Case Study on environmental performance of Partenopei International Ltd

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Place:	Sheffield

Sector Analysed:	Metal industry
Product Analysed:	Steel

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1 Introduction

The main goal of this analysis is to examine the supply chain of *Partenopei International Ltd (PIL)* and develop best practices of carbon management. PIL is involved in steel manufacturing and their supply chain network is complex and their raw materials such as lime, electrode, liquid oxygen, and alloy come from diverse sources. Moreover, the main raw material (steel scrap) are supplied by two different suppliers, one from Surrey and another from Edinburg. The complexity of supply chain network and the nature of steel manufacturing process put forth serious environmental concern with respect to emission of Carbon dioxide (CO_2). With growing awareness towards environmental sustainably, decreasing CO_2 emissions and move towards sustainable supply chain, PIL is aiming to develop better environmental policies by assessing their supply chain. But, due to several disadvantages of traditional life cycle assessment (LCA) tools, the company has deployed Supply Chain Environmental Analysis Tool (SCEnAT) which is developed by (Acquaye et al., 2011), an advanced computation tools with Big Data analytics (BDA) capabilities and intuitive visualisations.

In this report, the tool was used to perform several tasks such as 'supply chain mapping', SC Carbon calculations, low carbon interventions, performance evaluation and decision support. First, the supply chain map of PIL was created on the tool using the primary data collected by the company and the secondary data obtained from ECOINVENT. Then, the SC map is converted into carbon map, which demonstrates the hotspots of CO_2. Thus, some key hotspots were identified using the tool. Further, to optimise the energy usage and reduce the CO_2 emission two different SC scenarios were explored and its performance was evaluated. Consequently, an optimised environmental friendly SC was determined and suggested to PIL. The output provided by SCEnAT and the findings of different SC scenarios investigated are discussed further in this report.

2 Overview

2.1 Firm description

Partenopei International Ltd (PIL) is a manufacturing company based in the Yorkshire region and involved in the metal industry. *PIL's* Steel Ingot is primarily sold to the metal fabrication industry in the UK mainly for the wind energy market and the construction sector. The company is a large organisation having more than 500 employees. On the steel supply chain, PIL plays a central role as manufacturer and connects upstream and downstream actors of the network. On average, they produce 2 million tonnes of steel per year. The company obtains the main raw material (scrap metal) for the steel manufacturing process from two suppliers from Surrey and Edinburg. The company uses both road and rail transport to move raw material from suppliers and to distribute good to their customer in Doncaster.

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2.2 Product description

Main product of *PIL* is Steel Ingot. Steel Ingot is a semi solid material that used in a steelmaking process industry. *PIL uses* Electric Arc Furnace (EAF) process technology to produce steel ingot. Each year, *PIL* is able to produce 2 million tonnes of steel ingot. In order to produce Steel Ingot, *PIL* buys scrap iron from two main suppliers in Surrey and Edinburgh.

2.3 Supply chain of the product

Figure 1 provides a schematic representation of *Partenopei International Ltd (PIL)* steel ingot supply chain examined in the case study. PIL supply chain is illustrated as a network of six key categories, each one representing a different input or output class (scrap metal inputs, process inputs, energy inputs, waste outputs and the final product output). To simplify the process, the stages of furnace charging, melting and refining have been merged into *"Ingot steel manufacturing process"*. On the other hand, each arrow signifies the flow of the aforementioned input and outputs. Specifically, both product flows having *"Surrey Supplier"* as a starting point and *"Doncaster"* final customer as an ending point, relate to the same mode of transport thus the same dash type has been used. Similarly, scrap metal flow from Edinburgh supplier to PIL has a different dash as the transport of materials is made by train. With regard to the remaining input and outputs no particular information is given in the case study thus, no assumptions related to a specific mode of transport can be made.
Excluding the metal scrap suppliers and the final product customer where the point of origin and destination respectively are known (domestic) no additional information is given related the remaining inputs and outputs. Nonetheless, case study provided a list of Scope 3 emissions sources along with their respective input descriptions (domestic/imported). An overview of these missed inputs is given in Table 1.

Table 1 – Overview of Missing Inputs

Missing Inputs	**Input Description (Domestic/Imported)**
Staff Travel by Air, Rail and Road	All domestic
Casting of Metals	Domestic
Machine Tool	Imported
Other Special Purpose Machinery	Imported
Embodied Emissions of Factory	Domestic
Extraction of Crude Oil and Related Services in Electricity Production Supply Chain	Imported

Both product flows having "A" as a starting point relate to different inputs. In detail, the flow from "A" to "B" signifies the flow of seeds to the primary production stage (Cerutti et al., 2013; Kao et al., 2012; Barling et al., 2009) whereas "B" refers to the flow of fresh or already processed

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products to the processing stage (Grimm et al., 2016; Passuello et al., 2015; Grimm et al., 2014). With regard to the latter case, Passuello et al. (2015) involved the sourcing of both domestic and imported non-GM feed ingredients for a poultry meat processor. Thus, the sub-supplier stage does not make a distinction between domestic or imported products.

While the activities involved in primary production were clearly defined and limited to the growing of crops or animal husbandry, processing and distribution stages were found to be more complex. In particular, processors in agri-food supply chains did not engage only in transforming raw materials into food products but encompassed also the stages of storing, freezing, peeling, packaging as well as slaughtering in the case of animals (Glover et al., 2014; Lehtinen, 2012; Bruckmeier and Prutzer, 2007). This could be further supported from the fact that products such as fresh vegetables and fruits are forwarded directly towards consumption in their original form.

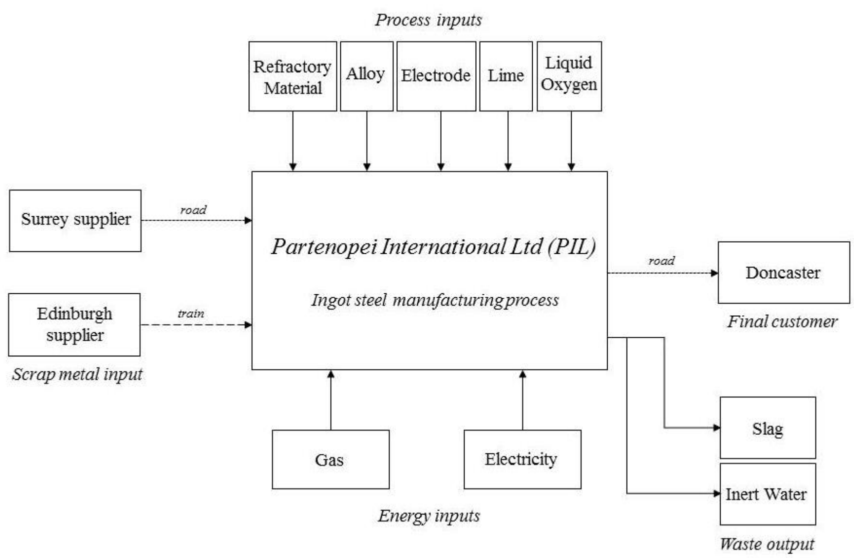

Figure 1 Steel supply chain -PIL

3 Main Analysis

3.1 Process approach

3.1.1 Resources and materials

Table 2 provides an overview of the resource and material cost analysis. Quantity is specified according to the production of 1kg of low-alloyed steel at plant using Electric Arc Furnace (EAF).

Although scrap metal inputs account for 38.08% of total cost, highest cost is associated with transportation, namely the sum of road and rail cost per tkm (50%). Specifically, there is not a major difference in cost between the two aforementioned transportation modes, as it is confined to 5%. In terms of energy utilities, electricity cost is approximately five times higher than gas consumption thus it is safe to assume that strategies towards the former's optimisation are deemed as significant. Furthermore, the manufacturing process generates two sources of waste linked with slag and water. Considering the substantial cost difference between slag and water, it is imperative to focus more either on the reduction or the redirection of slag to another manufacturing process.

Table 2 – Resource and Material Cost Analysis

Supply Chain Input	**Quantity**	**Unit**	**Avg Unit Cost**	**Unit (£/Unit)**	**Total Cost (£)**	**Cost %**
Electricity	0.42	kWh	0.08200	£/kWh	0.03444	6.43%
Gas	0.95	MJ	0.00700	£/MJ	0.00665	1.24%
Scrap Metal	1.2	kg	0.17000	£/kg	0.204	38.08%
Alloy	0.05	kg	0.16564	£/kg	0.008282	1.55%
Electrode	0.003	kg	0.80960	£/kg	0.0024288	0.45%
Lime	0.03	kg	0.09470	£/kg	0.002841	0.53%
Refractory Material	0.0135	kg	1.04420	£/kg	0.0140967	2.63%
Liquid Oxygen	0.05073	kg	0.11326	£/kg	0.00574568	1.07%
Transportation (Train)	0.25	tkm	0.55000	£/tkm	0.1375	25.66%
Transportation (Road)	0.22	tkm	0.50000	£/tkm	0.11	20.53%
Disposal of Slag	0.0928	kg	0.10000	£/kg	0.00928	1.73%
Wate Mgt: Inert Water	0.005	kg	0.10000	£/kg	0.0005	0.09%
				Total	**0.53576418**	100.00 %

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3.2 Scenat analysis

3.2.1 SC Carbon Map

Similar to cost assessment, carbon analysis is based on the same specification related to the production of 1 kg production of low-alloyed steel using EAF method. All units are based on kg apart from energy utilities and transportation. CO2 emissions data along with their respective units are provided in Table 2. According to Scenat analysis, electricity input represents the largest proportion, accounting for more than the half of total CO2 emissions. Scrap metal input follows with 12.15% whereas road transportation is responsible for the vast majority of the emissions linked with distribution (7.1%). With reference to remaining process inputs, lime and refractory material comprising approximately 15% of total emissions.

Table 2 – Total Emissions Analysis

Supply Chain Input	Quantity	Unit	GHG Intensity [kg CO2-eq/unit]	Unit	Total emissions [kg CO2-eq]	Emissions %
Electricity	0.42	kWh	0.53143	kWh	0.2232006	53.72%
Gas	0.95	MJ	0.0019927	MJ	0.001893065	0.46%
Scrap Metal	1.2	kg	0.042063	kg	0.0504756	12.15%
Alloy	0.05	kg	0.30174	kg	0.015087	3.63%
Electrode	0.003	kg	1.001	kg	0.003003	0.72%
Lime	0.03	kg	0.98382	kg	0.0295146	7.10%
Refractory Material	0.0135	kg	2.3187	kg	0.03130245	7.53%
Liquid Oxygen	0.05073	kg	0.40914	kg	0.020755672	5.00%

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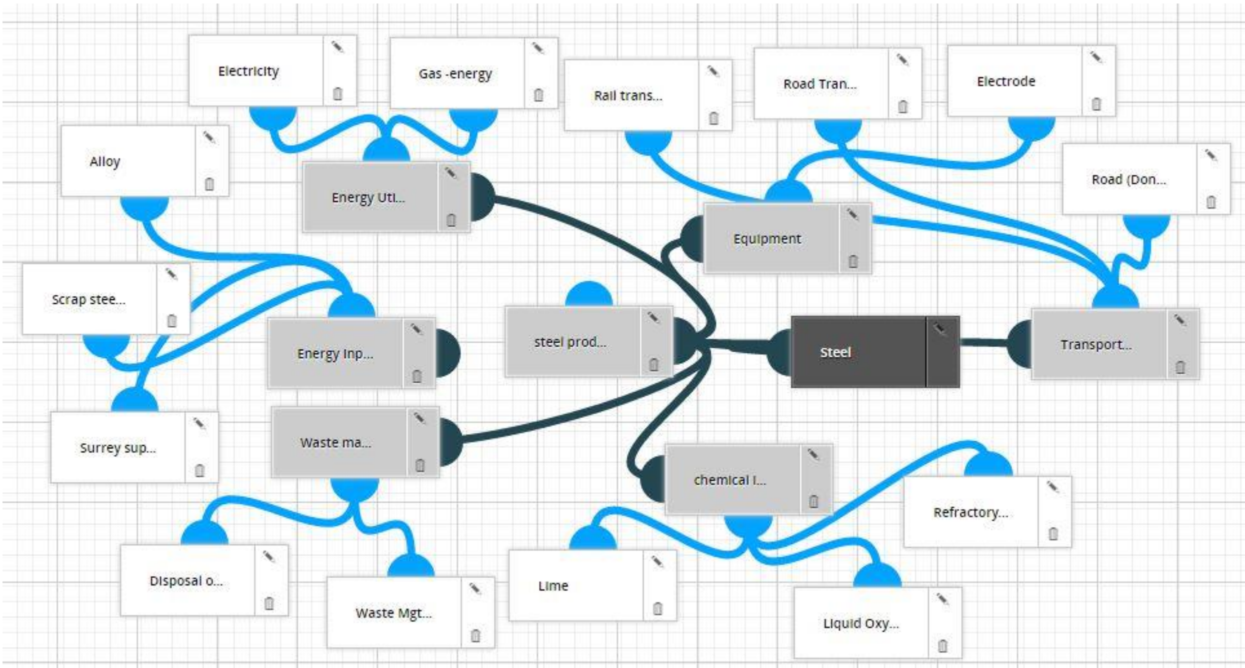

Figure 2 Supply chain map of PIL steel company

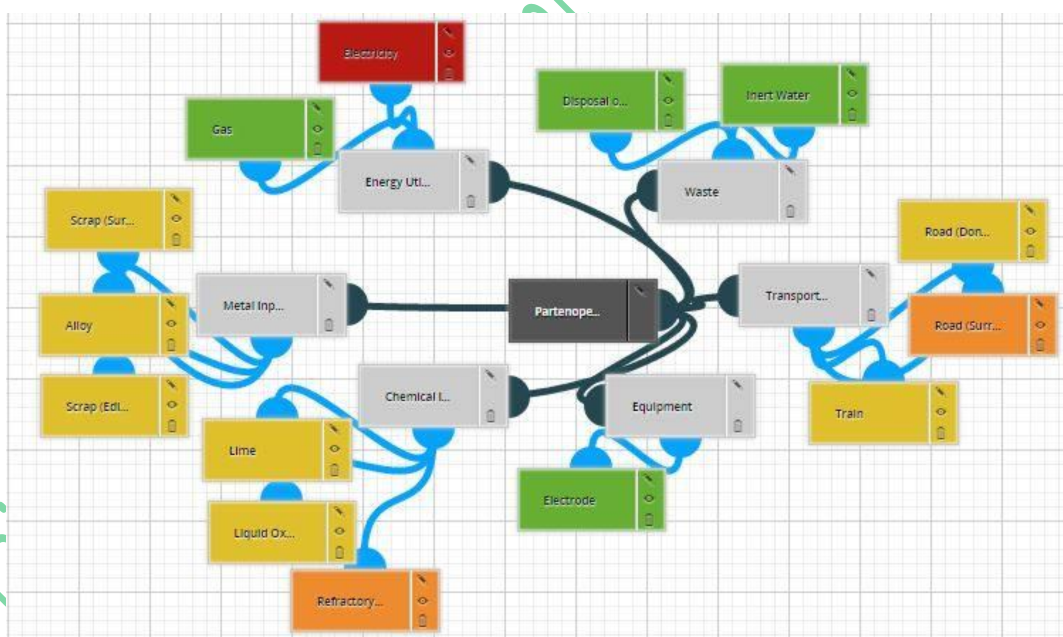

Figure 3 SC carbon map of PIL Ltd

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3.3 Results

Figure 4 shows our Co2 and cost performance of the supply chain in real scenario. From the figures 3 & 4 we can understand that electricity is the main hotspot in terms of excessive carbon emission. This lead us to modify energy utilisation in the supply chain, which is discussed in the following sections.

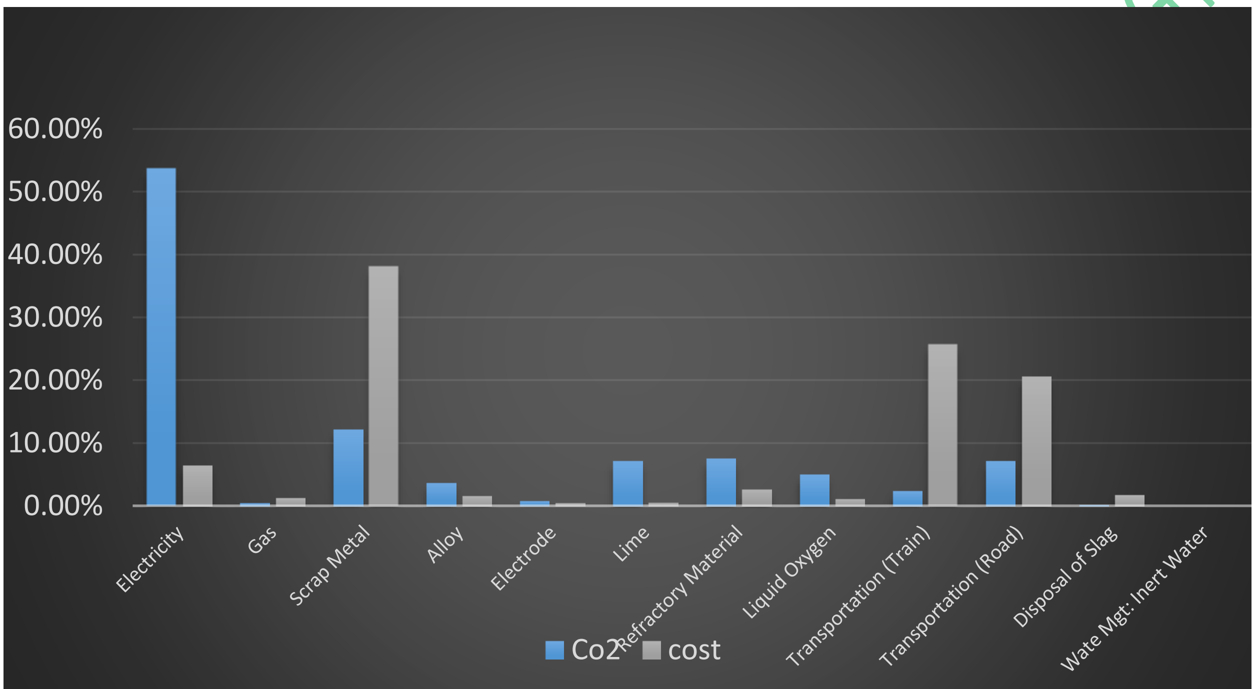

Figure 4 CO2 emission and cost percentage involved in original supply chain

4 Possible improvements

After investigation of carbon emissions of the original supply chain, we have identified that electricity usage is the main hotspot (shown in the figure 4), followed by scrap metal. Consequently, the supply chain was modified based on following two scenarios.

4.1 Scenario 2

In the scenario 2, we evaluated the carbon dioxide emission percentage by reducing the electricity consumption by 10%. However, the results shown in the figure below indicates that there is no significant difference between the original and the modified scenario.

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Table 3 – Resource and Material Cost Analysis of Scenario 1

Supply Chain Input	Quantity	Unit	Unit Cost	Unit (£/Unit)	Total Cost (£)	Cost %
Electricity	0.378	kWh	0.08200	£/kWh	0.030996	5.82%
Gas	0.95	MJ	0.00700	£/MJ	0.00665	1.25%
Scrap Metal	1.2	kg	0.17000	£/kg	0.204	38.32%
Alloy	0.05	kg	0.16564	£/kg	0.008282	1.56%
Electrode	0.003	kg	0.80960	£/kg	0.0024288	0.46%
Lime	0.03	kg	0.09470	£/kg	0.002841	0.53%
Refractory Material	0.0135	kg	1.04420	£/kg	0.0140967	2.65%
Liquid Oxygen	0.05073	kg	0.11326	£/kg	0.00574568	1.08%
Transportation (Train)	0.25	tkm	0.55000	£/tkm	0.1375	25.83%
Transportation (Road)	0.22	tkm	0.50000	£/tkm	0.11	20.66%
Disposal of Slag	0.0928	kg	0.10000	£/kg	0.00928	1.74%
Wate Mgt: Inert Water	0.005	kg	0.10000	£/kg	0.0005	0.09%
				Total	**0.53232018**	**100.00%**

Table 4 – Total Emissions Analysis of Scenario 1

Supply Chain Input	Quantity	Unit	GHG Intensity [kg CO2-eq/unit]	Unit	Total emissions [kg CO2-eq]	Emissions %
Electricity	0.378	kWh	0.53143	kWh	0.20088054	51.10%
Gas	0.95	MJ	0.0019927	MJ	0.001893065	0.48%
Scrap Metal	1.2	kg	0.042063	kg	0.0504756	12.84%
Alloy	0.05	kg	0.30174	kg	0.015087	3.84%
Electrode	0.003	kg	1.001	kg	0.003003	0.76%
Lime	0.03	kg	0.98382	kg	0.0295146	7.51%
Refractory Material	0.0135	kg	2.3187	kg	0.03130245	7.96%
Liquid Oxygen	0.05073	kg	0.40914	kg	0.020755672	5.28%
Transportation (Train)	0.25	tkm	0.039603	tkm	0.00990075	2.52%

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Transportation (Road)	0.22	tkm	0.13364	tkm	0.0294008	7.48%
Disposal of Slag	0.0928	kg	0.0095916	kg	0.0008901	0.23%
Wate Mgt: Inert Water	0.005	kg	0.0071333	kg	3.56665E-05	0.01%
				Total	**0.393139244**	**100%**

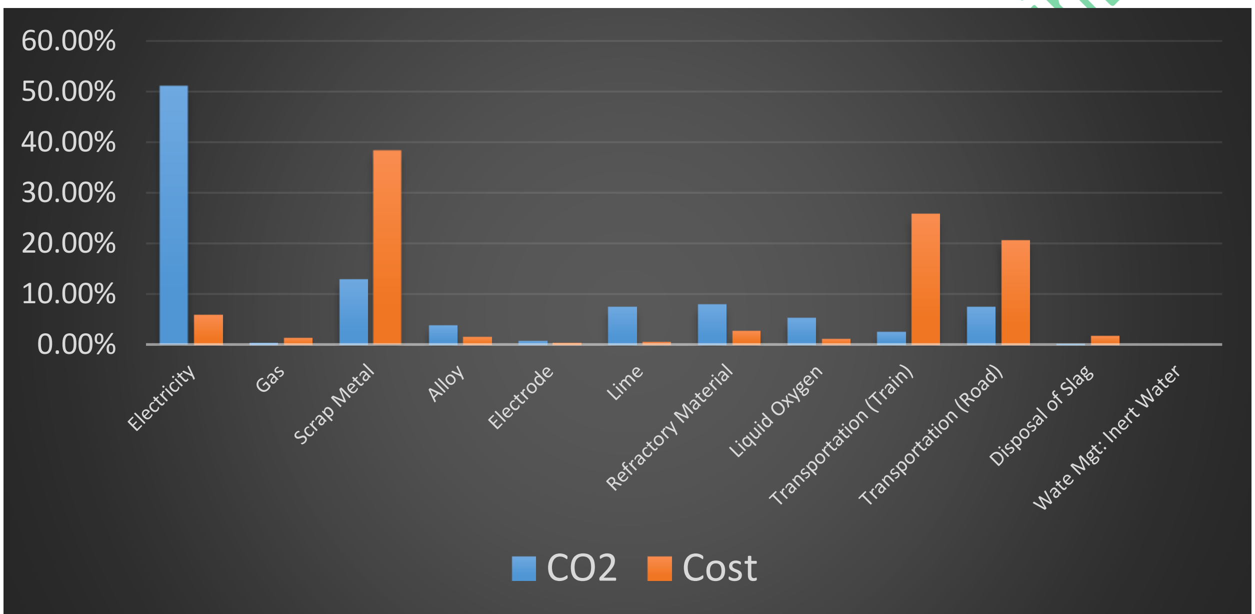

Figure 5 CO2 emission and cost percentage involved in scenario 2

4.2 Scenario 3

Since, the scenario 2 doesn't improve the environmental performance of the supply chain to significant level. We further tried to replace the source of electricity from grid to wind energy, which is a renewable source of energy. The change has got significant influence on the carbon emission, reducing it less than 10 percent.

Table 5 – Resource and Material Cost Analysis of Scenario 3

Supply Chain Input	Quantity	Unit	Unit Cost	Unit (£/Unit)	Total Cost (£)	Cost %
Wind	0.42	kWh	0.08200	£/kWh	0.03444	8.65%
Gas	0.95	MJ	0.00700	£/MJ	0.00665	1.67%

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Scrap Metal	1.2	kg	0.17000	£/kg	0.204	51.22%
Alloy	0.05	kg	0.16564	£/kg	0.008282	2.08%
Electrode	0.003	kg	0.80960	£/kg	0.002429	0.61%
Lime	0.03	kg	0.09470	£/kg	0.002841	0.71%
Refractory Material	0.0135	kg	1.04420	£/kg	0.014097	3.54%
Liquid Oxygen	0.05073	kg	0.11326	£/kg	0.005746	1.44%
Transportation (Train)	0	tkm	0.55000	£/tkm	0	0.00%
Transportation (Road)	0.22	tkm	0.50000	£/tkm	0.11	27.62%
Disposal of Slag	0.0928	kg	0.10000	£/kg	0.00928	2.33%
Wate Mgt: Inert Water	0.005	kg	0.10000	£/kg	0.0005	0.13%
				Total	**0.398264**	**100.00 %**

Table 6 – Total Emissions Analysis of Scenario 3

Supply Chain Input	**Quantity**	**Unit**	**GHG Intensity [kg CO2-eq/unit]**	**Unit**	**Total emissions [kg CO2-eq]**	**Emissions %**
Wind	0.42	kWh	0.011335	kWh	0.004761	2.54%
Gas	0.95	MJ	0.001993	MJ	0.001893	1.01%
Scrap Metal	1.2	kg	0.042063	kg	0.050476	26.98%
Alloy	0.05	kg	0.30174	kg	0.015087	8.06%
Electrode	0.003	kg	1.001	kg	0.003003	1.60%
Lime	0.03	kg	0.98382	kg	0.029515	15.77%
Refractory Material	0.0135	kg	2.3187	kg	0.031302	16.73%
Liquid Oxygen	0.05073	kg	0.40914	kg	0.020756	11.09%
Transportation (Train)	0	tkm	0.039603	tkm	0	0.00%
Transportation (Road)	0.22	tkm	0.13364	tkm	0.029401	15.71%
Disposal of Slag	0.0928	kg	0.009592	kg	0.00089	0.48%
Wate Mgt: Inert Water	0.005	kg	0.007133	kg	3.57E-05	0.02%
				Total	**0.187119**	**100%**

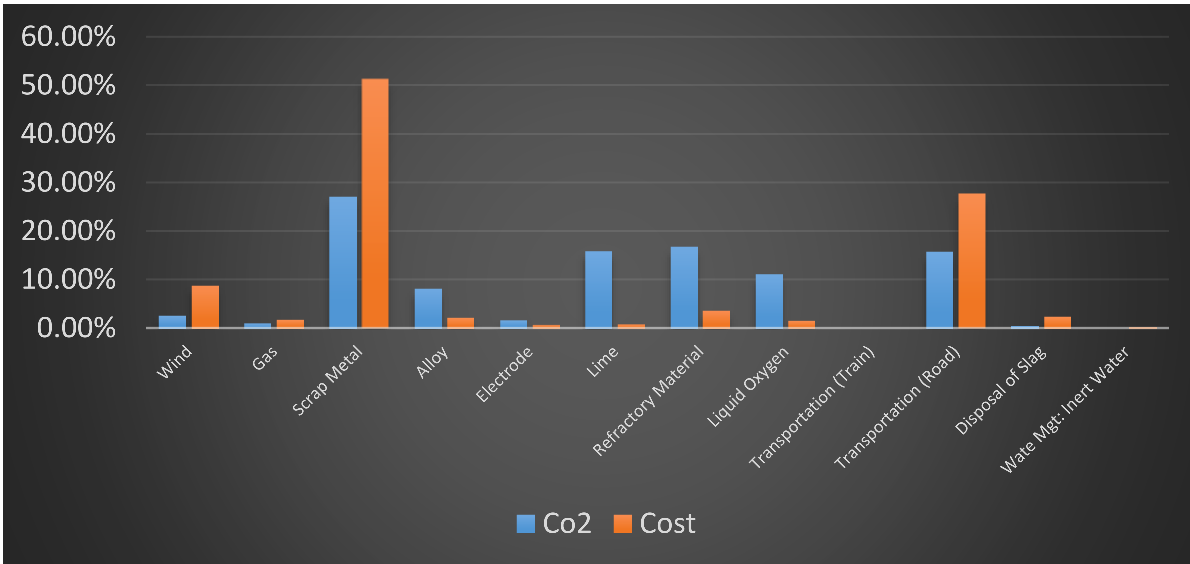

Figure 6 CO2 emission and cost percentage involved in scenario 3

5 Final conclusions

Based on our analysis, we conclude that PIL could greatly benefit by replace energy utility to renewable source, i.e. wind energy. Moreover, we have considered options for reducing the amount of slag disposal via the adoption of scrap sorting machine technology. The detailed description can be found in the 'Good Practice' document attached along with it.

Moreover, although we found SCEnAT tool interesting to use in terms of capabilities to include missing inputs in the life cycle assessment analysis, but interface of tool is not friendly as expected. Mainly, we found that there should be some improvements in terms of flexibility to add and remove missing inputs, which is not available.

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