MONTANA COAL ASH MARKET REPORT

Understanding Montana's coal ash resource and its economic viability in the current and evolving marketplace.

MONTANA DEPARTMENT OF COMMERCE

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The following report was generated by the Industry Development Program within the Research & Information Services Bureau at the Department of Commerce as required under MCA §90-2-202.

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EXECUTIVE SUMMARY

House Bill 648, which was codified in 2021 under Montana statute MCA §90-2-202, posed the question – What is the existence of economically viable markets to reuse Montana's coal ash? In summary, no immediate market is apparent given current limitations. Montana's coal ash resources lack the composition, resource density, and proximity to market to provide a sufficient return on investment.

Currently, the strongest markets for the beneficial use of coal ash are concrete/cement, construction materials, agriculture, and critical mineral extraction. Of these markets, critical mineral extraction may provide the most promise given the need for the United States to diversify its current supply chain and the price these minerals command. However, the market for these minerals is not without the possibility of disruptions as the world's largest supplier, China, is able to subsidize production in order to manipulate global prices, and as the world's mining industry is prospecting worldwide.

The Montana Department of Environmental Quality's (DEQ) Beneficial Use Determination Application allows for private companies to access and analyze regulated waste streams for potential beneficial use. The department currently has one open application regarding coal combustion residuals (CCRs; coal ash). This application focuses on the potential recovery of heavy metals, critical minerals, and Rare Earth Elements from the CCR located at the Colstrip Generating Plant. A private company is currently analyzing the resource for potential mineral extraction and return on investment to bring a product to market.

As technologies evolve, markets develop, and remediation efforts to contain and utilize the nation's coal combustion residual resources, viable market avenues may be revealed. The Department of Commerce will continue to monitor private investigation and development of coal ash resources in correlation with industry and the DEQ. The beneficial use of coal ash lends itself to a wide variety of applications, sub-applications, and products across a number of industries. All of these potentials require in depth analysis of product viability, marketability, and profitability. The department will continue to work with private partners to better understand and enhance potential markets as permissible under state statute.

This report provides an overview of the location and amounts of available coal ash within Montana so much as data is available, the primary makeup of the ash as provided by private industry, maps showing the location of the ash with text descriptions, potential uses of coal ash in general, and specific possible future opportunities for the use of Montana's fly ash if the cost to profit relationship can be improved.

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BACKGROUND

Montana's Coal Ash Landscape

Montana is a significant coal-producing state and generates substantial amounts of coal ash as a byproduct of electricity generation. This ash, primarily composed of fly ash and bottom ash, presents both environmental challenges and potential economic opportunities. Coal ash resources are in a number of locations across the state; however, most of the resources are located at the state's coal fired electrical generation facilities.

To understand the coal ash resource, what environmental liabilities it presents and what economic opportunities may lie within, a number of criteria must be considered. Resource composition is the primary factor in determining the potential for beneficial use, as well as environmental risk. Coal ash composition is derived from two influences: 1) coal feedstock composition. 2) coal fired processes within the electrical generation facility and associated waste management systems.

Montana is home to several varieties of coal. Powder River Basin coal which is the feedstock at the state's largest coal fired facility in Colstrip, varies greatly from Williston Basin coal, a lignite coal that was the feedstock for the Lewis and Clark generating facility in northeast Montana. The variety and composition of the coal burned will directly affect the coal ash produced. Likewise, coal generating facilities vary in design and engineering of their systems. Processing of the raw coal feedstock prior to combustion, combustion systems, and waste management systems can all have implications to the coal ash resources produced.

Testing the composition of Montana's coal ash has occurred throughout the years. The Montana Department of Environmental Quality and the federal Environmental Protection Agency have required the owners of Montana's coal ash resources to conduct regular testing to understand the environmental risks associated with Montana's coal ash ponds and landfills. Private companies have conducted laboratory testing to understand the composition of the coal ash in the ponds and its consistency throughout. Many of these private testing results are considered proprietary information and under the ownership of the companies who invested in their findings.

Colstrip Steam Plant. Courtesy of Billings Gazette.

Coal Ash Sites

Montana has several coal ash sites associated with coal-fired power plants and coal mining operations. These sites contain coal ash, a

byproduct of burning coal for electricity. It is noteworthy that Montana numerous coal ash sites recognized by the Montana DEQ and/or EPA; several other sites exist across Montana that are not currently under regulation. The primary source of Montana's coal ash is from the state's largest coal fired electricity generation facilities and are discussed in detail later in this report.

Environmental Regulation of CCRs and the Impact to Possible Use Cases

The Environmental Protection Agency (EPA) promulgated the Coal Combustion Residual (CCR) Rule in 2015 to address the environmental risks associated with the disposal of coal ash, a byproduct of burning coal for electricity generation. EPA defines CCRs as any coal ash materials including a number of by-products produced from burning coal, including fly ash, bottom ash, boiler slag, flue gas desulfurization material, fluidized bed combustion ash, cenospheres, and scrubber residues. For the simplicity, this document will refer to coal ash materials as CCR. This rule established national standards for the safe management of CCRs, aiming to protect public health and the environment.

KEY PROVISIONS OF THE CCR RULE

- **Disposal Requirements**: The rule outlines specific requirements for the design, construction, and operation of CCR disposal facilities, including landfills and surface impoundments. These requirements aim to prevent the release of contaminants into groundwater and surface water.
- **Groundwater Monitoring**: Facilities are required to implement a comprehensive groundwater monitoring program to detect and address any potential contamination.
- **Closure and Post-Closure Care**: The rule establishes standards for the closure of CCR disposal facilities and the long-term care of closed sites to prevent environmental hazards.
- **Public Notification**: Facilities are required to notify the public about their CCR management activities and any potential risks.

ENVIRONMENTAL BENEFITS OF THE CCR RULE

The rule helps to prevent the contamination of groundwater essential for drinking water and agriculture and reduces the risk of coal ash spills and leaching into surface waters, such as rivers and lakes. By limiting exposure to harmful contaminants, the rule contributes to the protection of public health.

FEDERAL EPA CCR RULE & BENEFICIAL USE

The EPA's CCR Rule does not explicitly address the beneficial use of CCR. However, it does acknowledge that CCR can be used as a material in various applications, such as construction materials and soil amendments. The rule focuses primarily on the safe disposal and management of CCR to prevent environmental risks, but it does not prohibit its beneficial use.

It is important to note that the beneficial use of CCR must comply with all applicable environmental regulations, including those related to water quality, air quality, and waste management. Additionally, the rule mandates that the beneficial use of CCR should not pose any significant risks to public health or the environment.

CONCLUSIONS - THE CCR RULE

Establishment of the EPA's CCR Rule increased the environmental liability of CCR deposits to their owners. This may provide further incentive to investigate beneficial use opportunities and markets for those holding the liability. However, timelines for remediation and closure of ponds, landfills, and other repositories are likely to limit the number of proposals and technological advancement options that are available for the beneficial CCRs within the marketplace.

Beneficial Uses of Coal Ash

Despite the environmental challenges, coal ash can be beneficially used in various applications. Some of these applications are listed below. See this report's Beneficial Use section for further detail.

COAL ASH APPLICATIONS

- **Construction Materials:** Fly ash can be used as a component in concrete and other construction materials, reducing the need for cement.
- **Soil Amendments:** Coal ash can be used to improve soil quality and reduce erosion.
- **Industrial Applications:** Coal ash can be used in the production of bricks, tiles, and other products.
- **Critical Minerals:** Coal ash may contain a number of critical minerals and rare earth elements that are growing in demand in various technology markets.
- **Water & Gas Purification:** Coal ash, particularly the fly ash component, can be used in water purification by acting as an adsorbent.
- **Flowable Fill and Embankment Material:** Coal ash's physical and pozzolanic properties allow it to be easily placed in tight spaces and then solidify over time.

CHALLENGES AND OPPORTUNITIES

- **Market Development:** Expanding the market for beneficial use of coal ash requires increased awareness and research into new applications.
- **Infrastructure:** Developing the necessary infrastructure for transporting and processing coal ash is essential for its beneficial use.
- **Environmental Stewardship:** Ensuring that the beneficial use of coal ash does not pose environmental risks requires careful management and monitoring.

Conclusion – CCR Rule Impact on MT Coal Ash Suitability

Montana's coal ash resource presents both challenges and opportunities. While the proper management of coal ash is crucial to protect the environment, its potential for beneficial use can contribute to a more sustainable and circular economy. By addressing the regulatory framework, expanding market opportunities, and developing appropriate infrastructure, Montana can effectively manage and utilize its coal ash resources.

2022 Site Visit: Units 1&2 STEP area.

Dried fly ash (white) with red clinker. Roads for drying equipment to access. Standing water on top of fly ash in background can be pumped when deep enough, or evaporates naturally. Photo courtesy of MT Department of Environmental Quality.

MONTANA COAL ASH RESOURCES

Understanding the Resource

Coal ash is a general term that refers to the residue left behind after coal is burned. It is typically composed of two main components, fly ash and bottom ash. Montana's coal powered generation facilities employ varying technologies to meet EPA emission regulations. Therefore, the coal ash that is produced as a part of the generation waste stream varies in its composition. No coal ash is exactly the same due to differences in input material composition, processing and combustion systems, and waste stream management.

The Colstrip Generating Station is (was) the second largest coal powered facility in the western United States. This facility has, and is, producing most of the coal ash in Montana. This facility has historically operated 4 generating units, of which, the oldest two units have been retired and their associated ash ponds are now inactive. Generating Units 3&4 remain in operation and their ponds are active. The coal ash resources for all these generating units vary only slightly as input material composition, processing and combustion systems, and waste stream management systems are all similar.

Two Primary Components of Coal Ash

FLY ASH

This is the fine, powdery material that is carried up the smokestack by the flue gas. It is typically composed of spherical particles. Fly ash is a specific type of coal ash that has a unique composition and properties. It is often used in construction materials, such as concrete and cement, due to its pozzolanic properties, which allow it to react with lime and water to form cement-type compounds. Fly ash can also be used as a soil additive and in other industrial applications.

BOTTOM ASH

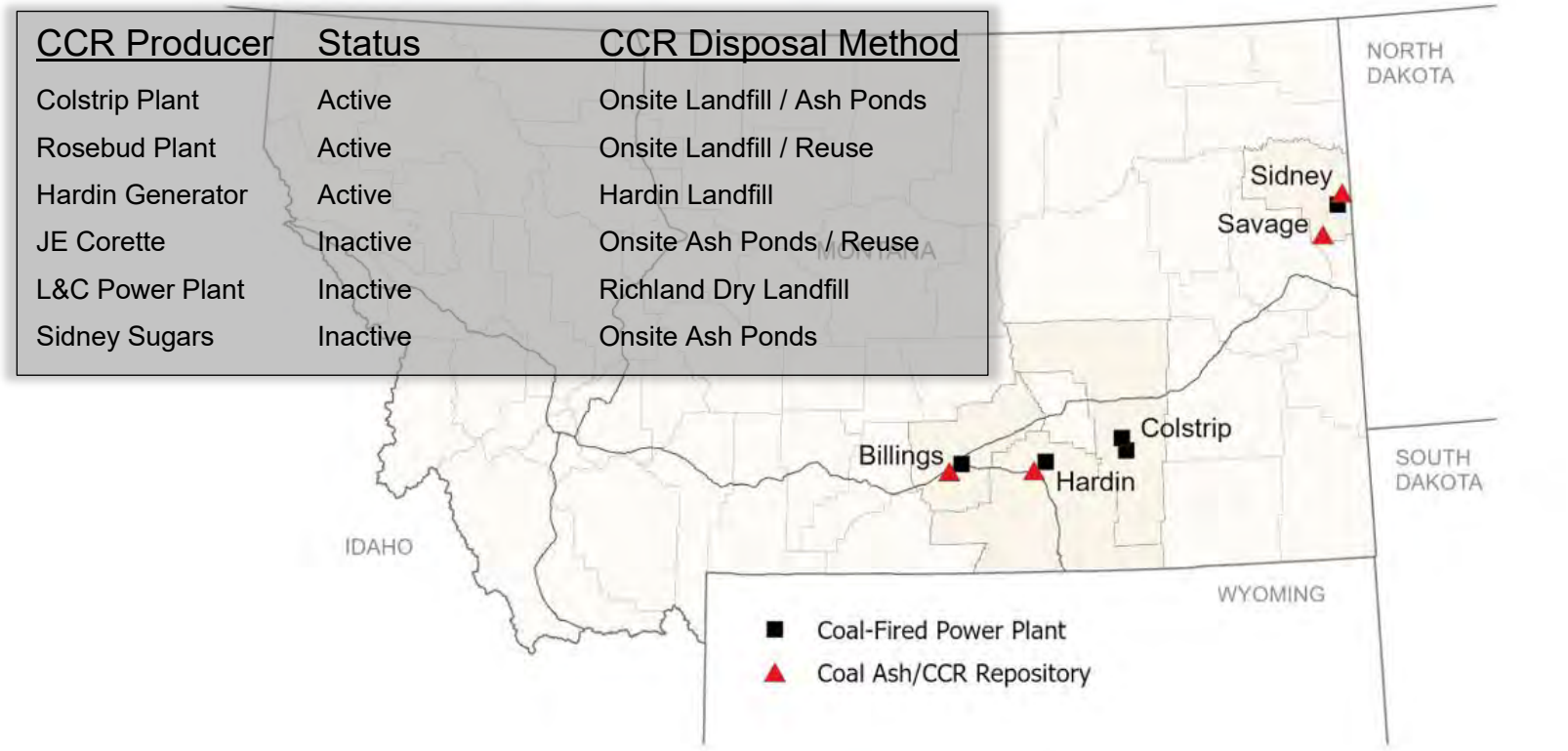
This is the heavier material that settles at the bottom of the boiler. It is typically composed of larger, more angular particles. Bottom ash from coal-fired generation contains a variety of substances which may include the following, as well as other substances. *Inorganic compounds:* These are the primary components of bottom ash and include silica, alumina, iron oxide, calcium oxide, magnesium oxide, and sulfur dioxide. *Trace elements:* Bottom ash can also contain trace amounts of heavy metals like arsenic, cadmium, chromium, lead, mercury, and selenium. *Organic compounds:* Polycyclic aromatic hydrocarbons (PAHs) and other organic compounds can be found in bottom ash, especially if the coal used contains significant amounts of sulfur. *Radioactive materials:* Due to the natural presence of radioactive isotopes in coal, bottom ash can contain small amounts of radioactive elements like uranium and thorium. It is important to note that the specific composition of bottom ash will vary depending on the type of coal used, the combustion process, and the pollution control technologies employed.

Sources of Montana Coal Ash & CCR

The Montana Department of Environmental Quality (DEQ) is the primary regulatory agency responsible for overseeing the management of coal ash in the state. Montana environmental regulation of coal ash occurs under several different regulatory requirements and legal orders under DEQ. DEQ coordinates with EPA on CCR regulation when the same facility is regulated under both state coal ash regulations and federal EPA CCR authority. DEQ works to ensure that coal ash is disposed of and managed in a manner that protects public health and the environment. The following tables depict the regulated coal ash deposits in Montana.

Montana Coal-Fired Power Plants and Coal Combustion Waste Facilities

CCR Producer	Status	CCR Disposal Method
Colstrip Plant	Active	Onsite Landfill / Ash Ponds
Rosebud Plant	Active	Onsite Landfill / Reuse
Hardin Generator	Active	Hardin Landfill
JE Corette	Inactive	Onsite Ash Ponds / Reuse
L&C Power Plant	Inactive	Richland Dry Landfill
Sidney Sugars	Inactive	Onsite Ash Ponds



Montana's coal ash repositories are primarily affiliated with coal-fired electrical generation. Other non-regulated coal ash deposits may exist within the state that are not depicted in the graphic above and likely hold very low volumes of ash.

TABLE 1: MONTANA COAL-FIRED POWER PLANTS WITH POTENTIAL/KNOWN COAL COMBUSTION WASTE/RESIDUALS (CCW/CCR)

Coal-Fired Power Plant Name	Montana DEQ Oversight of Coal Combustion Waste	Site Location and County; Coordinates (WGS84)	Power Generation Power Capacity/ Active Power Capacity 2024 (MW) Start – End Dates	Coal Ash or Coal Combustion Residual (CCR) Disposal Method	DEQ Data on Volume of Coal Combustion Waste/Ash Composition Data
Colstrip Steam Electric Station (SES) Generating Plant	Major Facilities Siting Act (MFSA §75-20-102) Certificate (1976), Administrative Order on Consent (AOC) (2012) for MFSA and MT Water Quality Act Violations, Coal-Fired Generating Unit Remediation Act (§75-8-101 to 110) (2017)	Colstrip, MT; Rosebud County 45.882386, -106.612847	2160/1480 MW Unit 1: 1975 – 2020 Unit 2: 1976 – 2020 Unit 3: 1984 – Active Unit 4: 1986 – Active	On site CCR closure in repositories (impoundments and landfills) AOC for MFSA (§75-20-102)and MT WQA: Documents link at the following: https://deq.mt.gov/cleanupandrec/Programs/colstrip US EPA CCR Website: https://www.talenenergy.com/ccr-colstrip/	>20M Cubic Yards in three areas across the 10,000-acre property and still in operation Contact Owner/Operator Talen Energy MT for ash composition data, explored for both building materials and rare earth elements (REE) Ash composition data provided to Dept. of Commerce Consultant and DEQ on 9/26/24 from Gordon Criswell of Talen Energy MT
Colstrip Energy LP Plant/Rosebud Power Plant	US EPA Primary Oversight	Colstrip, MT; Rosebud County 45.975156, -106.655244	46/41-46 MW Plant: 1990 – Active	On site CCR landfills/reuse US EPA CCR Website: https://celpccr.com/	Unknown – two landfill locations in Colstrip, MT Contact Colstrip Energy LP for ash composition data
Hardin Generator Project Plant	MT DEQ Solid Waste Permit for Coal Combustion Waste Cell - see Hardin Landfill in Table 2 MT DEQ Air Quality Permit #3185-07	Hardin, MT; Big Horn County 45.764342, -107.598292	116/116 MW Plant: 2006 – Active Owner Rocky Mountain Power and operator Herot Power Management	Hardin landfill in Big Horn County - From Hardin Coal Plant US EPA CCR Website: No CCR Website found, coal ash taken off-site to Hardin Landfill with MT DEQ permitted coal ash waste cell	No known coal ash storage at Hardin Generator Plant – transported to Hardin Landfill (See Table 2) Contact Herot Power Mgmt or Hardin Landfill for ash composition data
JE Corette Power Plant	NA DEQ Oversight – Volunteer information from Owner to DEQ Potential US EPA Oversight based on 2024 Legacy CCR Rule - US EPA included as potential legacy CCR facility in 2024 rule updates	Billings, MT; Yellowstone County 45.775175, -108.481322	153-173/0 MW Plant: 1968 – 2015	Coal ash generally sent off-site for reuse in construction materials/ concrete during operations. Potential coal ash locations closed in place called SPD-1 and SPD-2 and treated as one location during closure. US EPA CCR Website: https://www.talenenergy.com/ccr-corette/	Primarily beneficially used in building materials around Billings during operation, two locations closed in place on site (SPD-1/SPD-2) Contact Talen Energy MT for ash composition data
Lewis & Clark Plant/Sidney Sugars Plant	Primary CCR regulation by US EPA Former DEQ MPDES Discharge Permit: Montana Dakota Utilities (MDU) Lewis & Clark Plant MT0000302	Sidney, MT; Richland County 47.678611, -104.158	44-50/0 MW Sugar Plant Power Source: 1958 – 2021 Completing closure/cleanup activities currently. Terminated MPDES permit Dec. 7, 2022	Dry landfill in Richland County US EPA CCR Website: https://www.montana-dakota.com/energy-efficiency/ccr-rule/lewis-clark-station/	MDU notes two landfills (Landfill 1 and 2) in addition to potential ash/coal combustion waste at Temporary Storage Pad, East Scrubber, and West Scrubber areas on CCR website Contact MDU for ash composition data

TABLE 2: MONTANA COAL COMBUSTION WASTE FACILITIES FOR NON-COAL-FIRED ELECTRIC GENERATING POWER PLANT REPOSITORIES

Coal Ash/CCR Repository Name	Coal Ash or Coal Combustion Residual (CCR) Disposal Method	Site Location and County; Coordinates (WGS84)	Coal Ash Collection Dates	DEQ Data on Volume of Coal Combustion Waste/Ash Composition Data
Hardin Landfill – Received waste from Hardin Generator Project (see Table 1)	39.8 Acre licensed landfill cell for coal combustion waste (CCW). Permitted by DEQ for 2,526,000 cubic yards (2,557,000 tons) with potential operating life of the monofill is 25.7 years based upon a waste acceptance rate of 100,000 tons per year	Hardin, MT; Big Horn County 45.764342, -107.598292	2006 – Actively permitted, Annual Reports to MT DEQ, Receives coal ash waste from Hardin Generator Station and has previously received coal ash waste from the closure of the Former Curette Plant in Billings, MT MT DEQ Solid Waste License #348, Hardin Landfill with CCW Cell	Permitted for >2.5M Cubic Yards, not at full capacity as of 2024 Contact City of Hardin Landfill Operator Talen or Herot Power Mgmt for ash composition
Westmoreland Savage Mine	Possible CCR/coal ash waste from Lewis & Clark Station that notes a dry landfill in Richland County.	Savage, MT; Richland County 47.416389, -104.375	1925 through 2023 (Mothballed, no clear closure status) MT DEQ Coal Permit ID: C1984002 https://westmoreland.com/westmoreland-savage-mining-llc/	Unknown coal ash volume – may not be a coal combustion waste location Contact Westmoreland for confirmation and/or data and any coal ash composition
Sidney Sugars	Two coal ash slurry ponds on site – "Coal ash from the boilers was slurried to two bentonite-lined ash ponds."	Sidney, MT; Richland County 47.7167, -104.1347	Closed in 2023 – In process of closure. Responsible Party Working with DEQ Water Quality/ Enforcement MPDES Permit – Major Industrial Permit # MT0000248 for wastewater	Unknown coal ash volume. Contact American Crystal Sugar Co, owners
Western Sugars	002 Processed Wastewater Pond (Ash Pond) 005 Processed Wastewater (Proposed Ash Pond)	Billings, MT; Yellowstone County 45.769245, -108.498757	TBD - Operations – may be closing coal ash areas Montana Pollution Discharge Elimination System (MPDES) Permit – Major Industrial Permit # MT0000281 for wastewater	Unknown coal ash volume Contact Western Sugars, owners

THE COLSTRIP RESOURCE

Talen Montana has provided a general analysis of the fly ash and flue-gas desulfurization (FGD) materials from retired Colstrip Units 1&2 to the Montana Department of Environmental Quality (MT DEQ). The composition of these materials is similar to the composition of the materials generated by ongoing operation of Units 3&4. Over the past decade, a handful of companies have shown interest in the large volumes of coal ash stored at the Colstrip settling ponds but have been unsuccessful in the development of an economically viable product.

A one of the largest repositories of coal ash in the west, the Colstrip ponds have received attention from entrepreneurs for over a decade. Today, the MT DEQ requires the approval of a Beneficial Use Determination (BUD) Application with the department in order to beneficially reuse coal ash waste materials and reduce the amount of waste that is disposed of in the state. This determination ensures that safeguards are in place when handling and transporting the ash.

The MT DEQ describes the BUD process as follows:

Pursuant to ARM 17.50.508, prior to managing solid waste, a person shall obtain a solid waste management system license. A Beneficial Use Determination (BUD) is a determination that an industrial or manufacturing by-product material, otherwise destined for disposal, will be used in a specific and beneficial manner. In an effort to encourage diversion from the solid waste stream, the Department's approval of the BUD exempts the individual proposing to use this material from obtaining a solid waste management system license for the specific use identified. As long as the material is used in compliance with the approved BUD, there is no requirement for a solid waste license. The Department has the authority to modify, terminate or rescind any BUD approval. Further, although a successful BUD exempts an individual from licensure, the Department requires the submittal of an annual report documenting its use in the approved manner.

The beneficial use of coal ash is frequent in the manufacturing of cement products such as the concrete blocks seen above.

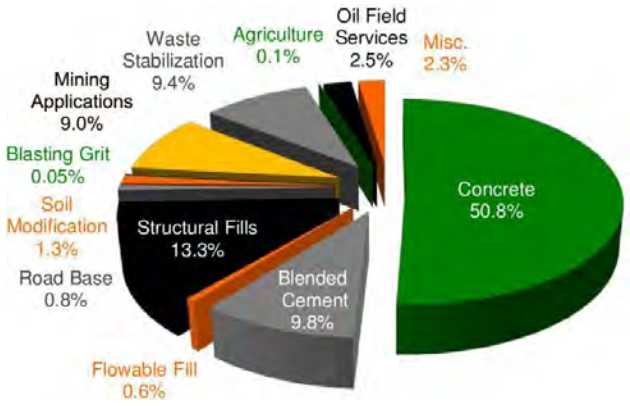
Beneficial Use Determination (BUD) Requirements

A BUD is a determination that a material will be used in a beneficial way instead of being disposed of. To get a BUD, an applicant must demonstrate that the proposed use:

- Protects human health and the environment
- Has benefits as a resource or benefits to reduce or save the waste owner's resources.
- Has a sustainable market
- Substitutes an analogous material effectively and stably
- Laboratory testing: The applicant must follow specific standards for testing the material's physical properties.
- Re-characterization: If the process that produces the material changes, the applicant must reanalyze a representative sample.
- Annual reporting: An approved BUD exempts the applicant from a solid waste management system license, and includes a requirement to submit an annual report documenting the material's use.
- Department approval: The Department can modify, terminate, or rescind a BUD approval.

BENEFICIAL USES OF COAL ASH

Coal Ash has been utilized in many products and applications for decades. The coal combustion products (CCPs) that are found in most coal ash resources can be utilized to create or enhance construction materials and other products, provide pH balance and nutrients to soils, and be utilized in other industrial processes like cement or glass manufacturing. These uses comprise the historic market for CCPs and coals ash in the United States. Several markets are gaining strength in today's global economy and could provide additional uses for coal ash outside of these historic uses.



Current uses of Coal Ash in the United States.

Primary Beneficial Uses

CONSTRUCTION MATERIALS

Construction materials represent one of the strongest markets for coal ash and CCPs. The chemical and structural properties of coal ash provide strength, durability, and lessen the demand on natural resource extraction from virgin ground.

Concrete	Coal ash, particularly fly ash, can be used as a partial replacement for cement in concrete. This reduces the carbon footprint of concrete production and improves its strength and durability.
Structural Fill	Coal ash can be used as a fill material for roads, embankments, and foundations, providing a stable and cost-effective solution.
Gypsum Board	Fly ash can be used as a core material in gypsum board, reducing the need for virgin gypsum.

SOIL AMENDMENTS

Coal ash can be utilized in a variety of soil applications. Ash can help to balance soil pH, provide nutrients, and stabilize soils areas of erosion. Coal ash is also used in ash pond remediation and closure to provide stability and capping properties.

pH Adjustment	Coal ash can help neutralize acidic soils, making them more suitable for agriculture and landscaping.
Nutrient Addition	Some types of coal ash contain beneficial nutrients like calcium and magnesium.
Erosion Control	Coal ash can be used to stabilize slopes and prevent erosion.

INDUSTRIAL APPLICATIONS

The chemical composition of coal ash provides numerous benefits to a variety of industries. Chemical engineers in cement and glass manufacturing utilize coal ash to adjust their end products performance.

Cement Production	Coal ash can be used as a raw material in the production of cement, reducing the need for limestone.
Glass Manufacturing	Coal ash can be used as a flux in glassmaking, improving its properties.
Soil Stabilization	Coal ash can be used to stabilize contaminated soils, reducing the risk of leaching and groundwater contamination.

Secondary Beneficial Uses

CRITICAL MINERAL EXTRACTION

Coal ash often contains a number of critical minerals, like rare earth elements (REEs), that can be extracted from coal ash using a variety of methods. These minerals are vital to the manufacturing of various global technologies and in high demand. This beneficial use is discussed at length in the following section.

Other Benefits

ENVIRONMENTAL BENEFITS:

The beneficial use of coal ash is a long-standing practice in recycling. Utilizing the resources within coal ash not only captures further economic benefit but has positive impacts to the environment as well.

Resource Conservation	By reusing coal ash, we conserve natural resources such as limestone, gypsum, and sand.
Reduced Landfill Waste	Beneficial use of coal ash helps divert waste from landfills, reducing environmental impacts associated with landfill disposal.
Greenhouse Gas Reduction	Using coal ash in construction materials can reduce greenhouse gas emissions associated with the production of traditional building materials.

Challenges and Considerations

Making use of coal ash is not without its challenges. Toxic or hazardous constituents may exist within the waste stream and carry the potential to contaminate water supplies. Handling of the resource, and the refining and processing of that resource into marketable products requires practices that meet state and federal regulations and safeguard the public and the environment.

Environmental Risks	If not handled properly, coal ash can pose environmental risks, such as groundwater contamination and leaching of heavy metals.
Regulatory Compliance	Beneficial use of coal ash requires compliance with strict environmental regulations to ensure safe and responsible practices.
Quality Control	The quality of coal ash can vary, and it is important to ensure that it meets the specific requirements of the intended application.

In conclusion, coal ash has the potential to be a valuable resource, providing numerous benefits in construction, agriculture, and industrial applications. By promoting beneficial use practices and addressing associated challenges, we can contribute to a more sustainable and circular economy.

CRITICAL MINERALS & RARE EARTH ELEMENTS

Ongoing research has found coal ash, particularly fly ash, contains notable quantities of critical minerals and rare earth elements (REEs), with studies showing concentrations ranging from 156 to 590 parts per million (ppm), making it a potential secondary source for REE extraction and other critical minerals. However, the exact concentration varies depending on the coal source and ash composition.

Certain coals can be relatively rich in these resources, recognized as critical elements for renewable power, aerospace industries, and other applications. Once combusted, the elements are concentrated in fly ash, and currently, demonstration programs are seeking economic extraction methods as a substitute to restricted supplies of these elements from China. In addition, coal fly ash (CFA) can be a commercial source of aluminum from alumina-rich CFA, and is also an established source of germanium and new facilities are under construction to extract magnesium from lignite ash.

While the economic extraction of critical minerals from coal ash is not yet a widespread practice, the potential benefits, including reduced reliance on foreign sources and environmental sustainability, are driving ongoing research and development efforts. As technology advances and market demand for critical minerals grows, it is possible that coal ash could become a significant source of these valuable materials.

Laboratory samples of critical minerals and rare earth elements.

Key Points about Rare Earths in Coal Ash

Elements Present	REEs found in coal ash include lanthanum, cerium, praseodymium, neodymium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium, along with scandium and yttrium.
Concentration Variation	Studies have shown significant variance in REE concentration across different coal ash samples, depending on the coal source and combustion conditions.
Potential For Extraction	Due to the presence of REEs in coal ash, researchers are exploring methods to extract and recover these valuable elements, potentially offering a new source of rare earths, especially considering the growing demand for these materials.
Advantages Of Using Coal Ash	Coal ash is readily available as a waste product from power plants, which can potentially reduce mining costs associated with traditional REE extraction.
Study By Seredin And Dai	This study highlighted the possibility of extracting significant quantities of REEs from coal ash, noting that some samples contained REE concentrations comparable to conventional REE ores
USGS Reports	The United States Geological Survey has published research on the occurrence of REEs in coal and coal ash, including their distribution and potential for extraction.
Concerns Regarding Extraction	While coal ash presents a potential REE source, challenges remain regarding the efficient and environmentally friendly extraction process, as REEs are often tightly bound within the ash matrix.

Markets for Critical Minerals & Rare Earth Elements

Critical Minerals (CMs) and Rare Earth Elements (REEs) are essential components in a wide range of modern technologies. Their unique properties make them indispensable in industries such as electronics, renewable energy, defense, transportation, healthcare, and other industries essential to a country's economic or national security.

Critical Minerals & Rare Earth Elements in Advanced Technologies *This is an incomplete list. Additional CMs/REEs may be used varying upon technology and application.*			
Application	**Critical Minerals**	**Rare Earth Elements**	**Product**
Electronics			
Magnets	Iron	Neodymium, praseodymium	Smartphones, laptops, hard drives, and speakers
Catalysts	Platinum, palladium, rhodium, vanadium, smectite clays	Cerium, yttrium	Catalytic converters
Displays	Indium	Yttrium, europium, neodymium	fluorescent lamps and color television screens
Renewable Energy			
Wind Turbines	Copper, aluminum, lithium, nickel, cobalt, manganese, graphite	Neodymium, praseodymium	Wind turbine generators
Solar Panels	Silicon, cesium, copper, indium, tellurium, aluminum, gallium, cadmium	Lanthanum, cerium	Solar cells
Batteries	Lithium, nickel, cobalt, manganese, graphite	Lanthanum, neodymium, dysprosium, praseodymium, cerium, yttrium	Rechargeable batteries, magnets
Transportation			
Electric Vehicles	lithium, cobalt, manganese, nickel, graphite	Neodymium, praseodymium, dysprosium, terbium, samarium	Electric motors
Hybrid Vehicles	lithium, cobalt, manganese, nickel, graphite	Neodymium, praseodymium, dysprosium, terbium, samarium	nickel-metal hydride batteries
Emissions Controls	Copper, lithium, nickel, cobalt	Cerium, lanthanum	Catalytic Converters
Other Industries			
Defense	Copper, aluminum, lithium, nickel, cobalt, manganese, graphite	Lanthanum, neodymium, dysprosium, praseodymium, cerium, yttrium	Radar systems, night vision goggles, and guided missiles
Imaging Equipment	Lutetium, silver, copper, zinc, manganese, titanium, sphalerite	Lanthanum, gadolinium, cerium, yttrium	MRI, CT scan
Lighting	Copper, aluminum, nickel, molybdenum, trona, gallium, zinc	Cerium, europium, gadolinium, lanthanum, terbium, yttrium	LEDs, fluorescents, phosphors

Market Projections

CRITICAL MINERALS

The International Energy Agency (IEA) released its first annual Critical Minerals Market Review, highlighting the surge in planned projects to meet the growing demand for minerals essential to the clean energy transition. The report reveals that the market for these minerals has doubled in size over the past five years (2017-2022: a tripling in overall demand for lithium, a 70% jump in demand for cobalt, and a 40% rise in demand for nickel), driven by the rapid deployment of technologies such as electric vehicles, wind turbines, and solar panels.

INVESTMENT IN CRITICAL MINERALS IS ON THE RISE

A strong indicator in market projections, investment in critical mineral development rose 30% in 2022, following a 20% increase in 2021. Among the different minerals, lithium saw the sharpest increase in investment, a jump of 50%, followed by copper and nickel.

- *International Energy Association*

RARE EARTH ELEMENTS

Wood Mackenzie has forecasted rare earth market strength and prices through 2050. The global research firm predicts strong demand growth for neodymium, praseodymium, dysprosium, and terbium, primarily in permanent magnets for electric vehicles wind turbines, and solar panels. Their forecast also states that most other rare earth elements will remain in significant oversupply due to their natural occurrence alongside neodymium.

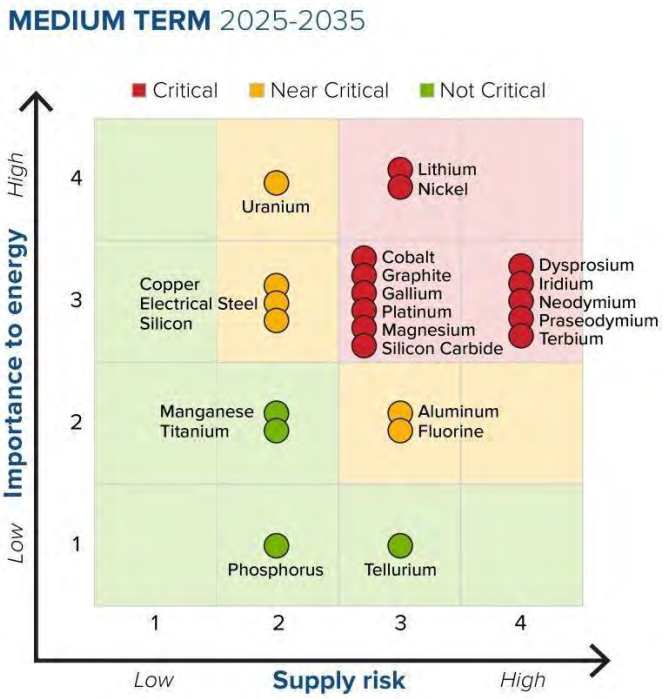
US DEPARTMENT OF ENERGY SUPPLY & DEMAND FORECAST OF CRITICAL MATERIALS

The forecasted supply and demand for critical materials is a complex issue with significant implications for global economies and technological advancements. The rapid growth of electric vehicle and renewable energy technologies has increased the demand for critical minerals, while geopolitical factors, supply chain disruptions, and technological advancements are influencing supply.

Key trends and challenges include:

- **Increasing demand:** The transition to a low-carbon economy is driving a significant increase in demand for critical minerals like lithium, cobalt, nickel, and rare earth elements. These minerals are essential for batteries, electric motors, and other components.
- **Supply constraints:** While there are abundant reserves of some critical minerals, geopolitical factors, supply chain disruptions, and technological challenges can limit their availability. For example, many critical minerals are concentrated in a few countries, making supply chains vulnerable to disruptions.

- **Price volatility:** The imbalance between supply and demand can lead to significant price fluctuations for critical minerals. This can create uncertainty for businesses and consumers and hinder investment upstream and downstream.
- **Technological advancements:** Innovations in mining, processing, and recycling technologies can help to address supply constraints and reduce the environmental impact of critical mineral extraction. However, these advancements may require significant investments and time to develop and implement.



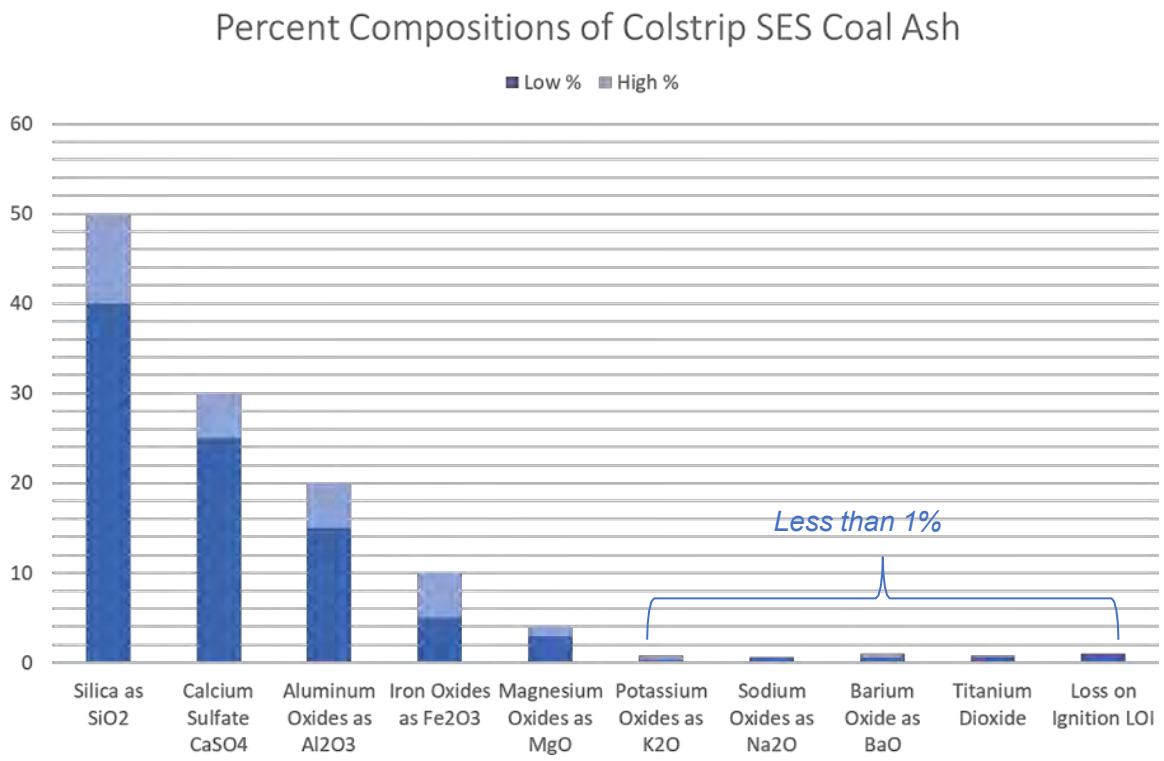
Overall, the future of critical materials is uncertain and depends on a variety of factors. Governments, businesses, and researchers are working to address the challenges associated with supply and demand, but significant investments and policy changes are needed to ensure a secure and sustainable supply of these essential resources.

The US Department of Energy conducted a critical materials assessment to help forecast the supply and demand of these materials through 2035. The results of the assessment are shown in the criticality matrices at left.

Prospecting efforts are on the rise across the globe for virgin material deposits. As are the headlines of potential *"treasure troves"* of the critical minerals. While these potential reserves indicate that there could be substantial deposits located across the globe, bringing them to market is a distant reality. Permitting, extraction, and economics are just some of the hurdles that must be overcome in the mine development process and often take years if not decades to complete. It is unlikely that these prospecting activities will have any effect on the current supply and demand dynamic.

CCR COMPOSITION AT COLSTRIP

Talen Montana has provided the Montana Department of Environmental Quality with a general assessment of the 20 million cubic yard coal ash resource affiliated with the generating facility. The following figures provide a first glance at what resources exist, and in what density, within the Colstrip's coal ash. This is essential information for companies interested in possible beneficial use application and product development from the ash.



Provided by Talen Montana

Critical Minerals and Rare Earth Elements at Colstrip Generating Station

Many critical minerals and rare earth elements can be found within the largest coal ash deposit in the state at Colstrip. These valuable minerals and elements have attracted a number of companies seeking to bring these materials to market. CCR and coal ash deposits represent an alternative to virgin material extraction.

Mining for metals high in demand, like lithium and cobalt, have experienced increased scrutiny across the globe. Environmental impacts, child labor, labor conditions, and exploitation have been flagged in multiple business operations by the global community. As these negative business practices are addressed, remedied, and regulated, the cost of virgin material extraction will increase in the global marketplace.

Material extraction from CCR and coal ash resources can provide additional positive benefits as the materials are recycled, and repositories of potentially toxic materials are better managed and stored for the future. This also displaces some of the need for virgin extraction of these elements leaving ground unbroken and available for future use.

The density of these materials within the CCR resource is an important factor for those looking to extract value. The economics of excavating, handling, and processing coal ash to obtain a quality product comparable to virgin processed material do not provide wide margins. Companies desire the highest densities available when considering these coal ash developments.

Another important consideration is whether these elements are bonded to other materials. Depending on the type of processing, combustion, emission, and waste stream systems utilized, these elements may require chemical or energy intensive processing to isolate the desired products. This processing adds expense to the manufacturing of the product making the business venture less attractive.

P - Phosphorus	600 ppm
Mn - Manganese	500 ppm
Li - Lithium	75-100 ppm
Co - Cobalt	5-10 g/t
Cu - Copper	55-80 ppm
V - Vanadium	50-100 ppm
Cr - Chromium	20 ppm
Sb - Antimony	20 ppm
Zn - Zinc	20-30 ppm
Mo - Molybdenum	15-20 ppm
Be - Berylium	3 ppm
Sr - Strontium	2000 g/t
La - Lanthanum	30-45 ppm
Ce - Cerium	55-70 ppm
Pr - Praseodymium	7-10 ppm
Nd - Neodymium	25-35 ppm
Sm - Samarium	4-5 ppm
Eu - Europium	1 ppm
Ga - Gallium	150 ppm
Ge - Germanium	30 ppm
Gd - Gadolinium	4-6 ppm
Tb - Terbium	1 ppm
Dy - Dysprosium	4-8 ppm
Ho - Holmium	1 ppm
Er - Erbuim	3 ppm
Tm - Thulium	0.5 ppm
Yb - Ytterbium	2-3 ppm
Lu - Lutetium	0.5-1 ppm
Y - Yttrium	20-30 ppm
Tl - Thalium	2000 ppm
Sc - Scandium	<25 ppm
Zr - Zirconium	150 ppm
U - Uranium	10-30 g/t
Th - Thorium	15 g/t

Provided by Talen Energy

Extraction of CMs and REEs from coal ash shows promise but is not without its economic and environmental challenges. Industry and government continue to invest heavily in these technologies as the vast deposits of CCR throughout the US could provide a significant supply of critical materials to the domestic pipeline.

2024 Units 3&4 Operations Coal Ash Disposal in Cell J-1, Colstrip MT

The darker ash seen is bottom ash, lighter ash is dry disposal fly ash, and the gray slurry on left is wet disposal area of fly ash. Photo courtesy of The MT Department of Environmental Quality.

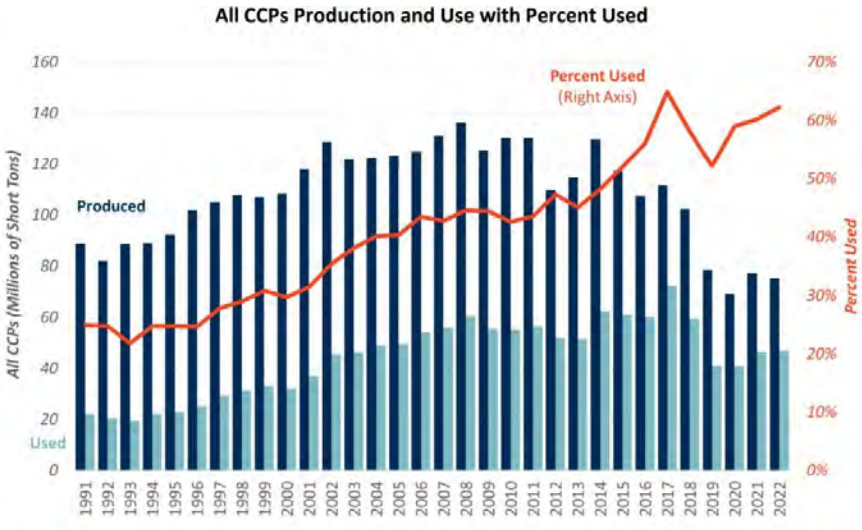
MONTANA COAL ASH VIABILITY FOR COMMERCIAL USE & ASSOCIATED MARKETS

The American Coal Ash Association is the leading organization tracking and promoting the recycling and reuse of coal combustion residuals (CCR). Nationally, the beneficial use of these materials is trending upward. This is evidence of a viable marketplace for coal ash and CCR materials. Understanding national trends and markets will help the State of Montana assess and analyze the potential use and marketability of coal ash resources within the state.

National Trends

Sixty-two percent of the coal ash produced during 2022 was recycled – increasing from 60 percent in 2021 and marking the eighth consecutive year that more than half of the coal ash produced in the United States was beneficially used rather than disposed.

Use of CCPs has steadily increased over the past 30 years. As coal combustion and production of CCPs has decreased over the past decade, the marketplace for these products has remained stable and increased year over year as a percentage of production.



The graph above depicts the declining production volume of CCPs and an increase in utilization of CCPs into available markets. (Figure provided by ACAA)

FROM THE

AMERICAN COAL ASH ASSOCIATION

"The rapidly increasing utilization of harvested coal combustion products ("CCP") shows that beneficial use markets are adapting to the decline in coal-fueled electricity generation in the United States. New logistical and technology strategies are being deployed to ensure these valuable resources remain available for safe and productive use. We must continue to support these practices that safely conserve natural resources while dramatically reducing the need for landfills."

Thomas H. Adams, ACAA
Executive Director

Product Categories for CCPs utilized in 2022

CCPs have been utilized in many product categories for decades. Industrial categories such as soil amendments, cement production, synthetic gypsum, and structural fill have been strong markets for CCPs. These markets continue to evolve alongside the products and technologies that drive them. This evolution gives promise to future markets and favorable economics of CCP utilization.

American Coal Ash Association
1616 17th Sreet Suite #226
Denver, CO 80202
Email: info@acaa-usa.org

Phone: 720-870-7837
Fax: 720-870-7889
Internet: www.ACAA-USA.org

2022 Coal Combustion Product (CCP) Production & Use Survey Report

Beneficial Utilization vs. Production Totals (Short Tons)

2022 CCP Categories	Fly Ash	Bottom Ash	Boiler Slag	FGO Gypsum	FGD Material Wet Scrubbers	FGD Material Dry Scrubbers	FGD Other	FBC Ash	CCP Production / Utilization Totals
Total CCPs Produced by Category	26,512,322	7,973,554	834,131	17,677,439	6,065,567	2,833,942	41,364	7,217,772	69,156,091
Total CCPs Used by Category	17,10.4,493	2,955,653	369,7.29	13,147,74.2	292,553	106..256	2,193	6,809.79	40,788,407
1. Concrete / Concrete Products / Grout	11,057,713	305,349		12.4,305					11,487.37
2. Blended Cement / Feed for Clinker	2,321,062	862.,160	73,727	1,546,731				6,512	4,810.19
3. Flowable Fill	95.272								95,272
4. Structural Fills / Embankments	306.379	510,165							816.5.43
5. Road Base / Subbase	128,967	83,782							21.7749
6. Soil Modification / Stabilization	57.558	80							57.638
7. Mineral Filler in Asphalt	16,195					33	2.193		18,421
8. Snow anc Ice Control		35.21	22,454						57.664
9. Blasting Grit / Roofing Granules		9,773	273,5.48						283,320
10. Mining Applications	53,930							6,730,060	6,783,990
11. Gypsum Panel Products (formerly Wall	18,308			9,963,467					9.98..7776
12. Waste Stabilization / Solidificaton	1,117.55	43.634		118854		13.415		73.216	1.366.670
13. Agriculture		3,901		764,996		78.806			8.4.7704
14. Aggregate	1.55								1.55
15. Oil & Gas Field Services	64,163					6.816			70.979
16. CCR Pond Closure Activities	1.558,156	1,026,079		537,176	292.553				3.413.964
17. Miscellaneous / Other	307,689	75,520		92.212		7.186			482.608

Summary Utilization to Production Rate

CCP Categories	Fly Ash	Bottom Ash	Boiler Slag	FGO Gypsum	FGD Material Wet Scrubbers	FGD Material Dry Scrubbers	FGD Other	FBC Ash	CCP Utilization Total
Totals by CCP Type / Applicabon	17.104.483	2.855.653	38,729	13.147.742	292.5.53	106,256	2.13	809.73	40.788.407
Category Use to Production Rate (%)	64.52%	37.07%	44.33%	74.38%	4.82%	3.75%	5.30%	94.35%	58.98%

CONCLUSION

Coal ash has provided the resource to create many byproducts for decades. Historically, the cement and concrete industries have consumed the largest volumes of this resource, followed by structural fill and agricultural applications. These market opportunities still exist for Montana resources and have been explored by a handful of private companies, although none have proven economically viable for a variety of reasons.

Several technological advancements in energy, transportation, computing, imaging, and healthcare have unlocked a new potential marketplace for coal ash / coal combustion residues (CCRs). The critical minerals and rare earth elements necessary to manufacture these technologies are often scarce, or victim to destabilized regions of the world, supply chain disruptions, and price volatility. CCRs represent a known repository of these elements and are actively being analyzed as a viable supply for domestic production.

Nationwide, the beneficial use of CCRs is trending upward. Since the federal CCR Rule was implemented in 2015, the percentage of coal ash being reproposed into a secondary marketplace has increased year over year. This is leading to innovation in multiple product and industry categories. As these technologies evolve to create more and better products from this resource, the economic viability for the beneficial use of coal ash will also increase.

The Montana coal ash resource has a strengths and weaknesses. Colstrip represents one of the largest coal ash resources in the west. This concentration is attractive to potential developers. Montana is largely seen as a business-friendly state whose regulatory agencies are open to working with the private sector to find economic pathways to remediate and manage the state's coal ash repositories. An undeniable factor in developing Montana's resource is distance to market. Nearly all the state's resource is in rural eastern Montana which is hundreds of miles from any metropolitan market. This has proven to be a significant hinderance for developers. The Colstrip generating facility operations have employed scrubber technologies unique to that plant. This in turn has created a coal ash that is unique in its composition. Over the years, some developers have found this ash incompatible with their potential uses, others in more recent years have been able to derive their product from the ash but could not economically produce it and deliver it to market.

The potential for Montana's coal ash resource to be reproposed and brought to market is there. A number of constraints continue to hinder its market viability: cost of extraction, transfer of ownership and liability, distance to market, infrastructure, and technological innovation. These constraints are normal components of the industrial development lifecycle and may be overcome in time. Current market demand is trending in the right direction and so long as there is not a market disruption, e.g. new technology to displace CMs/REEs, the private sector is likely to continue to pursue the use of these resources.

HELPFUL LINKS & RESOURCES

Montana Legislative Branch - Understanding Energy in Montana 2023
https://leg.mt.gov/content/Publications/fiscal/2025-Biennium/Special-Topics/Energy/Understanding- Energy-in-Montana-2023.pdf

Talen Montana
https://www.talenenergy.com/ccr-colstrip/

American Coal Ash Association
https://acaa-usa.org/wp-content/uploads/2023/12/News-Release-Coal-Ash-Production-and-Use- 2022.pdf

DOE Report on REEs in Coal Ash
https://www.energy.gov/sites/prod/files/2018/01/f47/EXEC-2014-000442%20-%20for%20Conrad%20Regis%202.2.17.pdf

USGS Report on REEs in Coal Ash
https://pubs.usgs.gov/publication/fs20193048#:~:text=They%20include%20yttrium%20(Y%2C%20atomic,71%20(lutetium%2C%20Lu)

Science Direct Article with multiple References regarding REEs in Coal Ash
https://www.sciencedirect.com/science/article/pii/S0166516217304597#bb0280

Critical Minerals Demand report from IEA
https://www.iea.org/news/critical-minerals-market-sees-unprecedented-growth-as-clean-energy- demand-drives-strong-increase-in-investment

Critical Minerals Data Explorer
https://www.iea.org/data-and-statistics/data-tools/critical-minerals-data-explorer

DOE Critical Materials Report – 2023
https://www.energy.gov/sites/default/files/2023-07/doe-critical-material-assessment_07312023.pdf

Montana DEQ Beneficial Use Application
https://deq.mt.gov/files/Land/SolidWaste/Documents/newapplications/BUD-0110.pdf

APPENDIX

SUPPORT BRIEFING FROM MT DEPARTMENT OF ENVIRONMENTAL QUALITY on HB648 Section 2 Coal Ash Markets Investigation Program for the MT DEPARTMENT OF COMMERCE (House Bill 648 was codified in 2021 under statute MCA §90-2-202)

TO: Dustin deYong, Freestone Development, Contractor to MT Department of Commerce (dustin@freestonedevelopment.com)
FROM: Sarah Seitz, Montana Department of Environmental Quality (DEQ), Waste Management, and Remediation Division Environmental Project Officer (sarah.seitz@mt.gov)
DATE: Updated October 23, 2024
RE: Montana DEQ Data and Information on Known Coal Ash Resources in Montana
CC DEQ WMRD Personnel: Rick Thompson, Waste Management Bureau Chief. Fred Collins, Solid Waste Section Supervisor/Beneficial Use Oversight Denise Kirkpatrick, Hazardous Materials Section Supervisor

MT DEQ Beneficial Use Determination Process

The Montana Department of Environmental Quality (DEQ) recognizes that diverting non-hazardous industrial and manufacturing by-products for beneficial reuse or recycling saves disposal costs for the generator, decreases material costs for end users, and preserves natural resources by decreasing the demand for virgin materials. In addition, the DEQ encourages the beneficial use of industrial by-products to protect the environment, preserve resources, conserve energy, reduce greenhouse gases, and reduce or eliminate the need to otherwise dispose of these materials in licensed landfills. Unless non-hazardous waste industrial or manufacturing by-products are used in an approved beneficial manner, they are to be managed as a solid waste or under remediation oversight.

A Beneficial Use Determination (BUD) is a determination granted from DEQ that an industrial or manufacturing by-product material, otherwise destined for disposal, will be used in a specific and beneficial manner. DEQ has a guidance manual and application available on Solid Waste Program website under "Special Waste."

Link:
https://deq.mt.gov/files/Land/SolidWaste/Documents/newapplications/BUD_Application_2021.pdf

In General, DEQ can help facilitation the BUD process as follows:

1. Discuss the beneficial use of waste material with the entity that owns/generated the waste material, if the BUD applicant is not the owner/generator of the waste material. Secure tentative agreements

with the owner/operator of the waste material to use that material for research and development of the BUD and for full-scale beneficial use.

2. Schedule a meeting, in person or remotely, with DEQ's Solid Waste Section Manager to discuss the process and the details of the proposed beneficial use including the following potential information that may be specific for each beneficial use process:
    a. Details on the following:
        i. The process to use/transform the waste into beneficial use products,
        ii. The end products/beneficial use product,
        iii. The potential or known waste streams for the process
    b. Known research results or analytical results already obtained on the process and end product
    c. Potential specifications/research or analytical results needed to evaluate the beneficial use process and the end products or waste streams
    d. The market and economic analysis that will need to be included in the BUD
    e. Any proprietary information that may need to be submitted to DEQ separately from the BUD application
    f. Timing for use of waste and BUD review process
    g. Potential additional permit or regulatory review processes that may apply to the beneficial use process that would be managed by DEQ sections other than Solid Waste
3. Submit a draft of the BUD application and work cooperatively with DEQ during the review process to finalize the BUD with the any additional or missing information
4. Finalize and submit a final BUD application to DEQ Solid Waste Section
5. DEQ will review and can then approve, deny, or request more information on the BUD
    a. With an approved BUD, DEQ will provide details on when and how the annual reporting of the beneficial use will be submitted toDEQ, and any additional DEQ specific permits or regulatory oversight needs.

MT DEQ Previous Work to Date forHB648:

In 2021, the DEQ Waste Management and Remediation Division updated the beneficial use determination (BUD) process that pertains to both coal ash material waste and other industrial wastes/by-products that can be beneficially reused. The process is outlined on DEQ's public website (https://deq.mt.gov/twr/Programs/solidwaste). DEQ updated its *Guide to Beneficial Use Determinations of Waste Industrial and Manufacturing By-Products* to include the components outlined in HB648,

Link: https://deq.mt.gov/files/Land/SolidWaste/Documents/newapplications/BUD_Application_2021.pdf), including the following cost-related information and request for information to be reviewed

SUPPORT BRIEFING FROM MT DEPARTMENT OF ENVIRONMENTAL QUALITY (continued)

"The Department of Environmental Quality (Department) recognizes that diverting non-hazardous industrial and manufacturing by-products for recycling saves disposal costs for the generator, decreases material costs for end users, and preserves natural resources by decreasing the demand for virgin materials. (Page 1);" and

"The applicant must provide the following information to the Department in the BUD petition:

… A brief description of the benefits realized: landfill space saved, resources saved, costs saved, energy saved, and more…. (Page 3)"

Between 2021 and 2024, DEQ has received two BUD applications that pertain to coal ash material. Details on those BUD applications are below:

1. DEQ provisionally approved a BUD to RamRock in 2020 for coal ash reuse associated with the Colstrip Steam Electric Station in Colstrip, MT. DEQ last communicated with RamRock in 2022 and does not believe the RamRock reuse activities continued with Talen Montana. RamRock was seeking to apply beneficial use of coal ash as a building product in cementitious applications. The Colstrip SES operator, Talen Montana, indicated to DEQ that they are not working with RamRock at this time. DEQ has not received the requested additional reporting or data associated with additional testing activities for the potential beneficial use of coal ash associated with the RamRock BUD. Please reach out to David White, CEO of RamRock, at david.white@ramrock.com or 423.314.3564 for additional information and status on the RamRock beneficial use of coal ash from the Colstrip SES facility.
2. DEQ is currently reviewing a 2024 BUD submission from Human Powered Future, LLC (formerly Neodymia and Human Powered Future) for coal ash reuse associated with the Colstrip Steam Electric Station in Colstrip, MT. Human Powered Future is looking to apply beneficial use of coal ash as a source of rare earth elements, specifically gallium. DEQ will continue to review and aid Human Powered Future in the application process. Please reach out to Bradley Layton, Owner Human Powered Future, at bradley.layton@humanpowedfuture.com or 406.203.2365.

DEQ has answered questions or had calls related to beneficial use of coal ash from several other individuals interested in the potential for coal ash BUDs in the near future. All inquiries were working with Talen Montana to potentially use coal ash waste from the Colstrip SES facility, Colstrip, MT. Please contact Gordon Criswell or Jennifer Petritz at Talen Energy Montana to discuss during DEQ's BUD review process: Beneficial use plans for the Colstrip SES facility: Gordon.Criswell@TalenEnergy.com or Jennifer.Petritz@TalenEnergy.com.

SUPPORT BRIEFING FROM MT DEPARTMENT OF ENVIRONMENTAL QUALITY (continued)

DEQ's Waste Management and Remediation Division will continue to provide guidance and review on the BUD process as outlined in the Guide to Beneficial Use Determinations of Waste Industrial and Manufacturing By-Products, and in accordance with any other applicable state laws on coal ash disposal or facility-based administrative order on consent.

MT DEQ Inventory of Coal Ash Repository and Waste Locations:

Separate from DEQ's BUD Evaluation Process, DEQ maintains tables, to the best of our general knowledge, of regulated and non-regulated locations of coal ash waste material. DEQ has several oversight programs and administrative orders that govern coal ash waste disposal.

- DEQ provides coal-fired power plant operation and coal ash remediation oversight for one facility, Colstrip Steam Electric Station (SES) through a certificate granted to the operator under the Montana Major Facility Siting Act (MFSA) and through an Administrative Order on Consent (AOC) associated with that MFSA certificate and violations of the Montana Water Quality Act.
- DEQ also has oversight of remediation activities associated with coal-fired generating units of 200 megawatts or greater through the Montana's Coal-Fired Generating Unit Remediation Act. This act currently only applies to remediation activities at the Colstrip SES.
- DEQ provides oversight over the City of Hardin's coal ash landfill cell through the Montana Solid Waste Management Act and associated rules. The Hardin landfill accepted waste from the privately-owned coal-fired Hardin Generator Plant.
- DEQ has oversight or had oversight in the past through the Montana Water Quality Act for discharge permits associated with industrial wastewater at several other facilities that used coal-fired electricity generation in their industrial processes. These discharge permits are/were for wastewater processes and are not specific to the disposal or management of coal ash materials.
- DEQ's Coal Mine Section provides oversight for coal mining activities through the Montana Surface and Underground Mining Reclamation Act, which applies to prospecting, exploration, and permitted mining and reclamation.

In addition to DEQ's oversight, the US Environmental Protection Agency (EPA) has additional oversight for Coal Combustion Residual (CCR) from Electric Utilities. The US EPA regulates management and disposal of active and legacy CCR generated by electric utilities and independent power producers with North American Industry Classification System (NAICS) code 221112. The Region 8 US EPA contact is Doug Knappe who can be reached at 303-312-6190 and Knappe.Doug@epa.gov.

SUPPORT BRIEFING FROM MT DEPARTMENT OF ENVIRONMENTAL QUALITY (continued)

DEQ has included two Tables to this memo that include DEQ's oversight and knowledge of coal ash repositories/waste locations that may be of value during the Department of Commerce's Coal Ash Markets Investigation Program. Please reach out to DEQ if you would like further information.

Table 1: Montana Coal-Fired Power Plants with Potential/Known Coal Combustion Waste/Residuals (CCW/CCR)

Coal-Fired Power Plant Name	Montana DEQ Oversight of Coal Combustion Waste	Site Location and County; Coordinates (WGS84)	Power Generation Power Capacity/ Active Power Capacity 2024 (MW) Start – End Dates	Coal Ash or Coal Combustion Residual (CCR) Disposal Method	DEQ Data on Volume of Coal Combustion Waste/Ash Composition Data
Colstrip Steam Electric Station (SES) Generating Plant	Major Facilities Siting Act (MFSA §75-20-102) Certificate (1976), Administrative Order on Consent (AOC) (2012) for MFSA and MT Water Quality Act Violations, Coal-Fired Generating Unit Remediation Act (§75-8-101 to 110) (2017)	Colstrip, MT; Rosebud County 45.882386, -106.612847	2160/1480 MW Unit 1: 1975 – 2020 Unit 2: 1976 – 2020 Unit 3: 1984 – Active Unit 4: 1986 – Active	On site CCR closure in repositories (impoundments and landfills) AOC for MFSA (§75-20-102)and MT WQA: Documents link at the following: https://deq.mt.gov/cleanupandrec/Programs/colstrip US EPA CCR Website: https://www.talenenergy.com/ccr-colstrip/	>20M Cubic Yards in three areas across the 10,000-acre property and still in operation Contact Owner/Operator Talen Energy MT for ash composition data, explored for both building materials and rare earth elements (REE) Ash composition data provided to Dept. of Commerce Consultant and DEQ on 9/26/24 from Gordon Criswell of Talen Energy MT
Colstrip Energy LP Plant/Rosebud Power Plant	US EPA Primary Oversight	Colstrip, MT; Rosebud County 45.975156, -106.655244	46/41-46 MW Plant: 1990 – Active	On site CCR landfills/reuse US EPA CCR Website: https://celpccr.com/	Unknown – two landfill locations in Colstrip, MT Contact Colstrip Energy LP for ash composition data
Hardin Generator Project Plant	MT DEQ Solid Waste Permit for Coal Combustion Waste Cell - see Hardin Landfill in Table 2 MT DEQ Air Quality Permit #3185-07	Hardin, MT; Big Horn County 45.764342, -107.598292	116/116 MW Plant: 2006 – Active Owner Rocky Mountain Power and operator Herot Power Management	Hardin landfill in Big Horn County - From Hardin Coal Plant US EPA CCR Website: No CCR Website found, coal ash taken off-site to Hardin Landfill with MT DEQ permitted coal ash waste cell	No known coal ash storage at Hardin Generator Plant – transported to Hardin Landfill (See Table 2) Contact Herot Power Mgmt or Hardin Landfill for ash composition data
JE Corette Power Plant	NA DEQ Oversight – Volunteer information from Owner to DEQ Potential US EPA Oversight based on 2024 Legacy CCR Rule - US EPA included as potential legacy CCR facility in 2024 rule updates	Billings, MT; Yellowstone County 45.775175, -108.481322	153-173/0 MW Plant: 1968 – 2015	Coal ash generally sent off-site for reuse in construction materials/ concrete during operations. Potential coal ash locations closed in place called SPD-1 and SPD-2 and treated as one location during closure. US EPA CCR Website: https://www.talenenergy.com/ccr-corette/	Primarily beneficially used in building materials around Billings during operation, two locations closed in place on site (SPD-1/SPD-2) Contact Talen Energy MT for ash composition data
Lewis & Clark Plant/Sidney Sugars Plant	Primary CCR regulation by US EPA Former DEQ MPDES Discharge Permit: Montana Dakota Utilities (MDU) Lewis & Clark Plant MT0000302	Sidney, MT; Richland County 47.678611, -104.158	44-50/0 MW Sugar Plant Power Source: 1958 – 2021 Completing closure/cleanup activities currently. Terminated MPDES permit Dec. 7, 2022	Dry landfill in Richland County US EPA CCR Website: https://www.montana-dakota.com/energy-efficiency/ccr-rule/lewis-clark-station/	MDU notes two landfills (Landfill 1 and 2) in addition to potential ash/coal combustion waste at Temporary Storage Pad, East Scrubber, and West Scrubber areas on CCR website Contact MDU for ash composition data

Table 2: Montana Coal Combustion Waste Facilities for Non-Coal-Fired Electric Generating Power Plant Repositories

Coal Ash/CCR Repository Name	Coal Ash or Coal Combustion Residual (CCR) Disposal Method	Site Location and County; Coordinates (WGS84)	Coal Ash Collection Dates	DEQ Data on Volume of Coal Combustion Waste/Ash Composition Data
Hardin Landfill – Received waste from Hardin Generator Project (see Table 1)	39.8 Acre licensed landfill cell for coal combustion waste (CCW). Permitted by DEQ for 2,526,000 cubic yards (2,557,000 tons) with potential operating life of the monofill is 25.7 years based upon a waste acceptance rate of 100,000 tons per year	Hardin, MT; Big Horn County 45.764342, -107.598292	2006 – Actively permitted, Annual Reports to MT DEQ, Receives coal ash waste from Hardin Generator Station and has previously received coal ash waste from the closure of the Former Curette Plant in Billings, MT MT DEQ Solid Waste License #348, Hardin Landfill with CCW Cell	Permitted for >2.5M Cubic Yards, not at full capacity as of 2024 Contact City of Hardin Landfill Operator Talen or Herot Power Mgmt for ash composition
Westmoreland Savage Mine	Possible CCR/coal ash waste from Lewis & Clark Station that notes a dry landfill in Richland County.	Savage, MT; Richland County 47.416389, -104.375	1925 through 2023 (Mothballed, no clear closure status) MT DEQ Coal Permit ID: C1984002 https://westmoreland.com/westmoreland-savage-mining-llc/	Unknown coal ash volume – may not be a coal combustion waste location Contact Westmoreland for confirmation and/or data and any coal ash composition
Sidney Sugars	Two coal ash slurry ponds on site – "Coal ash from the boilers was slurried to two bentonite-lined ash ponds."	Sidney, MT; Richland County 47.7167, -104.1347	Closed in 2023 – In process of closure. Responsible Party Working with DEQ Water Quality/ Enforcement MPDES Permit – Major Industrial Permit # MT0000248 for wastewater	Unknown coal ash volume. Contact American Crystal Sugar Co, owners
Western Sugars	002 Processed Wastewater Pond (Ash Pond) 005 Processed Wastewater (Proposed Ash Pond)	Billings, MT; Yellowstone County 45.769245, -108.498757	TBD - Operations – may be closing coal ash areas Montana Pollution Discharge Elimination System (MPDES) Permit – Major Industrial Permit # MT0000281 for wastewater	Unknown coal ash volume Contact Western Sugars, owners

Talen Montana LLC. Coal Combustion Residual (CCR) Beneficial Use Summary – 8/29/2024

The following is a status summary of Talen Energy's (Talen) efforts to evaluate a beneficial use program for Coal Combustion Residuals (CCR) material at the Colstrip Steam Electric Station (Colstrip), which is operated by its subsidiary Talen Montana.

Background

In August 2012, DEQ and Talen Montana entered into an Administrative Order on Consent (AOC) to address impacts from wastewater facilities at the Colstrip Power Plant. The AOC was entered as part of an enforcement action taken by DEQ, and it includes a step-by-step plan for remediation of the groundwater downgradient of the ash ponds, including closure of coal ash impoundments. For purposes of the AOC process, the site has been divided into three areas: the Plant Site area, the Units 1 and 2 Stage One Evaporation Pond (SOEP) /Stage Two Evaporation Pond (STEP) area, and the Units 3&4 Effluent Holding Pond (EHP) area. The Montana DEQ maintains Colstrip Coal Ash Pond Cleanup information on its public website for reference.

The Units 1 and 2 SOEP/STEP area includes approximately eight million tons of CCR impoundments. Talen Montana, as signatory to the Colstrip Wastewater AOC on behalf of the Colstrip Owners, is currently working to implement the remediation and closure activities under the AOC. For the Units 1&2 SOEP/STEP area, the current plan is to close the CCR impoundments by removal and place the CCR material in a newly designed and constructed landfill adjacent to the existing impoundments. All work, including closure of the new landfill, is to be completed by 2031.

Efforts to Date

Talen has been actively exploring potential solutions that will beneficially use the CCR material as an alternative to placing the material in a new landfill. At current, our efforts to identify a viable option have not yet been successful. As we pursue options, we must remain mindful of the regulatory requirement to complete closure activities for the SOEP and STEP areas by the end of 2031 in a way that is protective of human health and the environment. It is essential that any beneficial use option must be a proven technology with a demonstrated record of safe, environmentally compliant, and successful implementations.

Talen has engaged with groups regarding beneficial use for over nine years, and through this effort, has identified three main areas for potential CCR beneficial use. We have been actively evaluating these areas to determine if any type of beneficial use of CCR is feasible. These three areas are:

1. Rare Earth Element (REE) Extraction
2. Cementitious Type Applications
3. Emerging Technology Applications

Talen has an internal resource dedicated to Beneficial Use of CCR. This individual is highly active in the ACAA (American Coal Ash Association), USWAG (Utility Solid Waste Activities Group), and in the ASTM (American Society for Testing and Materials) which governs the requirements for use of coal fly ash in cement/ready mix type products. The individual continues to explore opportunities through these avenues.

Rare Earth Element Extraction

Talen has performed sampling, testing, and screening of Colstrip CCR material with six different vendors (Elixsys, Winner Waters, Neodymia LLC, American Resources, Battelle and MTL Corp.) in efforts to evaluate the viability of REE beneficial use for Colstrip's CCR. Talen has also been collaborating with different universities (University of Wyoming, Montana Tech, Cornell, and recently Penn State) that are developing a REE extraction process specific to Powder River Basin Ash (PRB) which is the type of coal utilized at the Colstrip Power Plant.

Talen has also been collaborating with the Montana Department of Commerce and Southeastern Montana Development Corporation (SEMDC) regarding beneficial use of Colstrip Power Plant CCR.

Additionally, Talen has had discussions with companies that are already in the REE industry including Mountain Pass, Bear Lodge, Energy Fuels, and American Fuels.

Talen has also been active with the DOE and National Energy Technology Laboratory (NETL), as both organizations are managing grants/funding included in the recent Bilateral Infrastructure Law and the Inflation Reduction Act - BIL and IRA respectively. Testing to date has shown that Colstrip CCR has a concentration of ~300ppm REE which is the threshold set by the US Department of Energy (DOE). Talen responded to the DOE request for information and has applied to their teaming lists to be visible to companies that may have a solution and wish to use Talen's feedstock, in this case the Colstrip Power Plant CCR.

Key findings:

- REE extraction will only utilize 1-3% of the gross volume of Colstrip CCR.
- Any REE solution would need to be paired with another process (for example cementitious type) to achieve full beneficial utilization of Colstrip's CCR.
- Specific to Colstrip CCR, there is a concentration of REE ~ 300 ppm which is the threshold for DOE involvement/funding, however we have not been contacted for participation in support of potential efforts through their programs.
- REE extraction from CCR has not been developed into the separation of individual elements, which limits potential opportunities.

Cementitious Type Beneficial Uses

Talen has also been in discussions with more than ten vendors, including Ashcor, Boral, Eco-Materials, CementLock, Engineered Aggregates, NuRock, Ashtek, Tephra, SEFA, Cinder Residuals, PSI/Winner Water Solutions, RamRock, ReSolve, and OTB Materials, in ongoing efforts to see if any cement type uses would be applicable.

Key findings:

- The chemical characteristics of the Colstrip CCR, including its collection in the Colstrip Power Plant wet scrubber system, results in a material that is not ideal for cement type use, due to the co-mingled nature of the products (ashes and scrubber products). However, the bottom ash that is stored in some areas, may be able to be harvested and marketed. Ashcor, a beneficial use marketer located in Canada, has expressed interest in this.
- There are potential processes/techniques for utilizing the Colstrip CCR in concrete type materials for the purpose of building or construction materials. Talen continues to evaluate these process/techniques.

Emerging Technology Applications

Talen has been actively monitoring emerging technologies through existing contacts and by attending industry conferences that were specific to CCR beneficial use and clean energy initiatives, including the latest WOCA (World of Coal Ash) held in Michigan in May of 2024. This has been in addition to our previously mentioned industry involvement. We continue to follow developments around the following emerging technologies:

- A Carbon Capture technology that can be injected into fly ash that is being utilized for cement type uses – chemically it creates a faster cure and better compressive strength in initial results.
- Potential asphalt and anti-skid processes are among other emerging technologies that could help enable 100% beneficial use of Colstrip CFA.

Key finding:

- Because they are novel unproven technologies, more study will be required.

Considerations

Through our continued exploration of beneficial use options, the following considerations have been identified, which are universal across the various potential areas outlined within.

- Through discussions regarding virtually all beneficial use opportunities, each has identified the same economic and logistical challenges with regards to the geographic location of the Colstrip site and limited modes of transportation that could be utilized to bring necessary materials in and take the finished product out.
- Rail access has also been identified as essential for any beneficial use option. Colstrip does have rail to the plant site area; however, it would need evaluation/refurbishment/modification to provide a cost-effective transportation method for any proposed beneficial use product.
- Many of the emerging technologies and REE work that have been evaluated would require the installation and operation of chemical industrial facilities at or near the Colstrip site. The timing and environmental impact of this would need to be evaluated.

Conclusion

Talen remains open to, and interested in, exploring beneficial use options, however, despite significant efforts to explore options and engage with a reputable, experienced industry partner, efforts have not yet identified a viable opportunity for beneficial use at Colstrip at this time.

Talen's focus remains on activities that are feasible, proven, and protective of human health and the environment, and which will permit us to meet our requirements to complete the required ash pond closure efforts on time and with this focus in mind.