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STOPDIGGING!

Stopdigging! Limited

Groundscrews
Carbon Footprint (CFP)

Groundscrews Carbon Footprint (CFP)

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Record of Amendment

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1. General information

Registered trade name of manufacturer

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Client

Stopdigging New Zealand

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Standards and Product Category Rules (PCR)

EN 15804:2012+A2.2019/AC:2021

CEN Standard EN 15804 serves as the Core Product Category Rules (PCR)

CPC CODE: 412 Products of iron or steel

PCR 2019:14 Construction products, (EN 15804+A2) Version 1.3.2 Published on 2022.11.01 valid until 2024.12.20.

2. Executive Summary

This Carbon Footprint of a Product (CFP) assesses Stopdigging Groundscrews in accordance with the ISO 14067:2018 standard. Utilising a life cycle assessment (LCA) approach aligned with ISO 14067, the study quantifies greenhouse gas emissions across the product's life cycle. The primary goal is to provide transparent information for stakeholders, enabling informed decision-making, and supporting reduction initiatives.

The total assessed GWP per 1 kg of Groundscrews is 1.16 kg CO2 eq.

This figure includes all modules except the 'Use Stage' and assumes that 90% of Stopdigging Groundscrews will be recycled at their end of life.

The study, covering cradle-to-gate, modules A4-A5, module C, and module D, focused on 1 kg of 'Stopdigging Groundscrews' product. In other words, the study covered all stages shown in 'Table 1'. Emissions from the use stage (module B) are not included as this is better modelled at the building construction level. Global Warming Potential (GWP) calculations adhere to EN 15804:2012+A2.2019/AC:2021 requirements, and guidelines provided in CPC CODE: 412 Products of iron or steel.

Noteworthy contributors to the Global Warming Potential (GWP), include the steel billet production in the raw material supply module (A1) shown in table 1. Recommendations include exploring recycled materials and electric arc furnaces for steel billet production.

The report is designed for Stopdigging New Zealand Limited and their key suppliers. Future intentions involve integrating this information into a broader framework (ISO 14040 and ISO 14044) for a more comprehensive life cycle assessment, to obtain a EPD through EPD Australasia.

Table 1: GWP results for 1 kg of Groundscrew Products

GWP per kg of Groundscrew											
	Raw Material Supply	Transport	Manufacturing	Total (A1 – A3)	Transport	Installation	Deconstruction	Transport	Waste Processing	Disposal	Future reuse, recycling potential
Indicator (kg CO2 eq.)	**A1**	**A2**	**A3**	**tot. A1-A3**	**A4**	**A5**	**C1**	**C2**	**C3**	**C4**	**D**
GWP - fossil	2.45E+00	1.67E-01	3.74E-02	2.66E+00	2.96E-01	7.36E-03	4.81E-04	1.78E-01	7.99E-03	2.32E-02	2.00E+00
GWP - biogenic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
GWP - luluc	-	-	-	-	-	-	-	-	-	-	-
GWP - total	2.45E+00	1.67E-01	3.74E-02	2.66E+00	2.96E-01	7.36E-03	4.81E-04	1.78E-01	7.99E-03	2.32E-02	2.00E+00

3. Goal of the study

The primary objective of this CFP study is to assess the potential impact of Stopdigging products on global warming, measured in kilograms of CO2 equivalent and aligned with ISO 14067 standards. This involves quantifying all notable greenhouse gas emissions and removals throughout the products' life cycle or specific processes, adhering to specified cut-off criteria. The aim is to facilitate reduction efforts and empower customers with information to make informed decisions for minimising their greenhouse gas emissions.

The target audience of this study is Stopdigging New Zealand Limited, and the study may provide benefit to Stopdigging international, and suppliers including Tianjin Baolai Steel Pipe Co., Ltd, and QingDao Wang Baoqiang Industry Co. Ltd.

In the foreseeable future the intention is that Stopdigging New Zealand Limited will be able to incorporate this information into their LCA (ISO 14040 and ISO 14044) and declare an EPD, through EPD Australasia.

4. Purpose of this Assessment

Greenhouse gas (GHG) emissions are a key contributor to climate change. Continued global GHG emissions increase is projected to cause further extreme weather events and cause negative impacts on assets and communities. Reducing GHG emissions into the atmosphere is a prime directive that nations, companies, and individuals have begun to address. Accordingly, the New Zealand Government has set unconditional national targets for reducing the country's emissions[1]. These are:

- 2030 target to reduce emissions to 50 percent below 2005 levels.
- 2050 net zero emissions target of all greenhouse gases other than biogenic methane.

This carbon footprint of a product (CFP) has been completed in accordance with ISO 14067, and in a manner consistent with International Standards on life cycle assessments (LCA) (ISO 14040 and ISO 14044). It's important to note that ISO 14067 only addresses a single impact category; climate change, this document does not address any social or economy impacts, or any other environmental impacts arising from the Life cycle of a product.

The CFP is expected to achieve;

- Avoiding burden-shifting from one stage of a product life cycle to another or between product life cycles;
- Facilitating CFP performance tracking in reducing GHG emissions;
- Providing a better understanding of the CFP such that potential opportunities for increasing GHG removals and reducing GHG emissions might be identified;
- Helping to promote a sustainable low carbon economy;
- Enhancing the credibility, consistency and transparency of the quantification and reporting of the CFP;
- Facilitating the evaluation of alternative product design and sourcing options, production and manufacturing methods, raw material choices, transportation, recycling, and other end-of-life processes;

[1] https://www.mfe.govt.nz/climate-change/climate-change-and-government/emissions-reduction-targets/about-our-emissions

- Facilitating the development and implementation of GHG management strategies and plans across product life cycles, as well as the detection of additional efficiencies in the supply chain;
- Reliable CFP information.

5. Product Information

5.1 Product description

StopDigging Limited manufacture ground screw foundation systems. They are a modern and cost-effective ground anchor for both large and small construction projects. StopDigging's business ethos is not only to provide a high-quality product but to deliver and install it to the highest professional standard.

StopDigging produce six types of Groundscrews, which are available in a range of sizes to suit different application methods. Detailed descriptions can be found on their website at https://stopdigging.co.nz/screws-in-various-lengths/.

SGC ADAPTER SCREWS

Our universal screw SGC has a round plate with several slots for attachments and the size of the plate allows a large adjustment space in two joints. The large dimensions of the screw in combination with an extra thick zinc coating make it strong and durable, and thus suitable for heavier work.

USES INCLUDE:

SGP ADAPTER SCREWS

Our SGP adapter screw has a central hole in the head along with strong threads, making it suitable for many different purposes. The design allows for precise adjustment, so it's perfect for projects that need flexibility but have lower load requirements.

USES INCLUDE:

SGU BEAM SCREWS

Our beam screws are the right choice when you want to install a foundation of horizontal joists, such as a floor for a hut or the supporting beams for a wooden deck. The screws are available in five lengths, which makes it possible to accommodate differences in ground levels while maintaining stability, just by using the screws.

USES INCLUDE:

SGN PIPE SCREWS

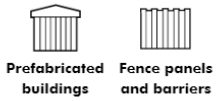
The pipe screw is exactly what it sounds like – a tube-shaped ground screw intended to hold an elongated or cylindrical object inside it. It's available in several dimensions for different needs. When the pipe screw is mounted, you only need to lower what is to be anchored and fix it with four bolts. It's quick and easy.

USES INCLUDE:

SG EX ADAPTER SCREWS

SGC EX are comprised of three parts. A base screw, an extension section , and a top section with mounting plate. With these extendable ground screws you can continue to build until you have reached the depth, or capacity, you need.

USES INCLUDE:



SGS POST SCREWS

Now you can stop using concrete foundation blocks for good. Our ground screws get the job done more quickly and easily but are just as stable as traditional posts. The screws are available in two different standard widths to suit your project.

USES INCLUDE:

5.2 Product variations

Screw types included in this study include all six products and all variations. These products include SDC adapter Screws, SGP adapter screws, SGU beam screws, SGN pipe screws, SG EX adapter screws, and SGS Post Screws. Since the results for the different screws differs less than 10% between any of the declared environmental performance indicators, all six product variations are included in this study.

6. Scope

6.1 Declared Unit

1 kg of StopDigging Groundscrew products.

6.2 The Function

The function of StopDigging products is to provide foundations for various construction methods. Lifespans of products typically assume 50 years for construction LCAs, and this has also been assumed for all Stopdigging Groundscrew products.

6.3 System Boundary

The boundary of the assessment follows the Product Category Rules (PCR) in which it falls into. The document PCR 2019:14 Construction Products EN 15804 + A2 (1.3.2) guided the boundary. There is no c-PCR available.

As per 2.2.2 of PCR 2019:14 Construction Products (EN 15804+A2) version 1.3.2) a type 'B' EPD has been selected. A type B EPD is determined by: Cradle to gate with options, modules C1–C4, module D and with optional modules (A1–A3 + C + D and additional modules). The additional modules may be one or more selected from A4–A5 and/or B1–B7. This has been chosen as the Groundscrews have been assessed from cradle to gate with modules A4-A5, modules C, and module D. Modules A4 – A5 has been included as a default construction scenario can be defined.

In other words, GHG emissions for all modules except the 'Use stage' (module C) have been included in this CFP study.

Figure 1 below shows the modules declared.

Figure 1: Modules Declared, Geographical Scope, Share of Specific Data, and Data Variation.

	Product stage			Construction Stage		Use stage						End of life stage				Recovery stage
	Raw Material Supply	Transport	Manufacturing	Transport	Construction/Installation	Use	Maintenance	Repair	Replacement	Operational energy use	Operational water use	Deconstruction / demolition	Transport	Waste Processing	Disposal	Future reuse - recycling or energy recovery potential
Module	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	D
Modules declared	X	X	X	X	X	ND	ND	ND	ND	ND	ND	X	X	X	X	X
Geography	GLO	GLO	GLO	NZ	NZ	NZ	NZ	NZ	NZ	NZ	NZ	NZ	NZ	NZ	NZ	NZ
Specific data	>90%			-	-	-	-	-	-	-	-	-	-	-	-	-
Variation - products	<10%			-	-	-	-	-	-	-	-	-	-	-	-	-
Variation - sites	Not relevant			-	-	-	-	-	-	-	-	-	-	-	-	-

X = included in the EPD

ND = Module not declared (such a declaration shall not be regarded as an indicator result of zero

6.4 Data Quality

Specific data for fabrication has been collected for financial year 22-23 from QingDao Wang Baoqiang Industry Co. Ltd. QingDao Wang Baoqiang Industry Co. Ltd manufacture various forms of Groundscrews for several companies, in which Stopdigging Groundscrews made up 3.45% of their workshop supply in 2023. Steel pipes, plates and helix are manufactured by Tianjin Baolai Steel Pipe Co, Wu'an Yuhua Steel Mill and Tianjin Fushunlong Steel Mill. Tianjin Baolai Steel Pipe Co are the major supplier and supply 98% of the steel. Due to budget constraints and communication challenges, no specific data from these steel mills was able to be obtained. As no specific data could be collected from Tianjin Baolai Steel Pipe Co., Ltd, or other suppliers, generic data regarding steel production has been gathered from Worldsteel. The 10-year age requirement for generic data has been meet.

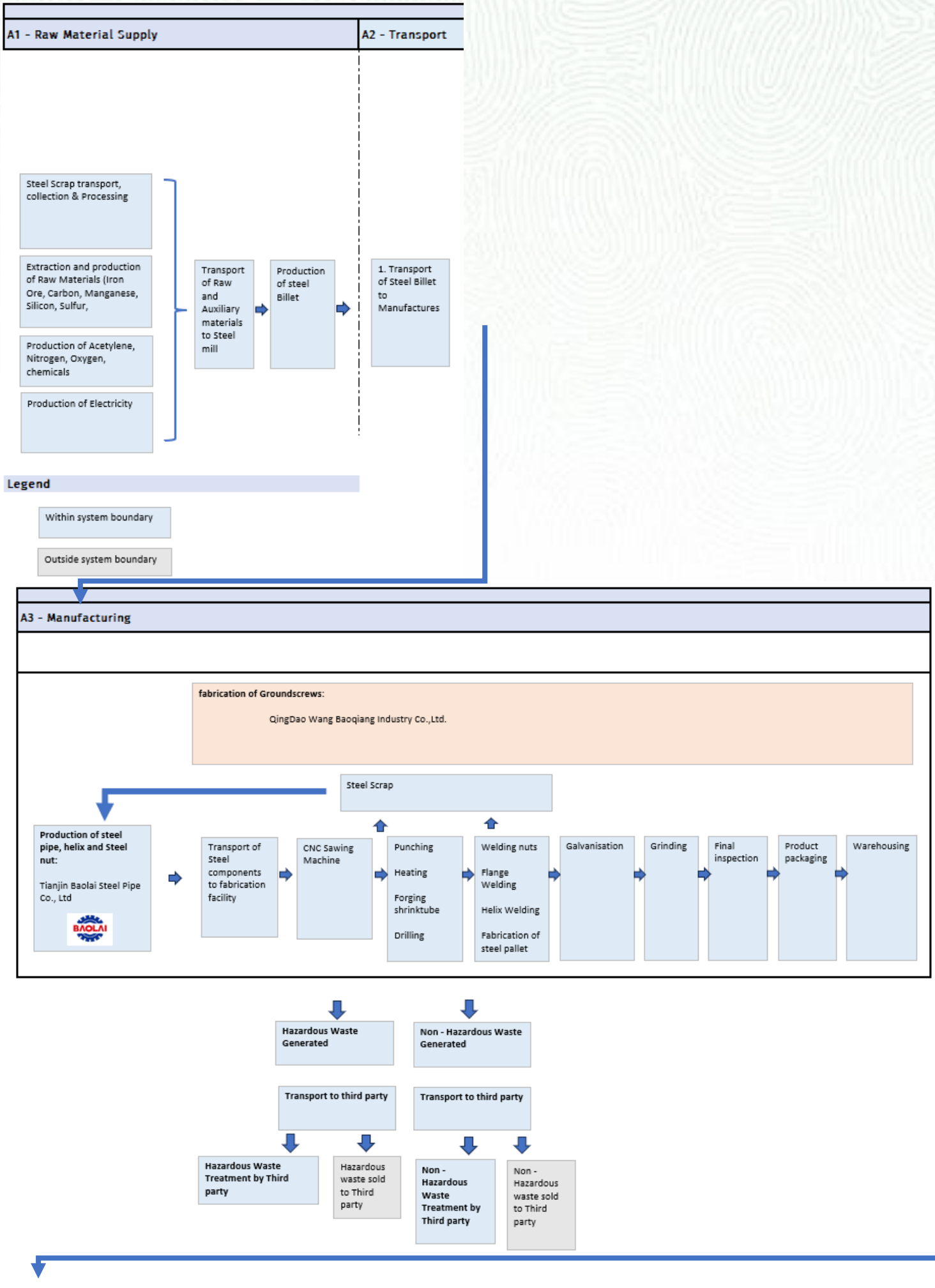
6.5 Geographical coverage

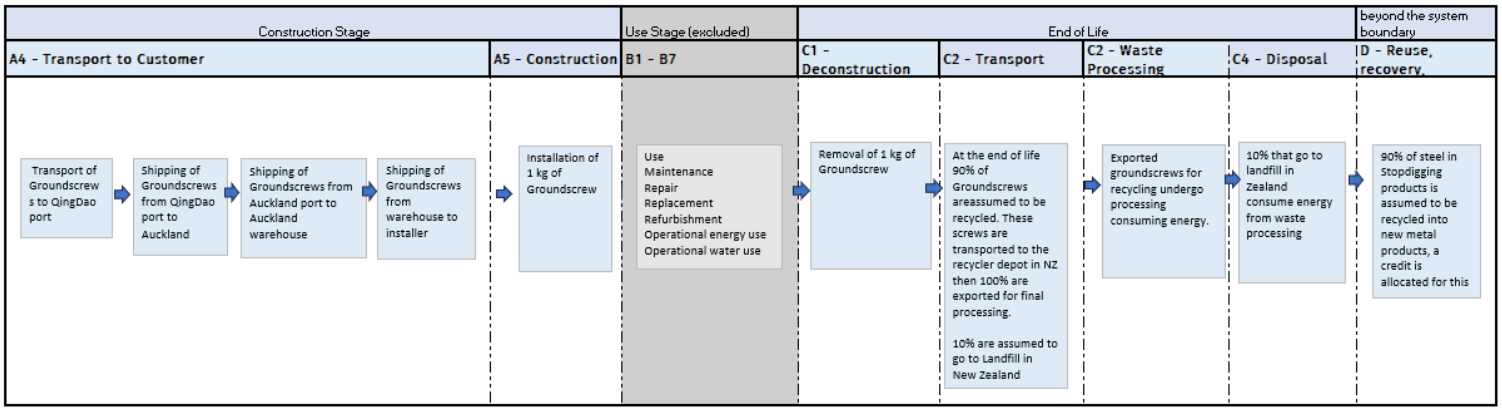
Manufactured in China, supplied to New Zealand.

6.6 Database

For production in China IPCC emission factors have been applied where possible. For steel billet manufacturing data from World Steel Association (2023) has been utilised. For emissions occurring in New Zealand, the most recent emission factors (2023) from Ministry for Environment have been applied. All calculations have been completed in Myimprint spreadsheets.

7. Process map





8. Key Assumptions and Limitations

(A1) Emissions factors applied for the production of the steel helix, pipe, and nut, has been based on generic data sourced from World Steel association (2023). This is because primary data was not able to be obtained as StopDigging Limited do not have operational control of Tianjin Baolai Steel Pipe Co., Ltd. Language and communication problems have limited the amount of data that was able to be collected. It's been assumed that 90.5% of steel has been produced via Blast Furnace (Blast oxygen furnace) and that 9.5% has been produced via Electric arc furnace in line with steel production in China, 2023.

(A2) Welding wire consumed has been based on detailed drawings provided by StopDigging Ltd. The exact type of welding wire is unknown therefore emissions calculations have been based on a similar product used called "Unibraze ER70S-3".

(A3) The exact Zinc galvanisation coverage is unknown, it's been assumed to be in line with similar products, with the assumption of 125 µm zinc cover.

(A3) The steel pallets used for Groundscrew distribution contribute 0.4% to the total weight per kilogram of Groundscrew and this steel input has been accounted for, along with steel scrap produced in the manufacturing process. Any welding material required associated with the steel pallets has been excluded, given its insignificance. Distributors reportedly reuse the steel packaging; however, the end of life is not clear. Due to uncertainty surrounding the recycling status of these steel pallets and their minimal environmental impact, emissions credits from recycling at the end of their life cycle have not been separately considered.

(A4) The distance of travel between Qingdao Port to Auckland Port has been assumed to be a constant of 12,232 km based on data sourced from http://ports.com/sea-route. This is deemed as the most accurate distance travelled, however, there may be variation in the routes taken.

(A5) It's been assumed that transport to the installer will be completed in a Post 2015, 2000cc-3000cc diesel Ute. The distance travelled from the distributors warehouse to each construction site has been estimated to be 43.35 km. This has been determined through estimation, considering the geographical area serviced by each partner, and subsequently adjusted based on the distribution of sales (table 2).

Table 2: Distance Travelled from Distributors to Construction Sites

Transport From Suppliers (Partners) to Construction Sites			
Origin	Assumed Distance	Sales Distribution of Groundscrews	Weighted Distance Travelled
Beatrice Tinsley Cres, Rosedale, Auckland	50	43%	21.5
Foreshore Road, Ahipara	30	2%	0.6
Jude Road, Mangawhai, Northland	70	8%	5.6
The Dr, Whangamatā	40	5%	2
Jocelyn Street, Te Puke	25	5%	1.25
Awatere Avenue, Beerescourt, Hamilton 3200	60	4%	2.4
Taringamotu Road, Taringamotu	20	2%	0.4
Milson Line, Milson, Palmerston North	50	2%	1
Barrett Road, Whalers Gate, New Plymouth	40	2%	0.8
Windsor Ave, Parkvale, Hastings	35	5%	1.75
Stanford Crescent, Whataupoko, Gisborne	30	5%	1.5
Parkes Line Road, Maymorn, Upper Hutt	25	5%	1.25
Mapua Drive, Māpua, Nelson	40	2%	0.8
Wilson Crescent, Karoro, Greymouth	30	2%	0.6
Wairakei Road, Bryndwr, Christchurch	60	2%	1.2
Rata St, Wānaka	35	2%	0.7
Green Island Bush Road, Blackhead, Dunedin	50	4%	2
Estimated Average Distance Travelled			45.35

(A5) It has been assumed that during the installation of the Groundscrews, the electric handheld screw installation machine (SGM06) is always used, and that the installation machine runs for 3 minutes per Groundscrew.

(C2) Its assumed that exported scrap metal travels 10,649 km in line with New Zealand Steel product recycling report 2021.

9. Cut–off

According to the Construction Products PCR, the life cycle inventory data shall, according to EN 15804, include a minimum of 95% of total inflows (mass and energy) per module. In case of insufficient input data for a unit process, the cut-off criteria shall be 1% of primary energy usage and 1% of the total mass input of that unit process. Proxy data or extrapolation should be used to achieve 100% completeness if only 95% of total inflow data is available. Inflows not included in the LCA shall be documented in the EPD (The International EPD System, 2021).

In this study, the following cut – offs have been applied.

(A1) Packaging and energy involved in the manufacture of welding wire. Welding wire makes up less than 5% of the total weight of the finished product. Excluding these items follows the PCR and ISO 14067 rules.

(A3) Cutting tool use, materials dissipated in the CNC machine, coolant, coolant waste, other wastes (flux), welding wire waste, Nitrogen gaseous, stream, wastewater to river, hydrogen chloride, and

waste to landfill from packaging manufacturing, have all been cut-off. Excluding these items follows the PCR and ISO 14067 rules as they make up less than 5% of total mass and energy in the A3 module.

(A5) During the installation stage, hydraulic load testing has been excluded. Excluding these items follows the PCR and ISO 14067 rules as they make up less than 5% of total mass and energy in the A5 module.

(C1) During the deconstruction stage, transport of labour to and from the construction site has been cut-off.

10. Allocation

10.1 Background allocation

Background emissions allocation has been addressed by avoiding allocation to background data. Instead, emissions have been calculated based on the weight of the product and well as materials lost in processing, aligning with EPD Australasia's emphasis on transparency and accuracy in environmental reporting.

10.2 Foreground allocation

Foreground data allocation is tailored to the unique characteristics of the Groundscrew fabrication facility. Grounds screws are manufactured at QingDao Wang Baoqiang Industry Co. Ltd. This Facility’s production is solely dedicated to producing a variety of Groundscrew products. A direct correlation between mass and emissions is evident. In accordance with EPD Australasia requirements, electricity and steel scrap have been allocated based on the annual consumption divided by the total annual steel output. This approach ensures a faithful representation of the environmental impact associated with the mass of the product.

For components like welding wire and welding gas consumption, where a direct relationship between emissions and mass or economic value is not apparent, volumes have been calculated based on detailed designs of the Groundscrews. This approach aligns with EPD Australasia's commitment to accuracy, recognising that not all aspects of production can be equally tied to mass or economic factors.

10.3 End of life allocation and recovery

In adherence to EPD Australasia guidelines, the allocation for end-of-life considerations and recovery has been calculated. This calculation is rooted in Life Cycle Assessment (LCA) scenarios deemed appropriate through thorough research into steel recycling practices specific to New Zealand. This comprehensive approach ensures that the environmental impact at the end of the product's life is accurately represented in the EPD.

11. LCA Scenarios

At the end of the product's life, the Groundscrews will be either be recycled or taken to landfill. According to research conducted by the NZ Steel Association (2021), it has been determined that 90% of the steel will undergo recycling, while the remaining 10% will be disposed of in a landfill.

It has been estimated that 90% of the Groundscrews will be transported via truck over 50km from the construction site to a recycling facility in New Zealand. The calculations have been based on the average emissions factor for road freight specified by MfE 2023. Subsequently, it is assumed that the Groundscrews will travel an additional 50km to the nearest port using the same mode of transportation.

As of 2023, all scrap metal is exported for recycling purposes. Therefore, it is assumed that the metal will be transported via cargo ship to steel mills worldwide, considering average distances outlined in the NZ Steel Association's study (2021). Upon arrival at the foreign port, it is expected that an additional 50km will be covered by truck transportation.

Please note that the distances and transportation methods mentioned above are approximate assumptions made for the purpose of this analysis and are deemed conservative.

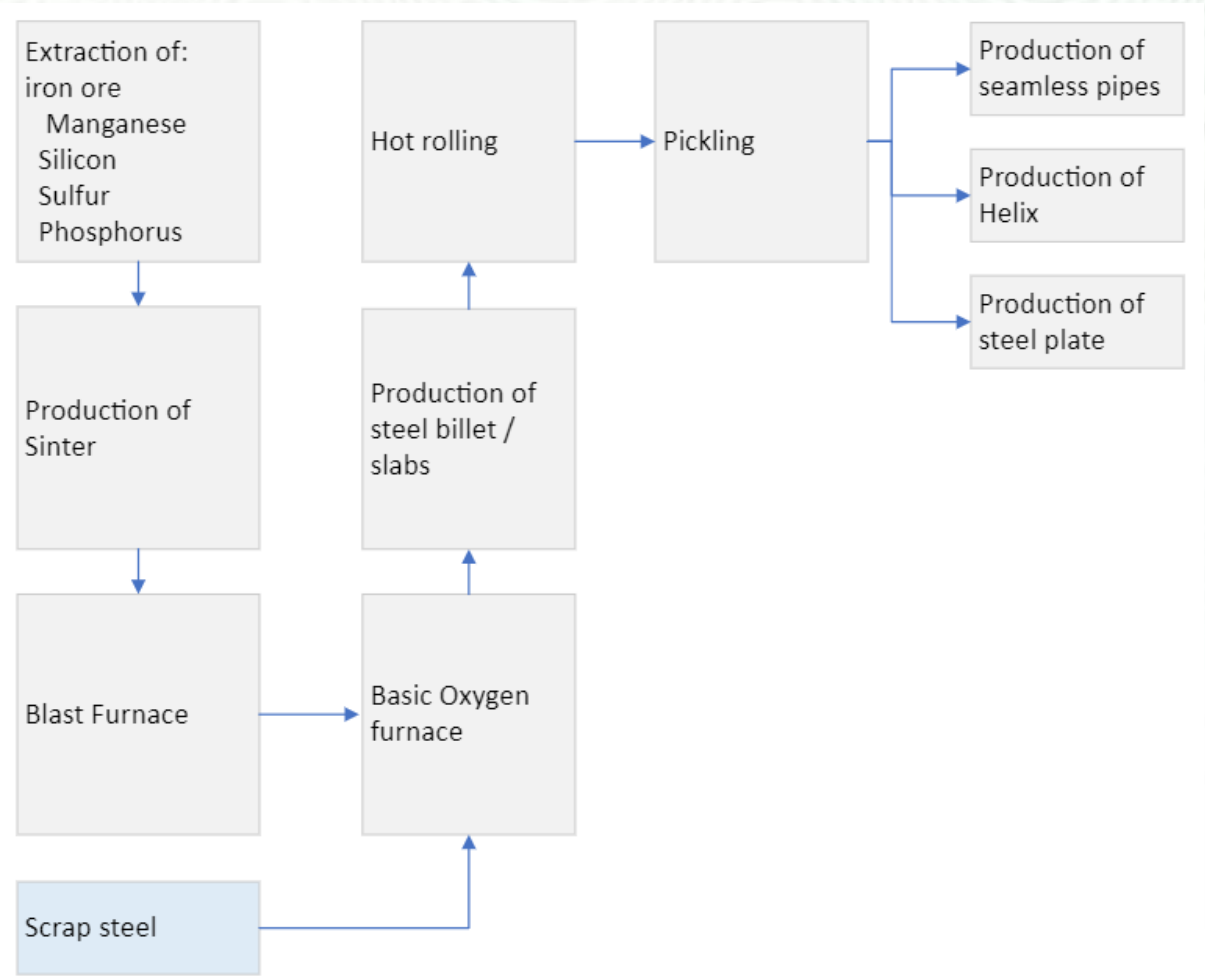
12. Land Use Change

In this report, land use change has been omitted as it was determined that there has been no significant alteration in land use. As a result, the impact of land use change is considered to be insignificant and immaterial for this assessment.

13. Production Process

13.1 Steel Production Process Via Furnace / Basic Oxygen Furnace

Figure 2: Steel Production Process Via Furnace / Basic Oxygen Furnace



The production of steel involves a series of well-defined steps, beginning with the extraction and processing of raw materials, such as iron ore and sinter, followed by ironmaking in blast furnaces. Once iron is obtained, it proceeds to steelmaking through the basic oxygen furnace (BOF) process to refine its composition (figure 3). The resultant molten steel is cast into semi-finished forms like slabs, billets, or blooms. These semi-finished materials then undergo hot-rolling or cold-rolling procedures to shape them into steel plates, sheets, or coils.

For steel pipe manufacturing, hot-rolled steel sheets or coils are employed to create steel pipes. This process often entails producing seamless tubes for various applications.

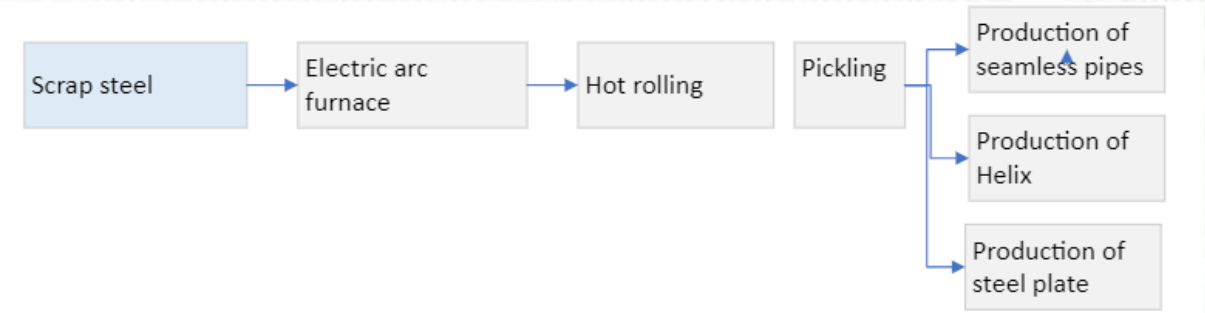
Creating steel plates involves gradually flattening and elongating the steel to reach the desired thickness, after which it is cut into specified lengths and widths.

To craft a helix on a large screw or threaded rod, the process is referred to as thread rolling. It commences with cutting the steel billet to the desired length, with one end machined to a point to facilitate threading. The billet is then placed in a thread rolling or cutting machine, where helical

threads are formed along its cylindrical surface. Following this, the threaded rod is cut to the required length, often undergoing additional finishing steps to meet precise quality standards.

13.2 Steel Production Process Via Electric Arc Furnace

Figure 3: Steel Production Process Via Electric Arc Furnace



The steel production process through the Electric Arc Furnace (EAF) route is generally simpler than the BOF method (figure 4). Usually, 100% scrap steel is feed into the EAF and the molten steel generated in EAFs is then cast into semi-finished shapes, such as slabs, billets, or blooms. These semi-finished products subsequently undergo hot-rolling or cold-rolling treatments to mould them into steel plates, sheets, or coils.

For the manufacturing of steel pipes, hot-rolled steel sheets or coils play a vital role in forming steel pipes, commonly producing seamless tubes tailored for various applications.

To manufacture steel plates, the steel undergoes the hot-rolling or cold-rolling process, enabling the material to be shaped and sized according to specific requirements.

When producing a helix on a large screw or threaded rod through EAF, a distinct method is employed. It begins by cutting the steel billet to the required length, with one end machined to a point to facilitate threading. The billet is then introduced into a thread rolling or cutting machine, where helical threads are generated along its cylindrical surface.

13.3 Stopdigging Groundscrew Fabrication

The Groundscrews are fabricated at QingDao Wang Baoqiang Industry Co. Ltd. The process of welding together the helix, pipe, and plate involve, preparation, welding, and quality control. The components are cleaned and aligned, with the fillet welding method to a thickness of 1.2 mm. After welding, rigorous inspections are carried out to ensure the welds and products meet quality standards EN 1090 and ISO 630 FE 360A. Subsequently, the assembly undergoes the galvanising process to the EN 1461 standard. Beginning with surface preparation through pickling or abrasive blasting, it is then immersed in molten zinc for hot-dip galvanising, forming a protective coating. After quenching and inspection for coating thickness a final inspection ensures the welding and galvanising process meet the required standards before being packaged onto steel pallets, stored in the warehouse onsite, then trucked to the port in Qingdao City.

The steel pallet used for packaging is also fabricated at QingDao Wang Baoqiang Industry Co. Ltd, these pallets are manufactured in a similar fashion to the Groundscrews.

14. Crude Steel Emission factors

Emission factors to determine the upstream emissions have been calculated from the emission factors published by the World Steel Association (2023), in their Sustainability Indicators Report 2023.

A suitable emission factor to reflect steel production in China has been determined by applying the national average emission factors for steel production in China. 90.5% of the steel produced in China is via the BOF method, and 9.5% of the steel is produced via the EAF method. Emission factors provided by World Steel Association (2023) have been weighted to determine an appropriate emission factor.

Figure 5. shows the global emission factors based on the route of production.

Figure 4: Emission factors from World Steel Association 2023.

2021-2022 CO_2 emissions and energy intensity

	CO_2 emissions intensity by production route		Energy intensity by production route	
	tonnes CO_2 per tonne of crude steel cast		GJ per tonne of crude steel cast	
	2021	2022	2021	2022
Global average	1.91	1.91	21.02	20.99
BF-BOF	2.33	2.33	24.13	23.98
Scrap-EAF	0.66	0.68	10.07	10.20
DRI-EAF*	1.39	1.37	22.58	22.37

* Data concerning global crude steel production using DRI is not currently collected, the denominator in this calculation is therefore calculated by the worldsteel data management team based on information contained in worldsteel's collective databases.

15. Attributable and Non-attributable Processes in Stopdigging Groundscrew

Table 3: Attributable and Non-Attributable Processes in Stopdigging Groundscrews

Attributable	Non-attributable
Mining of raw materials including Coke.	All capital investment including machinery in mining, transportation, steel manufacturing, fabrication, and installation
Production iron ore, sinter	
Energy used to transport materials raw materials	
Blast furnace for production of liquid iron	
Blast oxygen furnace and electric arc furnace	
Hot rolling for production of pipes, plates, and helix	
Transport of components to fabrication	
Welding of helix, pipe, and plate	
Galvanisation	
Transport from fabrication to New Zealand warehouse	
Transport from warehouse to distributors	
Transport to site	
Installation	
End of life emissions	

16. Results

16.1 Product Composition Per 1 kg Groundscrews

Product content	Percentage
Steel (virgin sources)	82.6%
Steel (recycled content)	8.7%
Filler material (FM1)	4.19%
Zinc (galvanisation)	4.5%

16.2 GWP Indicators

Impact indicator	Abbreviation	Unit	Characterisaion method
Environmental indicators, in accordance with EN 15804:2012+A2:2019			
Global Warming Potential – total	GWP-total	KG CO2 eq.	IPCC 2013
Global Warming Potential - Fossil fuels	GWP-fossil	KG CO2 eq.	IPCC 2013
Global Warming Potential – biogenic	GWP- biogenic	KG CO2 eq.	IPCC 2013
Global Warming Potential – land use and land use change	GWP- luluc	KG CO2 eq.	IPCC 2013

16.3 GWP results for 1kg Groundscrew products.

GWP per kg of Groundscrew											
	Raw Material Supply	Transport	Manufacturing	Total (A1 – A3)	Transport	Installation	Deconstruction	Transport	Waste Processing	Disposal	Future reuse, recycling potential
Indicator (kg CO2 eq.)	**A1**	**A2**	**A3**	**tot. A1-A3**	**A4**	**A5**	**C1**	**C2**	**C3**	**C4**	**D**
GWP - fossil	2.45E+00	1.67E-01	3.74E-02	2.66E+00	2.96E-01	7.36E-03	4.81E-04	1.78E-01	7.99E-03	2.32E-02	-2.00E+00
GWP - biogenic	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
GWP - luluc	-	-	-	-	-	-	-	-	-	-	-
GWP - total	2.45E+00	1.67E-01	3.74E-02	2.66E+00	2.96E-01	7.36E-03	4.81E-04	1.78E-01	7.99E-03	2.32E-02	-2.00E+00

17. Unit Process Results

17.1 A1 Processes and results

Steel Billet						
Life Cycle Stage	**Process**	**Inputs / Outputs**	**Process materials and energy**	**Cut-off**	**Unit**	**Quantity per kg Groundscrew**
Inputs						
A1	Preprocessing and manufacturing of Steel Billet	Includes all Background processes for the mix of steel billet produced from EAF and BOF. Coke Oven Sintering Blast furnace Basic Oxygen furnace Water	Already accounted for in Emission Factor under 'output' line Steel billet		kg	-
Outputs						
A1	Preprocessing and manufacturing of Steel Billet	Steel billet			kg	9.66E-01
A1		Scrap steel			kg	-
A1		Scale			kg	-
A1		Slag			kg	-

A1		Flue Gases			kg	-
A1		Particulate matter			kg	-
A1		Water			kg	-

Zinc						
Life Cycle Stage	**Process**	**Inputs / Outputs**	**Process materials and energy**	**Cut-off**	**Unit**	**Quantity per kg Groundscrew**
Inputs						
A1	Pre - processing and Manufacturing of Zinc	Includes all pre-processing	Already accounted for in Emission Factor		-	-
Outputs						
A1	Preprocessing and Manufacturing of Zinc	Zinc			kg	5.15E-02
A1		Sulphur dioxide			kg	-
A1		Slag			kg	-
A1		Particulate matter			kg	-
A1		Water			kg	-

Welding Wire						
Life Cycle Stage	**Process**	**Inputs / Outputs**	**Process materials and energy**	**Cut-off**	**Unit**	**Quantity per kg Groundscrew**
Inputs						
A1	Pre - processing and Manufacturing of ER 70S-3 Welding Wire	Carbon			kg	4.19E-05
A1		Silicon			kg	2.51E-04
A1		Nickel			kg	6.29E-05
A1		Molybdenum			kg	6.29E-05
A1		Copper			kg	2.10E-04
A1		Sulphur			kg	1.68E-05
A1		Chromium			kg	6.29E-05
A1		Iron			kg	4.05E-02
A1		Manganese			kg	4.82E-04
A1		Phosphorus			kg	1.26E-05
A1		Vanadium			kg	1.26E-05
A1		Others total			kg	2.10E-04
A1		Packaging	-	Cut off	kg	-
A1		-	Energy	Cut off	kWh	-
Outputs						
A1	Preprocessing and Manufacturing of ER 70S-3 Welding Wire	ER 70S-3 Welding Wire (filler material FM1)	Already accounted for in Emission Factor		kg	4.19E-02
A1		gases				-
A1		scrap wire				-

A1		chemical residues				-
A1		Water				-
A1		Used lubricants				-

17.2 A2 Processes and results

Transport						
Life Cycle Stage	**Process**	**Inputs / Outputs**	**Process materials and energy**	**Cut-off**	**Unit**	**Quantity per kg Groundscrew**
A2	Transport of steel billet from Steel mill to steel billet manufacture				tkm	4.19E-01
A2	All other transport included in each materials line				tkm	-
A2	Transmission and distribution losses		Electricity transportation		kWh	5.03E-02

17.3 A3 Processes and results

CNC Sawing Machine Blanking						
Life Cycle Stage	**Process**	**Inputs / Outputs**	**Process materials and energy**	**Cut-off**	**Unit**	**Quantity per kg Groundscrew**
Inputs						
A3	Steel plate fabrication	Steel Billet			kg	9.62E-01
A3			Electricity		kWh	5.03E-03
A3			cutting tool	Cut off		-
A3			Coolant (cutting fluid)	Cut off		-
Outputs						
A3	Steel plate fabrication	Cut steel billet			kg	-
A3		steel scrap			kg	1.15E-03
A3		Coolant waste		Cut off		
A3		Materials dissipated in CNC machine		Cut off		

Punching						
Life Cycle Stage	**Process**	**Inputs / Outputs**	**Process materials and energy**	**Cut-off**	**Unit**	**Quantity per kg Groundscrew**
Inputs						
A3	Steel plate fabrication	Unpunched Steel Billet			kg	-

A3			Electricity		kWh	5.03E-03
Outputs						
A3	Steel plate fabrication	Punched steel Billet			kg	-
A3		Steel scrap			kg	1.15E-03

Heating

Life Cycle Stage	Process	Inputs / Outputs	Process materials and energy	Cut-off	Unit	Quantity per kg Groundscrew
Inputs						
A3	Heating	Unheated Steel Billet				9.59E-01
A3			Electricity		kWh	5.03E-03
Outputs						
A3	Heating	Heated Steel Billet			kg	9.59E-01

Forging Shink tube

Life Cycle Stage	Process	Inputs / Outputs	Process materials and energy	Cut-off	Unit	Quantity per kg Groundscrew
Inputs						
A3	Forging shink tube	Unforged tube			kg	9.59E-01
A3			Electricity		kWh	5.03E-03
Outputs						
A3	Forging shink tube	Forged shink tube			kg	9.59E-01
A3		steel scrap			kg	1.15E-03

Drilling

Life Cycle Stage	Process	Inputs / Outputs	Process materials and energy	Cut-off	Unit	Quantity per kg Groundscrew
Inputs						
A3	Steel plate fabrication	Forged Shink tube			kg	9.58E-01
A3			Electricity		kWh	5.03E-03
Outputs						
A3	Steel plate fabrication	Drilled shink tube			kg	9.57E-01
A3		Steel scrap			kg	1.15E-03
A3		Waste		Cut off		

Welding

Life Cycle Stage	Process	Inputs / Outputs	Process materials and energy	Cut-off	Unit	Quantity per kg Groundscrew
Inputs						
A3	Welding	Helix, pipe & plate			kg	9.57E-01
A3		Filler material (welding wire)			kg	4.19E-02
A3			Shielding gas - 80% Ar + 20% CO2		Litres	6.45E+00
A3			Electricity		kWh	5.03E-03
A3			Flux	Cut off		-
Outputs						
A3	Welding	welded Groundscrew			kg	9.99E-01
A3		Welding wire waste		Cut off	kg	-
A3		Fumes		Cut off		-
A3		Slag		Cut off		-
A3		Slag (flux)		Cut off		-

Galvanising

Life Cycle Stage	Process	Inputs / Outputs	Process materials and energy	Cut-off	Unit	Quantity per kg Groundscrew
Inputs						
A3	Hot-dip galvanizing	Welded Groundscrew			kg	9.99E-01
A3		Zinc (125 µm zinc cover)			kg	5.15E-02
A3			Hydrochloric acid		kg	1.10E-02
A3			Natural gas		kg	2.03E-02
A3			Nitrogen, gaseous	Cut off	kg	-
A3			Sulfuric acid		kg	7.00E-03
A3			Water cooling fresh		kg	1.25E-01
A3			Basic oxygen furnace gas		MJ	1.02E-01
A3			Electricity		kWh	5.03E-03
A3			Steam	Cut off	MJ	-
A3			Compressed air	Cut off	Nm^3	-
Outputs						
A3	Hot-dip galvanizing	Galvanised Groundscrew			kg	1.00E+00
A3		Steel scrap			kg	1.15E-03
A3		Zinc scrap			kg	6.50E-03
Wastes for processing						
A3	Hot-dip galvanizing	Wastewater to processing plant			kg	1.34E-01

A3		Wastewater to river		Cut off	kg	6.50E-03
Emissions to air						
A3	Hot-dip galvanizing	Hydrogen chloride		Cut off	kg	6.17E-04
A3		Zinc		Cut off	kg	5.00E-05

Grinding

Life Cycle Stage	Process	Inputs / Outputs	Process materials and energy	Cut-off	Unit	Quantity per kg Groundscrew
Inputs						
A3	Grinding	Galvanised Groundscrew			kg	1.00E+00
A3			Electricity		kWh	5.03E-03
Outputs						
A3	Grinding	steel scrap			kg	1.15E-03
A3		Finished Groundscrew			kg	1.00E+00

Product Packaging

Life Cycle Stage	Process	Inputs / Outputs	Process materials and energy	Cut-off	Unit	Quantity per kg Groundscrew
Inputs						
A3	Packaging	Steel for pallet			kg	4.15E-03
A3			Electricity		kWh	5.03E-03
Outputs						
A3	Packaging	Finished pallet			kg	3.00E-03
A3		steel scrap			kg	1.15E-03
A3		Waste to landfill		Cut-off		-

Warehousing

Life Cycle Stage	Process	Inputs / Outputs	Process materials and energy	Cut-off	Unit	Quantity per kg Groundscrew
A3	Storage		Electricity		kWh	5.03E-03
A3			waste	Cut off		-

17.4 A4 Processes and results

Transport						
Life Cycle Stage	**Process**	**Inputs / Outputs**	**Process materials and energy**	**Cut-off**	**Unit**	**Quantity per kg Groundscrew**
A4	Transport of Groundscrews to QingDao port		Energy		tkm	1.14E-02
A4	Shipping of Groundscrews from QingDao port to Auckland		Energy		tkm	1.27E+01
A4	Shipping of Groundscrews from Auckland port to warehouse		Energy		tkm	2.08E-02
A4	Shipping of Groundscrews from warehouse to installer		Energy		kg	1.04E+00

17.5 A5 Processes and results

Construction						
Life Cycle Stage	**Process**	**Inputs / Outputs**	**Process materials and energy**	**Cut-off**	**Unit**	**Quantity per kg Groundscrew**
A5	Transport to construction site		Post 2015 Fleet, Diesel, 2000 - 3000 cc		tkm	4.54E-02
A5	Installation of one single pile (for load testing)		Handheld Ground screw installation machine SGM06		kWh	8.50E-02
A5	Hydraulic load testing			Cut off	kWh	-
A5	Installation of 1 Groundscrew		Handheld Ground screw installation machine SGM06		kWh	6.49E-03

17.6 C1 Processes and results

Deconstruction						
Life Cycle Stage	**Process**	**Inputs / Outputs**	**Process materials and energy**	**Cut-off**	**Unit**	**Quantity per kg Groundscrew**
C1	Unscrewing of 1kg of Groundscrews	Handheld Ground screw installation machine SGM06	Electricity		kWh	6.49E-03

17.7 C2 Processes and results

Transport						
Life Cycle Stage	**Process**	**Inputs / Outputs**	**Process materials and energy**	**Cut-off**	**Unit**	**Quantity per kg Groundscrew**
C2	Truck from construction site in NZ-to-NZ recycler		Energy		tkm	9.00E-01
C2	Truck from NZ recycler to NZ port		Energy		tkm	9.00E-01
C2	Sea freight		Energy		tkm	9.00E-01
C2	Transport to recycler		Energy		tkm	9.00E-01
C2	Transport to Landfill facility		Energy		tkm	1.00E-01

17.8 C3 Processes and results

Waste Processing						
Life Cycle Stage	**Process**	**Inputs / Outputs**	**Process materials and energy**	**Cut-off**	**Unit**	**Quantity per kg Groundscrew**
C3	Scrap Steel Recycling	Groundscrew	Energy		kg	9.00E-01

17.9 C4 Processes and results

Disposal						
Life Cycle Stage	**Process**	**Inputs / Outputs**	**Process materials and energy**	**Cut-off**	**Unit**	**Quantity per kg Groundscrew**
C4	Landfill emissions	Groundscrew	Energy		kg	1.00E-01

17.10 D Processes and results

Reuse, recovery, recycling potential						
Life Cycle Stage	**Process**	**Inputs / Outputs**	**Process materials and energy**	**Cut-off**	**Unit**	**Quantity per kg Groundscrew**
D	Recovery of steel	Groundscrew			kg	9.00E-01

18. Interpretation of results

These emission results show that steel billet production in module A1 are the highest contributor to GWP.

Transport of materials to the fabrication facility (A2), transport of the finished product to New Zealand (A4), and transport of the Groundscrew at its end of life (C2) are relatively significant.

The credit of the recycled steel billet in module D, is significant, and is far more beneficial than the emissions that occur due to transport and waste processing emissions involved to gain this credit.

19. Recommendations to Reduce Emissions

Investigating the source of steel billet will be beneficial as significant reductions can be made by using recycled steel that is produced in electric arc furnaces.

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21. List of Acronyms

EPD: Environmental Product Declaration

CFP: Carbon Footprint of a Product

LCA: Life Cycle Assessment

GWP: Global Warming Potential

ISO: International Organization for Standardization

CO2: Carbon Dioxide

PCR: Product Category Rules

c-PCR: Complementary Product Category Rules

Cut-off: The point in a product's life cycle where the system boundaries are defined or data is excluded

CPC CODE: Central Product Classification Code (used in product categorization)

GWPB: Global Warming Potential (Biogenic)

GWPF: Global Warming Potential (Fossil)

GWPLULUC: Global Warming Potential (Land Use and Land Use Change)