Engineering for
a better future

National Green Steel Ltd

Proposed Waikato Site

Emissions Plan for Resource Consent

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1. Introduction

This document is an emissions plan for National Green Steel's proposed new steel mill which contains the best practicable option (BPO) under the proposed operating conditions. The emissions plan has been considered at a site level rather than an equipment level due to complexity of the proposed site, and the interconnected nature of the process heat equipment.

1.1 Purpose of this plan

The purpose of this plan was to identify, quantify, and plot a roadmap of projects which would form the BPO to minimise process heat carbon emissions at National Green Steel's proposed new steel mill in Waikato. This plan and BPO are intended to support a consent application for the new heat devices at the site under the new NPS-GHG/NES-GHG.

1.2 Organisation Context

National Green Steel Limited is a New Zealand-based company incorporated in May 2008. It is pursuing the development of a green steel manufacturing plant in New Zealand, aiming to enhance sustainable steel production. The proposed facility is planned for a 53-hectare site in the Waikato region, specifically near Hampton Downs. This plant intends to utilise recycled shredded scrap metal from a new shredder to be installed on the site, instead of exporting it overseas. The proposed plant processing the shredded scrap metal will produce high-quality structural steel with a significantly reduced carbon footprint compared to traditional methods[1].

The project has been included in Schedule 2 of the Fast-track Approvals Act 2024 as a listed project. The Act is designed to expedite the consenting and approvals process for developments that stimulate economic growth. By leveraging Electric Arc Furnace (EAF) technology and incorporating New Zealand's renewable energy sources the proposed plant aims to produce a low carbon steel.

Through these projects, National Green Steel demonstrates a commitment to sustainable practices and the advancement of green steel production both locally and internationally.

1.3 Site Description & Process Heat Activity

National Green Steel Limited plans to establish a green steel manufacturing plant on a 53-hectare site near Hampton Downs in the Waikato region.

The facility aims to utilise domestically sourced scrap steel, processing it on-site to produce high-quality structural steel with a significantly reduced carbon footprint compared to traditional methods. The facility will include a shredder plant for processing scrap steel, an electric arc furnace (EAF) for melting recycled steel, a two-strand billet/bloom caster for casting semi-finished steel products, and a medium section-cum-bar mill for rolling steel into various structural shapes. Additionally, the plant will feature an oxygen production unit to support the steelmaking process.

[1] Ministry for the Environment. (2024). *National Green Steel Limited - Fast-track Approvals Bill Submission*. Ministry for the Environment

The facility will feature an electric arc furnace with capacity of 35 tonnes/hr of scrap metal with annual production quantity of 268,800 tonnes liquid steel from the electric arc furnace plant based on 320 production days per year.

1.4 Methodology

The general approach for developing the emissions plan was to:

1. Examine the proposed process, heat and temperature requirements of the site
2. Identify further opportunities to minimise energy consumption and demand through process change and energy efficiency.
3. Assess low carbon fuel switching opportunities.

After compiling a long list of opportunities, incorporating novel and innovative technologies, a short list of the most suitable opportunities was then analysed in more detail.

The opportunities from an agreed short-list of new opportunities were evaluated and those deemed technically feasible and financially viable were included in the BPO in Section 3. A comprehensive list of the opportunities investigated, including those that do not make up the BPO, are included in Appendix A – Opportunities Assessment.

2. Energy, Carbon & Asset Summary

This section summarises the process heat fossil fuel usage and resulting carbon emissions, fossil fuel-related processes and associated assets. The electrical consumption of the site is not included as it is not required for the emissions plan.

2.1 Expected Fossil Fuel Energy Consumption & Associated Emissions

Table 2.1 shows the projected fossil fuel energy consumed and related carbon emissions for 12-months of operation for the major process heat devices based on target production levels without accounting for energy efficiency initiatives (further detail provided later).

Table 2.1 – Summary of projected fossil fuel energy consumption and carbon emissions

Heat Device	Energy Type	Annual Consumption kWh/year	Annual Emissions tCO_2/year
Equalising Furnace	LPG	107,000,000	22,900

Note: the LPG consumption of 107GWh would equate to about 7,700 tonnes of LPG per year.

National Green Steel's overall process also includes some major assets which utilise electricity for energy. These are not included in the energy consumption and emissions because electricity is already a low emissions fuel source.

2.1.1 Consent Requirements

Due to the forecasted emissions from process heat fossil fuels (LPG) being greater than 2,000 tCO_2-e/year, this site will be considered a high emissions site and therefore an independent review by a suitably qualified professional (SQP) would be required. An internal review has been carried out by an SQP who was not involved in the preparation of this emissions plan to meet the requirements.

2.2 Process & Assets

This section describes the planned process and assets of the steel mill with a focus on fossil fuel consuming equipment. This provides an understanding of where the fossil fuel emissions arise.

2.2.1 Process

The steelmaking process using scrap metal involves several key stages, including shredding, melting in an electric arc furnace (EAF), continuous casting, rolling, and the use of an oxygen plant to enhance efficiency, see Figure 2.1.

The process begins with scrap metal preparation, where collected scrap is processed in a shredder to break it into smaller, more uniform pieces. This step improves handling and melting efficiency in the subsequent stages. The cleaned and sorted scrap is then transported to the EAF for melting.

In the EAF, the shredded scrap is charged at a rate of approximately 35 t/hr and melted using high-power graphite electrodes, which generate an electric arc to produce intense heat. Oxygen is injected into the furnace to accelerate the oxidation of impurities such as carbon, phosphorus, and sulphur. Fluxes like lime and dolomite are added to form a slag layer that captures unwanted elements.

A maximum heat demand of approximately 14 MW is required for the EAF, which aims to produce 268,800 tonnes of liquid steel per year. A Ladle Furnace (LF) is used to refine the liquid steel from the EAF which requires a maximum heat demand of approximately 2 MW.

After refining, the molten steel is transferred to the billet caster, where it is continuously poured into moulds at a rate of approximately 40 t/h to form semi-finished steel billets. These billets gradually solidify as they pass through a series of cooling zones before being cut into the required lengths. The billets are then stored before further processing in the rolling mill.

The next stage involves rolling in the medium section-cum-bar mill, where the billets are reheated in a furnace to reach the desired rolling temperature. The hot billets are then passed through multiple rolling stands to reduce their size and shape them into specific profiles such as angles, channels, beams, and bars (round, square, or flat). Controlled cooling methods are used to achieve the required mechanical properties before the final products undergo straightening, cutting, and quality inspection.

The reheating takes place in an Equalizer Furnace (EF) which uses LPG with a maximum heat demand of approximately 10 MW (for hot charging) or 20 MW (for cold charging) and a production rate up to 45 t/h. The target production rate of the section mill is 101,400 tonnes per year and the bar mill is 152,200 tonnes per year.

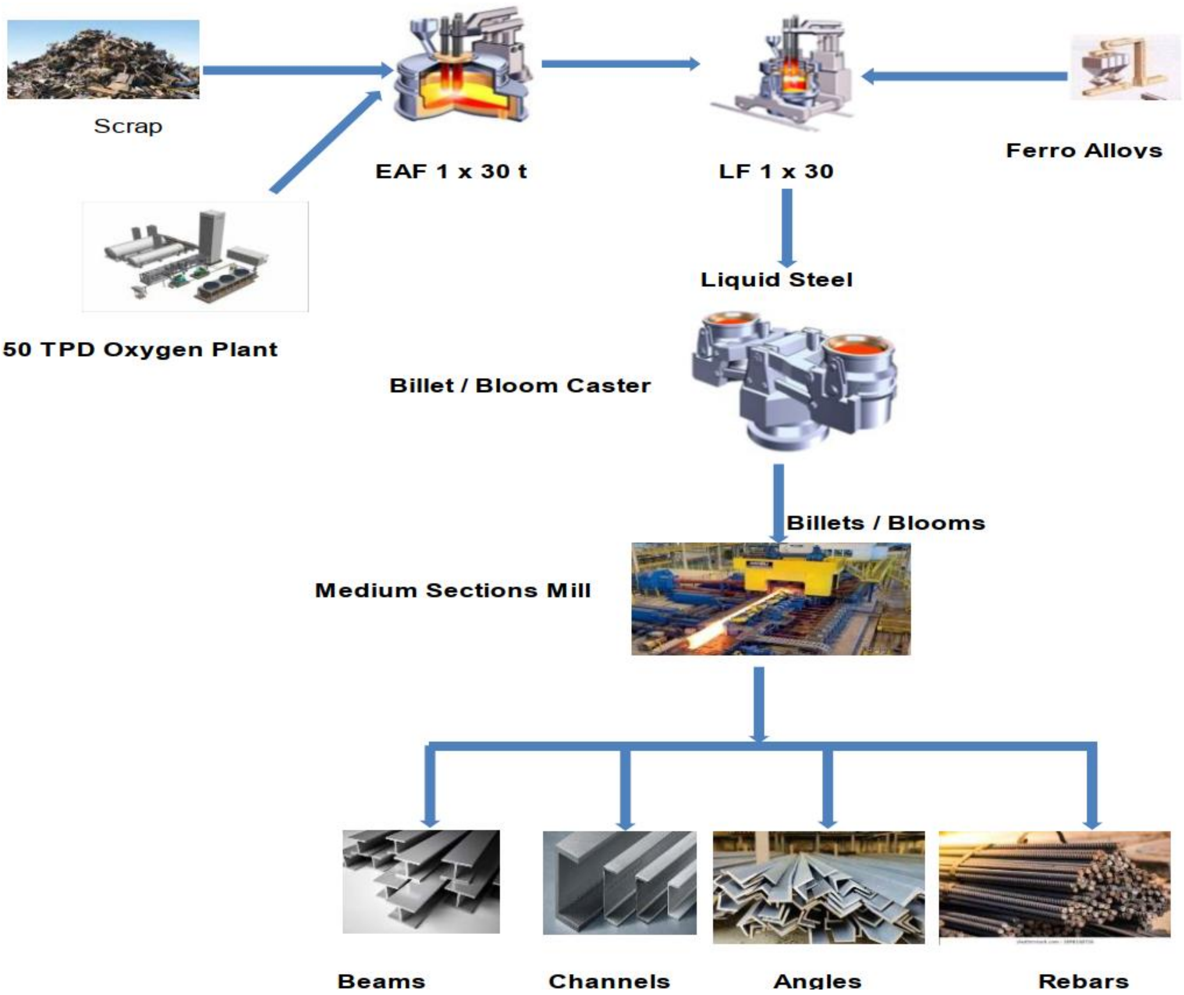

Figure 2.1 –Product flow diagram for the proposed plant

To support this entire operation, an oxygen plant is integrated into the facility to provide a steady supply of high-purity oxygen. This oxygen is primarily used in the EAF to improve melting efficiency by enhancing combustion, accelerating the decarburisation process, and reducing electricity consumption. The oxygen plant plays a critical role in optimising energy use and ensuring consistent steel quality. All major equipment in the proposed process, except for the medium section-cum-bar mill, will operate on electricity. The shredder, electric arc furnace (EAF), billet caster, and oxygen plant are all electrically powered, ensuring efficient and environmentally friendly operation.

However, the EF (used for to reheat material for the medium section-cum-bar mill) will be an LPG-fired system, chosen specifically for its superior controllability in achieving precise temperature profiles during reheating and rolling, which is critical for maintaining the desired mechanical properties of the final steel products. Further details of the process can be found in the supporting document supplied by Green Steel Limited[2].

2.2.2 Heat Devices Summary

The following table summarises the known details about the major heat devices that will be used in the process.

Table 2.2 – Electric heat device specifications

Specification	EAF	LF	Equaliser Furnace (EF)
Energy source / Fuel	Electricity	Electricity	LPG
Heating Capacity	14 MW	1.6 MW	10 -20MW
Production Flowrate	35 t/h	30 t	45 t/h
Batch Time	Continuous	35 mins	Continuous
Operating Temperature	1,500°C	1,500°C	1,200°C

[2] 5 – Brief Technical Specifications of Technological Units

3. Best Practicable Option and Emissions Target

A summary of the BPO opportunities and their associated fossil fuel emission savings is shown in Table 3.1 below. All opportunities will be re-evaluated closer to the implementation date to ensure that they are still technically feasible and financially viable. The entire list of opportunities that were evaluated for National Green Steel can be found in Appendix A – Opportunities Assessment.

Table 3.1 - BPO opportunities for National Green Steel

Year of implementation	Identified best practicable options (BPO)	Annual emissions savings (tCO_2-e/year)	Annual emissions (tCO_2-e/year)
0 (i.e. new build)	Projected year-1 (without energy efficiency)	-	22,900
0 (included in the new build)	Hot charging (direct rolling) would be implemented to minimise energy consumption of the LPG fired equalising furnace	19,000*	3,900
	Post BPO	-	**3,900**

*Refers to carbon emissions that would be avoided by implementing energy efficiency at the design phase.

Based on the BPO the following emissions target has been set:

Fossil Fuel Emissions Reduction Target at the Design Phase: 19,000 tCO_2-e/year.

The site aspires to continuously monitor the operation of the new plant for optimum operational and energy efficiency.

The target considers the opportunities that are both financially and practically viable and represents an 83% reduction in fossil fuel emissions under the planned operating conditions compared to a system that does not optimise energy efficiency. Should production change notably, the emissions target would need to be re-assessed based on the updated energy usage.

4. Transition Pathway

Figure 4.1 below shows the transition pathway for National Green Steel. The BPO (blue pathway) lists the opportunities which will be implemented during the consent period.

National Green Steel			Annual savings		
Category	Opportunity	Year	(t CO_2-e)	(%)	Remaining emissions
Baseline emissions		2026			100% (22,900 t CO_2-e/yr)
Energy efficiency	Implement hot charging (direct rolling) for the mill	2026	19,000	83%	17%
Total (blue highlighted pathway)			**19,000**	**83%**	**17% (3,900 t CO_2-e/yr)**

Figure 4.1 - Transition pathway for National Green Steel

National Green Steel is committed to improving energy and operational efficiency and has shown this in the design document where hot charging of the rolling mill is proposed for maximising energy efficiency. National Green Steel will continue to monitor and investigate the feasibility of further energy efficiency and fuel switching opportunities that were not included in the BPO throughout the consent period. Should an opportunity arise, National Green Steel will develop a business case and implement the viable opportunity in a timely manner.

5. Emission Impact Beyond Site

Currently, New Zealand exports large quantities of scrap metal overseas, only to import finished steel products back into the country. This practice results in unnecessary transport emissions and increases reliance on foreign steel supplies. By retaining and processing scrap metal domestically, the project enhances local steel production capacity, ensuring a more sustainable and self-sufficient supply chain.

The proposed new plant would process over 268,000 tonnes of scrap metal per year that would otherwise have been exported to Asia, significantly reducing sea freight-related carbon emissions. At an estimated 160 kg CO_2 per tonne of sea freight related emissions, avoiding the export of this scrap metal prevents 43,000 tonnes of CO_2 emissions per year. Additionally, with the final product exceeding 250,000 tonnes of steel per year, approximately 40,000 tonnes of emissions per year could be avoided by eliminating the need to import steel from countries like India.

The combination of reduced scrap metal exports and decreased steel imports results in a total emissions reduction of approximately 83,000 tonnes of CO_2 per year. Beyond emissions savings, this initiative supports New Zealand's decarbonisation goals and strengthens the country's circular economy by maximising resource efficiency. By keeping the entire process local, the project not only benefits the environment but also creates opportunities for job growth, industry resilience, and economic development in the steel sector.

6. Appendix A – Opportunities Assessment

6.1 Summary of the opportunities assessed

All the opportunities assessed are listed in Table 6.1 below, along with their feasibility assessment and date for review (if applicable). Detailed findings are available in the following sections.

Table 6.1 - Summary of the opportunities assessed

Option	Description	Practically feasible/financially feasible	Notes
Preheat the scrap metal using arc furnace flue gases	The electric arc furnace will be provided with continuous scrap metal preheating and charging system to preheat the material using the waste flue gas from the furnace.	Included for reference only	To be implemented during construction
Hot charging (direct rolling) to optimise energy consumption of the equalising furnace	Hot charging (direct rolling) would be implemented to minimise energy consumption of the LPG fired equalising furnace.	Included in the design	To be implemented during construction
Use landfill gas in the equalising furnace	Purified landfill gas could be used in the equalising furnace instead of LPG.	Not included as further investigation is required	Availability of landfill gas and practicality are to be confirmed
Install an electric resistive type/induction equalising furnace	An electric resistive heating equalising furnace was investigated to provide heating instead of LPG.	Not practically feasible	Product not available and temperature controllability issues
Installing electric infrared type equalising furnace	An electric infrared heating equalising furnace was investigated to provide heating instead of LPG.	Not practically feasible	Product not available and temperature controllability issues
Installed biomass fired equalising furnace	Potential of biomass fuel for use in the equalising furnace was investigated to provide heating instead of LPG	Not practically feasible	The heating temperature is higher than what biomass can achieve
Biomass gasification to use syngas in the equalising furnace	Potential of biomass fuel gasification and the use of syngas in the equalising furnace was investigated to provide heating instead of LPG.	Not practically feasible	Complex and potential operational challenges

6.2 Process Change Opportunity Descriptions

No process change opportunities exist for the proposed process.

6.3 Energy Efficiency Opportunity Descriptions

Detailed descriptions of energy efficiency opportunities assessed as part of the emissions plan development are presented below. Note that LPG savings and electricity savings have been shown separately for opportunities where there is a difference between the two.

6.3.1 Preheating of scrap metal using arc furnace flue gases

A preheating system in electric steelmaking utilises the sensible heat of waste gases from the EAF for the preheating of scrap. As well as significant energy savings, preheating also reduces the consumption of electrodes and refractory materials, increases furnace productivity, and reduces the overall production cost.

Endless scrap charging systems are the potential preheating technologies being considered for the site. These systems include a continuous conveyor system which transports the scrap through the preheating tunnel prior to passing through the EAF.

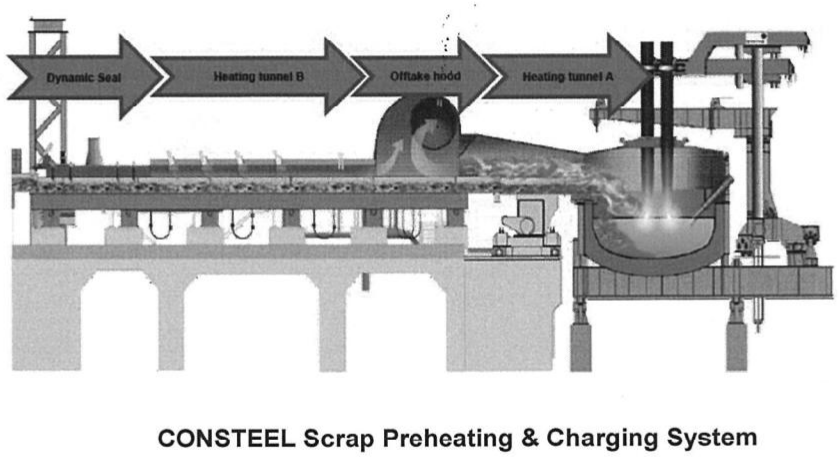

Figure 6.1 – Diagram of the proposed preheating system.

Analysis and assumptions

The analysis was based on the following:

- All scrap metal would be preheated by the outgoing flue gas to 350°C
- The common assumptions stated in Appendix B – Assumptions.

	Annual Savings (Year 1)		
Description	Electricity (MWh)	LPG (MWh)	Emissions (t CO_2)
Heat recovery for preheating scrap metal using furnace off gases	15,900	-	1,300

Project Outcome: Included for reference only

6.3.2 Hot charging (direct rolling) to optimise energy consumption of the equalising furnace

Hot charging (direct rolling) is very effective at making the process highly energy efficient by significantly reducing LPG consumption in the equalising furnace. In a traditional cold charging process, billets or blooms are cast, cooled to ambient temperature, and then reheated in a LPG fired reheating or equalising furnace before rolling. This reheating step consumes substantial amounts of LPG, leading to high energy costs and carbon emissions.

By implementing hot charging, billets from the continuous caster are directly transferred to the rolling mill at elevated temperatures (~950°C – 1,100°C), reducing or even eliminating the need for reheating. This typically results in a significant reduction in LPG consumption for the equalising furnace, as it only needs to fine-tune the temperature rather than fully reheat cold billets. Additionally, hot charging enhances overall process efficiency, reduces fuel costs, shortens production cycles, and lowers CO_2 emissions.

Analysis and assumptions

The financial cost/benefit analysis was based on the following:

- All the rolling process undergoes hot charging (or direct rolling) where hot billets will be sent to the equalising furnace at 1,000 °C
- Rolling occurs at a temperature of 1,200 °C
- The common assumptions stated in Appendix B – Assumptions.

	Annual Savings (Year 1)		
Description	Electricity (MWh)	LPG (MWh)	Emissions (t CO_2)
Implement hot charging (direct rolling) for the mill	-	89,000	19,000

Project Outcome: Included in the design as a BPO

6.4 Fuel Switching Opportunity Descriptions

Detailed description of fuel switching opportunities assessed as part of the emissions plan development are presented below. Note that LPG savings and total energy savings have been shown separately for opportunities where there is a difference between the two.

6.4.1 Use landfill gas in the equalising furnace

National Green Steel has identified a potential opportunity to utilize landfill gas (LFG) from EnviroNZ's Hampton Downs landfill. Should the gas be available, it could serve as a valuable alternative fuel source. While the landfill's total annual LFG generation is expected to be substantial, capable of producing a significant volume of gas, current publicly available information indicates that the LFG is being used for on-site electricity generation. This existing utilisation pattern shows uncertainty regarding the availability of LFG for sale to National Green Steel. Therefore, determining the feasibility of sourcing LFG from Hampton Downs requires direct and detailed discussions with EnviroNZ to assess their capacity and willingness to supply the gas. Methods of transportation of the LFG will also need consideration, and costing.

Landfill gas (LFG) heating is an alternative to LPG firing in the equalising furnace, offering the potential for reduced reliance on fossil fuels before rolling. LFG, primarily consisting of methane and carbon dioxide, can be captured and combusted to provide heat. When properly treated and utilised, LFG can lower reliance on traditional LPG and potentially reduce greenhouse gas emissions compared to direct venting of the gas.

Utilising LFG for billet equalising furnace presents some challenges. Primarily, extensive cleaning and purification are mandatory before it can replace LPG. Moreover, rigorous guarantees from the LFG supplier are essential, ensuring consistent flow and quality within the furnace's operational tolerances. Variations in these parameters would likely disrupt heating uniformity, potentially product quality issues. Furthermore, the substantial costs associated with LFG treatment, collection, and distribution infrastructure needs to be assessed prior to implementation.

Project Outcome: Not included as further investigation is required

6.4.2 Install an electric resistive type/induction equalising furnace

Replacing the LPG fired equalising furnace with electric resistive heating presents an opportunity to reduce LPG consumption and direct CO_2 emissions in steel processing. Electric resistive heating uses heating elements or induction technology to maintain billet temperature before rolling, offering a cleaner alternative. This approach can enhance energy efficiency and contribute to decarbonisation efforts by eliminating fossil fuel combustion in the reheating process.

However, electric resistive heating is not widely utilised in large-scale steel mills due to several practical challenges. The heat transfer efficiency in resistive heating is lower compared to LPG fired furnaces, making it less effective for large billet volumes.

National Green Steel aims to process large volumes of billet in their process. Therefore, electric resistive heating is not practical.

Project Outcome: Not practically feasible

6.4.3 Install an electric infrared type equalising furnace

Electric infrared (IR) heating is an alternative to LPG fired equalising furnaces, offering the potential for fossil-free billet heating before rolling. Infrared heaters emit high-intensity radiant heat, which directly warms the billet surface, reducing heat losses compared to convection-based gas furnaces. Infrared heating can significantly lower CO_2 emissions and contribute to decarbonisation efforts in steel processing.

Despite these benefits, infrared heating is not widely utilised for billet equalisation due to several practical challenges. First, IR heating primarily affects surface temperatures, leading to uneven heat distribution in large billets, which can result in thermal gradients and rolling defects. Second, maintaining consistent heating across large-scale, high-throughput operations requires a significant electrical load, increasing power infrastructure requirements and operating costs in regions with expensive electricity. Lastly, IR heating is most effective for thin materials, making it less suitable for thick billets or blooms, where induction heating or hot charging is more efficient.

National Green Steel requires consistency in their product to minimise waste and reworking. Therefore, an infrared furnace is not practical for the process.

Project Outcome: Not practically feasible

6.4.4 Install biomass fired equalising furnace

Although a low carbon fuel, biomass heating is not used for billet equalisation due to several practical challenges. Biomass combustion has slower heat response times compared to gas or electric heating, making it less suitable for high throughput rolling mills requiring precise high temperature control. Biomass fuels often produce ash and particulates, which can lead to fouling and maintenance issues in reheating systems.

Due to these factors, biomass heating adoption remains not practical.

Project Outcome: Not practically feasible

6.4.5 Biomass gasification to use syngas in the equalising furnace

Gasification of biomass, such as wood chips and wood residue, can serve as a low-carbon alternative to LPG in equalising furnaces for steel processing. By converting biomass into a synthetic gas (syngas) through a controlled process of high-temperature oxidation, it can generate heat for billet reheating before rolling. When biomass is sourced sustainably, this process can be considered carbon-neutral, as the CO_2 released during combustion is offset by the CO_2 absorbed by the plants during their growth. This approach can help reduce reliance on fossil fuels and contribute to lowering overall emissions, aligning with decarbonisation goals in the steel industry.

However, gasification of biomass presents several challenges that limit its widespread use in billet equalisation. The gasification process itself requires a steady and reliable fuel supply and maintaining consistent quality can be difficult. Moreover, the conversion process introduces impurities such as tar and particulates in the syngas, which can lead to fouling and operational issues within the furnace. Gasification systems also have slower response times compared to LPG, which is crucial for precise temperature control in high-throughput mills. The infrastructure needed to handle, store, and transport bulk biomass also adds complexity and increases operational costs.

While gasification of biomass offers a potential low-carbon alternative, its application in high-output steel mills remains limited due to these operational constraints.

Project Outcome: Not practically feasible.

As shown above, financial analysis has not been conducted for any of the opportunities, as the project is still in its early stages and no energy contract is in place. Additionally, all fuel-switching options for the LPG-fired equalising furnace have been ruled out due to practicality concerns.

7. Appendix B – Assumptions

Below are the assumptions made for the opportunity assessments in Appendix A.

Financial analysis has not been conducted for any of the opportunities, as the project is still in its early stages and no energy contract is in place. Additionally, most fuel-switching options for the LPG-fired equalising furnace have been ruled out due to practicality concerns. No financial analysis is required for the process heat system using electricity, as it is already a low-carbon alternative. Since the emissions plan specifically targets fossil fuel-consuming heat devices, no further comparisons are necessary.

Assumption	Value	Source
Electricity emissions factor	0.078 kg/kWh (2024)	MfE Guidance
LPG emissions factor	0.214 kg/kWh	MfE Guidance
LPG equalising furnace system efficiency	35% on average	Estimate based on literature
Electric furnace system efficiency	70% on average	Estimate based on literature

8. Appendix C – Site Maps

Figure 8.1 below shows a 3D view of the proposed steel plant site.

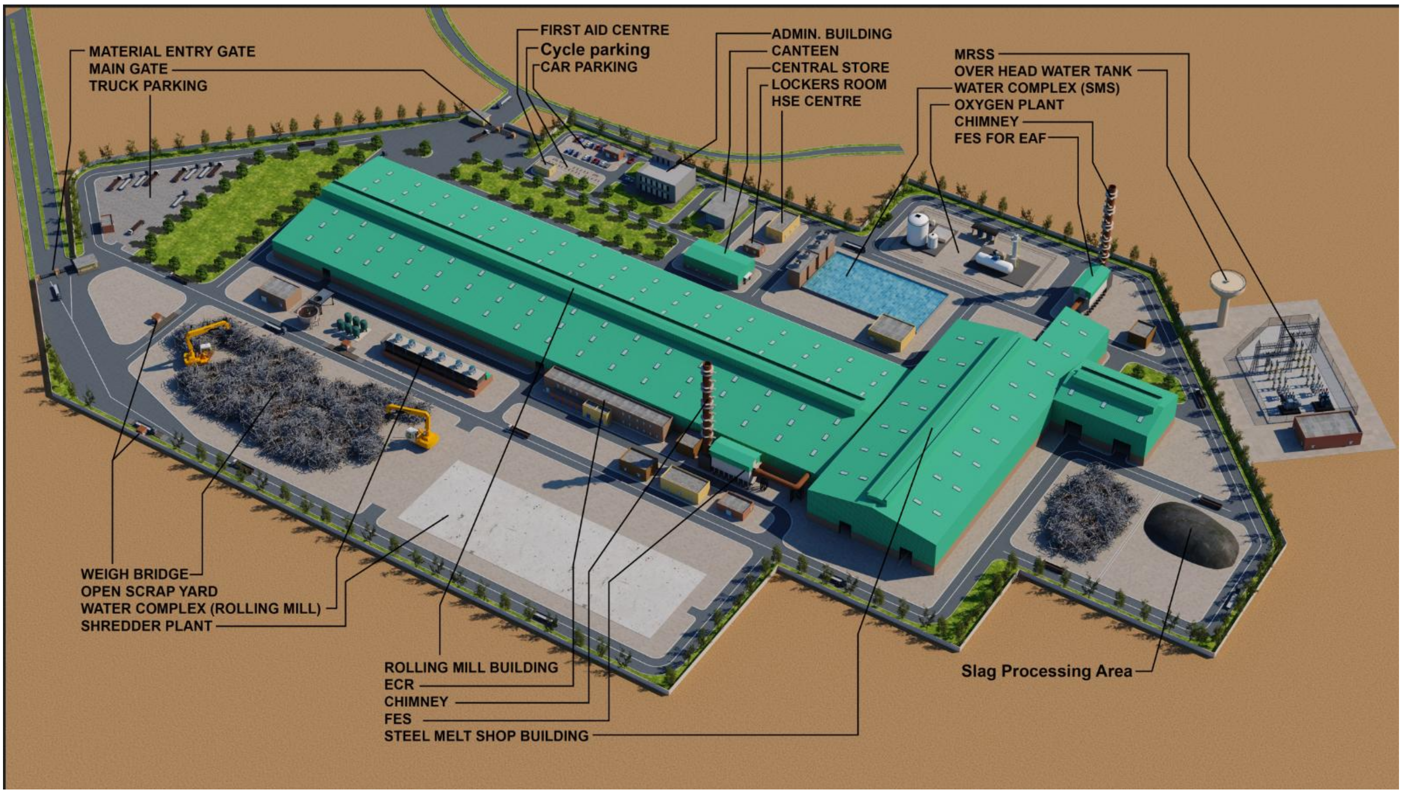

Figure 8.1 – 3D view of the proposed site.

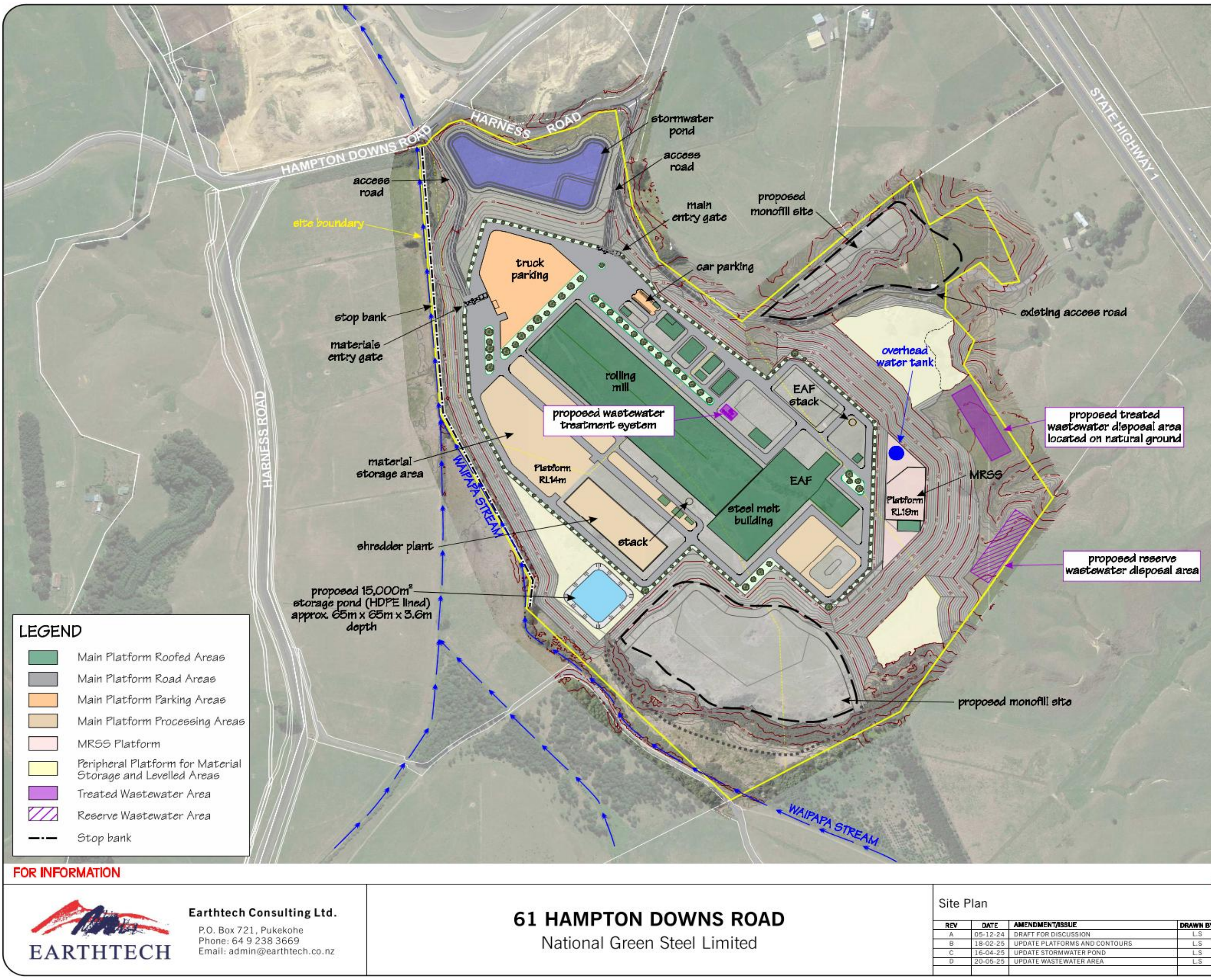

Figure 8.2 shows an extended view of the site and the surroundings.

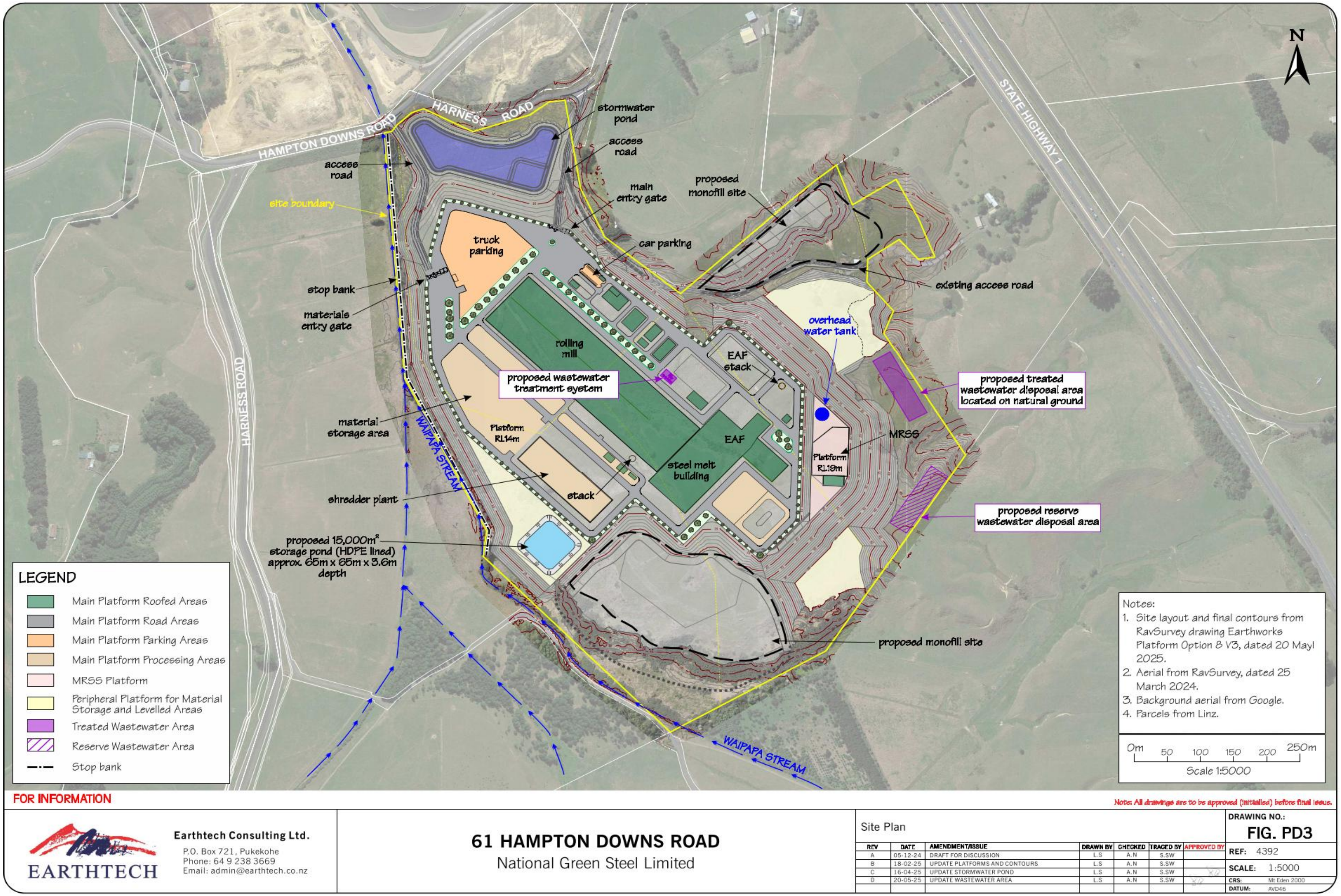

Figure 8.2 - Extended view of the site and surroundings

9. Appendix C – Internal SQP Review Letter

21 May 2025

To Whom It May Concern

The review of the Emissions Plan (*National Green Steel - Emissions Plan for Resource Consent - LUMEN report v3.0 210525*) prepared by Lumen was carried out in compliance with the requirements set out in the National Environmental Standards for Greenhouse Gas Emissions from Industrial Process Heat (NES-GHG IPH), as stipulated by Regulation 14 of the standard.

I, Ben Thomson, a suitably qualified person (SQP reviewer), was not part of the team who authored the report and have internally reviewed the emissions plan in accordance with the regulation and provided feedback on draft versions of the report prior to the final version. I am satisfied that the proposed Best Practicable Option (BPO) in the final plan complies with the NES-GHG IPH standard, specifically Regulations 15 and 16. The report indicates that the company has outlined plans to reduce GHG emissions through energy efficiency measures, contingent upon the business case conditions being met (i.e., financial viability and practical feasibility) before the implementation years.

Yours sincerely,

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