c. Protecting Intellectual Property

Joining UNCLOS would likewise secure U.S. intellectual property rights related to deep-sea mining, further ensuring a more stable domestic CM supply. Years ago, section 5 of UNCLOS flatly mandated transfers of relevant intellectual property from developing Member States to other Member States.[151] However, amendments fairly recently made to the treaty replaced this mandate with more nuanced principles relating to technology transfers.[152] Among other things, under these new provisions if a technology transfer poses a threat to national security the State Party is not forced to disclose the technology.[153] Ratifying UNCLOS would allow the U.S. to gain access to current data and technologies related to the deep sea and protect its intellectual property critical to national security.

In summary, accession to UNCLOS places the U.S. in a better position to protect both real and intellectual property rights related to deep-sea mining. Ratification would allow the U.S.'s claims to valuable CM locations in the Area to be recognized by 168 other parties, including China who is currently the largest holder of deep-sea mining rights. Moreover, the United States will secure and be able to defend its extended EEZ, likely containing additional valuable resources, which is closer to land and more appealing to industry because transportation costs from land are lower. Finally, the U.S. will secure its intellectual property by having access to information developed under UNCLOS as well as the protection afforded by article 302 which prevents disclosure of information related

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148. *Id.*
149. Tong, *supra* note 106, at 336.
150. Baker & Danely, *supra* note 104.
151. United Nations Convention on the Law of the Sea, *supra* note 108, at art. 144.
152. Tong, *supra* note 106, at 339.
153. United Nations Convention on the Law of the Sea, *supra* note 108, at art. 302.

to national security interests. Use of international law fills the gaps left in the federal government's strategy when relying on trade agreements alone. Joining UNCLOS will incentivize deep-sea mining and securing CM.

4. Expediting Permitting and Licensing

The U.S. federal government could further shore up the nation's domestic CM supplies by engaging NOAA to develop a programmatic EIS for deep-sea mining within the country's EEZ. A programmatic EIS would expedite permitting and leasing, which are costly hurdles for many offshore mining projects. Development of a traditional terrestrial mine requires a large investment of time, some seven to ten years.[154] NEPA frequently creates significant permitting delays for terrestrial mines because of its notoriously lengthy review process.[155] Federal agencies may spend up to three years preparing an EIS for a mining project.[156] The NEPA process then continues for potentially an additional six years before culminating in a Record of Decision granting final approval.[157] Under current regulations, deep-sea mining proponents must develop an EIS and thus be subject to this lengthy timetable.[158] To help address this problem, Congress expressly authorized NOAA to create a Programmatic EIS ("PEIS") for offshore mining in the DSHMRA.[159]

Although the federal government's current strategic plan for increasing CM supplies advocates for expedited permitting and leasing of terrestrial mines through the Fixing America's Surface Transportation (FAST-41) program,[160] the existing permitting will need to be significantly restructured to truly become an expedited process tailored to account for the unique characteristics of deep-sea mining work. FAST-41 is arguably inappropriate for deep-sea mining because, unlike surface transportation

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154. U.S. DEP'T OF ENERGY, CRITICAL MATERIALS STRATEGY 104 (2010), https://www.energy.gov/sites/prod/files/edg/news/documents/criticalmaterialsstrategy.pdf [https://perma.cc/3UUW-72LL].

155. *See Consolidation of the Office of Surface Mining Reclamation and Enforcement: Hearing Before the S. Comm. on Energy & Nat. Res.*, 112th Cong. 39 (2012) (prepared statement of Katie Sweeney, General Counsel, National Mining Association).

156. *Id.*

157. *Id.*

158. Deep Seabed Hard Mineral Resources Act §109(d), 30 U.S.C. § 1419(d) (2018).

159. *Id.* § 1419(c).

160. FEDERAL STRATEGY 2019, *supra* note 65, at 43.

and terrestrial mining, the environmental effects are largely unknown. Instead, a programmatic EIS would provide a promising alternative.

The increasing use of PEISs to accelerate solar energy development illustrates their potential value as tools for encouraging deep-sea CM mining. In response to growing interest in utility-scale solar energy development on federally owned lands, the Bureau of Land Management ("BLM") and DOE coordinated with States, Tribes, and the public to develop a programmatic EIS for prime solar energy development areas.[161] Through this process, BLM identified low conflict zones for solar installations and developed publicly vetted mitigation strategies that could be quickly adopted for subsequent solar projects.[162] As a result of this effort, in 2015 BLM approved projects in the low conflict zones in less than half the time previously required for similar projects.[163] By developing pre-screened, low conflict zones and providing vetted mitigation measures to protect wildlife and their habitat, the BLM and DOE dramatically expedited the permitting process for these important projects.[164]

By preparing a similar PEIS that designates low conflict deep-sea CM mining locations and a vetted mitigation strategy, NOAA could similarly accelerate the permitting process and incentivize more private companies to invest in these projects. NOAA's PEIS could feature many elements similar to those of the BLM's and DOE's Solar Energy Program. Specifically, the NOAA PEIS could include a process for identifying low conflict priority areas for deep-sea mining and establishing mitigation measures for deep-sea mining in the EEZ to ensure environmentally responsible development. Adoption of a PEIS that shortened NEPA timelines would attract greater private investment in developing a domestic supply of CM.

B. Increasing the Recycling of Critical Minerals

Improving the nation's CM recycling capabilities and driving the market demand for recycled CM is yet another essential component of any

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161. BUREAU OF LAND MGMT. & U.S. DEP'T OF ENERGY, ES-1, FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT ("PEIS") FOR SOLAR DEVELOPMENT IN SIX SOUTHWESTERN STATES (2012).

162. *Id.*

163. Alex Daue, *Dry Lake Success Demonstrates Public Lands Solar Potential*, MEDIUM (Dec. 20, 2017), https://medium.com/@alex_daue/dry-lake-success-demonstrates-public-lands-solar-potential-5034bf01e6eb [https://perma.cc/WA3T-9GYA].

164. *Id.*

comprehensive set of strategies for ensuring more reliable long-term CM supplies. Lithium-ion batteries, solar panels, and wind turbines often have lifespans of 25 years or less.[165] Unfortunately, the U.S. presently has very limited infrastructure for recycling the CM embedded in these and other products back into high quality minerals.

CM recycling transforms rare, finite CM supplies into at least somewhat renewable ones by making it possible to reuse those supplies in subsequently-manufactured products. For example, direct-drive wind turbines contain 51 to 208 kilograms of rare earth elements per megawatt of generating capacity.[166] The Toyota Prius, a hybrid electric vehicle, totes around 20 pounds of rare earth elements,[167] and Americans purchased over four million comparable hybrid electric cars from 1999 to 2016.[168] And more than seven million tons of solar panels exist in the U.S., all of which also contain CM.[169] Absent an adequate and viable recycling system for them, the tons of CM found in these products will ultimately become waste in landfills.[170]

Some large companies are already increasingly demanding recycled CM. For example, the technology behemoth Apple, Inc., has announced aggressive plans to transition from using virgin CM in its products to using recycled CM instead. The company boldly declared in its 2017 Environmental Responsibility Report, "[c]an we one day stop mining the

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165. Benjamin Mow, *STAT FAQs Part 2: Lifetime of PV Panels*, NAT'L RENEWABLE ENERGY LAB. (Apr. 23, 2018), https://www.nrel.gov/state-local-tribal/blog/posts/stat-faqs-part2-lifetime-of-pv-panels.html [https://perma.cc/L6YJ-BAXT]; *Repowering Wind Turbines Adds Generating Capacity at Existing Sites*, U.S. ENERGY INFO. ADMIN. (Nov. 6, 2017), https://www.eia.gov/todayinenergy/detail.php?id=33632 [https://perma.cc/5TE9-LN64].

166. D.D. Imholte et al., *An Assessment of U.S. Rare Earth Availability for Supporting U.S. Wind Energy Growth Targets*, 113 ENERGY POL'Y 294, 294 (2018).

167. Eichner, *supra* note 8, at 262.

168. Jeff Cobb, *Americans Buy Their Four-Millionth Hybrid Car*, HYBRID CARS (June 6, 2016), https://www.hybridcars.com/americans-buy-their-four-millionth-hybrid-car/ [https://perma.cc/B34E-9X2U].

169. Kirstin Linnenkoper, *U.S. Recyclers Await Critical Mass in Solar Panel Market*, RECYCLING INT'L (Dec. 16, 2019), https://recyclinginternational.com/e-scrap/getting-a-handle-on-the-new-kids-on-the-block-pv-modules/29006/ [https://perma.cc/B34E-9X2U].

170. Avery Thompson, *We Night Not Have Enough Materials for All the Solar Panels and Wind Turbines We Need*, POPULAR MECHS. (Dec. 13, 2018), https://www.popularmechanics.com/science/energy/a25576543/renewable-limits-materials-dutch-ministry-infrastructure/ [https://perma.cc/5BSZ-6JTU].

Earth altogether? It sounds crazy, but we're working on it."[171] Although commitments from companies like Apple are a valuable start, building a robust and mature CM recycling industry within the U.S. will require proactive new policies designed to ensure a steady supply of recyclable material, access to debt-financing, stronger financial incentives to develop CM recycling facilities, and a robust back-end demand for recycled CM products.

The federal government's plan described above acknowledges the need to increase the country's capacity to recycle CM.[172] To pursue this objective, the federal plan calls for the introduction of new investment tax credit programs, government purchase programs, and certain other DoD and DOE activities to help spur private sector investment.[173] Unfortunately, while the generic strategy descriptions in the plan are useful, they do not lay out a clear and viable path for building a robust domestic CM recycling industry. Among other things, the federal plan fails to explain how to ensure that recycled CM are able to compete on price with virgin CM sources. Fortunately, the strategy's shortcomings could be easily addressed through additional, compatible policies. A more comprehensive policy approach to developing a domestic CM recycling industry would focus on ensuring steady supplies of recyclables, access to affordable capital to build out CM recycling infrastructure, and a steady market demand for recycled CM. Policies capable of helping to achieve these conditions include landfill bans, loan guarantee programs, government purchase programs, production tax credits, and investment tax credits.

1. Landfill and Exportation Bans for Recyclable CM

One way to better promote domestic recycling of CM would be to impose a federal ban on the landfilling and exporting of CM-containing products. A functioning CM recycling industry must operate more frequently than just a few days a year to be viable, so creating a consistent domestic supply of CM recyclables for recyclers to process is key.[174] A federal ban on exporting and landfilling specific items that contain CM, including old solar panels, decommissioned wind turbine parts, and spent

171. Zoë Schlanger, *Apple Wants to Try to "Stop Mining the Earth Altogether" to Make Your iPhone*, QUARTZ (April 20, 2017), https://qz.com/964862/apple-says-it-will-stop-using-rare-earth-minerals-to-make-iphones/ [https://perma.cc/XF32-T9VL].

172. FEDERAL STRATEGY 2019, *supra* note 65, at 14.

173. *Id.* at 20–21.

174. Linnenkoper, *supra* note 169.

lithium ion batteries from vehicles, would help to generate this steady supply.

U.S. regulators have already succeeded in creating a reliable supply of recyclable materials for a similar product: the lead-acid batteries found in most gas-combustion vehicles. Lead-acid battery recycling represents one of the most successful recycling campaigns in the U.S., with 98% of all lead-acid batteries collected and recycled.[175] Factors contributing to the industry's success include prohibitions on the disposal and export of batteries and effective consumer education programs.[176]

Federal laws have long banned lead-acid batteries from landfills. The Resource Conservation and Recovery Act ("RCRA") classifies lead-acid batteries as hazardous waste due to their toxic levels of lead.[177] RCRA allows the Environmental Protection Agency ("EPA") to control hazardous waste generation, transportation, treatment, storage, and disposal.[178] RCRA limits the export of lead acid batteries.[179] With the limitation on exportation, the EPA aimed to create a demand for recycling.

Effective consumer education accompanied the federal government's lead-acid battery landfill ban in the form of nationwide labeling and education programs. The Battery Act preempts state laws to establish national, uniform labeling requirements for certain batteries.[180] The Act also mandates that the EPA establish and implement education programs on lead-acid battery recycling and proper disposal of used batteries.[181] Importantly, the Battery Act mandates that the EPA also consult with manufacturers and retailers when creating the education program.[182] Through these and other efforts, American consumers have been made

175. Lauren Neuhaus, *The Electrifying Problem of Used Lithium Ion Batteries: Recommendations for Recycling and Disposal*, 42 ENVIRONS ENVTL. L. & POL'Y J. 67, 78 (2018).

176. *Id.*; Linda Gaines, *The Future of Automotive Lithium-Ion Battery Recycling: Charting a Sustainable Course*, 1–2 SUSTAINABLE MATERIALS & TECHS. 2 (2014).

177. 40 C.F.R. pt. 261 (2019); James Griffin, *RCRA Options for Recycling Waste Lead-Acid Batteries*, LION NEWS (Sept. 25, 2012), https://www.lion.com/Lion-News/September-2012/RCRA-Options-for-Recycling-Waste-Lead-acid-Batteri [https://perma.cc/LW4J-87XA].

178. 42 U.S.C. § 6902 (2018).

179. 40 C.F.R. § 262.83 (2019).

180. U.S. ENVTL. PROT. AGENCY, IMPLEMENTATION OF THE MERCURY-CONTAINING AND RECHARGEABLE BATTERY MANAGEMENT ACT (1997), https://nepis.epa.gov/Exe/ZyPDF.cgi/10000MXZ.PDF?Dockey=10000MXZ.PDF [https://perma.cc/6JDK-C8LX].

181. *Id.*

182. *Id.*

aware of proper disposal procedures and thereby enabled the high recycling rates for lead-acid batteries seen today.

To create a steady supply for CM recyclers, the federal government should mimic aspects of the regulations on lead-acid batteries. Parts of RCRA and the Battery Act should be adopted to promote a supply of products for recycling. Banning particular CM products from export and landfilling would immediately create a demand for recycling as an alternative disposal strategy. Labeling would help better inform the public regarding which products are subject to the requirement and regarding the proper means of their disposal. Educating consumers and manufacturers of the disposal requirements would also increase the likelihood that specific items are properly disposed.

2. Federal Loan Guarantees for CM Recycling Projects

A federal loan guarantee program directed at CM recycling facilities could also help to spur greater private investment in CM recycling infrastructure. Companies tackling new technological challenges such as CM recycling often face hurdles when seeking debt financing. Commercial lenders tend to be understandably hesitant to take on risky, unproven ventures such as deployment of new technology—especially at relatively low interest rates.[183] Such risk aversion of lenders can unfortunately create major difficulties for companies intent on securing long-term debt financing to fund these projects.[184] Federal loan guarantee programs are a proven means of ensuring access to financing for new and important ventures.[185] A federal loan guarantee is a loan provided by an agency or another federal program that is backed by the full faith and credit of the U.S., meaning if the borrower ultimately defaults the full debt will be paid by the U.S. government.[186] Historically, these loan programs have been used to facilitate greater private investment in specific industry areas in furtherance of certain public policy goals.[187] Both the DOE and DoD have offered various loan guarantee programs over the years, some of

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183. *Title XVII Loan Programs Office*, U.S. DEP'T OF ENERGY, https://www.energy.gov/lpo/title-xvii [https://perma.cc/8SG4-KWQJ] (last visited Aug. 24, 2020).

184. *Id.*

185. Hilary Kao, *Beyond Solyndra: Examining the Department of Energy's Loan Guarantee Program*, 36 WM. & MARY ENVTL. L. & POL'Y REV. 425, 448 (2013).

186. *Id.* at 450.

187. *Id.*

which could be adapted to similarly promote investment in CM recycling facilities.[188]

Other important fledgling industries have recently benefited from similar federal loan guarantee programs. For instance, at least some of the rapid growth in the nation's renewable energy industry is likely attributable to loan guarantee programs. Among other things, Title XVII of the Energy Policy Act of 2005 provided a loan guarantee program that ultimately accelerated declines in the market prices for utility-scale solar power projects.[189] Congress authorized the 1705 loan program and for the DOE to issue loans in 2009.[190] In 2011, the DOE finally obtained funds for the 1705 Program and issued $10.5 billion in project financing in two months before the American Recovery and Reinvestment Act ("ARRA") sunset in September.[191]

Even with its limited funding timeframe, the DOE's 1705 loan guarantee program produced enormously successful overall results. The DOE issued guaranteed loans for five utility scale solar projects and five concentrating solar projects.[192] Overall, by investing $4 billion, the DOE closed $37.8 billion in loan guarantees for 36 innovative clean energy programs.[193] The loan guarantee program drove venture capitalists to invest in the best technology, allowing winners to emerge.[194] As stated in Forbes, "[f]inancing tools and direct investment from the federal government can help bridge this well-known 'Commercialization Valley of Death,' and the [loan guarantee program] is an effective way of doing that."[195] The federal loan guarantee program proved very successful in the solar industry.

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188. *See* Energy Policy Act of 2005, 42 U.S.C. §§ 16511–16515 (2018); 10 C.F.R. § 609 (2020); 48 C.F.R. § 32.303 (2020).

189. TROY RULE, RENEWABLE ENERGY LAW: LAW, POLICY, AND PRACTICE 369 (2018).

190. American Recovery and Reinvestment Act of 2009 (ARRA) § 406, 42 U.S.C. § 16516 (Supp. IV 2010).

191. Kao, *supra* note 185, at 454.

192. RULE, *supra* note 189, at 369.

193. Devon Swezey, *Solyndra's Failure is No Reason to Abandon Federal Energy Innovation Policy*, FORBES (Sept. 2, 2011 7:33PM), https://www.forbes.com/sites/energysource/2011/09/02/solyndras-failure-is-no-reason-to-abandon-federal-energy-innovation-policy/#2a35b9e12df9. [https://perma.cc/U4G7-LPFV] (Naysayers of the DOE's federal loan program latched on to the bankruptcy of loan recipient Solyndra, a solar panel manufacturer. However, the loan made to Solyndra represented less than two percent of DOE total loan commitments.)

194. *Id.*

195. *Id.*

Given the success of past programs in other technology areas, the DOE and DoD should expand their loan guarantee programs to target start-up CM recyclers. Recall, due to DOE's incentives, explosive growth is occurring in the renewable energy and battery sectors which is driving the consumption of CM. The DoD, while not increasing CM consumption via policies, is forcing CM depletion due to continuous purchases of defense items.[196] Because these agencies rely on CM for essential functions, they are in the best position to drive use of recycled CM. A federal loan program offers to mitigate some of the CM instability created by defense and renewable generation and storage growth due to previous policies and continue to grow industries crucial to decarbonization.

New loan programs would help the CM recycling industry to prove the financial viability of CM recycling, helping to pave the way for future growth in the industry. The DoD has purchased a considerable number of products containing CM, such as jet engines, smart missiles, and night vision goggles,[197] which suggests that the agency has a significant interest in further promoting the nation's CM security. Loan guarantee programs would assist in that effort. Startups are already pursuing a wide range of different methods for increasing CM recovery from products, but financing challenges could ultimately impede the growth of these innovative companies without such federal support.[198] Moreover, as the renewable energy federal loan guarantee programs described above showed, the federal government may well recoup more than it invests in such programs.

3. Production Tax Credits for Recycled Critical Minerals

A federal production tax credit ("PTC") aimed at recycled minerals would be another potentially promising means of stimulating the

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196. C. Todd Lopez, *DOD Finalizes Purchase Plan for F-35 Aircraft*, U.S. DEP'T OF DEFENSE (Oct. 29, 2019), https://www.defense.gov/explore/story/Article/2002585/dod-finalizes-purchase-plan-for-f-35-aircraft/ [https://perma.cc/SM77-8TY2].

197. MINERAL COMMODITY SUMMARIES 2019, *supra* note 3, at 51; Sanders, *supra* note 55.

198. Harmon Leon, *Startup Develops Eco-Friendly Process to Recycle Lithium-Ion EV Batteries*, OBSERVER (Dec. 27, 2019, 1:24PM), https://observer.com/2019/12/duesenfeld-lithium-ion-battery-recycling-eco-friendly/ [https://perma.cc/28WK-VPGV]; Mitch Jacoby, *It's Time to Get Serious About Recycling Lithium-Ion Batteries*, CHEMICAL & ENGINEERING NEWS (July 14, 2019), https://cen.acs.org/materials/energy-storage/time-serious-recycling-lithium/97/i28 [https://perma.cc/EV7W-5B4J].

production of recycled CM. Currently, many technologies for recycling CM-containing products remain in their infancy. For large format lithium-ion ("LF Li-ion") batteries, only three primary recovery processes are presently available.[199] LF Li-ion batteries may be smelted at high temperatures with some valuable minerals recovered.[200] However, the lithium recovered through this process is relatively low-grade and has historically been used primarily as an additive to concrete.[201] Direct recovery methods allow for retrieval of battery-grade materials with low energy requirements.[202] Intermediate recovery results in the salvage of lithium of a quality that is higher than that of smelting, but lower than that produced through direct recovery methods.[203] Wind turbine magnets are currently recycled through smelting.[204] To spur higher recovery rates, demand for this type of recycled CM needs to increase.

The total cost of recycling CM from old products are significantly higher today than those of other disposal options such as landfilling, which has led to minimal private investment in CM recycling technologies.[205] Moreover, the prospect that new CM alternative technologies could ultimately depress demand for valuable CM such as cobalt from batteries and solar panels further limits interest in CM recycling.[206] The federal plan does not include any strategies for increasing the market value of recycled CM. Instead, it focuses primarily on offering investment tax credits ("ITC") to attract additional private investment in the development of new recycling facilities.[207] Although the ITC could have positive effects, incentives may be needed to increase demand because even with an ITC

199. *Batteries for Hybrid and Plug-In Electric Vehicles*, U.S. DEP'T OF ENERGY, https://afdc.energy.gov/vehicles/electric_batteries.html [https://perma.cc/AKE2-3ANJ] (last visited Aug. 25, 2020).

200. *Id.*

201. *Id.*

202. *Id.*

203. *Id.*

204. Jan Dodd, *Rethinking the Use of Rare-Earth Elements*, WIND POWER MONTHLY (Nov. 30, 2018) https://www.windpowermonthly.com/article/1519221/rethinking-use-rare-earth-elements [https://perma.cc/TDL9-9RG9].

205. Jeff McMahon, *Innovation Is Making Solar Panels Harder To Recycle,* FORBES (Sept. 4, 2018) https://www.forbes.com/sites/jeffmcmahon/2018/09/04/innovation-is-making-solar-panels-harder-to-recycle/#304c3a214c0a [https://perma.cc/U35Q-SS4P].

206. *Id.*

207. FEDERAL STRATEGY 2019, *supra* note 65, at 20–21.

the market prices of recycled CM will likely be more expensive at first than their virgin domestic counterparts.[208]

A federal "renewable minerals" PTC could provide the additional boost needed to help recycled CM become cost-competitive with virgin CM and thereby unleash strong growth in CM recycling markets. In the renewable energy context, PTCs proved to be highly effective at generating strong market demand for a particular product. In 1992, Congress created a renewable energy PTC in the Energy Policy Act of 1992 to incentivize greater production and sale of certain types of renewable power as a means of diminishing U.S. dependence on foreign energy.[209] In its original form, the PTC allowed taxpayers to claim the credits for the production and sale of power from eligible renewable resources such as wind for ten years.[210] Further, the renewable energy PTC included curtailment and phase out provisions. Because the PTC was offered for a limited time, it created a strong financial incentive for developers to rapidly pursue the development of new wind energy projects.[211]

Recycled CM are similar to wind energy in multiple ways. Wind energy competes against finite and less-sustainable fossil fuel resources,[212] and recycled CM must likewise compete against an entrenched and less-sustainable virgin CM industry.[213] Both recycled CM and wind-generated electricity are also measurable on a per unit basis. Because of these similarities, it is easy to imagine how a PTC structure comparable to that used to promote wind energy development could similarly aid in fueling market demand for recycled CM.

A new federal "renewable minerals" PTC could be structured to award tax credits on a per unit basis as a means of helping recycled CM to

208. Curt Harler, *Rare Opportunity to Recycle Rare Earths*, RECYCLING TODAY (Jan. 3, 2018), https://www.recyclingtoday.com/article/rare-earth-metals-recycling/ [https://perma.cc/45JN-TKQK].

209. Energy Policy Act of 1992, 42 U.S.C. § 13317a (2018).

210. 26 U.S.C. § 45(a) (2018); *see* Victoria Chang, *Wind Energy Incentives in Texas*, 14 TEX. J. OIL GAS & ENERGY L. 189, 196 (2019); *see also Renewable Electricity Production Tax CREDIT*, DATABASE OF STATE INCENTIVES FOR RENEWABLES AND EFFICIENCY, https://programs.dsireusa.org/system/program/detail/734 [https://perma.cc/74EH-8E78] (last visited Aug. 25, 2020) (PTC is calculated on a per kilowatt hour basis).

211. RULE, *supra* note 189, at 124–25 (Describing the phasing out of the PTC).

212. Nicolas Loris, *The Wind Production Tax Credit and the Case for Ending All Energy Subsidies*, 23 DUKE ENVTL. L. & POL'Y F. 323, 323–24 (2014); *see also* General Mining Act of 1872, 30 U.S.C. §§ 22–42 (2018) (Congress began incentivizing terrestrial domestic mining as early as 1872).

213. General Mining Act of 1872, 30 U.S.C. §§ 22–42.

become price-competitive with virgin CM. Eligibility for the credits could likewise be limited to only certain types of recycled CM that are particularly needed to support renewable energy and battery growth and that met specific quality standards. By limiting the availability of renewable minerals PTCs to a certain number of years and then phasing it, Congress could incentivize private entities to invest sooner rather than later in developing new CM recycling facilities. Much like the PTC did for wind energy, such a "renewable minerals" PTC could potentially be a powerful instrument for increasing CM recycling capacity, advancing technologies in this area, and accelerating the maturity of domestic CM recycling markets.

4. Federal Investment Tax Credits for CM Recycling Facilities

Federal investment tax credits could be another powerful means of spurring growth and investment in the nation's emerging CM recycling industry. A federal ITC program has already proven successful at helping to catalyze rapid growth in the nation's renewable energy sector. The renewable energy ITC, established under the Energy Tax Act of 1978, rewards investments in renewable energy generation technologies such as solar, fuel cells, and small wind projects.[214] The ITC is available to any utility, private entity, or individual that makes a qualifying investment in eligible renewable energy projects or devices.[215] Like the renewable energy PTC, the ITC program has expiration dates built into it that have long helped to drive short-term investment.[216] By one account, the ITC is estimated to have helped the solar industry grow over 10,000% since 2006.[217]

Even as the renewable energy ITC sunsets, renewable energy markets in the U.S. remain poised for continued growth. Grid-level energy storage development is expected to increase rapidly in the coming years, with a jump from 12 gigawatt-hours of storage capacity in 2018 to 158 gigawatt-

214. Felix Mormann, *Beyond Tax Credits: Smarter Tax Policy for a Cleaner, More Democratic Energy Future*, 31 YALE J. ON REG. 303, 314 (2014).

215. Michael Seibert, *Ain't No Sunshine When It's Gone: The Future of the Louisiana–Solar Initiative After the Demise of the Solar Energy Income Tax Credit*, 78 LA. L. REV. 705, 710–11 (2018).

216. *Solar Investment Tax Credit*, SOLAR ENERGY INDUSTRIES ASS'N, http://www.seia.org/policy/finance-tax/solar-investment-tax-credit [https://perma.cc/5CU6-LSTP] (last visited Aug. 24, 2020).

217. *Id.*

hours by 2024.[218] Meanwhile, solar panel installations reached two million in mid-2019 and are expected to grow to over four million installations in the U.S. by 2023.[219] The DOE expects domestic wind energy generating capacity to increase by 110.66 gigawatts by 2030.[220]

As it has done for certain types of renewable energy, an ITC program for recycled CM could significantly increase private investment in CM recycling. Specifically, a "renewable minerals" ITC program could be structured to provide financial incentives for taxpayers that invest in the development of qualifying CM recycling facilities. A clear expiration date or phase-out schedule for the renewable minerals ITC could similarly create urgency and spur more short-term investment.

5. Leveraging Government Purchasing Power

Directing the federal government to purchase far more products containing recycled CM is an additional means of further bolstering demand for recycled CM. Of all the agencies, the DoD possesses the greatest purchasing power.[221] At times, the DoD's purchasing power has comprised as much as 2.5% of the U.S.'s gross domestic product.[222] Moreover, the DoD regularly purchases CM containing products like F-35 aircraft, smart bombs, and night vision goggles.[223] In 2019, the DoD purchased 478 F-35 aircraft worth a total of $34 billion.[224] The DoD's purchasing power and the necessity to continue purchasing products like jets for national security present a great opportunity to increase recycled CM demand.

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218. Jeff St. John, *Global Energy Storage to Hit 158 Gigawatt-Hours by 2024, Led by U.S. and China*, GREEN TECH MEDIA (Apr. 10, 2019), https://www.greentechmedia.com/articles/read/global-energy-storage-to-hit-158-gigawatt-hours-by-2024-with-u-s-and-china [https://perma.cc/DP9D-RMUG].

219. *United States Surpasses 2 Million Solar Installations*, SOLAR ENERGY INDUSTRIES ASS'N (May 9, 2019), https://www.seia.org/news/united-states-surpasses-2-million-solar-installations [https://perma.cc/E6QJ-H523].

220. *Wind Vision*, U.S. DEP'T OF ENERGY, https://www.energy.gov/maps/map-projected-growth-wind-industry-now-until-2050 [https://perma.cc/9PNP-JHCA] (last visited Aug. 25, 2020).

221. Samuel M. Borowski, *The Inchoate Mistake: Demystifying the Defense Department's Competition Problem*, 45 PUB. CONT. L.J. 183, 186 (2016).

222. *Id.*

223. VALERIE BAILEY GRASSO, CONG. RESEARCH SERV., RL33751, THE SPECIALTY METAL CLAUSE: OVERSIGHT ISSUES AND OPTIONS FOR CONGRESS 6 (2014).

224. Lopez, *supra* note 196.

Congress could harness more of the DoD's purchasing power to help grow the domestic CM recycling industry through new standards that mandated that the DoD gradually have an increasing proportion recycled CM in newly- procured equipment and products. The federal specialty metals statute presently prohibits the DoD from acquiring products "containing a specialty metal not *melted* or *produced* in the U.S.: aircraft, missile and space systems, ships, tank and automotive items, weapon systems, or ammunition."[225] This statute could be easily amended to require a gradually-increasing percentage of recycled CM to be present in these items.

The DoD could further use its purchasing power to help drive recycled CM demand through revisions to its Defense Federal Acquisition Regulation Supplement ("DFARS").[226] For example, via a recent DFARS final rule, DoD prohibited purchase of certain magnets from North Korea, China, Russia, and Iran.[227] In a similar way, the DoD could promulgate a rule requiring the contact-purchased items to aggregately contain some minimum proportion or quantity of domestically recycled CM. Such an action would not only increase demand for recycled CM; it would also reduce the capacity for foreign nations to use CM supplies as leverage against U.S. interests. By increasing the stability of domestic CM supplies, such actions could also help to accelerate the nation's transition to renewable energy and national security.

C. Promoting the Development of Critical Minerals Alternatives

Policies that promote the development of alternatives to CM use are one other important component of any comprehensive plan to increase the nation's CM security. In many types of renewable energy products and devices, there are strong reasons to believe that replacing CM with non-CM materials will ultimately be possible. When China briefly stopped supplying Japan rare-earth elements in 2010, Japan began working on alternative materials to reduce and replace the elements.[228] And when global rare-earth element prices spiked in 2011, some wind turbine

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225. 10 U.S.C. §2533b(a)(1) (2018) (emphasis added) (Currently "specialty metals" includes steel, metal alloys consisting of nickel and cobalt in excess of 10%, titanium, and zirconium.).

226. 48 C.F.R. pts. 200–253 (2020).

227. Defense Federal Acquisition Regulation Supplement, 84 Fed. Reg. 72,239 (2019) (heralded as "shield[ing] U.S. critical resource needs from the decisions of foreign adversaries").

228. Burnett & Dwyer, *supra* note 46.

manufacturers developed alternative magnet formulas with reduced use of rare-earth elements.[229]

Due to instabilities in the global CM market, companies are increasingly exploring possible means of using more common materials as substitutes. For instance, early studies suggest that carbon-based graphene batteries may potentially be superior to lithium-ion batteries in both energy density and charging speeds.[230] Even saltwater holds potential as a CM substitute.[231] Developing ways to replace CM with non-CM materials in wind turbines, batteries, and other parts of sustainable energy infrastructure could diminish insecurity in domestic supply chains and ultimately have very positive effects on renewable energy growth. In light of this, it is hardly surprising that the federal plan specifically recommends using federal funding to establish and continue public-private research relationships focused on alternatives to CM-based technologies.[232] Implementing such regulations could eventually prove highly influential in helping to drive the nation's transition to a carbon neutral economy.

1. Federal Research Grants

Federal research grants for technologies that involve alternatives to CM are a particularly promising means of driving more research and innovation in that area. The federal government has long used various research grant programs to fund research at universities and other nonprofit institutions.[233]

One recent successful example of a federally funded research grant program is the DOE's SunShot initiative for solar energy. In 2011, the DOE created a new research funding program aimed at reducing the cost

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229. Dodd, *supra* note 204.

230. Martyn Casserly, *Lithium-Ion vs Graphene*, TECHADVISOR (Sept. 24, 2019), https://www.techadvisor.co.uk/feature/mobile-phone/lithium-ion-vs-graphene-3702749/ [https://perma.cc/SNL2-WSQC]; Jelor Gallego, *Scientists Develop a Better Graphene Battery*, FUTURISM (Mar. 7, 2016), https://futurism.com/scientists-develop-better-battery-thanks-graphene [https://perma.cc/B6JE-NQJL].

231. Bianca Nogrady, *Build a Better battery for Wind and Solar Storage, and the Energy Sector will Beat a Path to Your Door*, ENSIA (Sept. 27, 2019), https://ensia.com/features/battery-innovations-renewable-energy/ [https://perma.cc/DAP7-MGT8].

232. FEDERAL STRATEGY 2019*, supra* note 65, at 14.

233. RULE, *supra* note 189, at 367.

of solar energy systems by 75% from 2010 prices by 2020.[234] The DOE determined that achieving such reductions in cost would enable solar energy technologies to finally become price-competitive with more conventional energy strategies.[235] Over the past decade, numerous national laboratories, universities, and other solar industry stakeholders received research funding through the SunShot initiative.[236] The DOE provided over $900 million to fund more than 350 projects during the initiative's first three years alone.[237] Impressively, SunShot ultimately reached its initial goal of reducing the cost of solar by 75% by 2017—three years ahead of schedule.[238] The SunShot Initiative's success demonstrates the potential effectiveness of federal research grant programs focused on a particular goal for incentivizing development of a new and important industry.

Although potential disruptions in CM supplies seem like a relatively new concern, research recognizing the potential for such disruptions began in earnest under the Obama Administration. In 2013, the DOE launched the Critical Materials Institute ("CMI") at Ames Laboratory.[239] In connection with the launch, the DOE acknowledged that "many of the fastest growing clean energy technologies, from batteries to solar panels, are made with . . . [CM]," which "are essential to the clean energy economy and are at risk for supply disruptions."[240] Research at the CMI

234. *The SunShot Initiative*, U.S. DEP'T OF ENERGY, https://www.energy.gov/eere/solar/sunshot-initiative [https://perma.cc/5MDK-QF8W] (last visited Oct. 23, 2020).

235. *Id.*

236. *SunShot Initiative Awardees*, OFF. OF ENERGY EFFICIENCY & RENEWABLE ENERGY, https://www.energy.gov/eere/solar/sunshot-initiative-awardees [https://perma.cc/9J45-XU84] (last visited Oct. 23, 2020).

237. Adam Wilson, *The Future Looks Bright, or Does It? An Analysis of Solar Energy Law and Policy in the United States*, 22 J. ENVTL. & SUSTAINABILITY L. 333, 348–49 (2016) (Research focused on: (1) improving efficiencies and reducing costs of photovoltaic and concentrating solar power technologies; (2) increasing grid penetration through systems integration; (3) helping new technologies get to market and become widely available, faster and more easily; and (4) reducing the soft costs of solar deployment, such as permitting, installation, and financing.).

238. *The SunShot Initiative*, *supra* note 234.

239. *Increasing Access to Materials Critical to the Clean Energy Economy*, U.S. DEP'T OF ENERGY (Jan. 9, 2013), https://www.energy.gov/articles/increasing-access-materials-critical-clean-energy-economy [https://perma.cc/LRG5-Y7JT] (national laboratories, universities and industry make up the participants in CM).

240. *Id.*

has since focused on reducing CM in products and on developing alternatives to CM.[241] The CMI has already proven successful in multiple ways. For instance, the Institute successfully produced phosphors for red and green lights that use 90% less or no CM at all, developed magnets that rely on cerium (a rare-earth element that is abundant and easy to obtain), and discovered acid-free methods recycling of rare-earth elements that eliminate significant environmental impacts.[242] In all, the federally funded CMI has generated more than 120 inventions related to reducing use of CM in the past six years.[243] Recognizing the Institute's success, the DOE opted to extend the project for another five years with an additional $125 million funding.[244]

Further increased funding to the CMI and comparable CM-related federal research initiatives and specifying detailed goals in connection with those initiatives could be a promising additional means of shoring up the nation's domestic CM supplies. For instance, the SunShot Initiative had an explicit goal of reducing the cost of solar energy by 75%.[245] Ideally, the DOE would establish similar goals to help guide grant-funded research into CM recycling and CM alternatives. Communicating clearer objectives and providing more generous funding for such research grant programs could be two additional means of ensuring that the nation continues to have the CM supplies necessary to facilitate embracing more sustainable, carbon-free energy technologies.

CONCLUSION

Maintaining reliable supplies of critical materials is an increasingly important aspect of supporting the nation's transition to a clean, sustainable energy system. Fortunately, there are policy strategies capable of addressing many of the obstacles and challenges that have historically

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241. *Id.* (Additional research goals included determining what materials will be important to clean energy technologies, creating new economically viable processing technology to extract rare earth elements from ores, developing material substitutes that are readily available for American manufacturers and reducing the amount of critical material needed in clean energy technologies and increase recycling and reuse.)

242. CRITICAL MATERIALS INST., ANNUAL REPORT — 2019, at 6 (2019), https://iastate.app.box.com/s/kq1ider2rru6c69t4sw0q6aw438ez29r [https://perma.cc/MXA6-GG7R].

243. *Id.* at 12.

244. *Increasing Access to Materials Critical to the Clean Energy Economy*, *supra* note 239.

245. *Id.*

limited domestic supplies of CM. Specifically, the U.S. federal government could greatly increase the nation's investment in deep-sea mining by acceding to UNCLOS and by developing a PEIS to shorten permitting and leasing timelines. Congress and certain federal agencies could also take numerous actions to strengthen the viability and growth of the domestic CM recycling industry. Specifically, the federal government could impose landfill bans for certain types of CM, create loan assistance programs for developers of CM recycling facilities and products, enact PTC and ITC programs to help recycled CM be more price-competitive with virgin CM materials, and leverage the DoD's purchasing power to further increase demand for recycled CM. In addition, Congress could increase federal funding for research grant programs focused on promoting the development of alternative technologies for batteries, wind turbines, solar panels and other types of renewable energy infrastructure that rely less heavily on CM. By aggressively embracing these initiatives, the U.S. is capable of finally stabilizing and shoring up its CM supplies, promoting greater national security, and accelerating the nation's adoption of carbon-free, renewable energy technologies.