

BR08 - Sustainably Transforming Bauxite Residue into Critical Minerals

Christopher Cannon Young

Chief Strategy Officer

Elementus Minerals, LLC

Corresponding author: Chris.Young@Element.us.com

Abstract

ElementUS plans to construct operations that will utilize bauxite residue to produce pig iron, alumina, critical minerals (CM) including scandium, and additional saleable products. The ElementUS process combines established chemical separation technologies with thermal separation technology in a novel and proprietary method that will require significantly less energy input than traditional smelting techniques. As a result of energy savings and the ready availability of raw material at surface level with no mining requirements, ElementUS will be the low-cost producer of pig iron in the United States and a near low-cost producer of other products. In addition, the energy savings provided by the ElementUS process will result in direct greenhouse gas emissions reductions. Additional benefits are the production of alumina and CMs which are critical in the transition to renewable energy and zero carbon goals. ElementUS will also remove a pollutant from the environment by reducing bauxite residue currently stagnant in retaining ponds while producing zero waste. The waste from this process will be used and sold as construction material while CO₂ emissions will be captured and used as feedstock. An independent third-party laboratory has completed successful testing of the process and preparations are underway to conduct pilot testing.

Keywords: Bauxite residue, Red mud, Critical materials, Scandium, Uses.

1. Introduction

The potential for bauxite residues as a resource of critical mineral commodities has been recognized worldwide and has been the subject of work in the U.S., including by the U.S. Geological Survey (USGS, Van Gosen and Choate, 2021), and internationally (Borra et Al., 2016). In addition to elevated grades of aluminum and iron, these residues can also contain significant concentrations of critical mineral elements including rare earths, titanium, gallium, and niobium.

Our management team, and our current list of interested investors, are developing this facility as a for profit business with an anticipated return on capital expenditures of under 4 years. This rapid return is made possible by the production of additional saleable products beyond metallic iron, including:

- Critical Minerals (Scandium)
- Alumina
- Construction Aggregate

Figure 1. provides a high-level overview of the ElementUS process and product mix. For clarification, “EcoIron” is our name for the metallic iron that will be produced, suitable for use in the electric arc furnace operations of steel mills, comparable in quality to pig iron and direct reduced iron, but made from waste.

2. Technology

Process technologies that can unlock the full value of bauxite residues in the U.S. has remained elusive. While multiple commodities could contribute to revenues for a commercial recovery operation, the lack of environmentally friendly process technologies capable of simultaneous recovery of these commodities, in saleable forms, has inhibited the development of production facilities for this purpose. In addition to recovery of critical minerals and other commodities that are needed for the U.S. economy, the reclamation of old bauxite residue dumps in the U.S. for this purpose can lead to the restoration of environmentally degraded lands that can be returned to productive use.

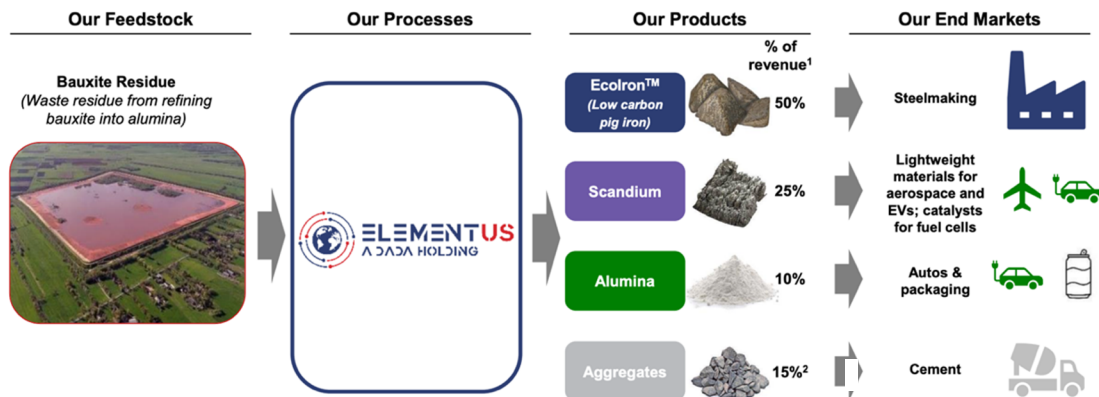


Figure 1. ElementUS High-Level Process and Anticipated Product Mix.

No single component that is included in our separation processes is proprietary or a new invention. However, the order in which these components are combined in this series, is new and unique. Moreso, the application of these separation technologies, and our methodology that incorporates them to create saleable products from bauxite residue, is completely new and proprietary. Our process is a substantial improvement over other tailing treatment processes. In 2022 ElementUS operated a pilot scale facility and this was expanded to a demonstration facility in Louisiana in H1 2023.

Separation processes intending to produce marketable products benefit from higher concentrations of the desired product in the raw material. The efficiency of the separation process is improved with higher concentrations versus lower concentrations of specific components, for example, an iron oxide content above 45% is advantageous. Our raw material, bauxite residue, or “red mud,” a waste product from an alumina refinery contains high concentrations of iron. In addition, the feedstock in Gramercy, Louisiana is a karstic bauxite, and has been tested to be higher in concentration of critical minerals than other deleterious materials such as coal mine tailings. We intend to establish a beachhead in the separation and refining of metallic iron, and the aforementioned list of products from this more highly concentrated raw material. Once optimized, our process can then be extended to other bauxite residue materials.

This above ground resource is readily available in holding ponds ready to be dredged. We plan to have dredging and a vertically integrated separation, and beneficiation process. Our process will produce no waste and has the potential to transform all bauxite residues across the globe. This process achieves zero-waste due to the conversion of our waste to marketable products, including aggregates that will be used in road construction and emissions that will be reused as feed stocks.

Not only is our selected location advantageous as a source of raw material (only dredging will be needed), but we also have access to the Mississippi River and the transportation corridors already in place for the refineries. These include truck, rail, barge, and ocean freight corridors.

3. Business Plan with Focus on Revenue Model

ElementUS has modeled the capital expenditures and anticipated return based on our bauxite residue analysis and the projected market value of the products we will produce. We have also modeled demand and based on that modeling, we anticipate a capital payback of 4 years. Our investors have reviewed and approved this model and we also have memorandums of understanding in place with notable supply chain customers and talks ongoing with others.

As depicted in Figure 1, we have developed a business model built on a diverse portfolio of products, serving a diverse range of markets. We will produce iron for a combination of the steel, water treatment and pigments markets. For the steel market, we aim to provide iron feedstock for the electric arc furnace market segment. For water treatment, we are exploring making iron based water treatment chemicals (for example, ferrous sulfate). For the pigments market, we will partner with pigments companies to make a semi-processed feedstock. Aluminum will meet needs in downstream aluminum processing segments. Scandium, a highly valuable rare earth, will serve the solid oxide fuel cell market, as well as the nascent scandium aluminum alloy market for aerospace and wind energy.

ElementUS already has memoranda of understanding (MOU's) and Letters of Intent in place with partners to market the oxides we will produce. Slipstreams will be part of our design to provide materials for testing for these partners and their processes.

4. Planned Sites

The first site is located in Gramercy, LA. A site with strategic access to bauxite residue and critical transportation infrastructure as evidenced by Figure 2. There are currently 4 bauxite residue Impoundments available on site with a total reserve of 28 million tonnes of red mud available. The site map with facility planning will be available with the feasibility study in the 3rd quarter of 2023.

ElementUS has also found a second location for bauxite residue separation and extraction. This site, located on the idle LAlumina facility in Burnside, LA, will provide ElementUS with an additional 15 Mt of bauxite residue. Hatch and Respec are performing concept studies on the feasibility of the bauxite present in the Burnside site as well as the construction of a manufacturing facility. These studies were completed mid-2023. Figure 3 depicts the location of the Burnside site and its notable aspects. The work completed on the Gramercy site directly impacts and results in benefits to the development of the Burnside site.

5. Design Features

The design for the plant is based on the proven extraction and separation techniques utilized around the world for mineral recovery.

5.1 Description of Project Design

ElementUS has developed a novel approach to effectively utilize the waste residue from aluminum manufacturing, bauxite residue, to become the low cost, low emission producer of both metallic iron and other critical minerals in the United States. As it currently stands, production of metallic iron and other critical materials requires extensive mining and processing resulting in high costs and high emissions. Through the combination of industry tested methods combined into a singular process, ElementUS seeks to revolutionize bauxite residue processing.

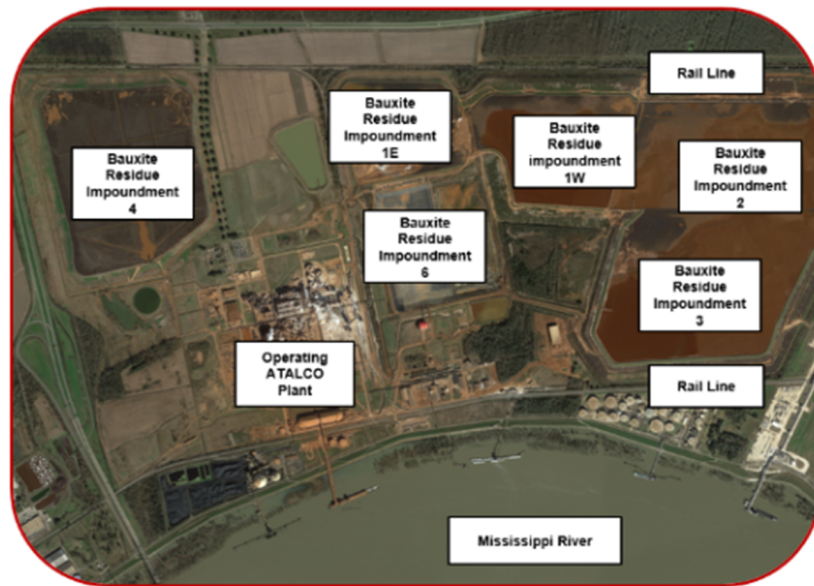


Figure 2. Map of Gramercy Site.

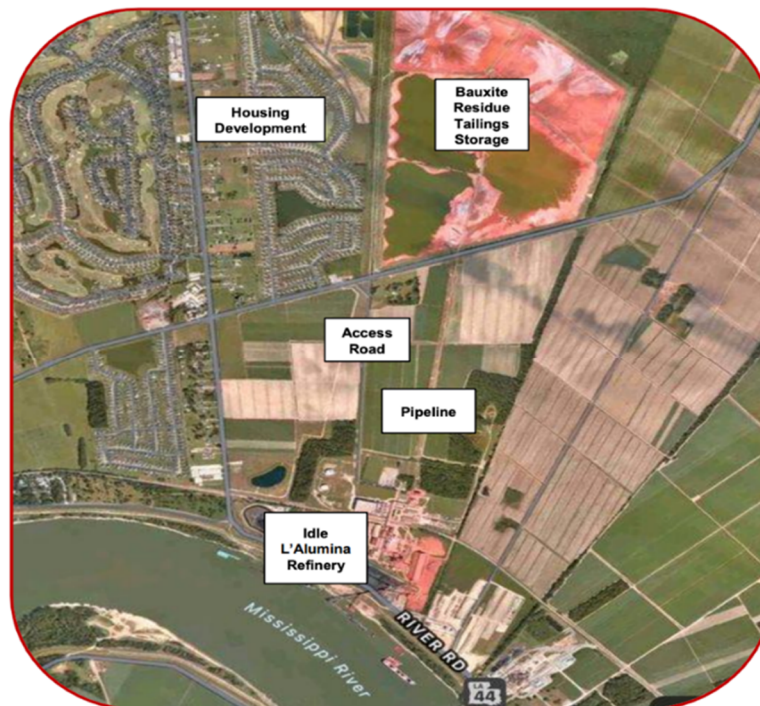


Figure 3. Burnside, LA Site Map.

5.2 Description of “New or Significantly Improved Technology”

This technology, while utilizing widely used industrial processes, will add significant value and result in a revolutionary change in the production of metallic iron and critical minerals. With a reduction in emissions, a readily available source of valuable metal containing waste, and a new combination of separation processes, ElementUS has effectively designed a simpler and valuable technique for bauxite residue utilization. This process will effectively increase domestic supply

of valuable materials produced through environmentally conscious ways to increase the value of both bauxite residue waste as well as the separation process as a whole with a resulting increase in productivity of each process. This discussion is expanded in the section determining why this technology is new or improved.

5.3 Description of Technology

This plant brings together the most effective processes to create a singular manufacturing pathway to extract the maximum amount of material from the bauxite residue. Figure 5 highlights the unique aspects of the ElementUS facility compared to some other processes looking at the utilization of waste. Another key aspect of the design is the use of readily available, plentiful feedstocks in bauxite residue. With no major operators focusing on this waste and with the consistent demand for alumina, the bauxite residue feedstock will remain secure for ElementUS.

Key Components of Our Process

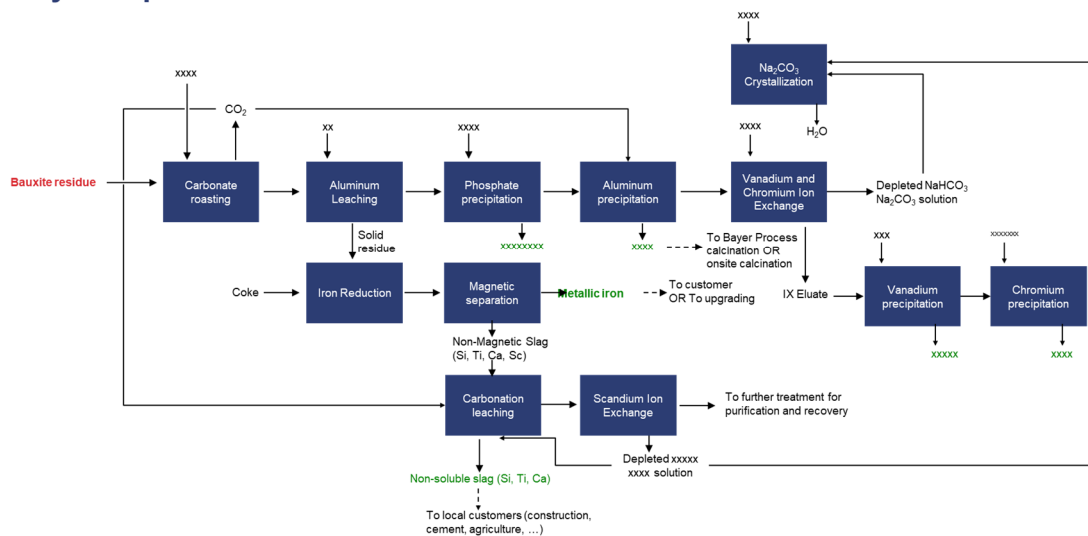


Figure 4. Flow Diagram of ElementUS Processes.

6. Key Metrics

Figure 6 gives a basic overview of the most important constituents of the bauxite residue and one of the most critical metrics used for this manufacturing development. As is shown, the Gramercy bauxite residue has high iron content which will allow for greater extraction and sale of useable metallic iron. Along with this, this bauxite residue is a karstic bauxite, meaning it has higher concentrations of alumina and critical minerals as compared to many other bauxite residue sources. Greater percentages of these metals and minerals will result in increased profits for the Gramercy Plant.

Figure 7 illustrates the amount of bauxite residue available to the Gramercy, LA location along with the additional impoundment scale at the Burnside, LA location, a potential second site for the facility. It is apparent that the ElementUS reserve makes up a small portion of global supply and that this operation has space to scale into other sources of bauxite residue waste.

		Integrated Steel Producers		Env. Services & Recycling	Steel Decarbonization	Rare Earth Producers
		ELEMENTUS A JASRA HOLDING	CLIFFS ALGOMA STEEL INC. United States Steel	HARSCO CleanHarbors GFL	LanzaTech H2green steel	RioTinto MP MATERIALS Lynas Rare Earths Ltd
Proven Processing Capabilities	✓	✓	✓	✓	✓	✓
Domestic Source of Supply	🌍	✓	✓	✓	✗	✓
Cleans Up Existing Environmental Waste	♻️	✓	✗	✓	✗	✗
Low Carbon Footprint	CO ₂	✓	✗	✗	✓	✗
No Waste / Tailings	🌱	✓	✗	✗	✓	✗
Secure Feedstock	🌐	✓	✗	✗	✗	✓

Figure 5. Design Feature Breakdown as Compared to Traditional Facilities.

Bauxite Residue Composition at Gramercy as of 2021

by Mass

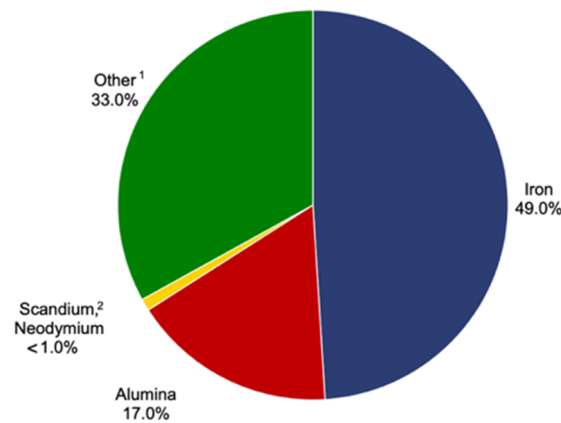


Figure 6. Bauxite Residue Composition at Gramercy, LA.

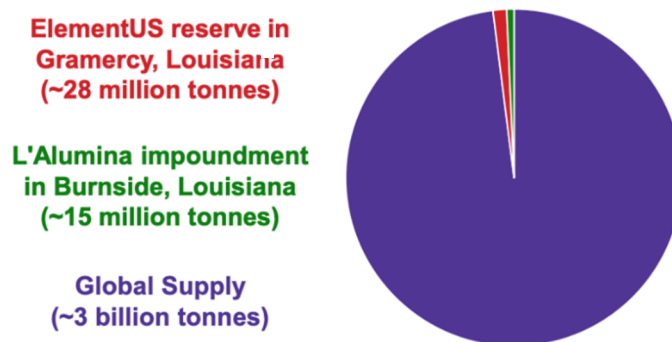


Figure 7. Potential Amount of Bauxite Residue that Could Be Processed.

7. Planned Key Milestones

ElementUS has already undergone significant validation assessments to ensure that these described techniques are feasible both technically and commercially. In preparing for operations, ElementUS enlisted several world-renowned 3rd party purveyors to rigorously test the bauxite residue and the various technical processes. Respec (a global mineral reserve estimating company headquartered in Rapid City, South Dakota, USA) was fundamental in establishing the anticipated product basket for the Gramercy bauxite residue and in confirming the general homogeneity of both wet and dry residue. Hatch through their suite of engineering testing has found that this process is feasible. There are still two planned validation milestones to hit that will be conducted by Hatch.

Along with this, ElementUS has successfully completed lab, bench, and pilot scale development stages for this separation process with the demonstration scale developmental stage in progress. The Demonstration scale began operations in the 2nd quarter of 2023 and will operate ongoing as the business's research and development center.

2018	<ul style="list-style-type: none"> Conceptual Process Validation of Bauxite Residue Recycling.
2020	<ul style="list-style-type: none"> ElementUS main separation process validated by globally recognized German laboratory using ElementUS feedstock.
2021	<ul style="list-style-type: none"> RESPEC independent testing of ElementUS feedstock confirms volume, chemistry, and consistency of the high-value bauxite residue at the Gramercy alumina refinery site.
2022	<ul style="list-style-type: none"> Secured exclusive rights to 30 million tons of bauxite residue and an option for an additional estimated 15 million tons. ElementUS laboratory, bench and pilot scale process validation testing along with Hatch Concept Study and Scoping report complete.
2023	<ul style="list-style-type: none"> Initiated Pre-Feasibility Engineering Study with Hatch, to be completed in 2023. Construction of demonstration plant underway to support Feasibility Engineering Study with Hatch and follow-on EPC award.

Figure 8. Key Development Milestones for Gramercy Plant.

We are engaging Hatch Engineering for the engineering work, a globally recognized leader in industrial engineering. We are also engaging leading research and technology entities in the rare earth enrichment space, notably West Virginia University, as well as other commercial entities. In the 2nd half of 2023, we will engage Hatch to develop full engineering, in order to put the construction to bid.

7.1 Marketing the Output

We have looked at 2020 market demand and estimated the expected growth in demand for these products (an increase that will result in part from President Biden's US\$2 trillion-dollar infrastructure bill). Based on the value of these products plus the projected demand, we anticipate a 4-year recovery of capital expenditure to build a 700 ktpa plant.

8. Additional Opportunities

We have not yet explored capturing the remaining CO₂ in the off-gas stream of the roasting furnace. It is still high in concentration and a good candidate for current technologies to concentrate the CO₂ for other commercial uses. Major industrial gas companies as well as new technologies in product based carbon capture.

From a business expansion and profitability perspective, we are exploring additional recovery of rare earths, production of water treatment chemicals, improved capital efficiency and operating costs reduction, and titanium dioxide separation. Regarding Rare Earth Elements (REE), there are low concentrations of vital REEs in the waste supply, such as neodymium and dysprosium, that could potentially be processed into usable materials. This extraction is still a part of research and development, but if feasible, could represent a huge benefit to domestic REE supply.

Iron, being the largest portion of the bauxite residue, presents opportunities to make iron based water treatment chemicals for the growing market as the need for clean water drives higher demand for ferrous sulfate and other iron based compounds.

From an engineering perspective, through work with Hatch and continued work at our research and development operation, we will explore further economics in capital and operating expense.

Titanium dioxide, which follows the process into the "slag" is another valuable mineral that presents an opportunity for further value enhancement.

9. Conclusions

ElementUS will construct a facility that will utilize an initial 45 million tons of existing red mud (bauxite residue) currently stored in retaining ponds in Gramercy and Burnside, Louisiana, to produce metallic iron, alumina, critical minerals (CM) including scandium, and additional saleable products. The ElementUS process combines established separation technologies with thermal separation technology in a novel and proprietary method that will require 40% less energy input than traditional smelting techniques. As a result of energy savings and the ready availability of raw material at surface level with no mining requirements, ElementUS will be the low-cost producer of metallic iron in the United States and a near low-cost producer of our other products. In addition, the energy savings provided by the ElementUS process will result in direct greenhouse gas emissions reductions. Additional benefits are the production of alumina and critical minerals (CM) which are critical in the transition to renewable energy and zero carbon goals. ElementUS will also remove a pollutant from the environment by reducing bauxite currently stagnant in retaining ponds while producing zero waste. The waste from this process will be used and sold as construction material while CO₂ emissions will be captured and used as feedstock. An independent third party conducted successful laboratory testing of the process and preparations are underway to conduct pilot testing.

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