S. HRG. 116–322

THE IMPORTANCE OF AND PATH TO ACHIEVING MINERAL SECURITY, AND CONSIDERATION OF S. 1052, THE RARE EARTH ELEMENT ADVANCED COAL TECHNOLOGIES ACT, AND S. 1317, THE AMERICAN MINERAL SECURITY ACT

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED SIXTEENTH CONGRESS

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CONTENTS

OPENING STATEMENTS

	Page
Murkowski, Hon. Lisa, Chairman and a U.S. Senator from Alaska	1
Manchin III, Hon. Joe, Ranking Member and a U.S. Senator from West Virginia	3

WITNESSES

Balash, Hon. Joseph, Assistant Secretary for Land and Minerals Management, U.S. Department of the Interior	5
Solan, Dr. David, Deputy Assistant Secretary for Renewable Power, Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy	11
Evans, Jonathan, President and Chief Operating Officer, Lithium Americas Corporation	20
Warner, Dr. John, Chairman, National Alliance for Advanced Technology Batteries, and Chief Customer Officer, American Battery Solutions	27
Ziemkiewicz, Dr. Paul, Director, Water Research Institute, West Virginia University	35

ALPHABETICAL LISTING AND APPENDIX MATERIAL SUBMITTED

American Air Liquide Holdings, Inc.:	
Letter for the Record	85
Balash, Hon. Joseph:	
Opening Statement	5
Written Testimony	7
Responses to Questions for the Record	67
Evans, Jonathan:	
Opening Statement	20
Written Testimony	23
Responses to Questions for the Record	81
Manchin III, Hon. Joe:	
Opening Statement	3
Murkowski, Hon. Lisa:	
Opening Statement	1
Solan, Dr. David:	
Opening Statement	11
Written Testimony	13
Responses to Questions for the Record	73
Umicore USA:	
Statement for the Record	89
Warner, Dr. John:	
Opening Statement	27
Written Testimony	29
Responses to Questions for the Record	82
(The) Wilderness Society:	
Statement for the Record	96
Women's Mining Coalition:	
Letter for the Record	98
Ziemkiewicz, Dr. Paul:	
Opening Statement	35
Written Testimony	37
Responses to Questions for the Record	84

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TUESDAY, MAY 14, 2019

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The Committee met, pursuant to notice, at 10:04 a.m. in Room SD–366, Dirksen Senate Office Building, Hon. Lisa Murkowski, Chairman of the Committee, presiding.

OPENING STATEMENT OF HON. LISA MURKOWSKI, U.S. SENATOR FROM ALASKA

The CHAIRMAN. Good morning, everyone. The Committee will come to order.

Thank you for joining us here this morning.

We are here to consider ways to strengthen our nation's mineral security. In many ways this is a little bit of déjà vu all over again. By my count, this is the seventh hearing that we have held on this issue since I have been on this Committee. That is a lot of hearings.

I wish that I could say that we are further along now than we were when we began. We are going to get it done. Over the course of several years, we have repeatedly heard from witnesses who have underscored our vulnerability in relying on foreign nations for the minerals used to keep our economy strong and our nation safe.

In 1997, we imported 100 percent of 11 different minerals and 50 percent or more of another 26. Now, a little over 20 years later, our dependence has almost doubled. So we are going in the wrong direction. According to the USGS, last year we imported at least 50 percent of 48 minerals, including 100 percent of 18 of them.

The concentration of that supply, who we buy it from, is also a problem. Of the 48 minerals that I mentioned, China is a primary supplier for 26 of them. China is actually mentioned 375 times in the USGS 204-page mineral commodities summary report—they get the front page there.

Of course, this issue is not limited to the sourcing of raw minerals. China is also monopolizing other aspects of the supply chain, including the technology used to process and refine minerals.

So why is this a problem? Whether we realize it or not, minerals are the foundation of our modern society. We use them in just about everything. But our foreign dependence threatens our national security and is driving jobs and industries, whether electronics or electric vehicles or something else, to other countries. Our foreign mineral dependence is our Achilles' heel for competitiveness, for manufacturing, and for geopolitics. And in my view, it is way past time that we seek to address it.

I do appreciate the steps that President Trump has taken, including his Executive Order to identify a list of critical minerals and to develop a "whole of government" strategy to reduce our foreign dependence. I look forward to their policy recommendations, which I understand should be released any day now.

The Administration's actions are important, but they are not enough, and Congress needs to complement them with legislation. That is why Ranking Member Manchin and I have put forth two legislative proposals: S. 1317, which is my American Mineral Security Act, and S. 1052, the Ranking Member's Rare Earth Element Advanced Coal Technologies, or "REEACT," Act. You get the prize for the better acronym. I just don't deal with the acronyms, but REEACT—it is good.

Senator MANCHIN. We hired a person for that.

The CHAIRMAN. Yes, you probably did.

[Laughter.]

Maybe I need to borrow them.

The American Mineral Security Act takes a comprehensive approach to rebuilding our mineral supply chain. It directs multiple departments to evaluate and update a list of critical minerals every three years and to conduct geological assessments to determine where deposits are located. It authorizes R&D to promote recycling and the development of alternatives, forecasting so we can better anticipate supply and demand and workforce development to ensure that we have qualified professionals operating at the highest standards in the world. Our legislation also takes modest steps to provide predictability to the federal permitting process, which of course we know is notoriously slow and bureaucratic. It can take seven to ten years to finish permitting here in the United States. We should all be able to agree that it is very hard to compete for capital and investment when other nations take a much shorter period of time, as little as two to three years, to finish permitting.

While my legislation provides a good framework to begin understanding and addressing our foreign mineral dependence, I think that there is more that we can do, and I look forward to working with my colleagues to ensure a robust domestic industry, one that continues to be held to the highest environmental and labor standards in the world, and to building the workforce and infrastructure needed to bring downstream processing and manufacturing back to the States.

I hope that this is finally the year that Congress will work together to advance bipartisan legislation that will help rebuild our mineral supply chain.

I want to thank you, Senator Manchin, Senator McSally, Senator Sullivan and Senator Cramer for cosponsoring my legislation. I

would ask other members of the Committee to take a look at it and consider signing on.

I thank our witnesses for being here this morning. I appreciate you, Mr. Balash, being here as a great Alaskan, being able to share your expertise from that perspective, but also from within the Department. So we thank you for that.

Senator Manchin, your comments this morning as we kick things off.

STATEMENT OF HON. JOE MANCHIN III,
U.S. SENATOR FROM WEST VIRGINIA

Senator MANCHIN. Thank you, Madam Chairman, for calling the hearing to discuss this most important topic which you and I both feel strongly about because we have two pieces of legislation which we are trying to move the dime, if you will.

I want to thank all the witnesses who have made an effort to be here. I am pleased to have from my home state, Dr. Ziemkiewicz, here to show the good work he is doing as Director of the West Virginia Water Research Institute at West Virginia University.

Today we are hearing testimony on two bills that take different, yet important, steps to help address our concerning dependence on foreign sources of critical minerals. I believe this Administration is taking some important steps to identify minerals considered essential to our economic and national security, but that are also vulnerable to potential disruption in the global supply chain. However, there is a great amount of work that needs to be done.

Not all minerals are created equal. Rare earth elements are among the critical commodities I would like to draw special attention to. Right now, we are about 100 percent dependent on China for these commodities which the Chairman has identified which are needed for our advanced defense systems and other pieces of equipment used on the front lines, not to mention countless consumer products.

As a member of the Senate Armed Services Committee, I believe that the men and women in our Armed Forces deserve nothing but the best, and the fact that China maintains a near monopoly on the critical components needed for our defense system makes no sense to me at all—and I am sure it doesn't to you either.

We did not arrive in this vulnerable position overnight. In fact, it was decades in the making and the result of both a commitment from China to lead the world in this area and an unforeseen consequence of classifying thorium as a source of nuclear fuel by the International Atomic Energy Agency in 1980. This is obviously a simplification of a complex set of issues but the fact of the matter is that, since then, China has continued to invest in the entire rare earth supply chain both inside and outside of its borders and has successfully created an artificial market that locks in and maintains access to rare earth metals, alloys, magnets and other post-oxide materials.

I believe if we are serious about breaking China's grip, we must not only focus on the importance of rare earth mining, but also on the entire rare earth supply chain because right now, China alone has the capacity to refine and convert rare earths into metals. In other words, we need to recover the resources as well as establish

an industrial base that is capable of processing and converting these minerals into metals we need for our defense and our consumer products. That is far preferable to what we are currently doing which is shipping them to China for processing. I am glad to report this is exactly what the team at the West Virginia University and NETL are doing today.

The commercialization of advanced separation technologies for rare earth elements from coal and coal by-products is the first step. Acid mine drainage (AMD) from abandoned mine coal mines, possess a lingering challenge to Appalachian states like West Virginia. Existing coal mine operations require water treatment at the source; however, when this is done it creates AMD sludge as a by-product.

Dr. Ziemkiewicz and his team have sampled and classified hundreds of deposits of AMD sludge from all across the region and have found it contains heavy deposits of rare earths. They have partnered with the National Energy Technology Lab in Morgantown to continue working toward commercializing the technology to separate rare earths from AMD sludge. In other words, they are working to turn unwanted waste into valuable resources as well as convert minerals recovered from the process into metals.

This is a process that is overall relatively benign for the environment. If successful, Appalachia's coal sludge could produce up to 800 tons of these elements each year, worth more than $190 million. This offers a potential win for the environment, a win for the state and a win for the national security interests of our nation.

I introduced the Rare Earth Element Advanced Coal Technologies, or REEACT, to ensure NETL's rare earth program that has the funds necessary to bring our investment to fruition. Great progress has been made, including a new pilot scale facility which opened in Morgantown last year.

I am also an original co-sponsor of the Chairman's bill, the American Mineral Security Act, which I believe offers a well-crafted approach toward addressing gaps across the entire domestic critical mineral supply chain. In particular, the American Mineral Security Act will help find ways to address our shortcomings in the critical minerals workforce in which we are drastically behind other countries. It also requires resource assessments and authorizes the Department of Energy to conduct research and development for recycling and alternatives for critical minerals, a key component to improving efficiencies of critical minerals and breaking China's stronghold.

Together, the American Mineral Security Act and the Rare Earth Element Advanced Coal Technologies Act, when implemented will help to move the needle in the right direction for our critical mineral dependence and our national and economic well-being.

I am pleased we are receiving testimony on these important bills today, and I look forward to discussing this issue and hearing from our panel of witnesses.

Thank you for being here, and thank you, Madam Chairman, for calling this hearing.

The CHAIRMAN. Thank you, Senator Manchin.

We will now begin with our panel.

I mentioned that we are joined by the Honorable Joe Balash, who is the Assistant Secretary for Land and Minerals Management at the U.S. Department of the Interior (DOI). We appreciate your leadership over there and being here this morning.

We are also joined by Dr. David Solan, who is the Deputy Assistant Secretary for Renewable Power at the Office of Energy Efficiency and Renewable Energy (EERE) over at the Department of Energy (DOE). Thank you.

Mr. Jonathan Evans is the President and COO for Lithium Americas. Welcome to the Committee.

Dr. John Warner is the Chairman for the National Alliance for Advanced Transportation Batteries and the Chief Customer Officer for American Battery Solutions. Welcome.

And Dr. Ziemkiewicz has been introduced by Senator Manchin. He is the Director for the West Virginia Water Research Institute at West Virginia University.

We welcome all of you. We thank you for giving us your time this morning.

Assistant Secretary Balash, if you would like to lead off. We would ask that you try to keep your comments to about five minutes. Your full statements will be included as part of the record.

I will note that we are scheduled to have two votes that are supposed to begin at 10:45 this morning, so my hope is that we will be able to get through everyone's testimony, maybe take a quick break for those votes and then be back.

With that, Mr. Balash.

STATEMENT OF HON. JOSEPH BALASH, ASSISTANT SECRETARY FOR LAND AND MINERALS MANAGEMENT, U.S. DEPARTMENT OF THE INTERIOR

Mr. BALASH. Good morning, Chairman Murkowski, Ranking Member Manchin and members of the Committee. I'm Joe Balash, the Assistant Secretary for Land and Minerals Management for the Department of the Interior.

Thank you for the opportunity to discuss the Department of the Interior's development and management of critical minerals and on S. 1317, the American Mineral Security Act.

The Department appreciates the Chairman and the Ranking Member's recognition of the great importance of critical minerals, and we're grateful for the hard work that's been done to draft this legislation. We look forward to working with you on the bill as it moves forward.

The United States has an extraordinary abundance of mineral resources, both onshore and offshore, and is a major mineral producer. In 2018, the USGS estimated the total value of non-fuel domestic mineral resources produced to be $82.2 billion. The United States, however, relies on other countries for more than 50 percent of dozens of minerals that are vital to our economy and security. In 2018 the country was 100 percent net import-reliant for 18 minerals as shown on this chart, one that I think you're fairly familiar with.

Critical minerals are those that are essential to the economic prosperity and national security of the United States and have a supply chain vulnerable to disruption. Of the 18 mineral commod-

ities for which the United States is 100 percent import-reliant, 14 of them have been identified as critical minerals by the USGS. These critical minerals are used in an increasingly broad range of high-tech applications. For example, antimony, cobalt and natural graphite are important for advanced batteries and electric vehicles, or germanium and gallium which are essential in the production of night vision goggles and other optical instruments that are important for national security.

To address this vulnerability, in 2017 the President issued Executive Order 13817, which called on agencies across the Federal Government to organize a strategy to reduce the nation's susceptibility to critical mineral supply disruptions. In 2018, as part of the implementation of the Presidential Order, the Department developed and published a list of 35 critical minerals.

The critical mineral list is a part of the foundation of the strategy report which will identify a number of actions that the Department will take. The Department has already committed to a number of activities, including having the USGS and the Bureau of Ocean Energy Management expand geologic mapping using cutting-edge technology which will be essential to assess our critical mineral resource potential and conducting a review of permitting processes on federal public lands.

Additionally, the Administration has made environmentally responsible development of all domestic sources of energy and minerals a priority through issuing Executive Order 13783. The Department and other federal agencies were called upon to increase access and reduce the burden on energy and mineral development of public lands as part of the implementation of this order. This includes renewable energy development which is heavily reliant on critical minerals. Also, as part of this effort, the Department focused on increasing efficiencies and streamlining environmental reviews which includes setting page and time limit goals on all National Environmental Policy Act (NEPA) analysis.

S. 1317 would require the Department to develop and maintain a list of minerals critical to the economic prosperity and national security of the United States and to improve the process of locating, developing and using those critical minerals. The bill includes several reporting requirements including one for an annual critical mineral forecast from the USGS and the Energy Information Agency. The Department supports these efforts as they align with the ongoing efforts by the Administration to promote mineral development. The Department also supports the reauthorization of the National Geologic and Geophysical Data Preservation Program at USGS. The Department looks forward to continuing to work with the sponsors on this important legislation.

Thank you again for this opportunity to present this testimony. The Department is committed to promoting domestically sourced critical minerals. Doing so will create and sustain jobs, promote U.S. technological innovation and reduce our nation's vulnerability to disruptions in the critical mineral supply chain.

I'd be happy to answer questions at the appropriate time.

[The prepared statement of Mr. Balash follows:]

Statement of
Joseph Balash
Assistant Secretary for Land and Minerals Management
U.S. Department of the Interior
Senate Energy and Natural Resources Committee
S.1317, American Mineral Security Act
May 14, 2019

Thank you for the opportunity to testify on the Department of the Interior's (Department) development and management of critical minerals and on S. 1317, the American Mineral Security Act. The bill would require the Department to develop and maintain a list of minerals critical to the economic prosperity and national security of the United States and to improve the process of locating, developing, and using those critical minerals. The bill would also require several other agencies -- including the Department of Energy, the Department of Labor, the U.S. Forest Service, the National Science Foundation, and the Small Business Administration -- to track and report on efforts to promote improved critical minerals management.

The Department appreciates the Chairman and the Ranking Member's recognition of the great importance of critical minerals. We are grateful for the hard work that has been done to draft legislation that will help us fulfill the critical minerals strategy developed in response to Executive Order 13817, *A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals*. We look forward to working with you on the bill to best achieve these goals.

Background

The United States has an extraordinary abundance of mineral resources, both onshore and offshore, and is a major mineral producer. In 2018, the U.S. Geological Survey (USGS) estimated the total value of non-fuel domestic mineral resources produced to be $82.2 billion[1]. Our nation is a major exporter of certain non-fuel mineral commodities. The United States, however, relies on other countries for more than 50 percent of dozens of minerals that are vital to our economy and security, and in 2018 the country was 100 percent net import-reliant for 18 mineral commodities. For comparison, in 1984 the country was 100 percent import-reliant for just 11 mineral commodities. China, followed by Canada, supplied the largest number of non-fuel mineral commodities to the United States.

Critical minerals are defined as (i) a non-fuel mineral or mineral material essential to the economic and national security of the United States, (ii) the supply chain of which is vulnerable to disruption, and (iii) that serves an essential function in the manufacturing of a product, the absence of which would have significant consequences for our economy or our national security.[2]. An increasingly broad range of critical minerals commodities are used in consumer and national security applications, especially those involving advanced technologies. These critical minerals are used for things like cell phones, computers, automobiles, airplanes, ships, and many other applications. Accordingly, ensuring a secure, reliable, and affordable supply of minerals and the resiliency of their supply chains is vital for the Nation's economic prosperity

[1] U.S. Geological Survey, *Mineral Commodities Summary 2019*
[2] Executive Order 13817, Section 2.

and national security. The United States is currently 100 percent reliant on imports of 14 critical minerals, and over 50 percent import-reliant on 15 critical minerals.[3]

Federal Critical Minerals Strategy

To address this vulnerability, in 2017 the President issued Executive Order 13817, *A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals*. This Executive Order called on agencies across the Federal Government to develop a report that lays out a strategy to reduce the Nation's susceptibility to critical mineral supply disruptions. To implement the President's order, Secretary Zinke issued Secretary's Order 3359, *Critical Mineral Independence and Security*. The Secretary of the Interior, with broad Federal interagency input, led development of the critical minerals list, which was published in the Federal Register on May 18, 2018. The list will be updated periodically to reflect current data on supply, demand, and concentration of production. The list currently includes 35 commodities.[4]

The critical minerals list forms the foundation of the full strategy in the Administration's report under E.O. 13817, which is forthcoming. The Department has already committed to a number of activities, including expanding geologic mapping using cutting edge technology which will be essential to assess our critical mineral resource potential. Furthermore, the Department is also conducting a review of permitting processes on Federal public lands. The Department will be fully engaged in implementing the strategy included in the forthcoming report, which will require collaboration across the Federal government and cooperation with States, Tribes, universities, and the private sector.

In order to ultimately improve the United States' access to critical minerals, the USGS and the Bureau of Ocean Energy Management (BOEM) will undertake a plan to expand the mapping of the United States. The USGS' Earth Mapping Resources Initiative (Earth MRI) will leverage the bureau's existing relationships with States and the private sector to conduct state-of-the-art mapping and airborne geophysical and topographic (lidar) surveys. Analyses of these datasets should point to potential buried critical mineral deposits. BOEM is beginning to focus its efforts on the potential for offshore critical mineral interest and development as part of their Marine Minerals Program, with an initial focus in Alaska. BOEM also proposed initiating a National Offshore Critical Mineral Inventory to supplement the work by the USGS and the Bureau of Land Management (BLM).

Additionally, the Administration has made environmentally responsible development of all domestic sources of energy a priority. Executive Order 13783, *Promoting Energy Independence and Economic Growth* calls upon the Department, and other Federal agencies, to increase access to and reduce burdens on energy development on public lands. This includes renewable energy

[3] Fortier, S., et al., "Draft critical mineral list—Summary of methodology and background information—U.S. Geological Survey technical input document in response to Secretarial Order No. 3359," Open-File Report 2018-1021

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

development - and certain renewable energy technologies, especially advanced photovoltaic cells and batteries, which rely on critical minerals[5]. Also, increasing access to oil and gas development will increase availability of helium, which is a byproduct of that development, and is a critical mineral.

In response to the President's Executive Orders, the Department and the BLM have improved environmental reviews and permitting authorizations for energy and mineral development. One such example is Secretary's Order 3355, *Streamlining National Environmental Policy Act Reviews and Implementation of Executive Order 13807*, which provides a number of internal Departmental directives to increase efficiency of environmental reviews, including setting page and time limit goals on all National Environmental Policy Act (NEPA) analysis. Over the last ten years, BLM Environmental Impact Statements (EISs) had an average preparation time of approximately five years. The BLM implemented Secretary's Order 3355 by establishing a new 12-month approval process for EISs and their associated Federal Register notices. The BLM also continues to coordinate with elected officials, engage with Tribes, other Federal agencies, and the public, to identify additional opportunities to streamline planning and NEPA processes at the BLM.

S. 1317, American Mineral Security Act

S. 1317, the American Mineral and Security Act, would require the Department to develop and maintain a list of minerals critical to the economic prosperity and national security of the United States and to improve the process of locating, developing and using those critical minerals. The bill would also authorize various other agencies to conduct activities that would promote critical mineral industry and its supply chain. The Department defers to those agencies on the provisions that affect them.

Designation & Assessment of Critical Minerals (Secs. 4, 5, 9 & 11)

The bill (Section 4) authorizes a process by which the USGS and other agencies would support the Secretary of the Interior's designation of critical minerals. These provisions closely align with the Department's successful work to designate critical minerals as part of our Federal critical minerals strategy. Section 5 of the bill directs the Secretary of the Interior to conduct resource assessments of those critical minerals, within four years and with an update at two years. The Department supports conducting these assessments. As part of the Federal critical minerals strategy, the Department is directing the USGS and BOEM to assess critical mineral resources, including mapping on Federal public lands and offshore lands. The Department would like to work with the Committee on the timelines for the assessments to align them with the Federal strategy. In lieu of completing a four-year assessment of all critical minerals, we would recommend instead authorizing that at least one national or regional domestic multi-commodity critical mineral resource assessment on prospective deposit types be delivered every two years. The Department also would like to discuss with the Committee opportunities to improve our offshore critical minerals inventory.

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[5] Fortier, S., et al., "Draft critical mineral list—Summary of methodology and background information—U.S. Geological Survey technical input document in response to Secretarial Order No. 3359," Open-File Report 2018-1021

Under the bill (Section 9), the USGS and the Energy Information Agency would be directed to expand current reports on mineral commodities to include an annual critical mineral forecast and certain other analyses. As part of the Federal critical minerals strategy, the Administration will improve certain critical mineral reporting, such as the annual USGS *Mineral Commodity Summaries*. The Department looks forward to further discussion with the Committee on this section to determine appropriate reporting requirements and timeframes, particularly for commodity forecasting. Finally, the Department supports the bill's (Section 11) reauthorization of the National Geologic and Geophysical Data Preservation Program at the USGS, which is important in the implementation of the Federal critical minerals strategy.

Permitting & Development (Sections 6 & 7)

The bill (Section 6) directs the Department and the U.S. Forest Service (Forest Service) to implement improvements to each respective agency's mineral development permitting processes for critical minerals. It would also require several reports, including an annual report on the progress of implementing these permit processing improvements. The bill directs the Department and the Forest Service, to the maximum extent practicable, to establish and adhere to timelines for processing the applications and final decisions for critical minerals. It also requires the Department to engage in early and active consultation with State, local, and Tribal governments to allow for concurrent reviews as a means to minimize delays in issuing permits. Under Secretary's Order 3355, the Department is committed to finding and implementing efficiencies in permitting, and this section of the bill aligns with these priorities. The Secretary's Order similarly directs the BLM to adhere to a schedule for processing environmental reviews.

Under the bill (Section 7), Federal Register notices must be published by the offices that issue critical mineral permits within 45 days of initial preparation. The Department supports the sponsors' goal of expediting permitting processes. We would like to continue to work with the sponsors on finding ways to help streamline the Department's notification process.

Provisions Affecting Other Agencies

The Department defers to the Department of Energy, the Department of Labor, the National Science Foundation and the Small Business Administration on the bill's provisions that affect their respective agencies.

Conclusion

The Department is committed to promoting domestically sourced critical minerals. Doing so will create and sustain jobs, promote U.S. technological innovation, and reduce our Nation's vulnerability to disruptions in the critical mineral supply chain. Thank you for the opportunity to present this testimony. I will be glad to answer any questions.

The CHAIRMAN. Thank you, Assistant Secretary. We appreciate that.

Dr. Solan, welcome.

STATEMENT OF DR. DAVID SOLAN, DEPUTY ASSISTANT SECRETARY FOR RENEWABLE POWER, OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY, U.S. DEPARTMENT OF ENERGY

Dr. SOLAN. Chairman Murkowski, Ranking Member Manchin and members of the Committee, thank you for the opportunity to testify today on behalf of the Department of Energy, and thank you for your continuing leadership and interest in critical minerals and materials.

The Department shares the goals of S. 1317, Chairman Murkowski's American Mineral Security Act, and S. 1052, Ranking Member Manchin's REEACT Act. DOE also appreciates the bill's recognition of program and laboratory capabilities in developing replacements for critical materials as well as improvements in the recycling, processing, extraction and recovery.

Critical minerals are used in many products important to the U.S. economy and national security, and they are particularly important to the most innovative clean energy technologies. For example, some of the minerals DOE considers the most critical in terms of supply risk include gallium for LEDs, the rare earths dysprosium and neodymium for permanent magnets and wind turbines and electric vehicles and cobalt and lithium for electric vehicle and grid batteries.

The U.S. is dependent on foreign sources of many critical minerals, and we also currently lack the domestic capability for downstream processing of materials as well as the manufacture of some products made from them.

Today I would like to highlight how DOE is working to address these vulnerabilities through our R&D and how we work closely together with our federal partners through interagency coordination. DOE has a three-pillared approach to our R&D investments for critical materials coordinated among our programs agency-wide. The three pillars are: (1) diversifying their supply—including domestic production, (2) developing substitutes, and (3) alternatives and recycling of use and more efficient use of them. And I would note that these pillars align very well with the bills that are being discussed today.

Possibly the most well-known of DOE's work is that of the Critical Materials Institute which appeared before this Committee last July. The Critical Materials Institute (CMI) is a multi-disciplinary consortium of national laboratories, universities and companies led by the Office of Sciences, Ames Laboratory, and managed by Energy Efficiency and Renewable Energy's Advanced Manufacturing Office.

Some technologies developed and licensed through CMI that exemplify DOE's three-pillared approach include a membrane solvent extraction for rare earth separations which is relevant to both primary production and recycling, the 3D printing of rare earth magnets to reduce waste, and the development of a cerium-alu-

minum alloy for creating lightweight components for vehicles and airplanes.

Much of the Department's advancements in any applied area such as critical materials are underpinned by our Office of Science which focuses on fundamental research to advance understanding of materials at the atomic scale. Its research employs novel synthesis techniques and computation identification of compounds for critical materials substitutes. This includes replacements for rare earths and magnets, lithium and cobalt in batteries and platinum in catalytic reactions.

In a similar vein to reduce dependence of batteries on critical materials, the Vehicle Technologies Office (VTO) at EERE is funding R&D to reduce the cobalt content in the battery cathode to less than five percent by weight. VTO has also established the ReCell Lithium Battery Recycling R&D Center at Argonne National Laboratory for current and future battery chemistries. And in January 2019, VTO and the Advanced Manufacturing Office announced the launch of the Lithium-Ion Battery Recycling Prize to incent American entrepreneurs to create cost-effective solutions to get to 90 percent of lithium-ion batteries to be recycled.

The Office of Electricity at DOE is funding efforts to develop non-lithium grid energy storage based on earth-abundant materials such as sodium and zinc with a goal of $100 per kilowatt-hour.

Additionally, the Department is pursuing unconventional resources to recover or harvest critical materials. Through the National Energy Technology Laboratory, the Office of Fossil Energy is focused on recovering rare earth elements from coal and coal-based resources, a subject of Ranking Member Manchin's bill. These efforts grew to 30 projects in the past year.

EERE is also working on unconventional resources through small business innovation research grants continuing to invest in the recovery of lithium in geothermal brines, and it is also investing in technologies to use marine and hydro-kinetic power to possibly extract critical materials from seawater.

ARPA-E and a number of offices within EERE, including the Wind Technologies Office, have had significant complementary efforts to develop alternative motor and generator technologies that do not require rare earth permanent magnets.

And finally, the Department closely coordinates with other federal agencies such as the Departments of Defense, Commerce and Interior through the National Science and Technology Council Subcommittee on Critical Minerals. As a co-chair since 2013, DOE continues to provide leadership and we have worked closely with the Department of Commerce as it leads to the final preparation of a report in response to the President's December 2017 Executive Order 13817 which will help define a national strategy to address critical minerals.

Thank you again for the opportunity to appear here today. DOE looks forward to working with the Committee and Congress to ensure appropriate stewardship and results from taxpayer investments, and I look forward to your questions.

Thank you.

[The prepared statement of Dr. Solan follows:]

Testimony of

David Solan

Deputy Assistant Secretary for Renewable Power,
Office of Energy Efficiency & Renewable Energy,
U.S. Department of Energy

Before the

U.S. Senate Committee on Energy & Natural Resources

May 14, 2019

Introduction

Chairman Murkowski, Ranking Member Manchin, and Members of the Senate Committee on Energy and Natural Resources, thank you for the opportunity to testify today on behalf of the Department of Energy.

Critical minerals are used in many products important to the U.S. economy and national security. The manufacturing and deployment of these goods provides employment for American workers and contributes to U.S. economic growth. The U.S. is dependent on foreign sources of critical minerals. Of the 35 mineral commodities identified as critical in the list published in the Federal Register by the Secretary of the Interior, the U.S. lacks domestic production of 14[1] and is more than 50% import-reliant for 31.[2] For example, some mineral commodities important to energy from those identified include gallium (imported from China, the United Kingdom, Germany and the Ukraine); rare earths including dysprosium and neodymium (imported from China, Estonia, France, and Japan); lithium (imported from Argentina, Chile, China, and Russia); and cobalt (imported from Norway, China, Japan, and Finland).[3] This import dependence is a problem when it puts supply chains and U.S. companies and mineral users at risk. The dependency of the U.S. on foreign sources of critical minerals creates a strategic vulnerability for both our economy and our military with respect to adverse foreign government actions, natural disasters, and other events that could disrupt supply.

Many of the mineral commodities identified by the Department of the Interior are vital to the energy technologies of today and the future. The Department of Energy's approach to mitigate risk is in alignment with the President's Executive Order 13817 to ensure secure and reliable supplies of critical minerals. The Department's three priorities for decreasing U.S. dependence on foreign sources of critical minerals are reuse/recycling, using minerals more efficiently and developing substitutes, and increasing domestic production across the supply chain.

All stages of the supply chain are important and can impact one another. The U.S. lacks downstream domestic processing and manufacturing capabilities for some critical minerals, which results in the export of domestically produced ores and concentrates for further processing into more value-added forms. Increasing domestic production without developing the domestic processing and manufacturing capabilities will simply move the source of economic and national security risk further down the supply chain and create dependence on foreign sources for these capabilities. For example, rare earth mining has resumed in the U.S. However, the U.S. lacks the domestic capability to extract and separate the useful elements from the bastnasite ore, which can contain more than ten different rare earth elements depending on the deposit. The separation and purification of rare earth elements from bastnasite ore must instead be handled at overseas processing facilities. Because of this, the U.S. lacks the domestic capability to extract and separate neodymium from bastnasite ore, which is used in magnets.

The U.S. also lacks the domestic capability to manufacture magnets containing neodymium and relies on imported magnets crucial for both civilian and defense applications. This reliance creates potential price and demand volatility and jeopardizes U.S. jobs and national security. Addressing the full critical mineral supply chain through increasing domestic production, recycling, reprocessing, and identifying commonly available alternatives will reduce our

dependence on imports, preserve our leadership in technological innovation, support job creation, and improve our national security and balance of trade. In addition, addressing the full supply chain through responsible domestic production and processing brings environmental outcomes - under American regulatory oversight, which may provide more environmental protection than other foreign producers.

Department of Energy's Approach to Critical Materials

The Department's Office of Policy has led several studies assessing material criticality across a range of energy technologies based on importance to energy and potential for supply risk. Early and on-going assessment is required to adapt the Department's priorities to changing material and energy technology markets. Over the years, some criticality levels have decreased (e.g., terbium and europium in florescent lighting phosphors); some have increased (e.g., lithium and cobalt in batteries); and some have remained prominent (e.g., neodymium and dysprosium in magnets). In addition, the Office of Policy has led several studies examining potential supply chain vulnerabilities related to market dynamics and volatility across each stage of the supply chain from mining to final product production and demand.

Within the Department, research and development (R&D) investments are coordinated among the program offices agency-wide around **three pillars** to address supply chain disruption risks: **(1) diversifying supply of critical materials – including increasing domestic production, (2) developing substitutes, and (3) driving recycling, reuse, and more efficient use of critical materials**. For example, the Department has made significant strategic investments to address rare earth permanent magnets for motors and generators. The Office of Energy Efficiency and Renewable Energy (EERE), through the Advanced Manufacturing Office (AMO), Vehicle Technologies Office (VTO) and the Wind Energy Technologies Office (WETO), and ARPA-E have made significant and complementary efforts to reduce or eliminate potential dependences on critical materials (such as rare-earth metals) that are essential to modern and clean energy technologies. The Office of Electricity (OE) is working on grid-scale battery storage technologies that use domestically sourced earth-abundant materials. The Office of International Affairs is focused on countering attempts to control or distort the critical materials markets.

While the Department has and continues to invest in R&D across the three pillars, as is described below, the Department is currently developing activities to support increased domestic production and recycling of critical materials. (A one page summary of current DOE programs involved is attached.)

R&D Across the Department

Critical Materials Institute
The Critical Materials Institute (CMI), an Energy Innovation Hub currently managed by EERE (through the Advanced Manufacturing Office), is a multi-institutional, multi-disciplinary consortium of U.S. national laboratories, universities, and companies led by the Ames Laboratory. CMI's mission is to create technological options for assured supply chains of materials critical to clean energy technologies. CMI carries out early-stage applied research in three areas: diversifying supply, developing substitutes, and reuse and recycling. These research areas are linked to industrial needs and are enabled with fundamental scientific research and

cross-cutting analysis. As a result, technologies developed by the CMI span the entire supply chain and lifecycle of materials, except geoscience and mining. While Congressional report language has continued to insist upon funding the CMI, the FY2020 Budget favors a transition away from the hub model because the mortgaging of future appropriations reduces budgetary flexibility. Instead, the Budget proposes a set of smaller and more directly managed, early-stage, R&D consortia activities.

In its first five years (using FY12-16 appropriations), CMI issued 78 invention disclosures, filed 50 patent applications, received six patents, created two open-source software packages and won two R&D 100 awards. It licensed seven technologies to U.S. companies. Examples of these technologies include:

- Membrane solvent extraction for rare-earth separations, relevant for both primary production and recycling,
- 3D printing of rare-earth magnets to reduce manufacturing wastes,
- A cerium-aluminum alloy for creating lightweight, strong components for advanced vehicles and airplanes,
- A cost-effective, high-throughput system for recycling rare-earth magnets from computer hard drives, and
- Replacements for the rare earths europium and terbium in fluorescent lighting.

CMI developed capabilities to include machine learning materials design and predicted and synthesized critical material-free permanent magnets that have the potential to reduce the demand for rare earth containing neodymium-iron-boron magnets in a number of applications. CMI researchers won an additional R&D 100 Award and Gold Award for Special Recognition in Green Technology for development of an acid-free magnet recycling process.

Addressing Critical Lithium-Ion Battery Materials
The demand for the critical materials cobalt and lithium is driven by the growth in demand for lithium-ion batteries used in electric vehicles.

To mitigate critical materials supply risks for lithium-ion batteries, EERE (through VTO) aims to reduce the cost of electric vehicle battery packs to less than $150/kWh by September 2022 (from a baseline of $197/kWh in 2018).[4]

To directly address dependence of lithium-ion batteries on critical materials, VTO is funding R&D to reduce cobalt content in the battery cathode to less than 5% by weight.

EERE is also funding efforts to address the challenges of recycling lithium-ion batteries, which have more than 15 different cathode chemistries across end-use applications. EERE's VTO has established the ReCell Lithium Battery Recycling R&D Center to develop innovative, efficient recycling technologies for current and future battery chemistries. ReCell funds R&D across four research areas: design for recycling, recovery of other materials, direct recycling or cathode-to-cathode recovery, and reintroduction of recycled materials.

Getting end-of-life lithium-ion batteries to recycling centers is also a challenge to the reuse, recycling and recovery of critical materials. ReCell reports that lithium-ion batteries are

currently recycling at a rate of less than 5%. In January 2019, the Department (through EERE's VTO and AMO) announced the launch of a Lithium-Ion Battery Recycling Prize to incentive American entrepreneurs to create cost-effective, disruptive solutions to collect, sort, store, and transport 90% of spent or discarded lithium-ion batteries for eventual recycling.

OE is funding efforts to develop non-lithium energy storage technologies for use on the grid. The program supports fundamental research to advance the development of batteries based on earth-abundant materials such as sodium and zinc, with a cell-level cost target below $100/kwh.

Unconventional Resources
The Office of Fossil Energy, though the National Energy Technology Laboratory (NETL) Feasibility of Recovery Rare Earth Elements Program, is currently focused on developing technologies for the recovery of rare earth elements and critical materials from coal and coal-based resources. This R&D program consists of three core areas: enabling technologies, separations technologies, and process systems. The R&D program grew to over 30 active projects in 2018, which span developing process and production technologies, environmental management, and field materials sampling and characterization, along with systems integration, optimization and efficiency improvements to produce rare earth elements and critical materials from coal and coal byproduct streams, such as coal refuse, clay/sandstone over/under-burden materials, power generation ash and aqueous effluents as acid mine drainage and sludge.

To further diversify critical materials supplies, EERE has invested and continues to invest in the recovery of critical materials, such as lithium, from geothermal brines (through the Geothermal Technologies Office (GTO) and AMO) and development of seawater mining (through the Water Power Technologies Office (WPTO)). The latter technology has the potential to use marine and hydrokinetic power to passively extract uranium, lithium, precious metals, and rare earths from seawater.[5]

Fundamental Science
In order to drive technological change, fundamental science is considered an essential input. Much of the progress by the Department's applied energy offices is underpinned by investments made by the Office of Science. These investments support fundamental research to advance understanding of critical materials at the atomic level. This research includes the development of novel synthesis techniques that control properties at the atomic level to develop unique capabilities for the preparation, purification, processing, and fabrication of well-characterized materials. The Office of Science also supports the development, validation, and application of models to theoretically and computationally identify compounds that are promising critical material substitutes. This research includes projects aimed at identifying replacements for rare earths in electronic and magnetic applications as well as alternatives to materials such as lithium and cobalt in batteries, and platinum in catalytic reactions.

Interagency Coordination
The Department also coordinates with other federal agencies, such as Department of Defense, Department of Commerce, Department of the Interior, through National Science and Technology Council (NSTC) Subcommittee on Critical Minerals. The Department has been a co-chair of the Subcommittee since 2013 and continues to provide leadership among the federal agencies to address critical minerals across the entire supply chain.

The Department and our national lab researchers and experts are committed to working in partnership with industry, academia, and other federal agencies to forge paths to critical mineral security, while also working with Congress to ensure appropriate stewardship of taxpayer investments. I appreciate the opportunity to appear before this committee to discuss the Department's efforts to increase critical mineral security.

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[1] U.S. Geological Survey, "Mineral Commodity Summaries 2018," 2018, https://doi.org/10.3133/70194932

[2] 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

[3] U.S. Geological Survey, "Mineral Commodity Summaries 2018," 2018, https://doi.org/10.3133/70194932

[4] Steven Boyd, Vehicle Electrification, Presented at DOE Vehicle Technologies, Annual Merit Review, June 2018, Washington, D.C.

[5] https://eere-exchange.energy.gov/FileContent.aspx?FileID=fcf63beb-3f9d-4e8b-9c35-aa1d746fef6d

Summary of Department of Energy Strategic Work on Critical Minerals

The Department of Energy's strategy under E.O. 13817 to ensure secure and reliable supplies of critical minerals involves coordinated investment among program offices agency-wide.

Office of Energy Efficiency and Renewable Energy (EERE)

Critical Materials Institute (CMI), an Energy Innovation Hub currently managed by the Advanced Manufacturing Office (AMO), is a consortium of U.S. national laboratories, universities, and companies. Technologies developed are linked to industrial needs and enabled with fundamental research and cross-cutting analysis.

Lithium Battery Recycling – Vehicle Technologies Office (VTO)'s ReCell Center funds research for current and future battery chemistries, including recycling, recovery materials, cathode-to-cathode recovery, and reuse of recycled materials. The VTO and AMO jointly launched the *Lithium-Ion Battery Recycling Prize* to incentivize cost-effective, disruptive solutions for 90% recycling of spent lithium-ion batteries.

Critical materials extraction activities from geothermal brines are coordinated between Geothermal Technologies Office (GTO) and AMO. Development of seawater mining is funded by Water Power Technologies Office (WPTO).

Office of Electricity is working on grid-scale battery storage technologies that use domestically sourced earth-abundant materials.

Office of Fossil Energy, National Energy Technology Laboratory (NETL)'s *Feasibility of Recovery Rare Earth Elements Program*, is currently focused on developing technologies for the recovery of rare earth elements (REE) and critical materials from coal and coal-based resources.

Office of International Affairs is currently focused on countering attempts to control or distort the critical mineral markets.

Office of Science drives fundamental science to advance our understanding of critical materials down to the atomic scale, leveraging novel synthesis techniques and advanced computational and modeling capabilities. This research includes identifying replacements for rare earths in electronic and magnetic applications and alternatives to materials such as lithium and cobalt in batteries, and platinum in catalytic reactions.

Office of Policy has led several studies assessing material criticality across energy technologies and potential for supply risk, and vulnerabilities related to market dynamics and volatility across supply chain stages—from mining to final product production and demand.

Advanced Research Projects Agency-Energy (ARPA-E) previously funded the Rare Earth Alternatives in Critical Technologies (REACT) program, which has fed into current activities across the Department, such as the EERE's Wind Energy Technologies Office (WETO) research into alternative motor and generator topologies that do not require rare earth permanent magnets.

The CHAIRMAN. Thank you, Dr. Solan.
Mr. Evans, welcome.

STATEMENT OF JONATHAN EVANS, PRESIDENT AND CHIEF OPERATING OFFICER, LITHIUM AMERICAS CORPORATION

Mr. EVANS. Madam Chairman, Senator Manchin, members of the Committee, my name is Jonathan Evans and I'm the President for Lithium Americas Corporation.

I greatly appreciate your focus on critical minerals and, in particular, lithium. We all depend on lithium-ion batteries in our daily lives. The United States is reliant on a supply chain that extends from Australia and South America to China, Japan and Korea.

Lithium Nevada's Corporation is a wholly-owned subsidiary of Lithium Americas. It is headquartered in Reno, Nevada, and is developing a project called Thacker Pass, which is the largest known lithium resource in the United States. Thacker Pass will profoundly improve the supply of lithium chemicals by producing 25 percent of today's global lithium demand when in full production.

Currently, the U.S. produces just one percent of lithium minerals and seven percent of lithium chemicals. The project is on track to begin construction in the first quarter of 2021 but we will not stay on schedule without the swift and dependable permitting as emphasized in S. 1317.

Lithium Nevada faces additional challenges securing a trained workforce and providing levels of financial certainty to our investors and business partners. We greatly appreciate your efforts to address these issues.

Thacker Pass is located in northern Nevada on public land managed by the Bureau of Land Management. Lithium Nevada and the BLM are working cooperatively to evaluate the project. We submitted a conceptual plan of operations to the BLM in late 2018 and will submit a detailed plan of operations this summer. We anticipate the BLM will publish a notice of intent to conduct the EIS in December and complete the study by December 2020 in accordance with Executive Order 13817.

In our experience NEPA processes could be slowed by administrative tasks at the state, regional and head offices that are removed from the actual environmental assessment process. We welcome the spirit of Executive Order 13817 and the other administrative reforms that recognize the value in concentrating the NEPA process on substantive environmental review and encourage state and federal permitting agencies to be diligent in their review of critical minerals projects.

Adhering to schedules like the one prescribed for Thacker Pass boosts confidence among employees, community partners and financial supporters. Conversely, jurisdictions that fail to consider permanent applications and predictable timeframes experience minimal private investment and essential workforces leave for other, more dependable projects.

This Committee, the Administration and Department of the Interior should be commended for working to provide predictability in permitting. It is essential for the United States to have an uncompromising, thorough permitting process and to do it swiftly.

Lithium Nevada insists on being part of a project that goes beyond simply getting through the approval process. Consistent with that vision, it is our duty to ensure these essential chemicals are made responsibly without compromising the benefits they ultimately bring to the environment. To that end, Thacker Pass's mining and processing facilities are being designed to be as efficient and environmentally sensitive as possible. Two examples are that we'll utilize very little water, 2,000 acre-feet per year, which is only slightly more than one day of current annual water usage in Humboldt County, and our operation will be nearly carbon-free. Heat from our plant will be captured to generate as much as 60 megawatts of clean energy, which is more than enough to power the Thacker Pass operation, and provide surplus power to the grid.

Lithium Nevada will struggle to employ the trained workforce we need of 300 permanent employees. Although these jobs will earn an appealing $86,000 a year compared to the state average of $55,000 a year, it will be difficult to fill the positions. The problem is due to the remote location of our project, a historic under-investment in domestic critical mineral processing which has limited the pool of technical professionals and skilled operators in this field.

As for capital, Thacker Pass is well-funded by private interests, but we will need to solidify the confidence of potential business partners and investors because lithium processing is a relatively emerging business here. We believe a dependable source of federal loan guarantees would confirm the government's commitment to the development of a critical mineral supply chain and would help to solidify investment interest. Federal loan guarantees would also lower the project's cost of capital, helping U.S. projects be competitive with government-supported investments by China, Japan and Korea.

Demand for lithium is soaring. All the major car manufacturers have been out billions of dollars of investment in electric vehicle manufacturing. Their current demand is anticipated to grow 500 percent by 2025. The supply chain is physically long and highly vulnerable to transportation risk, political disruptions and foreign economic policy. By and large, lithium minerals are currently mined in Australia, Chile and Argentina. Lithium concentrates and chemicals are then shipped mostly to China, Japan and Korea and formulated into cathodes utilized by battery manufacturers, such as Panasonic, who supply Tesla.

This global supply movement is inefficient and expensive. Cathode and anode materials for lithium-based battery cells are produced almost entirely in China, Japan and Korea. It will take a sustained public policy commitment to promote the development of the technology, expertise and capital needed to make the U.S. competitive in this area.

The Thacker Pass project presents a critical catalyst that will ignite extensive downstream business development. Lithium Nevada greatly appreciates the attention this Committee is giving to securing critical mineral production in the United States.

We support S. 1317. If enacted, it will bring invaluable assurances that the permitting process will be thorough and completed in a reasonable timeframe. It strives to invest in our next generation of engineers and operators, and it creates mechanisms to inject

essential capital into our critical minerals supply chains. Without this assistance in the battery industry, the U.S. will remain decades behind China, Korea and Japan while we continue depending on the stability of offshore supply chains to furnish the U.S. with essential battery components.

Thank you for attention to these important issues. I'm happy to answer questions you may have.

[The prepared statement of Mr. Evans follows:]

Senate Committee on Energy and Natural Resources
May 14, 2019
Testimony by Jonathan Evans, President and COO of Lithium Americas

Madame Chairman, Senator Manchin and members of the committee, my name is Jonathan Evans, and I am the President and Chief Operating Officer for Lithium Americas Corporation. I greatly appreciate your including Lithium Americas in the discussion of minerals critical to our economy and national security. Indeed, Lithium is a mineral on which we all depend and one that is critical to the electrification of transportation and the coming revolution of the auto industry; yet, the United States is reliant on a supply chain that extends from Australia and South America to China, Japan and Korea.

Lithium Nevada Corp, a wholly-owned subsidiary of Lithium Americas, is headquartered in Reno, Nevada and is developing a lithium project that will significantly reduce U.S. reliance of foreign mining, processing and manufacturing. Since 2010, Lithium Americas has invested more than $75 million in Lithium Nevada. The project is called Thacker Pass, which is the largest known lithium resource in the U.S., and it is expected to produce enough lithium chemicals to fulfill 25% of today's global lithium demand when in full production. Currently, the U.S. produces just 1 percent of lithium minerals and 7% of lithium chemicals. Once in production, Thacker Pass will produce enough domestically sourced lithium chemicals to encourage the development of large-scale cathode, battery and end-user manufacturing in the U.S.

Lithium Nevada is on track to begin construction of Thacker Pass in the first quarter of 2021, but we will not stay on schedule without the swift and dependable permitting emphasized in S. 1317. Lithium Nevada faces additional challenges securing a trained workforce and providing levels of financial certainty to our investors and business partners. We greatly appreciate your efforts to address these issues. This testimony provides a brief summary of the Thacker Pass project and sets forth recommendations for a sustained commitment to developing the domestic supply, production and manufacturing aspects of the critical minerals supply chain.

Thacker Pass
The Thacker Pass project is located in northern Humboldt County Nevada, 60 miles north of Winnemucca and 20 miles south of the Oregon Border on public land managed by the U.S. Bureau of Land Management (BLM). The area was first explored by Chevron in the 1970s in an effort to locate meaningful uranium deposits. Chevron found high concentrations of lithium bound in sedimentary clay deposits close to the surface. The project has been in active development since 2008 by Western Lithium Corporation and then by Lithium Nevada Corp after a 2015 merger. Over the last three years, Lithium Nevada has extensively explored and defined the largest known lithium deposit in the United States. Additionally, we have developed a proprietary cost-competive process to extract lithium from our uniquely high-grade ore and to produce lithium based chemicals. The area we are currently permitting will provide 30,000 to 60,000 tons of lithium carbonate equivalent per year for the next 40 years. Current world demand for lithium is 250,000 tons and is expected to grow to ~1 millions tons by 2025

Environmental Stewardship and Permitting
Lithium Nevada is finalizing its mine and plant design. We submitted a Conceptual Plan of Operations to the BLM in late 2018 and will submit a Detailed Plan of Operations to the BLM this

summer. We have completed all the necessary baseline environmental studies required to conduct a thorough Environmental Impact Statement (EIS). Consistent with the framework provided by Executive Order 13817, our early collection of baseline information relating to water resources, wildlife, cultural resources, and other environmental receptors will allow the BLM to 'hit the ground running' when the BLM begins to prepare its EIS. The BLM is currently undertaking an RFP process to retain an experienced contractor who will prepare the EIS. We also have been working closely with State and local agencies to ensure they have the environmental data they need to evaluate our permit applications. We anticipate the BLM will publish a Notice of Intent to conduct the EIS in December and complete the study by December 2020, in accordance with the Executive Order 13817.

Active management of the EIS process and effective coordination with State and Federal permitting agencies will be critical to regulatory permitting and the environmental-review process. In our experience, NEPA processes may be slowed due to administrative tasks occurring at State, Regional and Head offices that are removed from the actual environmental assessment process. We welcome the spirit of Executive Order 13817 and other administrative reforms that recognize the value in concentrating the NEPA process on substantive environmental review and encouraging State and Federal permitting agencies to be diligent in their review of critical minerals projects.

I have worked in the chemical industry the bulk of my career, including running the lithium division for a major public company and building projects around the world. In all cases, adhering to schedules like the one prescribed for Thacker Pass has boosted confidence among employees, prospective employees, community partners and financial supporters. Conversely, jurisdictions that have failed to consider permit applications in predictable timeframes have experienced minimal private investment, and essential workforces leave for other more dependable projects. Clearly, you appreciate the need to ensure a stable, thorough permitting process. This committee, the administration and Department of Interior should be commended for working to provide predictability in permitting.

Ensuring a stable supply of critical minerals like lithium also requires a high level of scrutiny on the potential environmental impacts caused by those projects. It is essential for the United States to have an uncompromising, thorough permitting process and to do it swiftly; Lithium Nevada expects this balance and these goals aren't mutually exclusive. We insist on being a part of a project that goes beyond simply getting through the approval process. After all, we'll produce critical chemicals for batteries that will dramatically improve the environment by reducing world carbon production. Consistent with that mission, it is our responsibility to ensure these essential chemicals are made responsibly, without compromising the benefits they ultimately bring to the environment.

To that end, Thacker Pass's mining and processing facilities are being designed to be as efficient and environmentally sensitive as possible. In particular, Thacker Pass will utilize very little water—2,000 acre-feet per year, which is roughly equivalent to 3 alfalfa pivots or slightly more than one day of current annual water usage in Humboldt County.

Water use will be contained mostly within the processing facility where it will be recycled in a closed-loop process. There will be no evaporation ponds, which are common at lithium-brine operations, and our tailings will be dry-stacked instead of using a more conventional wet-slurry impoundment.

While Lithium Nevada has a broad network of unpatented mining claims extending into Nevada's biologically diverse Montana Mountains, the Thacker Pass mine will be located off the mountain, away from sensitive headwaters and vast plant and animal species.

Lithium Nevada is investing more than $5 million in acoustic insulation, so the processing plant noises are contained and don't disrupt nearby bird populations.

Our operation will be nearly carbon free. Heat from our plant will be captured to generate as much as 60 megawatts of clean energy, which is more than enough to power the Thacker Pass operation and to provide surplus power to the grid.

We are proud of the project we are building and realize the Environmental Impact Statement may identify ways in which we can build an even better facility. We are up to the challenge.

Dependable Supply Chain

Demand for battery-grade lithium chemicals is soaring. All of the major car manufacturers have announced billions of dollars of investment in electric vehicle manufacturing. The current demand of approximately 250,000 tons of lithium carbonate equivalent is anticipated to grow 500% by 2025 with Australia fulfilling 1/3 of that demand followed by Chile, Argentina and China.

Lithium travels a long journey before ultimately rolling down American streets in a new plug-in vehicle. The supply chain is physically distant and highly vulnerable to transportation risk, political disruptions and foreign economic policy. By and large, lithium minerals are currently mined in Australia, Chile and Argentina. Lithium concentrates and chemicals are then shipped mostly to China Japan and Korea and formulated into cathodes utilized by battery manufactures such as Panasonic for electric vehicles, home storage and personal device batteries. This global supply movement produces financial inefficiencies that are ultimately shouldered by domestic consumers. In addition, the necessity of transporting every ounce of lithium material on two overseas journeys before becoming a final product in the U.S. generates greenhouse gas emissions from shipping that could be avoided by developing a vertical supply chain in the U.S.

Cathode and anode materials for lithium-based battery cells are produced almost entirely in China, Japan and Korea. There has been substantial under-investment in this business within the United States; it will take a sustained public-policy commitment to promote the development of the technology, expertise and capital needed to make the U.S. competitive in this area. The Thacker Pass project presents a critical catalyst that will ignite extensive downstream business development, with the right public support.

Workforce

Another challenge we are working to address is finding the skilled workforce required to operate our facility. Thacker Pass is a $1.3 billion project that will require 900 people to construct and 300 permanent employees to make the operation run on a 24/7 basis. Although Thacker Pass jobs will pay an appealing $86,000/year compared to the state average of $55,000/year, we will still struggle to fill our openings. This problem is due to both the remote location of our project—the nearest Home Depot is more than 200 miles away--and also the historic under-investment in domestic critical mineral processing, which has limited the pool of technical professionals and skilled operators in this field. We have begun working with the local community college and school district to provide the necessary training to nearby residents, including tribal communities. Despite

our efforts, so long as critical minerals remain a niche sector in the U.S., this business will continue struggling to appeal to our next generation of engineers and skilled production-plant operators. I welcome your help highlighting the critical minerals industries as vital to our economic future and areas where young people can have fulfilling, problem-solving, careers.

Capital

While Lithium Nevada's Thacker Pass project is well-funded by private interests, Lithium Nevada will need to solidify the confidence of potential business partners and potential investors who are interested in allying with our project. The technologies for lithium processing are not widely understood in the U.S. Because lithium processing is a relatively nascent business here, we believe a dependable source of federal loan guarantees would confirm the government's commitment to the development of a critical mineral supply chain and would help to solidify investment interest among technical services firms and other potential business partners. Federal loan guarantees would also lower the project's cost of capital helping U.S. projects be competitive with government supported investments in Japan, Korea and China.

We appreciate that Section 301 of the Defense Production Act authorizes loan guarantees for contract performance or other operations related to national defense, subject to amounts annually authorized by Congress, but we would appreciate greater certainty about the availability of federal loan guarantees for businesses within the critical minerals supply chain. All portable battlefield communications equipment uses lithium-ion, and specialized cells are used in weapon systems for guidance. Lithium-ion batteries provide power supply to aircraft in the case of power failure, and are increasingly used due to their low weight. Confirming the availability of federal loan guarantees would support the growing domestic demand for crucial critical minerals in defense applications.

Conclusion

Lithium Nevada greatly appreciates the attention this committee is giving to securing critical mineral production—particularly lithium production—in the U.S. We support S. 1317. If enacted, it will bring invaluable assurances to those pursuing developments like our Thacker Pass project that the permitting process will be thorough and completed in a reasonable timeframe. It strives to invest in our next generation of engineers and operators ensuring a stable workforce going forward. And, it creates mechanisms to inject essential capital into our critical minerals supply chains. Without this assistance in the lithium-ion industry, the U.S. will remain decades behind China, Korea and Japan while we continue depending on the stability of their supply chain to furnish the U.S. with essential battery components.

I am pleased to be a part of the project that will profoundly accelerate the United States' efforts to secure a lithium chemical supply and will also help spur the growth of a domestic supply chain for lithium-ion batteries. I am happy to provide additional information about Thacker Pass and answer questions you may have.

The CHAIRMAN. Thank you, Mr. Evans.
Dr. Warner, welcome to the Committee.

STATEMENT OF DR. JOHN WARNER, CHAIRMAN, NATIONAL ALLIANCE FOR ADVANCED TECHNOLOGY BATTERIES, AND CHIEF CUSTOMER OFFICER, AMERICAN BATTERY SOLUTIONS

Dr. WARNER. Good morning, Madam Chair, Senator Manchin and Committee members. Thank you for inviting me to speak this morning on this very important topic of minerals and chemical processing, especially as it relates to the growing technologies of lithium-ion batteries.

I've been in the U.S. advanced battery industry for over 10 years and spent nearly 20 years in the automotive industry. I currently serve in several different roles in the battery industry. First, as a Chief Customer Officer for a lithium-ion battery pack startup company based in Michigan called American Battery Solutions. Second, I serve as the current Chairman of the industry trade group, NAATBatt International, the National Alliance for Advanced Technology Batteries. I also serve on several different SAE, Society of Automotive Engineers, standards committees to help bring standardization to these technologies. I'm also the author of two books on lithium-ion batteries and, most importantly, I am a user and advocate of these batteries as a proud driver of a Chevrolet Volt with 115,000 miles.

Throughout history there have been several technologies that have helped to shape the direction of mankind, beginning with the taming of fire, to the invention of the wheel, and later the telegraph, the steam engine, the long-range electrical transmission, personal computers, the internet, space travel, cellular technologies and, for my purposes here, electrochemical energy storage, the modern battery.

The modern advanced lithium-ion battery is perhaps the most important technology of the 21st century due to its role enabling other technologies, and the U.S. is largely responsible for the invention of the lithium-ion battery based on work done by innovators such as Dr. John Goodenough and Dr. Stan Whittingham. Yet the manufacturing of these batteries and increasing of the expertise in the lithium-ion batteries, it is now becoming centered in Asia. China is making massive investments in lithium-ion batteries that's estimated to be more than $60 billion. And today, as a result, they account for 60 to 75 percent of all lithium-ion battery manufacturing in the world today.

In order to support these manufacturing efforts, China is aggressively acquiring sources of energy materials around the world and domesticating the processing of those materials into the complex battery cathodes and anodes.

Based on some of the recent U.S. Geological Survey minerals yearbook, both the largest mineral reserves and the largest mineral processing for lithium-ion battery materials is being done in China, Australia, Brazil and Chile with more than 67 percent of the world's supply of cobalt, a key chemical in batteries using lithium-cobalt oxide, nickel-manganese-cobalt and nickel cobalt aluminum

chemistries being mined in the Democratic Republic of the Congo (DRC) with more than 70 percent of that being processed in China.

Lithium presents a somewhat better story since it's more widely geographically distributed throughout the world. However, more than 98 percent of it's mined and processed in Chile, China, Argentina and Australia, and the vast majority of the chemicals being used in lithium-ion batteries, regardless of where they are mined, are being processed in China today due to the low environmental standards and the strong governmental support. This points out the complexity of the battery supply chain.

For a U.S. company to build lithium-ion cells would require lithium mined in Chile or Australia, cobalt coming from the DRC, graphite coming from Australia, Brazil, Canada or China, manganese coming from South Africa, copper from Chile, nickel from Australia or Brazil or Russia. These materials would then need to be shipped to other countries such as China or Korea or Japan, where they're processed into battery-grade materials and then shipped to the U.S. The cell makers would then need metal foils to coat the materials onto which typically come from Korea and Japan, polyethylene separators from China, Korea and Japan. So we have this largely Asian-centric supply chain which promotes and supports the development of the Asian manufacturers while putting the U.S.-based manufacturers at a disadvantage.

The reason why the supply chain problem should be a public policy concern is because the global competition for advanced battery manufacturing capacity and expertise, the ability to guaranty reasonably stable and ideally low energy material prices to manufacturers is a considerable advantage. Chinese companies are buying up energy material supply sources around the globe in order to ensure that battery manufacturers based in China have access to reasonably stable supplies of low-cost materials.

The loss of U.S. leadership in lithium-ion technology may well lead to the loss of U.S. leadership in other important technologies. The ability to supply electricity to a device without a power cord will be fundamental to most of the major new technologies of the 21st century. If you lose expertise in the battery technology, you risk falling behind those other technologies as well.

Finally, let me leave you with a thought from one of the earliest and greatest American battery innovators, Mr. Thomas Edison, whose first battery patents were issued in the late 1890s. Edison said, "I don't think nature would be so unkind to withhold the secret of a good storage battery if a real earnest hunt is made for it, and I'm going to hunt." This is a belief that most of us in the battery industry still have to this day, believing in the spirit of this hunt that drives American innovation, drives leading the creation of new markets, generating new high-tech jobs, developing new supply chains and enabling the technology of the 21st century and beyond while boosting the U.S. economy and securing our future.

NAATBatt continues to work with our members to help develop domestic sources for both the supply chain, the materials and the battery materials and the battery packs, and we look forward to supporting you in this bill.

Thank you.

[The prepared statement of Dr. Warner follows:]

Dr. John Warner
Chairman, National Alliance for Advanced Technology Batteries
Chief Customer Officer, American Battery Solutions

Testimony to the U.S. Senate Committee on Energy & Natural Resources
May 14, 2019
10:00AM
Washington, DC

Good morning, Madame Chair and Committee members. Thank you for inviting me to speak today on this very important topic of minerals and chemical processing especially as it relates to growing technologies such as lithium-ion batteries.

I have been in the U.S. advanced battery industry for over ten years and spent nearly 20 -years in the automotive industry. I currently serve in several roles: first, as Chief Customer Officer for a lithium-ion battery pack start-up company called American Battery Solutions; second, as the current Chairman of the industry trade group National Alliance for Advanced Technology Batteries; third, I serve on four different standards committees with SAE International; fourth, as an author of two books on lithium-ion batteries; and fifth, as a user and advocate for these technologies. These different roles have offered me some unique perspectives which I would like to share with you today.

Throughout history there have been several technologies that have helped to shape the direction of mankind, beginning with the taming of fire to the invention of the wheel, and later the telegraph, the steam engine, long-range electrical transmission, personal computers, the internet, space travel, cellular phones, and electrochemical energy storage – the modern battery. Today I will focus on this last one, the battery and its supply chain as it is truly the technology that has enabled of modern life. The modern advanced lithium-ion battery is perhaps *the* most important technology of the 21st Century.

In my new book I describe the last 150 years of battery development as falling into three eras: the Industrial Era, focusing mainly on lead acid batteries for automobiles and industrial equipment; followed by the Portable Era which began with the introduction of the modern lithium-ion battery; and today we are in what I refer to as the Mobile or Autonomy Era wherein energy storage truly enables a world of true freedom and mobility. The world today would be a very different place without these advanced battery technologies, for example imagine a world without our ever-present Smart Phones which grant us not only immediate communications, but access to a world of information and resources

at our fingertips. And as we move farther into the 21st Century advanced batteries, in many cases lithium-ion batteries, are the foundation for an entire new generation of technological disruptions such as the IoT, advanced robotics, the smart home, Smart Cities, blockchain, AI, autonomous vehicles and many other applications. These disruptor technologies fundamentally assume at least the following: resilient grid/energy source, cybersecurity & network security, and high speed (5G / rural broadband) communication. Lithium-ion manufacturing ability – fundamentally depending on access to requisite raw materials – is key to those baseline disruptor-enabling technologies by facilitating resilient energy sources.

The United States is largely responsible for the invention of the lithium-ion battery based on work done by innovators such as Dr John Goodenough and Dr Stan Whittingham. Yet the manufacturing of lithium-ion batteries and, increasingly, expertise in lithium-ion batteries, is now becoming centered in Asia. China is making a massive investment in lithium-ion battery technology estimated by some to be more than $60B and today, by most estimates, accounts for 60-75% of all lithium-ion battery manufacturing in the world today. In order to support these manufacturing efforts China is also aggressively acquiring sources of energy materials around the world and domesticating the processing of those materials into complex battery cathodes and anodes. The European Union/European Commission has also officially identified batteries as a Strategic Technology and are putting regulations in place to ensure sustainable sourcing of raw materials, development of the specialized skills needed in the industry, and the need for a developed recycling infrastructure.

While the "know-how" and innovations has largely being done here, most of the chemicals processing is being done offshore. Based on the 2016 U.S. Geological Survey Minerals Yearbook both the largest mineral reserves and the largest minerals processing for lithium-ion battery chemicals are being done in China, Australia, Brazil and Chile. More than 67% of the world's supply of cobalt, a key chemical in batteries using lithium-cobalt oxide (LMO), nickel-manganese-cobalt (NMC) and nickel cobalt aluminum (NCA) was mined in the Democratic Republic of the Congo and more than 70% of the cobalt processing was done in China. Lithium presents a somewhat better story since it is more widely geographically distributed throughout the world. However, more than 98% of it is mined and processed in Chile, China, Argentina and Australia. The vast majority of the chemicals being used in lithium-ion batteries, regardless of where they are mined, are being processed in China today due to low environmental standards and strong governmental support.

This points out the complexity of the battery supply chain. For a U.S. company to build lithium-ion cells would require lithium mined in Chile or Australia; cobalt coming from the DRC; graphite coming from Austria, Brazil, Canada, or China; manganese coming from South Africa; copper from Chile; and Nickel from Australia, Brazil or Russia. These materials would then be shipped to other countries such as China where they can be processed into battery grade chemicals. These U.S. cell makers would then need metal foils to coat these materials onto from Korea and Japan, polyethylene separators from China, Korea and Japan to prevent the electrodes from touching. This largely Asian centric supply chain promotes and supports the development of the Asian manufacturers while putting U.S. based manufacturers at a disadvantage.

The energy materials supply chain challenge in North America consists of two problems, which may at times be related but are best thought of separately: The market price problem and the geopolitical problem.

The market price problem exists, and exists inevitably, because the timing of the cycles of energy materials supply and energy materials demand are different. The supply cycle is longer than the demand cycle. It takes a long time to explore, develop and finance new mines for energy materials in many cases up to five years. The rise and fall in demand for electric vehicles and lithium-ion batteries, which drive much of the demand for energy materials, occurs more rapidly. When these cycles become out of balance, prices rise (in times of supply shortage) and fall (in times of oversupply). This is as true in all industries. We can simply look at the price of cobalt over the past few years to see this in action. Cobalt prices in 2016 were about $25,000 per ton, by March 2018 prices had jumped to more than $94,000 per ton and in 2019 have now dropped back down to about $35,000 per ton.

The reason why the supply price problem should be a public policy concern is because in the global competition for advanced battery manufacturing capacity and expertise, the ability to guaranty reasonably stable (and ideally low) energy materials prices to manufacturers is a considerable advantage. Chinese companies, acting almost certainly at the behest of the Chinese government, are buying up energy materials supply sources around the globe in order to ensure that battery manufacturers based in China have access to reasonably stable supplies of low cost energy materials. This strategy will serve China well in times of shortage and will be very costly in times of surplus. But the Chinese are focused on dominating a handful of strategic industries and are willing to pay the cost to do so (i.e., the Chinese are willing to bear the cost of 1,000 Solyndra's in order to dominate the solar industry and solar technology).

The public policy question the United States must answer is what strategic industries is it willing to invest in in order to regain leadership and dominate the market? It is wrong to suggest that the United States does not have an industrial policy that contemplates making such investments. The defense and aerospace industries in the United States are heavily if indirectly subsidized. As a direct consequence, the United States dominates those industries and technologies. The question to the Congress and the Administration is: to maintain the United States' leadership in the world economy of the 21st Century, are there other industries that the United States must invest in and try to dominate as well? NAATBatt and its members would argue strongly that the answer is yes and that one of those strategic industries in which public investment should be made is the industry of advanced battery technology, materials, processing and supply chain.

The second problem is the geopolitical problem. This is the threat of physical disruption of supply by foreign actors. The geopolitical problem likely terrifies the Chinese government and explains at least in part why it views advanced batteries and electric vehicles to be a strategic industry. The ability of the U.S. Navy to disrupt China's supplies of petroleum in a crisis doubtlessly looms large in its strategic thinking. Accordingly, China has invested heavily in electric vehicle technology and is willing to suffer the environmental degradation necessary to mine energy materials and rare earth metals in order to have a source of domestic supply. The United States socializes its investment in geopolitical energy security differently, through heavy expenditures on defense. But increasing Chinese interest in blue water naval technology may indicate that it is considering a different approach and calls into question whether the United States should consider additional approaches to energy materials security that would provide for more redundancy.

Another related topic is the subject of lithium-ion battery recycling and reuse. A recent DOE analysis concluded that by 2040 a full 60% of U.S. requirements for energy materials could be provided by the recycling of lithium-ion batteries already in the market in North America.

Recycling lithium-ion batteries is, at the moment, difficult and uneconomic. The Chinese, again, are leading in this area as a result of heavy recycling infrastructure investment. But there is new technology being developed in the United States that could make profitable lithium-ion battery recycling a possibility in North America. A profitable and robust system of recycling lithium-ion batteries in North America could go a long way towards moderating possible market price problems in future years and provide some redundancy in our defenses against geopolitical disruption.

Why should Congress care? Ordinarily it should not. Today's economy is global. We no longer manufacture t-shirts in the United States. That is not a crisis. But losing the lithium-ion battery race and the race for dominating the lithium-ion supply chain would be a crisis for three reasons:

First, the loss of U.S. leadership in lithium-ion technology may well lead to the loss of U.S. leadership in other important technologies. The ability to supply electricity to a device without a power cord will be fundamental to most of the major new technologies of the 21st Century. If you lose expertise in battery technology, you risk falling behind those other technologies as well. Congress recognized these phenomena in the 1980's when it funded SEMATECH in order to address the threat to U.S. leadership in semiconductor manufacturing and by extension the threat to U.S. leadership in the entire computer hardware industry. A similar threat exists today in batteries and electrochemical energy storage. Last year, it was reported that the first operational high energy rail gun was deployed on a military vessel. That vessel belongs to the Chinese navy, not our navy. And that is just the tip of the iceberg.

Second, losing control of lithium-ion manufacturing and manufacturing technology will disadvantage U.S. workers in the global competition for high-paying jobs. Vehicle technology is moving increasingly towards electrification, for a number of different reasons. NAATBatt believes that he who makes the batteries will one day make the cars. In my main area of focus, the mobility sector, we today see electrification reaching into some all new segments that many are not familiar with including the marine and maritime segments; construction, mining, forestry, and agricultural vehicles; industrial vehicles; aerospace, drone and satellite; robotics; and is now even entering the medium and heavy truck segments. Each of these segments are creating new industries, new technologies, new high-tech and skilled jobs, and new revenue streams within the United States. Electrification is also the major power source for the emerging autonomous vehicle markets, be they land, air or sea based. It is electrochemical energy storage, the batteries, that power these applications. Current forecasts by companies such as Avicenne Energy estimate that the global lithium-ion market will be nearly $55B by 2025 and nearly $75B by 2030. The vast majority of that market is now based in Asia and the current U.S. portion of that market is only between 1-2%.

Third, lithium-ion batteries are, and will increasingly become, a strategic commodity. The Chinese recognized this fact several years ago and are aggressively securing their own lithium-ion battery supply chain, both foreign and domestic. Today, the United States can rely on the U.S. Navy to protect its access to lithium-ion batteries and energy materials, just as we have relied upon it for the

past half century to protect our access to petroleum supplies. The 21st Century may see the rise of new threats to our ability to protect our strategic materials supply chains. Developing domestic supplies of strategic energy materials and lithium-ion battery components would add an important redundancy to future U.S. energy security.

Finally, let me leave you with a thought from one of the earliest and greatest American battery innovators, Mr. Thomas Edison whose first battery patents were issued in the late 1890's, Edison says "I don't think Nature would be us unkind to withhold the secret of a good storage battery if a real earnest hunt for it is made. I'm going to hunt". This is a belief that most of us in the advanced battery industry maintain to this day. It is this spirit of the hunt that drives American innovation, leading to creating new markets, generating new high-tech jobs, developing new supply-chains, enabling the technologies of the 21st Century and beyond, and securing America's future.

The CHAIRMAN. Thank you, Dr. Warner.
Dr. Ziemkiewicz.

STATEMENT OF DR. PAUL ZIEMKIEWICZ, DIRECTOR, WATER RESEARCH INSTITUTE, WEST VIRGINIA UNIVERSITY

Dr. ZIEMKIEWICZ. Thank you, Chairwoman Murkowski, Ranking Member Manchin and members of the Committee for giving me this opportunity to discuss and offer testimony on the role that rare earth elements can be derived from coal and coal-related products and support the federal effort to develop a domestic supply chain.

I'm the Director of the West Virginia University Water Research Institute. Every state and territory has one. We tend to focus on areas that are strongly focused on our main pollutant in the state which is acid mine drainage (AMD) from, largely, mines that were developed before the invention of the Clean Water Act. So they're pre-law mines, before SMCRA, any of this went into effect, these mines were abandoned and, therefore, just generate acid mine drainage, mucks up thousands of miles of streams in the northern Appalachians. So that's been our main effort, but this is almost a case study in how federal policy can lead in innovation in areas that would never have been considered otherwise.

So, for example, I'm one of the world's experts on the subject of acid mine drainage. If there's acid mine drainage anywhere in the world, I've probably been there. But it never would have occurred to me, I've been at this for 30 years at WVU, but it never would have occurred to me to look for acid mine drainage as a source of rare earth elements or critical minerals until the Department of Energy's NETL laboratory, through legislative action here, created a funded program to study exactly that issue.

So we started working on it and also give a lot of credit here to USGS' work, maybe 15 years earlier, back in the late '90s, supported by Congressman Jack Murtha, to look for platinum group metals in acid mine drainage of all things. Not much was found but a great database was generated.

A friend of mine at USGS, Chuck Cravotta, let me have his dataset from years gone by, and I looked at it when this opportunity came up from NETL and it turns out there are rare earth elements in acid mine drainage. No one had ever looked for them before.

So we decided to submit a proposal based on that alone, on the acid mine drainage side of it and we found that it has a couple of real strong advantages. One, it's, in a sense, it's a natural heap leach operation. If you think of a lot of modern metal mines are acid heap leaches, a lot of the metal mines operate as an acid leach through rock that contains precious minerals. Well, in this case, acid mine drainage is exactly that, it generates spontaneously all this acid so you get this free acid and it leaches, selectively leaches, these metals that we want out of this rock mass, the shales that surround the coal in the coal-related products. So any tailings, underground mines, surface mines, as long as they're acid, they generate acid mine drainage.

When we first got this opportunity, I called up some of my friends in the coal industry and asked if we could come out and sample some of their acid mine drainage and their treatment

sludges. They said sure, you can have all you want, because to them it's one of their biggest costs in treating acid mine drainage is getting rid of this stuff afterwards. So we went out and looked at it, and we were finding concentrations that were as high as some of the best deposits in the world.

And the other nice thing about it, not only is the concentration high, but the accessibility is high from a chemical point of view. You can just—this stuff starts out in solution and if you think of most of the mineral processing trains, you start by mining a cubic meter of rock, grind the daylights out of it, down to talcum powder, separate the good stuff from the bad stuff and then start leaching it with really strong acids and bases and it's a very complicated process until you get to the point where you actually have your desired minerals in solution, then you can start separating it on to all sorts of wonderful chemistry. Well, what we found out is that not only was the stuff already in solution but the treatment process itself just added hydroxide to the process, adding base knocks them out of solution. We can put it back in solution just by raising the acidity level. And so that goes off to solvent extraction and we've been able to get concentrates up into the 80 percent, 60 percent range of pure rare earth element out of some of our coal-derived, acid mine drainage products. So this is world class product now. This is also work supported through NETL.

The other nice thing about acid mine drainage as a source of rare earth elements is that the pH of acid mine drainage, believe me, I know, never gets much below about two and a half. In order to get thorium and uranium to go into solution, you have to be down below one, and most of the hard rock processing trains for that extraction of rare earths also puts the uranium and thorium into solution which is why most rare earth mines tend to produce a fair amount of uranium and thorium in their tailings. We don't have any of that. We looked at uranium and thorium in all of our samples, and it just isn't there.

I'd like to thank you for your leadership on the REEACT bill and previous authorizations. It's done great work, and I think we have a long ways to go here.

[The prepared statement of Dr. Ziemkiewicz follows:]

Recovery of Rare Earth Elements from Acid Mine Drainage

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14 jun 19

Rare earth elements in acid mine drainage become high-grade concentrates at WVU's Rare Earth Extraction Facility

Written Testimony of Paul F. Ziemkiewicz to the U.S. Senate Committee on Energy and Natural Resources 14 May 2019

Chairwoman Murkowski, Ranking Member Manchin and members of the Committee, thank you for the opportunity to offer relevant testimony and to answer your questions in my areas of experience and expertise.

I am the Director of the West Virginia University Water Research Institute, a component of WVU's Energy Institute. The Institute serves to facilitate collaborative and innovative solutions for the energy future of West Virginia and the United States.

West Virginia University is a public, land-grant, research-intensive university founded in 1867. It is designated an "R1" Doctoral University (Very High Research Activity) by the Carnegie Classification of Institutions of Higher Education; funding for sponsored research programs and grants exceeded $185 million in 2017

The Water Research Institute conducts sponsored and grant-funded research programs in the areas of watershed restoration, acid mine drainage treatment, mitigation of mining and gas development impacts on water and land. Most recently we developed a research initiative around recovery of critical minerals (CM) and rare earth elements (REE) from acid mine drainage.

Introduction: Rare Earth Elements or REE are essential for advanced technologies from smart phones and robots to top-secret national defense systems. The REE metals have remarkable chemical properties but are so evenly dispersed throughout the earth's crust that economically attractive concentrations are extremely rare. Also, nearly all conventional sources of REE occur with the radioactive elements thorium and uranium and they are concentrated by the same processes used to release REE from their host minerals. The result is commonly a mildly radioactive tailings stream that must be managed in perpetuity. As a result, the U.S. imports nearly all its rare earth elements from China, which supplies about 89 percent of the world's rare earth needs. India and Russia provide most of the balance of these strategically important materials. However, researchers at West Virginia University found that treating one of the biggest sources of pollution in the United States, acid mine drainage or AMD is a rich source of rare earth elements, or REEs (figure 1).

Figure 1. Typical AMD sludge settlement cells at a Pennsylvania coal mine. The orange material in the foreground is enriched with rare earth elements. After the metals precipitate, the clear water in the far cells is discharged via a regulated discharge point.

The U.S. has one operating REE mine, at Mountain Pass, CA. It ships its REE concentrate to China for refining to metal where companies often use it to manufacture advanced electronic products for export. With no domestic supply chain, the U.S. is vulnerable to interruptions in the international market. So, in 2015, the U.S. Department of Energy's National Energy Technology Laboratory solicited ideas across the U.S. for extracting rare earth elements from coal and related byproducts. Our research team at West Virginia University, was awarded the first of three grants in early 2016 to study the potential of extracting rare earth elements from the solid residues or sludges left over after treatment of AMD.

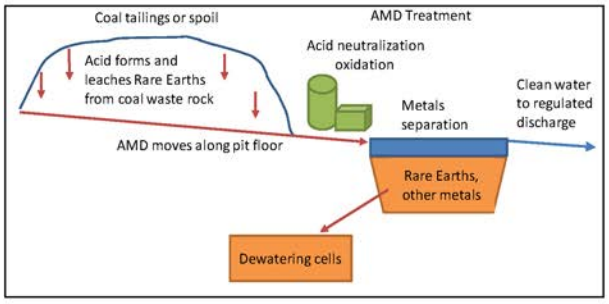

Figure 2. Acid mine drainage leaches rare earth elements out of surrounding rock. AMD treatment then causes all metals including rare earth elements to precipitate.

AMD forms when pyritic waste rock from coal mines is exposed to air (figure 2). This acid then leaches rare earth metals out of the rock. AMD treatment concentrates the rare earths in sludges from which the REEs can be captured and refined into marketable products. Recovery of value from AMD would also help stimulate AMD treatment

at abandoned mines and allow operators to offset treatment costs.

We found that REE concentrations in AMD treatment solids exceed many of the world's best commercial deposits. And, whereas most conventional rare earth deposits are encased in hard rock and located in remote wilderness, AMD sludge is already extracted from the host rock and easily accessible resulting in modest processing costs.

In the near future the AMD treatment systems at both operating and former mine sites could be managed as rare earth production facilities, recovering rare earths from ongoing AMD production and from sludge stored in dewatering cells (figure 3). For example, REEs at one site that is treated by the WVDEP's Office of Special Reclamation has an estimated value of $1.9MM exclusive of transport and processing. The goal of our currently funded USDOE/NETL project is to quantify those processing costs.

The WVU researchers evaluated the reserves at 140 acid mine drainage treatment sites throughout West Virginia, Pennsylvania, and Ohio. They are also developing commercially viable refining methods. If successful, the project could lead to economic diversification and new economic development opportunities for Appalachia's coal towns. While the coal market may fluctuate over time, acid mine drainage is constant. Long after mining is done, the mines still generate AMD and REE. Some of the richest AMD comes from sites where mining ceased 30 years ago. Our strategy involves extracting a REE concentrate from AMD at the mine for refining at a central facility. This involves treatment of the AMD for compliance with regulatory requirements while leaving the bulk of the waste stream for disposal at the mine under its currently permitted conditions.

Figure 3. Typical AMD sludge storage cell at a West Virginia coal mine. The contained rare earth value of this small cell is estimated at $325,000.

We conducted a regional survey and found 700 tons of REE in AMD sludge cells on mine sites in the northern and central Appalachian Coal Basins. Those mines produce about 1,000 tons of REE annually with an estimated, contained value of $245 million. The stored number is low because most AMD treatment sludge is disposed in underground mines or buried on active mine sites. For comparative purposes, the Congressional Research Service in 2011 found that the U.S. Defense establishment uses about 800 tons of REE per year while the overall economy uses about 16,000 tons. Most of those REE are in components manufactured offshore.

To make this a commercial reality, WVU is partnering not only with USDOE/NETL but also members of the coal industry, Rockwell Automation, Inc. and WVDEP. The support received has been tremendous. Success will turn an environmental liability into become an economic opportunity while cleaning up the environment.

Program Status: Our approach takes advantage of autogenous processes that occur in coal mines and associated tailings which liberate then concentrate REEs. In addition, we've found that AMD feedstock yields a favorable mix of valuable heavy and critical REE relative to many REE projects (figure 4). It is important to note that the Mountain Pass REE mine in California and China's largest REE mine at Bayan Obo, both produce largely light REEs while China's heavy REE supply is said to be depleting rapidly (figure 5). REE sourced from coal AMD is non-radioactive, unlike conventional, hardrock sources. A typical, recent sample of our concentrate contained 62% REE oxide with only 0.01% uranium + thorium.

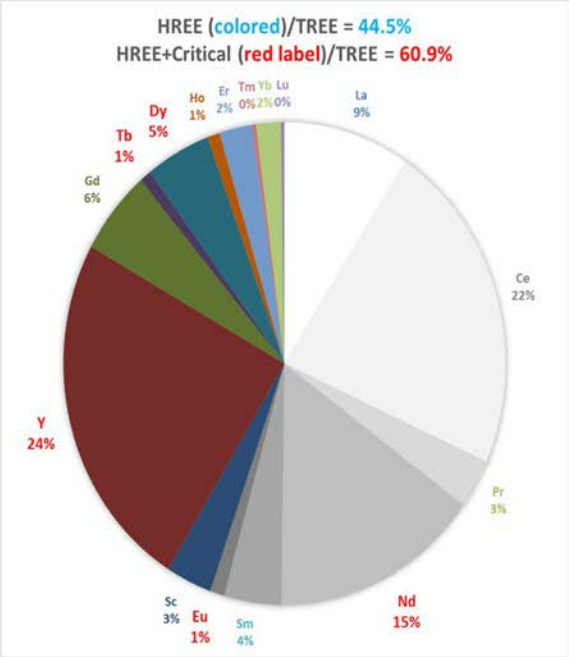

Figure 4. AMD contains a high proportion of the valuable critical and heavy rare earth elements. Together they comprise about 60% of the total rare earths in Appalachian acid mine drainage.

A techno-economic analysis found that REE extraction from AMD feedstock is economically attractive with a refining facility projected to generate positive cash flow within five years. In 2018 we commissioned a pilot plant to demonstrate continuous operations yielding 3 g/hour of REE concentrate. Rockwell Automation is providing technical expertise as well as its sensor and control technology to accelerate market readiness.

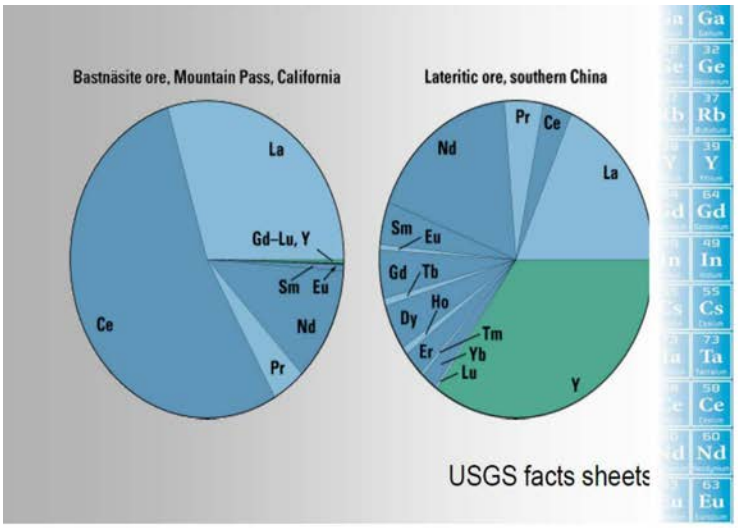

Figure 5. Bastnasite ores are mined at Mountain Pass CA and China's largest REE mine at Bayan Obo (left) they contain less than 12% heavy REE. Nearly all of China's heavy REE come from their laterite deposits (right) which contain about 50% heavy REE.

Thus far, we have produced pre-concentrates from acid mine drainage with 5% REE. Using hydrometallurgical methods at the bench scale, we produced a concentrate with 80% Rare Earth Oxides from AMD treatment sludge (figure 6).

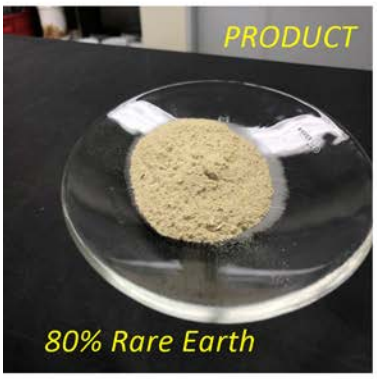

Figure 6. High-grade rare earth concentrate produced by the WVU research team.

Next steps will involve a pilot plant and scaleup of the our REE oxide technology to commercialization. Success will support the base of a domestic supply chain but that is only the start of a broader need to stimulate refining to REE metal and transitioning of domestic REE users to domestic supplies.

The CHAIRMAN. Thank you, very interesting. It is always interesting to hear about some of the technologies out there.

We focused in our legislation, I think very keenly, through USGS, through Department of Energy, on the issue of accessing these critical minerals, recognizing that we have a vulnerability. But I think it is equally important to talk about the ways that we can, through different technologies—whether it is recycling or looking for those alternatives, recognize that we may have more than even we think we do.

I want to go back to you, Secretary Balash, with regards to the mapping initiative. I have always felt that we are not doing ourselves any favors when we don't know what it is that we have within our inventory of our public lands and certainly within our resources.

You mentioned the mapping. I understand that the President, well, we know that he has requested funding to topographically, geographically and geophysically map the country. This is the Earth MRI. We included some funding last appropriation cycle to support this. Where are we within USGS' effort to implement the program? What is the status of this?

Mr. BALASH. Thank you, Senator, and thank you, Madam Chair.

The Earth MRI program, as you noted, is contained. There's a budget request in the FY20 request from the Department. The Service has been working through and with multiple state surveys as well to identify those opportunities for partnerships and, then again, with third parties.

The CHAIRMAN. Let me ask you, have most states conducted their own inventories or their own mapping so that we can compile this into one resource or are we still shy of real information?

Mr. BALASH. I think that the situation varies from state to state in the maturity of their information and also the amount of physical area that they have to assess.

Our home state, for example, there is a great deal of work left to do to complete the mapping there. But in some places, you have a better understanding and are able to put that information together more rapidly than in others. But the figures are a spectrum.

The CHAIRMAN. So we are still a ways behind in really understanding what our true inventory is as a nation when it comes to our critical minerals and our rare earths?

Mr. BALASH. That's absolutely correct, particularly when you consider the advances in remote sensing that are available today as compared to even 30 years ago. So in terms of having a modern and comprehensive assessment, I think as a nation we have quite a ways to go.

The CHAIRMAN. With regard to the Mineral Security Act that we have introduced, you have all had an opportunity to review it, and you have all said some relatively kind things about it. Does it do enough?

One of the things that I am very aware of is that oftentimes by the time we get around to passing legislation, it is already a little bit stale. Are we forward thinking enough with the legislation that we have laid down here?

I will throw that out to all of you.

Dr. Warner.

Dr. WARNER. Yes, I would like to recommend, I think that some of the lithium-ion battery materials are definitely an area of concern.

As we look at things like cobalt and lithium, the supply of those is in very high demand. And with the growth of lithium-ion chemistry, I think continuing to add to those materials, the lithium, nickel, manganese and cobalts, expanding to make sure that those are included and covered—those could be very strategic resources. And they're going to be key to the current generation of technologies as well as the next generation of technologies for energy storage moving forward. As we think of beyond lithium, some of these other materials are going to get us into some of the lanthanums and some of the other lanthanides that are going to move forward.

The CHAIRMAN. Okay. Anything else?

Dr. Ziemkiewicz and then Mr. Evans.

Mr. EVANS. Yes, thanks, Senator Murkowski.

Dr. ZIEMKIEWICZ. One of the things that we've noticed is that as soon as we mention to a landowner that the acid mine drainage sludge on their property may have value, it goes from being how fast can DEP get it off my site to this is my stuff and no one is going to touch it.

[Laughter.]

So the whole issue of ownership and control is really important to nail down in some sort of federal guidance, because right now it's a free for all and it will be handled on a—it would be like coalbed methane, if you're familiar with that controversy. It will drag on forever. Resolution on that count, I think, would be very useful to include in a bill.

The CHAIRMAN. Very good. Thank you.

Mr. Evans.

Mr. EVANS. I think the permitting is going to help out a lot. I think the tracking and the KPIs that you'd mentioned in the details of the bill are going to be important.

We've seen when you get to the federal level at the BLM, resourcing is a challenge to get to permitting through on timelines. They're going to be competitive to develop projects.

I think the workforce development is excellent. If you look at our university in technical college programs, it's not focused around a lot of these technologies and I think it's really important, even with some of the technology you've talked about in rare earth.

The one thing I did mention around credit facilities and loan guarantees is something it would be a next step that I think would be important to consider as our competitors offshore, governments help push development through their agencies and even with helping their own companies and it's not something that we have done in this country in a long time, but we need a strategy around that because we're a decade or two behind foreign governments in that strategy.

The CHAIRMAN. Okay, I appreciate that.

Let me turn to Senator Manchin.

Senator MANCHIN. Very quickly, because I know we are all going to have to run and go, votes and everything.

But how we got ourselves into this position to where we are depending on more and more of this product coming offshore—I mean, we do nothing here. This couldn't have just happened by chance. I mean, you had to know and your companies had to know that, basically, the development, whether it is in manufacturing of cell phones, medical equipment, batteries, whatever we use every day, was going to grow. Twenty, 30 years ago, we knew that.

And as that was growing in demand and demand was growing, it had to be that we were chasing it, the capitalist society were chasing the price. And China was able to go out and gather up all the resources they could to own this base resource for it to come into their country, to have total control.

The only way we are going to change this right now, because I don't think we will ever be price competitive with China, knowing that they got this much of a jump. The only way the American people will continue and for us the support with the legislation we have is the security of our nation. It is truly the security of the nation.

You all can benefit from that if we have a product but you are not going to buy our product if it is cheaper somewhere else. It is not the way the game is played.

So I am trying to figure out how we thread this.

Dr. Paul, you might want to talk about this but we are now being able to turn a liability into an asset and you know it can be done.

What is the price point? You have had to look at the price points of what China is charging for these. Where do you think the break even is and can you ever get to where we can be competitive or do we have to go down the role of truly being, having this stockpile of this rare earth minerals for the security and defense of our nation?

Mr. ZIEMKIEWICZ. It's a very good point. I think that some price support, if not market support, is needed in the early stages because the first thing the Chinese will do, and they've done it before, is drop the price on the world market.

Senator MANCHIN. Sure, we know that.

Mr. ZIEMKIEWICZ. Because of its monopoly and that will drive anyone out of business. Mountain Pass, which is our only active mine right now in the United States, sends all of its oxide product to China for refining.

Senator MANCHIN. Is that because of environmental laws in America where we make it very difficult for us to do that process?

Dr. ZIEMKIEWICZ. I just, I think, and I'm not an economist, but I think it's just because they have the supply chain. They can fit it right now. There's really no market.

Senator MANCHIN. Tell me the price point. Tell me the price point when you think that Dr. Warner there is going to buy the product, the raw ingredients from America and not overseas, because it is cheaper.

Dr. ZIEMKIEWICZ. Well, we have a concept called a contained value for a mineral and ours, because we have a very high ratio of heavy rare earths and critical minerals, including cobalt, by the way, which is what, 75 percent of our total rare earth supply in acid mine drainage sludge. If we move all that together, the cost,

the contained value is about, on average, $237 per kilogram. So that becomes a market factor. Now how that plays out in terms of full-scale production is something we need to do in the next research steps with NETL.

Senator MANCHIN. And what time period are we talking about?

Dr. ZIEMKIEWICZ. We're working on a proposal right now actually.

Senator MANCHIN. Because I think our bill here, the REEACT bill, gives you, is it $23 million a year?

Dr. ZIEMKIEWICZ. Yeah.

Senator MANCHIN. For a period of time here until we can get this thing up and running.

The only thing I have found, unless there is a private sector partnering up with the public sector which is going to be the universities or NETL, the timeframe seems to grow longer and longer and we are trying to shorten this because we need it desperately, as quickly as we can, to put ourselves in a position.

Dr. ZIEMKIEWICZ. Well, one of the nice things about acid mine drainage is that it doesn't require any permitting. So it's not like putting in a green field mine in the wilderness somewhere. You've got infrastructure. You've got a workforce. You've got, already, SMCRA permits and clean water right permits.

Senator MANCHIN. Sure.

And you said we could produce about 800—how many?—800,000?

Dr. ZIEMKIEWICZ. Eight hundred tons of rare earths per year just in the sites that we've looked at in central Appalachia.

Senator MANCHIN. What type of consumption do we use, do we have?

Dr. ZIEMKIEWICZ. The Department of Defense uses about 800 tons per year. The total economy is about 16,000 tons.

Senator MANCHIN. Sixteen thousand. So it would be a drop in the bucket to the total economy, but it would be a help.

Anybody have any comments on that real quick before we run out of time?

Dr. WARNER. I would add that from the battery manufacture standpoint, and I've had the privilege of working with several companies, we found some interesting things as U.S. cell manufacturers is that simply getting access to some of these, even offshore, materials is difficult when you're not producing in the same volumes as a LG or a Samsung, getting the materials manufacturers to be able to dedicate quantity to you or material to you becomes very challenging. So they're pricing it higher. So you challenge and you struggle to get those competitive pricing.

In the final product, you know, we see batteries coming down to $125 or $150 per kilowatt-hour in the relatively near future. And with new technologies coming in the next and beyond lithium applications, we see potentially hitting below $100 a kilowatt-hour. But that's probably ten years out.

Today, I think, we're targeting in this $125 to $150 at the complete pack level. So that's where from battery manufacturers we need to be able to afford that and then find those solutions which get us some materials that can allow us to reach those numbers.

Senator MANCHIN. Thank you, Madam Chair.

The CHAIRMAN. Thank you, Senator Manchin.

Senator McSally and then after her, Senator Cortez Masto will go. I am going to pop out and vote, and we will just keep moving here.

Senator McSally.

Senator MCSALLY. Thanks, Chairman Murkowski, Ranking Member Manchin. I appreciate you holding this hearing.

I was proud to join you as an original co-sponsor in the American Mineral Security Act of 2019. Critical minerals are not only essential for manufacturing modern technology all of our lives depend on, but mineral production is critical in Arizona's economy. The mining industry in Arizona generates $4.29 billion of economic impact, supports 44,000 jobs across the state and delivers $482 million in state and local taxes, in addition to much more in federal taxes.

While not listed as a critical mineral, copper is indeed essential. In Arizona, we have a lot of copper, one of the five Cs. We produce 65 percent of the nation's copper output, more than any other state.

Mr. Balash and Mr. Solan, we know copper is an essential component to electricity production and renewable energy technology. What is the demand for copper going to look like as the forecast for solar energy, electric vehicles and charging infrastructure continues to grow?

And it is important to note, many of the critical minerals needed for advanced battery technology, like nickel and cobalt, are byproducts of copper production. So I am interested to hear your perspectives, Mr. Balash, on copper byproducts and the Department of the Interior, what they are doing for byproduct research and development.

Mr. BALASH. Thank you, Senator.

The compilation of our critical minerals list last year received a fair bit of scrutiny on the question of where to put copper on that list for precisely the reasons you've identified. Its growing demand that we see coming down the pike as well as depleted reserves that are being produced as we speak is adding up to something that we can see out in the future as being a bit of a challenge. And that's reflected in some of the commodity pricing that we've seen over the last year.

I would say that the byproducts associated with copper production, many of those are already on that, the list, and something that bears monitoring. The ability to identify what those byproducts are going to be in these larger assessments that we've done are difficult to identify in some of the older research and assessments that have been done for resources around the country. I think a modern assessment will help identify some of those additional products that are present in the ore body.

Senator MCSALLY. Great.

Dr. Solan, do you want to add anything?

Dr. SOLAN. Sure.

We would definitely agree that copper is essential to our society. We depend on it for electrical infrastructure and one of the things that we're looking at, at the Department of Energy, is the relationship between the supply and demand and how quickly we may or may not electrify our society.

You did mention, too, in regard to clean energy technologies and electric vehicles, electric vehicles also depend on copper. I mean, we tend to talk just about battery chemistries themselves, but that's important. And we also forget too that copper is essential to internal combustion engine vehicles as well. So this is something that we think is important and is likely to grow in the future.

Senator MCSALLY. Great.

I want to follow up a little bit about this.

I am truly an all-of-the-above energy strategy kind of person. Some of the loudest advocates for renewable energy production, however, are some of the biggest opponents of mining. Those are contradictory in my view. It may work politically for them but not scientifically. Any serious conversation about lowering our emissions needs to include robust support for America's mineral production.

Dr. Solan, can you comment again on whether our ambitious renewable energy goals can happen without increased production of critical minerals?

Dr. SOLAN. I would say that critical minerals are definitely important in achieving the goals that we have and also pushing the technologies forward and providing producers and manufacturers with the widest range of technologies available.

I mentioned before that our three pillars also look at, not only diversifying our supply and production, but also taking a look at alternatives and substitutes. And we've put in quite a bit of work on that, but there's only so far that you can go in terms of certain technologies, mechanical versus say, direct drive, if the minerals aren't there. So this is something that we think is really important moving forward.

Senator MCSALLY. Great, thank you. I will yield back so we can vote.

Senator MANCHIN [presiding]. Senator Cortez Masto.

Senator CORTEZ MASTO. Thank you. Thank you, everyone, for being here. Mr. Evans, good to see you again.

Mr. EVANS. Thank you, Senator.

Senator CORTEZ MASTO. I have a few questions for you.

I know many of the critical minerals for the battery supply chain are included in the list of strategic minerals. How long, typically, does it take to develop a resource and get it to market?

Mr. EVANS. For a mine, a lithium mine?

Senator CORTEZ MASTO. Correct.

Mr. EVANS. Cobalt, seven to ten years.

Senator CORTEZ MASTO. Seven to ten years. And are enough critical resource projects at the right stage of active development domestically, or even internationally, to meet the projected needs for the future and what do we need to do to meet those expectations?

Mr. EVANS. No, not even close.

Senator CORTEZ MASTO. No, yes.

Mr. EVANS. There's not enough in development. Certainly, if you look at where demand, whether it's for electrification, going out seven or eight years from now, we need to be doing a lot more.

I think the legislation that's been introduced here is very, very helpful and I think the other difficult thing that, and we've talked

about it and Senator Manchin as well mentioned it, was that it's attracting capital to get these projects developing.

The United States has cobalt and lithium and manganese and copper. We need to push for the development and get private funds involved. And it might require some government support to help catalyze that, get it started, but that's been one of the biggest barriers. I think the permitting reform here is great but it's getting people off the sideline and getting public funds to move.

Senator CORTEZ MASTO. Do you think passing this legislation and also promoting or investing in a federal loan guarantee program would help bring in investors and the private sector?

Mr. EVANS. I would. I do, very much so.

Senator CORTEZ MASTO. Okay.

Mr. EVANS. Yes.

Senator CORTEZ MASTO. Let me ask you this. What areas in the battery supply chain are we missing besides the development of critical raw materials?

Mr. EVANS. It's the donut to me which is the cathodic materials for the electrodes. A lot of that technology is done all in Asia now, Dr. Warner talked about that, and a lot of research and development is done there. So if we had the minerals here, the next step is to actually make the electrodes here as well.

Graphite can come from Alaska. The other minerals from the U.S., but that R&D we can focus here. The separator which came from the U.S., now is made primarily in Asia is another key component and then the electrolyte. With those three we can then manufacture cells, and we'd have the complete supply chain.

Nevada is a great example. We've got Tesla. We're assembling batteries but all those other pieces we need as well besides the minerals which is just beginning.

Senator CORTEZ MASTO. Then one final thing that you talked about was workforce development as a challenge. What are you doing to address that right now and what can we do at a federal level to support that?

Mr. EVANS. We have training with Great Basin College that we initiated. I think the elements of this bill and the funding around college and university development around curriculums is critical. There's some great programs in metallurgy at University of Nevada at Reno which I think we can expand, especially around mineral beneficiation.

Those things are really, really important and I think we need to continue to focus on them because even with these projects we don't have the workforce.

Senator CORTEZ MASTO. I appreciate that.

Let me open that up to the panel. What else can we do at a federal level or, in general, to address the workforce issue because we can pass this legislation and identify critical minerals that we need, but at the end of the day if we don't have the workforce, that is going to be the biggest challenge for us.

Mr. BALASH. I know from our own experience, Senator, at the Department of the Interior, we're seeing a graying of our staff in terms of the expertise or mining in general.

Senator CORTEZ MASTO. Right.

Mr. BALASH. And that is something that we see nationwide. It's not specific to any particular part of the Bureau.

And so, I think there's definitely a need to come back up the ramp. We've seen, sort of this, sort of the downside of the curve. We need to come back up in terms of our opportunities for education. The number of School of Mines that are present in the West has fallen almost in half in the last 30 years. That's something that, I think, is a problem as well. If students who are enrolled in the university systems don't get exposed to those opportunities as part of their regular curriculum, as youngsters wander their way through college years and finding their path, that opportunity needs to be presented to them.

Senator CORTEZ MASTO. Okay, thank you.

Does anybody else have any thoughts?

Dr. WARNER. Hi, good morning.

I would add that from a battery standpoint we find that there's actually no battery engineering programs. I think there's two universities that actually have battery engineering programs.

There's mechanical engineering, chemical engineering, thermal engineering, but there's very few universities today that actually do focus on a program to develop battery engineers which is one of the most unique engineering fields because it does compromise and compose of all of the engineering facets from thermodynamics to electronics and software to the chemistry of it.

Many universities have bits and pieces in programs of them but very few actually have programs set out to develop, you know, actual battery engineering. That's one of the areas we struggle with.

Senator CORTEZ MASTO. Thank you.

Sure.

Dr. ZIEMKIEWICZ. Well, I asked, anticipating this question, I asked one of my mineral processing colleagues where the jobs are for their graduates. And they said a lot of them are in mining, a lot of them are in downstream manufacturing, for example. But the least amount of jobs was in mineral processing right now.

And certainly, our experience, my experience personally, watching the graduates and the size of the different departments come and go over the years, if there's a job opportunity out there, then students will flood into those fields.

Senator CORTEZ MASTO. Right. Thank you.

Thank you. I appreciate the conversation today.

Thank you, Madam Chair.

The CHAIRMAN [presiding]. Thank you, Senator.

Senator King.

Senator KING. Thank you, Madam Chair.

I think several of you touched on this in your earlier testimony. What potential is there for mining recyclables, in other words, recycling? Do the rare earths in a battery disappear in the chemical process or are they there if we could develop a very strong recycling process around this problem? You are in the battery business, tell me.

Dr. WARNER. Thank you, Senator.

This is actually an area that NAATBatt has been actively working on for several years now, and it's an interesting dilemma.

If you look at the vehicle life cycle, the average vehicle in the United States has about an 11.5-year life cycle. So the first electric vehicles were actually launched in late 2009 or early 2010 which would be——

Senator KING. I have a 2012.

Dr. WARNER. Perfect.

[Laughter.]

So the Chevy Volt, the Nissan Leaf and Tesla model or the Tesla Roadster all were launched then. So they should be nearing their end of life now.

Within NAATBatt we've been working on trying to put together some industry information to figure out how do we handle these, when these vehicles start coming back.

Senator KING. But my basic question, the chemicals are still there.

Dr. WARNER. The chemicals are still there.

So today the processing either involves a hydro-metallurgical process or a pyro-metallurgical process. There's actually new work going on by several organizations, even here in the U.S., to do what they're calling cathode, de-cathode or roll-to-roll recycling by which they're able to take the active cathode materials to reprocessing and get them done quickly.

Senator KING. So there is some significant potential here?

Dr. WARNER. Absolutely, absolutely.

Senator KING. Let me ask a different question.

I am sorry to rush you.

Dr. WARNER. No, no.

Senator KING. You don't know it, but we have numbers that go down from five minutes sitting here.

[Laughter.]

As I understand the testimony, the principal environmental problem may be partially mining but it seems to be processing and the waste from processing. Is there hope of additional or new technologies for processing that will minimize the environmental side effects so that we can move forward with that here rather than places that have more lax environmental standards?

Anybody want to touch that?

Mr. EVANS. Yeah, I'll take that. Thank you, Senator.

At least in our process, I think, there are ways to do this and it can be done very, very safely, we could look at traditional sources leased in lithium, but I also know in cobalt and others. I think projects can do good and do well even under the current environmental laws that we have or what's being promulgated in the future, it's possible to, I think, live in both worlds.

In our own case here, we're going after an unconventional deposit and that's been a hallmark of what we're doing here is not only to create, look at the waste pile itself and look at it differently and see if we can come up with, maybe even, a secondary use for it, but also to dry stack it so that we can store it and put it away in a safer method than might have been traditionally done in the past, all of this while the project is still economical. We have a backdrop in this industry of demand is going up.

Senator KING. Right.

Mr. EVANS. So pricing for a lot of things has gone up as well too. That supports——

Senator KING. Which opens up additional technologies.

Mr. EVANS. Exactly.

Senator KING. Let me follow up a bit on that.

I used to say in Maine that I wanted the strongest environmental standards in the country and the most timely and predictable process.

Is that what we are talking about here? Are we—we are not talking about lowering environmental standards, but we are talking about improving the process so that it is more timely and less expensive, is that correct?

Mr. EVANS. Yes, Senator. So, timely and predictable.

That's the difference in that you go next across the border to Canada or Australia, they still have strict environmental standards as well, but they accomplish what Senator Murkowski had said takes seven to ten years to get approvals here in the United States. There's a lot of mineral resources in those countries, it's usually about two years because there's a very strict process. Agencies work together and they have to get back and close the process out where things can drag——

Senator KING. Well, one of the things we did in Maine that was helpful, that might be useful, is one-stop shopping. In other words, you don't have to go serially to five agencies.

Mr. EVANS. Right.

Senator KING. You have one lead agency and everybody else works through that process, and we found that to be very effective.

I may have missed this because I was out for a few minutes. A lot of talk about China. There is also a lot of talk in the news today about China, are the tariffs and this trade unpleasantness going to affect this part of our strategic supply of these minerals that are—many of which come from China? Are they included in any of the tariffs or anything anybody know?

Dr. SOLAN. Senator, as I understand it, in terms of the tariffs that we were applying that rare earth elements were not included with that in the initial list. That was also in addition to that, it was on pharmaceuticals, but rare earth elements we were not putting tariffs on, was my understanding.

Senator KING. But China, as part of their retaliation, could diminish, restrict the supply if they chose to take that financial hit, is that, that is correct? I mean, that is the strategic danger, right, whether it is in the context of a trade war or just national competition?

You are nodding. That won't show in the record. Somebody has to say, yes. The better term is "yes, Senator, you are right."

Dr. WARNER. Yes, Senator, you're right.

Senator KING. Thank you.

Dr. ZIEMKIEWICZ. I do have an example of that.

The Japanese had a territorial dispute on some islands between Japan and China. I think it was a few years ago, 2010 maybe. The Chinese simply restricted the ability for the Japanese to get their rare earth supply and the Japanese caved within something like three or four months.

Senator KING. Because of the Japanese manufacturer of these high-tech devices that needed that supply?

Dr. ZIEMKIEWICZ. That's correct, Senator.

Senator KING. That is an object lesson to us, it seems to me.

Dr. ZIEMKIEWICZ. Oh, yes.

Senator KING. Thank you. Thank you, Madam Chair.

The CHAIRMAN. Well, and Senator King, that is exactly why we are here. That is exactly why we are here.

You think about that level of vulnerability when you have one nation that really holds the keys to so much of this, and we have heard that many of the resources are actually located there. But even if they are not located there, if they are from other countries, even if they are from the United States, where are we sending this to be refined, to be processed. It is all going back to China.

We have, what we believe to be, a very interesting prospect for critical minerals and rare earths in Alaska, and we would like to try to figure out how we can move forward with it. But part of the problem is do we want to be accessing that in Alaska only to send that to China, only to be vulnerable to them for the return when it comes back in a reprocessed state?

This is exactly why we need to be having this conversation, is the vulnerability that we have as a nation now and what we can do about it. So——

Senator KING. Madam Chair?

The CHAIRMAN. Sir?

Senator KING. I just was handed a news piece. Lithium-ion batteries are among the list of about $300 billion worth of Chinese goods upon which the Trump Administration plans to levy tariffs, of concern.

The CHAIRMAN. It should be of concern to all of us, yes. This is real time for us right now.

I want to ask, Dr. Warner, you raised the issue when we were talking about the supply chain here, and you call it an Asia-centric supply chain.

It seems to me that, perhaps, we don't have to own the whole supply chain there, but we need to have some piece of it. We need to be intervening in some way. Is there some focus on a particular part of the supply chain for batteries that you think would be more important than others, I guess?

Dr. WARNER. Yeah, absolutely, thank you, Senator. That's a wonderful question.

I think that the processing of the materials, as we look globally, there's materials in many places other than China as well, as well as we've got here. So I think the processing of them is actually an area of key importance.

If I can give you one short example. There's some work going on right now with some, several, companies working on a process called atomic layer deposition. And this is a process by which they're actually able to layer single atoms onto molecules that we use in lithium-ion batteries which promotes longer life, better energy density and better performance.

And the only reason they're able to do that is because they're partnering with the processing people, understanding how the materials are coming out, how they're making it. So if we can delve

deeper into that manufacturing and processing of those minerals here, that will certainly help ensure those future technologies coming forward.

And then, I'm a proponent always of the cell manufacturing. I think as we look at our armed services and the lithium-ion cells used in much of the military, the space programs, most of those cells are coming from foreign sources right now. So that does put us at some strategic disadvantage. So being able to build cells here and packs here to support those applications is vital, I think, to our security.

The CHAIRMAN. Let me go back to you, Secretary Balash, when I mentioned just an inventory in understanding. We also know that many of the minerals that we are consuming are not mined independently, that they are produced in conjunction with other minerals. We have a large copper mine in Utah that also produces molybdenum and radium as byproducts.

I am assuming that it is relatively common that we have this coproduction in these mineral deposits that if you are going for say, for instance, copper, there are other elements that we know to be colocated with these minerals, right?

Mr. BALASH. Yes, Madam Chair, that is absolutely correct.

The CHAIRMAN. Is it economic or even realistic to produce some critical minerals on their own?

Mr. BALASH. In some cases, it's not economically feasible. The process of what is typically hard rock mining involves moving efficiently, a large body of ore, crushing it, milling it and refining it.

Ultimately, those economics rest on the base or primary material or product that comes out. All of their own, the additional supplies of whether it's platinum metals groups or, you know, some of the other moly products, byproducts, those economics wouldn't stand on their own without the underlying recovery of whether it's copper, gold or silver.

The CHAIRMAN. So let me ask, Mr. Evans, are there other minerals that could be produced from your lithium product?

Mr. EVANS. There are other chemical compounds, yes, Senator.

The CHAIRMAN. Are you working to access them?

Mr. EVANS. Yes, as part of the chemical process that we do the byproducts, if you will, we're looking for, there are already markets for those. Actually, there's two byproducts and even our tailings, as I mentioned to Senator King, we're looking, actually, at uses for that as well because it's not toxic at all and it looks like there might be some construction uses for that.

The CHAIRMAN. Good.

Senator Daines, you have not yet asked questions, have you?

Senator DAINES. I have not.

The CHAIRMAN. Let me turn to you.

Senator DAINES. Chair Murkowski, thank you, and I want to thank you for holding this hearing, truly. And thank you for working on bipartisan solutions to address the United States' growing dependence on foreign-sourced minerals and metals.

Let's talk about Montana for a moment. Montana alone is home to about a dozen minerals that are on the USGS' net import reliance list. This includes copper, which the U.S. is 32 percent import reliant, as well as silver, which the U.S. is 65 percent import reli-

ant. Both of these can be responsibly mined in Montana at the Rock Creek and the Montanore mines. However, and this is a big however, these mines have spent decades jumping through bureaucratic and litigation hoops, and we still don't have a date in sight. This lengthy and burdensome process hurts high-paying jobs that these mines can supply, jobs the community fully supports. Tax revenue supports local governments in that part of our State in Northwest Montana and by delaying it, it perpetuates the U.S.' dependence on foreign countries.

Mr. Balash, what is the Administration doing to speed up reviews so that mines like Montanore and Rock Creek are not stuck in an endless, endless cycle of permit authorization?

Mr. BALASH. Thank you, Senator Daines.

The Department of Interior has undertaken a variety of changes to our business processes wherein we review the NEPA documents, the foundational documents, for permitting mining activity on most public lands. And through those changes to our business processes in DC, we've seen dramatic reductions in the amount of time that it takes for a NEPA notice, whether it's at the beginning or at the final stage, to move its way through our building here in DC. And that has empowered our state offices to undertake the work on a basis where they understand and are accountable for the product that comes out.

So, as we've addressed the issues here in the way headquarters operates, we're now turning our attention to the state level activities. And what we have found is that Nevada, in particular, has, the Nevada BLM, has identified some best practices for engaging in the permitting of mines and conducting the NEPA associated with hard rock mine activity, in particular.

So we're now in the process of, in essence, exporting those best practices from Nevada to other states that have had difficulties in front of the courts or elsewhere in getting across the finish line.

Senator DAINES. Mr. Balash, I appreciate the administrative view on that.

I want to shift gears, as we think about legislative action besides Chair Murkowski's bipartisan bill, what more can be done in Congress to promote responsible development of critical minerals in the U.S. so we are less dependent on foreign and sometimes even hostile governments?

Mr. BALASH. So I think the way to describe this is there's a multi-step process here.

First, we need to understand what it is we have, and I think the legislation does a good job of calling on the GS and others to understand what our resource potential is within our borders.

The second step is to make it incumbent upon the resource agencies, BLM, but also our partners at the Forest Service and the Fish and Wildlife Service, to ensure that our land plans make those resources available, that they don't foreclose or withdraw them from the playing field.

And then finally, the issue that you've hit on is on the permitting side, and while in this Administration the one federal decision doctrine has been identified by the President and we are seeing some successes in certain places, we encounter on a fairly routine basis incongruities and differences between one agency and another. And

so, our timelines don't always sync up well. I think that's an area where we could be helped along to be able to function more efficiently overall in the processing of permits for hard rock mines, in particular.

Senator DAINES. Thank you for the thoughtful answer.

I want to ask a second question regarding the green new deal.

We have the potential to responsibly produce valuable minerals while also protecting our environment. We see that in Montana where we have the Stillwater mine there, literally, in the backdrop of the Absaroka-Beartooth Wilderness.

What I think some people don't understand is that wind farms and solar panels do not grow naturally in the wild. You have to mine and refine raw materials to make them. If the U.S. wants to be a leader in renewable energy, they also have to be a leader in responsible mining. You can't have it one or the other. We need to have it both ways. There is no green new deal without mining. Wind, solar and storage systems use significant amounts of mined materials and some forecasts project, listen to this, a 12-fold increase in mining to meet the demands. If we want to increase renewable energy, we must also increase development of our natural resources, particularly our mining capabilities.

Mr. Balash and Dr. Solan, shouldn't we be spurring responsible development of critical minerals for energy systems, instead of making it nearly impossible to mine in the United States?

Dr. Solan, why don't you start?

Dr. SOLAN. So as I mentioned before, at the Department of Energy our first pillar in terms of our R&D portfolio is trying to diversify our supply and encourage U.S. production as part of that.

One of the ways that we do that is trying to improve critical minerals recovery from ores. And we'd like to look at the whole supply chain in terms of our R&D because it will be really tough, as the Chairman noted, to reprocess or do separations if we don't have a product to do that with.

It's the same on down the line. If we could improve things throughout the supply chain and add value throughout, it makes more economic sense to do all of that in the U.S. So that's something that also, too, when we talk to our allies around the world and we have talks with them, is we would like to bring production to the U.S. and bring it under the American regulatory umbrella because that would definitely improve environmental outcomes. It would also add to American jobs and U.S. economic growth.

You know, that said, the President's December 2017 Executive Order 13817, we've been a part of that. Secretary Balash has noted the list of critical minerals, and the Department of Commerce is putting out a report soon whereas at least leading the report, that will help define a national strategy for critical minerals. And a big part of that which we're all working together on has to do with permitting and streamlining and recommendations for U.S. production.

Senator DAINES. I am out of time, Chair Murkowski, so I will yield back to you. Thank you.

The CHAIRMAN. Thank you, Senator. Good questions.

Let me ask about the impact that this lengthy permitting process has on just an investor's willingness to be participating here. Mr.

Evans, we have acknowledged that it is just longer here, oftentimes twice as long, maybe more. What is that doing to the investment environment and the willingness to even get in the game here in this country?

Mr. EVANS. Thank you, Senator.

I think it suppressed interest in domestic projects here. I think one of the questions earlier is how did this happen before and the history here is that its investors have gone overseas. They've gone other places and ignored the assets that we have here.

And it's going to be a challenge even now to get people off the sidelines, private investors, because that's what we really want here is private funding to fund these projects. A reliable permitting process where people understand it's going to be a finite amount of time and then construction can start and cash flow could start and they can basically make a profit after that is going to help immensely, I think, to drive more public money and capital into these projects.

The CHAIRMAN. Let me ask you, Secretary Balash, when we think about different ways that we can provide the right incentives, sometimes it is, well, much of the time it does focus on the permitting side of it.

There has been a lot of discussion around this place about an infrastructure package and what that might look like. We all know that includes things like highways and courts and transmission systems and bridges, but I also think that we need to be doing all that with minerals that are produced domestically. I think that just makes a lot of sense.

What is the Administration doing to keep an eye on the entire supply chain when we are talking about infrastructure and an infrastructure package? And then, is there consideration that within a broader infrastructure bill we are looking to the permitting side that might include our critical minerals?

Mr. BALASH. Thank you, Madam Chair.

The list of materials that will be important to support the development and reinvestment in infrastructure in this country goes far beyond what we've identified in the critical minerals package. However, many of the improvements that both the legislation calls for and that the Administration has undertaken to bring timeliness, efficiency and certainty to the permitting process, at least as it relates to NEPA, are things that we think can be quite helpful overall in ensuring that the suppliers of strategic and industrial minerals, to differentiate from critical ones, are available in time to meet the needs for the construction activities that would be undertaken as a consequence.

So whether it's as simple as gravel fill or getting iron ore for steel beams that go on bridges and trestles, all of those things need to be available to meet the market signals that would come about in the lead time running up to actual construction.

The CHAIRMAN. Thank you for that.

I am going to go ahead and vote.

Senator Lee, if you want to go ahead and proceed and then I will be back.

Senator LEE. Thank you, Madam Chair. Thanks to all of you for being here today.

I want to start with Mr. Balash.

You know, we have had a lot of discussion today about streamlining the permitting process and about workforce development, and those are all important things. It seems to me that none of those will make a difference, none of those will matter if we don't have minerals to extract, if we have taken them all off the table. I think that is something we have to take into account.

New mining operations are either restricted or banned altogether on more than half of all federally-owned lands. That is a stunning figure, especially when you consider the fact that federally-owned lands make up about 30 percent of all the land mass in the United States. And a lot of the minerals that we have in this country are actually on federal public lands.

So, a lot of us, a lot of members of the Senate, while claiming in one breath to be very concerned about the domestic supply of critical minerals are, at the same time or in the very next breath, trying to make it more difficult to do this, routinely introducing bills to withdraw thousands, sometimes hundreds of thousands of acres, from any and all new mineral exploration.

In fact, this very afternoon the Public Lands Subcommittee will be holding a hearing on some bills that would do precisely that on a series of bills that when cobbled together would take out nearly a million acres of federal public land from mining exploration and development.

Is there any way to guarantee that just because there are no active claims on given parcels of land that future exploration or future technology would not discover or make accessible and economical the mineral development on that land? In other words, I guess my question is, when we look at bills like that, that would force mineral withdrawals on our system of federal public lands, can we always know what is there or what reasonably could be there given future developments in technology?

Mr. BALASH. Thank you, Senator Lee.

Your comment reminds me of something that stuck with me for many, many years. It was a conversation with an old "rock licker" geologist who told me, "markets change, technology changes, but rocks don't change." And understanding what we have in our mineral estate is critical, not only for understanding what the opportunity is today, but what it might be 100 years from now.

And so, I think one of the really important aspects of the legislation in front of us is, is the assessments that the GS is called on to perform and to do so periodically because over time our understanding, our ability, to source and detect those minerals at deeper and finer resolution levels will improve over time as well. So that is a long-term understanding we all need to have.

Senator LEE. In light of that, I appreciate your analysis on that.

Any time we are having a discussion about critical minerals and about our ability to access them, whether or not we have an adequate domestic supply, is it even possible to have a rational conversation about that without also having an honest conversation with ourselves about mineral withdrawals on public lands?

Mr. BALASH. So one of the things that, I think, in this Administration we've tried to take a hard look at is whether or not administrative actions that withdraw the mineral estate make sense in

that light. And there's a couple that we have, in fact, reversed from the prior Administrations. And one of those had to do with a very large withdrawal in the mountain region, having to do with the targeted efforts to protect sage grouse habitat. And as we took a look at what was approaching a ten-million-acre withdrawal, mining activity, surface activity would have affected, maybe, you know, a fraction of a percent of that surface. And so, we didn't think that really made sense, withdrew that or canceled that withdrawal, lifted that withdrawal and also one in the California desert. So, and we've resisted granting other administrative withdrawals.

Now, when Congress in its wisdom chooses to take things off of the federal mineral estate, that's your business.

Senator LEE. I was relieved that you did not use air quotes there, but you would have been well within your right to do so.

Mr. Chairman, I have one more question, do you care if I ask that?

Senator MANCHIN [presiding]. Sure, go ahead.

Senator LEE. Okay, thank you.

Within our system of laws, we have state laws and federal laws that both have to be complied with. In many instances you have environmental laws, you have federal NEPA law and state NEPAs or NEPA-like legislative frameworks in the various states. This adds a layer of complexity and understandably, states are themselves sovereign entities, they have their own right to exist, their own right to make laws.

Are there ways that you can think of that we could reduce some of the overlap between the federal and state requirements that could allow applicants to comply with both of them? We could streamline the processes so they dovetail one with another.

Mr. BALASH. Senator Lee, as a former state executive, I appreciate your recognition of states' sovereigns and would note that there are some opportunities, I think, with CEQ, if they were to maybe address through their regulations our ability at other federal agencies to take into account the work that's been done by other governments, specifically state governments. That would reduce some of the duplication that we have to undertake in the course of doing our own NEPA reviews or permitting actions.

Senator LEE. Great. Thank you very much.

Thank you, Mr. Chairman.

Senator MANCHIN. Thank you.

I will follow up, and then we will see who comes back from voting. The second vote is going on right now.

Let me ask the question on the tariffs, basically what tariffs are going to do since it seems that China has very much of a monopoly on rare earth elements which we are using every day and it is going to be, I am sure on the batteries, Dr. Warner.

Do you see the impacts so far? Has it affected you all and do you anticipate an effect?

Dr. WARNER. I think that's an excellent question, Senator. Thank you.

As of today, we haven't seen the impacts, but I'm looking to buy cells. So with our new company, as we buy cells globally, that will make them more expensive which will make our end products more expensive. The raw materials are still likely being processed in

Asia for those Asian cell manufacturers, so we'll receive them as a completed unit, as a lithium——

Senator MANCHIN. But I am saying that tariffs have been placed high.

Dr. WARNER. And the tariffs are going to be, as the tariffs are added, they will make those cells more expensive for us to acquire and that's going to make it more expensive for our customers down the line. So yes, it's going to add challenges.

Senator MANCHIN. Dr. Ziemkiewicz, in West Virginia we know we have an awful lot of change pre-SMCRA that you are probably looking at and dealing with. Are you basing on if we produced in all the streams that we have, that we know that we have acid mine drainage, which gives you, pretty much, a food chain, a link to join things expediently? That is where you are getting the 800 tons when you are anticipating that, or where did your estimation of 800 tons production come from?

Dr. ZIEMKIEWICZ. Eight hundred tons, Senator, are the number of discharges that we actually sampled. So these were largely regulated discharges as opposed to the unregulated discharges.

We reckon there are something like five gallons of unregulated AML discharge for every gallon of regulated discharge in the Northern Central App.

Senator MANCHIN. So it could be four, five, six thousand tons?

Dr. ZIEMKIEWICZ. Potentially, yes.

Senator MANCHIN. And that is just in West Virginia, that was including all the acid mine drainage we have in——

Dr. ZIEMKIEWICZ. That would include Western Pennsylvania and also Eastern Ohio.

Senator MANCHIN. Okay.

So it could pretty much have a tremendous effect on the supply chain?

Dr. ZIEMKIEWICZ. Oh, absolutely.

And another thing, I think it's important to note that this, if you think about an ore body, ore bodies have the easily accessible ores, usually on top of the ore body, easy to mine. The sulfides have gone away and you've got pretty pure metal. And then you've got the more difficult to extract, deeper stuff where you have to go underground.

Senator MANCHIN. Sure.

Dr. ZIEMKIEWICZ. And start exploring.

Senator MANCHIN. We are talking, I think that Senator Lee was mentioning about permits, how difficult permits can be, Mr. Balash, acquiring them. Sometimes it wears people out, they just don't fool with it.

We have already got a ready-made supply of product and that is why I can't believe we have not used it or why we are not looking. But DOE, we are hoping with this piece of legislation, we have bipartisan support. It makes a lot of sense.

Dr. ZIEMKIEWICZ. Right, it's the high-grade end of an ore body. That's how I see the acid mine drainage picture. And that's not even counting the hard rock acid mine drainage which is gigantic by comparison.

Senator MANCHIN. What do we do to the water quality after we process it to take the rare earth minerals out? Are we able to return it in much better condition?

Dr. ZIEMKIEWICZ. Oh, absolutely.

In fact——

Senator MANCHIN. Can we bring the stream back to life?

Dr. ZIEMKIEWICZ. Oh, yeah. Yeah, in fact what you'd have is a classic acid mine drainage plant.

We're putting together a proposal right now for DOE that would integrate a West Virginia DEP acid mine drainage plant under their bond forfeiture program with a rare earth extraction facility integrated in one facility up near Mount Storm, by the way.

Senator MANCHIN. Will the DOE take the product to buy, you know, for what we are producing? Will they be able to use that or can they process that or do we have to be able to refine it?

Dr. ZIEMKIEWICZ. We would have to create that supply chain, yeah.

Senator MANCHIN. So there are no refineries in the country right now?

Dr. ZIEMKIEWICZ. Not right now, but again, that's something that could happen fairly quickly.

Senator MANCHIN. Yes.

Anybody else have anything, because I know if the second vote is going on and no one returns, we might be wrapping up.

Mr. Evans, do you have anything that you want to add to this whole process of where we are? You have seen it from the private sector. Where you are today, do you see getting pinched from the standpoint of supply?

Mr. EVANS. Well, obviously, prices are and costs are going to go up with the tariffs now and have a knock-on effect as they will.

Permitting, we've talked about, is critical to have certainty around that, if you're a private investor or tracking private investment. You know, things are measured in what your IRR is, your return, and those processes can go on seven or ten years and, basically, projects are abandoned or they go broke. So that's going to continue to be a challenge. Permitting, I think, is the first start.

We talked about education, and I think that will help some of the things that Dr. Z. talked about here as well, by putting some of these things, it's going to spur more innovation around the country and be able for us to build new supply chains.

Senator MANCHIN. Dr. Solan, if you could talk to us about, a little bit, what position you are in for the Department of Energy, where you all are going, how serious you take this and how committed are you?

Dr. SOLAN. We take it very seriously, sir.

I just wanted to echo the point that we see technology in innovation as the key behind this, and we thank you both for your leadership in the bills you've put forward. We definitely look forward to working with you throughout the process.

One of the things that I wanted to mention too is leadership and innovation and technology is one of the things that we need to remember whether it's with critical minerals or, for example, hydrocarbon production in the past is that the unconventional eventually

becomes conventional. And the only way that you do that is through R&D.

So, for example, Dr. Ziemkiewicz talking about NETL's programs and the Office of Fossil Energy's programs that need to begin somewhere. They need to show results. And when that happens with partnerships with the private sector and academia and other stakeholders, we can help move things forward.

Senator MANCHIN. Just to follow up on that. Everyone has an opinion on the tariffs and I look at a tariff, we have lost a lot of our desirability, if you will, to do some of the things we should always be doing for the building blocks for this great country. The steel and aluminum, if you don't have steel or aluminum production in your country, it is hard to maintain the superpower status. If these tariffs are driving back some of the things that should have never left, it is a good thing.

If we are able to get back to where we can extract and produce and also refine to where we don't have to be dependent, wholly dependent, on subsidiaries outside and other countries, especially foreign entities who are not too favorable and do not really worry about our economy as much, it could be a good thing.

This is one that I look at that could be if it gets us back into that. And I think the Department of Energy, you are going to be the one driving it so I don't know how much that Secretary Perry has, I'm sure, talking, conversing, with the White House on how important the rare earth minerals are that we are not producing, we are not refining, we are not doing anything. And that might spur that on to accelerate what we can into production commercially much quicker than just continuing to analyze.

Do you know if there has been conversation there on a level from the Secretary to the White House?

Dr. SOLAN. Not specifically regarding that. I can't say what the discussions have been.

Senator MANCHIN. I am happy to follow up with him, but if you have a chance, you follow up yourself and this is something I think is very important for our country.

Dr. SOLAN. Yeah, I could do that.

Senator MANCHIN. Okay, thank you, Madam Chairman.

The CHAIRMAN [presiding]. Thank you, Senator.

I really appreciate the discussion that we have had this morning and just the information that you have shared with the Committee.

One last question, and it is probably to you, Dr. Warner, and maybe you, Dr. Solan.

As we think about the new technologies that are out there, the prospects for recycling, there is a lot of excitement and anticipation in terms of what that can yield. I have heard some suggest that we don't need to do more to access our own minerals here in this country. We don't need to make steps in that direction. We can recycle our way forward. I am wondering if we are being visionary enough in understanding what the demand going forward may be so that we are taking into account the broader increases in electrification, in the associated infrastructure, that in the future, is going to be relying on these.

Can any of you give me your comments? Are we to the point where we can just rely on technology to allow us to meet this de-

mand or do we need to continue to be the producer of these raw materials at the same time that we are working on the technology, because I think there are some who believe that there is a very easy way out of this and I would like to hear your thoughts on that.

Dr. Warner.

Dr. WARNER. Thank you, Senator.

I think that is an excellent question where we sit now in the industry. And I don't think that there's a one-size-fits-all solution. I think that the recycling is absolutely going to be necessary with just the pure number of lithium-ion batteries coming into the end of life. But I think, and I think it could add to a significant portion of the minerals used, but I think it's going to have to be a policy that includes both the processing and the mining of natural materials and the refining of the used ones.

There's new technologies happening today, such as the roll-to-roll recycling, where they're able to pull cathode materials off, reprocess those and be able to use those. But those are still in their infancy stages. Today, most of the recycling processes will allow you to get some of the copper, some of the cobalt and some of the rare minerals out of there through a very expensive process that uses a lot of energy going into it.

But I think going into the future, as we see more and more of these batteries coming out, as we look at our cell phones, every cell phone that we've got in the room here and probably sitting in Washington, DC, use the lithium cobalt oxide battery. All of those cobalt, what do we do with them when we're done? How many people have one or two sitting at home in a drawer somewhere? I know I do. If we have policies which would allow us to bring those back in and do some urban recycling, that could be another source of some of these raw materials.

So I think that using some of the recycling technologies, continue to develop those recycling technologies will help supplement the need for some of the natural ones, but it will certainly help improve our—reduce our dependence on some of those foreign sources.

The CHAIRMAN. Anybody else care to weigh in?

Are the minerals that we have on the list, these are the ones that we have identified for today, but again, forecasting into the future, are we going to need to be adding more to that list, that we just have not even envisioned yet?

Assistant Secretary Balash.

Mr. BALASH. Well, Madam Chair, I think that's why having a periodic reassessment of the list, every couple of years, is really important.

The CHAIRMAN. Yes.

Mr. BALASH. Because over time the market demands will change, the technology will improve and draw on different pieces and parts of that list.

So, you know, with that dynamism in mind, you can't just set the list one time and that's going to be it for 20 years. It just, it won't stand up.

The CHAIRMAN. Alright.

Dr. Solan.

Dr. SOLAN. I agree with that, and one of the things we need to take a look at is constant evaluation. You bring up a very good point which is we really need to take a look at trying to forecast and figure out what's risky and what's not.

The CHAIRMAN. Are we doing that?

Dr. SOLAN. That's one of the things that we do at the Department of Energy. But some of the sensitivities that we have, particularly in some of the technologies you've mentioned, moving forward is how quickly is society going to electrify and are we going to, are automotive makers going to, follow through on their commitments on electric vehicles? How quickly might the consumer be brought to bear in terms of choosing electric vehicles and how quickly will battery technologies be used as storage for the grid? So these are all things that are important.

You know, that said, we constantly take a look at these issues at Department of Energy according to a specific mineral or materials, importance to energy and also its supply risk. And in the past, going back in time, we actually thought that rare earth phosphors were going to be really important and had high supply risk, because at that time we thought compact fluorescent bulbs would be technology moving forward and technology of the future. And low and behold, it was not the rare earth phosphors. Now we're talking about gallium because industry has innovated, and now we have LED light bulbs that are actually penetrating in the market enough to move world markets.

I'd just like to close and talk about that which is we have to take a look at this in terms of a global demand equation. All the different countries and companies around the world are competing for the same things, and much of the world's growth in demand is not going to be in the United States, it's in the rest of the world or it's in Asia. So in order for us to remain competitive, we have to take a look at our own supply chain and our own production.

The CHAIRMAN. Very good.

Dr. Ziemkiewicz.

Dr. ZIEMKIEWICZ. One of the things that we tend to overlook in this whole discussion is that markets themselves tend to be fairly elastic. And when I say that, the Washington Monument originally had an aluminum cap on it just to show the world how rich we were because aluminum prior to the Hall process was more valuable than silver. Now once the Hall process came along, then all of that useless bauxite in the tropics became a valuable ore.

Well, I think the same thing may happen with some of the rare earths and critical minerals. For example, the cheapest rare earths right now go for about $8 per kilogram, $8,000 a ton. Well that blocks out a lot of markets. If we had the supply, if we had the low-cost processing, then all of a sudden, the price goes down, but the market increases in size. So we have to keep that in mind over making these assessments.

The CHAIRMAN. Very interesting.

We have had good input here today from Department of the Interior as well as Department of Energy, but I am reminded that it is the Department of Commerce that has led the development of a strategy to reduce this country's reliance on foreign minerals. We have been waiting to see that report for months.

I am sorry that we have not seen that be released yet. We certainly are looking forward to that. But again, it is just a reminder that this is, kind of, a "whole of government" approach here when we are talking about our minerals and mineral security and what that means. It is not only what Interior does with accessing them from our lands, what Energy is doing to work on the technologies, but how that fits then from a broader view of Commerce, not to mention the perspective from Defense, obviously, very, very key to the discussion as well.

I hope that Interior and Energy, just as you have outlined today, your Departments are working aggressively on this. Hopefully there is coordination with the Department of Commerce as we are talking about the broader strategy.

You are nodding your head to affirm that that level of coordination is going on?

Mr. BALASH. Yes, ma'am.

Dr. SOLAN. Yes, it is.

The CHAIRMAN. You do not say that with levels of exuberant enthusiasm which kind of concerns me.

[Laughter.]

Can you give me any insight in terms of when we might expect this from Commerce on a release? I know it is not your Department, but what do you know?

[No response.]

The CHAIRMAN. Okay, there's a lot of cooperation going on between the three.

[Laughter.]

I won't hold you to that, but maybe I will follow up with the folks over at Commerce and see if we can rattle some cages over there.

I thank you for the leadership that we are seeing, not only within our Departments but on the private sector side and in academia. This is an issue that will continue to be on my front burner in terms of priorities.

I really feel like we did something extraordinarily significant when we were able to release the United States' potential when it came to reducing our vulnerability on oil by lifting the oil export ban. It was a policy that was holding us back. And it has really, truly helped make a difference when it comes to levels of vulnerability.

But I fear that we are going in the same direction that we were previously with oil when it comes to minerals and our mineral security. That is not a place where I want to be. I don't think it is a place where any of us want to be. And it is going to take accessing these resources domestically, it is going to take the skilled workforce at all levels and it is going to take the ingenuity to build out these technologies.

Dr. Ziemkiewicz, it has been fascinating hearing your report here today just in terms of what cool and neat things that we are finding in places that one would never have anticipated, nor expected. And just again, a reminder of the greatness that we have in so many of our learning institutions, our national labs and the bright people that we have that are focused on these difficult issues.

Thank you for joining us, and thank you for your testimony. We will look forward to advancing both the bill I have been leading as

well as Senator Manchin's, and would appreciate your continued input as we move forward with these.

With that, the Committee stands adjourned.

[Whereupon, at 11:56 a.m. the hearing was adjourned.]

APPENDIX MATERIAL SUBMITTED

Questions for the Record submitted to the Hon. Joseph Balash
Senate Committee on Energy and Natural Resources
Pending Legislation
May 14, 2019

Questions from Chairman Lisa Murkowski

Question 1: At the conclusion of the hearing, I expressed the hope that the Department of Energy and the Department of the Interior were "working aggressively" and coordinating with the Department of Commerce on the broader strategy. You replied affirmatively when I asked whether this "level of coordination" was occurring.

(a) To your knowledge, is there an existing Policy Coordination Committee (PCC) dedicated to critical minerals, including the coordination of interagency efforts to reduce reliance on foreign sources?

Response: Federal activities related to critical minerals are coordinated via the National Science and Technology Council's (NSTC) Committee on Homeland and National Security's (CHNS) Critical Minerals Subcommittee. The purpose of the subcommittee is to coordinate interagency efforts to ensure that the United States has a secure and reliable supply of critical minerals.

(b) If so, how many times and when has that PCC convened, and which departments and agencies participate in this process?

Response: The panel meets bimonthly. The following National Science and Technology Council (NSTC) departments and agencies are represented on the subcommittee:

- Department of Agriculture
- Department of Commerce
- Department of Defense
- Department of Education
- Department of Energy (Co-Chair)
- Department of Homeland Security
- Department of the Interior (Co-Chair)
- Department of Labor
- Department of State
- Department of Transportation
- Environmental Protection Agency
- National Aeronautics and Space Administration
- National Science Foundation
- U.S. International Development Finance Corporation

The following organizations from the Executive Office of the President are also represented on the subcommittee:

- Office of Management and Budget
- Office of Science and Technology Policy (Co-Chair)

Questions for the Record submitted to the Hon. Joseph Balash
Senate Committee on Energy and Natural Resources
Pending Legislation
May 14, 2019

Question 2: During the period 2004-2014, the U.S. Geological Survey (USGS) published a number of research products focused on Afghanistan's natural resources. This project included the release of dozens of hyperspectral, geologic, and topographic maps, as well as summaries of areas of interest for particular minerals and much else.

(a) Since 2001, how many times have USGS personnel deployed to Afghanistan on official geological work (i.e., not as part of the Reserves or National Guard)? How many times since January 20, 2017?

Response: Approximately 245 individual trips to Afghanistan were made by various USGS scientists prior to Jan 20, 2017. Since Jan 20, 2017 there have been 11 individual trips by USGS scientists.

(b) How many USGS personnel have deployed to Afghanistan to support this work? How many personnel since January 20, 2017?

Response: Approximately 39 USGS scientists travelled to Afghanistan prior to Jan 20, 2017. Since Jan 20, 2017, 6 USGS scientists have travelled to Afghanistan.

(c) How many times have USGS personnel deployed in the field (e.g., by helicopter) to conduct geological surveys in Afghanistan? How many times since January 20, 2017?

Response: There were approximately 83 trips where USGS scientists deployed to the field (all by helicopter) prior to Jan 20, 2017. No USGS scientists have deployed to the field after Jan 20, 2017.

(d) What was the collected mineral resource data used for, if anything, in Afghanistan? How has it been used since January 20, 2017?

Response: More than 350 reports, maps, and databases were produced by the USGS covering Afghanistan. Those products have had many uses including the following brief summary:
- Development and planning of critical infrastructure - USGS data were used in the planning and construction of the country's roads, cell towers, airports, and railroads.
- Specific mineral data were used for tendering and leasing mineral and oil and gas tracts throughout the country.
- Planning for water resource needs, such as recharge of the Kabul Basin, and locating dams for power, irrigation, and flood control.

The uses of these data and products have been increasing over time and it is difficult to ascribe these activities to a pre- or post-Jan 20, 2017 timeframe.

(e) Overall, how much money was spent directly by the U.S. Geological Survey and the broader Department of the Interior (or reimbursed by another department or agency) on surveying Afghanistan's minerals? How much money has been spent since January 20, 2017?

Response: The USGS spent approximately $76.86 million pre-Jan 20, 2017 and $4.5 million after Jan 20, 2017. All USGS Afghanistan project funds were reimbursed by the Department of Defense, the U.S. Agency for International Development (USAID), the U.S. Trade and Development Agency (USTDA), and the Afghan government.

Question 3: As we discussed during the hearing, S. 1317 directs additional geographic mapping to ensure that we understand the location and potential for development of critical minerals. Once that mapping has occurred, how would the results be incorporated into the Department's land use plans and what more can be done administratively or in legislation to ensure the most current data about critical mineral potential and production is utilized to update and modify existing land use plans?

Response: The Bureau of Land Management (BLM) land use planning process requires that the agency follow all of the requirements of the Federal Land Policy and Management Act (FLPMA) and the National Environmental Policy Act (NEPA). Additional mapping called for in the legislation will allow the BLM to better respond to specific challenges such as reducing the risk of wildfire and locating natural resources, including critical minerals, for development on public lands. The BLM utilizes all relevant available data in the land use planning process; however, critical minerals have not yet been mapped, and therefore cannot inform the process. When developed, new information about critical minerals will assist the BLM in amending its existing land use plans in order to adequately address access to those minerals. The BLM may also use the results of the mapping effort to perform plan maintenance, an action that reflects minor changes in data but does not expand decisions in the approved land use plan.

Question 4: As the United States looks at mineral resources, has Interior conducted an assessment of hardrock minerals in our Extended Continental Shelf? How does our status as a non-Party to the Convention on the Law of the Sea impact our ability to claim these resources?

Questions for the Record submitted to the Hon. Joseph Balash
Senate Committee on Energy and Natural Resources
Pending Legislation
May 14, 2019

Response: The US Extended Continental Shelf (ECS) and Exclusive Economic Zone (EEZ) have only been assessed at a speculative level for hard mineral and critical mineral resource. The USGS has identified 'permissive regions' that are likely to contain deposits of hard-rock and critical mineral bearing material in both the EEZ and ECS. Two regions of special interest are the ECS off of the Commonwealth of Northern Mariana Islands, and the Arctic ECS extending into the Chukchi Sea. Both of these identified regions require extensive mapping to determine the scope and resource potential of the inferred mineral deposits.

As a non-party to the United Nations' Convention on the Law of the Sea, the United States is unable to submit claims regarding our ECS to the Commission on the Limits of the Continental Shelf. Further discussion regarding the legal status of the United States ECS can be addressed to the Department of State U.S. Extended Continental Shelf Task Force.

Questions for the Record submitted to the Hon. Joseph Balash
Senate Committee on Energy and Natural Resources
Pending Legislation
May 14, 2019

Questions from Ranking Member Joe Manchin III

Question 1: Disruptions in supply chains can occur for a variety of reasons, and some of them we can control better than others. When the USGS developed its critical minerals list, supply chain considerations were utilized in the selection process. Meaning a commodity was determined to be critical if any step in its supply chain was considered to be problematic and vulnerable to a disruption. I understand the segments of a commodity supply chain vary from mineral to mineral, but can you please tell me which phase of the supply chain you think is most problematic - extraction, processing, components, or end-use applications?

Response: As might be expected, the answer varies by commodity. For some commodities, for example tantalum, there is simply a lack of domestic geological resources. For others, including several byproduct metals, there is a lack of domestic processing (i.e., the commodity is extracted domestically but sent abroad for processing). For others still, including the rare earths, the entire supply chain from mining through the manufacturing of components is dominated by a single foreign country. For any given commodity, understanding which stage of the supply chain is most problematic is crucial to determining which strategy will likely be most effective at reducing the risk of a supply disruption.

Question 2: I understand many of the critical minerals listed by USGS are recovered as byproducts during the processing, smelting, of refining of a host metal. This means that the availability of these "companion" metals is largely at the whim of the "host metal." This introduces an additional dynamic, where companion metals are not able to respond to changes in demand because the production of the companion metal depends on the production of the host metal. Whether or not a metal is capable of being obtained largely or entirely as a byproduct from a host product varies from metal to metal. Some host products yield higher concentrations and higher recovery rates of companion metals than others. This impacts whether or not companion metals will be processed or simply discarded. If the costs of recovering a companion metal is more than it costs to process, it makes financial sense for an operator to simply discard it in its mill tailings.

How is a companion metal defined? Is it on the basis of its revenue contribution to a host metal, and how does that impact whether a metal will be considered a by-product or a coproduct?

Response: A companion metal is simply a metal that is present in the ore along with the primary metal, such as molybdenum in porphyry copper ore. The companion could be termed a

"byproduct", recovered if market economics at that time warrant, or a "coproduct" where the companion metal must be recovered along with the primary metal for the mine to operate economically.

Question 3: As we examine different proposals to reduce our net import reliance on critical minerals, I think it is import to note there is a difference between import reliance and import vulnerability. What is the amount of critical minerals we need to domestically produce in order to no longer be considered vulnerable?

Response: The vulnerability portion of the criticality assessment focused on mineral commodities for which the U.S. was greater than 50% net import reliant. However the ability to source critical minerals from reliable, friendly trade partners allows a higher ratio to be accepted (such as potash from Canada). Also, the end use application for that critical mineral might require a larger or smaller quantity and thus could alter the acceptable ratio. Those determinations could be made on a case-by-case basis by national security partners like Defense Logistics Agency - Strategic Materials in their scenario analyses.

U.S. Senate Committee on Energy and Natural Resources
To Examine the Importance of and Path to Achieving Mineral Security and to Receive Testimony on S. 1052, the Rare Earth Element Advanced Coal Technologies Act, and S. 1317, the American Mineral Security Act
Questions for the Record Submitted to Dr. David Solan
May 14, 2019

QUESTIONS FROM CHAIRMAN LISA MURKOWSKI

Q1. At the conclusion of the hearing, I expressed the hope that the Department of Energy and the Department of the Interior were "working aggressively" and coordinating with the Department of Commerce on the broader strategy. You replied affirmatively when I asked whether this "level of coordination" was occurring.

Q1a. To your knowledge, is there an existing Policy Coordination Committee (PCC) dedicated to critical minerals, including the coordination of interagency efforts to reduce reliance on foreign sources?

A1a. Mitigating risks associated with foreign dependence on sources of critical minerals is important and consistent with the National Security Strategy and National Defense Strategy to promote American prosperity and to preserve peace through strength. The dependency of the United States on foreign sources of critical minerals creates a strategic vulnerability for both our economy and our military with respect to adverse foreign government actions, natural disasters, and other events that could disrupt supply.

To address this problem and reduce the Nation's vulnerability to disruptions in the supply of critical minerals, the President issued Executive Order 13817, A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals, on December 20, 2017. The Executive Order (EO) directs:

- The Secretary of the Interior, in coordination with heads of selected branch agencies and offices, to publish a list of critical minerals.
- 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;

(ii) an assessment of progress toward developing critical minerals recycling and reprocessing technologies, and technological alternatives to critical minerals, source diversification, and improving processes for critical mineral extraction, separation, purification, and alloying;

U.S. Senate Committee on Energy and Natural Resources
To Examine the Importance of and Path to Achieving Mineral Security and to Receive Testimony on S. 1052, the Rare Earth Element Advanced Coal Technologies Act, and S. 1317, the American Mineral Security Act
Questions for the Record Submitted to Dr. David Solan
May 14, 2019

(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 Assistant Secretary for Fossil Energy is the Department of Energy (DOE) representative to the PCC. DOE coordinated with departments across the federal government on the response to EO 13817. DOE assisted in the development of the screening methodology used by the Department of the Interior (DOI) in developing the initial list. DOE also contributed to several aspects of the report, with the Department of Commerce (DOC) responsible for the overall report. This report was published by DOC on June 4, 2019. DOE coordinated with DOC, the Department of Defense, DOI, and other agencies, to help develop a cohesive response that addresses the entire supply chain of critical minerals. As the United States lacks domestic processing and manufacturing capabilities for some critical minerals, domestically produced ores and concentrates must be exported for further processing into more useful forms. Increasing domestic mining without increasing corresponding domestic processing and manufacturing capabilities will simply move the source of economic and national security risk further down the supply chain.

Q1b. If so, how many times and when has that PCC convened, and which departments and agencies participate in this process?

A1b. The most recent PCC meeting was in June 2018.The Federal departments and agencies represented were: the Central Intelligence Agency, Department of Homeland Security, Department of Commerce, Department of Defense, Department of Education, Department of Energy, Department of the Interior, Department of Justice, Department of Labor, Department of State,

U.S. Senate Committee on Energy and Natural Resources
To Examine the Importance of and Path to Achieving Mineral Security and to Receive Testimony on S. 1052, the Rare Earth Element Advanced Coal Technologies Act, and S. 1317, the American Mineral Security Act
Questions for the Record Submitted to Dr. David Solan
May 14, 2019

Department of Transportation, Environmental Protection Agency, National Aeronautics and Space Administration, National Science Foundation, the Department of Agriculture, the Council on Environmental Quality, the Office of Science and Technology Policy, and the Office of Management and Budget.

Q2. Please provide the Department's views on sections in S. 1317 for which it will be involved.

A2. The Department of Energy shares the goals of the *American Mineral Security Act,* S. 1317, which seeks to facilitate the availability, development, and environmentally responsible production of domestic resources to meet national material or critical mineral needs. The Department testified to the U.S. Senate Committee on Energy and Natural Resources on May 14, 2019.

The Department's research and development investments are coordinated around three pillars to address supply chain disruption risks: (1) diversifying supply of critical materials – including increasing domestic production, (2) developing substitutes, and (3) driving recycling, reuse, and more efficient use of critical materials. This is in alignment with the Federal response to Executive Order (EO) 13817, [1] *A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals*, published by the Department of Commerce on June 4, 2019.[2]

In line with the Federal response to EO 13817 – the Department recognizes the importance of interagency collaboration to address the critical mineral supply chain. To fully address these challenges, coordination and collaboration across the executive branch is needed. Encouraging that collaboration in S.1317 would reinforce the interagency activities outlined in the EO response.

An organizing principle of the Federal strategy is to address the full supply chain of critical minerals, which spans from securing raw materials to end-uses in both civilian and defense

[1] https://www.whitehouse.gov/presidential-actions/presidential-executive-order-federal-strategy-ensure-secure-reliable-supplies-critical-minerals/
[2] https://www.commerce.gov/news/reports/2019/06/federal-strategy-ensure-secure-and-reliable-supplies-critical-minerals

applications. S. 1317 seeks to address the full supply chain, ranging from resource assessment to critical mineral manufacturing to recycling.

The draft methodology and list of critical minerals developed by the Department of the Interior was a direct result of interagency collaboration through the National Science & Technology Council Subcommittee on Critical Minerals. The Department looks forward to continued contribution to this effort. It should be noted that Sec. 4 (f) describes written notice to Congress as "any revision to the methodology" implying that even small, non-substantive edits would need to be noticed to Congress, which may create an unnecessary burden for both Congress and the Federal agencies.

In Section 5, there may be a gap in the assessment of supply vulnerability with the proposed activities, as in many cases minerals/materials processing occurs outside of the country where mining occurs. There would be a benefit in also assessing processing capabilities and technical needs for the prioritized critical materials.

Section 8 outlines key R&D activities that align with current efforts underway at the Department. However, a major challenge in the critical minerals supply chain is the lack of private sector companies to adopt and deploy technologies developed by Federal R&D in the U.S.

Section 9 directs the Department of Interior "to evaluate existing critical minerals policies and inform future actions that may be taken to avoid supply shortages, mitigate price volatility, and prepare for demand growth and other market shifts." Estimating future demand for materials across multiple sectors is difficult and often proves to be inaccurate in a retrospective analysis. At a minimum, proposed forward-looking analyses should be an interagency effort and include key industries. A more qualitative approach to monitor potentially disruptive technologies may provide the Federal Government the needed input to assess new critical minerals.

DOE would like to emphasize that the Energy Information Administration (EIA) does not forecast the future or advocate for a certain set of policies. Rather, EIA models projections of what may

U.S. Senate Committee on Energy and Natural Resources
To Examine the Importance of and Path to Achieving Mineral Security and to Receive Testimony on S. 1052, the Rare Earth Element Advanced Coal Technologies Act, and S. 1317, the American Mineral Security Act
Questions for the Record Submitted to Dr. David Solan
May 14, 2019

happen given certain assumptions and methodologies. An "Annual Critical Minerals Outlook" would be an opportunity to baseline projections under existing policies and assess changes.

DOE recognizes the importance of education and workforce development and is open to collaborating with the Secretaries of the Interior and Labor, the Director of the National Science Foundation, and the National Academies of Science and Engineering to assess higher education needs in critical minerals exploration, development, assessment production manufacturing, recycling, analysis, forecasting, education, and research as described in Section 10.

Q3. As of May 14, 2019, the date of this hearing, the Department of Energy has not published an updated Critical Materials Strategy since 2011. Does the Department intend to update the strategy? If so, is it following the 2011 version until it is updated? If it is not following the 2011 version, what strategy is it following?

A3. Early and on-going assessment is required to adapt the Department's priorities to changing material and energy technology markets. Since 2011, the Department has assessed material criticality across a range of energy technologies based on importance to energy and potential for supply risk.

The Department has internally updated the strategy, which it has shared with the Committee.

Within the Department, research and development investments are coordinated among the program offices agency-wide around three pillars to address supply chain disruption risks: (1) diversifying supply of critical materials – including increasing domestic production, (2) developing substitutes, and (3) driving recycling, reuse, and more efficient use of critical materials.

Q4. The attachment to your testimony states: "[DOE's] Office of Policy has led several studies assessing material criticality across energy technologies and potential for supply risk, and vulnerabilities related to market dynamics and volatility across supply chain stages—from mining to final product production and demand." When were these studies initiated and completed? Please provide copies as available.

U.S. Senate Committee on Energy and Natural Resources
To Examine the Importance of and Path to Achieving Mineral Security and to Receive Testimony on S. 1052, the Rare Earth Element Advanced Coal Technologies Act, and S. 1317, the American Mineral Security Act
Questions for the Record Submitted to Dr. David Solan
May 14, 2019

A4. In 2015, Office of Policy analysts and modelers from Argonne National Laboratory co-authored a paper entitled: Global Critical Materials markets: An Agent-Based Modeling Approach, which was published in *Resources Policy*.

Office of Policy analysts and modelers from Argonne National Laboratory also have a working manuscript entitled: Can domestic material supply chains mitigate market shocks? The work for this paper began in 2017.

In addition, the Department has internally updated its 2011 Critical Materials Strategy, which it has shared with the Committee.

U.S. Senate Committee on Energy and Natural Resources
To Examine the Importance of and Path to Achieving Mineral Security and to Receive Testimony on S. 1052, the Rare Earth Element Advanced Coal Technologies Act, and S. 1317, the American Mineral Security Act
Questions for the Record Submitted to Dr. David Solan
May 14, 2019

QUESTIONS FROM RANKING MEMBER JOE MANCHIN III

Q1. I introduced S. 1052, the *Rare Earth Element Advanced Coal Technologies Act*, on April 4, 2019. Please provide the Department's prospective on S. 1052 and offer any guidance or technical corrections you may have.

A1. The Administration has not taken a position on this bill at this time. Please see the attached technical assistance comments for bill S. 1052, *the Rare Earth Element Advanced Coal Technologies Act.*

The Department shares the goal of the *Rare Earth Element Advanced Coal Technologies Act* (REEACT), S. 1052, to reduce the country's dependence on foreign minerals. The dependency of the U.S. on foreign sources of critical minerals creates a strategic vulnerability for both our economy and our military with respect to adverse foreign government actions, natural disasters, and other events that could disrupt supply. The Department also recognizes that the U.S. currently lacks the domestic capability to extract and separate useful rare earth elements. The Department appreciates REEACT's focus on the development of new technologies to increase U.S. capability to extract these rare earth elements.

Q2. I understand many of the critical minerals listed by USGS are recovered as byproducts during the processing, smelting, of refining of a host metal. This means that the availability of these "companion" metals is largely at the whim of the "host metal." This introduces an additional dynamic, where companion metals are not able to respond to changes in demand because the production of the companion metal depends on the production of the host metal. Whether or not a metal is capable of being obtained largely or entirely as a byproduct from a host product varies from metal to metal. Some host products yield higher concentrations and higher recovery rates of companion metals than others. This impacts whether or not companion metals will be processed or simply discarded. If the costs of recovering a companion metal is more than it costs to process, it makes financial sense for an operator to simply discard it in its mill tailings.

Q2a. How is a companion metal determined? Is it on the basis of its revenue contribution to a host metal, and how does that impact whether a metal will be considered a by-product or a coproduct?

A2a. The U.S. Geological Survey (USGS) defines "byproduct commodities" as "commodities that are not mined directly, but are instead recovered during the processing, smelting or refining of a host

material." (Source: 83 FR 23295). USGS uses the term "co-product" if the production of the material is needed to make the production process economically viable (Critical Mineral Resources of the United States, Professional Paper 1802-A, USGS). As noted in that report, the terms "are not always used consistently across the industry."

Q3. Please discuss how the recoverable resources of companion metals are quantified?

A3. The U.S. Geological Survey (USGS) defines a resource as "A concentration of naturally occurring solid, liquid, or gaseous materials in or on the Earth's crust in such form that economic extraction of a commodity is regarded as feasible, either currently or at some future time." USGS defines a reserve as that portion of an identified resource "which could be economically extracted or produced at the time of determination." (Mineral Commodity Summaries 2019, USGS). Per the USGS, government assessments, academic research journal articles, company reports, and trade journal articles (or a combination) are used to quantify or estimate recoverable reserves reported in the USGS Mineral Commodity Summaries.

U.S. Senate Committee on Energy and Natural Resources
May 14, 2019 Hearing: ***To Examine the Importance of and Path to Achieving Mineral Security and to Receive Testimony on S. 1052, the Rare Earth Element Advanced Coal Technologies Act, and S. 1317, the American Mineral Security Act***
Questions for the Record Submitted to Mr. Jonathan Evans

Questions from Ranking Member Joe Manchin III

Question 1: The mining sector faces significant workforce challenges, as approximately 70 percent of mining engineers are expected to retire in the next decade. Can you please speak to the workforce challenges in your field and how that threatens our mineral security?

The workforce development issues aren't limited to lithium. They are widespread across the natural resources industries. We suffer from an ageing workforce with little backfilling of younger employees. The problem spans our industry jobs from operators, geologists, engineers, processing technicians, chemists and metallurgists. We have done a poor job appealing to high school and college students and providing them with the information they need to understand jobs in the mining and chemical industries are challenging, create opportunities to see the world, and provide compensation for high standards of living.

The problem is exacerbated by the fact that many natural resource projects—like ours—are in remote areas that require our workforce to be long distances away from urban hubs.

The threat to national security is that minerals like lithium are found throughout the world and investors are going to develop the projects that are most cost-effective, efficient to permit, and have the willing, skilled, workforce to make the project thrive.

Lithium Nevada is developing the Thacker Pass project in Nevada because the project will have low overhead, the permitting process will be thorough and efficient, and we're working with the local community college and university to provide the workforce on which we will depend. Despite our efforts—and high salaries that will average $86,000/year—we'll still struggle to fill openings. We'll compete with the robust precious minerals industry in Nevada and have difficulties getting young people to live more than 2 hours from the closest city—Reno.

Question 2: In what part of the supply chain do you believe has lost the most ground in terms of the workforce? Mining, refining, or end-use manufacturing?

All three sectors are struggling to develop the next generation of workers and innovators. Industry supply chains like to create ecosystems with co-located links. A good example is automotive industry where suppliers of major manufacturers cluster around a plant. Given the historic permitting delays for mining/processing, the U.S. has lost/ceded entire supply chains associated with the mined minerals to offshore sources.

Going forward, the focus should be on mining/processing first as that would drive interest in restoring some of the manufacturing that has left (or was never considered to be located here before).

U.S. Senate Committee on Energy and Natural Resources
May 14, 2019 Hearing: ***To Examine the Importance of and Path to Achieving Mineral Security and to Receive Testimony on S. 1052, the Rare Earth Element Advanced Coal Technologies Act, and S. 1317, the American Mineral Security Act***
Questions for the Record Submitted to Dr. John Warner

Questions from Ranking Member Joe Manchin III

Question 1: The mining sector faces significant workforce challenges, as approximately 70 percent of mining engineers are expected to retire in the next decade. Can you please speak to the workforce challenges in your field and how that threatens our mineral security?

The lithium-ion battery field shares many of the same workforce and education challenges as the mining sector. In this space the challenges come in three main areas:

First, the engineering field lacks sufficient university programs to create new battery engineers. The lithium-ion battery industry is relatively new and therefore struggles with high demand for knowledgeable and experienced engineers. Lithium-ion battery engineering is somewhat unique in that it requires a true systems approach based on knowledge of all other engineering fields from mechanical, to thermal, to electrical, to chemistry, physics and software. There are many engineers skilled in single fields of engineering in the field, but few have the full cross-field knowledge needed to grow in this field. These lithium-ion batteries are an advanced engineered system and require training and engineering programs to create qualified system engineers. Many Universities are now offering individual classes in lithium-ion battery engineering, but few offer complete battery engineering programs.

Second, training for first responders will continue to need additional efforts on a national level. Organizations such as the NFPA have been leading efforts to help train first responders, but with the upcoming onslaught of new electric vehicles there will be a wide variation in lithium-ion battery design and installation in the vehicle which will create challenges for those responding to vehicular incidents in determining how to respond, whether the vehicles are safe, and how to deal with these vehicles. Additionally, there is a need to better train those service organizations who move and store vehicles that have been involved in on-road incidents.

Third, for service technicians and assemblers there is a need for better "high voltage" training for all areas of lithium-ion battery industry. As most automotive and other applications work at low voltages, there is need to educate anyone that is working on or near high voltage batteries as to the dangers of working in high voltage environment, where the risk to humans becomes dangerous with the possibility of burns, shock or electrocution exists. Additionally, with the rise of second life, remanufacturing and recycling of lithium-ion batteries there will be additional need to educate the members of those groups as to the challenges of lithium-ion batteries.

The industry trade group NAATBatt International, the National Alliance for Advanced Technology Batteries, has previously offered a "Batteries 101" class to help educate new members to our industry about the basics of battery technology. Today, NAATBatt International, PlugVolt and the Battery Innovation Center (BIC) have teamed up and are in the process of developing a series of courses in concert with one or more university to offer a "certification" for lithium-ion battery technology.

U.S. Senate Committee on Energy and Natural Resources
May 14, 2019 Hearing: ***To Examine the Importance of and Path to Achieving Mineral Security and to Receive Testimony on S. 1052, the Rare Earth Element Advanced Coal Technologies Act, and S. 1317, the American Mineral Security Act***
Questions for the Record Submitted to Dr. John Warner

From a public policy perspective, the rise in vehicle electrification will expose many more people to a technology that is yet not well understood by many. Creating sources of funding to improve and expand the education.The market for electrified applications is now expanding at an unprecedented rate, which will drive a need for better education among all players in the industry.

Question 2: In what part of the supply chain do you believe has lost the most ground in terms of the workforce? Mining, refining, or end-use manufacturing?

From the lithium-ion battery market, the cell manufacturing has lost the most ground. While mining and refining are only just beginning to emerge in support of these markets, the lithium-ion battery cell and pack manufacturing experienced an initial investment boom with the American Reinvestment and Recovery Act (ARRA) but as the market was still not developed those investments struggling to survive and with most of the companies that received investments ending up being sold to foreign owned entities. In fact, the U.S. taxpayers funded lithium-ion battery investments that were either sold to or owned by foreign entities in China, Korea, France, Russia, and Canada. Today, no large-scale U.S. owned lithium-ion battery manufacturer exists other than Panasonic/Tesla.

China now produces more than 60% of the world's lithium-ion batteries, the U.S. now produces less than 1-2% of the world's lithium-ion battery capacity. China continues to maintain protectionist policies requiring that for any vehicle to receive the federal government incentives they must be on the "white list", which is a list of "approved" cell manufacturers that meet two main requirements. First that they produce the cells entirely in China and second that they install more than 8GWh of capacity. This policy has encouraged domestic Chinese vehicle manufactures to use only batteries made in China.

Europe is now on track to have multiple "gigafactories" and is anticipated to have more than 150GWh of installed capacity within the next five years. The EU has just approved a €350 million investment into the Swedish battery company Northvolt in order to support their 32GWh factory in northern Sweden. France and Germany have earmarked €1.7 billion ($1.9 billion) to support company alliances to help reduce European carmakers' dependence on Asian suppliers.

While the U.S. started out as a leader in the lithium-ion industry, we are now far behind the rest of the world and without a true domestic supply of lithium-ion batteries the need for the minerals or processing of those minerals into lithium-ion cathodes, anodes and other materials is limited. Creating a supply of raw materials only adds value when there is a demand for those materials. Therefore, the complete supply chain from mining to processing to cell manufacturing must be prioritized, supported and defined as being of strategic importance to the nation if the U.S. is to recover and maintain a position in the global market. At the same time the supply and demand sides of the market must be equally invested in – infrastructure, manufacturing and end product markets must be created and supported.

U.S. Senate Committee on Energy and Natural Resources
May 14, 2019 Hearing: ***To Examine the Importance of and Path to Achieving Mineral Security and to Receive Testimony on S. 1052, the Rare Earth Element Advanced Coal Technologies Act, and S. 1317, the American Mineral Security Act***
Question for the Record Submitted to Dr. Paul Ziemkiewicz

Question from Ranking Member Joe Manchin III

Question: How do you see AMD fitting into an overall domestic supply base that would support a rare earth supply chain?

Answer: A simplified rare earth supply chain, like that for any mineral commodity, would have three major components that lead to the market:

1. the mineral resource
2. refining
3. manufacturing

A **mineral resource** is typically divided into high to low grade ores. The high-grade ores are easily accessed, have favorable concentrations of the target minerals and they are easily refined. Required capital investment (capX) and operating expenses (opX) are low and return on investment is high. But, their volume is relatively low. At the other end of the spectrum, low grade ores are difficult to access and they have lower concentrations of the target mineral. They require a large capital investment and their extraction and processing costs are high. High grade resources are needed to attract investment, recover capX and reduce opX. They would have a leading role in stimulating investment and development of the remaining elements of the supply chain. Since AMD is produced continuously, its economic importance would not decline. However, the mid to low-grade resources would provide the volume needed to sustain the remainder of the supply chain over time.

Most mining enterprises seek to balance high and low-grade resources to maintain a favorable cash flow through the life of its resource base.

I see the AMD based rare earth supplies as the high-grade end of the domestic mineral reserve. Other coal based rare earth resources such as tailings/refuse and coal ash would represent the low-grade end of the resource base. So, I would anticipate that a blend of grades feeding into a refining infrastructure would be needed to generate the 16,000 tons of rare earth minerals that the U.S. economy needs every year.

May 24, 2019

The Honorable Lisa Murkowski
Chairman
The Honorable Joe Manchin
Ranking Member
U.S. Senate Committee on Energy and Natural Resources
Washington, D.C. 20510

RE: FOR THE MAY 14, 2019 RECORD

Dear Chairman Murkowski and Ranking Member Manchin:

American Air Liquide Holdings, Inc. ("Air Liquide") respectfully submits the attached comments on the Department of Interior's Draft List of Critical Minerals to be entered into the record for the May 14, 2019 "Full Committee Hearing on Mineral Security and Related Legislation." The comments address the helium market and the domestic supply of helium.

Air Liquide's Americas headquarters is in Houston, Texas, and we have more than 20,000 employees across all 50 states. The Air Liquide Group is the world's leading industrial gas company and the largest in the U.S. We operate in 80 countries and have more than 65,000 employees globally.

Air Liquide is the leading supplier of refined helium in the United States and globally to customers that range from companies on the cutting edge of the electronics industry, to health researchers, automotive suppliers, laboratories, and manufacturing facilities all over the world.

Air Liquide supports the Committee's efforts to secure supplies of minerals critical to our economy and national security. We look forward to working together, and if you have any questions or would like additional information, please don't hesitate to ask. I can be reached directly at (202) 756-1292 or Joe.Fawell@airliquide.com.

Sincerely,

Joe Fawell

Joe Fawell
Vice President of Government Affairs
Air Liquide USA LLC

Attachment

March 19, 2018

Hon. Ryan Zinke, Secretary
Department of Interior
1849 C St. NW
Washington, DC 20240

Re: Draft List of Critical Minerals, Docket No. 178D0102DM

Dear Secretary Zinke:

American Air Liquide Holdings, Inc. (Air Liquide) appreciates the opportunity to provide the U.S. Department of Interior (DOI or Agency) the following comments on the Agency's Draft List of Critical Minerals (Draft List). Air Liquide supports the Agency's efforts to secure supplies of minerals critical to our economy and national security. In the case of helium, however, we believe the domestic supply situation is more complex than the Agency indicates in its explanation for including helium in the Draft List. Specifically, these comments will explain why the Agency's assumptions regarding the helium market and the United States' status as a net exporter are in need of revision.

I. Introduction

Air Liquide's Americas headquarters is in Houston, Texas, and we have more than 20,000 employees across all 50 states. The Air Liquide Group is the world's leading industrial gas company and the largest in the U.S. We operate in 80 countries and have more than 65,000 employees globally. The Air Liquide Group serves millions of customers and patients in a range of industries, including oil and gas, chemicals, metals, construction, food and beverage, research and analysis, electronics, and healthcare. We are committed to supporting technological innovations to help make our nation's manufacturing and industrial sectors more efficient and productive.

Air Liquide is the leading supplier of refined helium in the United States and globally to customers that range from companies on the cutting edge of the electronics industry, to health researchers, automotive suppliers, laboratories, and manufacturing facilities all over the world.

II. DOI Should Change its Assessment of the U.S.' Status as a Net Helium Exporter

In the Agency's Summary of Methodology and Background Information, the U.S. is identified as a "net exporter of helium."[1] Due to a number of factors, but principally the Congressionally-mandated sell-off of Bureau of Land Management (BLM) helium reserves, this assessment is far from certain. In fact, it is highly probable that the United States will become a net importer of helium within the next five years.

[1] Fortier, Steven et al. "Draft Critical Mineral List—Summary of Methodology and Background Information—U.S. Geological Survey Technical Input Document in Response to Secretarial Order No. 359." U.S. Department of Interior, Open-File Report 2018-1021.

The bipartisan Helium Stewardship Act of 2013 (the 2013 HSA), which was passed by Congress and signed into law by President Obama, established a glide path for the federal government's eventual departure from the commercial helium market, a sector it has served for the past 90+ years. Historically, the redeliveries from the BLM reserve have represented close to the equivalent of 100% of U.S. commercial and federal demand. In combination with other domestic helium sources (such as the ExxonMobil Shute Creek, Wyoming plant), this has resulted in the U.S. being a net exporter of helium over the past several decades. In 2018, however, helium redeliveries from the BLM reserve will account for less than 50% of U.S. commercial needs and, more pertinently, will soon cease to be an adequate or stable sourcing solution for many of the nation's users in the coming years.

The 2013 HSA built on previous reforms made to the nation's Federal Helium Reserve system to better reflect the uses and demands for helium in the current global market. The bill was intended to prevent global helium shortages and promote market-based reforms through the implementation of a three-phase system, of which a central component was a revised program of semi-annual BLM helium auctions. The 2013 HSA also set new guidelines for operating the Federal Helium Reserve over the next decade, until a point at which the reserve was depleted down to 3 billion cubic feet of helium. At that trigger point, "Phase C" of the reserve's operation would begin, wherein commercial sales of helium would end and the remaining helium would only be made available for federal national security and scientific needs.

BLM staff have now indicated they expect to reach the 3 billion cubic foot level in the reserve earlier than expected -- following this summer's planned auction – and, as a result, they expect to cease all further commercial auctions and sales as they enter the final Phase C of the reserve's operation. Once this occurs, the domestic helium supply will tighten significantly and U.S. consumers will face greater sourcing challenges for predictable helium supplies absent a robust import market for the molecule.

Helium is the second most abundant element in the universe, but its diffusive properties mean that atmospheric helium leaks into space, rendering it relatively scarce on Earth. At only 5.2 parts per million (ppm) in the air, it is not economically feasible to extract helium from the atmosphere using current technology. Rather, the principal source of helium is natural gas fields. Further complicating the domestic supply situation, helium is not always found in high enough quantities in natural gas streams to warrant the costly investments needed to extract the molecule and refine it. Even given the existing domestic helium production capabilities, after the depletion of the BLM reserve occurs, the United States is likely to face a domestic helium deficit for commercial uses, potentially as early as 2022/2023 onwards, and as such will require increased imports of the molecule to support ongoing U.S. consumer needs.

Discovery and industrial production of new domestic helium-rich gas projects will take years to materialize and are unlikely to adequately compensate for the significant and near-term shortfalls arising from the BLM reserve depletion. These anticipated shortfalls will have to be compensated by imports from overseas sources to ensure U.S. consumers are not impacted.

Although the analysis in the Draft List is "a snapshot in time," that snapshot should include all currently available information and be sensitive to predictable near-term changes.[2] We believe that, in light of known facts about the helium market, including the availability of helium from the BLM reserve, the Agency should revise its assessment of the helium market.

III. DOI Should Pursue Alternative Means to Protect U.S. Helium Users

Given the critical aspect of helium for national security, healthcare, and commercial advances, regardless of inclusion in the Draft List, we recommend the federal government develop a multifaceted approach to protect U.S. users of helium into the future and ensure a ready and predictable supply continues:

(1) Facilitate the development of new helium exploration and production projects in the U.S. where applicable.
    (a) For example, should the Helium Extraction Act of 2017 (HR 3279) or similar legislation become law, utilize federal land for helium production similarly to what has been done for oil and gas.

(2) Waive import tariffs on imported helium.
    (a) Continuing to levy tariffs on helium would hamper competitiveness and likely motivate job transfers out of the U.S. of Tier 1 U.S. industry players *(for example, large scale electronics manufacturers in the U.S. may shift production to their Asian operations)*.
    (b) "Deep tech" countries like Taiwan, Singapore, and Japan do not levy duties on imported helium, which presents a risk to maintaining similar manufacturing operations in the U.S.

IV. Conclusion

Air Liquide is pleased to offer these comments. We commend the Agency for taking steps to safeguard critical minerals; however, we believe that certain assumptions relating to the supply of helium in particular require specific consideration.

[2] Draft List of Critical Minerals, 83 Fed. Reg. 7066 (February 16, 2018) (Hereinafter "Draft List")

Written Testimony of Mark Caffarey

President, Umicore USA

before the

Subcommittee on Energy

of the Senate Committee on Energy & Natural Resources

May 21, 2019

Madam Chairwoman, Ranking Member Manchin, and Members of the Committee, my name is Mark Caffarey, and I am President of Umicore USA. Thank you for holding this hearing and for providing the opportunity to submit written testimony on this topic. You may recall that I testified in person before this Committee on June 9, 2011; this testimony will provide some important updates.

Umicore is a global energy materials and recycling company, with nearly US$4 billion in revenue,[1] 70% of which is from clean mobility and recycling. Of our 10,420 employees world-wide, approximately 600 are in the United States with facilities in ten US States: in Michigan, Oklahoma, Texas, Massachusetts, Ohio, Tennessee, New Jersey, New York, Alabama, and the U.S. headquarters in Raleigh, North Carolina.

[1] Financial figures can be found in Umicore's annual report here: https://annualreport.umicore.com/performance/key-figures

Umicore's history can be traced back to 1805 with Napoleon Bonaparte and the Vieille-Montagne (VM) zinc mine. After over a century in mining and metal smelting, in 1985 Umicore began a transition to recycling and away from mining, eventually becoming the world's leading recycler of complex waste streams, including precious and other valuable and critical metals. We are now able to refine and produce over 20 elements, including lithium, cobalt, and nickel to better serve the growing energy storage and electric vehicle industries. Because Umicore knows that metals can be infinitely recycled without losing any of their properties, a key component of our business strategy is to increase even further the range and quantity of materials we derive from recycling.

Umicore is a leader in what is called the Circular Economy—the principle of keeping the value of products, materials and resources in the economy as long as possible without having to extract new resources. While we understand that mining is still an important component to extracting materials, we believe that recycling will become increasingly crucial, as more and more technological innovation is deployed that requires these materials. Given the exponential deployment of lithium ion batteries alone, and the 10-50 times increase in the number of operating cells we predict by 2025 for rechargeable batteries containing cobalt, nickel, and lithium (all of which we are able to recycle—but some of which, such as cobalt, are often mined in politically unstable areas using unethical practices), recycling will become important from an environmental and humanitarian point of view, and to the global integrated supply chain.

Umicore today is recycling end of life electronics, spent automotive catalysts, end of life industrial catalysts and other precious metals containing materials to recover and provide a new life to Au (Gold), Ag (Silver), Cu (Copper), In (Indium), Pb (Lead), Sn (Tin), Sb (Antimony), Pd (Palladium), Pt (Platinum), Rh (Rhodium), and other metals in a half million metric ton yearly

processing facility in Hoboken, Belgium. Umicore introduced its environmentally friendly battery recycling technology in 2011 and is prepared to recover battery materials from portable electronics, and electric vehicle batteries once they reach their end of life. The current fraction of end of life batteries that is recycled is very low. Every year the equivalent output of two large cobalt mines is 'lost' because these batteries do not find their way to efficient recycling. While recycling cannot completely replace mining, it can complement it and be a sustainable supply of energy materials as the battery industry grows.

In addition to recycling, Umicore is one of three global leaders in emission control catalysts for light and heavy-duty vehicles. With catalyst facilities in Auburn Hills, Michigan, and Tulsa, Oklahoma, our materials are in approximately 1/3 of all catalysts within the global vehicle fleet. Umicore is also a leading supplier of cathode materials for rechargeable batteries used in electrified transportation, energy storage, and portable electronics. 1 out of 5 batteries ever made contains Umicore rechargeable battery materials technology. Umicore's electro-optic germanium wafers were on the Mars Opportunity Rover and are installed on low earth orbit satellites which is the foundation of an expanded internet and Space 2.0. We also provide the U.S. Department of Defense with germanium materials used in optics and infrared technologies.

I am submitting testimony to offer Umicore's support for S. 1317,[2] which directs the Department of Energy to launch programs in the recycling of critical materials, and to voice support of the President's Executive Order on a Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals,[3] which includes recycling as a key component in understanding

[2] Full text of the bill can be found here: https://www.congress.gov/bill/116th-congress/senate-bill/1317/text?q=%7B%22search%22%3A%22S.+1317%22%7D&r=1&s=3
[3] Full Executive Order can be found here: https://www.whitehouse.gov/presidential-actions/presidential-executive-order-federal-strategy-ensure-secure-reliable-supplies-critical-minerals/

and managing our nation's critical resources. Umicore has served as an expert resource, both by submitting written comments,[4] but also through ongoing discussions with the U.S. Geologic Survey (USGS), Department of Defense, and Department of Commerce. To date, the U.S. has had no national policy to set a course for critical minerals recycling and evolution to a circular economy. Only half the U.S. states have any legislation related to end of life electronics and most do not consider lithium ion batteries and other new energy technologies in their policies. While much remains to be done, S. 1317 and Executive Order 13817 recognize the importance of recycling and the former tackles research and programmatic issues that can begin to demonstrate leadership in this country.

As you consider S. 1317, Umicore would urge that you take note of the benefits of recycling. First, this bill seeks to ensure that the U.S. has a secure, ready, domestic access to critical materials required for defense and civilian high-technology products. Our nation's industrial scrap, end-of-life batteries from cars and energy storage, electronics, and electronic appliances could provide nearly boundless valuable resources that could be recycled and put back into the economy. Recycling critical materials found in these products will avoid having to purchase materials mined in unstable parts of the world and will provide a home-grown resource stream for those materials. For example, China and Russia provide nearly 70% of the world's refinery and production reserves for Germanium while the United States is one of the largest consumers.[5] The recycling of Germanium which Umicore does in Quapaw, Oklahoma helps offset the lack of natural sources for critical applications using Germanium like 5G fiber networks and Low Earth Orbit satellites. Furthermore, Umicore Specialty Materials Refining in

[4] Umicore comments can be downloaded here: https://www.regulations.gov/document?D=DOI-2018-0001-0387
[5] See the USGS Mineral Commodity Summaries 2019 (page 68-69) here: https://prd-wret.s3-us-west-2.amazonaws.com/assets/palladium/production/atoms/files/mcs2019_all.pdf

Wickliffe, Ohio recycles a variety of Rhenium-bearing feeds including used military and commercial jet engine turbine blades. Rhenium is an important metal due to its extremely high melting point allowing for it to be used in high performance alloys in the aerospace industry. The supply for this metal is limited, and Rhenium is not mined for itself, making recycling important to the overall market.

Second, recovering metals from end-of-life products yields more material per ton than mining from primary resources. For example, for every ton of gold-containing ore taken from the ground through mining, on average less than five grams of gold can be recovered. By comparison, for every ton of mobile phones recycled, we can harvest up to 250 grams of gold, or approximately 50 times the yield from mining. For automotive catalysts, we can recover 400 times the yield in recycling for Platinum Group Metals (PGMs) than we harvest in mining. New electrification technologies—like electric vehicles and energy storage—provide markets for the increased need for battery materials. Electric vehicle sales increased over 80% from 2017 to 2018 in the U.S.[6] The number of vehicles sold in the U.S., however, was dwarfed by China which has 60% of the total electric vehicle market.[7] Bloomberg New Energy Finance increased its prediction of the adjacent energy storage market to $1.7 Trillion by 2040.[8] Thus, the need for materials is clear and only increasing.

Finally, the economic growth benefits of a domestic commitment to the recycling of critical materials could be enormous. The employment potential of a robust U.S. critical materials recycling industry is significant, involving not only a high number of jobs but also

[6] See analysis here: https://www.greentechmedia.com/articles/read/us-electric-vehicle-sales-increase-by-81-in-2018#gs.bmvm7v
[7] See article in Detroit Free Press here: https://www.freep.com/story/money/cars/mark-phelan/2019/03/27/china-electric-vehicles-production/3217195002/
[8] Article from Utility Dive here: https://www.utilitydive.com/news/bnef-raises-forecast-for-global-battery-deployment-to-12t-by-2040/541541/

employment of varying skill levels at the first three stages of the recycling process: (1) the collection of discarded end-of-life products and scrap; (2) the dismantling and sorting of products and the separation of components; and (3) the pre-treatment of the separated components. Employment possibilities at the fourth stage, the refining (Umicore's business) of the pre-treated materials into the final critical material products, is limited due to the economies of scale needed to economically recycle these materials. In addition to primary jobs, indirect jobs could include supporting services in IT, engineering, transportation, sales, administration, as well as research at universities and research centers.

Umicore believes the federal government has an important role to play in both leadership as well as in research and development. Stakeholder collaboration, public-private partnerships, standards, and a systems approach, will be important to sharing information about these processes and what it will take to move toward more sustainable practices. Umicore is excited that the Department of Energy has taken a greater interest in these issues this year by launching a Battery Materials Recycling Hub at Argonne National Laboratory and supporting a lithium ion battery recycling prize competition, which will promote best practices for the collection and the initial processing of these critical materials. We are also optimistic that, because of this hearing and discussion about the Executive Order and S. 1317, we can implement policy that opens up new markets to recycling, creates highly skilled jobs, and secures our critical resources for a clean, safe, and wealthy future for all.

Thank you again for the opportunity to submit this testimony. Please do not hesitate to contact me should you have any questions regarding this testimony or critical minerals recycling.

Respectfully Submitted,

/Mark Caffarey/

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May 21, 2019

The Wilderness Society

May 14, 2019

The Honorable Lisa Murkowski
Chairman
Committee on Energy & Natural Resources
U.S Senate
Washington, D.C. 20510

The Honorable Joe Manchin
Ranking Member
Committee on Energy & Natural Resources
U.S. Senate
Washington, D.C. 20510

Dear Chairman Murkowski, Ranking Member Manchin, and Members of the Senate Committee on Energy and Natural Resources:

On behalf of more than one million of our members and supporters, The Wilderness Society writes to offer views on S. 1317, the American Mineral Security Act, being heard in the Senate Committee on Energy and Natural Resources on May 14, 2019. We respectfully request our views be submitted into the hearing record.

The Wilderness Society opposes S. 1317, the American Mineral Security Act, which gives away resources that belong to all Americans to multinational mining companies at the expense of protections for local communities and the environment. While the purpose of the bill is "to facilitate the availability, development, and environmentally responsible production of domestic resources to meet national material or critical mineral needs," the bill does little to provide for protection of our lands and waters. Rather, under Section 6(h) of S. 1317, hardrock mining permits would be expedited under the Fixing America's Surface Transportation Act (FAST-41), which was intended for surface infrastructure projects. Hardrock mining poses unique and very significant environmental concerns and the application of the FAST-41 permitting structure is not suitable to adequately conduct the necessary environmental review, meaningful tribal consultation, and community outreach. Furthermore, S. 1317 limits the public comment period on Draft Environmental Impact Statements to 60 days, unless the project applicant – a mining company – agrees to a request to extend the comment period.

We also would like to discern uranium's classification as a mineral. Section 2(B) states that "'critical minerals' does not include (i) fuel minerals, including oil, natural gas, or any other fossil fuels; or (ii) water, ice or snow." The Energy Information Agency classifies uranium as a "nonrenewable fuel." As, written, it is unclear whether uranium would be excluded since the current list of "critical minerals," pursuant to Executive Order 13817, includes uranium as a "critical mineral," despite its status as a fuel mineral. Furthermore, S. 1317 provides secretarial discretion on the development of minerals deemed "critical" without backstops to that discretion and Section 4(e)(2)(C) allows the Secretary of the Interior to "designate additional minerals, elements, substances, or materials as critical minerals." Based on EIA's definition of uranium as a "nonrenewable fuel," and the significant impacts uranium mining has on the landscape, air, water, and communities, we believe these impacts warrant extensive environmental review that should not be expedited if uranium were to be qualified as a "critical mineral."

While TWS recognizes the need to expand and secure sources of the few truly strategic and critical minerals needed to build clean energy technologies, we believe we must do so in ways that protect communities, safeguard our air and water, and protect wildlife and wild lands. S. 1317 would undermine these vital safeguards and move our country in the wrong direction. For these reasons, we strongly oppose S. 1317.

Thank you for considering our views.

Sincerely,

Drew McConville
Senior Managing Director for Government Relations
The Wilderness Society

U.S. Senate Committee on Energy and Natural Resources

To Examine the Importance of and Path to Achieving Mineral Security and to Receive Testimony on S. 1052, the Rare Earth Element Advanced Coal Technologies Act, and S. 1317, the American Mineral Security Act

Tuesday, May 14, 2019

Women's Mining Coalition
Statement for the Record

The Women's Mining Coalition (WMC) is pleased to see the introduction of the bipartisan American Minerals Security Act. As a group, WMC has emphasized the need for congressional action to provide the framework for supporting the development of minerals critical to the present and future needs of the U.S. We support this bill and thank Senators Murkowski, Manchin, McSally and Sullivan for sponsoring legislation that will provide a firm foundation for mineral development in the US – including the many minerals essential for renewable energy.

Lynne Volpi
Women's Mining Coalition
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