



Environmental Aspects of Nodule Processing

Nodule processing has the same environmental challenges as conventional ore processing.

Nodule processing has the same environmental challenges as conventional metallurgical processing.

Spoiler alert: Also some unique opportunities.

Gas

- Metallurgical process gases;
- Secondary gases;
- Utility gases (e.g. acid plant);
- Infrastructure gases (e.g. power plant);

In metallurgical processes, gas emissions are captured and transported to cleaning equipment that removed particulate, hazardous or environmentally harmful compounds before releasing through a stack.

- Settling chambers / water quench;
- Combustion chambers (heat gas very hot to destroy organics, oxidize CO, etc...);
- Dust removal equipment (Baghouse, Scrubber, Electro-static Precipitators (ESP)).

Must consider both magnitude of emission and Ground Level Concentrations (GLCs).

Gas



Water

Consumption

Water consumption in metallurgical processing is becoming a major issue.

- Minimize water consumption;
- Maximize water recycling.

Emissions

Process water is treated to remove any solids and chemicals harmful to human health or the environment. Even benign components must be removed to very low levels to meet regulations.

- Settling ponds;

Solids

Solid waste is the components of the ore that has not been extracted and any other material added as part of the process.

- Tailings is the solid waste from minerals processing / concentrating;
- Residue is the solid waste from hydrometallurgical processes;
- Slag is the solid waste from pyrometallurgical processes.

Solid waste is typically stored on-site for the duration of operations and rehabilitated during the closure process.

- Tailings ponds;
- Residue storage facility;
- Dry stacking;
- Slag dump.

Smaller streams of solid waste (e.g. refining residues) are managed separately.

Solids



Residue Storage Facility

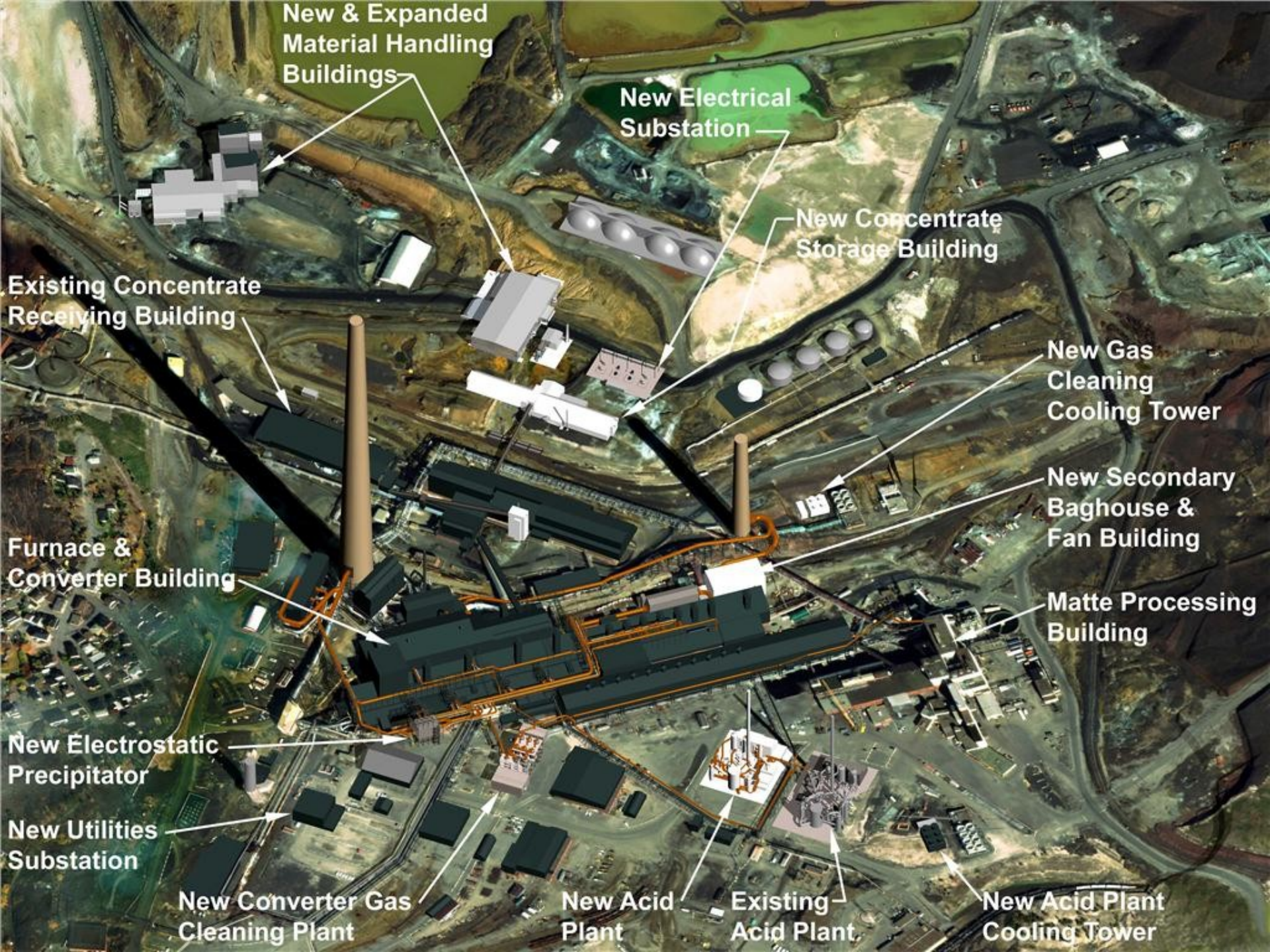
Secondary Emissions

Secondary emissions are indirect emissions from the operations:

- Process gases that have not been captured;
- Water run-off from rain or other waster source;
- Dust from roads, stockpiles, under ventilated operations.

Managed through:

- Housekeeping and care in operations;
- Dust containment and suppression;
- Site water and run-off management;
- Secondary & tertiary gas capture and treatment.



New & Expanded
Material Handling
Buildings

New Electrical
Substation

New Concentrate
Storage Building

Existing Concentrate
Receiving Building

New Gas
Cleaning
Cooling Tower

Furnace &
Converter Building

New Secondary
Baghouse &
Fan Building

Matte Processing
Building

New Electrostatic
Precipitator

New Utilities
Substation

New Converter Gas
Cleaning Plant

New Acid
Plant

Existing
Acid Plant

New Acid Plant
Cooling Tower

Monitoring Stations for GLCs



Workplace Environment

The quality of the workplace environment within the operating plant boundaries must be managed to ensure the health and safety (and productivity) of workers.

- Adequate ventilation;
- Adequate lighting;
- Housekeeping;
- Tightly controlled hazardous materials and emissions.



Energy

Energy is both expensive and environmentally impact intensive.

However, metallurgical processing is an energy intensive exercise, as defined by thermodynamics.

To maximize energy efficiency:

- Design to minimize heat losses;
- Energy recovery through co-generation or re-use of heat;
- Employ energy efficient and environmentally friendly energy sources.

Greenhouse Gases (GHGs)

Greenhouse gas emissions in metallurgical operations are from:

- Carbon based power sources, such as coal or natural gas;
- Direct CO₂ or other GHG generation in the process;
- Indirect GHG emitted as part of the production of consumables;
- Mobile equipment, etc...

To minimize Greenhouse Gases (GHG):

- Low carbon energy sources (e.g. hydroelectric power);
- Maximize energy efficiency (see previous);
- Minimize material and consumable transport.

GHG Intensity for Various Metals

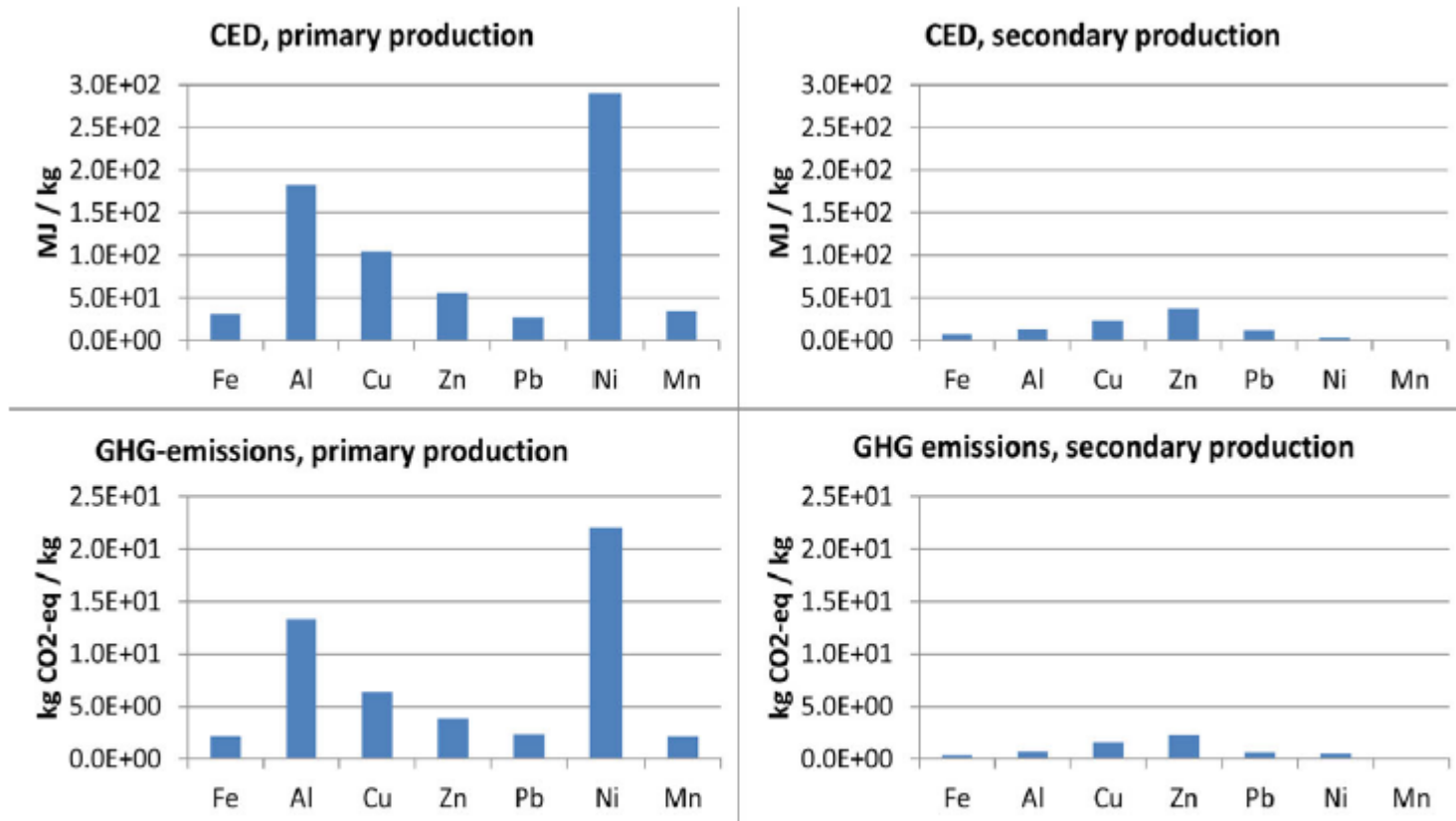


Figure 1 Cumulative energy demand (CED) and greenhouse gas (GHG) emissions per kg of produced metal, 2010 (numbers for iron, nickel, and manganese include steelmaking). MJ/kg = megajoules per kilogram; kg CO₂-eq/kg = kilograms of carbon dioxide equivalent per kilogram.

DeepGreen intends to select a site with existing infrastructure and skilled labour for construction & operations.

By definition, a developed (urban?) setting.

Environmental Considerations of a Developed Site

- Less site development impact in comparison to a native greenfield site;
- Baseline studies possibly complete;
- Historical industrial impacts;
- Less buffer between operations and population:
 - Noise considerations;
 - GLC design impacts;
 - Impact and complications of neighbouring industrial operations emissions;
- Less impact from transport of consumables (closer to source).
- Market for by-products.

Elimination of waste
products is a
DeepGreen principle and
key project objective

Elimination of waste products is a DeepGreen principle and key project objective.

Three unique critical project elements to eliminate waste:

- 1) The nodules contain remarkably low levels of elements and compounds detrimental to the environment and human health. Thus, the same will be true for the solid waste.
- 2) DeepGreen will develop a process and invest in the by-products such that they are useful. Probable markets are cement and aggregate.
- 3) DeepGreen's unique ability to choose its processing site enables the elimination of waste through proximity to by-product markets.

By-Product Marketing Considerations

Solid Waste Products

- Cement require silica and iron additives. Our solid by-products can meet these requirements.
- With appropriate particle sizes and shapes – road, rail aggregates are a high potential market;
- Proximity to the market is key to the economics.

Other Products

- DeepGreen will work with customers to ensure our other products are useful.

Summary

- The environmental challenges of nodule processing are the same as conventional metallurgical processing;
- DeepGreen will develop the project in a compliant and environmentally responsible manner that minimizes negative impacts;
- The elimination of solid waste is a DeepGreen principle and important project objective;
- Solid waste can be eliminated due to project & process design and the benign nature of the nodules and proximity to cement, aggregate and other markets.

Thank you!

Dr. Jeffrey Donald
Head of On-Shore Development

DeepGreen Metals

Phone: +1 416 275 3991

Email: jeff@deepgreen.com

jeffrey.donald@snclavalin.com





DEEPPGREEN

