Greenhouse Gas emissions from manufacturing of mining equipment

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Abstract

Carbon Footprint has emerged as an industrial tool to assess the Greenhouse Gases (GHGs) emitted by companies. Australia is currently considering the target of turning carbon neutral and sizable pressure lies on Mining and Manufacturing sectors due to their higher emissions. Being an important and responsible part of the mining supply chain, Austin Engineering Ltd. is determined to contribute its share in the endeavour. This project assesses its current carbon footprint levels to inform future reduction targets based on the key emission sources identified through life-cycle mapping. The project adopts the methodology enlisted in GHG Protocol Standard to design a carbon footprint calculator for Austin's products manufactured at its Perth facilities, and forms in-house 'green rating' standards for its products. The resultant assessment report presents recommendations for improvement to lower Austin's GHG inventory based on scenario planning.

1. Introduction

One of the major contributors to Australia's GHG inventory is the mining sector which is a strong part of Western Australia's economy (Quaterly Update of Australia's National Greenhouse Gas Inventory: March 2019, 2019). The burden of the emission reduction is shared by its supply chain (Li-yuan Liu et al., 2020; Liua et al., 2020). For Austin Engineering, whose clientele is the mining companies, this means that it must lower its carbon footprint levels to stay abreast of the competition. This project is an important step by Austin Engineering in the direction of assessing its emissions and setting reduction targets.

Carbon footprint consists of the GHGs emitted during the various life cycle stages. Extensive literature is available on the Life Cycle Assessment of products and companies. The method of applying the demarcation to the flow of energy, materials and substances is highlighted in the life cycle inventory of machine tools with case studies (Zendoia et al., 2014). Considering the specific case of applying carbon footprint model to production lines (Liu et al., 2018), the fabrication process of Austin Engineering can be targeted in a better manner for the corresponding calculation. However, there is little published literature on the carbon footprint assessment for mining equipment manufactured in Australia, making Austin a leader in industry to conduct this study for their product range and location. Having said that, a close approximation for calculations can be made with the stoichiometry explained in 'GHG emissions analysis of manufacturing of hydraulic press slider within forging machine' (Zhang et al., 2015) because it utilizes the same raw material i.e., steel. It highlights the assessment methodology using Input-Process-Output (IPO) models for quantifying the various attributable processes in a product's life cycle. This methodology is followed by various similar applications (Liua et al., 2020; Penga et al., 2020). While drafting the green star ratings, research on green steel was carried out to find Emission Factors (EFs) of steel manufactured through various technologies (Conejo et al., 2020; Holappa, 2020).

Despite employing "green" measures such as lean manufacturing, reuse or recycling of waste material wherever possible, and separation of waste streams on site, Austin Engineering has never assessed its carbon footprint. Environmental assessment has now become an important tool for marketing, and the client aims to record its baseline footprint levels and devise green star ratings for its products through this project.

2. Process

The overall project steps have been mapped in Figure 1.

Figure 1 Project steps

Considering the wide range of Austin's products and the one-year timeframe of this project, the 830E Ultima truck body was considered for calculations because it was identified to be manufactured in large numbers due to its importance to Austin's mining clients. At the client's side, a truck body is loaded on trucks used to haul the mined material. As the life cycle of a product was to be assessed, guidance was taken from GHG protocol's 'Product Life Cycle' Standard and the 14000 series of ISO Standards. The product function is to be loaded on a truck that hauls the mined material (iron ore) from one point and unloads to another point. The unit of analysis was one unit of mining tray and the project boundary was Draper and Chisholm workshops.

After the various life cycle stages were defined, the attributable processes and corresponding emission sources were identified. For these processes, primary activity data was then collected from the relevant departments in the workshop using a questionnaire designed for the purpose of this project. The activity data primarily consisted of power consumption, gaseous consumption, activity time, and quantity of resources utilized. For future work, Austin is considering installation of solar panels (capacity 100kW) at Chisholm workshop.

This, along with the annual electricity consumption data, was used to evaluate scope 2 emissions. The data quality was assessed based on technological representativeness, geographical representativeness, reliability, temporal representativeness, and completeness, placing a higher emphasis on the first three (Environmental Protection Agency, 2016; WRI & ghgprotocol.org, 2011). The resultant database was tested against the Pedigree matrix for the parameter uncertainty analysis (Greenhouse Gas Protocol, 2011). The GHG inventory was then calculated using the 'activity data times emission factor' model (ISO, 2018) for direct emissions of carbon dioxide gas. These calculations were then converted in form of an Excel-based carbon footprint calculator.

Finally, four different environmental scenarios were mapped to project the emissions into the future and provide recommendations for reductions by dividing the emission sources into 2 categories. These include (a) within Austin's boundary and (b) outside Austin's direct control.

3. Results and Discussion

The overall GHG inventory of the product along with sequential individual process emissions are tabulated in Table 1. It is to be noted that the total emissions represented are the scope 1 emissions of a single tray.

Manufacturing Process	**Amount (kgCO2eq)**
Raw material	(+)64000
Plasma cutting	(+)1320
Steel Reuse/ Recycling	(-)9000
Welding	(+)1590
Pressing machine	(+)1322
Line boring	(+)6
Painting	(+)703
Transportation	(+)1450
Total emissions per tray	61391

Table 1 Inventory of cable tray manufacturing

During the cutting phase, the waste steel is either reused or recycled, resulting in negative emissions while accounting. Within transportation emissions, the internal transfer of fabricated parts between the Draper and Chisholm workshops and the final delivery to the client site are accounted. It is clear that the use of raw material emerges as the highest contributor in the overall emission picture (~90%), followed by welding (~3%), cutting (~2%), pressing (~2%), transportation (~2%), and painting (~1%). The impact of line boring is negligible (<1%). The data quality and uncertainty analysis revealed approximately 21% uncertainty in the inventory results. The scope 2 calculations reveal a potential annual savings of 10% in the emissions by implementation of the solar project.

Following the methodology of dividing the above results into internal and external components, two scales of star ratings are devised as per Table 2. One is for the internal processes under direct control of Austin, and another is for the steel which is external (manufacturing) to the facility. The extreme possible cases were projected during the scenario building exercise and the scale descriptors (Table 2) were decided accordingly.

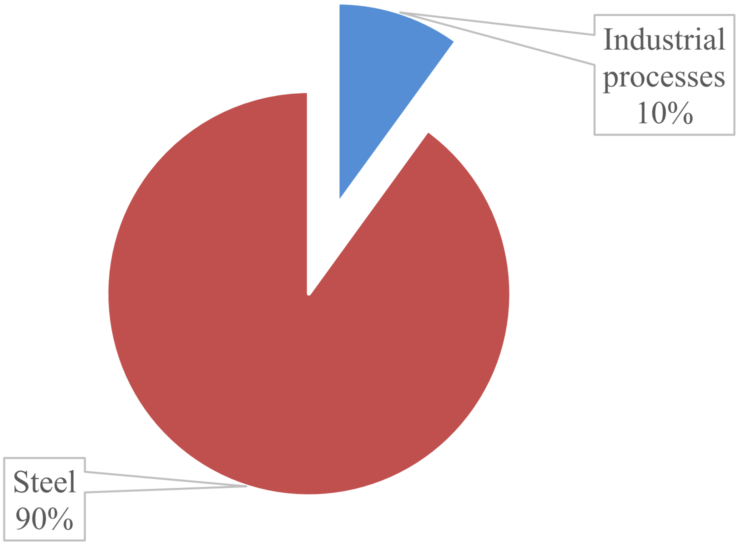

Figure 2 Proportionate contribution of emission sources to the overall inventory

4. Conclusions and Future Work

Currently, there exists a method to assess the carbon emissions for the manufacturing of machine tools but not mining equipment in Australia, which is what Austin Engineering aimed to address through this project as their primary clientele are mining companies. Through the carbon footprint calculator built in this project, it was understood that Austin's emissions can be reduced by making changes in the sourcing of steel because of its high impact on the overall GHG inventory. Based on the above findings and literature review on improvements in the technology, the overall recommendations to reduce the inventory include procurement of steel from 100% scrap based EAF steel manufacturer, sourcing electricity from solar supplier or installation of solar panels, end-of-life recycling of steel, and incorporation of recyclable material in product design.

The upcoming final stage in the project will include scope 3 emissions of the product. Furthermore, reduction targets based on the scenario planning will be determined through stakeholder consultation and secondary research. Each of the recommendations provided herewith demand a timeframe ranging from a few months to 2 years. Hence, Austin can carry out further research and technological improvements in the near future and monitor its GHG inventory every year against these baseline results.

Green Star Rating	Steel emissions (ton CO2eq/tray)	Emissions from industrial processes (ton CO2eq/tray)	Scenario Description
0	> 80	> 6	• Maximum possible (EF) of steel manufactured through Corex + Blast Oxygen Furnace technology considered
★	65 - 80	5 - 6	• Maximum possible EF of steel considered • Waste steel within factory reused or recycled • Process emissions as per current state
★★	50 - 65	4 - 5	• EF of currently used steel through Blast Furnace considered • Waste steel within factory reused or recycled • Solar panels installed
★★★	35 - 50	3 - 4	• EF of green steel manufactured through Electric Arc Furnace (EAF) with 80% scrap steel considered • Solar panels installed
★★★★	20 - 35	2- 3	• EF of green steel manufactured through Electric Arc Furnace (EAF) with 100% scrap steel considered • Waste steel within factory reused or recycled • Solar panels installed • Incorporation of recycled material in product design
★★★★★	< 20	< 2	• Minimum possible EF of steel considered • Waste steel within the factory reused or recycled • End-of-life product recycling practised • Electricity sourced from solar supplier • Steel supplier's 2045 CO2 reduction target achieved • Incorporation of recycled material in product design

Table 2 Proposed green star rating system for Austin's products with the current state represented in highlighted cells

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