DE-FOA-0002358: Request for Information on the Office of Energy Efficiency & Renewable Energy's in support of Battery Critical Materials Supply Chain R&D

DATE: June 29, 2020
SUBJECT: Request for Information (RFI)

Description

This RFI pertains to a Research & Development (R&D) Battery Critical Materials Supply Chain Workshop planned to be hosted by the Office of Energy Efficiency & Renewable Energy (EERE), Advanced Manufacturing Office (AMO), Geothermal Technologies Office (GTO) and Vehicle Technologies Office (VTO).

Background

Critical materials are used in many products important to the U.S. economy and national security. Of the 35 mineral commodities identified as critical in the list[1] published in the Federal Register by the Secretary of the Interior, the U.S. is 100% net import reliant for 14[2] and is more than 50% import-reliant for 17 of the remaining 21 mineral commodities.[3] This import dependence is a problem when it puts supply chains, U.S. companies, and material users at risk.[4] To reduce the nation's vulnerability to disruptions in the supply of critical minerals, the President issued Executive Order (EO) 13817, *A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals*.[5]

The EO directs the Secretary of Commerce, in coordination with heads of selected executive branch agencies and offices, to submit a report to the President that includes:

I. a strategy to reduce the Nation's reliance on critical minerals;

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[1] Aluminum (bauxite), antimony, arsenic, barite, beryllium, bismuth, cesium, chromium, cobalt, fluorspar, gallium, germanium, graphite (natural), hafnium, helium, indium, lithium, magnesium, manganese, niobium, platinum group metals, potash, the rare earth elements group, rhenium, rubidium, scandium, strontium, tantalum, tellurium, tin, titanium, tungsten, uranium, vanadium, and zirconium

[2] U.S. Geological Survey, "Mineral Commodity Summaries 2020," 2020, https://doi.org/10.3133/mcs2020

[3] [3] Department of the Interior, "Final List of Critical Minerals 2018," 83 Fed. Reg. 23295; 2018, https://www.federalregister.gov/documents/2018/05/18/2018-10667/final-list-of-critical-minerals-2018

[4] Department of the Interior, "Final List of Critical Minerals 2018," 83 Fed. Reg. 23295; 2018, https://www.federalregister.gov/documents/2018/05/18/2018-10667/final-list-of-critical-minerals-2018

[5] https://www.whitehouse.gov/presidential-actions/presidential-executive-order-federal-strategy-ensure-secure-reliable-supplies-critical-minerals/

This is a Request for Information (RFI) only. EERE will not pay for information provided under this RFI and no project will be supported as a result of this RFI. This RFI is not accepting applications for financial assistance or financial incentives. EERE may or may not issue a Funding Opportunity Announcement (FOA) based on consideration of the input received from this RFI.

II. an assessment of progress toward developing critical minerals recycling and reprocessing technologies, and technological alternatives to critical minerals;
III. options for accessing and developing critical minerals through investment and trade with our allies and partners;
IV. a plan to improve the topographic, geologic, and geophysical mapping of the United States and make the resulting data and metadata electronically accessible, to the extent permitted by law and subject to appropriate limitations for purposes of privacy and security, to support private sector mineral exploration of critical minerals; and
V. recommendations to streamline permitting and review processes related to developing leases; enhancing access to critical mineral resources; and increasing discovery, production, and domestic refining of critical minerals.

The Department of Commerce (DOC) subsequently published the report to the President on June 4, 2019.[6]

The U.S. Department of Energy (DOE) assesses material criticality based on importance to a range of energy technologies and the potential for supply risk. To mitigate risk for supply chain disruption, DOE coordinates research and development (R&D) around three pillars:

1. Diversifying supply of critical materials – including domestic production and processing;
2. Developing substitutes; and
3. Driving recycling, reuse, and more efficient use.

The National Science & Technology Council (NSTC) Critical Minerals Subcommittee (CMS) is the interagency body that will coordinate implementation of the Federal Strategy. An organizing principle of this strategy is to address the full supply chain of critical minerals, which spans from securement of raw materials to end-uses in both civilian and defense applications. The strategy is organized around six Calls to Action, supported by 24 goals with corresponding specific agency level recommendations that will be pursued over the next five years. DOE is the lead for Call to Action 1 of the Federal Strategy: "Advance Transformational Research, Development and Deployment across Critical Mineral Supply Chains." In coordination with broad Federal agency input,[7] DOE will lead the development of a roadmap that identifies key R&D needs and coordinates on-going activities for source diversification, more efficient use, recycling, and substitution for critical minerals; as well as cross-cutting mining science, data science

[6] A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Materials. U.S. Department of Commerce. June 2019. Available online at: https://www.commerce.gov/sites/default/files/2020-01/Critical_Minerals_Strategy_Final.pdf.

[7] Other key coordinating agencies for Action 1 encompass the Department of Commerce (DOC) including the National Institute of Standards and Technology (NIST) and National Oceanic and Atmospheric Administration (NOAA); the Department of Defense (DOD), the Department of the Interior (DOI) including the United States Geological Survey (USGS), and the Environmental Protection Agency (EPA).

techniques, materials science, manufacturing science and engineering, computational modeling, and environmental health and safety R&D.

Critical materials used in the fabrication of cathodes for lithium-ion batteries include cobalt (Co), lithium (Li), and manganese (Mn). Nickel (Ni) is also a material used in cathode fabrication, and while not included on the list of critical mineral commodities published by the Secretary of Interior, industry has expressed concern about the ability of the market to meet demand in the future due to the high purities required for cathode production.

There is limited domestic production of Co and Li in the upstream supply chain. In 2019, the U.S. produced an estimated 500 metric tons of Co from a nickel-copper mine in Michigan and mine tailings in Missouri (less than 1% of global mine production), plus an additional 2,700 metric tons in secondary production (recycled materials, post-industrial, and post-consumer materials). Li can be extracted from brines[8] or hard rock, and the U.S. has significant resource potential. There are 6.8 million metric tons of Li identified resources from continental brines, geothermal brines, hectorite, oilfield brines, and pegmatites. The only domestic Li primary production in 2019 was from continental brine extraction. Ni is produced both as a primary product from mining and as a byproduct from refining operations. In 2019, the U.S. produced 14,000 metric tons of Ni concentrates from mining (less than 1% of global mine production). These concentrates are exported for smelting.[9]

The ability for U.S. manufacturers to process powders and fabricate cathodes in the midstream supply chain for these critical materials is constrained in part by the lack of domestic raw material production and refining (Figure 1). In 2019, the U.S. was more than 50% import-reliant for supply of Co, more than 25% import-reliant for supply of Li, and more than 57% import-reliant for supply of Ni.[4] Refinement of materials – both critical and not – for battery cathode fabrication generally flow through China. In 2019, 64% of the world's Co mine production was supplied by the Democratic Republic of Congo, with most of the processing occurring in China. Some processing of Li from brine extraction into precursors (Li_2CO_3 and LiOH) for cathode fabrication does occur in the U.S., but the production of cathode powders is dominated by foreign markets.

[8] Such as continental brines, salar brines, ambient brines, geothermal brines, tail brines and oilfield brines.
[9] U.S. Geological Survey, "Mineral Commodity Summaries 2020," 2020, https://pubs.er.usgs.gov/publication/mcs2020

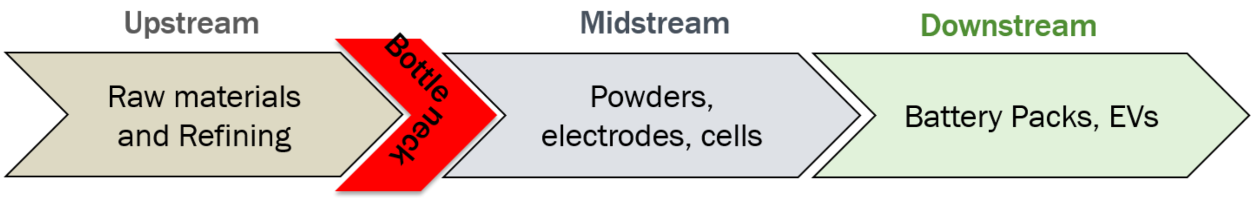

Figure 1. Bottleneck in the battery critical materials supply chain between upstream raw materials production and refining and midstream material processing and component fabrication.

This RFI is being issued by DOE's Advanced Manufacturing Office (AMO), in collaboration with the Geothermal Technologies Office (GTO) and Vehicles Technologies Office (VTO). The mission of AMO is to catalyze research, development and adoption of energy-related advanced manufacturing technologies and practices to increase energy productivity and drive U.S. economic competitiveness. AMO strategic goals to achieve this mission include:

- Improve the productivity, competitiveness, energy efficiency and security of U.S manufacturing;
- Reduce lifecycle energy and resource impacts of manufacturing goods;
- Leverage diverse domestic energy resources and materials in U.S. manufacturing, while strengthening environmental stewardship;
- Transition DOE supported innovative technologies and practices into U.S. manufacturing capabilities; and
- Strengthen and advance the U.S. manufacturing workforce.

In support of these goals as they relate to critical materials for lithium-ion batteries, AMO funds lithium-ion battery recycling and reuse R&D as part of the Critical Materials Institute (CMI), a DOE Energy Innovation Hub led by Ames Laboratory. CMI's mission is to accelerate the development of technological options that assure supply chains of materials essential to clean energy technologies—enabling innovation in U.S. manufacturing and enhancing energy security. CMI's battery recycling efforts focus on physical, chemical, and biological approaches to recover precursor and elemental critical materials from end-of-life products.

This RFI and *R&D Battery Critical Materials Supply Chain Workshop* will be coordinated with the DOE Energy Storage Grand Challenge,[10] which was announced in January 2020. The vision for

[10] The Energy Storage Grand Challenge is a cross-cutting effort managed by DOE's Research and Technology Investment Committee (RTIC). DOE established the RTIC in 2019 to convene the key elements of DOE that support R&D activities, coordinate their strategic research priorities, identify potential cross-cutting opportunities in both basic and applied science and technology, and accelerate commercialization. The Energy Storage Subcommittee of the RTIC is co-chaired by the Office of EERE and Office of Electricity and includes the Office of Science, Office of Fossil Energy, Office of Nuclear Energy, Office of Technology Transitions, Advanced Research Projects Agency-Energy (ARPA-E), Office of Strategic Planning and Policy Office of Policy, the Loan Programs Office, and the Office of the Chief Financial Officer.

the Energy Storage Grand Challenge is to create and sustain global leadership in energy storage utilization and exports, with a secure domestic manufacturing supply chain that does not depend on foreign sources of critical materials. Using a coordinated suite of R&D funding opportunities, prizes, partnerships, and other programs, the Energy Storage Grand Challenge includes following goal for the U.S. to reach by 2030:

> Manufacturing and Supply Chain: Design new technologies to strengthen U.S. manufacturing and recyclability, and to reduce dependence on foreign sources of critical materials.

Collaborating Offices

The Geothermal Technologies Office (GTO) researches, develops, and validates innovative and cost-competitive technologies and tools to locate, access, and develop geothermal resources in the United States. Beyond the traditional value that geothermal resources can provide for electricity or thermal applications, tapping into geothermal brines for valuable byproducts including critical materials presents a promising opportunity. Since 2014, GTO has funded two competitively awarded R&D solicitations focusing on mineral recovery from geothermal brines through novel extraction technologies, as well as better resource characterization for critical materials and rare earth elements in U.S. geothermal resources. However, commercial demonstration of mineral recovery from geothermal brines has not advanced beyond pilot scale and details of process and performance are known only to Intellectual Property (IP) owners and operators (including partly DOE-funded pilot demonstrations). In addition to supporting novel technology development, GTO recognizes the important co-location potential of hidden geothermal systems and critical materials deposits, and how acquiring data that supports the identification of these upstream resources is of significant strategic importance. The office is exploring opportunities to enhance the collection of data that leads to improved understanding of the distribution of lithium and other critical materials and hidden geothermal resources by enabling utilization of advanced machine learning techniques. The RFI is an opportunity for GTO to identify impactful research and performance metrics for developing future research pathways for both GTO specifically, as well as integrated across broader EERE supply chain research.

The Vehicle Technologies Office (VTO) has a comprehensive portfolio of early-stage research to enable industry to accelerate the development and widespread use of a variety of promising sustainable transportation technologies. The research pathways focus on fuel diversification, vehicle efficiency, energy storage, and mobility energy productivity that can improve the overall energy efficiency and efficacy of the transportation or mobility system. VTO supports early-stage research to significantly reduce the cost of electric vehicle (EV) batteries while reducing battery charge time and increasing EV driving range. Over the past 10 years, VTO R&D has lowered the cost of EV battery packs by over 80% to $185/kWh in 2019. Current battery technology performance is far below its theoretically possible limits. Near-term opportunities exist to develop innovative technologies that have the potential to significantly reduce battery cost and achieve the operational performance needed for EVs to achieve cost competitiveness with gasoline vehicles.

With these rapidly decreasing costs, there have been increased demand for battery materials for lithium ion batteries. This has caused fluctuation and uncertainty in the battery materials supply chain. To mitigate potential lithium ion battery supply risks, DOE has established following goal: **By September 2022, reduce the cost of electric vehicle battery packs to less than $150/ kWh with technologies that significantly reduce or eliminate the dependency on critical materials (such as cobalt) and utilize recycled material feedstocks.**

To achieve this goal and address potential critical materials issues, VTO launched 3 key complimentary areas of R&D meant to reduce dependence on critical materials.

- Supporting laboratory, university, and industry research to develop low-cobalt (or no cobalt) active cathode materials for next-generation lithium-ion batteries to less than 5%.
- Established the ReCell Lithium Battery Recycling R&D Center in 2019 focused on innovative cost effective recycling processes to recover lithium battery critical materials to make lithium ion recycling profitable for current and next generation lithium batteries.
- Launched the Lithium-Ion Battery Recycling Prize to incentivize American entrepreneurs to find innovative solutions to solve current challenges associated with collecting, storing, and transporting discarded lithium ion batteries for eventual recycling to reduce battery disposition costs.

Purpose

The purpose of this RFI is to solicit feedback from industry, academia, research laboratories, government agencies, and other stakeholders on issues related to challenges and opportunities in the upstream and midstream critical materials battery supply chains. EERE is specifically interested in information on raw minerals production and refining and processing of cathode materials including cobalt, lithium, and nickel.[11] **This is solely a request for information and not a Funding Opportunity Announcement (FOA). EERE is not accepting applications.**

[11] Nickel is not a critical mineral commodity on the list published by the Secretary of Interior.

R&D Battery Critical Materials Supply Chain Workshop
On February 15th, 2019, VTO organized a roundtable event, bringing together senior leaders across DOE and the National Labs, technical experts and strategic thinkers to discuss the status of battery technology, its impact on US competitiveness, and the role played by DOE. A significant gap identified by the experts was the lack of a strong coupling between the materials discovery effort and the associated manufacturing processes to ensure that new materials are rapidly scaled and integrated into large-format devices.

To address this gap, on September 25th 2019, EERE organized a second roundtable focused on scaling issues, bringing together experts from industries ranging from material suppliers, to cell makers, to end users, to gain an understanding on the challenges to US manufacturing. The discussion focused on electrode/cell fabrication and raw material supply and battery material production.

Key takeaways from these roundtable discussions about minimizing critical material supply chain risk include:

- The US does not have a big presence in the raw material supply and refining capacity related to Li-ion batteries and is reliant on other countries.
- The US does have significant resources relevant to batteries (e.g., Li, Co and Ni). A more comprehensive examination of the available resources and the R&D challenges to move them downstream is needed.
- Recycling of batteries, urban mining of materials etc. hold potential to increase the availability of materials for new batteries.
- While raw materials are available in diverse places, consolidation occurs as we move up the value chain with only a few countries reaping the benefits.
- DOE should continue pushing materials R&D that take material availability into consideration, such as the low/no cobalt efforts, while also examining approaches to increase domestic production of raw materials.

Informed by previous roundtable discussions, EERE plans to organize an *R&D Battery Critical Materials Supply Chain Workshop* in the fall of 2020 to determine opportunities, gaps, and bottlenecks in the battery cathode materials supply and the value chain. This workshop will be guided by the goal to create a diverse, domestic battery supply chain in the next 5 years. EERE is specifically seeking input on the current state of the battery cathode materials supply chains and gaps and opportunities for near-term and long-term R&D. Such input will inform the agenda of the workshop planned for this fall as well as to inform the development of the R&D

roadmap as part of implementation of the Federal Strategy. Specific questions are outlined below.

Request for Information Categories and Questions

Category 1: Future Battery Chemistries and Material Supply

1.1.) Will battery materials 5 years from now be similar to today (oxide cathodes) or will there be new materials (Li for pre-lithiation and Li metal)? If so, what are the most prospective materials?

1.2.) Of the different components in batteries, which materials do you see as problematic from a domestic supply perspective in the short term (1-3 years)? And in the intermediate term (3-5 years)?

1.3.) What purities for powders (including Li, Co, and Ni) are needed to be considered battery grade? How are impurity studies performed? What impurities are more problematic than others? How does this evolve with transition to higher nickel cathodes and Li-metal anodes?

1.4.) Describe any incumbent or other rapidly growing competing uses for Li, Co, or Ni that have the potential to disrupt supply for battery manufacturing?

Category 2: Economics and Battery Supply Chain

2.1) At what scale does diversification of material sources become economic for lithium, nickel, and cobalt power manufacturers? What are the underlying economic drivers (e.g., length of contract)?

2.2.) How important is co-locating powder fabrication facilities near a raw-materials or refining source? How does the calculation of tradeoffs of transportation costs work?

2.3.) How many sources does a large battery material manufacturer need to provide enough material for the Gigafactory-scale production? How does the tradeoff of material source qualification to diversify sources for price stability work? Or is this something powder manufacturers rely on refiners for?

Category 3: Lithium Powder Processing

3.1) What are the energy and chemical intensity reduction opportunities in lithium extraction?

3.2.) What are the energy and chemical intensity reduction opportunities in processing of Li2CO3 and LiOH from raw material sources and for conversion of Li2CO3 to LiOH?

3.3.) What are the energy and chemical intensity reduction opportunities in processing of LiCl and LiOH from raw material sources and for conversion of LiCl to LiOH?

3.4.) What are the life cycle and environmental impacts/risks of current legacy industrial practices and state-of-the-art technologies, and what are the R&D opportunities to improve these? (e.g., dewatering)

3.5.) What criteria determine success for pilot-scale lithium extraction and processing? What are the technical and engineering challenges to scaling extraction and refinement processes?

3.6.) Geothermal Brines

3.6.1) Given that the Salar de Atacama evaporative brine resources are the largest, what are the underlying reasons why the Australia hard-rock lithium resources have been able to capture so much of the growing market – despite the higher production costs as compared to Direct Lithium Extraction (DLE) technologies?

3.6.2.) Of the three classes of direct lithium extraction (DLE) technologies available (Adsorption, Ion Exchange, Solvent Extraction) – which of these holds the greatest promise for Lithium recovery for geothermal brine resources like those from the Salton Sea, and why?

3.6.3.) Performance metrics for lithium extraction from geothermal brines:

a. Besides lithium quantity and purity, what other performance metrics are important to consider for lithium extraction from geothermal brines?

b. Are there additional metrics to consider when thinking of the broader supply chain?

c. What criteria determine success for pilot-scale lithium extraction from geothermal brines?

3.6.4.) What value does improved lithium resource characterization in geothermal resources provide? What steps are needed to be beyond high-level regional assumptions?

Category 4: Cobalt and Nickel processing

4.1.) What are the processing challenges for cobalt arsenide deposits?

4.2.) What are the challenges in achieving more nickel refining in the US?

4.3.) Are there alternative metallurgical routes to produce battery grade nickel other than refinement from Class 2 Ni to Class 1 Ni?

4.4.) Are US nickel deposits good candidates to get battery grade nickel? If so, what are the economic, engineering, and/or technical challenges to achieve that?

4.5.) Are there additional processing steps necessary to requalify cobalt and nickel from recycled batteries? Are there problematic impurities from achieving that quality?

4.6.) What are the energy and chemical intensity reduction opportunities in extraction and processing of Co and Ni?

4.7.) What are the life cycle environmental impacts/risks of currently legacy industrial practices and state of the art technologies, and what are the opportunities of R&D to improve these?

Disclaimer and Important Notes

This RFI is not a Funding Opportunity Announcement (FOA); therefore, EERE is not accepting applications at this time. EERE may issue a FOA in the future based on or related to the content and responses to this RFI; however, EERE may also elect not to issue a FOA. There is no guarantee that a FOA will be issued as a result of this RFI. Responding to this RFI does not provide any advantage or disadvantage to potential applicants if EERE chooses to issue a FOA regarding the subject matter. Final details, including the anticipated award size, quantity, and timing of EERE funded awards, will be subject to Congressional appropriations and direction.

Any information obtained as a result of this RFI is intended to be used by the Government on a non-attribution basis for planning and strategy development; this RFI does not constitute a formal solicitation for proposals or abstracts. Your response to this notice will be treated as information only. EERE will review and consider all responses in its formulation of program strategies for the identified materials of interest that are the subject of this request. EERE will not provide reimbursement for costs incurred in responding to this RFI. Respondents are advised that EERE is under no obligation to acknowledge receipt of the information received or provide feedback to respondents with respect to any information submitted under this RFI. Responses to this RFI do not bind EERE to any further actions related to this topic.

Proprietary Information

Because information received in response to this RFI may be used to structure future programs and FOAs and/or otherwise be made available to the public, **respondents are strongly advised to NOT include any information in their responses that might be considered business sensitive, proprietary, or otherwise confidential.** If, however, a respondent chooses to submit business sensitive, proprietary, or otherwise confidential information, it must be clearly and conspicuously marked as such in the response.

Responses containing confidential, proprietary, or privileged information must be conspicuously marked as described below. Failure to comply with these marking requirements may result in the disclosure of the unmarked information under the Freedom of Information Act or otherwise. The U.S. Federal Government is not liable for the disclosure or use of unmarked information, and may use or disclose such information for any purpose.

If your response contains confidential, proprietary, or privileged information, you must include a cover sheet marked as follows identifying the specific pages containing confidential, proprietary, or privileged information:

> **Notice of Restriction on Disclosure and Use of Data:**
> Pages [List Applicable Pages] of this response may contain confidential, proprietary, or privileged information that is exempt from public disclosure. Such information shall be used or disclosed only for the purposes described in this RFI DE-FOA-0002358. The Government may use or disclose any information that is not appropriately marked or otherwise restricted, regardless of source.

In addition, (1) the header and footer of every page that contains confidential, proprietary, or privileged information must be marked as follows: "Contains Confidential, Proprietary, or Privileged Information Exempt from Public Disclosure" and (2) every line and paragraph containing proprietary, privileged, or trade secret information must be clearly marked with double brackets or highlighting.

Evaluation and Administration by Federal and Non-Federal Personnel

Federal employees are subject to the non-disclosure requirements of a criminal statute, the Trade Secrets Act, 18 USC 1905. The Government may seek the advice of qualified non-Federal personnel. The Government may also use non-Federal personnel to conduct routine, nondiscretionary administrative activities. The respondents, by submitting their response, consent to EERE providing their response to non-Federal parties. Non-Federal parties given access to responses must be subject to an appropriate obligation of confidentiality prior to being given the access. Submissions may be reviewed by support contractors and private consultants.

Request for Information Response Guidelines

Responses to this RFI must be submitted electronically to BatteryCriticalMaterialsRFI@ee.doe.gov no later than 5:00pm (ET) on July 31, 2020. Responses must be provided as attachments to an email. It is recommended that attachments with file sizes exceeding 25MB be compressed (i.e., zipped) to ensure message delivery. Responses must be provided as a Microsoft Word (.docx) or pdf attachment to the email, and no more than 10 pages in length, 12 point font, 1 inch margins. Only electronic responses will be accepted.

Please identify your answers by responding to a specific question or topic if applicable. Respondents may answer as many or as few questions as they wish.

EERE will not respond to individual submissions or publish publicly a compendium of responses. A response to this RFI will not be viewed as a binding commitment to develop or pursue the project or ideas discussed.

Respondents are requested to provide the following information at the start of their response to this RFI:

- Company / institution name;
- Company / institution contact;
- Contact's address, phone number, and e-mail address.