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Sustainable and Ethical Uranium Mining: Opportunities and Challenges

A report to explore how the uranium mining industry can help achieve a low-carbon energy future while respecting human rights and the environment

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Good Energy Collective is a policy research organization building the progressive case for nuclear energy as an essential part of the broader climate change agenda. We develop smart policies at every scale to accelerate the just and equitable deployment of advanced nuclear technologies.

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Contributions

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Cover page photo: Radiation zone in Grand Canyon National Park, close to former uranium mine sites. Credit: Akos Kokai (2015).

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Executive Summary

Demand for nuclear energy—and the uranium needed to fuel it—is expected to grow over the coming decades in response to concern for climate change and energy security. Unfortunately, the extraction of uranium has left behind a troubled legacy, particularly for Indigenous communities and other marginalized groups.

For nuclear to be considered a truly clean energy technology, uranium mining must proceed with minimal environmental and public health impacts. Governments need strong regulations on mining, but they also need to invest more resources into remediation. These problems are not unique to nuclear energy, however. The transition to low-carbon energy necessitates a significant expansion of mining activities, often in regions with few environmental safeguards. The Biden administration has projected that global demand for critical minerals for energy production and other industries is set to increase 400–600 percent over the next several decades. For minerals such as lithium and graphite used in electric vehicle batteries, demand could increase by as much as 4,000 percent.

No matter the mineral, government and voluntary standards are necessary to ensure mining companies operate ethically and sustainably and invest in the host community long-term. Smart policies and strong standards can minimize the impacts and maximize the benefits to communities. Mining can be rethought to include cleaning up the dirty legacy of mining's past, protecting the environment, and investing in the community. Policymakers can identify and support activities that reduce demand for new mining, including alternative mineral sourcing options like reprocessing spent nuclear fuel, reprocessing waste at abandoned mine sites, and extracting minerals from seawater. Successful community consultation practices and community benefit agreements can offer a blueprint for mining project developers to earn trust and support for new projects. And wherever possible, Indigenous communities should lead the way in land management to ensure that new extraction activities do not harm cultural and spiritual sites.

Introduction

Nuclear energy currently supplies 10% of electricity globally and 19% in the United States,[1] but nuclear generation could grow significantly to meet environmental and energy security goals. In comparison to extractive activities for oil, coal, and gas, the footprint of mining for nuclear is tiny due to the high energy density of uranium fuel. However, demand for uranium is expected to grow in parallel with demand for low-carbon energy. The International Energy Agency projects that global nuclear generation will need to double by 2050 to reach net-zero global emissions by mid-century.[2] In addition, the U.S. and European countries are looking to reduce their reliance on Russian nuclear fuels after they invaded Ukraine. The U.S., in particular, is putting forward policies to ramp up domestic production. Currently, the U.S. imports almost all of its uranium fuel.[3]

However, in the U.S. and abroad, the extraction of uranium for defense and civil use has left behind a troubled legacy. Uranium mining has often disproportionately harmed Indigenous communities and other marginalized groups. Historic uranium mining left radon-emitting waste piles outside of mine sites, dispersing radioactive particles and contaminating local ground and surface water.[4] Environmental degradation and public health impacts from uranium mining and milling are among the primary reasons that many environmentalists do not consider nuclear energy to be a "green" or sustainable energy source.[5,6] For nuclear to be a legitimate clean energy technology in the fight against climate change, new uranium mining must proceed with minimal environmental and public health impacts, and the federal government or other responsible parties must remediate legacy contamination.

A global transition away from fossil fuels toward clean energy has significant benefits beyond reducing greenhouse gas emissions, including reducing ecosystem degradation from extractive activities like coal mining and oil and gas drilling. However, all clean energy technologies will require an expansion of mining activities in some form, often in previously untouched regions. Unfortunately, minerals needed for renewable energy and batteries, such as cobalt and lithium, face their own problems, from mine safety and human rights violations to environmental destruction.[7] Many of the "clean energy minerals" that are critical to the U.S.

clean energy transition face supply risks and therefore have been categorized as critical minerals by the U.S. government.[8]

The Biden administration has projected that global demand for critical minerals for energy production and other purposes is set to increase 400 percent–600 percent, while demand for minerals such as lithium and graphite used in electric vehicle batteries will increase by as much as 4,000 percent.[9] The push to transition global energy systems will increase demand for mining significantly over the next few decades, with implications for environmental and public health. And yet many people who care about climate change and clean energy are not aware of the potential impacts of this new mining.

Minimizing the impacts of mining and the mineral supply chain for clean energy technologies is critical for ensuring a just and sustainable clean energy transition. Globally, government entities and private industry coalitions have started to develop and implement standards for mineral supply chains to ensure that miners produce these resources as sustainably and ethically as possible. However, as mining expands to accommodate the growing demand for clean energy technology, more mining operations may move to regions with fewer environmental and community safeguards. Policymakers must urgently move to ensure that the future of clean energy does not come at a high cost for the environment and local communities.

Proponents of sustainable and ethical mining recognize that mining carries an inevitable impact, but one which miners and regulators can minimize with proper safeguards. While applications and definitions vary, sustainable and ethical mining standards tend to follow certain principles: supply chain due diligence from the mine, to the processor, to the manufacturer; listening to community feedback and concerns; protecting the health and environment of nearby communities; protecting mine workers and providing a living wage; anti-corruption policies; direct community investment via community development agreements or funds; expedient mine cleanup and biodiversity restoration; and addressing abandoned mine pollution.

This report explores sustainable and ethical mining in the context of past and future U.S. uranium extraction, including (1) legacy uranium mine clean-up; (2) the current state of uranium mining globally; and (3) the future of mining, including standards for responsible and sustainable mineral supply chains and alternative mineral sourcing options to reduce the necessity for new mining. Policy recommendations around each of these topics are proposed as a starting point for the government and industry to better understand and implement sustainable and ethical mining practices and policies.

I. Uranium Mining's Legacy in the United States

Overview

The General Mining Act of 1872 covers most hardrock mining exploration, including uranium mining on U.S. federally-managed and public land, with the exception of coal mining.[10] The law allows individuals to purchase title to unappropriated federal land for a small fee if they "discover a valuable deposit" of minerals on the land.[11] For nearly 150 years, the law has been virtually unchanged and has enabled mining companies to stake claims on federal lands and abandon the mines and waste. This practice has resulted in thousands of abandoned mines in the U.S. The law does not require miners to pay mineral royalties to the federal government and does not always include land-bonding requirements to cover remediation costs.[12,13] In practice, miners can still use this law today to break ground and search for mineral deposits on federal land with little oversight, often resulting in a financial drain on states and local communities left with the mine waste and environmental hazards.[14]

Most major projects on U.S. federal public land are subject to the National Environmental Policy Act, which requires an accounting of the potential environmental impacts of large infrastructure projects with federal involvement.[15] However, historic mining claims under the General Mining Law can be patented and sold to mining proponents. This means mine claims under the law do not usually trigger federal requirements to create mining operation plans or conduct analysis under the National Environmental Policy Act, unless the claim was established after 1976, or other exceptions apply."[16,17] This has raised concerns that the current U.S. mining law framework does not provide enough federal oversight for the potential

environmental impacts of mine claims patented under the General Mining Law prior to 1976, which accounts for many historic uranium mine sites that could come back into operation.

Abandoned mines of all varieties continue to be an environmental hazard for many communities due to contamination of water, air, and land from leftover waste and structures. In the U.S., the Environmental Protection Agency estimates that there are 100,000–500,000 abandoned mines of all mineral varieties, with 52,000 or more on federal land. That total includes 15,000 abandoned uranium mines on U.S. federal lands. Cleanup of hazardous abandoned mine sites can cost hundreds of millions of dollars and take many years to address. For example, the U.S. Government Accountability Office found, as of July 2019, abandoned mine cleanup ranged from $50 million to $583 million per site, and many of the sites had been under the remediation process for over 20 years.[18] From fiscal years 2008 through 2017, federal agencies spent, on average, about $287 million annually identifying, cleaning up, and monitoring abandoned hardrock mines, for a total of about $2.9 billion.[19] The clean-up estimate for abandoned mines of all types on U.S. federal public lands is around $50 billion.[20,21]

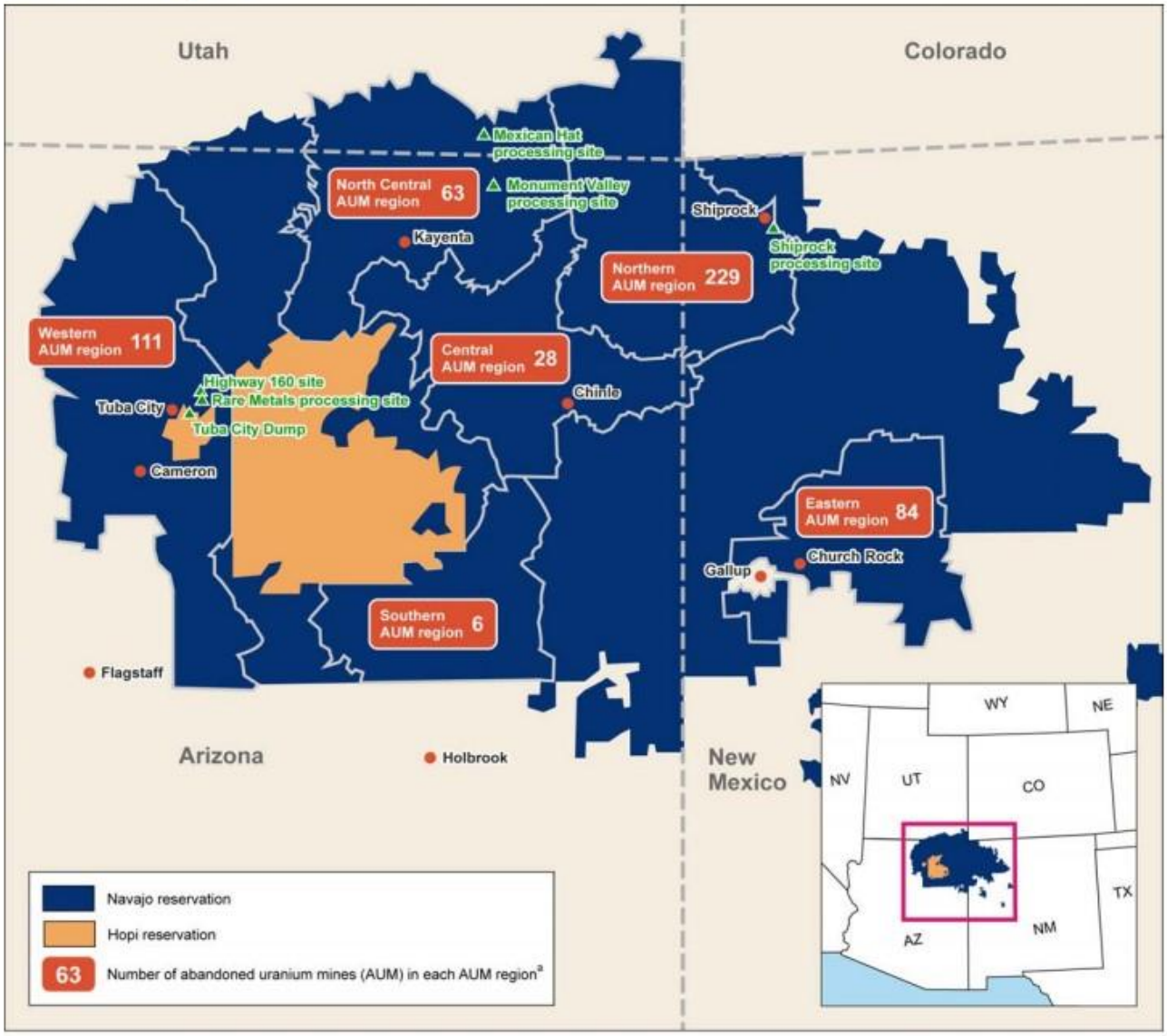
The History of U.S. Uranium Mining

In the U.S., mining has a long history of boom and bust cycles. The first mining boom began in 1849 and was centered around gold in California.[22] At the height of the early mining boom, uranium ore was a byproduct of other mining operations and was seen more as a nuisance than a treasure. The discovery of nuclear fission in the late 1930s—and the potential of a weapon based on this discovery—motivated a group of scientists to call on the U.S. government to stockpile uranium ore and pursue research into fission bombs. This led to the creation of the Manhattan Project in 1941, through which the U.S. government sought large quantities of uranium in order to build nuclear weapons.[23] After World War II ended, the government established the U.S. Atomic Energy Commission, which helped prioritize the prolific leasing of new uranium mining claims on federal public lands through the 1872 Mining Law.[24] During the height of the uranium boom from the 1940s to the 1980s, mining communities saw their economies thrive and populations double, but the mining busts led to people fleeing mine towns in droves and left behind environmental hazards and health impacts that still linger today.[25]

In the U.S., most of the highest-grade uranium is in Western states, particularly in the Four Corners Region, where the borders of Colorado, Utah, New Mexico, and Arizona meet. Wyoming, Montana, and Texas also host large uranium deposits. Smaller uranium deposits have also been discovered in Washington state and, more recently, in Virginia.[26]

The Navajo Nation, which borders New Mexico, Arizona, Colorado, and Utah, opened its land to vanadium mining at the government's request during WWII. The Navy used vanadium as a waterproof coating for ships during the war, and the government told the Navajo people that the extraction of this precious resource on their land would help young Navajo soldiers win the war. In reality, vanadium was not the true prize buried deep beneath Navajo land—the government was searching for uranium (or what the Navajo people call "Leetso," or "yellow dirt,") for atomic bombs.[27,28] From 1944 to 1986, miners extracted 30 million tons of Leetso from the Navajo Nation to aid federal government programs to fuel nuclear weapons and nuclear reactors.[29] Leetso continues to wreak havoc on the health and environment of the Navajo community due to radioactive contamination.[30] An estimated 523 abandoned uranium mines and four abandoned uranium mills languish throughout the Navajo Nation. Other studies estimate the total number of abandoned uranium mines in the area at closer to 1,000.[31] The Environmental Protection Agency has received funding to assess and remediate 230 of the 523 mines and has invested as much as $5 million per year toward investigation and cleanup of contamination and technical support for Navajo government agencies.[32] No cost estimate exists for the remediation of all uranium mines in the Navajo Nation, as cost varies by level of complexity and contamination.

Figure 1: Map of the Navajo and Hopi Reservations with 521 Abandoned Uranium Mines, Four Former Uranium Processing Sites, and Other Key Sites



Sources: GAO analysis of EPA and DOE data; Map Resources (map).

Abandoned Uranium Mines on the Navajo Nation. Credit: Government Accountability Office.[33]

The Havasupai Tribe, with homelands in the Grand Canyon and the surrounding areas, has also felt the impacts of uranium mining. The Havasupai Tribe lives near one of the few active uranium mines left in the region, the Pinyon Plain Mine (formerly known as the Canyon Mine) located on the Grand Canyon's South Rim, which is also the location of their traditional spiritual homelands at Red Butte.[34] While the U.S. Department of the Interior placed a moratorium on new uranium mines in the Grand Canyon watershed area in 2012, mines operating before the moratorium date are still open to mining.[35] The Havasupai Tribe has

raised concerns that the resumption of uranium mining in the Grand Canyon watershed area could contaminate their only freshwater resources, force them out of their homes, and destroy their most sacred sites.[36]

The Lakota Tribal Nations Territories, which cover South Dakota, North Dakota, Nebraska, Wyoming, and parts of Colorado, have been fighting mining on their spiritual homelands in the sacred area of the Black Hills since 1870 during the Gold Rush, despite an 1868 Treaty promising the Black Hills would remain in Lakota control in perpetuity. The Black Hills are also sacred to Cheyenne, Kiowa, and Arapaho tribes.[37] The Lakota Tribal Territory hosts approximately 3,272 uranium mines with unknown reclamation status.[38]

Other communities in the Western U.S. uranium regions share similar problematic histories with uranium mining. For example, Grand Junction, Colorado, an essential mining and milling site for the federal government's test operations, has suffered from radioactive waste from pilot uranium mills and sampling plants that buried the waste onsite, leading to groundwater leaching and pollution of the Gunnison River.[39] Communities throughout Utah and New Mexico similarly have felt impacts from legacy uranium mining and milling, including water and air contamination.[40,41]

Monument Valley, Navajo Tribal Park. Credit: Cayetano Gil.

Health and Environmental Impacts of Legacy Mine Sites

Historically, uranium mining has resulted in health impacts on mine workers and nearby communities. Heavy metal discharge, chemical leaching, acid leaching, explosives, open mine shafts, and erosion all contribute to human and environmental health impacts.[42] Water contamination is the main concern behind legacy mines, especially uranium mines that contain radioactive substances that leach into groundwater and surface water. As climate change increasingly causes drought and water quality issues, concerns continue to grow that legacy mine sites and new mining activities will contaminate and drain limited water resources.

The detrimental health impacts from exposure to uranium and its byproducts were not initially understood in the 1940s at the beginning of the uranium mining boom but were widely studied in 1950–1980 because of growing concerns that uranium mining could cause lung cancer.[43] Uranium miners in the early days extracted uranium without protective equipment or radiation monitoring and mines were poorly ventilated, resulting in miners breathing in hazardous levels of radioactive particles daily.[44] By the early 1960s, uranium miners in the U.S. were developing demonstrable health issues from inhalation of uranium and radon in mines and in their communities through ingestion of contaminated water, vegetation, and livestock that fed on contaminated vegetation.[45] Common health issues from ingestion and inhalation of uranium include asthma, lung cancer, renal and bone cancer, kidney damage, and premature death.[46,47] Indigenous mine workers and their families in the Navajo Nation suffered some of the worst impacts from U.S. uranium mining because mine supervisors and government officials failed to warn them of the radiation risks. According to a 2000 Health Physics study, Navajo uranium miners' lung cancer rate is nearly 29 times more than Navajos who did not work in the mines.[48]

Uranium mining waste has continued to cause contamination in many mining communities long after the mines have closed. Mining waste piled outside former mine sites (also known as tailings piles) containing uranium and radium creates radioactive dust that leads to air and water contamination as the dust migrates. Some tailings piles also contain heavy metals and other hazardous substances like arsenic that migrate and cause long-term ecosystem impacts.[49]

Some uranium mining communities in Colorado, Utah, and the Navajo Nation built their home foundations and walls and landscaped their yards with tailings from abandoned uranium mines without knowledge or notice of its radioactivity.[50] Many radioactive homes in former uranium mining communities await remediation or remain unidentified.

Meanwhile, large amounts of uranium mine waste on the Navajo Nation remain unsecured and migrate from abandoned mine sites through the wind into washes and tributaries, leading to surface and groundwater contamination.[51] For example, although there are no uranium mines in the Sanders, Arizona community 80 miles from the Navajo Nation, studies have found evidence of uranium in groundwater and unregulated water sources tested in Sanders in 1986 and 1987.[52,53] Livestock studies in the Navajo Nation have also uncovered uranium in the organs of animals.

The experiences and preferences of various communities differ. Many Indigenous leaders and environmental activists in the U.S. prioritize the cleanup of legacy sites and oppose new or expanded mining operations.[55] However, some Indigenous community members value stable employment from the mines and mills close to reservations where other economic opportunities are sometimes few and far between.[56] Meanwhile, some predominantly White former uranium mining boom towns in the U.S. have developed into tourist attractions that still bring revenue to these communities.[57]

U.S. Laws and Programs for Legacy Mine Sites

Through the Superfund program of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the U.S. Environmental Protection Agency identifies and remediates hazardous waste throughout the country. The Environmental Protection Agency also identifies sites for the National Priorities List (NPL) that contain "known releases or threatened releases of hazardous substances, pollutants, or contaminants" and warrant further investigation and potential CERCLA enforcement action.[58]

Abandoned mine and mill sites, including for uranium, are eligible to be listed as Superfund or NPL sites, but historically only about 70 abandoned uranium mines and mills have been

listed as Superfund sites, more than 30 of which still remain on the Superfund list. Three uranium mines are currently on the National Priorities List.[59]

The U.S. Environmental Protection Agency Brownfields Program provides grants and technical assistance to communities, nonprofits, and other groups to clean up contaminated structures and revitalize it for productive use. A 2002 amendment to CERCLA expanded the program to include "mine-scarred land."[60] While the focus of the program's mine cleanups has centered primarily on abandoned coal mine lands, abandoned uranium mine lands could be a viable new focus of the program in communities seeking reclamation and economic opportunities.

The Good Samaritan Initiative is an effort started in 2007 by the U.S. Environmental Protection Agency to reduce barriers to the cleanup of abandoned mine sites by non-liable volunteers. Through the program, volunteers can apply for "Good Samaritan Orphan Mine Permits" to conduct remediation activities on abandoned mines in their community. However, many prospective volunteers are concerned that they will be held liable under the Clean Water Act for any pollution that remains there or any possible mistakes made during cleanup efforts.[61] Reform of this initiative and its liability provisions could allow more communities to address legacy mine pollution in their backyards without concerns of financial and legal liability.

Policy Recommendations

1. Congress should reform the General Mining Act of 1872 to prevent the future abandonment of new mine sites.

Reform of the 1872 mining law is necessary to ensure that new mines permitted on federal lands are not abandoned and continue to harm communities with legacy pollution. Despite many attempts, Congress has never meaningfully reformed the General Mining Law of 1872.[62] As early as 1880, lawmakers floated the need for reform due to abuses of the law that have allowed the industry and artisanal miners to mine minerals without paying value back to the government or the community.[63] Reform of the 1872 mining law has gained traction recently as the demand for U.S. critical mineral mining is steadily increasing to support the clean energy transition. Notably, any law reform would only apply to new mining operations and

leave existing mining operations to continue to operate under the 1872 mining law framework.

The Clean Energy Minerals Reform Act of 2022 (H.R. 7580) introduced in the House Natural Resources Committee in April 2022, is one approach to reforming the General Mining Law of 1872.[64] Bill proponents and environmental advocates are hoping for four main concessions: (1) a formal permitting system for new mines; (2) royalty payment requirements; (3) better enforcement and bonding requirements (i.e., financial assurances for mine remediation); and (4) better mechanisms for community involvement on how to select lands for mining, including more robust tribal consultation requirements. Mining companies argue that these requirements will drive out new U.S. mining operations and increase domestic reliance on other countries with less stringent regulatory requirements. However, other democratic countries with robust mining industries, such as Canada and Australia, already have minimum requirements for mine permitting, royalty payments, land bonding, and First Nations consultation. Oil and gas production on U.S. public lands also utilizes a similar system to what is being proposed.

The proposed mining law reform also suggests a flat royalty rate of 12.5% – which mirrored the minimum legal royalty rate on oil and gas operations on federal public lands, until the Inflation Reduction Act raised this rate.[65] Mining companies have argued that future mine royalty payment structures should be based on the profits from the mine, not a flat rate that does not account for the potential for low mineral prices in the market. A good balance to strike could be a lower baseline royalty (i.e., somewhere between 6-8%) combined with the use of a "net revenue royalty" structure that bases additional royalties on the price of the mineral in the market. Royalty payments and fees can create a fund for the clean-up of mine-scarred lands and polluted waters resulting from mining activity.[66]

2. Congress should appropriate resources to the U.S. Bureau of Land Management and cooperating federal agencies to identify, inspect, and inventory abandoned uranium mine sites on federal lands.

In 2012, the U.S. Government Accountability Office estimated it would cost $39 million to inspect all U.S. Bureau of Land Management mine sites of all types.[67] In a 2013 Bureau of Land

Management Feasibility Study for an Abandoned Mine Inventory, it was estimated that it would cost approximately $212 million to validate the estimated remaining abandoned mine sites in Nevada, California, and Utah.[68] There are thousands more abandoned mine sites throughout the country yet to be inspected.[69] It is unclear how many of these are uranium mine sites or may contain uranium. Identifying, inspecting, and inventorying the remaining abandoned uranium mine sites is crucial to address legacy contamination. Congress must ensure that there are adequate resources for the Bureau of Land Management and other cooperating federal agencies to take the first step in addressing legacy uranium mine contamination by conducting this work.

3. Reform of the Good Samaritan Initiative to enable more community clean-up.

The Good Samaritan Remediation of Abandoned Hardrock Mines Act of 2022 (S.3571) introduced in the Senate Environment and Public Works Committee in February 2022, is a proposed bill to reform the Good Samaritan Initiative.[70] The proposed reform would apply to mine sites where no documented owner can be found and create a formal permitting system for Good Samaritan volunteers. The proposal would allow reprocessing of mining waste materials found onsite that may contain valuable minerals and rare earth materials. The bill would also waive liability for any accidental violations of the Federal Water Pollution Control Act and the Comprehensive Environmental Response, Compensation, and Liability Act that may occur during mine clean-up. Under the proposal, Good Samaritan permits would initially be limited to 15 permits total, and re-mining at legacy sites would not be allowed. Thus, the impact to the total number of abandoned mine sites and the mineral market will be limited. Depending on the success of the program, policymakers could expand the total number of permittees and reconsider allowing some re-mining operations to increase the impact, scope, and interest of the initiative. Environmental groups have expressed concern about abandoned mine land re-mining efforts being used as an excuse for mining companies to stake never-ending claims to mine sites without actually cleaning them up. However, these concerns could be addressed with time limits on re-mining permits, financial bonding requirements, and strict clean-up requirements. Environmental Protection Agency technical oversight. A requirement to conduct activities with the local workforce could also be an economic selling point for communities.

The proposed reform could help alleviate many of the concerns of potential Good Samaritan volunteers and allow more community cleanups of abandoned mines to occur. Mining companies could also view this reform as a win because it would allow companies to take part in mineral reprocessing efforts at abandoned mines and produce more sustainably sourced minerals and rare earth materials. In turn, this could help build social goodwill with communities that have a history of mistrust of the mining industry and create a more secure domestic supply of responsibly mined minerals and rare earth materials necessary for the carbon-free energy transition.

4. The U.S. Environmental Protection Agency Brownfields Program should be used to revitalize abandoned uranium mine lands into community assets.

The Environmental Protection Agency Brownfields Program has the potential to turn abandoned uranium mine clean-up into a lucrative opportunity for communities to reuse land and build a local workforce. The Brownfields Program expansion into abandoned mine lands cleanup has supported many communities that want to address legacy mine pollution and revitalize the land for other economic uses. While the program has been used on coal mine lands, there is no precedent of using it in the U.S. for abandoned uranium mine land due to concerns about the potential for radiation exposure during clean-up or reuse of the land. Nevertheless, there is precedent for successful brownfield revitalization of abandoned uranium mine land in what was once the site of the largest uranium mine in Germany. There, in Ronneberg, the area was safely converted into a greenway that has become a main recreational area for local residents with hiking trails, event spaces, and a museum to inform the community about the history of the space. The local community job force was also invested in every step of the project, from reclamation, revitalization, and construction of the new structures on site.[71] This is a great example of how abandoned uranium mine lands in the U.S. could be safely revitalized into valuable community assets.

Potential regulatory hurdles exist if the government licensed the uranium mine operations after 1978 and used chemical applications for extraction or milling (i.e., in-situ leaching), which triggers Nuclear Regulatory Commission jurisdiction over the site under the Uranium

Mill Tailings Radiation Control Act (UMTRCA).[72] However, for the majority of former uranium mine sites on federal land licensed before 1978, or former mine sites that utilized traditional mining methods (i.e., open pit or open shaft mining), the Environmental Protection Agency Brownfields Program is a viable option for revitalization.

A potential reuse for abandoned uranium mine brownfield sites could be new clean energy projects. RMI and The Nature Conservancy have been working to identify 2.8 million acres of brownfield mine sites in the Southwestern U.S. that could be utilized for wind and solar energy projects. These projects are already occurring in some locations.[73] While state and local regulations may be a barrier in some locations, on federal lands, the federal government has the authority to license new clean energy facilities. The Environmental Protection Agency, in collaboration with the Department of Energy, could pilot new brownfield revitalization projects on abandoned uranium mine lands that include clean energy infrastructure. The Department of Energy's Office of Clean Energy Demonstrations recently issued a Request for Information toward a new $500 million program to support two to five new clean energy projects on current and former mine land across the country.[74] This is a great first step in the potential reuse of former mine land to create more clean energy. Where possible, former uranium mine lands should be explored as high-priority locations for the program.

5. Congress should pass Senate Bill 387, the Grand Canyon Protection Act.

The bipartisan Grand Canyon Protection Act (S.387) will protect 1 million acres of public land surrounding Grand Canyon National Park from uranium mining[75] and will help protect homes and freshwater supplies in Supai Village, according to Havasupai Tribal members.[76] The Navajo Nation President, Jonathan Nez, has also endorsed this bill as a continuation of the work to remedy the harm caused by uranium mining in the region.[77] The bill would authorize the study of uranium stockpiles that may be available to meet future national security requirements, including evaluating existing and potential future national security program demands for uranium; existing and projected future inventories of domestic uranium that could be available to meet national security needs; and the extent to which national security needs are capable of being met with existing uranium stockpiles. The bill aligns with current domestic uranium

supply goals and will help to protect delicate ecosystems and Indigenous communities in and around the Grand Canyon from further destruction.[78]

Grand Canyon, Arizona. Credit: Tim Hart.

II. The Current State of the Uranium Mining Industry

Overview

Uranium demand is steadily increasing alongside critical mineral demand as the global transition to carbon-free energy takes off. Kazakhstan (45% of the world's supply), Namibia (12%), Canada (10%), and Australia (9%) are the main global suppliers of the uranium needed for nuclear power.[79] Currently, less than 1% of global uranium is produced in the U.S., and many of its active uranium mines have remained dormant due to the low price of global uranium and the low grade of domestic uranium deposits.[80] Global uranium exploration and mine development is trending downward; since 2014, there has been a drop of 1.5 billion in funding in the uranium sector. This is due in part to the legacy left by the Fukushima Daiichi nuclear accident in 2011, which led to community concerns about nuclear energy safety and government officials responding by decommissioning nuclear plants and temporary closures for safety upgrades.

Even as the contemporary market is depressed, demand for uranium is expected to rise steadily in the next 10-20 years due to the increase in global energy demand and the critical need for carbon-free baseload energy sources to replace coal and natural gas generation. The number of identified recoverable uranium resources has grown in the U.S. and globally, with the largest increases expected in East Asia.[82]

In light of past failures, the modern global uranium industry has some of the highest standards of any mineral mining sector.[83] Australia maintains the world's largest uranium resources at the Olympic Dam.[84] The mine has continuously produced uranium since 1988.[85] Critical to Australia's approach is rigorous environmental impact assessments with opportunities for public comment to ensure equitable mining practices are taking place.[86] Uranium producers must account for environmental degradation, cultural heritage, nuclear safeguards, and Aboriginal rights.[87] Yet, even with these requirements, Australia has a controversial uranium mining legacy, particularly with regards to Aboriginal land rights and cultural resources.[88]

Canada sets strict uranium mining and milling licensing requirements on uranium mines. It requires industry participants to undergo five-year periodical environmental risk assessments and mandates that mines face continuous inspections, reviews, and data analysis to ensure adherence to strict standards. However, Canada has attracted criticism from progressive environmental groups that say the state fails to protect vulnerable populations, including First Nations, and the environment. The Watershed Sentinel, a grassroots environmental policy publication from Canada, finds that the Elliot Lake Mines have been responsible for the release of 170 million tonnes of radioactive tailings into Lake Huron.[89] Canada's Nuclear Safety Commission asserts that Cameco, the largest industrial employer of First Nations people in Canada, has continuously shown high levels of safety for their workers.[90] Canada also has one of the most extensive uranium mine and mill licensing standards and requires licenses and environmental reviews through the entire life cycle of uranium mines and mills from pre-planning, operation, decommissioning, and post-closure.[91]

Kazakhstan has outlawed open pit and underground mining for uranium and restricts in-situ leach mining to areas far away from population centers and where water is already unusable (due to high salt content) to ensure the lowest environmental impact.[92] Other notable innovations in uranium mining in Kazakhstan include: a liquidation fund to eliminate the effects of operations on subsoil use; a requirement that 1% of the cost of exploration be deposited in the liquidation fund; all contracts for uranium exploration and mining require financial contributions to local social and cultural improvements.[93] The government also requires uranium mining profit to go toward healthcare for employees and local citizens, education, sport, recreation, and other activities.

While the U.S. does not currently produce much uranium, policymakers are increasingly exploring ways to increase domestic supplies to reduce reliance on Russian or Russian-enriched uranium after the invasion of Ukraine.

Geopolitics of Global Uranium Supply Post-Invasion of Ukraine

Today, most uranium fuel powering U.S. nuclear reactors comes from Russia and its allies, Kazakhstan and Uzbekistan. This fuel represents roughly 10% of U.S. electricity production.[94] Russia's war on Ukraine has reinvigorated interest in increasing U.S. uranium mining and

establishing a U.S. Strategic Uranium Reserve. The Trump administration first proposed this reserve in 2020 at an initial level of $150 million to incent the production of more uranium.[95] In Fiscal Year 2021, Congress appropriated $75 million toward the establishment of the reserve.[96]

Congressional activity and interest in insulating the United States against reliance on foreign uranium has increased amid Russia's invasion of Ukraine. Senators have introduced legislation to ban Russian uranium imports and to authorize the Department of Energy to establish a Strategic Uranium Reserve, as well as to support the build-out of domestic uranium conversion and enrichment infrastructure.[97,98,]

In July 2022, the Department of Energy's National Nuclear Security Administration issued a Request for Proposals toward a Strategic Uranium Reserve. It plans to purchase up to 1 million pounds of domestically-produced uranium in storage at an existing conversion facility in Illinois toward a strategic uranium reserve.[99]

Tribal nations' leadership has expressed concerns about a potential increase in domestic uranium mining. A resumption of greater levels of domestic uranium mining might result in the reopening of the Pinyon Plain Mine in the Grand Canyon after a long hiatus. Past uranium mining projects in the Grand Canyon area pierced an aquifer that now pumps out water containing uranium and arsenic into a lined holding pond.[100] Potential contamination concerns the local Havasupai Tribe, which relies on the Grand Canyon watershed for survival. Members of the Navajo Nation have also expressed concern at the prospect of new uranium mines opening on their lands.[101] Meanwhile, as recently as 2020, companies proposed new uranium mines in the Black Hills area in South Dakota, an area sacred to the Lakota Tribes and other nearby tribal nations. If the uranium mines were to proceed there, concerns have been raised that the mine would use up to 8,500 gallons of groundwater per minute from the Inyan Kara aquifer, impacting the region's water quality and destroying ancient burial grounds.[102]

Environmental advocates argue that establishing a Strategic Uranium Reserve would run counter to the Biden administration's environmental justice goals, put taxpayers on the hook for propping up the domestic uranium mining industry, and place Indigenous and Western communities at the frontlines of further ecological harm.[103] Mining advocates argue that the

highest quality uranium in the U.S. is located in Northern Arizona, close in proximity to the Havasupai Tribal Nation and the Navajo Nation.[104]

A 2020 U.S. Department of Energy report evaluating the benefits of a Strategic Uranium Reserve proposed expediting environmental impact reviews on new uranium mines.[105] Under the National Environmental Policy Act and Executive Orders 13175 and 13007, government-to-government consultation with tribal nations is required before a significant federal project that may impact the nation's land and natural and cultural resources.[106] Historically, the tribal consultation process has often left their governments in the dark about projects until the last minute without meaningful opportunities to provide community input or consent.[107] Many tribes have complained that consultation is not designed for meaningful participation and sometimes consists solely of a phone call or an email notification without further discussion.[108] There are concerns that attempts to expedite the tribal consultation process will result in tribes having even less capacity to give feedback or informed consent on proposed uranium mines. Insufficient consultation practices could result in legal challenges to mine projects and slow new extraction.

The proposed reform of the General Mining Law under the Clean Energy Minerals Reform Act of 2022 could help address the potential community and environmental issues arising from expanding domestic uranium mining efforts. However, the bill only addresses minerals that the Interior Department lists as "critical," which currently excludes uranium. The Trump Administration listed uranium as a critical mineral under a 2018 executive order, a move that the U.S. Geological Survey reversed in 2021.[109] The Critical Minerals Classification Improvement Act of 2022, introduced in the House in June 2022, attempts to amend the definition of critical minerals to include fuel minerals such as uranium.[110]

Current Uranium Mining Practices

Conventional uranium mining involves creating a pit or shaft in rock to extract uranium ore from the ground, breaking up the uranium ore, and taking the ore offsite to treat the rock to extract the uranium ore. Until the early 1960s, all uranium extraction followed this method. Today, the most common way to mine uranium is in-situ leach mining, where miners leave ore

in the ground and recover the uranium through a chemical application.[111] This technique is a less environmentally impactful method of uranium extraction, as there is no need for large, open pits or explosives to extract uranium.

In-situ leach mining operations in the U.S. are permitted and regulated by the Nuclear Regulatory Commission (NRC) or the states through special agreements with the NRC. These mine operations "must obtain an aquifer exemption permit to degrade the quality of groundwater resources and an underground injection control permit from a state regulatory agency or the Environmental Protection Agency to pollute the groundwater during the mining operation." Although the NRC requires in-situ leach mine permits NRC to restore groundwater quality following mining, aquifers used in these mining operations cannot be used as a future underground source of drinking water, and remediation efforts can take decades. Environmental groups worry that even remediated groundwater will never return to pre-mining quality.[112] The Environmental Protection Agency has previously considered adopting stricter water quality protection standards for in-situ leach mining but has faced industry pushback.[113]

In-situ leach uranium mining near Crow Butte, Nebraska. Credit: U.S. Nuclear Regulatory Commission.

Beyond Uranium: Context for the Clean Energy Transition

Other clean energy minerals share some of the same sustainability and ethics issues as uranium. According to the International Energy Agency, solar power will require drastically increased production of aluminum, copper, and rare earth elements. Wind turbines will require more production of steel, iron, and rare earth elements. Electric vehicle (EV) batteries require lithium, cobalt, rare earth elements, and precious metals. The new transmission lines necessary to balance the grid will require significant amounts of copper.[114]

However, the International Energy Agency identifies nuclear energy as requiring the least mining activity compared to other forms of carbon-free energy (see Figure 1)

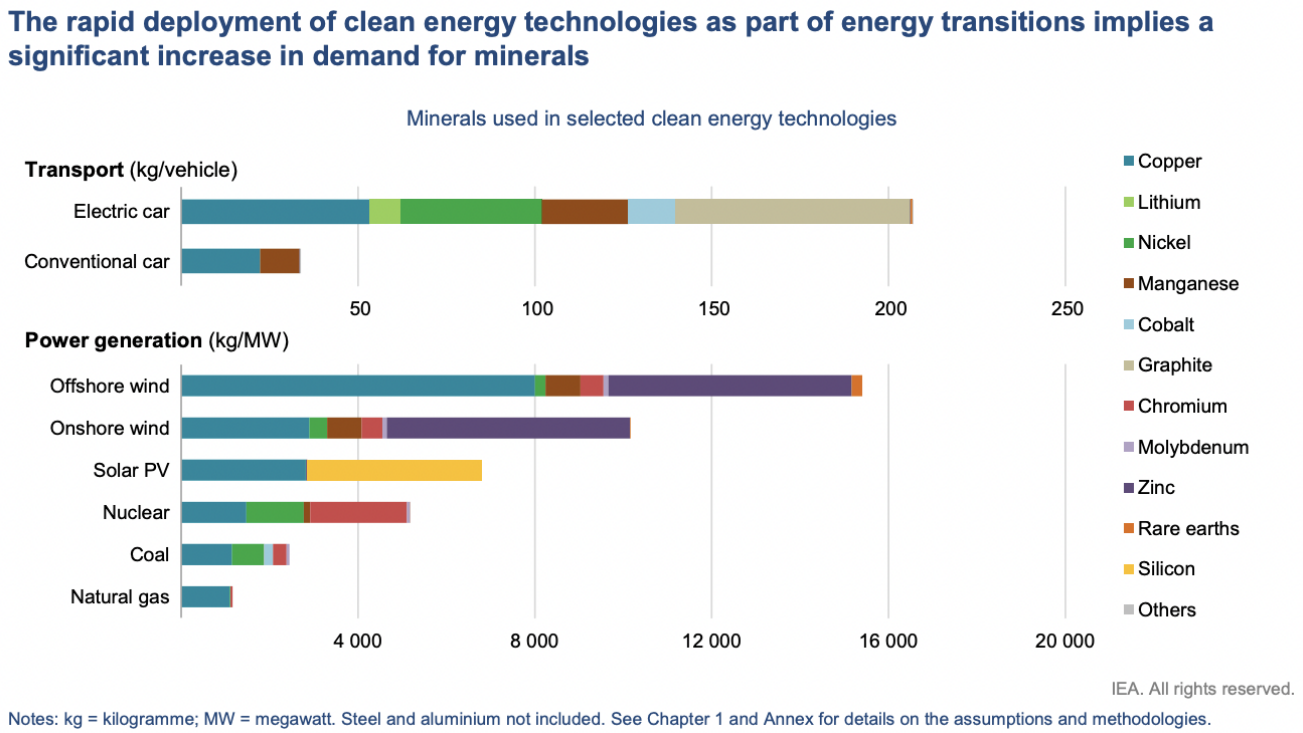


Figure 1. *Mineral Demands for Clean Energy Technologies. Credit: IEA 2022.*[115]

Like uranium, other elements critical to the clean energy transition face geopolitical threats. In light of global conflicts with Russia and growing tension with China, a bipartisan group of U.S. senators is supporting legislation on multiple fronts that ensure more secure domestic supplies of critical minerals. The U.S. relies heavily on China for raw mined materials and processing. There are concerns that China will use critical mineral supplies as a geopolitical

tool like Russia, which has withheld natural gas supplies from Europe in retaliation for sanctions. Stronger energy interdependencies with Canada have been proposed to combat reliance on China, including creating a more robust North American critical minerals supply chain through a "North American Energy Alliance."[116]

Mining projects for critical minerals and uranium mining have similarly faced community backlash from Indigenous communities and environmental advocates worried about impacts to water, biodiversity, and places of cultural and spiritual significance.[117] Efforts to expedite permitting for these mines have fueled further controversy. Currently, the extraction of critical elements like lithium faces domestic dissension. A proposed lithium mine at Thacker Pass in Nevada offers a glimpse into the dynamic challenges facing the efforts to revive the U.S. mining industry (see Appendix II for a case study on Thacker Pass Lithium Exploration).

Policy Recommendations

1. The Clean Energy Minerals Reform Act of 2022 (H.R. 7580) permitting system should be expanded to cover uranium mining.

Uranium mining should be included in the new mineral mining permitting systems proposed under the Clean Energy Minerals Reform Act of 2022 (H.R. 7580). Adding uranium to the list of covered minerals could help temper the potential environmental and community engagement issues with new uranium mining and alleviate some community concerns that the Strategic Uranium Reserve efforts may lead to exceptions to regulatory requirements meant to protect tribal nations and ecosystems and ensure mine reclamation. This would result in a more straightforward regulatory process for all mineral and hardrock mine leasing.

2. Efforts to increase domestic uranium production in the U.S. should require proper environmental safeguards and community engagement.

Some communities may be concerned that increased domestic uranium mining and production will carry exemptions to protective environmental laws. Community engagement should be prioritized, especially with tribal nations with a long and contentious history with uranium production.

3. Co-management with tribal nations for uranium projects on federal lands should be explored.

Past uranium mining occurred on sacred Indigenous sites and delicate ecosystems that have suffered irreversible impacts to the water, air, vegetation, and wildlife. To protect these areas from the impacts of new mining, the federal government and developers should work with tribes to allow more co-management of public lands and ensure that Indigenous communities have a say in whether an extractive industry is allowed near sacred sites. For example, in June 2022, the U.S. Bureau of Land Management and the U.S. Forest Service signed a cooperative agreement with the Hopi Tribe, Navajo Nation, Ute Mountain Ute Tribe, Ute Indian Tribe of the Uintah and Ouray Reservation, and the Pueblo of Zuni to share management responsibility of Bears Ears National Monument, a sacred location to the tribes.[118] Through this land management plan, tribal nations will have a say in how the sacred land in Bears Ears is used, as well as how and where the extractive industry will be allowed to operate within the boundaries of the monument. Such agreements should be explored for other federal public lands to ensure that new mining projects do not encroach on sacred sites.

4. Robust and meaningful tribal consultation should be required throughout the mine permitting process.

Tribal consultation is a legal requirement for the federal government to have government-to-government consultation with tribal nations when large infrastructure projects permitted by the federal government may encroach on a tribe's land, natural resources, or cultural resources. In January 2021, the Biden administration issued a memorandum directing all federal agencies to plan and engage in regular, meaningful, and robust consultation in the development of policies that have implications for tribal nations, including hardrock mining regulations.[119] Consultations and regulations on mining activity should achieve the free, prior, and informed consent of Indigenous communities through ongoing conversations and demonstrations with tribes during the permitting process.[120,121]

5. Federal agencies should prioritize new uranium mining and milling in supportive communities.

Federal agencies should work to identify, through public engagement, which communities are interested in hosting new uranium mining and milling projects. In these communities, permitting should be executed as efficiently and effectively as possible while still prioritizing environmental protection and environmental justice.[122]

6. The Environmental Protection Agency should adopt in-situ leach mining water quality monitoring standards.

To protect groundwater resources from contamination, the Environmental Protection Agency should adopt stricter standards for water quality protection, in line with its 2017 proposal, as soon as possible.[123] The 2017 proposed regulations would have created standards for aquifer testing, chemical use, monitoring, and water restoration,[124] and would have allowed in-situ leach mine operators to use computer models to monitor the aquifers—a concern for environmental groups.[125] Ideally, the Environmental Protection Agency would continue to require groundwater quality monitoring until the aquifer is restored to pre-mining standards. Public disagreement over the impact of the regulation on the mining industry was among the reasons the standards were not implemented in 2017.[126] Any new set of in-situ leach mining water quality standards should balance protection with efficiency.

III. The Future of Uranium Mining and Alternative Sourcing

Overview

While uranium mining standards have improved significantly since the 1940s, regulatory standards for other mining industries globally in the clean energy sector have lagged, causing concerns over potentially unsafe or illicit mining practices.

Government regulatory bodies are starting to lead the charge in implementing regulations to address some of the worst parts of mining through mineral import regulations, touching on supply chain issues such as child labor, human rights abuses, support for militant groups, and environmental degradation. Private voluntary standards are helping to incentivize the market to respond to demand for more ethical mining practices and transparency through supply chain auditing and reporting. Many new regulatory standards applicable to the mining industry started as voluntary industry group standards and created a framework for regulators to track the metrics of sustainable and ethical mining and align with regulatory requirements. Other voluntary standards have expanded beyond federal requirements. Together, both government and private sector mining and mineral sourcing standards are setting the stage for the future of a sustainable and more ethical mineral industry.

This section details how government regulatory standards and voluntary private industry standards inform ethical and sustainable mining. The section also explores how governments could expand these standards to include uranium and identifies opportunities to reduce the necessity of new uranium mining in line with environmental justice and sustainability.

Government Regulatory Standards for Mineral Supply Chains

Under U.S. and EU laws, publicly traded companies that use "conflict minerals, such as tin, tantalum, tungsten, and gold, must ensure that the minerals are ethically sourced. These minerals are considered high-conflict because many mining operations for these minerals, directly and indirectly, support militant groups, child labor, and other human rights and

environmental abuses.[127] Some EU member countries have their own standards that take mineral supply chain due diligence requirements that go even further, such as the newly promulgated Swiss Conflict Minerals and Child Labor Due Diligence law. The Swiss law requires companies to conduct due dilegence and report on conflict minerals supply chains to prevent child labor, creating additional obligations for global corporations doing business in Switzerland.[128,129] As Europe is a large share of the global demand for these minerals, their regulations help lift up international standards in the mineral supply chain. However, current U.S. and EU conflict mineral regulations do not cover all the minerals necessary for a clean energy transition, including uranium.

Successful implementation of conflict mineral standards in the U.S. and EU has the potential to shift global market standards and can serve as a case study for future mining and mineral import/export regulations. The EU Conflict Minerals Regulation went into effect in January 2021 and is intended to stop "conflict minerals and metals from being exported to the EU; global and EU smelters and refiners from using conflict minerals, and mine workers from being abused."[130] The regulation requires companies that work with high conflict minerals to establish strong company management systems. Such systems require them to conduct due diligence studies that trace the exact mine trace where the minerals were consolidated, traded, and processed. Third-party audits of the supply chain are also required.[131]

U.S. conflict mineral standards fall under Section 1502 of the Dodd-Frank Act, which requires publicly traded companies to ensure that their supply chains for high-conflict minerals from the Democratic Republic of the Congo and other African nations do not fund armed groups or human rights conflicts. Companies report annually to the U.S. Securities and Exchange Commission on their efforts to avoid those abuses.[132]

Nothing in these regulations prevents U.S. and EU companies from sourcing minerals from historically high-conflict countries. In fact, some global affairs experts say that complete divestment from high-conflict countries causes more harm for local communities and supplies a larger illicit market for minerals.[133] Conflict mineral regulations are intended to pressure high-conflict global mineral markets to comply with standards in human rights and environmental protection as a prerequisite for mineral imports and exports.

The EU is also leading the charge in using technology to change the way the global battery mineral supply chain operates. The bloc has proposed regulations to ensure that all batteries that enter the EU market are sustainable and safe throughout the battery's life-cycle—from mining and manufacturing to marketing and recycling—through a Battery Passport System.[134] The Battery Passport would operate like a unique digital ID for each battery and provide information on the sourcing of battery elements.[135] The implementation of Battery Passports in the EU can serve as a case study for best practices in the use of digital tracing technology for mineral supply chains. It will likely set the stage for other mineral supply chain tracing efforts.

EU and U.S. regulations around conflict minerals are some of the first steps to align the mining industry and mineral supply chains with sustainable and ethical business practices. The EU Battery Passports also serve as an example of how mineral tracing technology may operate in the regulatory space in the future. Other countries have been working on the ground to ensure that mining projects operate ethically by allowing the community to have a say in the projects well before mines are permitted.

Community Engagement in the Mining Process Creates a Social License to Operate

Meaningful community engagement and long-term local investments are necessary steps for mining operators to undertake to build trust. Many communities reject mine projects because of legacy mining issues that remain in their communities. Historically, many communities have felt frustrated that they lacked the option to provide their consent to mining projects or meaningfully engage with mining companies to ensure that miners would provide sustainable economic investment in their community rather than short-term economic gains.

Canada's uranium mining and milling stakeholder engagement process exemplifies how miners can achieve both meaningful community engagement and timely mine permitting. In Canada, mining laws require project proponents to engage the community to learn about all the interests and issues at stake and prepare an outline before the licensing process begins.[136] Every part of the mineral process—from pre-exploration, exploration, development, operation, closure, and post-closure—involves the nearby community through work plans and

community agreements.[137] Canada also requires consultation with Indigenous groups when their rights may be affected by the government, and the country passed a law in 2021 to require provincial governments to follow the UN Declaration of Indigenous Peoples, which requires the free, prior, and informed consent of Indigenous communities before government projects begin.[138] The country has also implemented the OECD Due Diligence Guidance for Meaningful Stakeholder Engagement in the Extractive Sector, which works to ensure that extractive industries respect the rights of Indigenous people, minorities, and women. With these protections in place, the average permitting process for mines in Canada lasts about 2-3 years, compared to 7-10 years in the United States.

Mine-Community Conflict Resolution Through Public-Private Partnerships

In a community conflict with mining operations, equity issues may arise between mining companies and under-resourced communities. Many communities that host mines do not have the means to litigate when a problem arises because of a lack of funds to access legal assistance or informational disparities due to the technical nature of mining issues. Mining companies also feel the blow from community conflict that can lead to costly delays or project cancellations.

An Example from Brazil: Funding Community Engagement and Conflict Resolution with Mine Operators

The U.S. Agency for International Development, the Amazon Conservation Team, and the mining company Mineração Rio Norte established in 2019 the *Quilombola Fund,* which is an excellent example of how to address community mining conflicts equitably.[139] The Quilombola are descendants of enslaved people in Brazil, whose ancestors mostly worked in mines and sugarcane plantations. The Quilombola community has a long history of conflict with the extractive industry. The intention of the Quilombola Fund is to create community development agreements between mining companies and the community to directly address priorities identified by the Quilombola themselves through Life Plans.[140] The fund has resulted in contributions to public institutions and infrastructure such as schools and hospitals, roads, cultural and environmental conservation, and the cost of community participation in the plans.[141] The fund also includes provisions for funding community members to air grievances

with mining companies and provides access to lawyers and technical assistance. The hope is that with this mechanism in place for the communities to directly collaborate with the mining companies on community priorities and economic investment in the community will be long-term and help disentangle conflicts that do arise. Such community funds, while often requiring an upfront capital investment, offer a path forward for mining companies to earn a social license to operate – especially in communities like Quilombola that have a long history of mistrust in mining operations.

Private Voluntary Standards for Mineral Supply Chains

Voluntary mining standards set by membership and certification organizations are also instructive on how community engagement and investment can contribute to improvements in the sustainability of mineral supply chains overall (See Appendix I for a list of voluntary standards). Voluntary membership organizations and private certification bodies allow mining companies, mineral processors, manufacturers, and utilities to certify that they source the minerals they use sustainably and ethically. Many institutions developed voluntary standards primarily to help companies track the origins and movement of high-conflict minerals such as tin, tungsten, tantalum, gold.[142] Specific standards for minerals such as cobalt, lithium, copper, mica, steel, and mineral processors are evolving.[143,144,] While no such standards for uranium supply chains exist yet, the World Nuclear Association has worked since 2017 to create a checklist for "Sustainable Development Performance of Uranium Mining and Processing Sites" reporting for members to ensure future uranium production is ethical and sustainable.[145]

Elements of voluntary standards include:

- Due diligence requirements for senior management;
- Identifying "red flags" in the supply chain;
- Performance evaluations;
- Stakeholder engagement requirements;
- Community grievance mechanisms;
- Systems for control and transparency;
- Supplier engagement;
- Human rights standards;

- Environmental standards;
- Reporting requirements; and
- Third-party auditing requirements

Many voluntary membership organizations issue certifications that can be published in a company's annual financial, environmental, and social governance reports or added to product labels to prove sustainable and ethical sourcing.

For example, one of the most well-known voluntary membership organizations in the mineral supply chain world is the Responsible Minerals Initiative (RMI). RMI has multiple voluntary standards for high-conflict materials such as cobalt, copper, lead, nickel, zinc, tin, tantalum, and gold.[146] In December 2021, RMI launched an "All-Minerals standard," which applies to all mineral supply chains.[147] RMI uses these standards to set operational and procedural standards for companies all along the supply chain, from miners to smelters and manufacturers. RMI-approved audit firms use these standards to determine whether a member company has followed the due diligence requirements of the Organisation for Economic Co-operation and Development (OECD).[148]

The OECD sets voluntary standards for responsible business conduct across various industries and covers issues including human rights, labor rights, and environmental standards. The group has also established a government-backed process to address complaints between OECD-covered companies and individuals impacted by irresponsible business conduct. Under the OECD guidelines, every group or government body that adheres to the standards must identify a National Contact Point (NCP) to handle complaints.[149]

The goal of these standards is to change company behavior to be more diligent about ensuring ethical supply chains and giving people a way to air grievances against unethical and unsustainable mining operations.[150] The standards also require companies to take direct action to ensure that mining and processing operations are sustainable and ethical, or risk being delisted as a compliant company. The risk of being delisted as a compliant company operates a punitive measure and has been quite effective in practice. According to case studies on the impact of voluntary standards used for a few cobalt mines in the Democratic Republic of

Congo, voluntary standards resulted in marked improvements in the mineral supply chain, reducing bribery, child labor, and environmental impacts.[151]

What metrics can be used to track sustainable and ethical mining mineral supply chains?

Mining companies are facing increasing community scrutiny and pressure not only to commit to operating ethically and sustainably but to back up those claims with metrics. Communities are increasingly becoming mining industry watchdogs through faster and easier access to mining activity information. More investment firms are starting to divest from businesses that have negative environmental and social impacts.[152]

For example, RMI compiles a list of compliant refiners and smelters that are audited and assessed.[153] While RMI member companies are not directly audited, member companies ask RMI to audit their supply chains to determine if they are in compliance with the standards. This means mineral suppliers and smelters can be delisted as a compliant entity if there are red flags in the supply chain from an environmental and social standpoint. If member companies want to remain in compliance with RMI standards, they need to work with their suppliers to correct these issues in the supply chain or remove the offending suppliers from their supply chain altogether – or risk being delisted as compliant companies themselves. This creates considerable market pressure to ensure all elements of the supply chain remain compliant with sustainable and ethical business practices. This system, which leverages a business' reputation, tends to be more effective than a monetary fine system, which many large companies could easily pay without any changed behavior.[154]

Many companies are also looking to blockchain technology to track their mineral supply chains to ensure compliance with mineral regulations and to provide greater transparency to consumers. Blockchain technologies enable companies to track transactions and data points through a closed network in a way that cannot be changed once inputted. This allows users to track the location and status of minerals from the mine to the smelter or processor, to the manufacturer, and ultimately to the consumer.[155]

Minespider is one example of blockchain technology leading the charge in mineral supply chain traceability. Minepsider's blockchain development began in 2018 in Germany, and was supported by companies such as Google, Volkswagen, Cisco, SGS, and Minsur mining company to track the movement of tin from Minsur's San Rafael mine in Peru to the smelter, manufacturers, and the consumer.[156] In 2020, the Minespider project expanded its end-to-end traceability concept to Rwanda's Great Lakes Region and partnered with RMI, LuNa Tin Smelter in Rwanda, and the Rwanda Mines, Petroleum, and Gas Board.[157] The Minepsider app creates blockchain digital IDs via QR codes called Product Passports to track mineral movements at each link of the supply chain.[158] The passports show data on where the minerals came from and information about the material's due diligence and emissions.[159] This data can be used by companies as a cross-market accountability metric and to demonstrate compliance with the EU, U.S., and other countries' regulations on conflict minerals. It also helps to publicly bolster companies' social and environmental reputation in the eyes of investors and consumers.

Alternative Mineral Sourcing May Reduce the Need for New Mining

Today, extracting new minerals like uranium is often much cheaper than reusing and recycling them. However, new mines carry long-term environmental costs. While stronger standards could improve the sustainability of mining activities, alternative sourcing of minerals could reduce the number of new mines required to support the clean energy transition. Methods of sourcing will vary by mineral, but for nuclear fuels, options include: reprocessing mine waste at abandoned mines, reprocessing spent nuclear fuel, extracting uranium from seawater, and downblending weapons-grade nuclear material for new nuclear power plant fuel.

Uranium mine tailings (greenish dirt) at the old Shinarup Mine close to Moab, Utah. Credit: Foreade, Mar. 8, 2020.

Project Spotlight: Legacy Mine Remediation Efforts that Re-Mine and Reprocess Waste

Sustainable re-mining of existing mine sites is demonstrable today. The Salmon Gold project incubated by RESOLVE, an NGO focused on mediating solutions to environmental issues, has created a new way to sustainably source gold and restore critical salmon habitat. The Salmon Gold project remediates former gold mines that have damaged streams crucial to salmon migration while producing new gold for consumer electronics and jewelry. The project works with miners and local communities to find historical gold mining sites and re-open them with responsible practices. Stream restoration and the establishment of new vegetation are the main focus, while modern mining techniques can extract new gold with minimal impact. These practices leave the areas in better shape than before, restoring salmon migratory patterns and removing hazardous mined material that was previously blocking streams.[160] After mining, the gold undergoes extensive chain-of-custody documentation before going to the refiner to ensure that the materials are high quality and fully abide by the standards of the project. Apple and Tiffany & Co. were the first companies to use Salmon Gold in their products.[161] While this process has only been applied to two pilot sites, this method could be expanded further once the process is refined.

Re-mining efforts at abandoned mine sites are also taking off as a possible win-win for addressing legacy mine sites that require remediation but still contain valuable minerals and

rare earth materials. One example of private remediation efforts focused on re-mining as a means of alternative mineral sourcing is the Regeneration Project. This project emphasizes re-mining abandoned mine sites to obtain minerals and rare earth materials from mine tailings, waste rock, and water.[162] The global mining giant Rio Tinto recently invested $2 million for Regeneration to assess 100 of their legacy mine sites in the U.S.[163,164] The goal of the project is to use earnings from selling the re-mined minerals to support habitat restoration and closure work at the sites.[165] Ideally, community members will also be active participants in the restoration process and benefit from economic investment through job creation and restoration of recreation areas.

Mineral reprocessing projects at legacy mine sites could expand in the next few years with reform of the Good Samaritan initiative that would limit liability for volunteer groups and NGOs that wish to conduct remediation work at abandoned mine sites. Mining companies could also look at re-mining legacy mine sites, whether or not they are the original project proponents, as a creative way to source raw materials and build social goodwill with communities suffering from legacy pollution.

Reprocessing Spent Nuclear Fuel

Reprocessing or recycling spent nuclear fuel could be one way to help reduce the need for new uranium mining. Currently, France, Japan, Germany, and Switzerland recycle spent nuclear fuel from nuclear reactors. If nuclear fuel recycling occurred in the U.S., reprocessed spent nuclear fuel could power the global fleet of nuclear reactors for at least one hundred years.[166] Paired with advanced reactor technology, recycling spent fuel could power reactors for thousands of years.[167] Former Nuclear Regulatory Commission Commissioner and current Director-General of the OECD Nuclear Energy Agency, William Magwood, has argued that reprocessing makes sense to deal with nuclear waste in the absence of a permanent geologic waste repository like the one formerly proposed for Yucca Mountain in Nevada and would reduce the volume of waste needed to be stored permanently by 80 percent.[168] Reprocessing waste also reduces the amount of time the waste is radiotoxic, making long-term storage of spent nuclear fuel less hazardous.[169]

The main hurdles to nuclear fuel recycling are cost and the risk of nuclear proliferation. Reprocessing spent fuel often isolates weapons-grade plutonium, which can be used to make nuclear weapons. Processing raw uranium remains the cheapest and easiest option for powering nuclear reactors in the U.S. The potential long-term environmental costs of new uranium mining paired with the imperative of addressing the nuclear waste storage stalemate, however, make investments in U.S. reprocessing capabilities and facilities worth a second look.

Downblending Weapons-Grade Nuclear Material

Through the Megatons to Megawatts program, Russia converted 500 tonnes of weapons-grade uranium (the equivalent of 20,000 nuclear warheads) into fuel for U.S. reactors.[170] Over a 20-year history, 10 percent of U.S. electricity came from former Russian weapons material.[171] A similar project in the U.S. to turn 34 tonnes of weapons-grade material into mixed-oxide (MOX) fuel was canceled in 2018.[172] Rough estimates suggest that the U.S. has over 400 tonnes of highly enriched uranium (HEU) available, which could be used in advanced reactors needing high-assay low enriched uranium (HALEU) fuel, or downblended further to low enriched uranium (LEU) fuel.[173] As advanced nuclear reactor projects in the U.S. and worldwide are eager to ensure there is a stable supply of HALEU fuel from sources other than Russia, restarting projects for downblending weapons-grade nuclear material should be on the table domestically and in other democratic countries with large stockpiles of nuclear weapons.

Uranium Extraction from Seawater

The Pacific Northwest National Laboratory and Oak Ridge National Laboratory have demonstrated extracting uranium from seawater. Japan is also investigating the process.[174] Proponents of this method say that seawater uranium extraction makes nuclear power "completely renewable."[175] The process requires no digging or earth extraction. However, the cost is high: Current estimates place the cost at $557 per pound of a particular uranium compound. While this option is not economically competitive compared to land-based mining, uranium extraction from seawater may be worth further developing as a hedge against supply disruptions. Seawater extraction of other minerals and metals such as magnesium, lithium, aluminum, iron, gold, and lead, is also possible.[176]

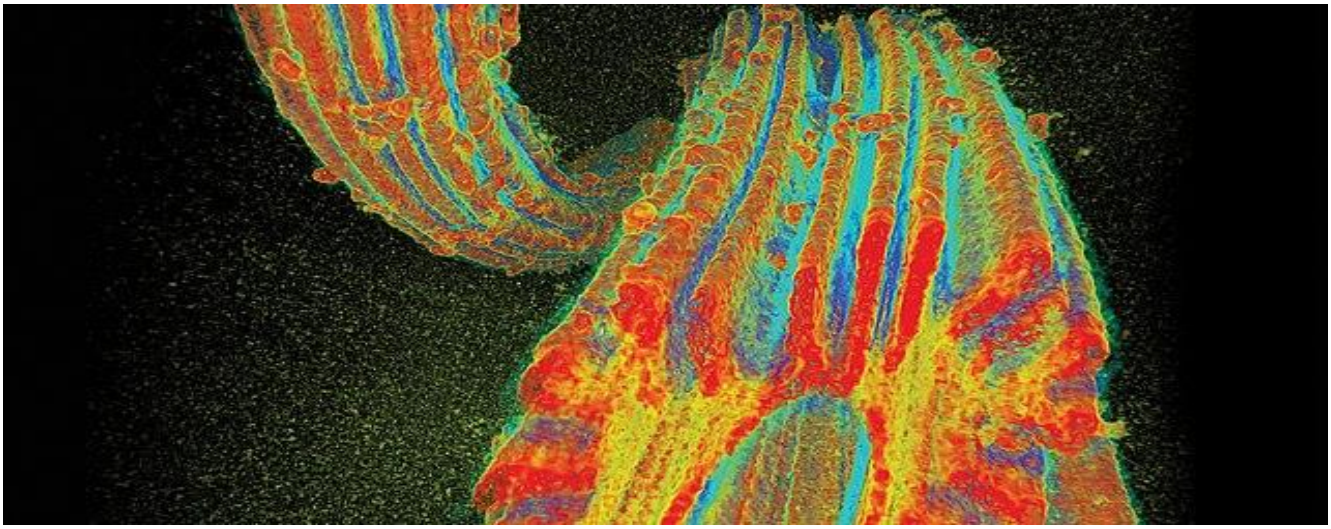


Image of fibers designed to absorb uranium from seawater, in research conducted by the Pacific Northwest National Laboratory. Credit: Oak Ridge National Laboratory.

Current and Proposed U.S. Policies Around Alternative Mineral Sourcing

The U.S. Department of Energy's Advanced Research Projects Agency-Energy has issued $36 million in grants for applicants seeking to find creative ways to reduce waste from nuclear reactors, including studying safer ways to reprocess spent nuclear fuel to be reused in advanced nuclear reactors.[177] While it's unclear whether the U.S. will develop nuclear fuel reprocessing capacity, these projects could reduce the need for new uranium mining as new reactor projects come online.

Policy Recommendations

1. Conflict minerals standards must evolve to capture other mineral supply chains and potential issues in human rights, environmental degradation, and community economic development.

While some voluntary standards seek to cover all mineral supply chains, many government standards have yet to capture all minerals necessary for the carbon-free energy transition and have focused primarily on high-conflict minerals such as tin, tungsten, tantalum, and gold. Additional government standards will be necessary to cover the cultivation, import, and sale of minerals such as uranium, lithium, cobalt, nickel, and other rare earth elements essential for the carbon-free energy transition. In theory, laws such as Section 1502 of the Dodd-Frank

Act could be expanded to create due diligence requirements for all mineral supply chains, including uranium. More regulatory tools similar to Battery Passports that track the movement of minerals from mine to consumer could also be expanded to encompass all mineral supply chains and assist in due diligence requirements. In practice, these types of regulations could help to prevent materials from all types of unethical mining operations from entering the global supply chain.

2. New mine permitting should require strong community engagement.

High levels of domestic mistrust in mining should motivate better mechanisms for miners to gain community trust and support for new projects. Community backlash and legal challenges against mining projects contribute toward much of the delay in launching new mine operations. U.S. policymakers can consider implementing a regulatory process similar to Canada's requirements on mining companies to earn community support and address possible concerns before permitting is considered. According to Canada's Guide on Good Practices in Community Engagement and Readiness for the Mineral and Metals Mining sector, building relationships with the community at every step of mineral development, from pre-exploration to closure to post-closure, is crucial to reducing risks, delays, and having the optimal outcome in mining projects. Proponents of strong community engagement argue that communities involved in a project are more likely to work towards its success. Canada emphasizes the need for early, effective engagement with First Nations and communities during the planning stages of mining projects.[178]

In the U.S., community engagement requirements for mining projects are usually limited to tribal consultation and a short public comment period for the wider community to give input. However, the community engagement piece feels hollow for many stakeholders, as engagement tends to occur when the project is already far along in the approval process, and project developers often do not need to change anything about the proposed project based on community feedback.

The Clean Energy Minerals Reform Act of 2022 appears to outline special tribal consultation requirements that must occur before the federal government spends money or issues permits.

However, these requirements could go a step further and require wider community engagement throughout the entire process. This could look like a requirement to create a formal agreement with the community affected by a proposed project that guarantees a certain percentage of local labor would be used, and a portion of profits would be invested in community needs. Lawmakers could also consider requiring developers to conduct biodiversity restoration in consultation and collaboration with the community. Canada's regulatory requirements for mine permitting can be used as an instructive model of how to incorporate community engagement and planning throughout the mine permitting process.

3. Mining proponents should explore creating community benefit agreements and conflict resolution funds in communities where new uranium mines are proposed.

As the land mass for new domestic uranium mining in the U.S. is limited, community support of mines will be make-or-break for new projects. In other mineral-rich communities that have faced challenges with the mining industry, mine operators have found success by creating community benefit agreements and conflict resolution funds to help equitably address conflicts between mine operations and the community. The Quilombola Fund established in Brazil is an example of how private industry mine operators can create partnerships with the community to provide long-term monetary support for regional land management and strengthening public institutions.

4. Mining companies and mineral processors should work to make uranium supply chains as transparent as possible through blockchain technology.

The use of blockchain technology in the mining and mineral processing industry has been demonstrated as a viable tool for transparency in the mineral supply chain. As mineral supply chains have become more complex than ever, and more regulatory bodies are requiring corporate due diligence in every link the supply chain, traceability technology will be crucial to ensuring mineral supply chains are operating ethically and sustainably.

Blockchain technologies can also help serve as the foundation for future government regulatory systems, as demonstrated by the EU's adoption of Battery Passport technology to allow regulators to trace minerals from mine to smelter and manufacturer to end-of-life

recycling. As the uranium mining industry has many complexities, from the potential for human rights issues, environmental degradation, and use in weapons, close monitoring of the uranium supply chain through traceability technology like blockchain could help build trust for communities and regulators that new uranium mining can be achieved sustainably, ethically, and safely.

5. Where possible, policymakers working to establish a U.S. Strategic Uranium Reserve should also identify alternative sources of uranium that minimize the need for new mining.

U.S. lawmakers and the Department of Energy seek to create a Strategic Uranium Reserve to ensure a steady supply of uranium for use in nuclear energy and national security purposes. In light of environmental justice concerns, efforts for the Strategic Uranium Reserve should be paired with investments in alternative sourcing including reprocessing spent nuclear fuel from domestic power plants, downblending weapons-grade nuclear material, extracting uranium from seawater, or re-mining abandoned mine waste.

Conclusion

To fight climate change, the world will need to transition global energy systems away from fossil fuel-based energy to carbon-free energy sources, including nuclear. There is growing concern that the mining required for clean energy minerals and fuels like uranium will not be conducted sustainably and ethically. Uranium, in particular, has had a long and contentious history of public health impacts in marginalized communities and will need to reckon with that past for nuclear power to be accepted as a source of clean energy.

The future of the uranium mining industry will hinge on sustainable use of resources and community support for mining projects. Mining does not need to be destructive to communities. Mining can be rethought to include cleaning up the dirty legacy of mining's past, protecting the environment, and investing in the community. Policymakers can identify and support activities that reduce demand for new mining.

There is growing interest in government and voluntary standards that ensure mining companies operate ethically and sustainably, and invest in the community long-term. However, uranium operations in the U.S. still have a long way to go to build community trust and support. Voluntary and private-sector standards for high-conflict minerals offer policymakers lessons for creating and securing sustainable and ethical supply chains. Likewise, successful community consultation practices and community benefit agreement negotiations offer a blueprint for mining project developers to earn trust and support for new projects. Alternative mineral sourcing options could reduce public health and environmental impacts while securing U.S. uranium supplies.

Achieving sustainable and ethical uranium mining globally will require policymakers, private industry, and environmental advocates to work together to find shared solutions that enable a clean energy transition that can slow the effects of climate change while also protecting ecosystems and empowering communities.

Endnotes

Introduction

[1] "Statistical Review of World Energy | Energy Economics" BP Global, https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html. Accessed Aug. 24, 2022.

[2] International Energy Agency, Nuclear Power and Secure Energy Transitions, (2020), https://iea.blob.core.windows.net/assets/0498c8b8-e17f-4346-9bde-dad2ad4458c4/NuclearPowerandSecureEnergyTransitions.pdf

[3] Where Our Uranium Comes from - U.S. Energy Information Administration (EIA). https://www.eia.gov/energyexplained/nuclear/where-our-uranium-comes-from.php. Accessed Aug. 24, 2022.

[4] Environmental Contamination from Uranium Production Facilities and their Remediation, International Atomic Energy Agency (2004), https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1228_web.pdf.

[5] "Nuclear Power Is Not Clean or Green!" Public Citizen, https://www.citizen.org/article/nuclear-power-is-not-clean-or-green/. Accessed Aug. 24, 2022.

[6] Uranium: The Problem, Center for Biological Diversity, https://www.biologicaldiversity.org/programs/public_lands/energy/dirty_energy_development/uranium/index.html . Accessed Aug. 24, 2022.

[7] International Energy Agency, "Executive Summary – The Role of Critical Minerals in Clean Energy Transitions – Analysis." https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/executive-summary. Accessed Aug. 24, 2022.

[8] As of February 24, 2022, the U.S. has identified the following minerals as critical minerals: aluminum, antimony, arsenic, barite, beryllium, bismuth, cerium, cesium, chromium, cobalt, dysprosium, erbium, europium, fluorspar, gadolinium, gallium, germanium, graphite, hafnium, holmium, indium, iridium, lanthanum, lithium, lutetium, magnesium, manganese, neodymium, nickel, niobium, palladium, platinum, praseodymium, rhodium, rubidium, ruthenium, samarium, scandium, tantalum, tellurium, terbium, thulium, tin, titanium, tungsten, vanadium, ytterbium, yttrium, zinc, and zirconium. Federal Register, Vol. 87, No. 37, (February 24, 2022), https://www.govinfo.gov/content/pkg/FR-2022-02-24/pdf/2022-04027.pdf.

[9] "FACT SHEET: Securing a Made in America Supply Chain for Critical Minerals." The White House, (Feb. 22, 2022), https://www.whitehouse.gov/briefing-room/statements-releases/2022/02/22/fact-sheet-securing-a-made-in-america-supply-chain-for-critical-minerals/.

I. Uranium Mining's Legacy in the United States

[10] U.S. Government Accountability Office. Hardrock Mining on Federal Lands. Accessed Aug. 24, 2022. https://www.gao.gov/hardrock-mining-federal-lands.

[11] Carl J. Meyer, The 1872 Mining Law: Historical Origins of the Discovery Rule, The University of Chicago Law Review, (1986), pp. 624- 627, https://chicagounbound.uchicago.edu/cgi/viewcontent.cgi?article=4467&context=uclrev

[12] 1872 Mining Law Fact Sheet, EarthWorks, (March 21, 2019) https://earthworks.org/wp-content/uploads/2021/09/FS_1872MiningLaw_EW-EJ-WORC_201903.pdf.

[13] 43 CFR § 3802.1-3 Operations existing on October 21, 1976; 43 CFR § 3802.2 Bond requirements. *See* 40 CFR § 3802.1-1. https://www.ecfr.gov/current/title-43/subtitle-B/chapter-II/subchapter-C/part-3800.

[14] US Environmental Protection Agency, OECA. Fact Sheet: Good Samaritan Administrative Tools. 6 June 2013, https://www.epa.gov/enforcement/fact-sheet-good-samaritan-administrative-tools.

[15] 42 U.S.C. §4321, The National Environmental Policy Act.

[16] Technical Document: Background for National Environmental Policy Act (NEPA) Reviewers on Non-Coal Mining Operations, (December 1994), pp. 1-6. https://www.epa.gov/sites/default/files/2014-08/documents/non-coal-mining-background-pg.pdf; 16 U.S.C. §1531, The Endangered Species Act; 54 U.S.C. §300101, The National Historic Preservation Act.

[17] 43 CFR § 3802.0-6 Policy. https://www.ecfr.gov/current/title-43/subtitle-B/chapter-II/subchapter-C/part-3800

[18] United States Government Accountability Office, ABANDONED HARDROCK MINES: Information on Number of Mines, Expenditures, and Factors That Limit Efforts to Address Hazards, (March 2020), https://www.gao.gov/assets/gao-20-238.pdf

[19] Ibid.

[20] Bureau of Land Management Abandoned Mine Lands Program, Feasibility Study for AML Inventory Validation and Physical Safety Closures, July 2013, pp. 17-19. https://www.blm.gov/sites/blm.gov/files/uploads/AML_PUB_Closures.pdf

[21] Environmental Protection Agency, Cleaning Up the Nation's Waste Sites: Markets and Technology Trends (2004), https://nepis.epa.gov/Exe/ZyPDF.cgi/30006II3.PDF?Dockey=30006II3.PDF.

[22] Library of Congress, California as I Saw It: First-Person Narratives of California's Early Years, 1849 to 1900: The Mines, Accessed Aug. 24, 2022.

[23] Atomic Heritage Foundation, Nuclear Power Today, (June 15, 2017) https://www.atomicheritage.org/history/nuclear-power-today

[24] Judy Pasternak, Yellow Dirt: An American Story of a Poisoned Land and a People Betrayed, Free Press, (2010), pp. 56-58.

[25] Moab Gear Trader, The Radioactive History of Moab, (January 11, 2022)

https://moabgeartrader.com/2019/11/30/uranium-mining-history-the-moab-area/#:~:text=During%20the%201940s%20and%201950s,similar%20to%20California's%20Gold%20Rush.

[26] U.S. Environmental Protection Agency, Region 09. Navajo Nation: Cleaning Up Abandoned Uranium Mines. (July 2015), https://www.epa.gov/navajo-nation-uranium-cleanup.

[27] Doug Brugge PhD, MS, and Rob Goble PhD, The History of Uranium Mining and the Navajo People, (2002) https://ajph.aphapublications.org/doi/10.2105/AJPH.92.9.1410

[28] The term Leetso translates to "yellow dirt" in the Navajo language. It also has a connection to ancient Navajo creation stories. See: "Leetso, the Powerful Yellow Monster" - by Esther Yazzie-Lewis and Jim Zion / Healthcare / In Motion Magazine. https://www.inmotionmagazine.com/hcare/db_npum.html. Accessed 7 July 2022.

[29] U.S. Environmental Protection Agency, Abandoned Mine Lands, (July 29, 2021) https://www.epa.gov/superfund/abandoned-mine-lands.

[30] Morales, Laurel. "For The Navajo Nation, Uranium Mining's Deadly Legacy Lingers." NPR, 10 Apr. 2016. NPR, https://www.npr.org/sections/health-shots/2016/04/10/473547227/for-the-navajo-nation-uranium-minings-deadly-legacy-lingers.

[31] Brugge, Doug, and Rob Goble. "The History of Uranium Mining and the Navajo People." American Journal of Public Health, vol. 92, no. 9, Sept. 2002, pp. 1410–19. PubMed Central, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3222290/.

[32] U.S. Environmental Protection Agency, Ten Year Plan to Address Impacts of Uranium Contamination on the Navajo Nation, (2020). pp.11. https://www.epa.gov/sites/default/files/2021-02/documents/nnaum-ten-year-plan-2021-01.pdf

[33] U.S. Government Accountability Office, URANIUM CONTAMINATION: Overall Scope, Time Frame, and Cost Information Is Needed for Contamination Cleanup on the Navajo Reservation, (May 2014), https://www.gao.gov/assets/gao-14-323.pdf

[34] Ophelia Watahomigie-Corliss, Uranium mining threatens our home, the Grand Canyon, High Country News, (April 14, 2020) https://www.hcn.org/articles/indigenous-affairs-mining-uranium-mining-threatens-our-home-the-grand-canyon.

[35] Camila Pedrosa, Uranium Mine near Grand Canyon Permitted by Court, Despite Mining Ban, Cronkite News, (February 22, 2022) https://cronkitenews.azpbs.org/2022/02/22/uranium-mine-near-grand-canyonpermitted-by-court-despite-mining-ban/.

[36] Joanna Walters, In the Grand Canyon, Uranium Mining Threatens a Tribe's Survival, the Guardian (July 2017) https://www.theguardian.com/environment/2017/jul/17/grand-canyon-uranium-mining-havasupai-tribewater-source.

[37] Lakota Mall, History and Ancestry of the Lakota People, (2017) https://www.lakotamall.com/history-and-ancestry/

[38] Lilias Jones Jarding, Ph.D., Uranium Activities Impacts on Lakota Territory, (March 2010) http://www.cleanupthemines.org/wp-content/uploads/2013/11/URANIUM-IMPACTS-IN-LAKOTATERRITORY.pdf

[39] Atomic Heritage Foundation, Grand Junction, CO. https://www.atomicheritage.org/location/grand-junction-co. Accessed 11 July 2022.

[40] "Uranium Legacy Issues In New Mexico." New Mexico Bureau of Geology & Mineral Resources, https://geoinfo.nmt.edu/resources/uranium/legacy.html. Accessed Aug. 24, 2022.

[41] "The Water around a Utah Uranium Mill Is Growing More Polluted. What Does It Mean for the Nearby Town?" The Salt Lake Tribune, https://www.sltrib.com/news/environment/2018/10/21/ute-tribal-members-living/. Accessed 12 July 2022.

[42] Environmental Protection Agency, (August 2000), Abandoned Mine Site Characterization and Cleanup Handbook https://www.epa.gov/sites/default/files/2015-09/documents/2000_08_pdfs_amscch.pdf

[43] Worker Health Study Summaries - Uranium Miners | NIOSH | CDC. 22 Oct. 2021, https://www.cdc.gov/niosh/pgms/worknotify/uranium.html

[44] Judy Pasternak, Yellow Dirt: An American Story of a Poisoned Land and a People Betrayed, Free Press, (pp. 70-79), (2010)

[45] United States Government Accountability Office, URANIUM CONTAMINATION: Overall Scope, Time Frame, and Cost Information Is Needed for Contamination Cleanup on the Navajo Reservation, (pp. 1, 15, 26)(2014), https://www.gao.gov/assets/gao-14-323.pdf

[46] U.S. Environmental Protection Agency, *Radionuclide Basics: Uranium,* https://www.epa.gov/radiation/radionuclide-basics-uranium. Accessed Aug. 24, 2022.

[47] Virginia, Committee on Uranium Mining in, et al. Potential Human Health Effects of Uranium Mining, Processing, and Reclamation. National Academies Press. (2011). National Institute of Health: National Center for Biotechnology Information, https://www.ncbi.nlm.nih.gov/books/NBK201047/.

[48] Doug Brugge PhD, MS, and Rob Goble PhD, The History of Uranium Mining and the Navajo People, (2002) https://ajph.aphapublications.org/doi/10.2105/AJPH.92.9.1410

[49] International Atomic Energy Agency, Hu Ruixia, Gao Bai, Hu Baoqun, & Feng Jiguang, Migration of heavy metals in soils in a uranium mining area. Uranium Mining and Metallurgy, (2009) https://inis.iaea.org/search/search.aspx?orig_q=RN:42086619

[50] Sullivan, Sharon, et al. "Uranium Mill Tailings Legacy Continues." Colorado Newsline, 7 June 2021, https://coloradonewsline.com/2021/06/07/uranium-mill-tailings-legacy-continues/.

[51] Film Club: The Return of Navajo Boy | Good Energy Collective, (May 10, 2022), http://www.goodenergycollective.org/policy/film-club-the-return-of-the-navajo-boy

[52] Dixon, Earle Campbell. Hydrogeology and ground-water quality in the Sanders area, western Puerco River basin, Arizona. Diss. University of Nevada, Las Vegas, (1990)

[53] Webb, Robert H., Glenn R. Rink, and Dean B. Radtke. Preliminary assessment of water quality in the alluvial aquifer of the Puerco River Basin, northeastern Arizona. Vol. 87. No. 4126. Department of the Interior, U.S. Geological Survey, 1987.

[54] Film Club: The Return of Navajo Boy | Good Energy Collective. (May 10, 2022) http://www.goodenergycollective.org/policy/film-club-the-return-of-the-navajo-boy.

[55] "Navajo Nation President Jonathan Nez Supports Grand Canyon Protection Act and Ban on Uranium Mines", Navajo-Hopi Observer News, (Aug. 23, 2022), https://www.nhonews.com/news/2022/aug/23/navajo-nation-president-jonathan-nez-supports-gran/.

[56] Tribes Explore Mining For Potential Jobs, Income | The Seattle Times. (December 15, 1991), https://archive.seattletimes.com/archive/?date=19911215&slug=1323210..

[57] "Revisiting Utah's Mining Past." Utah Stories, July 12, 2017, https://utahstories.com/2017/07/revisiting-utahs-mining-past/.

[58] U.S. Environmental Protection Agency, OLEM. Basic NPL Information. (Aug. 14, 2015), https://www.epa.gov/superfund/basic-npl-information.

[59] U.S. Environmental Protection Agency, OLEM. Search for Superfund Sites Where You Live. (Sept. 4, 2015), https://www.epa.gov/superfund/search-superfund-sites-where-you-live. (See: Advanced Superfund Site Search Engine https://cumulis.epa.gov/supercpad/cursites/srchsites.cfm)

[60] "Mine scarred-lands are defined as lands, associated waters and surrounding watersheds where extraction, beneficiation, or processing of ore and minerals (including coal) has occurred." Environmental Protection Agency, Use of Brownfields Mine-Scarred Land Initiative to Clean Up Abandoned Mines, (Sept. 12, 2017), https://www.epa.gov/sites/default/files/2017-10/documents/brownfields_msl_fact_sheet_091217.pdf.

[61] Wood, Jonathan. "Bill Would Enable Good Samaritans to Cleanup Mines." Colorado Politics, https://www.coloradopolitics.com/opinion/bill-would-enable-good-samaritans-to-cleanup-mines/article_414ba052-9124-11ec-afac-4b5566e2bbb4.html. Accessed 24 Aug. 2022.

[62] "General Mining Law of 1872." Ballotpedia, https://ballotpedia.org/General_Mining_Law_of_1872. Accessed Aug. 24, 2022

[63] Hearing on Reforming the Mining Law of 1872, The House Committee on Natural Resources. https://naturalresources.house.gov/hearings/reforming-the-mining-law-of-1872. Accessed Aug. 24, 2022.

[64] H.R.7580 - Clean Energy Minerals Reform Act of 2022, 117th Congress (2021-2022), Introduced April 26, 2022, https://www.congress.gov/bill/117th-congress/house-bill/7580/text#toc-H9E391C59085C474D95CD27C07821FF77

[65] "Inflation Reduction Act Can Achieve Emissions Reductions Even with Oil and Gas Provisions." Resources for the Future, https://www.resources.org/common-resources/inflation-reduction-act-can-achieve-emissions-reductions-even-with-oil-and-gas-provisions/. Accessed 29 Aug. 2022.

[66] EARTHWORKS. "1872 Mining Law - Reform Requirements." Earthworks, https://earthworks.org/issues/1872-mining-law-reform-requirements/. Accessed Aug. 24, 2022.

[67] U.S. Government Accountability Office, URANIUM MINING Opportunities Exist to Improve Oversight of Financial Assurances, (2012), pp. 34, https://www.gao.gov/assets/gao-12-544.pdf

[68] Bureau of Land Management. Abandoned Mine Land Inventory Study for Bureau of Land Management-Managed Lands in California, Nevada, and Utah: Site and Feature Analysis. Nov. 2014, https://www.blm.gov/sites/blm.gov/files/uploads/AML_PUB_Inventory.pdf.

[69] Office, U. S. Government Accountability. Abandoned Hardrock Mines: Information on Number of Mines, Expenditures, and Factors That Limit Efforts to Address Hazards. https://www.gao.gov/products/gao-20-238.

[70] S.3571 - Good Samaritan Remediation of Abandoned Hardrock Mines Act of 2022, 117th Congress (2021-2022), Introduced Feb. 3, 2022, https://www.congress.gov/bill/117th-congress/senate-bill/3571/text?q=%7B%22search%22%3A%5B%22good+Samaritan%22%2C%22good%22%2C%22Samaritan%22%5D%7D&r=1&s=2

[71] The Experience of Brownfield Regeneration in Ronneberg, Germany; Case Study on Former Uranium Mining Redevelopment (2011), https://www.isocarp.net/Data/case_studies/1950.pdf.

[72] Fact Sheet on Uranium Recovery, U.S. Nuclear Regulatory Commission, Updated June 29, 2015, https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/fs-uranium-recovery.html.

[73] "Repowering Old Mines with New Energies in the Southwestern United States." RMI, 18 Mar. 2019, https://rmi.org/repowering-old-mines-with-new-energies-in-the-southwestern-united-states/.

[74] Financial Opportunities: Funding Opportunity Exchange. DE-FOA-0002811: Request for Information (RFI): Bipartisan Infrastructure Law Clean Energy Demonstration Program on Current and Former Mine Land, https://oced-exchange.energy.gov/Default.aspx#Foaldfc57cda4-4a1d-4680-86c2-e09f4c46169a.

[75] S.387 - Grand Canyon Protection Act, 116th Congress (2021-2022), Introduced in Senate Feb. 23, 2022, https://www.congress.gov/bill/117th-congress/senate-bill/387/text

[76] Ophelia Watahomigie-Corliss, Uranium mining threatens our home, the Grand Canyon, High Country News, (April 14, 2020) https://www.hcn.org/articles/indigenous-affairs-mining-uranium-mining-threatens-our-home-the-grand-canyon

[77] "Navajo Nation President Jonathan Nez Supports Grand Canyon Protection Act and Ban on Uranium Mines.", Navajo-Hopi Observer News, (Aug. 23, 2022), https://www.nhonews.com/news/2022/aug/23/navajo-nation-president-jonathan-nez-supports-gran/.

[78] S.387 - Grand Canyon Protection Act, 116th Congress (2021-2022), Introduced in Senate Feb. 23, 2022.

II. The Current State of the Uranium Mining Industry

[79] World Uranium Mining - World Nuclear Association. https://world-nuclear.org/information-library/nuclear-fuel-cycle/mining-of-uranium/world-uranium-mining-production.aspx Accessed Aug. 24, 2022.

[80] US Uranium Mining and Exploration - World Nuclear Association. https://world-nuclear.org/information-library/country-profiles/countries-t-z/us-uranium-mining.aspx. Accessed 29 Aug. 2022.

[81] Nuclear Energy Agency, Uranium 2020: Resources, Production and Demand https://www.oecd-nea.org/jcms/pl_52718/uranium-2020-resources-production-and-demand

[82] Nuclear Energy Agency, Uranium 2020: Resources, Production and Demand https://www.oecd-nea.org/jcms/pl_52718/uranium-2020-resources-production-and-demand

[83] Good Energy Collective interview with uranium industry group representative on March 10, 2022.

[84] Aden Mckay et. al, Australia's Uranium Resources and Production in the World Context, https://inis.iaea.org/collection/NCLCollectionStore/_Public/33/034/33034290.pdf.

[85] Nuclear Energy Agency, "Uranium Resources, Production and Demand (Red Book)", (2020), https://www.oecd-nea.org/jcms/pl_52718/uranium-2020-resources-production-and-demand.

[86] NSW Australian Government, Indicative Secretary's Environmental Assessment Requirements (SEARS), (2015), https://www.planning.nsw.gov.au/-/media/Files/DPE/Other/for-state-significant-mining-developments-indicative-secretarys-environmental-assessment-requirements-sears-2015-10.pdf?la=en.

[87] Kate Fitz Gibbon, "Rio Tinto: How Australian Law Tolerates Heritage Destruction." Cultural Property News, (Sept. 14, 2020), https://culturalpropertynews.org/rio-tinto-how-australian-law-tolerates-heritage-destruction/.

[88] Keri Phillips, The long and controversial history of uranium mining in Australia, (July 14, 2015), https://www.abc.net.au/radionational/programs/rearvision/history-of-uranium-mining-in-australia/6607212

[89] Watershed Sentinel, On the Yellowcake Trail, (June/July 2009), https://watershedsentinel.ca/wp-content/uploads/2009/06/Yellowcake%20Series%20WS%2020092010.pdf

[90] Canada Nuclear Safety Commission, Regulatory Oversight Report for Uranium Mines and Mills in Canada: 2019 (last updated Oct. 10, 2021), http://nuclearsafety.gc.ca/eng/resources/publications/reports/regulatory-oversight-reports/umm-report-2019.cfm

[91] Branch, Legislative Services. Consolidated Federal Laws of Canada, Uranium Mines and Mills Regulations. 22 Sept. 2017, https://laws-lois.justice.gc.ca/eng/regulations/sor-2000-206/page-1.html.

[92] G.V. Fyodorov, Atomic Energy Committee Kazakhstan, Uranium production and the environment in Kazakhstan https://inis.iaea.org/collection/NCLCollectionStore/_Public/33/032/33032913.pdf Accessed Aug. 24, 2022.

[93] Nuclear Energy Agency, International Atomic Energy Agency, "Uranium 2020: Resources, Production and Demand", (2020), https://read.oecd-ilibrary.org/nuclear-energy/uranium-2020_d82388ab-en#page3.

[94] U.S. Uranium Imports Continue as Domestic Production Remains at Historical Lows. https://www.eia.gov/todayinenergy/detail.php?id=37192. Accessed Aug. 24 2022.

[95] "Trump Budget Proposes $150 Million for Creation of Uranium Reserve." Reuters, (Feb. 10 2020) https://www.reuters.com/article/us-usa-trump-budget-uranium-idUKKBN2042JM.

[96] Granholm: Department of Energy Developing "Full-on Uranium Strategy." (May 10, 2022), https://www.ans.org/news/article-3952/granholm-doe-developing-fullon-uranium-strategy/.

[97] "Ranking Member Barrasso Leads Legislation to Establish Strategic Uranium Reserve." U.S. Senate Committee on Energy and Natural Resources, (Mar. 31 2022), https://www.energy.senate.gov/2022/3/ranking-member-barrasso-leads-legislation-to-establish-strategic-uranium-reserve.

[98] S.4064 - International Nuclear Energy Act of 2022, Introduced in Senate April 7, 2022, https://www.congress.gov/bill/117th-congress/senate-bill/4064/text.

[99] U.S. NNSA to Purchase Strategic Uranium - Nuclear Engineering International. (July 6, 2022), https://www.neimagazine.com/news/newsus-nnsa-to-purchase-strategic-uranium-9827262

[100] Marizco, Michel. "The Reopening of an Uranium Mine in Arizona Has Indigenous People Worried." NPR, (June 2, 2022). NPR, https://www.npr.org/2022/06/02/1102575257/the-reopening-of-an-uranium-mine-in-arizona-has-indigenous-people-worried.

[101] "Navajo Nation President Jonathan Nez Supports Grand Canyon Protection Act and Ban on Uranium Mines." Navajo-Hopi Observer News, https://www.nhonews.com/news/2022/aug/23/navajo-nation-president-jonathan-nez-supports-gran/. Accessed 24 Aug. 2022.

[102] Delilah Friedler, 'Get the hell off': The indigenous fight to stop a uranium mine in the Black Hills, Grist, (May 10, 2020) https://grist.org/justice/get-the-hell-off-the-indigenous-fight-to-stop-a-uranium-mine-in-the-blackhills/.

[103] "Feds Mull Uranium Reserve Despite Environmental Injustice." Grand Canyon Trust, (Aug. 17, 2021), https://www.grandcanyontrust.org/blog/feds-mull-uranium-reserve-despite-environmental-injustice.

[104] Marizco, Michel. "The Reopening of an Uranium Mine in Arizona Has Indigenous People Worried." NPR, (June 2, 2022). NPR, https://www.npr.org/2022/06/02/1102575257/the-reopening-of-an-uranium-mine-in-arizona-has-indigenous-people-worried.

[105] U.S. Dept. of Energy, Restoring America's Competitive Nuclear Advantage (2020), https://www.energy.gov/sites/default/files/2020/04/f74/Restoring%20America%27s%20Competitive%20Nuclear%20Advantage_1.pdf.

[106] U.S. General Services Administration, Tribal Consultation. https://www.gsa.gov/resources-for-%E2%80%A6/native-american-tribes/tribal-consultation. Accessed Aug. 24, 2022.

[107] U.S. Government Accountability Office, TRIBAL CONSULTATION: Additional Federal Actions Needed for Infrastructure Projects, (2019), https://www.gao.gov/assets/gao-19-22.pdf.

[108] Tarah Bailey, Consultation with American Indian Tribes: Resolving Ambiguity and Inconsistency in Government-to-Government Relations, University of Colorado Law Review, (2018), https://www.colorado.edu/law/sites/default/files/attached-files/bailey_final_1_web_1.pdf

[109] Jael Holzman, USGS proposal yanks uranium from critical minerals list, E&E News, (Nov. 9, 2021), https://www.eenews.net/articles/usgs-proposal-yanks-uranium-from-critical-minerals-list/.

[110] H.R.8045 - Critical Minerals Classification Improvement Act of 2022, Introduced in House June 13, 2022, https://www.congress.gov/bill/117th-congress/house-bill/8045/text.

[111] In Situ Leach Mining (ISL) of Uranium - World Nuclear Association. (September 2020). https://world-nuclear.org/information-library/nuclear-fuel-cycle/mining-of-uranium/in-situ-leach-mining-of-uranium.aspx.

[112] "In-Situ Leach Uranium Mining." Earthworks, https://earthworks.org/issues/in_situ_leach_uranium_mining/. Accessed Aug. 24, 2022.

[113] U.S. Environmental Protection Agency, OAR. 40 CFR Part 192: Proposed Rulemaking and Background Documents. (Jan. 2017), https://www.epa.gov/radiation/40-cfr-part-192-proposed-rulemaking-and-background-documents.

[114] IEA, The Role of Critical Minerals in Clean Energy Transitions, (2022), https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions.

[115] IEA, The Role of Critical Minerals in Clean Energy Transitions, (2022), https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions.

[116] Senate Energy & Natural Resources Committee, Full Committee Hearing to Examine The U.S.-Canada Energy And Minerals Partnership, Chairman Manchin Opening Statement, (May 17, 2022), https://www.energy.senate.gov/services/files/FDECEC4F-5D17-4D60-8289-E8D97A7E6E10

[117] "Past, Future Collide in Dispute Over Northern Nevada Lithium Mine." Nevada Public Radio, (Aug. 26, 2021), https://knpr.org/knpr/2021-08/past-future-collide-dispute-over-northern-nevada-lithium-mine.

[118] Streater, Scott. "Tribes Will Co-Manage Bears Ears with Feds in Historic Deal." E&E News, (June 12, 2022), https://www.eenews.net/articles/tribes-will-co-manage-bears-ears-with-feds-in-historic-deal/.

[119] The White House. "Memorandum on Tribal Consultation and Strengthening Nation-to-Nation Relationships." The White House, (Jan. 26, 2021), https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/26/memorandum-on-tribal-consultation-and-strengthening-nation-to-nation-relationships/.

[120] EARTHWORKS. "1872 Mining Law - Reform Requirements." Earthworks, https://earthworks.org/issues/1872-mining-law-reform-requirements/. Accessed Aug. 24, 2022.

[121] In some cases, tribal consultation can also be used as an avenue to create long term economic and cultural community benefits agreements, especially for projects that may not occur on tribal land but have an impact on tribal resources. These types of agreements should be explored with tribal nations wherever possible.

[122] See: Aspen Institute, Building Cleaner, Faster Report, (June 15, 2021), https://www.aspeninstitute.org/publications/building-cleaner-faster-report/.

[123] U.S. Environmental Protection Agency, OAR. 40 CFR Part 192: Proposed Rulemaking and Background Documents. (Jan. 2017), https://www.epa.gov/radiation/40-cfr-part-192-proposed-rulemaking-and-background-documents.

[124] "In-Situ Leach Uranium Mining." Earthworks, https://earthworks.org/issues/in_situ_leach_uranium_mining/. Accessed Aug. 25, 2022.

[125] Ibid.

[126] "EPA Worked with Mining Industry to Abandon Rule Protecting Taxpayers from Toxic Cleanup Costs." Earthjustice, (May 13, 2019), https://earthjustice.org/from-the-experts/2019-may/epa-worked-with-mining-industry-to-abandon-rule-protecting-taxpayers-from-toxic-cleanup-costs.

III. The Future of Uranium Mining and Alternative Sourcing

[127] From Dodd-Frank to the EU Conflict Minerals Regulation. https://www.minespider.com/blog/evolving-legislation-from-dodd-frank-to-the-eu-conflict-minerals-regulation. Accessed Aug. 31, 2022.

[128] Swiss Conflict Minerals and Child Labor Due Diligence Legislation Takes Effect – Will Require Due Diligence and Reporting by Many U.S.-Based Multinationals Doing Business in Switzerland. http://www.ropesgray.com/en/newsroom/alerts/2022/February/Swiss-Conflict-Minerals-and-Child-Labor-Due-Diligence-Legislation-Takes-Effect. Accessed 31 Aug. 2022.

[129] See also: "France's Duty of Vigilance Law." Business & Human Rights Resource Centre, https://www.business-humanrights.org/en/big-issues/corporate-legal-accountability/frances-duty-of-vigilance-law/. Accessed Aug. 24, 2022.

[130] EU Conflict Minerals Regulation. https://policy.trade.ec.europa.eu/development-and-sustainability/conflict-minerals-regulation_en. Accessed Aug, 24 2022.

[131] The EU Conflict Minerals Regulation – Frequently Asked Questions and Take-Aways for Downstream Companies (or Why Should I Care About Yet Another New Supply Chain Regulation?). http://www.ropesgray.com/en/newsroom/alerts/2017/09/The-EU-Conflict-Minerals-Regulation-Frequently-Asked-Questions-and-Take-Aways-for-Downstream. Accessed Aug. 31, 2022.

[132] "Section 1502 of the U.S. Dodd Frank Act | Global Witness." Global Witness, https://www.globalwitness.org/en/campaigns/conflict-minerals/dodd-frank-act-section-1502/. Accessed Aug. 24, 2022.

[133] Ha Thi Thu Nguyen, Jorma Larimo, Pervez Ghaur, Understanding foreign divestment: The impacts of economic and political friction (2022), https://doi.org/10.1016/j.jbusres.2021.10.009.

[134] Charging up for the New EU Battery Regulation Proposal. https://www.minespider.com/blog/charging-up-for-the-new-eu-battery-regulation-proposal Accessed Aug. 24, 2022.

[135] Ibid.

[136] Branch, Legislative Services. Consolidated Federal Laws of Canada, Uranium Mines and Mills Regulations. (Sept. 22, 2017), https://laws.justice.gc.ca/eng/regulations/sor-2000-206/page-1.html.

[137] Good Practices in Community Engagement and Readiness Compendium of Case Studies From Canada's Minerals and Metals Sector. (August 2014). https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/www/pdf/publications/emmc/Good_practice_Compendium_e.pdf.

[138] United Nations, Declaration of the Rights of Indigenous People, https://www.un.org/development/desa/indigenouspeoples/wp-content/uploads/sites/19/2018/11/UNDRIP_E_web.pdf.

[139] Comunicaciones, CIAT. Building the Autonomy of Quilombola Communities in Brazil | CIAT Blog. https://blog.ciat.cgiar.org/building-the-autonomy-of-quilombola-communities-in-brazil/. Accessed Aug. 25, 2022.

[140] Ibid.

[141] "Mining Companies and Communities Come Together to Discuss Sustainable Local Development." Partnership for the Conservation of Amazon Biodiversity PCAB, https://pcabhub.org/en-us/news/news-highlights/mining-companies-and-communities-come-together-to-discuss-sustainable-local-development. Accessed Aug. 31, 2022.

[142] RESOLVE, World Economic Forum, Voluntary Responsible Mining Initiatives: A Review, (2015), https://www3.weforum.org/docs/Voluntary_Responsible_Mining_Initiatives_2016.pdf.

[143] RMI, Mineral Due Diligence: Other Minerals. https://www.responsiblemineralsinitiative.org/minerals-due-diligence/other-minerals/. Accessed Aug. 31, 2022.

[144] RMI, List of Mineral Due Diligence Standards, https://www.responsiblemineralsinitiative.org/minerals-due-diligence/standards/. Accessed Aug. 31, 2022.

[145] Internationally Standardized Reporting on the Sustainable Development Performance of Uranium Mining and Processing Sites ("Checklist"), (March 2017), https://world-nuclear.org/getattachment/Our-Association/Publications/Online-Reports/Internationally-Standardized-Reporting-on-the-Sust/CSR-Checklist.pdf.aspx.

[146] RMI, Mineral Due Diligence Standards. https://www.responsiblemineralsinitiative.org/minerals-due-diligence/standards/. Accessed Aug. 25, 2022.

[147] Responsible Minerals Initiative Releases New Global Standard for All-Minerals Due Diligence. https://www.responsiblemineralsinitiative.org/news/responsible-minerals-initiative-releases-new-global-standard-for-all-minerals-due-diligence/. Accessed Aug. 31, 2022.

[148] Global Responsible Sourcing Due Diligence Standards for Mineral Supply Chains and Minerals, RMI (December 2021) https://www.responsiblemineralsinitiative.org/media/docs/standards/RMI_Standard_AllMinerals_EN_2.pdf.

[149] "The OECD Guidelines." OECD Watch, https://www.oecdwatch.org/oecd-ncps/the-oecd-guidelines-for-mnes/. Accessed Aug. 25, 2022.

[150] Petrina Schiavi, Fiona Solomon, "Voluntary Initiatives in the Mining Industry: Do They Work?", (January 2007), https://www.researchgate.net/publication/43479096_Voluntary_initiatives_in_the_Mining_Industry_Do_they_work.

[151] Mancini, Lucia, et al. "Assessing Impacts of Responsible Sourcing Initiatives for Cobalt: Insights from a Case Study." Resources Policy, vol. 71, (June 2021), p. 102015. ScienceDirect, https://doi.org/10.1016/j.resourpol.2021.102015.

[152] Crawford, Clare Church, Alec. Green Conflict Minerals. Introduction, https://www.iisd.org/story/green-conflict-minerals Accessed Aug. 25, 2022.

[153] Smelters & Refiners Lists. https://www.responsiblemineralsinitiative.org/smelters-refiners-lists/. Accessed Aug. 25, 2022.

[154] Good Energy Collective interview with private mining industry standards group representative on May 24, 2022.

[155] Waldersee, Victoria. "German-Funded Consortium to Develop 'Battery Passport' for Europe." Reuters, (Apr. 25, 2022). https://www.reuters.com/technology/german-funded-consortium-develop-battery-passport-european-batteries-2022-04-25/.

[156] "Supply Chain Meets Blockchain for End-to-End Mineral Tracking." Google Sustainability, https://sustainability.google/progress/projects/traceability/ Accessed Aug. 25, 2022.

[157] Mineral Marketplace Minery to Integrate Minespider's Blockchain Traceability. https://www.minespider.com/press/mineral-marketplace-minery-to-integrate-minespiders-blockchain-traceability. Accessed Aug. 25, 2022.

[158] Ibid.

[159] Ibid.

[160] "Salmon Gold." RESOLVE, https://www.resolve.ngo/salmon_gold.htm. Accessed Aug. 24, 2022.

[161] Ibid.

[162] RESOLVE Press Release, Rio Tinto invests in start-up to support habitat restoration, (November 9, 2021), https://www.resolve.ngo/docs/regeneration_press_release.pdf,.

[163] Ibid.

[164] Good Energy Collective interview with RESOLVE NGO on March 18, 2022.

[165] RESOLVE Press Release, Rio Tinto invests in start-up to support habitat restoration, (November 9, 2021), https://www.resolve.ngo/docs/regeneration_press_release.pdf,.

[166] Biello, David. "Is Reprocessing the Answer to Eliminating Fissile Materials from Bombs and Nuclear Waste?" Scientific American, (April 15, 2010), https://www.scientificamerican.com/article/is-reprocessing-the-answer-to-eliminating-fissile-materials/

[167] Fast Reactors Provide Sustainable Nuclear Power for "Thousands of Years." (Mar. 1 2013), https://www.iaea.org/newscenter/news/fast-reactors-provide-sustainable-nuclear-power-thousands-years.

[168] Nuclear Fuel Recycling Could Offer Plentiful Energy | Argonne National Laboratory, (June 22, 2012), https://www.anl.gov/article/nuclear-fuel-recycling-could-offer-plentiful-energy.

[169] Biello, David. "Is Reprocessing the Answer to Eliminating Fissile Materials from Bombs and Nuclear Waste?" Scientific American, (April 15, 2010), https://www.scientificamerican.com/article/is-reprocessing-the-answer-to-eliminating-fissile-materials/

[170] "Megatons to Megawatts." Centrus Energy Corp, https://www.centrusenergy.com/who-we-are/history/megatons-to-megawatts, Accessed Aug. 25, 2022.

[171] Ibid.

[172] U.S. MOX Facility Contract Terminated: Uranium & Fuel - World Nuclear News. (October 23, 2018), https://world-nuclear-news.org/Articles/U.S.-MOX-facility-contract-terminated.

[173] International Panel on Fissile Materials, "United States.", https://fissilematerials.org/countries/united_states.html. Accessed Aug. 31, 2022.

[174] Abate, Tom, How to Extract Uranium from Seawater for Nuclear Power | Stanford University School of Engineering, (Feb. 17, 2017), https://engineering.stanford.edu/magazine/article/how-extract-uranium-seawater-nuclear-power,

[175] Conca, James. "Uranium Seawater Extraction Makes Nuclear Power Completely Renewable." Forbes, July 1, 2016), https://www.forbes.com/sites/jamesconca/2016/07/01/uranium-seawater-extraction-makes-nuclear-power-completely-renewable/.

[176] Stanford University, Mineral Makeup of Seawater, https://web.stanford.edu/group/Urchin/mineral.html Accessed Aug. 25, 2022.

[177] "Department of Energy Awards $36 Million to Reduce Waste from Advanced Nuclear Reactors." Energy.Gov, (March 10, 2022), https://www.energy.gov/articles/doe-awards-36-million-reduce-waste-advanced-nuclear-reactors.

[178] Good Practices in Community Engagement and Readiness: Compendium of Case Studies From Canada's Minerals and Metal Sector (August 2014), https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/www/pdf/publications/emmc/Good_practice_Compendium_e.pdf

Appendix II

[179] CNN, Ella Nilsen and Rene Marsh. "A Rush to Mine Lithium in Nevada Is Pitting Climate Advocates and Environmental Groups against Each Other." CNN, https://www.cnn.com/2021/12/17/politics/lithium-mining-energy-climate/index.html. Accessed Jan.18, 2022.

[180] Ibid.

[181] Ibid.

[182] "Megafactories Buildout Could up Nickel Demand in Batteries 19 Fold—Benchmark." MINING.COM, (Feb. 2019), https://www.mining.com/battery-megafactories-buildout-nickel-demand-19-fold-benchmark/.

[183] "Can a Tiny Territory in the South Pacific Power Tesla's Ambitions?" The New York Times, (Dec. 30, 2021). NYTimes.com, https://www.nytimes.com/2021/12/30/world/asia/tesla-batteries-nickel-new-caledonia.html.

[184] Ibid.

[185] Ibid.

[186] Bartlett, John. "Mining of Lithium, Key to the Climate Fight, Faces New Scrutiny in Chile." *The New York Times*, 6 Jan. 2022. *NYTimes.com*, https://www.nytimes.com/2022/01/06/climate/lithium-chile.html.

[187] Nicole Greenfield. "Lithium Mining Is Leaving Chile's Indigenous Communities High and Dry (Literally)." *NRDC*, https://www.nrdc.org/stories/lithium-mining-leaving-chiles-indigenous-communities-high-and-dry-literally. Accessed May 18, 2022.

[188] Morse, Ian. "Chile's New Constitution Could Rewrite the Story of Lithium Mining." Quartz, https://qz.com/1948663/chiles-new-constitution-could-rewrite-the-fate-of-lithium-mining/ Accessed Aug 24, 2022.

[189] Nicole Greenfield. "Lithium Mining Is Leaving Chile's Indigenous Communities High and Dry (Literally)." NRDC, https://www.nrdc.org/stories/lithium-mining-leaving-chiles-indigenous-communities-high-and-dry-literally Accessed Aug 24, 2022.

Appendix I

Non-exhaustive list of private voluntary standards applicable to mineral, metal, and ore supply chains:

ARM-RESOLVE CRAFT Code of Risk Mitigation for ASM engaging in Formal Trade
ASI Performance Standard (CJ)
ASM Cobalt Framework (CAP Framework) (ASR)
AccountAbility AA 1000 Assurance Standard
Africa Mining Vision
Alliance for Responsible Mining (ARM)
Aluminum Stewardship Initiative
Better Gold Initiative
Business and Biodiversity Offsets Program (BBOP)
Business for Social Responsibility
Communities and Small-Scale Mining
Conflict-Free Sourcing Initiative (CFSI)/Smelter Program (CFSP)
Conflict-Free Tin Initiative
Council for Responsible Jewellry Practices
Devonshire Initiative
Diamond Development Initiative
EGC- Responsible Sourcing Standard
Equator Principles
Equitable Origin
Extractive Industries Transparency Initiative (EITI)
FTSE 4 Good
Free, Prior and Informed Consent (FPIC) Dialogue
Global Business Coalition on HIV/AIDS, Tuberculosis and Malaria (now called GBCHealth)
Global Mining Initiative (author of the Minerals, Mining, and Sustainable Development reports)
Global Reporting Initiative - Mining and Metals Supplement
Green Lead

ICMM- Mining Principles (ASR)

IFC - Environmental and Social Performance Standards

IRMA - Standard for Responsible Mining (ASR)

IRMA - Standard for Processing Companies (in consultation)

Initiative for Responsible Mining Assurance

Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development

International Council on Mining and Metals (ICMM)

International Cyanide Management Code for the Gold Mining Industry

International Finance Corporation (IFC) Performance Standards

International Organization for Standardisation 14001 (ISO 14001)

Kimberley Process

Millennium Development Goals (MDGs)/Sustainable Development Goals (SDGs)

Mining Association of Canada - Towards Sustainable Mining (ASR)

OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas

Occupational Safety and Health Assessment Series 18001

Oxfam and ECOWAS- West African Mining Code Project (regional initiative)

Partnering Against Corruption Initiative

Prospectors and Developers Association of Canada (PDAC) e3 Plus (regional initiative)

Public-Private Alliance for Responsible Minerals Trade

RBA- Validated Assessment Program

RMI - Environmental, Social & Governance (ESG) Standard for Mineral Supply Chains (CJ)

RMI- Cobalt Refiner Due Diligence Standard

RMI- Joint due diligence standard for Copper, Lead, Nickel, and Zinc

RMI- Risk Readiness Assessment

Responsible Jewelry Council

Responsible Mica Initiative- Global Workplace standard for Mica processors (CJ)

Responsible Mineral Development Initiative (RMDI)

Responsible Mining Index

Responsible Steel Standard (CJ)

Social Accountability 8000

Social Accountability International - SA8000

Solutions for Hope

The Copper Mark Assurance Framework (Copper Mark Criteria for Responsible Production) (CJ)

Towards Sustainable Mining (regional initiative)

Transparency International

United Nations Global Compact Profile

United Nations Voluntary Principles on Security and Human Rights (VP on S &HR)

Verra- Sustainable Development Verified Impact Standard

Whitehorse Mining Initiative (regional initiative)

World Business Council on Sustainable Development

World Gold Council Conflict-Free Tool

World Mines Ministries Forum (WMMF website is no longer active)

World Steel Association

Sources: RESOLVE NGO, Levin Sources

Appendix II: Case Studies of Critical Mineral Conflicts

Case Study: Lithium Deposit Exploration in Thacker Pass, Nevada

One of the largest lithium deposits in the world, and the largest lithium deposit in the U.S., is located in Thacker Pass, Nevada. The proposed mine has become one of the most contentious modern-day mine proposals in the U.S. Lithium Americas Corporation has proposed a 17,933-acre open pit mine and sulfuric acid plant to process lithium domestically.[179] Opponents of the mine claim that the Environmental Impact Statement submitted to the Bureau of Land Management was rushed and failed to outline the real environmental hazards and cultural impacts of the mine. Environmental groups are especially concerned with carbon dioxide emissions, water use, and potential threats to threatened species such as the greater sage grouse and the Lahontan cutthroat trout.

Environmental justice concerns have been raised with Indigenous communities in the area as well. At least 15 tribes attach significance to Thacker Pass, including the Fort McDermitt Paiute and Shoshone Tribes, who say that mining could desecrate sacred burial sites in the area. Tribal nations do not believe they were properly consulted in the creation of mining plans.[180]

Lithium Americas has denied claims of impropriety in the process and has stated that the mining methods likely to be employed are minimally invasive and more sustainable than other options. In an interview with CNN, president and CEO of Lithium Americas stated that the company is committed to decreasing emissions and conserving water use to the greatest extent possible.[181] At this stage, the project is moving forward; the Bureau of Land Management provided permits in 2021.

Situations like these raise questions about the issue of trade-offs. If new lithium mines are not allowed in the U.S., lithium mines will likely move to other countries without the same capacities for regulation and governance and without access to upfront capital investment for least-invasive extraction methods. Likewise, if new lithium mining cannot happen, it will

further delay the necessary transition away from fossil fuels, causing other pollution concerns. Compromises in the critical mineral mining space will be important if the U.S. hopes to meet carbon-free energy goals.

Case Study: The Goro Nickel Mine in New Caledonia

Nickel is a critical mineral whose demand analysts expect could skyrocket in the coming years.[182] Nickel is used for electric car batteries, solar panels, and other clean energy technologies, including nuclear. Like many other critical minerals, demand for nickel has brushed up against indigenous communities globally fighting against colonization and private industry pushing for profits and progress.

The contention between the future of sustainable mining and its exploitative past are coming to fruition in the largest nickel mine in the world — Goro, in New Caledonia, a small French territory in Oceania. The Goro mine has been associated with continuous exploitation of the indigenous populations since colonization in 1853.[183] The Native Kanak people have reported stolen land, eroded traditions, and continuous labor and environmental violations.[184] In recent years, the Kanak people have responded with riots, strikes, and barricades as a result of the colonial abuses and environmental degradation from the mine.

Currently, the provincial government is the majority owner of the Goro mine and aims to include mine workers and local community members in decision-making to build trust and transparency. Tesla, the main purchaser of nickel from the Goro mine, is also working to institute sustainable practices by working directly with mine operators to ensure the mine packages its tailings as a dry residue, uses more renewable energy to power equipment, and builds a nickel processing facility. The local Kanak people will also partner with the mine operators to have a say in the impacts of mining.[185] The organizational scheme at the Goro mine is a somewhat novel concept and has yet to be proven. But if the new ownership scheme is successful, it could offer a blueprint for future mining operations in places with a contentious past with the mining industry.

Case Study: Lithium Extraction in Chile

Chile is another example of a country managing conflict over mining permits, where political strife is leaving many questions about the future of mining in the country. Chileans are heavily divided over the environmental risks and social costs of mining.[186] Lithium mining in Chile is exhausting water resources, damaging wetlands, and hurting local communities.[187] The mining technique used in Chile, brine evaporation, has been likened to the practices of the coal industry in terms of harmful environmental impacts.[188] As Lesley Muñoz Rivera, a member of the indigenous Colla community of the Copiapó commune in northern Chile, puts it: "Nothing stays in Chile; it all goes to other places. We don't have electric vehicles in Chile. We suffer from the contamination, and the green energy goes to the Global North. But at whose cost?"[189]