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West Africa Energy Program
An Assessment of Mining Industry Electricity Demand in Guinea

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ACRONYMS

Acronym	Definition
CBG	Compagnie des Bauxites de Guinée
COVID-19	Corona Virus Disease 2019
CT	Carat
FSRU	Floating Storage Regasification Unit
HFO	Heavy Fuel Oil
KW	Kilowatt
kWh	Kilowatt Hour
LNG	Liquified Natural Gas
MT	Metric Tonne
MW	Megawatt
MWh	Megawatt Hour
OZ	Ounce
SMB	Société Minière de Boké
USAID	United States Agency for International Development
USGS	United States Geological Survey

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EXECUTIVE SUMMARY

Mining is integral to Guinea's national economy, with mining industry activities contributing to more than 25% of national gross domestic product. The electricity-intensive nature of mining operations and Guinea's low electricity access rates create a mutual need for reliable large-scale power sector development. Developing electricity infrastructure to support mining activities is an area where the interests of the mining industry, the need for electricity to run mining operations, and Guinea's national development, the need for increased electricity infrastructure, overlap.

Supporting mining industry activities in the long-term will require a significant power sector planning effort and a range of steps to facilitate both mining company connection to existing grid infrastructure and determining how to best position new power sector infrastructure to serve both mining operations and non-mining interests. **The purpose of this Report is to provide that first step – outlining the potential electricity demand of Guinea's mining industry from 2020 to 2030.**[1]

This Report uses available production data – the quantity of a mineral that is mined – as a common denominator across each mineral covered in this Report (i.e., bauxite, iron ore, gold, and diamonds) to estimate overall industry electricity demand. To complete this forward-looking estimate, the Report relies on international benchmarks that estimate how much electricity is generally required to both produce and process a single unit of each mineral to complete. The Report's analysis yields four primary recommendations for Guinea to utilize in the early stages of better integrating mining industry electricity demand into long-term power sector planning. These recommendations are summarized below:

1. **Focus power sector support efforts on bauxite mining and processing operations in the near term and actively engage mine operators to plan out potential processing activities in the long-term.** Bauxite processing operations completed in-country would dramatically increase electricity demand far beyond bauxite production alone. Prioritizing power sector support in the short-term to a few large bauxite operations by SMB, CBG, and others, is likely to have greater impact on adequately supplying electricity demand and expanding mining operations than prioritizing small-to-medium sized bauxite mining operations.
2. **Actively support alternative electricity generation options** to account for potentially higher industry demand in the dry season where hydropower resources may be reduced as a result of lower rainfall volume.
3. **Position power sector support efforts for potential iron ore development in the medium-to-long term**, as significant iron ore production could dramatically increase industry electricity demand and eventually outpace bauxite industry demand.
4. **Refocus power sector support efforts from precious metal and gemstone mining operations** such as gold and diamonds in the near term because they will not dramatically influence industry electricity demand compared to Guinea's other mineral resources.

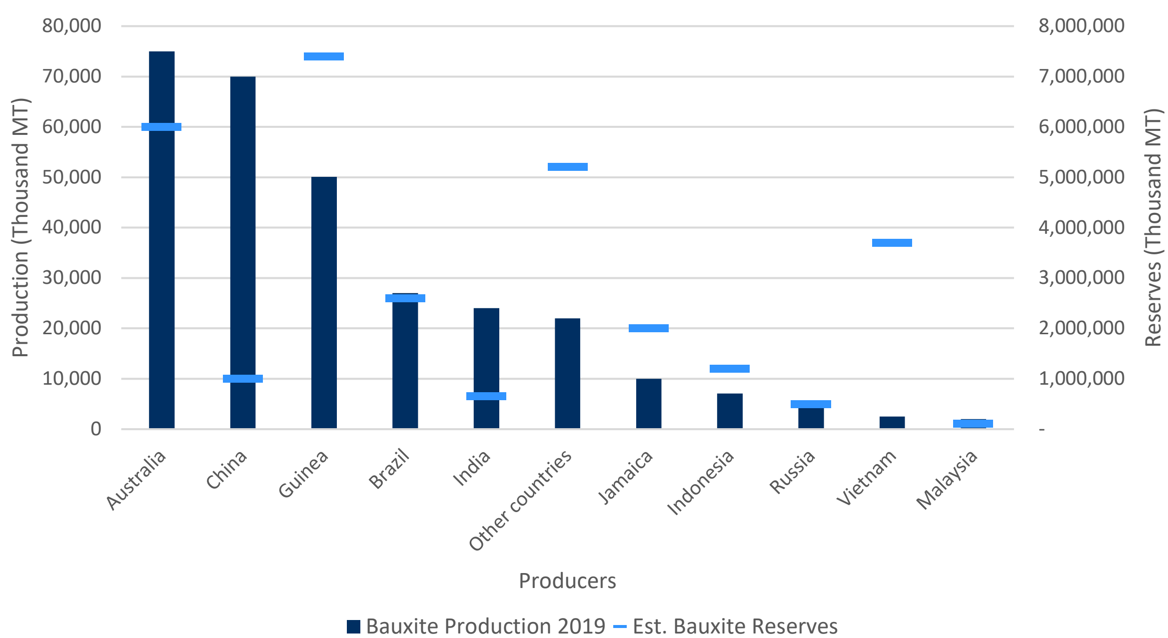
[1] The forecasts for electricity demand contained in this Report are estimates. Findings and forecasts contained herein are based on publicly available resources and data provided by the Guinea Ministry of Mines.

1. INTRODUCTION

Guinea hosts one of the most rapidly expanding mining economies in Africa and is increasingly becoming a large-scale commodity exporter in the global marketplace. Creating an environment for private companies to produce these minerals for export to global commodity markets is a substantial driver of national economic growth, with the mining industry accounting for nearly 26% of gross domestic product.[2] In any scenario, mining is likely to be integral to Guinea's economic growth, regional influence, and as an entry point for other non-mining industries to expand into global markets.

Guinea's growing mining economy is largely driven by bauxite – the primary raw component used for producing aluminum, a metal frequently used in industrial, consumer, defense, and infrastructure applications world-wide. Guinea's bauxite production – highlighted in Figure 1 below – has increased to such a degree that the country has become the third largest bauxite producer in the world. While high bauxite production levels (i.e., the amount of bauxite ore produced from the earth) have made Guinea a leader in the current bauxite landscape, Guinea's more than 7 billion metric tonnes (MT) of bauxite reserves (i.e., the amount of bauxite economically extractable bauxite in Guinean soil) are what makes Guinea an attractive destination for bauxite miners. Guinea's world-class bauxite resources coupled with aluminum's staying power as a core input to aluminum are likely to drive growth in Guinea's mining industry for decades to come.

Figure 1: Guinea's Position as a Bauxite Producer[3]



The current economic significance – and substantial untapped potential – of Guinea's mining industry emphasizes the need to sustainably support its maturation. A primary requirement of a robust national mining industry is the ability to provide steady, stable electricity for mining operations. From pit to port,

[2] https://www.wto.org/english/tratop_e/tpr_e/s251_sum_e.pdf
[3] United States Geological Survey (USGS)

bauxite mining is a highly electricity-intensive activity. Producing raw minerals (e.g., excavation, crushing, grinding) often requires significant amounts of electricity, while processing stages (e.g., chemical processing, smelting via electrolysis) that transform raw mineral product into a product fit for export can require more electricity than the production itself. This high demand for electricity is a challenging prospect for countries lacking adequate or reliable electricity infrastructure.

Guinea's national grid does not currently have the geographic reach to meet mining industry demand. Mining companies operating far from the existing grid employ diesel engines or stationary generators using heavy fuel oil (HFO) or diesel to supply their operations with electricity – solutions that are expensive and environmentally harmful. In short, Guinea must develop a path toward determining how to best provide electricity to mining operations in order to fully capitalize on its substantial mineral resources. The first step in this process is to develop a comprehensive understanding of mining industry electricity demand in the near, medium, and long-term. This should identify the demand of individual mining operations, establish the potential for existing and planned generation to connect to those operations, and enable long-term plans that coordinate private and public investment in Guinea's national electric grid.

The purpose of this Interim Report (hereinafter, the "Report") is to provide that first step – estimating the current and future electricity demand of Guinea's mining industry. This report estimates electricity demand across Guinea's major mineral classes from 2020 to 2030, and establishes multiple scenarios for how increasing localization of processing activities could influence electricity demand. The scenarios presented in this interim report are intended to foster additional, increasingly specific studies that advance a strategy of utilizing the mining industry's electricity demand requirements to support investment in Guinea's national electricity grid.

II. METHODOLOGY

This methodology is designed to provide reasonable estimates of electricity demand for Guinea's mining industry over a ten-year timeframe which can be used to support more granular research and technical analysis as more detailed data become available. The methodology outlines the procedural steps this Report follows to estimate the electricity demand of Guinea's mining industry by combining national data from Guinea's Ministry of Mines with international mining industry electricity demand benchmarks from publicly available data from Guinea's Ministry of Mines, the United States Geological Survey (USGS), and other sources. This Report is an interim assessment based on national-level data and international benchmarks.

A. Mineral Selection

The first step of the methodological approach is to establish the minerals that will be covered by this Report. This process narrows the Report's analytical scope and follows a few general guidelines. Firstly, this Report considers only minerals with significant current, or estimated (within the 2020-2030 timeframe), production levels. This step focuses the Report on minerals Guinea is producing at-scale and, therefore, the mining operations that are likely to be the largest drivers of electricity demand. Secondly, this approach considers how mining operations are geographically dispersed across Guinea. The geospatial nature of electricity demand is important for determining how – and where – to plan future power sector infrastructure investments. This ensures that electricity demand estimates are geographically representative and that Report findings support developing a national picture of mining industry demand. Given these criteria, this Report focuses on the following minerals and their standard unit of measurement:

- Bauxite (MT)
- Iron Ore (MT)
- Gold (Ounces)
- Diamonds (Carat)

Bauxite is the most important mineral in Guinea. The primary mineral input for aluminum production, bauxite is integral to Guinea's mining economy and the national economy as a whole. Guinea is home to the largest estimated bauxite reserves in the world, with approximately 25% of total global reserves.[4] These substantial reserves have enabled Guinea to increase production over the past decade. In 2019, Guinea was the second-largest producer of bauxite in the world and could overtake the current top producer, Australia, in the next several years.

The downstream processing steps required to produce aluminum from bauxite are among the most electricity-intensive portions of the bauxite value chain. Therefore, it is important to take into account potential downstream processing activities in order to more fully understanding the potential electricity demand impact of bauxite mining in Guinea. The general process for making aluminum first requires processing raw bauxite ore into aluminum oxide, more informally known as "alumina". Alumina is then smelted into raw aluminum that can then be cast and rolled into a variety of thicknesses and shapes. This process where alumina is smelted into aluminum is the most electricity-intensive process in the aluminum value chain, and one of the most energy-intensive processing stages in any mineral value chain.

[4] USGS https://pubs.usgs.gov/periodicals/mcs2020/mcs2020-bauxite-alumina.pdf

While Guinea does process small percentages of local bauxite production into alumina[5], smelting alumina into aluminum remains a distant goal that would require significant investments from both mining companies, industrial processors, and utility providers to erect electricity infrastructure capable of providing large quantities of electricity to processing facilities.

Iron ore represents an opportunity for Guinea to open another world-class mineral deposit to private sector development and expand large-scale mining operations beyond bauxite. Despite having no significant iron ore production to-date, Guinea holds some of the largest untapped iron ore reserves in the world. Guinea's iron ore reserves are significant for two reasons. First, Guinea's anticipated reserves are large – with estimated reserves of more than 2 billion MT – and are within order of magnitude of other jurisdictions which have successful iron mining industries. For example, South Africa, a country with a robust iron mining industry, holds more than 1.1 billion MT of iron ore reserves.[6] Secondly, Guinea's deposits contain high grade iron ore, with multiple large deposits above 55% iron.[7] At this grade, iron ore is often characterized as "direct shipping ore" because it can be exported and used to produce steel with minimal downstream processing beyond standard crushing and screening of product.[8] Recent developments at SMB-Winning's Simandou concession[9] and High Powered Exploration's Nimba operation[10] have advanced potential large-scale projects to the point that Guinea could feasibly produce more than one hundred million MT of iron ore per year within the next 5-10 years if project development remains on-schedule.

Beyond bauxite and potential iron ore resources, this Report includes gold and diamond production. This is due to their respective geographic locations of major mining operations and the fact that, other than bauxite, gold and diamonds are the only commodities which Guinea's Ministry of Mines reports production in its monthly mining bulletin, indicating that both minerals are relevant contributors to Guinea's mining industry. Artisanal mining – small-scale mining operations that often use hand tools and/or small diesel-powered front-end loaders and other minor equipment – is common method for producing gold in Guinea. Approximately half of Guinea's total gold production is produced by artisanal operations. Due to their small physical footprint and limited use of electrified equipment, artisanal operations are likely to account for a negligible amount of overall electricity demand. Therefore, only industrial scale gold mining operations are included in this Report.

Diamond production in Guinea has decreased substantially within the previous decade. Diamonds are produced both industrially and artisanally. Diamonds were included in this Report for geographic comprehensiveness and because, like gold, diamond production is reported by Guinea's Ministry of Mines. Unlike gold, artisanal diamond production will be included in this Report in order to include the data set the Project Team was provided as monthly production data (the production data best-fit for developing seasonal demand forecasts) was not available for industrial diamond operations.

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[5] https://aluminiuminsider.com/rusal-restarts-operations-at-guineas-friguia-alumina-refinery/

[6] USGS https://pubs.usgs.gov/periodicals/mcs2020/mcs2020-iron-ore.pdf

[7] https://mines.gov.gn/en/resources/iron-ore/

[8] https://www.energy.gov/sites/prod/files/2013/11/f4/iron.pdf

[9] Reuters, Guinea approves SMB-Winning deal for Simandou iron mine project, https://www.reuters.com/article/us-guinea-simandou/guinea-approves-smb-winning-deal-for-simandou-iron-mine-project-idUSKBN23B2XI

[10] HPX, High Power Exploration acquires the world-class Nimba iron ore deposit in the Republic of Guinea, https://hpxploration.com/news/2019/high-power-exploration-acquires-the-world-class-nimba-iron-ore-deposit-in-the-republic-of-guinea/

B. Establishing Electricity Demand Drivers

There are multiple methods to estimate the electricity demand of mining operations. Ideally, individual electricity demand data could be collected from individual mining operations, summed, and then extrapolated. However, mine-site level electricity demand data could not be accessed for this Report due to a challenging data collection environment. For this reason, production data – the quantity of a mineral that is mined – was used as a common denominator across each mineral covered in this Report (i.e., across bauxite, iron ore, gold, and diamonds). This allowed the project team to rely on international benchmarks that estimate how much electricity is generally required to both produce and (in some cases) process a single unit of each mineral.[11] This approach results in three primary factors that will drive electricity demand estimates in this Report: (1) mineral production; (2) the electricity per unit of production (i.e., the electricity required to produce a single unit of that mineral in raw form), and (3) the electricity per unit of processed material (i.e., the electricity required to process a single unit of that mineral through a downstream processing stage).

- Mineral Production: Mineral production will be defined as the weight of the mineral ore extracted from the ground. Production is a common, data-rich metric that government mining ministries and mining companies alike track and report and can be effectively compared across minerals. Monthly production data is also used to determine the seasonality of electricity demand. For the purposes of this Report, it's assumed that as more or less of a mineral is produced electricity demand is likely to increase or decrease to proportional degree. Production data used in this Report is drawn from both historical data provided by Guinea's Ministry of Mines and publicly available information (e.g., formal news releases, company estimates, geological survey data (e.g., USGS).

- Forecasting Production: Production data will be the primary driver of electricity demand estimates from 2020-2030. Forecasting electricity demand in the mining industry is particularly challenging due to the extended time horizon, the need for monthly estimates to determine potential demand seasonality, and the intense variability of commodity markets and mineral production. Therefore, forecasts will be driven by maximizing the use of available historical time-series production data – a data point that can be verified – and the use of statistical approach to developing a forecasting model based on historical trends from production metrics acquired predominantly from 2016 through 2019. This foundation will then be used to forecast future performance within an upper and lower bound of forecasted values calculated to a 95% confidence interval.12 This approach will produce electricity demand forecasts that follow the following range of estimates:

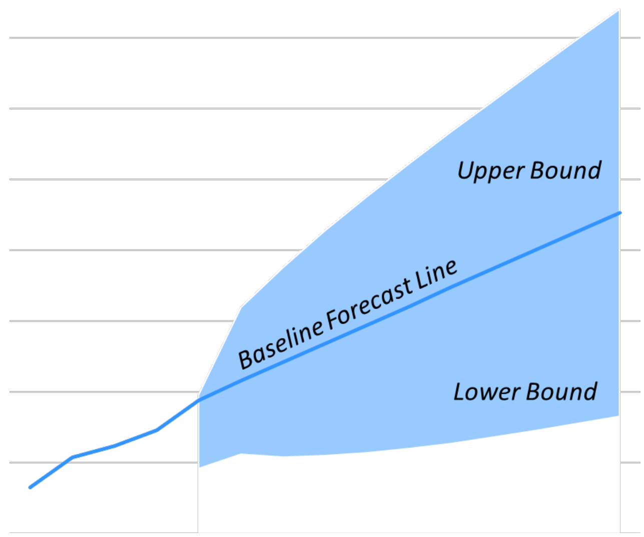
    - *Baseline Forecast*: A linear forecast based on historical production data, falling in between the upper and lower bounds.

[11] The international benchmarks used do not account for potential losses and inefficiencies and should be considered "prefeasibility level estimates, ±25 percent of actual per unit electricity consumption, especially for cumulative estimates", US Geological Survey, *Estimates of Electricity Requirements for the Recovery of Mineral Commodities, with Examples Applied to Sub-Saharan Africa*

[12] Confidence interval: The confidence level of a true unknown value falling within a range of potential values

- *Upper Bound Forecast*: Highest estimated electricity demand within a 95% confidence interval. As the time-series progresses and estimates become more tenuous the upper bound increases in order to maintain that a range of forecasted estimates to that are within a 95% confidence interval.
- *Lower Bound Forecast*: Lowest estimated electricity demand within a 95% confidence interval. For the purposes of this Report, the potential for negative demand is not considered. Thus, the lower down does not decrease below zero.

Figure 2: Forecast Example



This approach to forecasting compensates for the inherent unpredictability of commodity production by relying on proven historical data while producing a range of estimates that are statistically rigorous. This approach to forecasting will be used for bauxite, gold, and diamonds – minerals where there is sufficient historical data to extrapolate a historical trend. Due to the lack of historical production data, iron ore production forecasts are based on publicly available data that outlines when specific iron ore operations may begin production and how those mines may increase in production to their theoretical maximum annual production. For the purposes of this report, all potential iron ore production is assumed to begin in 2025, the earliest year in which the Simandou operation, one of the larger potential iron ore operations, could begin production.[13]

- Electricity Per Unit of Production: The amount of electricity required to produce a single unit of each mineral classification is covered in this Report. Estimates used in this Report are drawn from relevant international benchmarks from the U.S. Geological Survey.

- Electricity Per Processed Unit: For the purposes of this Report "processing" refers to the chemical and physical procedures that occur downstream from mineral production. Processing is often multi-stage. For example, converting bauxite (the raw mineral mined from the earth) into aluminum (the final go-to-market product) requires first processing bauxite into alumina and then smelting alumina into aluminum. The potential for downstream processing to be performed in Guinea is most relevant for bauxite, as Guinea is already processing moderate amounts of bauxite into alumina. If Guinea pushes to localize more of this processing capability, it is conceivable that Guinea could both process as much bauxite into alumina as some peer bauxite producers and begin to process small amounts of alumina into aluminum in the coming years and decades.

[13] https://www.spglobal.com/platts/en/market-insights/latest-news/metals/112519-guinea-simandou-iron-ore-developer-seeks-partners-eyes-2025-start

The inputs to assessing electricity demand based on production data – (1) mineral production, (2) the electricity required to produce a unit of that mineral, and (3) the electricity required to process a unit of that mineral – can be represented by the following general equation for estimating electricity consumption.

$$\sum E = (X * M) + \left((X * Y_1) * R_1\right) + (((X * C) * Y_2) * R_2)$$

- **C** = Conversion factor for any degree of reduced mass resulting from some processing stages[14]
- **E** = Total electricity required to produce and process 1 unit[15] of material
- **M** = Electricity (kWh) required to produce one unit
- **R** = Electricity (kWh) required to process one unit. This can be repeated as necessary for multiple processing stages (e.g., R_1, R_2)
- **X** = Amount (weight) of mineral produced
- **Y** = Percentage of mineral produced that can be processed into an exportable form. This can be repeated as necessary for multiple processing stages (e.g., Y_1, Y_2)

C. Processing Scenario Development

The amount of electricity required to process some minerals into a final, market-ready stage (i.e., processing bauxite into alumina, processing alumina into aluminum) can be so significant, that the inclusion, or omission, of processing can dramatically alter forward-looking electricity demand estimates – both for that individual mineral and the mining industry as a whole. Multiple scenarios have been developed to accommodate possible outcomes of efforts to perform more bauxite downstream processing in-country and allow for electricity demand estimates to envision a scenario where Guinea successfully localizes certain downstream processing stages in some minerals (and dramatically increasing mining electricity demand as a result). Scenario development is a better fit for mineral processing, as compared to mineral production, due to a lack of historical data in the processing stage and the fact that processing alters electricity demand to such an extreme degree that including processing in a non-scenario-based format could bias electricity demand forecasts.

This Report considers only general mineral processing stages that Guinea is either already performing or is reasonably likely to be able to perform locally within the next ten years. By this definition, the following processing stages will be covered for bauxite:

- Processing raw bauxite ore into alumina
- Smelting alumina into aluminum through electrolysis

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[14] For example. Processing 1 MT of bauxite does not yield 1 MT of alumina. Mass is lost during each processing stage. Therefore, a "conversation factor" is required to determine how much alumina will be produced per MT of bauxite processed.

[15] "Unit" meaning the standard measurement of weight for each mineral as outlined on page 6 of this Report

Downstream processing for both gold and diamonds is minimal compared to bauxite making variable scenarios redundant. Large-scale iron ore operations are not yet operational; therefore any processing projections would be highly anecdotal and are not included in the processing scenarios.

Determining what percentage of bauxite will be processed into alumina, and what percentage of alumina will be smelted into aluminum, will be based on both Guinea's current estimated processing capacity and the potential processing benchmark by Jamaica – a country with a long history of bauxite processing and of a similar economic scale to Guinea (*See* Figure 3). Two scenario drivers were considered in order to determine how different processing levels would be influenced in each scenario. These two drivers include (1) global commodity markets and (2) local processing infrastructure. Both drivers are defined below in greater detail.

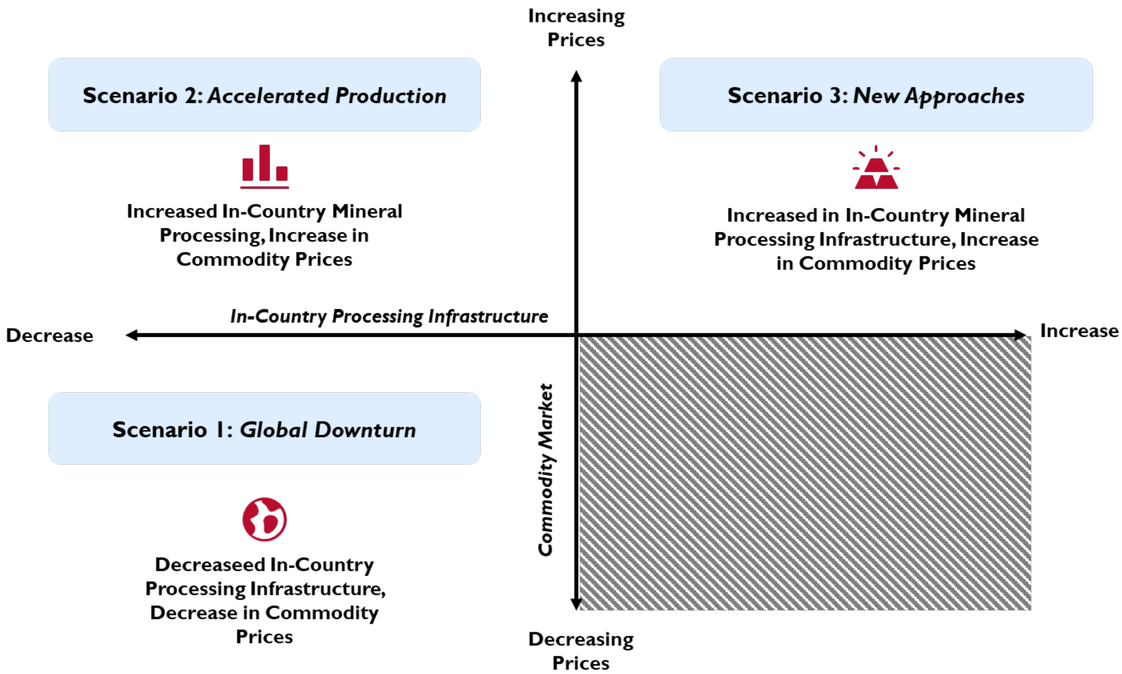
Figure 3: Jamaica as a Bauxite Processing Benchmark

> Jamaica produced bauxite for more than 70 years and has been locally processing bauxite into alumina for much of that period. Jamaica's gross domestic product exceeds $15.7 billion (compared to Guinea's $10.9 billion). Jamaica processed approximately 64% of its national bauxite production into alumina in 2018. This percentage of locally-processed bauxite provides a point from which to gauge Guinea's potential processing capacity.

- **Global Commodities Markets:** As commodity prices fluctuate, mining firms and government entities will have more – or less – revenue and profits to re-invest into local mineral processing activities.
- **Local Processing Infrastructure:** The degree to which Guinea is able to advance local downstream processing infrastructure (e.g., roads, transmission lines, stable power supply, skilled labor).

The relationship between these two drivers and how they serve as the foundation for determining different processing scenarios and, ultimately, estimating how bauxite industry electricity demand will vary based on the quantity of bauxite processed in-country. As outlined in Figure 4 below, areas the axis of global commodity prices and local processing infrastructure are strong result in a scenario (Scenario 3 – New Approaches) where the percentage of bauxite production processed into alumina are highest. Similarly, areas of the intersection between these two drivers where commodity prices and in-country processing infrastructure are weakest yield a scenario (Scenario 2 – Global Downturn) where the percentage of bauxite processed into alumina is lower than the status quo.

Figure 4: Bauxite Processing Scenarios Development



Based on this relationship between global commodity markets and local processing infrastructure, the specific processing percentages (i.e., what percent of bauxite is processed into alumina, and what percent of alumina is smelted into aluminum) for each scenario were aligned to the scenario best-fit to the general market characteristics outlined in that respective quadrant of Figure 4. The specific processing percentages for the status quo and each additional scenario are outlined in Figure 5 below and have been developed by working backwards from the benchmark set by Jamaica's bauxite processing industry. These results of modeling these scenarios will be outlined in more detail in Section III of this Report.

Figure 5: Bauxite Processing Scenarios

	Status Quo: ***Baseline Scenario***	**Scenario 1:** ***Global Disruption***	**Scenario 2:** ***Accelerated Growth***	**Scenario 3:** ***New Approaches***
Scenario Description	The status quo is maintained for current in-country bauxite and alumina processing levels and little to no significant advancement in downstream processing infrastructure.	A large scale economic downturn has negative ramifications for Guinea's entire mining industry, including bauxite, and the global commodities markets.	Global economic growth is strong, increasing demand for alumina drives accelerated bauxite production, enabling Guinea and its mining companies to generate more revenues to reinvest into downstream processing infrastructure.	Guinea significantly increases investment in the long-term, increasing localized bauxite processing efforts in-country at a fast pace.
Percent of Bauxite Processed into Alumina	**1%** Minimal in-country processing (on the order of 1% of production) of bauxite into alumina.	**0.5%** Current bauxite processing activities are reduced by 50%.	**16%** Moderate Increase in in-country processing on the order of 25% of current bauxite processing levels in Jamaica.	**64%** Increased investment sees localization of Bauxite processing at record rates on par with Jamaica; with medium-to-large scale Bauxite production and in-country processing capabilities.
Percent of Alumina Smelted into Aluminum	**0%** No in-country processing of Alumina into Aluminum.	**0%** No in-country processing of Alumina into Aluminum.	**0%** No in-country processing of Alumina into Aluminum.	**1%** The scale of investment enables some minor processing of alumina into aluminum on the same scale as Guinea currently processes bauxite into alumina.

D. *Requesting Relevant Data*

The Project Team developed an approach to collecting data from Guinea's Ministry of Mines, Ministry of Energy, and individual mining companies in order to provide inputs to the methodological approach outlined in above. The Project Team developed a Request for Information (RFI) document that outlines the data requested from each stakeholder including data on mine-site level production, geospatial considerations, fuel consumption, and other data relevant to this Report. The Project Team faced data collection challenges during this approach (*See* Figure 6). A summary of data requested from each stakeholder is outlined below.

Figure 6: Data Collection Challenges in Guinea

> Data collection from Guinea's Ministry of Mines, Ministry of Energy, and individual, privately-owned mining companies was constrained due to communication and workplace challenges associated with the ongoing COVID-19 pandemic. The data collection challenges faced by the Project Team resulted in gaps in the data set. International benchmarks and publicly available information were used where relevant to compensate for the absence of mine-site specific information.

- Ministry of Mines: Data requested from Guinea's Ministry of Mines was tailored to be relevant to mining operations. This includes monthly production information, geospatial coordinates of specific mine sites, and detailed information on the characteristics of mining operations underway at each site (e.g., underground vs surface operations). The Project Team received some monthly production information for bauxite, gold, and diamond mining operations. Beyond this, data collection from Ministry of Mines was limited. No data could be collected on individual mine-sites. This prohibited a detailed geospatial analysis of demand, something integral to future long-term planning efforts.

- Ministry of Energy: Data requested from Guinea's Ministry of Energy was targeted to power sector data and potential electricity demand considerations of the mining industry. This included data related to the location and capacities of hydropower plants, existing and planned transmission lines, and existing mine electricity demand information. The Project Team received some transmission line geospatial information from the Ministry of Energy, but overall data collection was challenged by COVID-19.

- Private Mining Companies: The Project Team worked with the Ministry of Mines to request data from individual, privately-operated mining companies. Data requested from individual mining companies included, current site production, current site generation sources, and specific site electricity demand information, and fuel consumption information that could indicate the viability of supplying alternative electricity generation fuel source (e.g., liquified natural gas) to the mine site. As of the drafting of this Report, this data request is currently in-process.

III. ESTIMATING MINING INDUSTRY DEMAND

The section will provide estimates for mining industry electricity demand both in total and by mineral (bauxite, iron ore, gold, and diamonds) from 2020 through 2030. These calculations rely on the methodology described in Section II and data provided to the Project Team both by the Government of Guinea and as retrieved from publicly available sources. Further, these forward-looking estimates rely on a general assumption regarding the three electricity demand drivers outlined in Section II of this Report.

A. Summary Findings

The estimated electricity demand of Guinea's mining industry in 2020 is 862,591 MWh per year based on current mineral production levels.[16] Meeting this demand would require approximately 246 MW of installed generation capacity, more than 35% of Guinea's estimated total installed generation capacity of more than 699 MW.[17] This overall estimate of demand yields the following general conclusions that are outlined in greater detail in Subsections B through F of Section III:

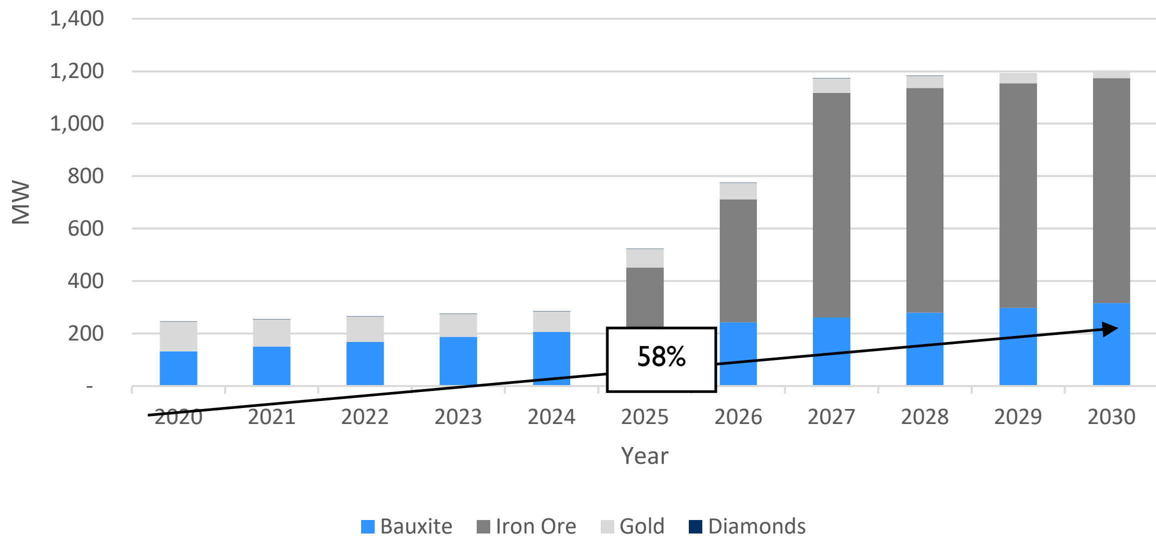
- **Bauxite** is the primary driver of mining industry electricity demand in Guinea today and will continue to play a significant role in future demand.
- **Localizing aluminum manufacturing** capabilities to a degree that is similar to bauxite processing levels of other peer countries would significantly increase the electricity demand of Guinea's mining sector.
- Significant **iron ore** production would dramatically increase total electricity demand and could overtake bauxite as the primary driver of national mining industry electricity demand if significant production begins within the next ten years.
- The **dry season** is anticipated to be the highest period of annual electricity demand based on current production trends. These time periods correspond to Guinea's period of lowest rainfall. Lower rainfall and lower river flows during times of high mining industry demand could impact the degree to which hydropower resources are able to reliably supply some mine sites, the need to import electricity, and the possible cost of new, alternative generation sources.
- **Gold and diamond mining** operations are not currently a significant driver of electricity demand and are unlikely to become significant influences on electricity demand.

B. Bauxite production is currently the largest driver of electricity demand

This annual forecast from 2020 through 2030 reveals the dominant role of bauxite production in Guinea's electricity demand landscape. Of the minerals which Guinea currently produces, bauxite accounts for approximately 53% of total electricity demand in 2020. As outlined in Figure 7 below, this baseline could increase more than 58% during the ten-year period from 2020-2030. In turn, this would require more than 316MW of installed capacity in 2030 for bauxite mining operations alone. If current downward trends in gold and diamond production remain steady and iron ore production does not begin at a significant level within that timeframe, bauxite mining could account for more than 90% of electricity demand.

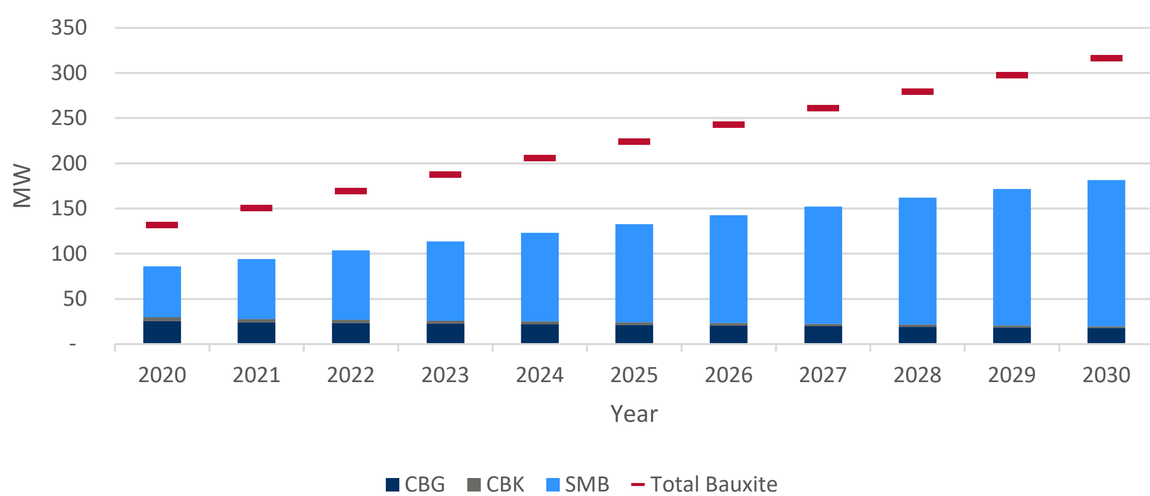
[16] Unless otherwise specified, all forecasts presume the "status quo" processing scenario. All forecasts are estimates.
[17] World Bank, 2019, Guinea Electricity Access Scale Up Project, http://documents1.worldbank.org/curated/en/869041550631657109/pdf/Guinea-Electricity-Access-Scale-Up-Project.pdf

Figure 7: Annual Bauxite Electricity Demand (MW)



Bauxite's position as the primary driver of electricity demand in Guinea's mining industry is due in large part to the operation of large Bauxite mining companies. Of those companies that the Project Team was able to collect consistent year-over-year data, just two represented approximately 71% of Guinea's total bauxite production in 2019 – Société Minière de Boké (SMB) and Compagnie des Bauxites de Guinée (CBG). Together SMB and CBG accounted for nearly 280,000 MWh of this Report's estimated 462,484 MWh of electricity demand for bauxite mining operations in 2020, requiring approximately 82MW of installed capacity for CBG and SMB alone. Figure 8 emphasizes the importance of a few large producers in influencing total estimated electricity demand for all bauxite operations in the near term, and how these same producers could lose a small degree of influence over time as other bauxite operations increase production.

Figure 8: Annual Bauxite Electricity Demand by Company (MW)



C. *Bauxite processing scenarios dramatically increase electricity demand*

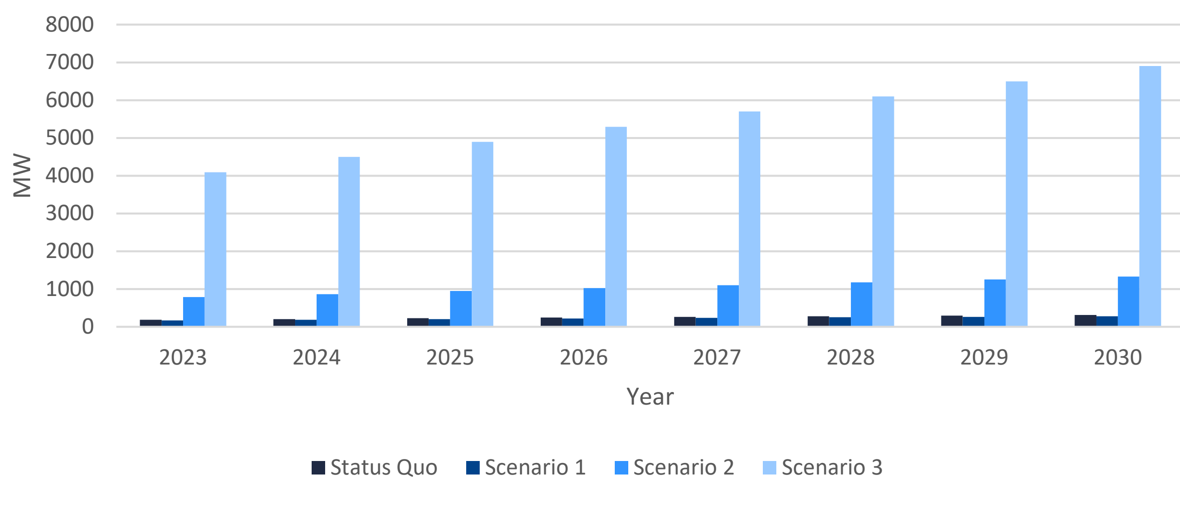
This section of the Report summarizes the electricity demand estimates resulting from the multiple scenarios outlined in Section II.C of this Report: *Processing Scenario Development*. As Guinea progresses towards localizing more downstream processing capabilities and increases the share of bauxite production that it can process in-country, understanding the implications of mineral processing activities on mining industry electricity demand becomes more important. Multiple scenarios have been developed to compare the potential impacts of localizing bauxite processing activities in Guinea. Table 1 below outlines the percentage of bauxite and alumina that are, respectively, processed and smelted in each of the three scenarios outlined in Figure 5 from Section II of this Report. The percentage of total mineral production that is processed and smelted drive the variance in forward-looking demand forecasts between the three scenarios.

Table 1: Bauxite Processing Scenario Coefficients

	Status Quo	Scenario 1: Global Downturn	Scenario 2: Accelerated Production	Scenario 3: New Approaches
Percent Bauxite Processed into Alumina	*1%*	*0.5%*	*16%*[18]	*64%*[19]
Percent Alumina Smelting into Aluminum	*0%*	*0%*	*0%*	*1%*[20]

This scenario-based approach to forecasting the potential implications of localized bauxite processing stages in Guinea demonstrates the extreme influence that bauxite processing – and even minor alumina smelting – can have on bauxite mining electricity demand. Figure 9 below compares the status quo scenario, where bauxite processing operation in country continue at current levels, to the other three scenarios which have varying degrees of bauxite processing percentages compared to the status quo from years 2023 to 2030.

Figure 9: Forecasted Bauxite Electricity Demand for Multiple Processing Scenarios



[18] 25% of the Jamaica benchmark
[19] Jamaica's approximate current processing of bauxite into alumina
[20] Should Guinea smelt a similar percentage of alumina into aluminum as they currently process of bauxite into alumina

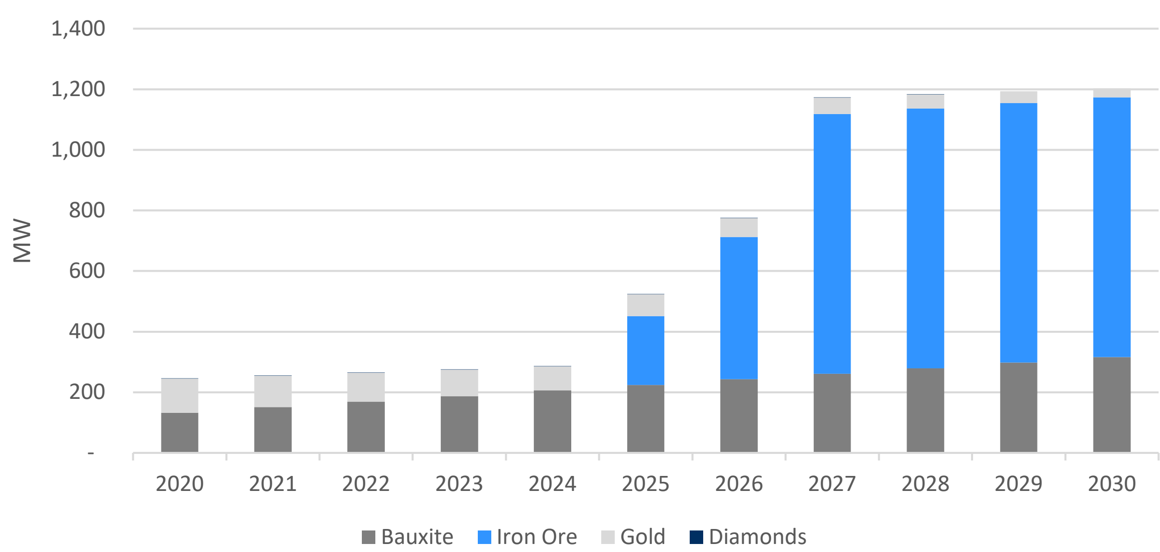
Figure 9 demonstrates how significantly bauxite processing can impact electricity demand compared to Guinea's current (i.e., status quo) processing capabilities. In 2030, there could be a 95% difference in electricity demand between the status quo processing scenario and the Scenario 3: New Approaches. This difference is even more extreme considering the Scenario 3 includes only 1% of Guinea's alumina production is smelted into aluminum – an amount that corresponds to fully one-third of Guinea's bauxite electricity demand (~2,319 MW) in this scenario. These types of results underscore the potential impact on Guinea's power sector landscape if bauxite processing capabilities are further localized in Guinea in the coming decade or beyond.

D. Iron ore development could dramatically increase electricity demand

Iron ore could replace bauxite as the largest driver of electricity demand if large-scale iron ore production begins. Based on recent reported statements by iron ore mining companies planning to operate in Guinea, it is possible that Guinea could begin producing iron ore at significant levels (i.e., 50 million MT or more) by 2025[21]. If large mining operations such as Simandou, Nimba, and others begin production within that approximate 2025 timeframe, overall production could increase to more than 180 million MT by 2030 if multiple mines begin production by 2025. As outlined in Figure 10 below, this scenario could result in, iron ore electricity demand reaching more than 2,978,000 MWh per year by 2030, requiring more than 850MW of installed capacity.

Despite current public plans, it is uncertain whether proposed iron ore operations (notably SMB-Winning's Simandou Blocks 1 & 2 and High Powered Exploration's Nimba project) will begin production "on schedule" within a 5 to 10-year timeframe given the history of project delays and ownership disputes that have hampered Guinea's iron ore development to-date.

Figure 10: Iron Ore Electricity Demand Forecast (MW)

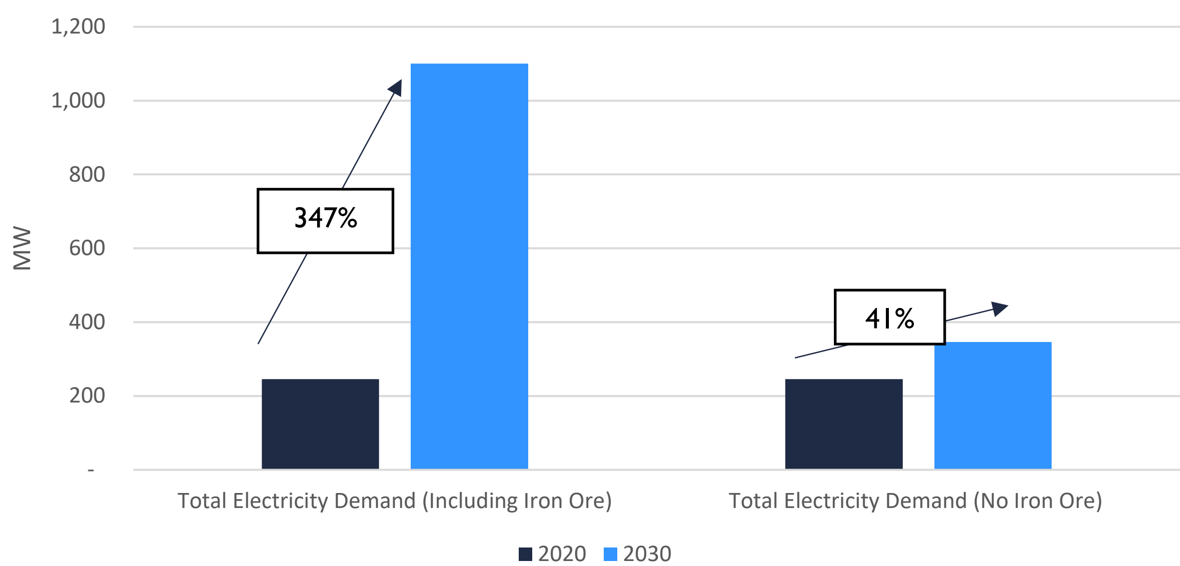


These forward-looking electricity demand estimates for iron ore would exceed the electricity required by bauxite mining operations and make iron ore the primary driver of mining industry electricity demand by 2026, so long as Guinea does not further localize downstream bauxite processing operations.

[21] https://www.spglobal.com/platts/en/market-insights/latest-news/metals/112519-guinea-simandou-iron-ore-developer-seeks-partners-eyes-2025-start

Guinea's iron ore potential production is so significant that, under the same forecasting conditions, the influence of iron ore alone could increase the sector's electricity demand by more than 300% between 2020 and 2030 compared to a scenario where iron ore production does not occur at a substantial level within that ten year period and bauxite production continues to be the primary driver of electricity demand. Figure 11 below demonstrates this disparity. The scenario on the left, which includes iron ore production, sees an increase in estimated electricity demand by 347% from 2020 to 2030. Comparing this to a scenario where iron ore production remains at zero, and where bauxite processing in-country remains at current levels, estimated electricity demand increases only 41% over the same timeframe.

Figure 11: Iron Ore's Influence on Total Electricity Demand (MW)

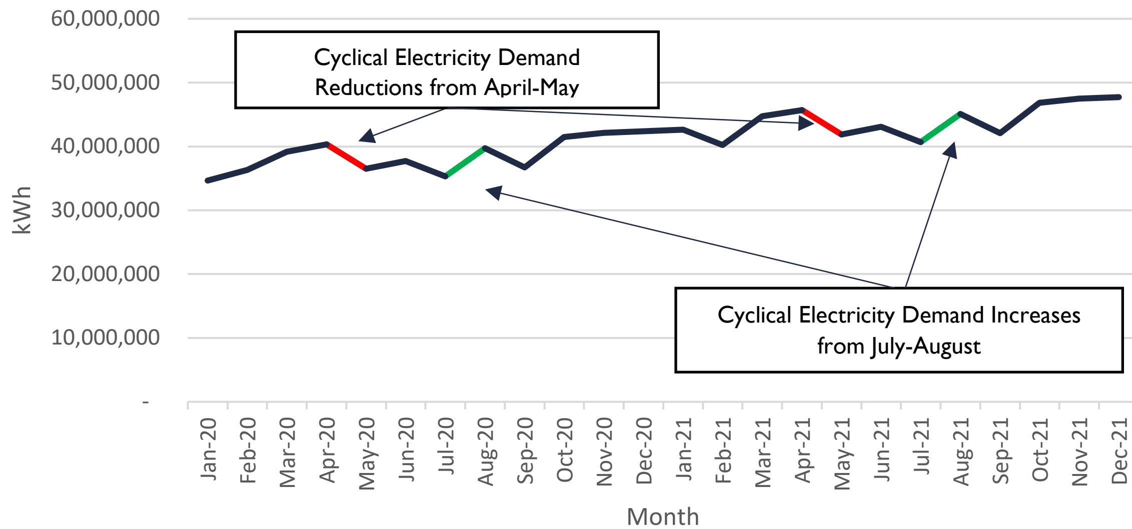


E. *Seasonality: The dry season is likely to have the highest electricity demand*

In addition to forecasting the total electricity demand at the industry and mineral levels, it is equally important to forecast the seasonality of Guinea's mining industry demand. Estimates regarding when certain minerals may trigger the highest – and lowest – electricity demand can facilitate long-term planning and assessments of which available generation options could be best-fit for mineral-specific mining operations.

Because electricity demand is tied largely to mineral production in this Report, the seasonality of demand largely reflects seasonal trends in production. Focusing on bauxite – currently the primary driver of industry-wide electricity demand – a recurring cadence emerges. Generally, as Figure 12 demonstrates, bauxite production increases during the dry season, with forecasted month-to-moth decreases and increases during specific months. This forecast is grounded in more than three years of monthly production data provided by Guinea's Ministry of Mines.

Figure 12: Bauxite Forecasted Electricity Demand Seasonality (kWh)



Across all minerals reviewed in this Report, similar seasonal patterns can be identified based on mineral production. Table 2 below outlines the seasonality of production for each month. This is the average influence of each respective month compared to the average production level.[22]

This summary reveals that, generally, Guinea's mining industry is likely to experience more extreme seasonal increases in electricity demand during the dry months, whereas the summer and winter months such as January and February may generally see decreases in demand. This conclusion is supported by conversations with personnel within Guinea's mining industry and evidence from relevant news reports.[23]

Table 2: Seasonality Index (Percent Variation from Average)

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Bauxite[24]	-2.3%	-7.1%	8.8%	5.1%	-6.0%	-4.3%	-20.2%	-3.2%	-20.1%	14.0%	16.1%	19.2%
Iron Ore[25]	-6.2%	5.3%	-3.4%	0.7%	-8.5%	-1.9%	6.5%	0.8%	-4.8%	-1.6%	3.8%	9.4%
Gold[26]	-4.9%	-4.2%	2.8%	7.1%	3.3%	-1.6%	-4.1%	1.6%	-8.9%	-1.6%	-6.1%	16.6%
Diamonds[27]	-55.6%	19.3%	-18.9%	33.9%	-14.9%	-39.3%	-26.4%	-93.9%	103.9%	54.4%	-17.9%	55.5%

[22] Production data varies in comprehensiveness by mineral based on what data was able to be retrieved from the Ministry of Mines.

[23] https://news.metal.com/newscontent/100986372/Update:-China%27s-bauxite-imports-fell-2-months-as-Guinea-in-rainy-season/

[24] Benchmarked to actual monthly production January 2016 – March 2020

[25] Benchmarked to Iron Ore 62% Fe, CFR China (TSI) January 2016 – December 2019

[26] Benchmarked to actual monthly production January 2016 – March 2020

[27] Benchmarked to actual monthly production January 2019 – December 2019

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Total[28]	*-5%*	*-1%*	*3%*	*4%*	*-6%*	*-3%*	*-7%*	*-2%*	*-11%*	*6%*	*8%*	*15%*

One of the values of seasonal data is that it can be compared to the requirements of potential generation sources that are alternatives to HFO. Hydropower is one of these potential alternatives and is a generation source where Guinea is actively trying to expand capacity. In 2017 Guinea commissioned the 240MW Kaleta hydroelectric facility, approximately midway between Conakry and the Boke region in the country's northwest, an area known for bauxite mining. Additional projects such as the 450MW Souapiti hydroelectric facility could dramatically alter Guinea's generation landscape. This significantly increased Guinea's installed generation capacity and strengthening its ability to supply steady renewable energy to mine sites.

Hydropower is reliant on water volume to produce electricity at maximum capacity. Without relevant data on individual mine sites and diagnostics on individual hydropower resources, it is challenging to determine how electricity demand seasonality may align to current or potential hydropower resources. However, overlaying total electricity demand seasonality to average rainfall in Conakry – a proxy for nationwide rainfall – can provide an estimate of this potential alignment. This is outlined in Figure 13 below.

Figure 13: Average Mining Demand Seasonality Compared to Average Rainfall (Conakry)[29]

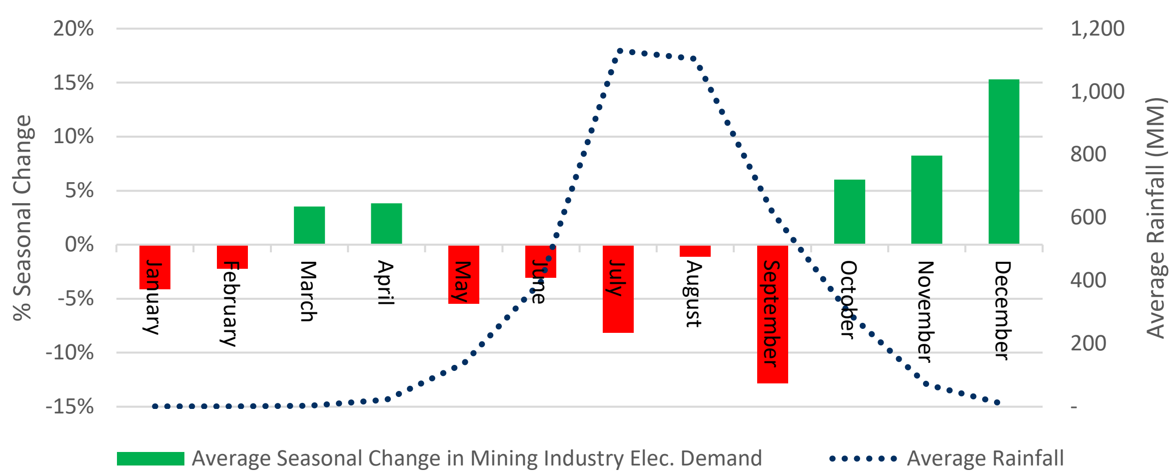


Figure 13 outlines the likelihood that Guinea's electricity demand seasonality may run opposite to when rainfall, and therefore hydropower capacity, is at its highest. This increases the likelihood that hydropower resources have the strongest likelihood of being able to meet mining industry demand for portions of the year during the wet season in the May through September timeframe – when water levels are highest and industry demand may be lowest – but may not be able to meet industry demand

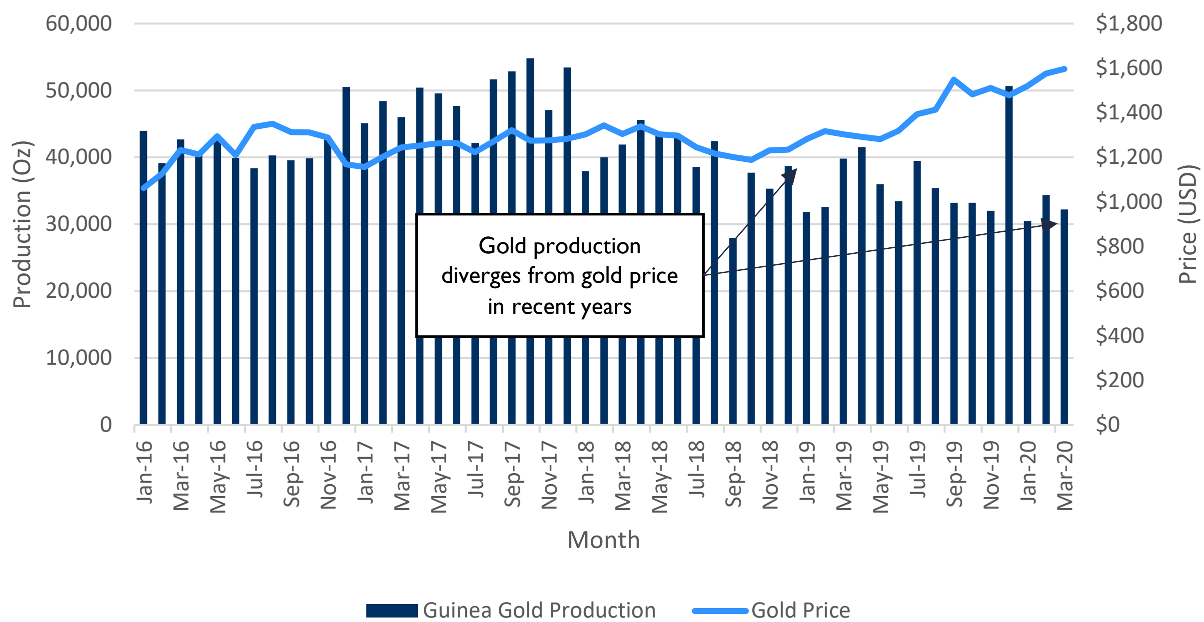
[29] https://www.weather-atlas.com/en/guinea/conakry-climate

on its own during dry season months that generally see increased production and electricity demand, such as October through December.

F. *Gold and Diamond production does not significantly influence demand*

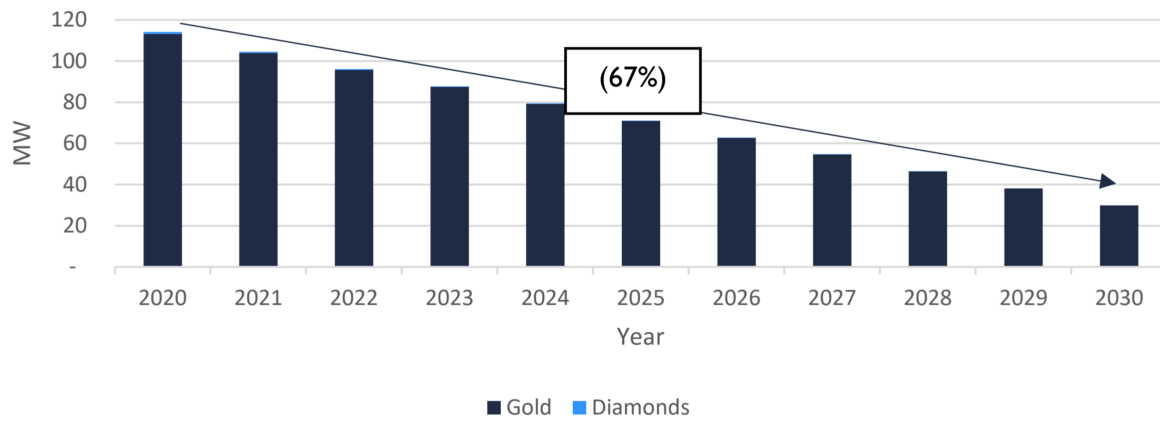
Compared to bauxite's current production trends and the vast potential of Guinea's iron ore resources, neither gold nor diamond production will significantly influence overall mining industry demand if current production trends continue. Figure 14 below emphasizes that gold production in Guinea has historically not been highly responsive to the price of gold. The divergence between production and price within the past two years has been significant despite surging gold prices in that same period.

Figure 14: Gold Price and Production (Oz / USD)



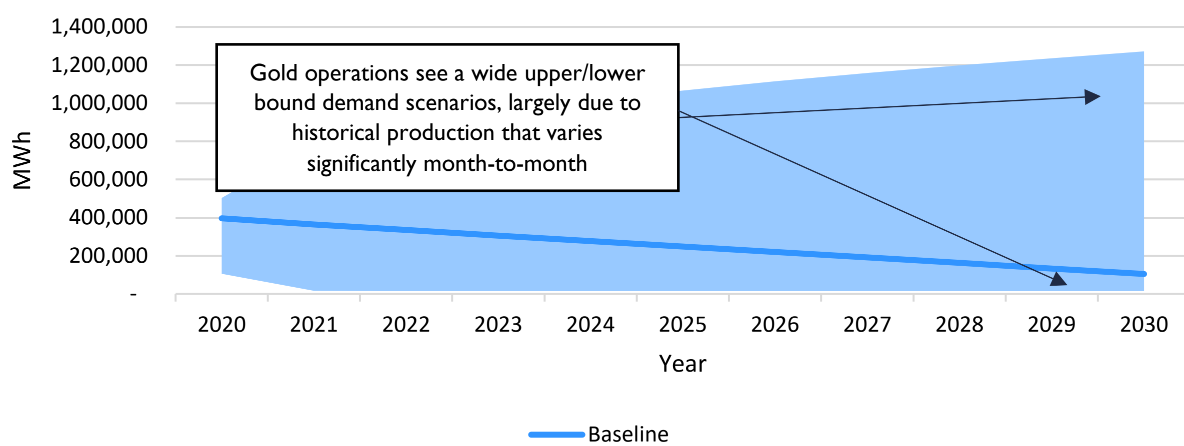
This recent decline in gold production significantly impacts the baseline forecast of Guinea's gold production through 2030, with the forward-looking estimate of production trending significantly downwards – again in the face of rising gold prices. The fact that Guinea's gold production is not highly responsive to the price of gold may support the overall downward forecast, which could occur irrespective of how the price of gold performs over the same period. In turn, this forecasted decrease in production influences the forecasted electricity demand. As outlined in Figure 15 below, if the downward trend in production carries through the coming years and into the coming decade, gold operations' power demand could decrease steadily, from nearly 120MW of installed capacity in 2020 to less than 40MW in 2030, a 67% decrease in electricity demand during a ten-year period.

Figure 15: Forecasted Gold Electricity Demand (MW)



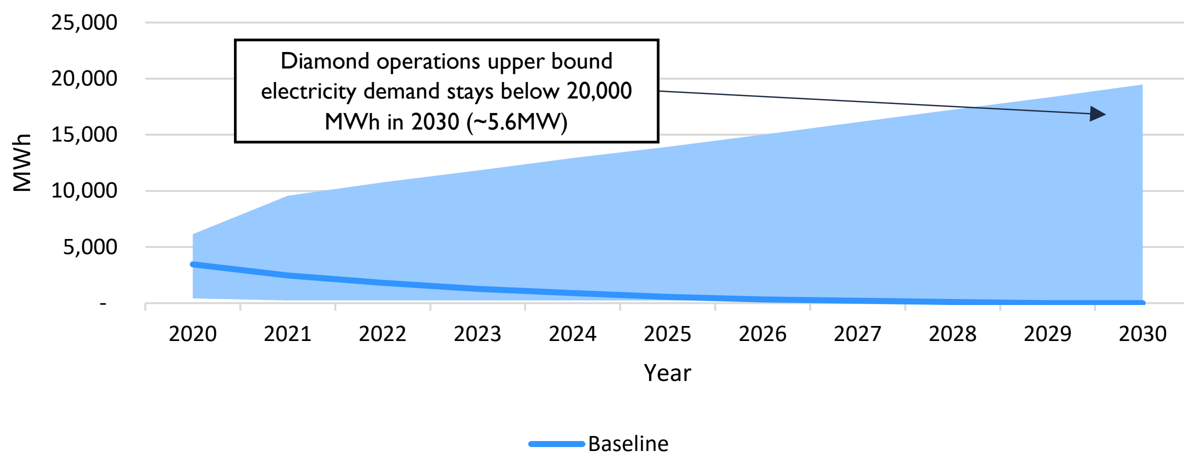
If gold production deviated substantially from this current trend, it could rapidly increase its share of overall mining industry electricity demand, as gold consumes more electricity per MT than either bauxite or iron ore (not including downstream processing stages). This causes the range of potential electricity demand outcomes for gold to vary significantly, with the forward-looking demand's upper bound estimating more than 1,200,000MWh in 2030, which could require more than 342MW of installed capacity. As Figure 16 highlights, this upper bound forecast for gold electricity demand would exceed the baseline forecast for bauxite electricity demand, however, this would require deviating significantly from historical production trends.

Figure 16: Gold Electricity Demand Upper Bound and Lower Bound (MWh)



Diamond production, even when including production data from artisanal operations that are likely to consume less energy than industrial operations, is not significant enough to influence overall sector electricity demand at current production levels. Figure 17 emphasizes the conclusion that if diamond production were to increase substantially by 2030, diamond operations are still not anticipated to exceed 5.6MW in installed capacity (19,480MWh) in the upper bound scenario. This would remain a small fraction of Guinea's forecasted overall mining industry electricity demand.

Figure 17: Diamond Electricity Demand Upper Bound and Lower Bound (MWh)



IV. CONCLUSION AND RECOMMENDATIONS

In any scenario, the electricity demand of Guinea's mining industry is likely to remain strong throughout the next decade. For now, this is likely to be driven almost exclusively by bauxite mining operations – which will continue to be the bellwether of overall industry demand, with non-artisanal gold mining and both artisanal and non-artisanal diamond mining accounting for minor portions of overall electricity demand. The inflection points for this demand forecast – events that could dramatically influence the electricity demand landscape – are twofold: (1) the timing and scale of Guinea's iron ore operations and (2) the degree to which Guinea can localize bauxite processing operations in-country.

As large iron ore projects begin production (e.g., Simandou Blocks 1 & 2), either between 2020-2030 or at any point in Guinea's future, the electricity demand landscape is likely to shift. Three to five large mining operations potentially producing more than 180 million MT of iron ore annually would likely be sufficient to make iron ore the largest driver of electricity demand in Guinea's mining industry. If Guinea can maintain or expand current bauxite production levels during this time, the effects on electricity demand could be even more significant.

In parallel, Guinea's ability support private industry to localize bauxite processing facilities – both processing bauxite into alumina and smelting alumina into aluminum – could dramatically increase mining industry electricity demand well beyond levels driven by increased iron ore production. Due to the highly energy-intensive nature of these processes, any significant increase in localized downstream processing is likely to be precipitated by the expansion and upgrade of existing, grid-based power sector infrastructure.

This Report provides a range of potential estimates of the electricity demand for Guinea's mining industry, provide a foundation for long-term decision making by the Guinean government, and lays the foundation for additional, more in-depth technical assistance to Guinea's mining industry. The necessary next steps to this Report, and the data collected therein, will be to continue collecting mine-site specific data and provide increasingly targeted recommendations on potential best-fit generation options for Guinea's mining industry and how Guinea can integrate this substantial mining industry demand into its long-term planning efforts. In the interim, the recommendations of the Project Team stemming from this Report are as follows:

1. **Focus power sector support efforts on bauxite mining operations in the near term and actively engage mine operators to develop potential processing activities in the long-term:** Bauxite operations are likely to remain the most significant driver of mining industry electricity demand in the near term. Focusing power sector support efforts on these operations, and specifically the operations of CBG and SMB, will support the most immediate large base of electricity demand. Prioritizing power sector support to a few large bauxite operations such as these is likely to have greater impact on adequately supplying electricity demand and expanding mining operations than prioritizing small-to-medium sized bauxite mining operations.

   In the long-term, processing bauxite in-country could dramatically alter the mining industry demand landscape. Actively engaging existing bauxite miners to solicit in-country bauxite processing capabilities may both accelerate how much alumina is produced in-country and facilitate long-term planning efforts between Government of Guinea, individual mining companies, and potential third-party power sector developers.

2. **Develop alternative electricity options that can supply mining operations during the dry season to account for potentially higher industry demand at times when hydropower resources may be reduced:** Dry season months with higher mining industry electricity demand tend to be months where Guinea sees little average rainfall. This means that hydropower resources may not be the best fit for large mining industry operations in those seasons. Supporting development of Direct Power Purchase Agreements between the larger mining companies, open access transmission regulations to liberalize the flow of electricity around the country, and collaborating with developers who could provide variable renewable energy technology solutions such as solar and wind could complement the inherent seasonality of hydropower and supply mining industry operations in high-demand months when hydropower resource may be at their lowest output.

3. **Actively position power sector resources for potential iron ore electricity demand in the medium-to-long term:** Iron ore production could dramatically increase industry electricity demand. In the event this occurs, develop long-term planning efforts to increase generation capacity in areas that are targeted by large-scale iron ore operations (e.g., Simandou Blocks 1 and 2) to facilitate industry expansion and increase production. This could potentially include geospatially identifying the specific locations where future iron ore production may begin and determining potential generation options to serve those operations.

4. **Refocus power supply efforts to precious mineral and gemstone mining operations to bauxite operations in the near term:** Precious mineral and gemstone mining operations such as gold and diamonds are not likely to dramatically influence industry electricity demand compared to Guinea's other mineral resources. Power sector planning efforts to support these operations can likely have greater impact on the mining industry, and Guinea, by focusing on mining operations with higher potential electricity demand such as bauxite.

ANNEX A – METRICS

Table 3: Electricity Demand Calculation Assumptions

	Unit of Measurement	Electricity Per Unit (Produce)	Electricity Per Unit (Process)	Mineral Conversion Ratio	Seasonality	Notes
Bauxite	*Metric Tonne (MT)*	*4 kWh/MT*[30]	*Bauxite Processing: 109 kWh/MT*[31] *Smelting: 15,400 kWh/MT*[32]	*2.64:1 Bauxite to Alumina*[33]	*Calculated from historical data (2016-2020)*	*N/A*
Diamonds	*Carat (Ct)*	*26.3*[34]	*N/A*	*N/A*	*Calculated from historical data (2019)*	*Minimal historical monthly production data is available therefore artisanal and diamond production is included*
Gold	*Ounce (Oz)*	*1,017.8/Oz*[35]	*N/A*	*N/A*	*Calculated from historical data (2016-2020)*	*Artisanal gold production is not included.*
Iron Ore	*Metric Tonne (MT)*	*16.5 kWh/MT*[36]	*N/A*	*N/A*	*Seasonality is benchmarked to Iron Ore 62% Fe, CFR China (TSI) January 2016 – December 2019*	*No historical data is available. Estimates are based on publicly available information:* • *Nimba*[37] • *Simandou Blocks 1&2*[38] • *Zogota*[39] • *Kalia*[40]

30 U.S. Geological Survey, *Estimates of Electricity Requirements for the Recovery of Mineral Commodities, with Examples Applied to Sub-Saharan Africa,* https://pubs.usgs.gov/of/2011/1253/report/OF11-1253.pdf (USGS)

31 https://www1.eere.energy.gov/manufacturing/resources/aluminum/pdfs/al_theoretical.pdf

32 *See id.*

33 *See id.*

34 Average of Argyle and Diavik Mines (*See* USGS, Treasures of the Earth, Saleem Ali)

35 *See* USGS (Average of 14 sites across Africa)

36 *See id.*

37 High Powered Exploration Press Release

38 https://www.spglobal.com/platts/en/market-insights/latest-news/metals/112519-guinea-simandou-iron-ore-developer-seeks-partners-eyes-2025-start

39 https://www.mining.com/mick-davis-step-closer-mining-iron-ore-guinea-liberia-deal/

40 https://www.mining-technology.com/projects/kaliaironoreproject/

Table 4: Electricity Demand Estimates in Status Quo Scenario (Upper Bound, Baseline, Lower Bound)

Measurement	Unit	Jan-20	Jan-21	Jan-22	Jan-23	Jan-24	Jan-25	Jan-26	Jan-27	Jan-28	Jan-29	Jan-30
Total Electricity Demand												
Total With Iron Ore Included												
Installed Capacity Requirement Upper Bound	*MW*	282	450	516	573	625	1,043	1,485	2,164	2,207	2,248	2,286
Installed Capacity Requirement Baseline	*MW*	246	255	265	275	285	523	775	1,173	1,183	1,193	1,203
Installed Capacity Requirement Lower Bound	*MW*	91	79	76	77	80	84	89	95	102	108	116
Total Without Iron Ore												
Installed Capacity Requirement Upper Bound	*MW*	282	450	516	573	625	673	719	762	804	845	885
Installed Capacity Requirement Baseline	*MW*	246	255	265	275	285	295	306	316	326	336	346
Installed Capacity Requirement Lower Bound	*MW*	91	79	76	77	80	84	89	95	102	108	116
Total Bauxite	*MW*	132	151	169	188	206	224	243	261	279	298	316
Total Iron Ore	*MW*	-	-	-	-	-	228	469	857	857	857	857
Total Gold	*MW*	113	104	96	87	79	71	63	55	46	38	30
Total Diamonds	*MW*	1	1	1	-	-	-	-	-	-	-	-
Demand Upper Bound	*MWh/Year*	989,300	1,576,163	1,808,936	2,008,804	2,189,978	3,655,150	5,203,335	7,584,163	7,734,589	7,875,475	8,010,001
Demand Baseline	*MWh/Year*	862,591	894,488	929,470	964,568	999,870	1,832,661	2,715,085	4,109,095	4,144,634	4,180,189	4,215,836
Demand Lower Bound	*MWh/Year*	317,390	276,184	265,791	269,249	279,500	294,516	312,712	333,383	355,895	380,151	405,583
Mineral Electricity Demand												
Bauxite Electricity Demand												
Upper Bound	*MWh/Year*	478,920	782,108	919,504	1,044,907	1,163,344	1,277,362	1,388,027	1,496,217	1,602,394	1,707,171	1,810,601
Baseline	*MWh/Year*	462,484	528,217	592,647	657,078	721,422	785,939	850,369	914,800	979,145	1,043,661	1,108,092
Lower Bound	*MWh/Year*	225,715	274,326	265,791	269,249	279,500	294,516	312,712	333,383	355,895	380,151	405,583
Iron Ore Electricity Demand												
Upper Bound	*MWh/Year*	-	-	-	-	-	1,296,621	2,685,100	4,912,948	4,915,678	4,913,190	4,907,747
Baseline	*MWh/Year*	-	-	-	-	-	797,500	1,644,500	3,003,000	3,003,000	3,003,000	3,003,000
Lower Bound	*MWh/Year*	-	-	-	-	-	-	-	-	-	-	-
Gold Electricity Demand												
Upper Bound	*MWh/Year*	504,231	784,478	878,670	952,081	1,013,708	1,067,230	1,115,197	1,158,875	1,199,296	1,236,795	1,272,174
Baseline	*MWh/Year*	396,650	363,794	335,011	306,227	277,535	248,661	219,878	191,094	162,402	133,528	104,745
Lower Bound	*MWh/Year*	91,490	1,858	-	-	-	-	-	-	-	-	-
Diamond Electricity Demand												
Upper Bound	*MWh/Year*	6,149	9,577	10,762	11,816	12,925	13,938	15,012	16,123	17,222	18,318	19,480
Baseline	*MWh/Year*	3,457	2,477	1,813	1,263	912	561	338	201	87	-	-
Lower Bound	*MWh/Year*	184	-	-	-	-	-	-	-	-	-	-

ANNEX B – LIQUIFIED NATURAL GAS

Currently, Guinea does not possess the specialized regasification infrastructure required to successfully import liquified natural gas (LNG) and develop it for use in the mining context, however, this landscape is changing. The purpose of this Annex is to outline, at a high level, how this landscape is changing and to highlight the potential for LNG to serve portions of the electricity demand estimated in the body of this Report.

A. *Background*

LNG is natural gas cooled until it reaches a liquid form. This allows the gas, now liquid and approximately 1/600th its gaseous volume, to be transported more easily and safely by ship when pipeline transport is not feasible. The multiplication of LNG supply sources and more particularly on the Atlantic market offers supply opportunities to countries lacking natural gas. Upon reaching its destination by LNG vessel or LNG ISO-container, LNG is regasified through an industrial process which requires specialized infrastructure to slowly reheat the cooled liquid into a gaseous form which can be burned to generate electricity that is both cleaner and cheaper than HFO and can mitigate the intermittency inherent in hydropower generation. Successfully developing LNG capabilities in Guinea would create a new fuel source that is potentially both cleaner and cheaper than HFO and could be used to augment Guinea's generation capacity and increase capability to serve mining industry demand, specifically in the Boké 21region – an area where demand is anticipated to be high due to the number of large bauxite mining operations and because this region borders the Atlantic Ocean, making it ideal for ocean-bound LNG cargos.

B. *LNG Development*

Multiple endeavors are actively working to alter the LNG landscape in Guinea and across West Africa. This includes, but is not limited to the following projects. Among these is projects is the Guinea-focused West Africa LNG Group. West Africa LNG is partially funded by a U.S. Trade and Development Agency grant to complete a feasibility study for an LNG import terminal in Kamsar, a port in the Boké region, and associated distribution infrastructure. This will assess the economic, financial, and technical viability of an LNG project at Kamsar to enable direct LNG supply to bauxite mining operations in Boké. Longer term aspirations include developing LNG export infrastructure to accommodate potential offshore natural gas resources in the Gulf of Guinea.

- Floating Storage Regasification Unit (FSRU) LNG hub (International Finance Corporation / Sierra Leone)
- LNG-to-Powership Project (Mitsui O.S.K. Lines and Karpowership / Senegal)
- Greater Tortue Ahmeyum FSRU LNG project (BP and Kosmos Energy / Senegal and Mauritania)
- West Africa LNG Group (AfricaGlobal and Schaffer International Services / Guinea)

C. *Establishing a Path Forward for Deploying LNG to Serve Mining Industry Electricity Demand*

Estimating the potential impact of LNG on the ability of Guinea's mining industry to generate electricity, and which mine sites may be best-fit for this type of fuel resource, requires additional analysis that is outside the scope of this Report. However, developing an approach to retrieving necessary data from mining operations in Boké and determining which mine sites may be best-fit for LNG use may include:

- **Mine Identification**: Identifying specific mine locations, existing generation facilities, and the type of heavy equipment used
- **Transport and Electricity Infrastructure**: Existing and planned grid infrastructure and capacity. Infrastructure required to transport fuels to the mine site, including road, railway, and navigable waterways.
- **Generation Infrastructure**: This could also include establishing the availability and location of potential hydropower resources that do or could supply mining operations.
- **Detailed Data Request**: This would likely include establishing a data request which may include:
    - GPS locations for mining operations
    - Mine demographic information
    - Fuel supply for power generation
    - Fuel supply for heavy equipment
    - Fuel supply for processing
    - Fuel logistics