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Before the

Senate Committee on Energy and Natural Resources

March 10, 2022

Mr. Chairman, Ranking Member Barrasso, members of the committee, thank you for the opportunity to testify this morning on a topic that is critical for navigating in today's very difficult times – the uses of energy both as an instrument of collective strength and as a weapon of aggression.

To more fully inform these important issues, some historical perspective is instructive. In 2014, we received an early warning signal about Russia's current designs on Ukraine when in February, it invaded, then annexed Crimea a month later. The response of the US and our allies was swift. In March of that year, the G8 became the G7 after its leaders expelled Russia from its ranks. At that time, the G-7 leaders also issued this statement: "International law prohibits the acquisition of part or all of another state's territory through coercion or force. To do so violates the principles upon which the international system is built. We condemn the illegal referendum held in Crimea in violation of Ukraine's constitution. We also strongly condemn Russia's illegal attempt to annex Crimea in contravention of international law and specific international obligations."

As it is now, energy was at the forefront of serious concerns in 2014, when Russia started moving in on Ukraine. I was working as the Energy Counselor to then US Secretary of Energy Moniz and was alarmed by the implications these events had for global energy security. I was concerned that our focus on energy security at that time was largely about oil supplies when there were many other pressing energy issues, including natural gas supplies and climate change, that were impacting or could impact the energy security of both the US and its allies.

I took those concerns to Secretary Moniz who, in response to the range of energy issues raised by Russia's actions, decided to advance the idea that the definition of energy security used by the US and its allies was antiquated – a relic of the oil embargoes of the 1970s – and that it needed updating. Although oil supplies remained a concern, it was just one of many – and a more modernized understanding of energy security was needed to inform collective and individual actions to protect and promote overall energy security and stability. We then drafted a proposed set of modernized energy security principles and developed a final set after negotiations with our G7 energy minister counterparts in Rome in May 2014. Later that year, these new modernized energy security principles were adopted by G7, EU and European Commission leaders in Brussels. Excerpted text from the Brussels' declaration offers some valuable guidance about a collective responsibility for energy security and how we should view and respond to Russia's most recent invasion of Ukraine:

> "The use of energy supplies as a means of political coercion or as a threat to security is unacceptable. The crisis in Ukraine makes plain that energy security must be at the center of our collective agenda and requires a step change to our approach to diversifying energy supplies and modernizing our energy infrastructure…Under the Rome G7 Energy Initiative, we will identify and implement concrete domestic policies by each of our governments separately and together, to build a more competitive, diversified, resilient and low-carbon energy system. This work will be based on the core principles agreed by our Ministers of Energy … in Rome:
>
> - Development of flexible, transparent, and competitive energy markets, including gas markets
> - Diversification of energy fuels, sources and routes, and encouragement of indigenous sources of energy supply
> - Reducing our greenhouse gas emissions and accelerating the transition to a low carbon economy as a key contribution to sustainable energy security
> - Enhancing energy efficiency in demand and supply, and demand response management

- Promoting deployment of clean and sustainable energy technologies and continued investment in research and innovation
- Improving energy systems resilience by promoting infrastructure modernization and supply and demand policies that help withstand systemic shocks
- Putting in place emergency response systems, including reserves and fuel substitution for importing countries, in case of major energy disruptions

Based on these principles we will take the following immediate actions:

- Promote the use of low carbon technologies (renewable energies, nuclear in the countries which opt to use it, and carbon capture and storage) including those which work as a base load energy source; and
- Promote a more integrated Liquefied Natural Gas (LNG) market, including through new supplies, the development of transport infrastructures, storage capabilities, and LNG terminals, and further promotion of flexible gas markets, including relaxation of destination clauses and producer-consumer dialogue.

The recommendations for these "immediate actions" at that time addressed both climate needs and fossil fuels (LNG). This approach is also needed today as the US and its allies are working hard to address Europe's near term need for natural gas as well as the ongoing need to mitigate climate change. This requires carefully sequenced actions and policies to address both critical imperatives.

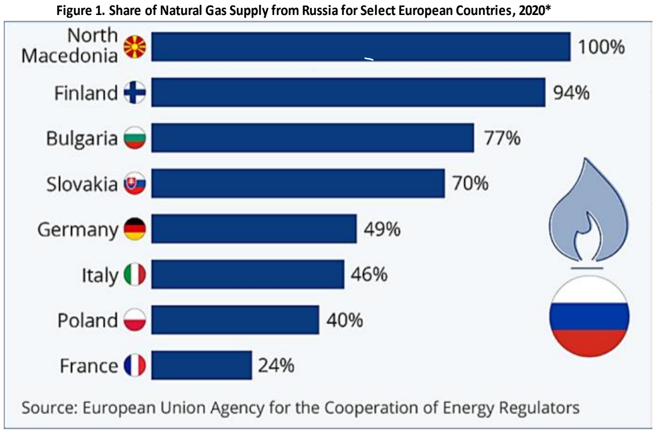
As noted, key to these modernized energy security principles was collective action between the US and its allies, to "…identify and implement concrete domestic policies by each of our governments separately and together". In the current crisis we have already seen a collective response on energy security issues when the Ministers of International Energy Agency (IEA) countries agreed to release 60 million barrels of oil from their emergency reserves "to send a unified and strong message to global oil markets that there would be no shortfall in supplies as a result of Russia's invasion of Ukraine." This action also underscored the importance of one of the key principles of modern energy security adopted by the G-7 in 2014: putting in place emergency response systems, including reserves and fuel substitution for importing countries, in case of major energy disruptions.

In addition to the G7 principles, the IEA – an energy security, treaty-based organization in Paris established by the US and its allies after the Arab oil embargoes of the 1970s -- recently put together a set of near-term recommendations for how Europe could address its overall vulnerabilities to Russian actions and diminish the ability of Russia to use energy as a weapon in the current conflict. In describing this 10-point plan, Fatih Birol, executive director of the IEA noted, "Nobody is under any illusions anymore. Russia's use of its natural gas resources as an economic and political weapon show Europe needs to act quickly to be ready to face considerable uncertainty over Russian gas supplies next winter… The IEA's 10-Point Plan provides practical steps to cut Europe's reliance on Russian gas imports by over a third within a year while supporting the shift to clean energy in a secure and affordable way. Europe needs to rapidly reduce the dominant role of Russia in its energy markets and ramp up the alternatives as quickly as possible." The IEA recommendations are:

- Do not sign any new gas supply contracts with Russia.
- Replace Russian supplies with gas from alternative sources.
- Introduce minimum gas storage obligations to enhance resilience of the gas system by next winter
- Accelerate the deployment of new wind and solar projects.
- Maximize power generation from bioenergy and nuclear to reduce gas use
- Enact short-term tax measures on windfall profits to shelter vulnerable electricity consumers from high prices
- Speed up the replacement of gas boilers with heat pumps
- Accelerate energy efficiency improvements in buildings and industry
- Encourage a temporary thermostat reduction of 1 °C by consumers
- Step up efforts to diversify and decarbonize sources of power system flexibility

As seen in this plan, an immediate concern raised by the Russian invasion is ensuring that our allies in Europe have adequate supplies of natural gas, reflected in the first three IEA recommendations: sign no more gas supply contracts with Russia; replace Russian supplies with gas from alternative sources; and introduce minimum gas storage obligations to enhance resilience of the gas system by next winter. These critical energy security concerns are reinforced by two G7 energy security principles: supporting the development of flexible, transparent, and competitive energy markets, including gas markets; and diversifying energy fuels, sources, and routes.

Figure 1. Share of Natural Gas Supply from Russia for Select European Countries, 2020*

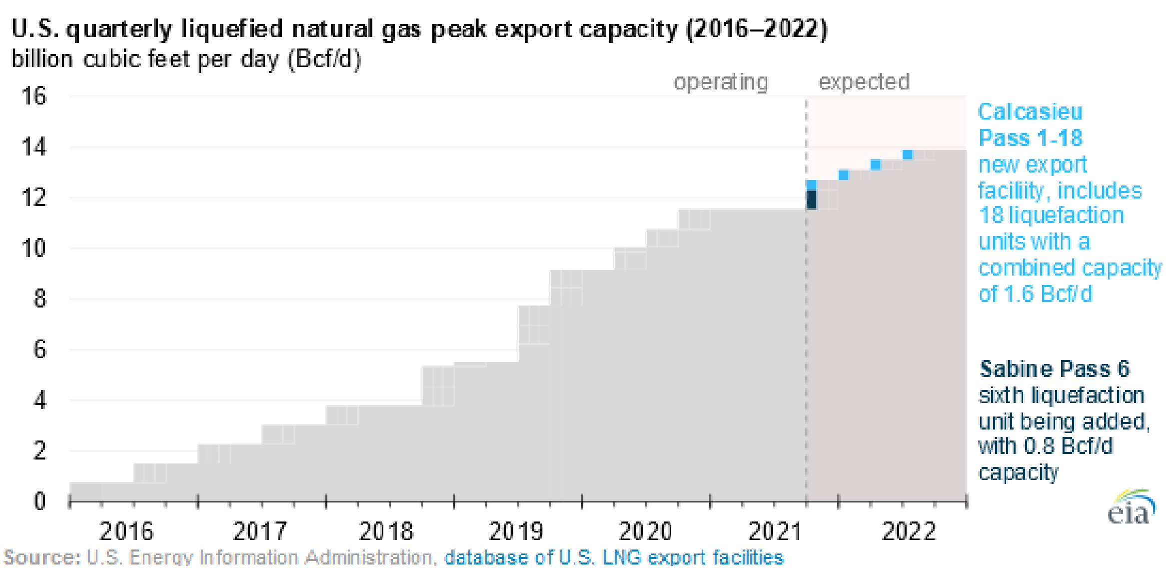


*or latest available info

Replacing Russian gas in Europe via supply source diversification, will however be difficult in the near to mid-term. Figure 1 shows the extent of Russian gas use by several European countries and underscores both the need for – and the difficulty of – reducing Europe's reliance on Russian gas. In that same time-period, Bosnia-Herzegovina, Moldova, and Latvia were also 100% dependent on Russian gas and Latvia was 93% dependent.

Fortunately, the US is in a strong position to provide major assistance in this area. The US is now the number one natural gas producer in the world and has a robust natural gas export infrastructure. In fact, the Energy Information Administration (EIA) forecasts that in 2022, the US will be the largest LNG exporter in the world (Figure 2), a position that is supported by abundant domestic natural gas supplies.

Figure 2. US Liquefied Natural Gas Export Capacity Largest in the World in 2022

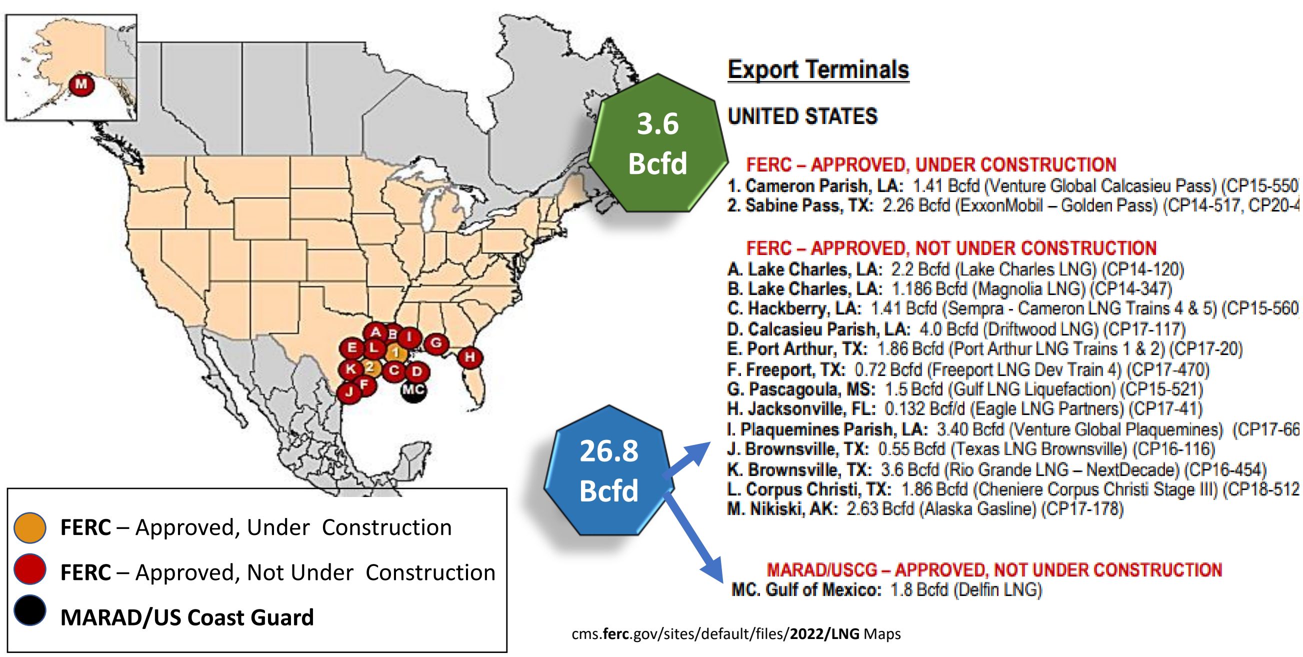


In its analysis of this new prominence, EIA noted that "…by the end of 2022, U.S. nominal capacity is expected to increase to 11.4 Bcf/d, and peak capacity will increase to 13.9 Bcf/d, exceeding capacities of the two largest LNG exporters, Australia (which has an estimated peak LNG production capacity of 11.4 Bcf/d) and Qatar (peak capacity of 10.4 Bcf/d). In 2024, when construction on Golden Pass LNG—the eighth U.S. LNG export facility—is completed and the facility begins operations, U.S. LNG peak export capacity will further increase to an estimated 16.3 Bcf/d."

I would note that as recently as 2003, Alan Greenspan testified before Congress that the "…a major expansion of U.S. import capability appears to be under way. These movements bode well for widespread natural gas availability in North America in the years ahead." In 2007, Exxon CEO Lee Raymond said "…gas production has peaked in North America". Innovations in unconventional natural gas development (one of the first actions DOE took after it was formed in the lates 1970s was to characterize US shale basins), including new drilling and production technologies were key to this transformation of the US energy profile, enabling it, again, to become the largest natural gas (and oil) producer in the world, the largest LNG exporter by the end of this year, and to provide assistance to its allies in Europe during this crisis. While the development of shale gas and oil has generated significant controversy and raises environmental concerns that must be addressed, it has totally changed the US energy profile and provides us with a powerful tool for helping our allies in this time of crisis.

Figure 3 shows FERC/MARAD approved LNG export projects and approved projects under construction and associated volumes as of last month. Many of these projects are however, fully subscribed so ensuring surplus capacity is an essential need for addressing the current crisis in Europe and enabling it to, as recommended by Director Birol, to "…not sign any new gas supply contracts with Russia". Approvals and construction need to be expedited.

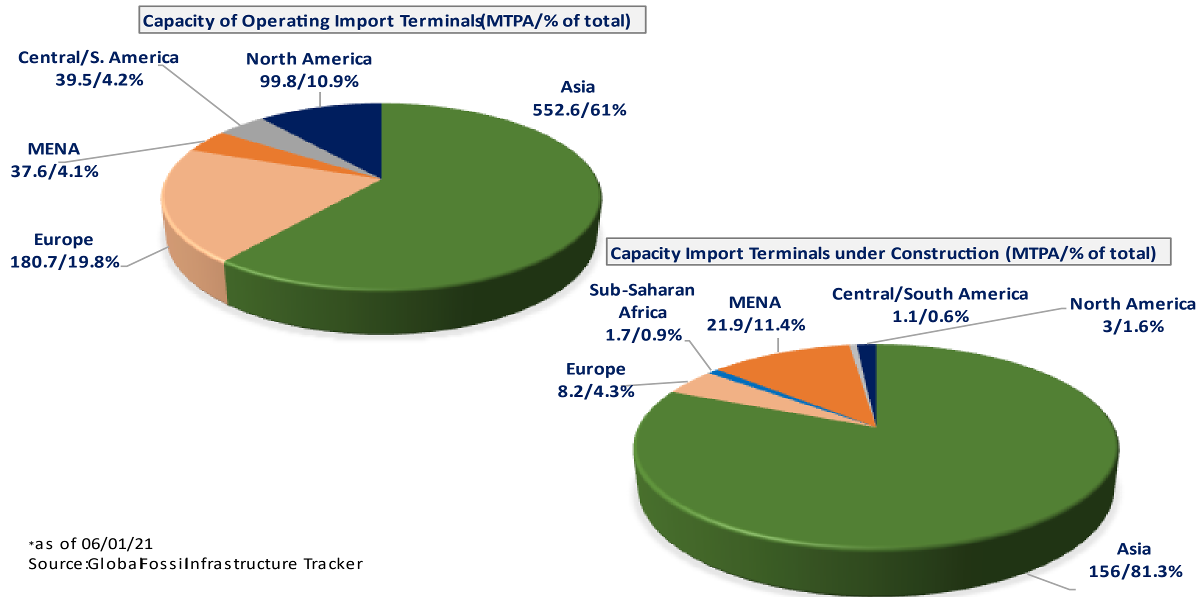
Figure 3. Approved US LNG Export Terminals as of 2/16/2022



cms.**ferc**.gov/sites/default/files/**2022/LNG** Maps

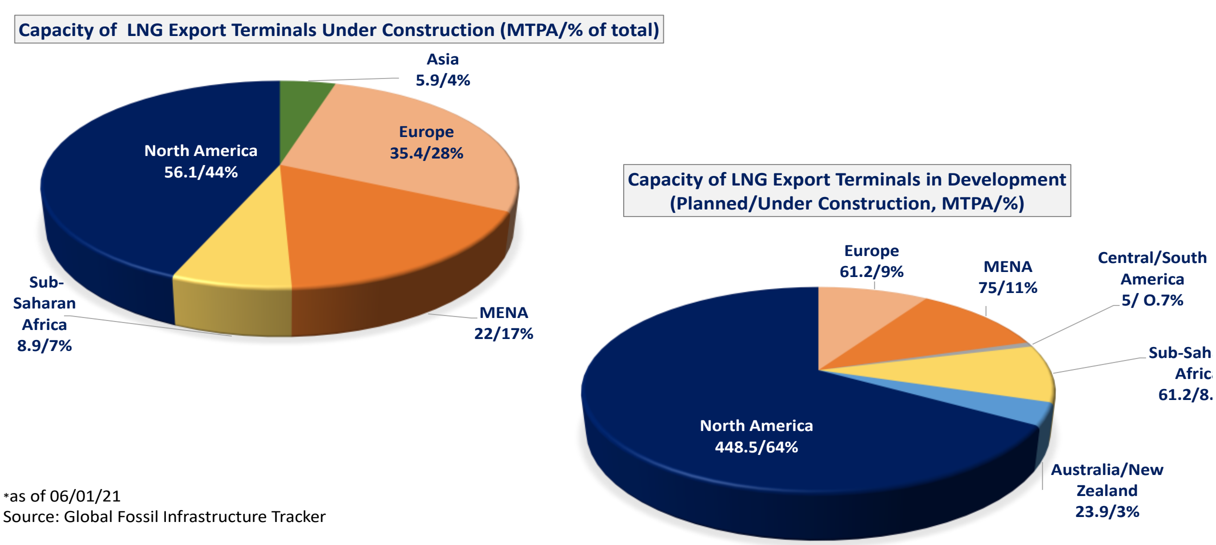
While providing Europe with natural gas is an immediate and critical need, it is not without implications for other US allies around the world, who also rely on natural gas exports from the US. Figure 4 shows the current import capacity by volume by country and import capacity under construction by region of the world (note that numbers in Figure 4 are in million tons per year; Figure 3 units are in billion cubic feet per day. One bcfd equals roughly 7.4 MTPA). The existing import terminals and terminals under construction in Asia are notable, representing 61% of current import capacity and over 81% of capacity under construction.

Figure 4. Capacity of Operating LNG Import Terminals and Import Terminals Under Construction*



Going forward, the US will have to carefully balance the need to address the current crisis with the needs of our trading partner and allies around the world. Clearly, the interests of our allies in Asia – Japan and South Korea are our two largest customers – will be affected by our efforts to replace Russian gas in Europe and need to be factored into our calculus as we and our allies manage responses to Russian aggression. It is important to note that the lack of destination clauses in US LNG export contracts provides greater flexibility for addressing the crisis. We have already talked to the Japanese about help in diverting supplies to Europe -- they offered assistance as long as their domestic needs were met. It is also clear that for the near- to mid-term, more supply and additional export capacity, including additional LNG tankers, are needed.

Figure 5. LNG Export Terminals Under Construction or in Development*



On this front, as seen in Figure 5, US export capacity under construction as of 06/01/21 was 44% of the global total and capacity under development was 64% of total. From an energy security perspective, it is also important to note that *all* of Europe's export terminals under construction and in development are in Russia.

Importantly, we cannot lose sight of the fact that producing, transporting, and shipping natural gas has the potential to increase greenhouse gas emissions in both the US and Europe. Another key energy security principle we advanced for G-7 adoption was, as noted, "Reducing our greenhouse gas emissions and accelerating the transition to a low carbon economy as a key contribution to sustainable energy security" -- addressing this principle is critical.

To do so, the Biden Administration has committed to a target for the United States to achieve a "50-52 percent reduction from 2005 levels in economy-wide net greenhouse gas pollution in 2030", rejoined the Paris agreement, and has set goals of "creating a carbon pollution-free power sector by 2035 and net zero emissions economy by no later than 2050." Also, in September, 2021, President Biden and the European Commission President Ursula von der Leyen announced the Global Methane Pledge as "…an initiative to reduce global methane emissions to be launched at the UN Climate Change Conference (COP 26) in November in Glasgow [that]…aims to catalyze global action and strengthen support for existing international methane emission reduction initiatives to advance technical and policy work that will serve to underpin Participants' domestic actions. The Pledge also recognizes the essential roles that private sector, development banks, financial institutions and philanthropy play to support implementation of the Pledge and welcomes their efforts and engagement."

These goals create a natural tension between current demands for natural gas and net zero targets by mid-century. In Europe, near term options for addressing this tension include delaying planned retirements of nuclear power plants, efficiency (another G-7 principle) and energy conservation policies and practices such as demand response. Deploying more wind and solar, while a longer-term option, is also desirable.

On the US side of the Atlantic, these tensions can be managed in several ways. Importantly, the industry needs to dramatically reduce its methane emissions from the production, transport, and processing of natural gas systems. The technologies exist for doing so and many gas producers are actively engaged in mitigating emissions. While the adequacy of EPA's data on methane emissions is in question and may need to be revised to more accurately reflect sources and amounts of methane emissions, existing data suggest that between 1990 and 2018, methane emissions associated with natural gas (and oil systems) has declined by 23%. Also, according to both EPA and EIA data, average methane intensity declined by more than 70 percent between 2011 and 2020 in five major US production regions.

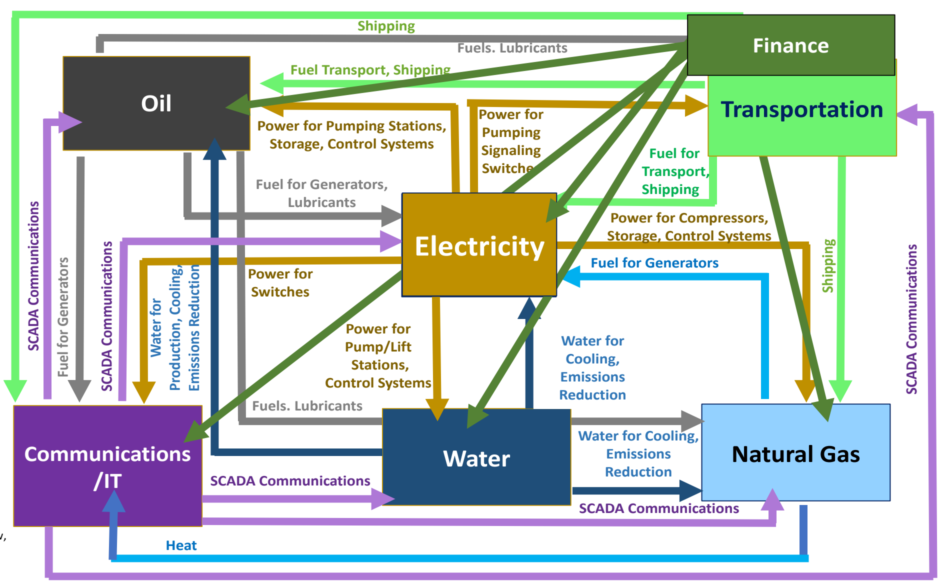
At the same time, carbon capture and storage could dramatically reduce emissions from power generation and industrial uses of natural gas. In 2014, the value and need for CCS were highlighted by the G-7 ministers in Brussels when they adopted the modernized energy security principles. At that time, as noted, the ministers urged immediate action on, among other things, promoting "…the use of low carbon technologies", including "carbon capture and storage". In a similar vein, in 2020, IEA analysis concluded that "Reaching net zero will be virtually impossible without CCUS." In addition, analysis conducted by the Energy Futures Initiative and Stanford University concluded that there were local air quality benefits to capturing carbon from industrial facilities. This happens because some industrial facilities with high CO_2 emissions also emit high levels of criteria air pollutants such as sulfur dioxide (SO_2), nitrous dioxide (NO_2), and particulates. Post-combustion carbon capture requires reduction of these other pollutants resulting in improved local air quality.

There could be an additional benefit to CCS and the pipeline infrastructure needed to move it from capture to storage sites. These pipelines take CO_2 away from emitting sites but could also transport clean hydrogen to facilities that could use it as a fuel for a range of needs for which electricity is inadequate, such as generating high quality process heat. Because hydrogen embrittles pipelines, special treatment of CO_2 pipelines upfront could enable this valuable infrastructure to re-purposed for transporting hydrogen in the future. A tax credit for the additional expense of this initial treatment could support early emissions reductions vis a vis CCS, while supporting the buildout of infrastructure needed in the longer term to provide clean fuel for a clean energy future.

While the G7 principles were an important step forward for defining and guiding individual and collective actions to ensure energy security of the US and its allies, two additional issues have been identified that suggest these principles need to be updated on an ongoing basis. First, is the need to address cyber security threats to energy systems. This energy security concern was illustrated by another Russian attack on Ukraine. In 2015, a Russian cyber-attack on Ukraine's grid shut down power for 230,000 Ukrainians for 1-6 hours.

The broad impact of cyber-attacks is underscored by the fact that all lifeline networks in the US rely on electricity to operate. Figure 6, from the second installment of the government-wide Quadrennial Energy Review released by the Obama Administration in January 2017 (my DOE office did the analysis and writing of this government-wide review), shows that electricity, finance, and communications networks are connected to all other lifeline networks; the financial and communications networks, however, rely on electricity to operate, making it both central and essential to our economy, energy security and well-being.

Figure 6. Electricity and Lifeline Network Interdependencies



Source: Modified from the Second Installment of the Quadrennial Energy Review, Transforming the Nation's Electricity Systems, 2017

This figure illustrates the critical importance of our electric grid and the potential for great damage from cyber-attacks. I am not, however, a cyber expert and the essential pathways for managing cyber-security threats (again, the Russians used cyber-attacks on Ukraine in 2015, shortly after we developed the G7 Energy Security Principles); this is a topic for another day and a different witness. I would, however, suggest that the G7 principles be updated to reflect this vulnerability and to also address another issue that has surfaced, post 2014: the growing demand for metals and minerals for clean energy technologies.

I first started paying attention to the issue in 2017, shortly after we left the Department of Energy and launched the Energy Futures Initiative. Around that time, the UN's Environment Program concluded that, "…low carbon technologies will need over 600 million metric tonnes more metal resources in a 2° C scenario compared to a 6° C scenario where fossil fuel use continues on its current path." Around the same time, a World Bank Study noted that "Simply put, a green technology future is materially intensive and, if not properly managed, could bely the efforts and policies of supplying countries to meet their objectives of meeting climate and related Sustainable Development Goals." I would note that the UNEP conclusion was based on a 2-degree scenario, not on a 1.5 degree or net zero scenarios and that since that time, 130 countries around the world have either implemented in policy or law net zero targets or are strongly considering net zero targets. This will further increase the demand for key metals and minerals needed to support a clean energy future. Over the five or so years since these analyses were released, the US Geological Survey (USGS) has been reporting on critical metals and minerals, their sources, production, and reserves around the world including in the US, and the degree to which the US relies on imports of these key metals and minerals. It should be noted that the Energy Act of 2020 defined critical minerals as those that:

- are essential to the economic or national security of the United States;
- the supply chain of which is vulnerable to disruption (including restrictions associated with foreign political risk, abrupt demand growth, military conflict, violent unrest, anti-competitive or protectionist behaviors, and other risks through-out the supply chain); and
- serve an essential function in the manufacturing of a product (including energy technology-, defense-, currency-, agriculture, consumer electronics-, and healthcare- related applications), the absence of which would have significant consequences for the economic or national security of the United States

Figure 7 illustrates three different but related issues: the percentage of imports of a range metals and minerals the US imports; what those metals and minerals are used for; and which minerals the USGS identified as "critical" earlier this year.

Figure 7. Metals/Minerals, 2020 % US Import Dependence, Key Uses

100% Import Dependent

Arsenic	Lumber preservatives, pesticides, lead acid batteries, solar cells
Tantalum	Electronic components, gas turbine alloys
Strontium	Pyrotechnics, ceramic magnets, drilling fluids
Scandium	Alloys, fuel cells, electronics
Rubidium	Electronics, glass
Rare Earths	Catalysts, ceramics, glass, alloys, metallurgy
Niobium	Steel alloys
Manganese	Steel production
Indium	LCD screens, electrical components
Graphite	Lubricants, batteries, fuel cells steel making
Gallium	Integrated circuits, optical devices (LEDs)
Fluorspar	Aluminum manufacturing, gasoline, uranium fuel, refrigerants
Cesium	Oil/gas well drilling, fuel cells
Yttrium	Catalysts, ceramics, metallurgy, jet engines
Asbestos	Oil industry, rubber sheet, vehicle friction products
Mica (sheet)	Oil drilling, roofing, rubber products

Note: Navy type indicates on USGS Critical List 2022
Red type highlights some key energy uses

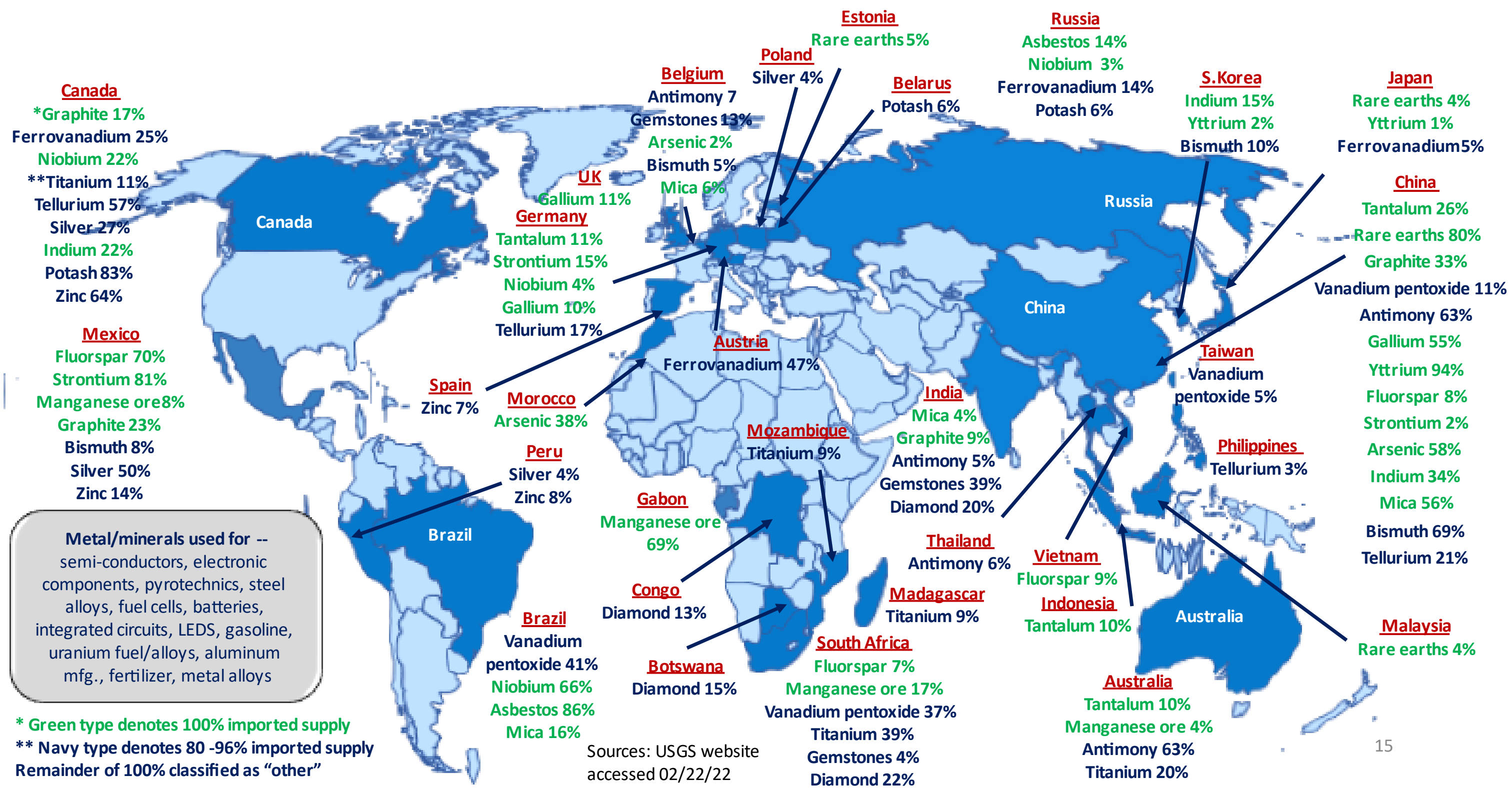
96 - >50% Import Dependent

Vanadium	96%	Metal, steel, uranium alloys
Tellurium	>95%	Cooling, energy production, solar cells, cast iron production
Bismuth	94%	Used in medical/ atomic research
Potash	90%	Fertilizer, chemical, & industrial apps
Titanium*	>88%	White pigment, metal alloys
Diamond	84%	Computer chips, O&G drilling, transportation
Zinc	83%	Metal galvanizing
Antimony	81%	Flame retardants, metal products, ceramics, glass
Silver	80%	Electricity, electricity conductivity, batteries, plastics
Platinum	79%	Catalytic agents
Rhenium	76%	Lead-free gasoline, super alloys
Cobalt	76%	Rechargeable batteries, superalloys
Barite	>75%	Oil/gas drilling
Bauxite	>75%	Cement, petroleum industries
Iron Oxide	>75%	Concrete, construction materials
Tin	75%	Coatings & alloys for steel
Chromium	75%	Stainless steel, other alloys
Gold	>52%	Electrical/electronics
Tungsten	>50%	Wear-resistant metals
Germanium	>50%	Fiber optics, solar cells
Lithium	>50%	Batteries, EVs
Nickel	>50%	Steel alloys

Sources: USGS; Methodological Note to the Inventory of Export Restrictions on Industrial Raw Materials
*Titanium mineral concentrates

Also important to the level of import dependence is the source of those imports. Figure 8 shows metals and minerals for key industry/energy applications on which the US is 80-100% import reliant and the source of those imports by percentage. Note that green type indicates 100% import dependence, blue type 80-96% import dependence.

Figure 8. US Metals, Minerals on Which the US 80 to 100% Import Dependent,Country Suppliers of US Market/% Total Imports from Country



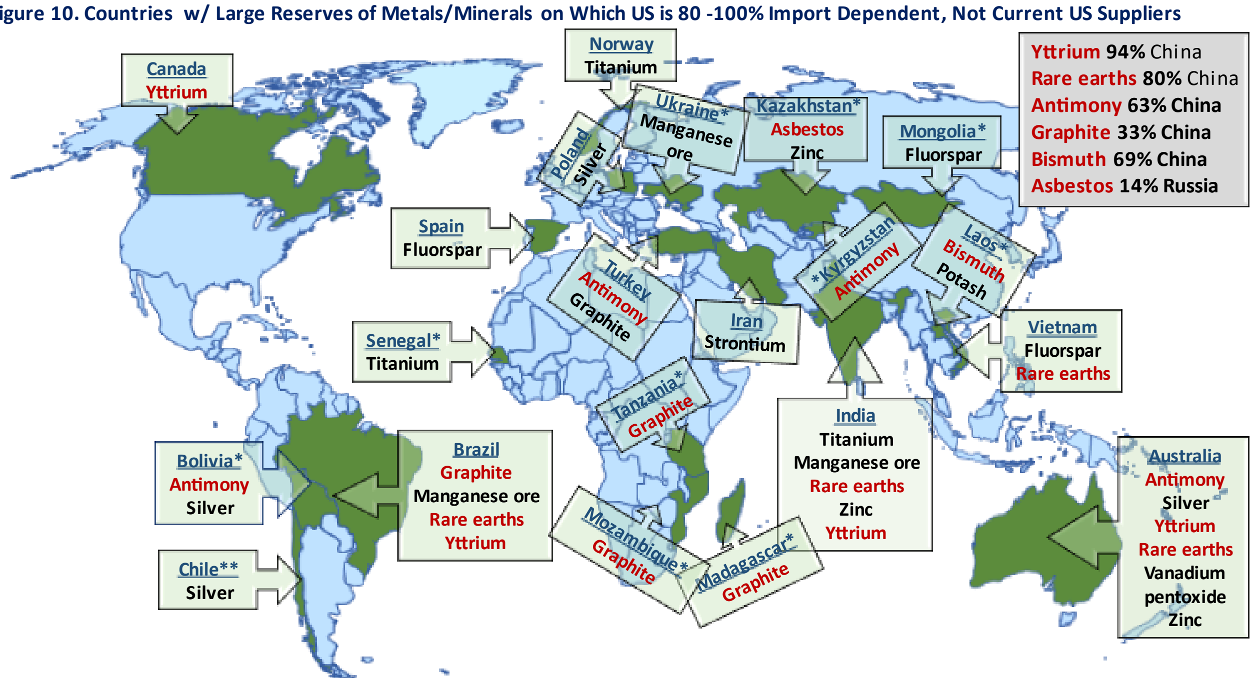
Of special concern in these critical times are imports from China, which abstained from a UN vote on the Russian invasion and has denounced sanctions against Russia. Also of concern are imports from Russia and Belarus; while not substantial, they supply, for example, 12% of US potash imports and 14% of our ferrovanadium supplies, important for fertilizers, metal, steel, and certain industrial applications.

These imports raise critical supply chain issues. These global supply chains are relatively new, growing in importance and raise a new set of energy security issues. Clean energy technologies must accommodate potential material and process limitations, and the geopolitical risks that could, without policy support, delay, or hinder U.S. and global decarbonization efforts. Figures 9 and 10 are instructive in this regard. Figure 9 shows which countries and the metals and minerals they supply to the US that are currently supplied to the US by Russia and China, as well. The figure also shows which of those countries have net zero targets, important because this could raise their own domestic demand for those metals and minerals, thereby potentially diminishing the supplies available for export to the US. The figure also shows the top 15 recipients of US exports and which international forums – the G-7, G-20, OECD, the United States-Mexico-Canada Agreement, the participants in the Obama Administration's Trans-Pacific Partnership Agreement, from which the Trump Administration withdrew, and participants in its successor organization (absent the US), the Comprehensive and Progressive Agreement for the Trans-Pacific Partnership formed in 2018 – forums where critical metals and mineral supply chain agreements and protections could be discussed and developed.

Figure 9. Potential Forums for Dialogue with Key Suppliers of US Imported Metals/Minerals (80-100% imports dependent, non -Russia/China/Belarus suppliers)

Figure 10 offers a look at *potential* suppliers of US imports of key metals and minerals is a set of countries with resources on which the US is 80-100% import dependent but that are not current suppliers of these metals and minerals to the US.

Figure 10. Countries w/ Large Reserves of Metals/Minerals on Which US is 80 -100% Import Dependent, Not Current US Suppliers



It should be noted that the starred countries in Figure 10 – Bolivia, Chile, Mozambique, Tanzania, Madagascar, Laos, Iran, Ukraine, Kazakhstan, Kyrgyzstan, Mongolia, and Senegal – are members of none of the forums outlined in Figure 9. Chile has a pending application to become a member of the CPTPP.

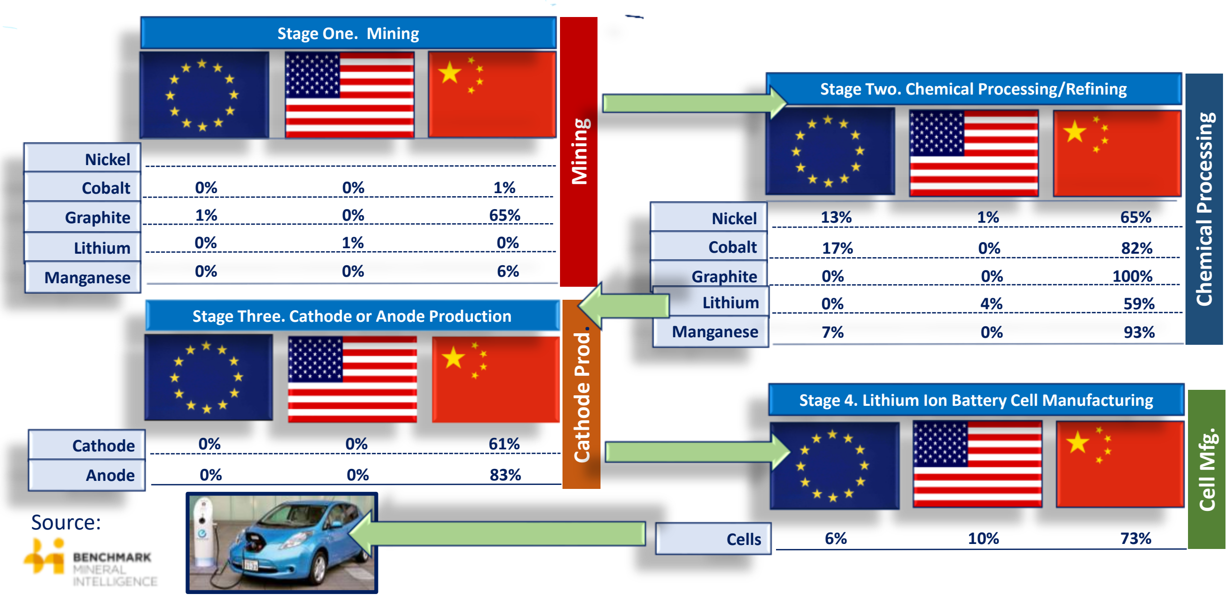
Also of interest are the four countries in Africa that have graphite and titanium resources. Increased bilateral relationships and work with entities such as Africa50, which has a large investment fund for 26 countries in Africa, could help diversify sources of supplies of metals and minerals on which the US is highly import dependent.

Supply chain issues were highlighted in President Biden's Executive Order 14017, *America's Supply Chains*, which noted that "More resilient supply chains are secure and diverse—facilitating greater domestic production, a range of supply, built-in redundancies, adequate stockpiles, safe and secure digital networks, and a world-class American manufacturing base and workforce. Moreover, close cooperation on resilient supply chains with allies and partners who share our values will foster collective economic and national security and strengthen the capacity to respond to international disasters and emergencies." DOE's response to Executive Order 14017, "*America's Strategy to Secure the Supply Chain for a Robust Clean Energy Transition*" released on February 24th of this year, highlights these issues, and identifies several supply chain strategies to:

- Promote adoption and implementation of traceability standards to improve global supply chain mapping capabilities, instill integrity of product custody, promote social responsibility, and support carbon foot-printing of energy supply chains;
- Invest in and support the formation of diverse and reliable foreign supply chains to meet global climate ambitions;
- Establish and fund an initiative for expanding clean technology manufacturing capacity globally to achieve the dramatic scale-up in manufacturing of key climate and clean energy equipment associated with meeting net-zero commitments;
- Support studies that assess and quantify the economic, environmental, social, and human rights impacts of different aspects of the energy supply chain for all clean technologies; and
- Create and maintain a manufacturing and energy supply chain office as well as a database and analytical modeling capabilities.

On the topic of manufacturing, it is important to note that the US is not only dependent on imported metals and minerals for clean energy technologies but is also highly dependent on their processing and manufacturing by other countries, especially China. Figure 11 compares mining, processing, production, and manufacturing percentages for lithium-ion battery storage in the EU, US, and China.

Figure 11. Select Metals, Minerals and Processes for Battery Storage: Global Production Shares, 2019



As Figure 11 shows, the US has very low percentages in all categories (zero percent in most), underscoring that the energy security issues associated with metals and minerals for clean energy technologies extend far beyond raw materials. In this regard, DOE's strategy for securing robust supply chains for a clean energy future includes a focus on expanding domestic manufacturing capabilities.

This is important from an emissions perspective as well. Many raw materials from the US are often shipped to China for processing then shipped back. Global shipping emissions, around three percent of total greenhouse gas emissions, are not counted in any country's nationally determined contribution. While three percent sounds relatively small, it's significant when trying to meet net zero targets. Developing domestic processing and manufacturing capabilities will both create jobs and reduce emissions from shipping.

This figure also highlights another critical strategy for meeting the energy security challenges posed by metals and minerals supply chains; increasing domestic mining, albeit mining that employs environmentally sustainable practices. The mining industry has a long history of creating environmental problems and needs to demonstrate responsible mining practices. Acknowledging both the need for domestic mining and the history of environmental problems associated with mining, the Biden Administration recently announced its, "*Fundamental Principles for Domestic Mining Reform*." These principles recommend that the US:

- Establish strong responsible mining standards
- Secure a sustainable domestic supply of critical minerals
- Prioritize recycling, reuse, and efficient use of critical minerals
- Adopt fair royalties so taxpayers benefit
- Establish a fully funded hardrock mine reclamation program
- Conduct comprehensive planning
- Provide permitting certainty
- Protect special places
- Submit community input and conduct tribal consultation
- Utilize the best available science and data
- Build civil service expertise in mining

This is an extensive list of principles. I would, however, suggest yet another action for consideration by the Congress and the Administration to encourage, enable and achieve responsible mining to help meet clean energy, net zero and energy security objectives. According to the *Responsible Mining Index*, "Responsible mine management requires that companies understand the important environmental values and take steps to avoid impacting threatened ecosystems and resources that are of high significance to the social and economic wellbeing of communities. Where impacts are not preventable, a 'mitigation hierarchy approach' can be followed, which requires that unavoidable impacts be avoided and minimized to the greatest extent possible, damaged landscapes and ecosystems are restored, and companies compensate for remaining impacts.

This index (see Responsible Mining Index, Framework 2020), in addition to providing criteria for managing ESG issues associated with mining, offers a list of criteria/indices for environmentally responsible mining. These include indicators such as:

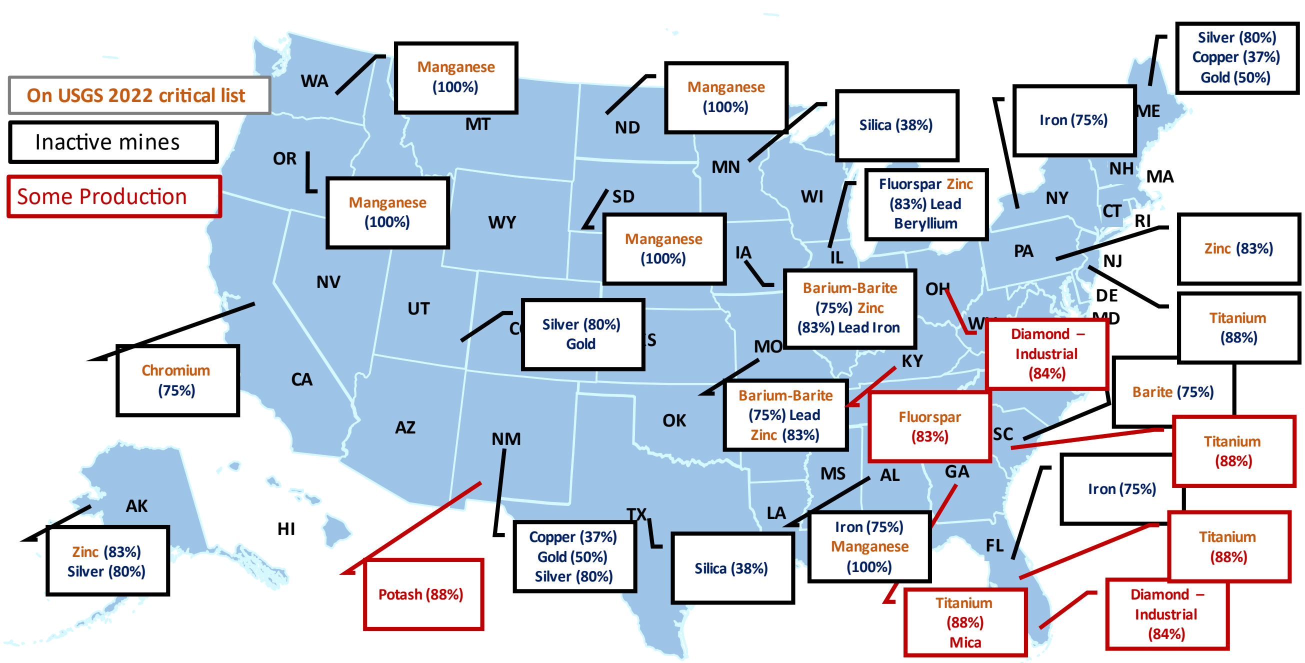
- o The company has systems in place to ensure its operations conduct and disclose regular assessments of its environmental impacts through an integrated approach that considers the linkages between socioeconomic and environmental impacts
- o The company commits to not use riverine, lake or marine disposal of tailings

- Where applicable, the company tracks, reviews and acts to improve its performance on addressing potential risks related to its tailings facilities, including seepage and tailings dam failure
- The company has systems in place to ensure its operations design and implement water stewardship strategies and plans, based on a catchment-level approach, to address water security in the affected area for current and future water users and the environment
- The company tracks, reviews and acts to improve its performance on reducing its water consumption and its adverse impacts on water quality
- The company has systems in place to ensure its operations limit the impacts of noise and vibration on affected communities, structures, properties, and wildlife
- The company commits to not explore or mine in World Heritage Sites and to respect other terrestrial and marine protected areas that are designated to conserve cultural or natural heritage.
- The company has systems in place to identify and report on the potential implications of climate change on its current and future operations' impacts on communities, workers, and the environment, and to design and implement appropriate adaptation and transition strategies.

Most people are familiar with the LEEDs standard for buildings that offers a means to "objectively measure how sustainable a building is". I would propose that, using the indicators listed above as a starting point, we consider using LEEDS as an example for developing a "*Leadership in Equitable and Environmentally Responsible Mining (LEERM)*" standard to certify mines. Such a certification would have to be re-issued on a regular basis – mining, unlike a building, is not static -- but it could provide the necessary impetus for increased domestic mining of metals and minerals needed for clean energy, offering a "carrot and not a stick" approach where companies would be incentivized to use sustainable mining practices as a key differentiator for their businesses.

Figure 12 shows state locations of inactive mines for key metals and minerals, locations where there is some mining of these key metals and minerals, the percentage of import dependence, and metals and minerals in these locations that the USGS has deemed "critical" in 2022. This figure highlights how domestic mining of key metals and minerals could enhance energy security – a "LEERM" certification could help ensure that this is achieved in an environmentally responsible way.

Figure 12. States with Inactive US Mines or Limited Production of Select Metals and Minerals, % Import Dependence



On a related issue, the recycling of metals and minerals could create additional jobs at the same time it enhances energy security by extending the supplies of critical materials**.** Analysis in the IEA's sustainable development scenario suggests that between 2030 and 2040, recycling/reuse of batteries could meet up to nine percent of the copper, nickel, lithium, and cobalt needed to meet demand. This raises another issue important for the energy transition -- creating additional and critical jobs with a focus on rural America. Auto repair is currently a major center of commerce in small rural towns and could be affected by vehicle electrification. Creating recycling centers for batteries and other key materials could provide new commercial opportunities in small rural towns. Recycling of lithium-ion batteries, which can be dangerous and will require training programs to enhance safety of recycling, while creating jobs, and aiding rural America as we transition to clean energy.

I would like to raise a final energy security issue in the metals and minerals space. We tend to think of energy security in terms of "fuels". Beyond the costs of commodities such as copper, the metals and minerals needed for clean energy technologies represent capital, not fuel costs. The lifespan of clean energy technologies will determine the draw on many critical metals and minerals. Accurate assessments of clean energy technology lifespans will become indicators of energy security; analysis, standards, and updated methods and metrics for may be necessary for ensuring energy security as technologies evolve.

This discussion has highlighted some of the evolving energy security issues that have been brought into clear focus by the crisis in Ukraine. It has underscored the value of a set of modernized energy security principles adopted by the G-7 in 2014 that can help guide and enhance our energy security at a time when energy is being used as a weapon by Russia.

In the near term, US natural gas production to support exports of LNG to Europe can help reduce Europe's dependence on Russian gas. At the same time, we must meet the demand for natural gas of other key US allies and trading partners. This will require increased production and additional export infrastructure, and is consistent with the G7 principle, "diversification of energy fuels, sources and routes, and encouragement of indigenous sources of energy supply". We also need to support the innovation, technologies and infrastructure needed to reduce the emissions associated with these activities, develop a suite of technologies and policies to minimize the tensions inherent in these two pathways, and provide a supportable pathway for deep decarbonization of energy systems by mid-century.

In the longer term, as we transition to clean energy technologies, protecting global supplies and supply chains for critical metals and minerals, and reducing our reliance on China and Russia as suppliers of some of these materials will help enhance our energy security. This will involve finding new trading partners, increasing environmentally responsible domestic mining, investing in processing and manufacturing capabilities and capacities, developing alternatives, and recycling, re-using, and re-purposing key metals and minerals. The synergy between energy security and climate change mitigation offers many opportunities for addressing energy transition challenges in a coherent, sequenced manner.

Thank you for this opportunity and I look forward to your questions and comments.

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