Product Carbon Footprint Assessment Report

3rd August 2022

Table of Contents

Nomenclature

ABBREVIATION	EXPLANATION
CE	Conformité Européenne
PCF	Product Carbon Footprint
CO_2	Carbon Dioxide
CH_4	Methane
CO_2e	Carbon Dioxide Equivalent
CSR	Corporate Social Responsibility
CCC	Carbon Consulting Company
CDP	Carbon Disclosure Project
DECC	Department of Energy and Climate Change
ELCD	European reference Life Cycle Database
FDA	Food and Drug Administration
GHG	Greenhouse Gas
GWP	Global Warming Potential
HFC	Hydrofluorocarbon

ABBREVIATION	EXPLANATION
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organisation for Standardization
JIS	Japan Industrial Standards
LCA	Life Cycle Assessment
NBR	Nitrile Butadiene Rubber
NR	Natural Rubber
N_2O	Nitrous Oxide
PAS	Publicly Available Specification
PCR	Product Category Rule
PFC	Perfluorocarbon
RM	Raw Material
SF_6	Sulphur Hexafluoride
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute

Project Summary

Client	**Traffi Safe Limited**
Site Location	Free Trade Zone Road, Avissawella
Assessment Type	Product Carbon Footprint Assessment
Applied Standards	ISO/TS 14067 and PAS 2050
Consolidation Approach	'Cradle-to-Grave' (from raw material extraction to disposal of the final product)
Reporting Period	01st June 2021 – 30th June 2021 (period during which data for Cradle-to-Gate stages were collected) 1st April 2022 – 30th June 2022 (period during which data for Gate-to-Grave stages were collected) *Results will be valid for a period of 24 months following the study [24th December 2021] on the condition that **NO** changes are made to the product specifications, processes or the product supply chain following the study.*
Base Year	2021
Intended User	Management and Stakeholders of Traffi Safe Limited
Report ID	CCC/PCF/2022-08/001/V2 F
Assessor	Kaushalya Herath | temp4@carbonconsultco.com
Quality Assurance Assessor	Maheshi Wickramasinghe | temp7@carbonconsultco.com
Client Contact	Chaminda Pushpakumara | qa1@Traffigroup.com

Executive Summary

The Carbon Consulting Company (CCC) was commissioned to conduct a comparative study on the Carbon Footprint of a Product (CFP) for three selected types of a selected range of products (Examination Gloves) of Traffi Safe Ltd (hereafter referred to as 'Traffi), which are manufactured by Lalan Rubbers (Pvt) Ltd (hereafter referred to as 'Lalan') in order to assess the Greenhouse Gas (GHG) emissions arising from the 'Cradle-to- Gate' (from extraction of raw materials to the point final goods leave Lalan factory gate) life cycles of all three types and 'Gate-to-Grave' (from Lalan factory gate to disposal of final product) for the TD02 Product only. This CFP study was based on the PAS 2050 Standard and the ISO 14067:2018 Standard, and the following report was prepared in conformance to the requirements and guidelines of the ISO 14067:2018 Standard and highlights the processes used to quantify the emissions of the selected products.

Table 1: Total GHG Emissions per Piece of selected Gloves (Cradle-to-Gate)

GLOVE TYPE	GHG Emission (kgCO_2e/piece)
TD 02 (Neo 03 - Latex/Nitrile/Neoprene Blended)	**0.0193**
100% Latex Glove	**0.0178**
100% Nitrile Glove	**0.0431**

Table 2: Total GHG emissions per Piece of TD02 (Cradle-to-Grave)

ASSESSMENT BOUNDARY		CARBON FOOTPRINT (kgCO_2e/Piece)
Cradle-to-Gate		0.0193
Gate-to-Grave	Downstream Transport – Sea Freight	0.0045
	Downstream Transport – Air Freight	0.0309
Total Carbon Footprint per Piece*	Sea Freight	**0.0238**
	Air Freight	**0.0502**

***Note: Since the final product has both sea and air deliveries, the CFP values were calculated separately for both.**

About the Company

The Carbon Consulting Company

CCC is a firm dedicated to helping organisations develop and communicate effective sustainability practices. Our consultants are committed to helping companies reduce their environmental impact and maximise the resulting CSR and marketing opportunities. CCC provides professional services based on the fundamental principles of calculation, mitigation and communication and offers the following services:

- Corporate Carbon, Water and Waste Footprints
- Goods and Services Carbon and Water Footprints
- Facilitating the purchase of high quality, ethical carbon offsets
- Providing carbon reduction and implementation strategies
- Life Cycle Analysis (LCA) for products and services
- Sustainable business development consultancy
- Sustainability Product Labelling

About the Client

Traffi Safe

Traffi are hand protection specialists and the industry-leading provider of cut-resistant work gloves. They are the originators of the colour-coded safety glove system, an innovative and easy way to ensure that a workforce is wearing an appropriate level of protection for the task in hand. This system has been replicated all over the world, and the traffic light colour coding (RED, AMBER, GREEN) relates to the safety glove performance, measured against the EN388 test for cut resistance.

Traffi retained the services of CCC to conduct a PCF Assessment for 1 type of their examination gloves and a three-way comparative analysis between the assessed product and two other selected types of gloves. This effort of Traffi to assess the Carbon Footprint of its selected product and further compare against potential similar products (hypothetical scenario) is another important milestone in an environmentally sustainable business strategy, and a long-term commitment to reduce the environmental impact of the company. Through such initiatives, Traffi can become a more responsible corporate citizen, whilst ensuring it reaps the benefits of being a sustainable, ethical and eco-friendly corporation.

1. Introduction

1.1 What is a Product Carbon Footprint Assessment?

A Product Carbon Footprint Assessment quantifies the total GHGs produced over the total life cycle of a product. This kind of study can be carried out from “Cradle to Grave” – from the point of raw material extraction to disposal, or from “Cradle to Gate” – from the point of raw material extraction to the point of distribution/final goods leaving the factory gate, and is an important tool to understand and manage the impact of a specific product on Climate Change.

A PCF quantifies all seven Kyoto Protocol GHGs (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, sulphur hexafluoride, perfluorocarbons and nitrogen trifluoride) where applicable and is measured in units of Carbon Dioxide Equivalents (CO_2e). It is a distinct measure that describes how much global warming a given type and amount of Greenhouse Gas is resulted per a declared unit of a certain product, using the functionally equivalent amount or concentration of CO_2 as the reference.

Carbon Footprints of Products and corresponding Carbon Labels allow businesses to be transparent about their impact on Climate Change through the reporting of GHG emissions to customers, shareholders, employees and other stakeholders. Following this assessment, Traffi can take concrete steps to not only mitigate CO_2 emissions caused by the specific product but can completely offset the product footprint through an internal and/or external offsetting programme.

1.2 Assessment Methodology

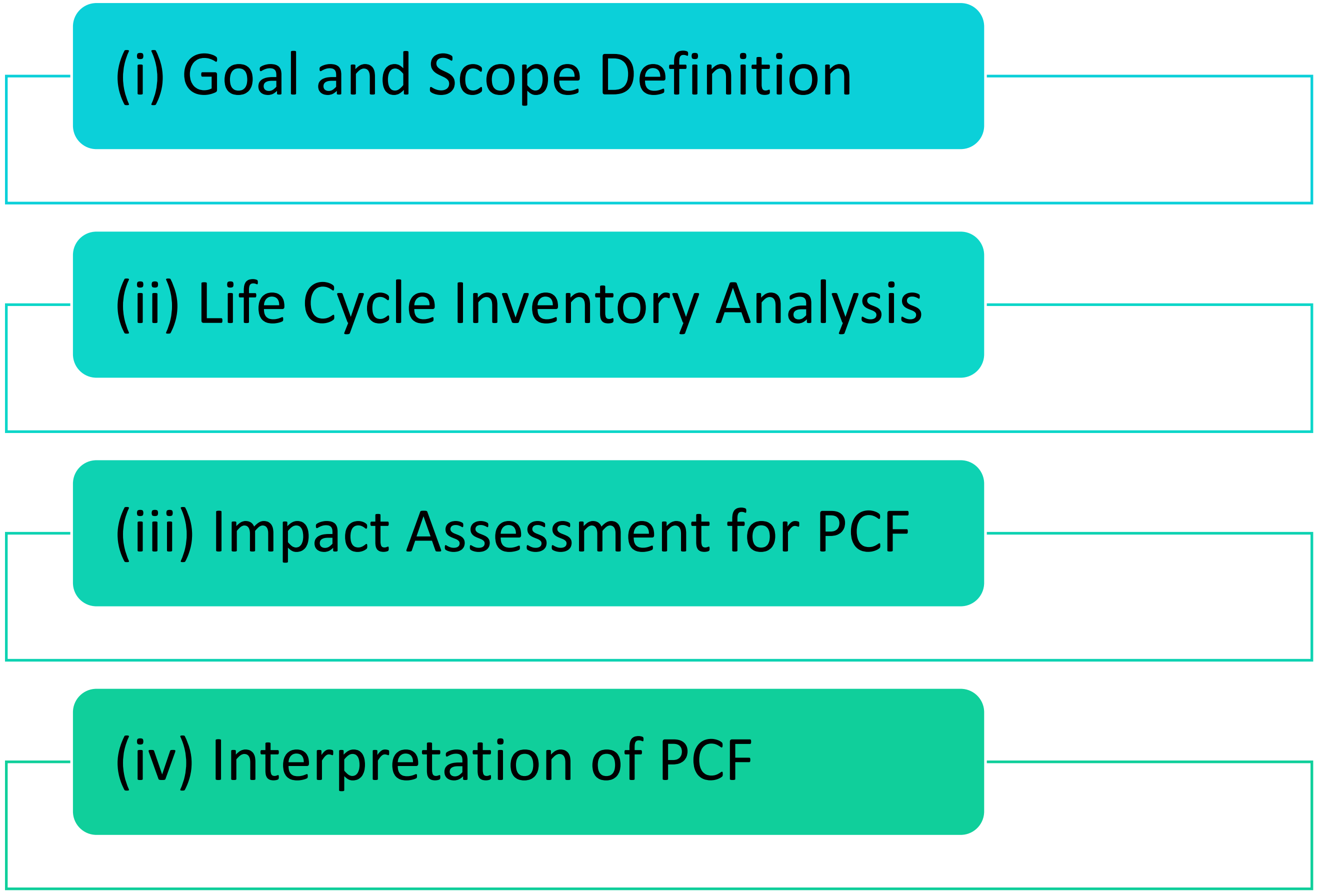


Figure 1: Stages of a Product Carbon Footprint Assessment

1.3 Standards and Methodologies

- ISO 14067:2018 Standard
- Publicly Available Specification (PAS 2060) Standard
- WRI/WBCSD Greenhouse Gas Protocol Product Standard
- “ecoinvent” Database
- SimaPro 9.0.0.49 Software

Figure 2: Applicable Standards, Protocols and Databases

Results of Assessment and Comparative Analysis of Three Selected Products

- TD02, 100% Latex &100% Nitrile

(Assessment Boundary: Cradle-to-Gate)

2. Assessment Scope and Boundary

2.1 Goal and Scope

The end goal of this study was to quantify the total carbon emissions of the product system and conduct a comparative analyis.

With technical guidance from CCC, the scope of this study was determined to include all applicable emissions sources from "Cradle to Gate" and focused on the single impact category of 'Climate Change'. For this study, client-supplied data were verified and analysed, and the GHG emissions were derived from the most current emission factors in line with the ecoinvent 3.6 Database.

2.2 Declared Unit

The PCF Study for the selected type of ‘Examination Glove’ and comparative analysis with two other similar products were carried out within the agreed boundary of “Cradle-to-Gate” (a partial PCF), and the Declared Units were kilograms of CO_2e per manufacture of a single glove of TD 02 (Neo 03), 100% Latex Glove Natural Rubber (NR) and 100% Nitrile Glove Nitrile Butadiene Rubber (NBR).

For the comparison of all three different products, data was normalised to the above-mentioned declared unit and was defined for a piece of glove weight as 6.45g.

A Product Category Rule (PCR) has not been developed for a rubber glove before. Therefore, the declared unit for this assessment was determined based on peer-reviewed LCA studies that have been conducted for rubber gloves.

2.3 Assessment Boundary

As per the ISO 14040:2006 Standard, for the purpose of this study, the boundaries for the selected products were set as "Cradle to Gate", which included raw material extraction and processing, upstream transport, glove manufacturing and waste treatment. The emissions arising at the transport of the end-product to the first customer, the use phase and the end-of-life treatment have not been included in this assessment and will be considered in the future as a part of an extended study.

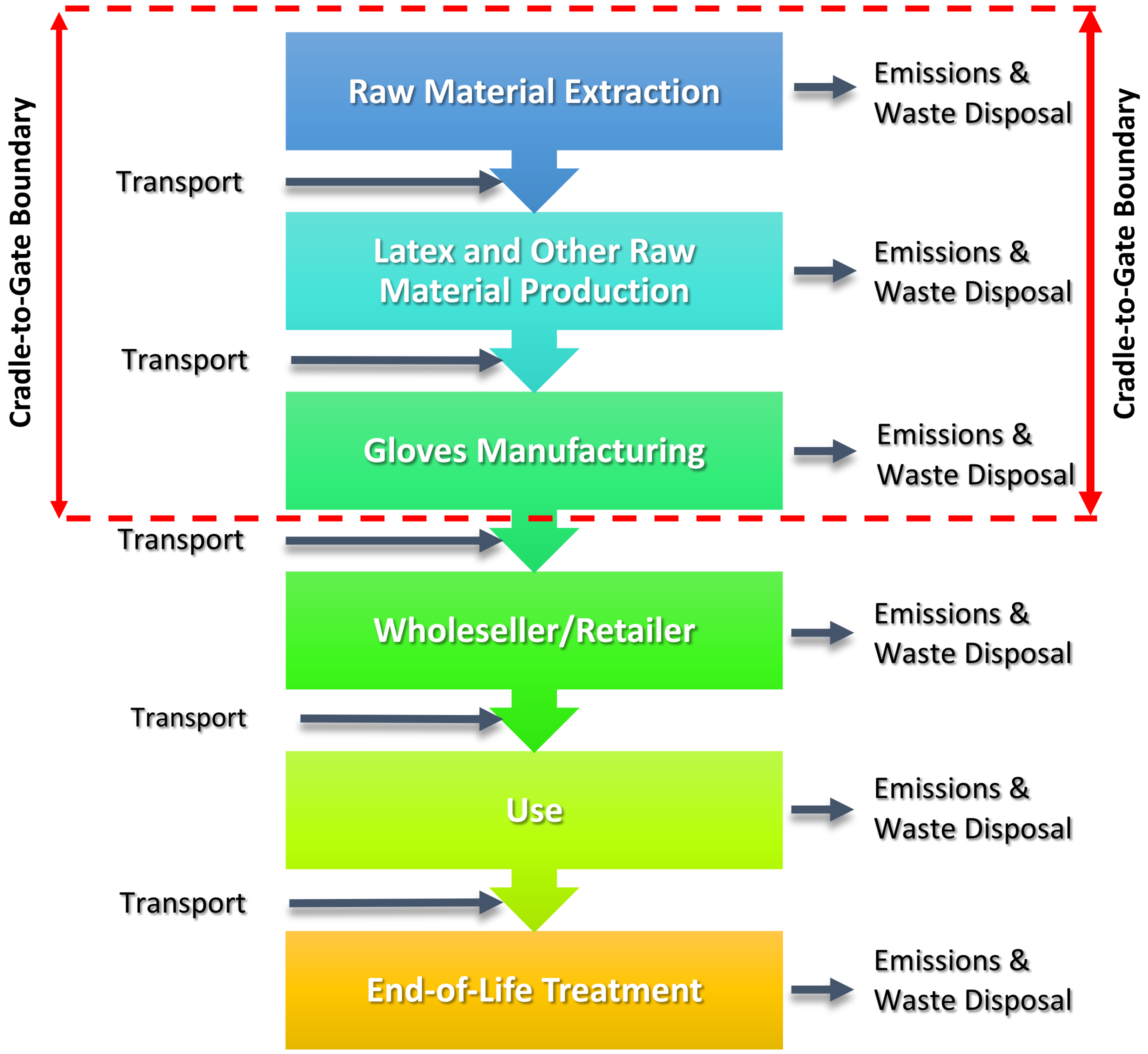


Figure 3: Assessment Boundary

3. GHG Inventory

3.1 Data Availability and Quality

- In line with the ISO 14040 Standard and ISO 14044 Standard, this assessment encompassed all mandatory emissions. Certain data on carbon rucksack (embedded) values on compounds were not available (no documented proof on certain emissions sources), thus affecting the completeness of the carbon footprint estimation. Therefore, certain activity data were derived based on assumptions. Annex 1 contains further details on the main assumptions and exclusions that were made in this calculation.
- Quantities of raw material used for each process step, electricity consumption and waste were obtained using factory-maintained records, calculations and secondary data from published sources for the manufacturing period of 01st – 30th June 2021 of the selected product.

3.2 Emission Factors

- CO_2 emission factors for certain processes, electricity, packaging materials and chemical compounds were sourced from the 'ecoinvent 3.6' database, which was incorporated into the 'SimaPro' Software. In addition to the above, certain factors were sourced from other publicly available information regarding embedded emission factors.
- Selected emission factors are geographically relevant, pertaining to the specific location of the emissions-generating activity in question. In order of preference, emission factors and secondary data were applied first from local, sub-national datasets; then from national datasets; and finally, from regional datasets. In the absence of required data from all these datasets, available global factors and data were applied.

3.3 Allocation Procedures

This study used a physical allocation procedure to allocate the environmental loads from each manufacturing process. Mass and volume are typically used for physical allocations. Hence, almost all the environmental loads including raw material embodied emissions, transport emissions, waste disposal emissions and production-related emissions (not possible to calculate specifically for the assessed product types) were allocated using the physical allocation procedure.

The allocation of the latex formulation for the 100% Latex Glove and 100% Nitrile Glove was done based on the mass of latex formulation of the Neo 03 Glove, which was a blend of Natural Rubber, Nitrile and Neoprene.

For instance, Waste and Wastewater disposal emissions were allocated based on the production quantities.

4. Life Cycle Impact Assessment

4.1 Cutoff Criteria

All processes and flows that are attributable to the manufacturing process of the selected type of the ‘Examination Glove’ product range were included in the assessment. Therefore, a consistent set of cutoff criteria was not defined for this assessment. However, all the assumptions, data exclusions and limitations of the assessment have been reported in Annexure 01.

4.2 Assessment Tool

The Environmental Impact Assessment was carried out in the SimaPro 9.0 life cycle assessment software. SimaPro is the global-leading LCA software developed by PRé Consultants and trusted by industry and academia. SimaPro is the professional tool to collect, analyse and monitor the sustainability performance data of products and services. It is equipped with science-based methods and reliable databases, including the renowned ecoinvent database, the new industry-specific Agri-footprint database and the ELCD database. The software can be used for a variety of applications, such as sustainability reporting, carbon and water footprinting, product design, generating environmental product declarations and determining key performance indicators.

As the most consistent and transparent life cycle inventory database in the world, the ecoinvent database supports environmental assessments of products and processes worldwide. The ecoinvent database contains around 18,000 reliable life cycle inventory datasets, covering a range of sectors such as agriculture and animal husbandry, building and construction, chemicals and plastics, energy, forestry and wood, metals, textiles, transport, tourist accommodation, waste treatments and recycling, and water supply, among other industrial sectors.

Figure 4: Assessment Tools

4.3 Processes Evaluated during the Assessment

The assessed product undergoes three main manufacturing processes namely, Latex Compounding, Dipping, and Packaging (after process).

However, several sub-processes have been included in the dipping process, and the assessment included all raw material data, electricity consumption, and waste associated with the dipping process.

Figure 5: Glove Manufacturing Processes

4.3 Processes Evaluated in the Assessment (cont'd)

Following is the list of sub-processes of Dipping of the TD 02 (Neo 03) Glove.

- Acid Washing
- Acid Rinsing
- Alkaline Washing
- Alkaline Rinsing
- Vertical And Horizontal Brushing
- Hot Rinsing
- Former Drying
- Coagulant Dipping
- Coagulant Drying
- Compound Dipping
- Latex Drying
- Pre-leaching
- Drying
- Post-leaching
- Chlorination
- Chlorine Neutralising
- Chlorine Rinsing
- Final Drying
- Pre-stripping Brushes
- Auto Stripping
- Stacking

The production team confirmed that the other two products (100% Latex and 100% Nitrile) also follow the same manufacturing processes that are similar to TD 02 (Neo 03).

It was assumed that the chemical formulation too was the same for all three variants, except the latex type used in the **compound dipping** sub-process for the three variants, while other processes, inputs RM, and energy remained the same.

4.4 Product Evaluated in Assessment

The life cycle GHG emissions of the TD 02 (Neo 03) examination glove as shown in Figure 06 below was assessed in this assessment.

TD 02 (Neo 03)

Figure 6: Assessed Examination Glove Type

4.4.1 TD 02 (Neo 03)

The product GHG emissions of a piece of ‘TD 02 (Neo 03)’ was assessed under the following three main manufacturing processes and wastewater treatment plant separately:

I. Glove Manufacturing – Latex Compounding

This stage included only the emissions of diesel utilisation for generators apart from raw water as a raw material, emissions arising from the use of electricity, and emissions from the raw material (Diesel) transport from the RM supplier to the factory gate.

II. Glove Manufacturing – Dipping

The emissions from all raw material-input, their associated outputs including the emissions of waste transportation, emissions arising from the use of electricity, compressed air and biomass, emissions from raw material transport from the manufacturing facility (as per the address provided by the Client) to the local port of the manufacturer (estimated to the nearest seaport), emissions from that port to the Colombo Port, and the emissions from raw material transport from the locations of local suppliers/ports to the factory gate were assessed under this stage for all the sub-processes listed in section 4.3.

4.4.1 TD 02 (Neo 03) (cont'd)

III. Glove Manufacturing – Packaging (after process)

This stage included the emissions of raw materials used for packaging, emissions arising from the use of electricity for lighting in warehouses and the emissions of raw material transport from the local suppliers to the factory gate.

IV. Wastewater Treatment

The emissions arising from the wastewater treatment of the glove manufacturing process were accounted for in this stage. This included the emissions from the chemicals used for the water treatment and the emissions arising from the electricity for the operation of the plant.

4.4.1 TD 02 (Neo 03) (cont'd)

Table 3: GHG Emissions Results of a Piece of TD 02

Process Stage	TD 02 (Neo 03)	Unit
Latex Compounding	0.00005	$kgCO_2e$
Dipping	0.0175	$kgCO_2e$
Packaging	0.0015	$kgCO_2e$
Wastewater Treatment	0.0003	$kgCO_2e$
TOTAL GHG EMISSIONS PER PIECE	**0.0193**	**$kgCO_2e$**

4.5.1 TD 02 (Neo 03) (cont'd)

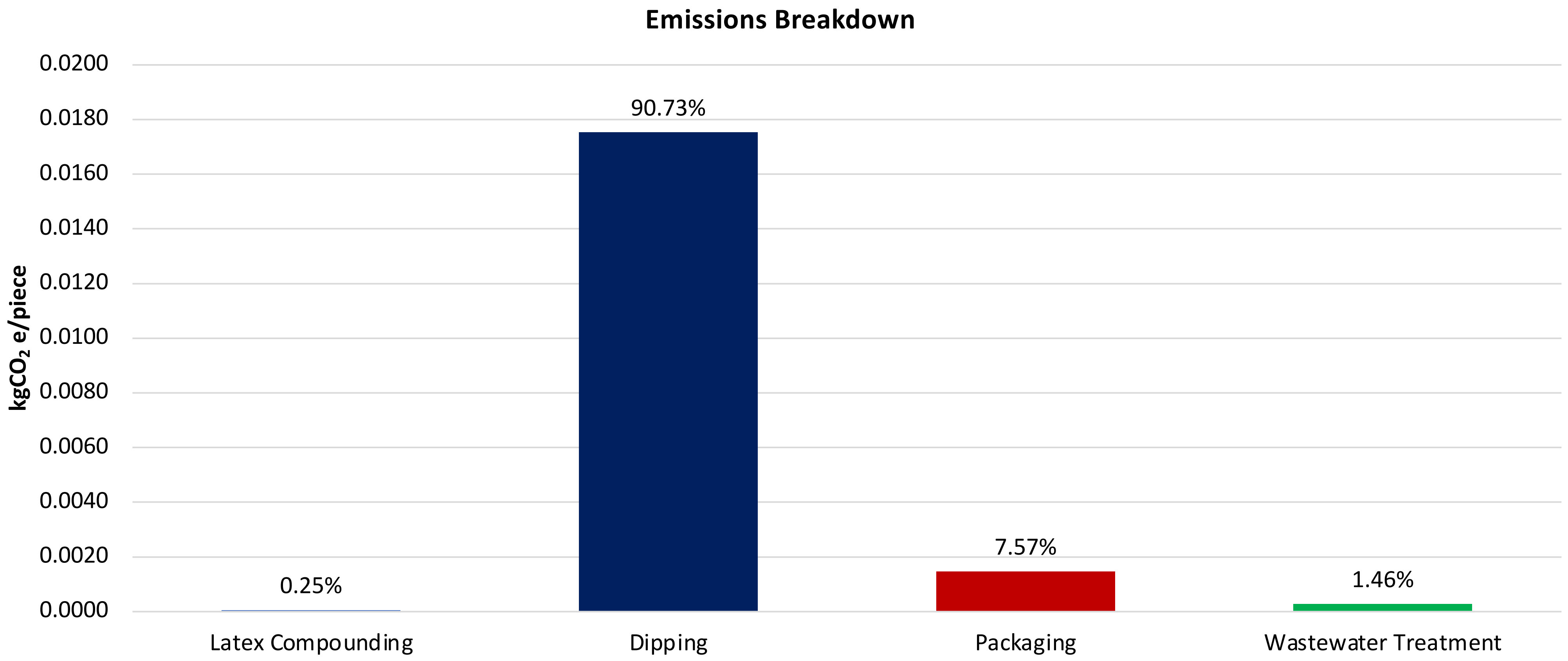


Figure 7: Emissions Breakdown for a Piece of TD 02(Neo 03) Glove

4.5 Products Evaluated in Comparative Study

The comparative life cycle GHG emissions of the selected two examination gloves as shown in Figure 08 below were analysed in this comparative study.

100% Latex Glove (NR)

100% Nitrile Glove (NBR)

Figure 8: Gloves used in Comparative Study

4.5.1 Latex Glove – 100%

The product GHG emissions of a piece of the '100% Latex Glove' was assessed under the following three main manufacturing processes and wastewater treatment plant separately:

I. Glove Manufacturing – Latex Compounding

This stage included only the emissions of diesel utilisation for generators apart from raw water as a raw material, emissions arising from the use of electricity, and emissions from the raw material (Diesel) transport from the RM supplier to the factory gate.

II. Glove Manufacturing – Dipping

The emissions from all raw material-input, their associated outputs including the emissions of waste transportation, emissions arising from the use of electricity, compressed air and biomass, emissions from raw material transport from the manufacturing facility (as per the address provided by the Client) to the local port of the manufacturer (estimated to the nearest seaport), emissions from that port to the Colombo Port, and the emissions from raw material transport from the locations of local suppliers/ports to the factory gate were assessed under this stage for all the sub-processes listed in section 4.3.

4.5.1 Latex Glove – 100% (cont’d)

III. Glove Manufacturing – Packaging (after process)

This stage included the emissions of raw materials used for packaging, emissions arising from the use of electricity for lighting in warehouses and the emissions of raw material transport from the local suppliers to the factory gate.

IV. Wastewater Treatment

The emissions arising from the wastewater treatment of the glove manufacturing process were accounted for in this stage. This included the emissions from the chemicals used for the water treatment and the emissions arising from the electricity for the operation of the plant.

4.5.1 Latex Glove – 100% (cont'd)

Table 3: GHG Emissions Results of a Piece of 100% Latex Glove

Process Stage	100% Latex Glove (NR)	Unit
Latex Compounding	0.00005	$kgCO_2e$
Dipping	0.0160	$kgCO_2e$
Packaging	0.0015	$kgCO_2e$
Wastewater Treatment	0.0003	$kgCO_2e$
TOTAL GHG EMISSIONS PER PIECE	**0.0178**	**$kgCO_2e$**

4.5.1 Latex Glove – 100% (cont'd)

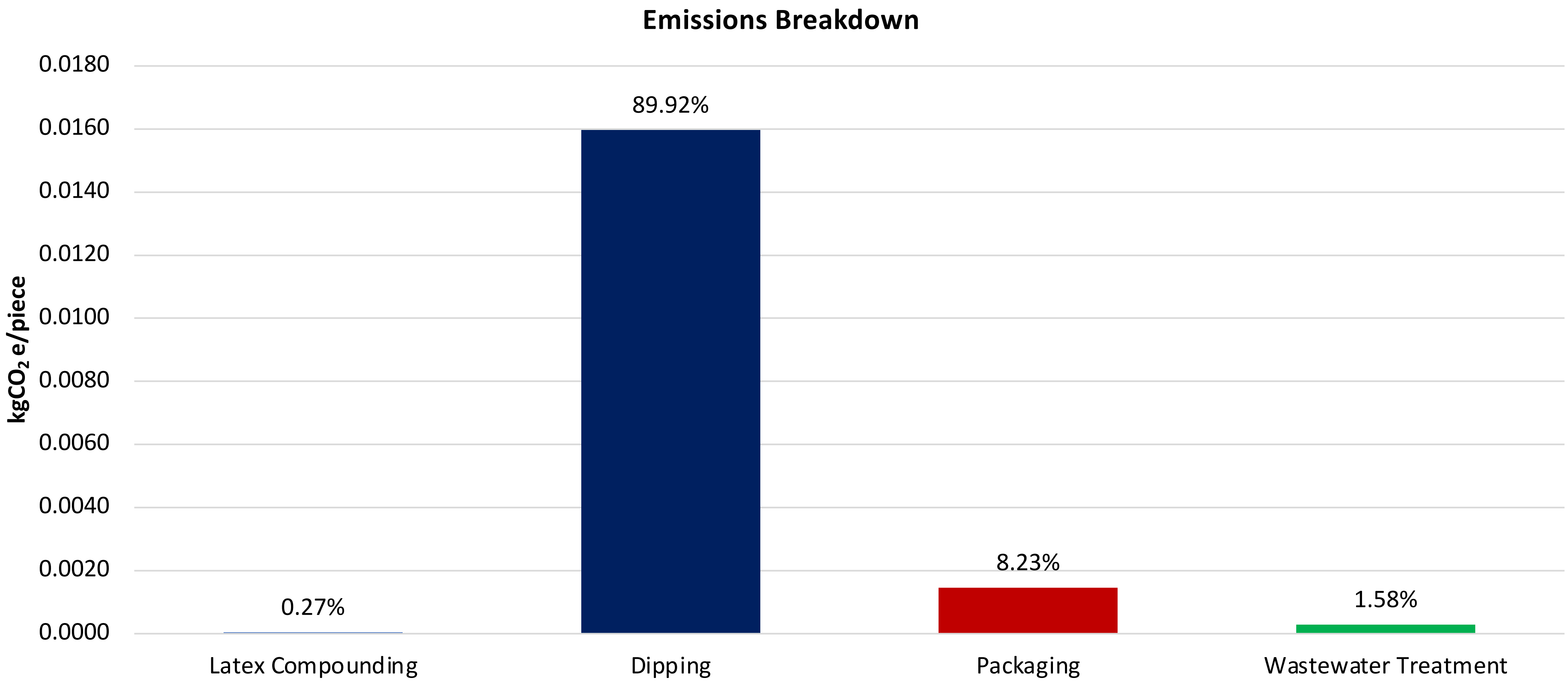


Figure 9: Emissions Breakdown for a Piece of 100% Latex Glove

4.5.2 Nitrile Glove – 100%

The product GHG emissions of a piece of ‘100% Nitrile Glove’ was assessed under the following three main manufacturing processes and wastewater treatment plant separately :

I. Glove Manufacturing – Latex Compounding

This stage included only the emissions of diesel utilisation for generators apart from raw water as a raw material, emissions arising from the use of electricity, and emissions from the raw material (Diesel) transport from the RM supplier to the factory gate.

II. Glove Manufacturing – Dipping

The emissions from all raw material-input, their associated outputs including the emissions of waste transportation, emissions arising from the use of electricity, compressed air and biomass, emissions from raw material transport from the manufacturing facility (as per the address provided by the Client) to the local port of the manufacturer (estimated to the nearest seaport), emissions from that port to the Colombo Port, and the emissions from raw material transport from the locations of local suppliers/ports to the factory gate were assessed under this stage for all the sub-processes listed in section 4.3.

4.5.2 Nitrile Glove – 100% (cont'd)

III. Glove Manufacturing – Packaging (after process)

This stage included the emissions of raw materials used for packaging, emissions arising from the use of electricity for lighting in warehouses and the emissions of raw material transport from the local suppliers to the factory gate.

IV. Wastewater Treatment

The emissions arising from the wastewater treatment of the glove manufacturing process were accounted for in this stage. This included the emissions from the chemicals used for the water treatment and the emissions arising from the electricity for the operation of the plant.

4.5.2 Nitrile Glove – 100% (cont'd)

Table 4: GHG Emissions Results of a Piece of 100% Nitrile Glove

Process Stage	100% Nitrile Glove(NBR)	Unit
Latex Compounding	0.00005	$kgCO_2e$
Dipping	0.0413	$kgCO_2e$
Packaging	0.0015	$kgCO_2e$
Wastewater Treatment	0.0003	$kgCO_2e$
TOTAL GHG EMISSIONS PER PIECE	**0.0431**	**$kgCO_2e$**

4.5.2 Nitrile Glove – 100% (cont'd)

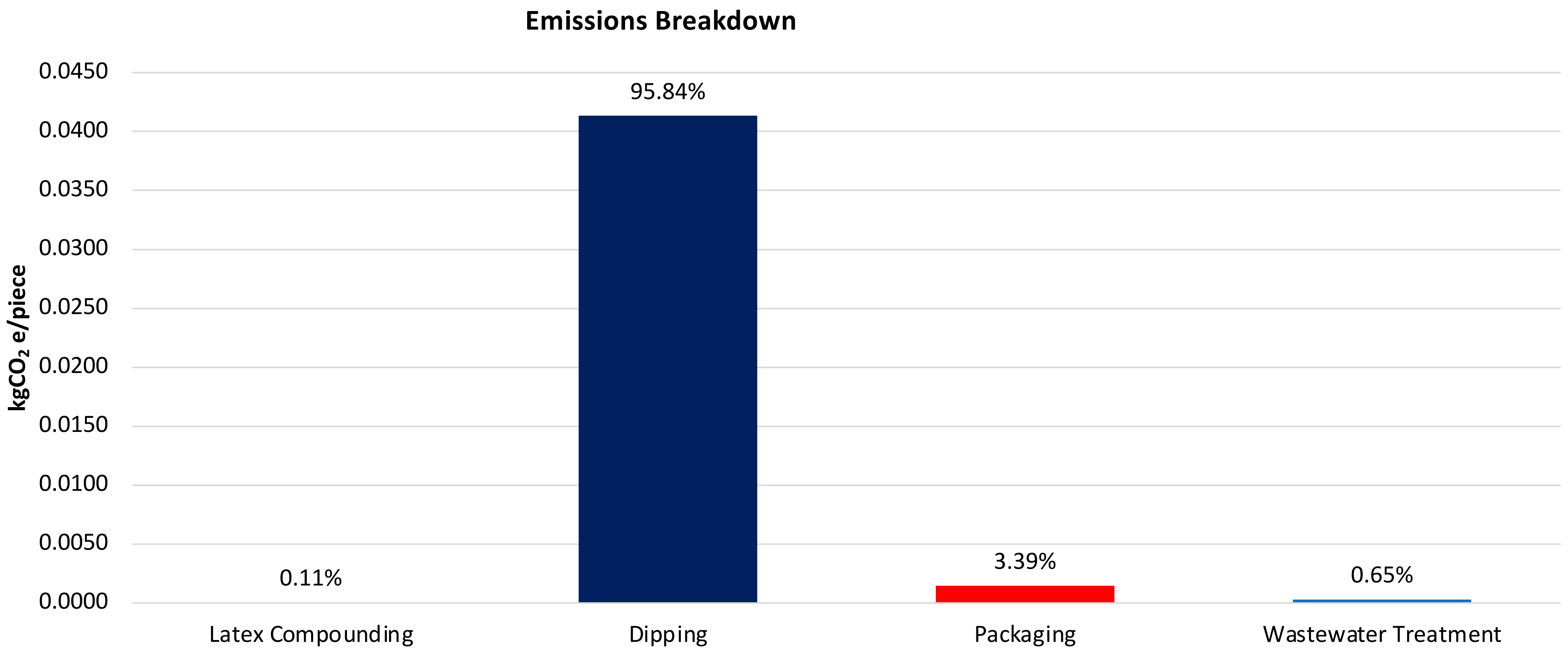


Figure 10: Emissions Breakdown for a Piece of 100% Nitrile Glove

4.6 Life Cycle Stage-wise Emissions Breakdown (Cradle-to-Gate)

Table 5: Life Cycle Stage-wise GHG Emissions Breakdown

Life Cycle Stage	TD 02 (Neo 03)	100% Latex Glove	100% Nitrile Glove	Unit
Raw Material Extraction & Processing	0.01120	0.00970	0.03439	$kgCO_2e$
Upstream Transport	0.00045	0.00039	0.00104	$kgCO_2e$
Glove Manufacturing				
Compounding	0.00005	0.00005	0.00005	$kgCO_2e$
Dipping	0.00761	0.00761	0.00761	$kgCO_2e$
Packaging	0.00001	0.00001	0.00001	$kgCO_2e$
Wastewater Treatment	0.00001	0.00001	0.00001	$kgCO_2e$
TOTAL GHG EMISSIONS PER PIECE	**0.0193**	**0.0178**	**0.0431**	**$kgCO_2e$**

4.7 Comparative Analysis

As per the assessed result, the following figure illustrates the overall emissions of evaluated three different products. Accordingly, 100% Nitrile Glove has been accounted for the highest GHG emissions of 0.0431 $kgCO_2$ e.

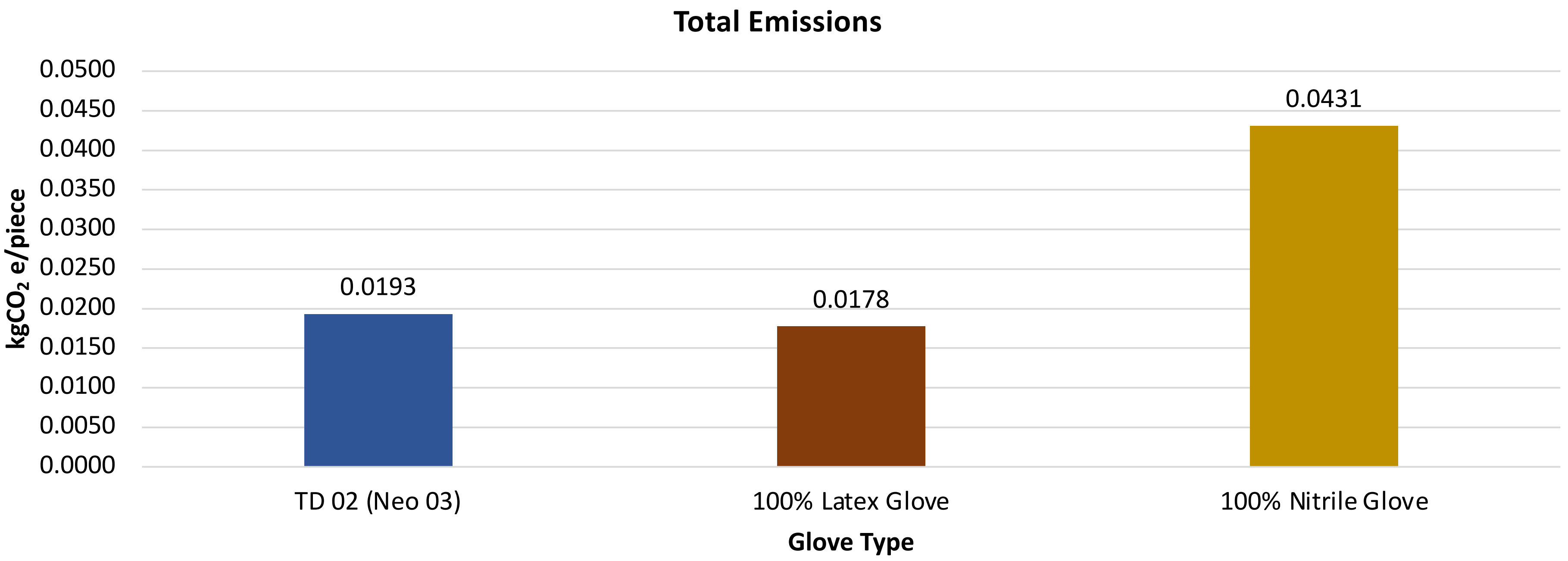
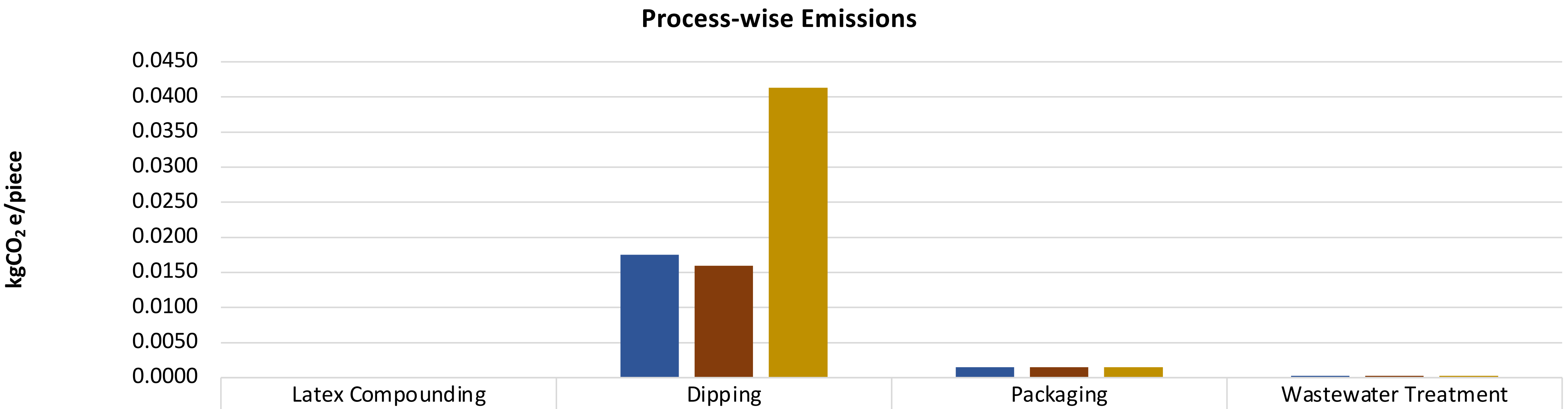


Figure 11: Total GHG emissions from Three Types of Gloves

4.7 Comparative Analysis (cont'd)

The following figure shows the breakdown emissions of three different products at three different manufacturing stages and the wastewater treatment. Accordingly, the GHG emission from the Latex Compounding, Packaging and wastewater treatment remains the same for all three products, while the emissions from the dipping process have been changed. This is because of the use of the different types of latex in the compound dipping sub-process for each variant.



	Latex Compounding	Dipping	Packaging	Wastewater Treatment
TD 02 (Neo 03)	0.0000	0.0175	0.0015	0.0003
100% Latex Glove	0.0000	0.0160	0.0015	0.0003
100% Nitrile Glove	0.0000	0.0413	0.0015	0.0003

Figure 12: Process-wise GHG emissions from Three Types of Gloves

4.7 Comparative Analysis (cont'd)

The following table provides the emissions of the latex types that have been used for the three variants and their contribution of emissions to the final footprint of the selected product. NBR extraction and processing have the highest amount of emissions from all the types of latex used for the three variants.

Table 6: GHG Emissions Results of Latex Formulations of Three Variants per Piece

Glove Type	Latex Formulation	GHG Emissions ($kgCO_2eq$/piece)	GHG Emission Contribution to the Final Product (%)
TD 02 (Neo 03)	60% Centrifuged NR Latex (Dry) 45% NBR Latex (Dry) 59% Neoprene Latex (Dry)	**0.0059**	30.32%
100% Latex Glove	60% Centrifuged NR Latex (Dry)	**0.0044**	24.55%
100% Nitrile Glove	45% NBR Latex (Dry)	**0.0290**	67.39%

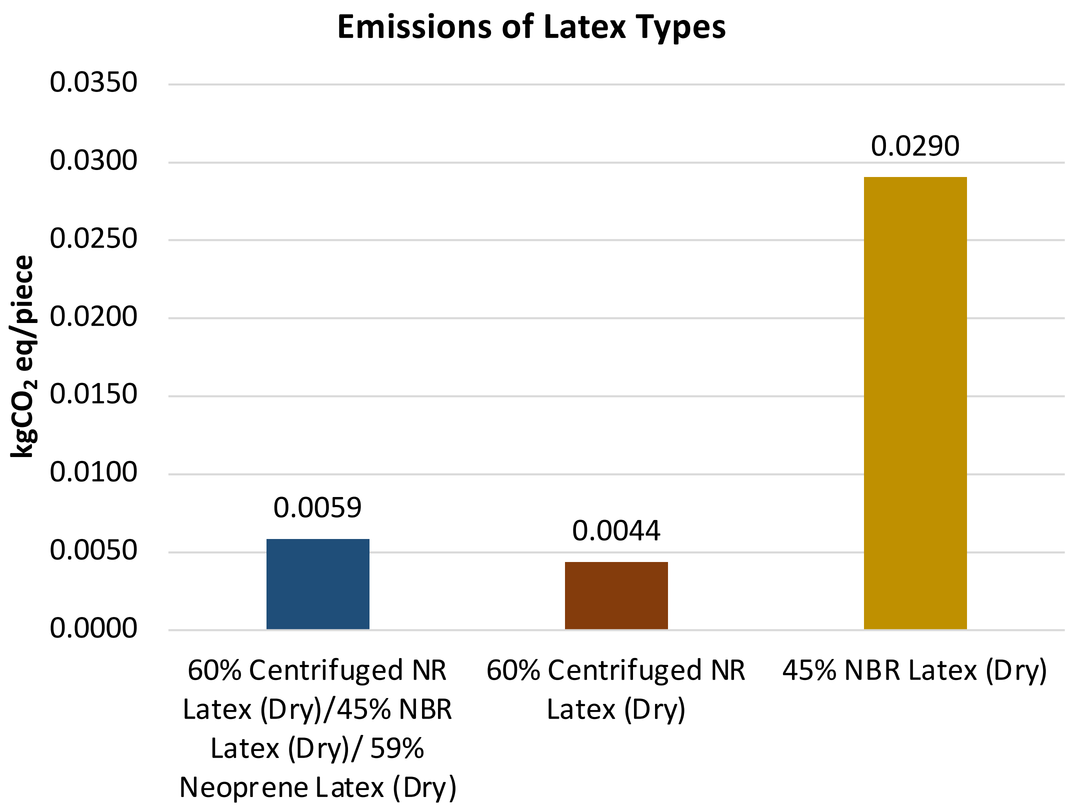


Figure 13: GHG emissions from the Latex Formulation used for Three Glove Variants

4.8 Fossil and Biogenic GHG Emissions and Removals

Table 7: Fossil GHG Emissions of TD 02 (Neo 03)

Fossil GHG Emissions of TD 02		**GHG Emissions of TD 02 ($kgCO_2e$/Piece)**
Glove Manufacturing – RM Transportation	Land Freight	0.00035
	Sea Freight	0.00009
Glove Manufacturing Stage		0.00002
NET FOSSIL GHG EMISSIONS		**0.00047**

There are no air freight deliveries/usage of aviation services for the assessed glove. Therefore, no aircraft-related GHG emissions were included in the emissions calculations

Table 8: Biogenic GHG Emissions of TD 02 (Neo 03)

Biogenic GHG Emissions and Removals of TD 02	**GHG Emissions of TD 02 ($kgCO_2e$/Piece)**
Glove manufacturing – Biomass Consumption Emissions	0.00089
NET BIOGENIC GHG EMISSIONS AND REMOVALS	**0.00089**

5. Conclusions and Recommendations

5. CFP Benchmarking

Table 9: CFP Benchmarking

Product	kgCO2e/unit	Description	Reference
Natural Rubber Glove - Thailand	0.4207kgCO2e/pair	• Used natural rubber • "Cradle to Grave" assessment • Functional unit – 200 pieces of rubber gloves (box of rubber gloves) • The effect of global warming was taken as mid-point characterisation factors and calculated using the International Panel of Climate Change (IPCC) methodology following AR4	Usubharatana, P., Phungrassami, H., (2018), Carbon Footprints of Rubber Products Supply Chains (Fresh Latex to Rubber Glove).
Latex Household Glove – Sri Lanka	757 kgCO2e/hectare/year	• Used natural rubber • "Cradle to Gate" assessment • Declared unit- household gloves produced using the latex yield per hectare per year • Impact assessed – Global Warming	Weerasinghe,N., Kulatunga, A., (2014), Carbon footprint of Latex Dipped Products in Sri Lanka.

Results of Extended Assessment Scope

- TD02

(Assessment Boundary: Gate-to-Grave)

1. Assessment Scope and Boundary

1.1 Goal and Scope

At the request of the client, a separate assessment was carried out to quantify the GHG emissions arising during the activities of the life cycle stages of Gate-to-Grave for the selected product TD02, with the end goal of amalgamating the total emissions of the entire product system from Cradle to Grave.

With technical guidance from CCC, the scope of this study was determined to include all applicable emissions sources from “Gate to Grave” (from Lalan factory gate to disposal of final product) and focused on the single impact category of ‘Climate Change’. For this study, client-supplied data were verified and analysed, and the GHG emissions were derived from the most current emission factors in line with the ecoinvent 3.6 Database.

1.2 Functional Unit

The extended CFP Study for the selected type of 'Examination Glove' was carried out within the agreed boundary of "Gate-to-Grave", and the combined report was prepared to quantify the Cradle-to-Grave GHG emissions. Therefore, the Functional Unit was defined as the "Use of a TD 02 glove manufactured by Lalan for Traffi for the examination process".

A PCR has not been developed for a rubber examination glove before. Therefore, the functional unit for this assessment was determined based on peer-reviewed LCA studies that have been conducted for rubber gloves.

1.3 Assessment Boundary

As per the PAS 2050 Standard, for the purpose of this extended study, the boundary for the selected product was set as “Gate to Grave”, which included downstream transport, warehousing, use phase and end-of-life treatment.

The emissions arising during the stages of raw material extraction and processing, upstream transport, glove manufacturing, and wastewater treatment were included in the Cradle to Gate assessment previously.

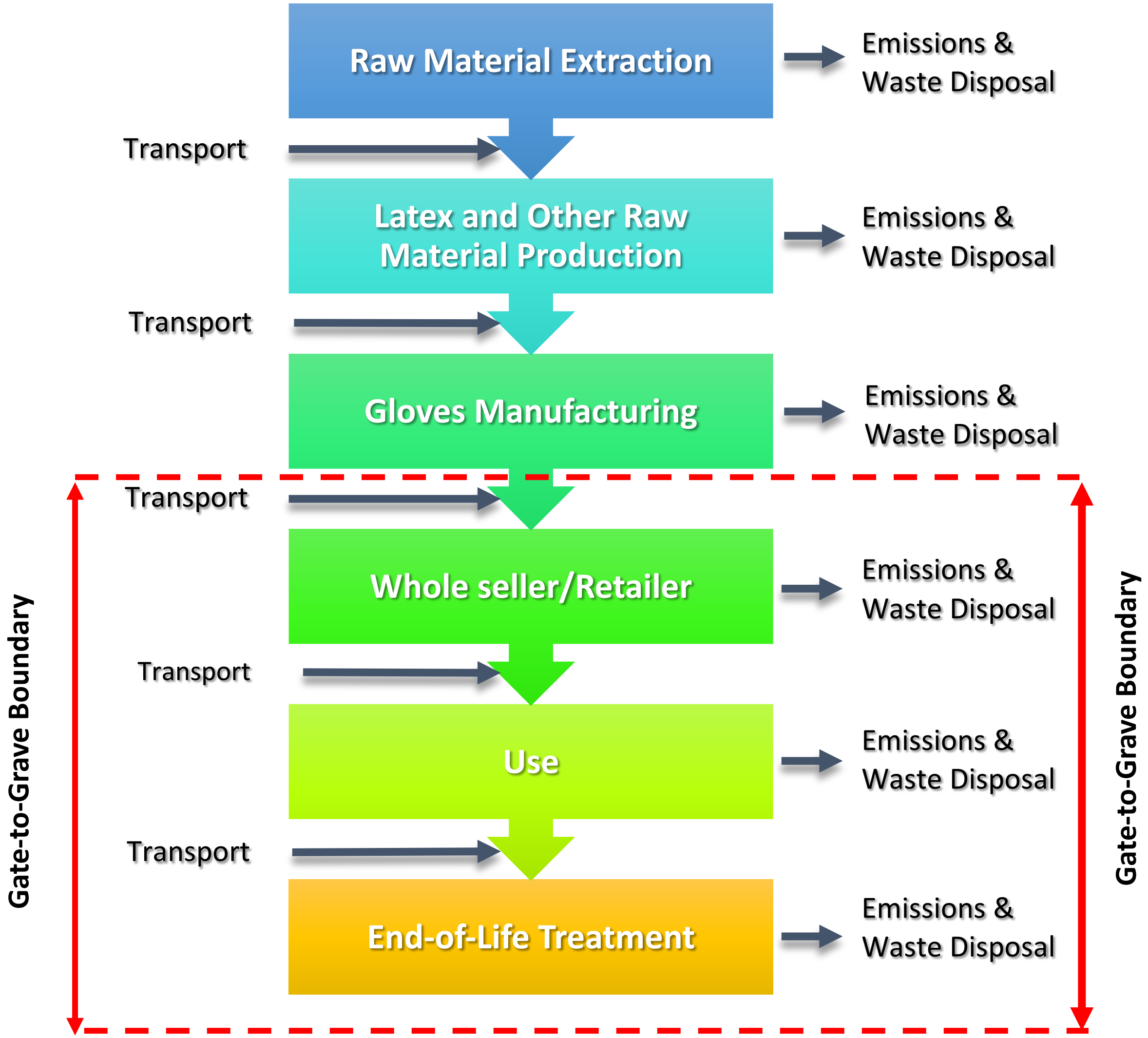


Figure 14: Assessment Boundary

2. Assessment Results

2.1 TD 02

The following stages were accounted for quantifying the product GHG emissions of a piece of TD 02 from the Gate-to-Grave assessment boundary.

I. Downstream Transport

This stage included the emissions of the transport of finished goods with packaging from the Lalan factory gate to Colombo Seaport or Katunayake Airport, from the sea/airport to destinations sea/airports of clients, from those sea/airports to the Traffi warehouse, and from the warehouse to the first customer/retailer.

II. Warehousing

The emissions arising from the use of electricity during the storage period of the final product were accounted for in this stage.

III. Use Phase

The emissions from the transport of the final product from the first customer/retailer to the end consumer were considered in this phase. There were no emissions during the use of gloves as this is a single-use glove.

2.1 TD 02 (cont'd)

IV. End-of-Life

The disposal stage included the emissions of transport of used products from the end user to the locations of disposal sites (landfill sites) and the emissions arising from the disposal method (landfilling) of the end product.

2.2 Life Cycle Stage-wise Emissions Breakdown (Gate-to-Grave)

Table 12: GHG Emissions Results of a Piece of TD 02 (Gate-to-Grave)

Life Cycle Stage		TD 02	Unit
Downstream Transport	Sea Freight	0.00158	$kgCO_2e$
	Air Freight	0.02800	
Warehousing		0.00024	$kgCO_2e$
Use Phase		0.00002	$kgCO_2e$
Glove Disposal - Landfill		0.00264	$kgCO_2e$
GATE TO GRAVE GHG EMISSIONS PER PIECE OF TD 02*	Sea Freight	**0.0045**	**$kgCO_2e$**
	Air Freight	**0.0309**	

***Note: Since the final product has both sea and air deliveries, the PCF value was calculated separately for both.**

2.3 Life Cycle Stage-wise Emissions Breakdown (Cradle-to-Grave)

Table 13: GHG Emissions Results of a Piece of TD 02 (Cradle-to-Grave)

Life Cycle Stage		GHG Emissions	Unit
Raw Material Extraction & Processing		0.01120	$kgCO_2e$
Upstream Transport		0.00045	$kgCO_2e$
Glove Manufacturing			
Compounding, Dipping & Packaging		0.00767	$kgCO_2e$
Wastewater Treatment		0.00001	$kgCO_2e$
Downstream Transport	Sea Freight	0.00158	$kgCO_2e$
	Air Freight	0.02800	
Warehousing		0.00024	$kgCO_2e$
Use Phase		0.00002	$kgCO_2e$
Glove Disposal - Landfill		0.00264	$kgCO_2e$
TOTAL GHG EMISSIONS PER PIECE OF TD 02*	**Sea Freight**	**0.0238**	**$kgCO_2e$**
	Air Freight	**0.0502**	

***Note: As the final product has both sea and air deliveries, the final PCF values were calculated separately for both.**

2.3.1 Emissions Breakdown of TD 02 (Sea Freight)

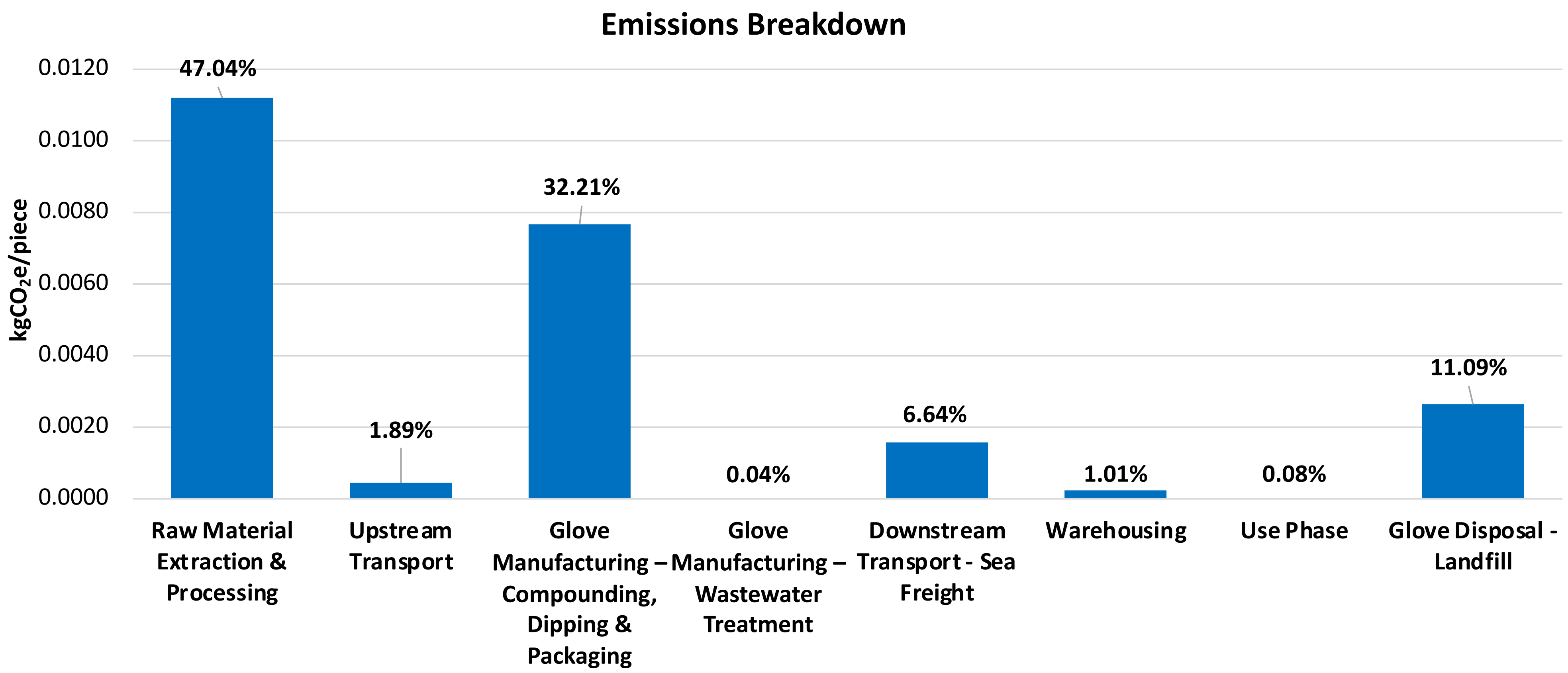


Figure 15 : Emissions Breakdown for a Piece of TD 02 Glove – Sea Deliveries

(The Network Model is illustrated in Annex 2)

2.3.2 Emissions Breakdown of TD 02 (Air Freight)

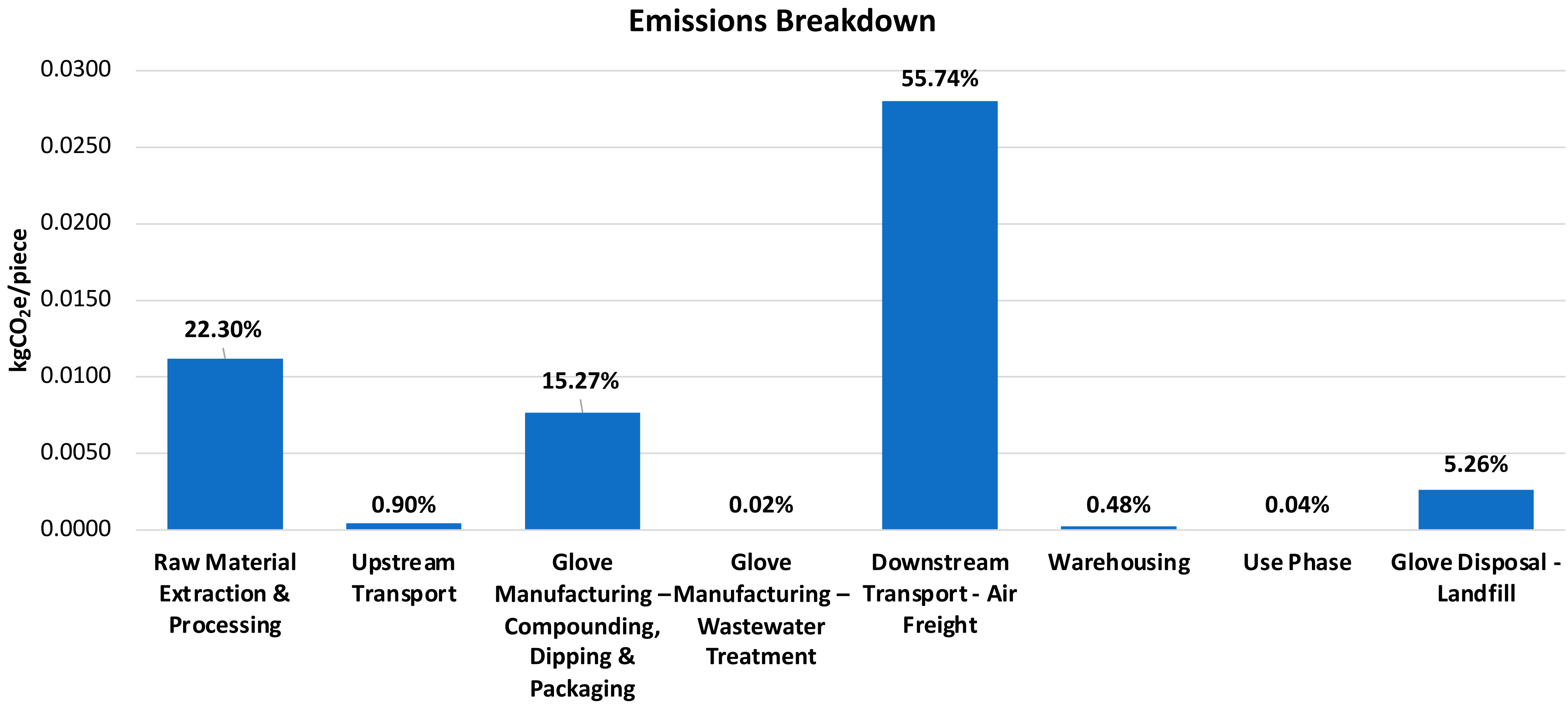


Figure 16 : Emissions Breakdown for a Piece of TD 02 Glove – Air Deliveries

2.4 GHG Emissions from Downstream Transport – Sea Freight Vs Air Freight

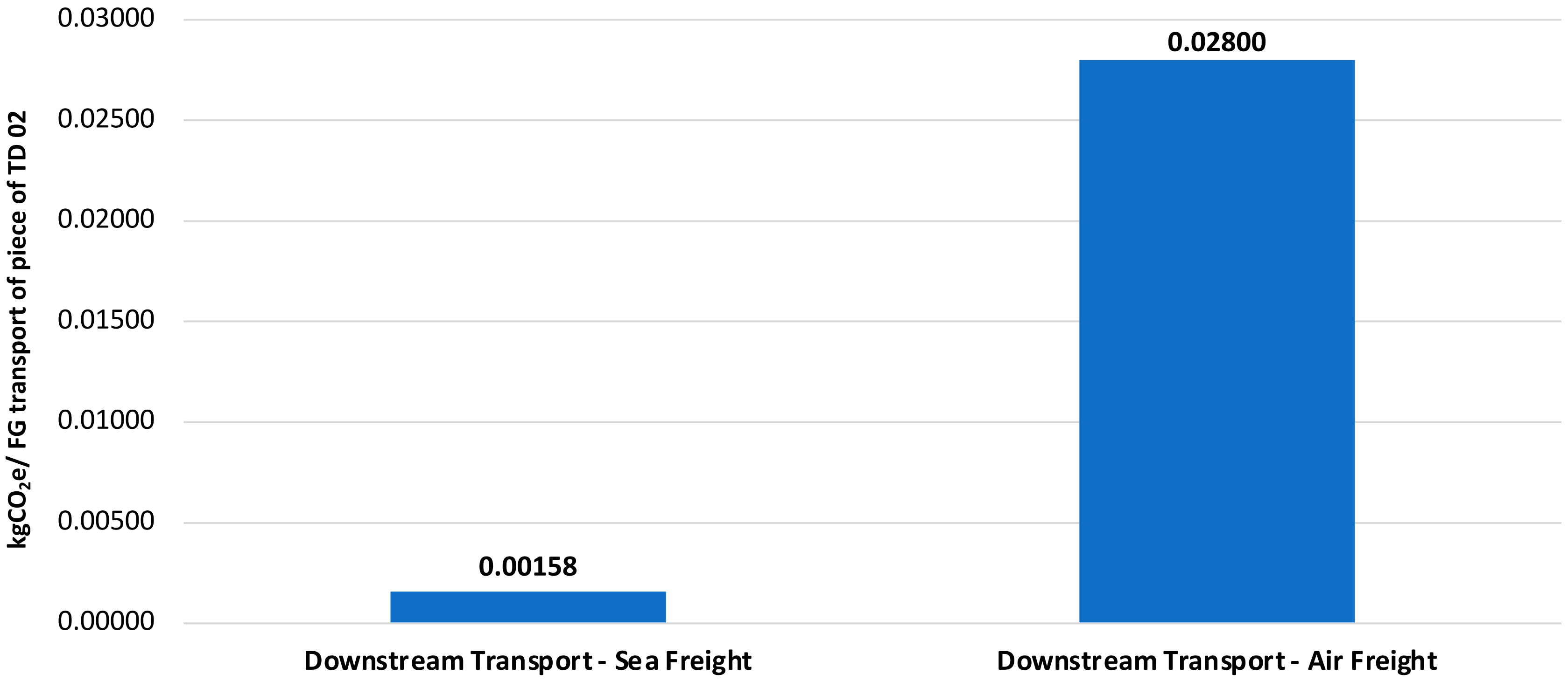


Figure 17: GHG emissions from Sea Freight Vs Air Freight

2.4 Fossil and Biogenic GHG Emissions and Removals

Table 14: Fossil GHG Emissions of TD 02 (Neo 03)

Fossil GHG Emissions of TD 02		GHG Emissions of TD 02 ($kgCO_2e$/Piece)
Upstream Transport – Raw Materials	Land Freight	0.00035
	Sea Freight	0.00009
Glove Manufacturing Stage		0.00002
Downstream Transport – Sea Deliveries	Land Freight	0.00070
	Sea Freight	0.00084
Downstream Transport – Air Deliveries	Land Freight	0.00044
	Air Freight	0.02757
Use Phase – Land Freight		0.00002
NET FOSSIL GHG EMISSIONS	**Sea Freight**	**0.00202**
	Air Freight	**0.02849**

2.4 Fossil and Biogenic GHG Emissions and Removals (cont'd)

Table 15: Biogenic GHG Emissions of TD 02 (Neo 03)

Biogenic GHG Emissions and Removals of TD 02	GHG Emissions of TD 02 ($kgCO_2e$/Piece)
Glove Manufacturing – Biomass Consumption Emissions	0.00089
NET BIOGENIC GHG EMISSIONS AND REMOVALS	**0.00089**

3. Conclusions and Recommendations

The results reveal that the **dipping stage has the highest contribution of GHG emissions** compared with the other two product stages for all 3 products, because of the extensive use of chemicals and the highest energy utilisation amongst the three production stages.

As per the results, 100% Nitrile Glove (NBR) shows the highest GHG emissions at 0.0431 kgCO_2e and TD 02 Glove (Neo 03) is the next highest with emissions at 0.0193 kgCO_2e. However, the least GHG emissions were noted from the 100% Latex Glove (NR) at 0.0178 kgCO_2e.

For the overall emissions of a single TD 02 Glove and a 100% Latex Glove combined, and for a 100% Nitrile Glove, more than 20% and 67% of emissions are from the specific types of latex that were used, respectively (Table 5). Contribution of electricity is next at 20.84%, 22.67%, and 9.34% from the total emissions of TD 02 Glove, NR Glove, and NBR Glove, respectively.

In conclusion, 100% Latex Glove (Natural Rubber) can be considered as the product that has the lowest impact on GHG emissions for the assessed boundary of 'Cradle-to-Gate'.

However, it is recommended to conduct a complete/partial LCA for the 100% Latex Glove and 100% Nitrile Glove separately, as there may be changes in the types and quantities of the chemicals required for glove production according to the latex type from NR to NBR, or vice versa.

3. Conclusions and Recommendations (cont’d)

As per the results in Table 12, the Gate-to-Grave (from Lalan factory gate to disposal of final product) GHG emissions of a TD 02 glove are 0.0045 kgCO_2e if sea freight or 0.0309 kgCO_2e if air freight.

Since the final product is distributed over both sea and air freight, the CFP is calculated for both scenarios separately to avoid double counting. Accordingly,

I. **IF Air Freight, the Cradle-to-Grave GHG emissions of a TD 02 glove – 0.0502 kgCO_2e**

II. **IF Sea Freight, the Cradle-to-Grave GHG emissions of a TD 02 glove – 0.0238 kgCO_2e**

Therefore, if air freight is used as the mode of transport of distributing the final product, it has amounted to **more than double** the GHG emissions of that of sea freight for the entire life cycle of the product.

Only if considering the downstream transport stage, air freight deliveries have resulted in around 17 times greater than the GHG emissions of sea freight as in Figure 17.

3. Conclusions and Recommendations (cont'd)

Table 16 shows the overall emissions savings of 0.0264 $kgCO_2e$/piece of TD 02 glove from sea freight over air freight for the entire life cycle of the product. Hence, it can be recommended to move towards sea deliveries for the transportation of the finished goods.

Table 16: GHG Emissions Reduction per Piece of TD over Sea Freight

Scenario 1 – Air Freight ($kgCO_2e$/piece)	Scenario 2 – Sea Freight ($kgCO_2e$/piece)	Emissions Savings ($kgCO_2e$/piece)	Emissions Reduction (%)
0.0502	0.0238	0.0264	52.59

3. Conclusions and Recommendations (cont'd)

There is a growing need for integrating environmentally-sound decisions into supply-chain management for various benefits such as obtaining a better understanding of GHG inventory of products, identifying Climate Change hotspots with options for reduction, and better value additions for a brand, all of which can also create more avenues for engagement with stakeholders.

Green Supply Chain Management

Green Supply Chain Management (GSCM) integrates environmental management and sustainability into the overall management of the supply chain. GSCM works from the design stage of the products, sourcing and selecting materials, manufacturing process, and transport of finished products to even consider end-of-life product management.

GSCM aims to minimise inefficiencies and hazardous chemicals, emissions, energy and solid waste along the supply chain. Organisations that combine environmental consciousness with operational practices can create a competitive advantage to enhance profitability, access to new markets, strengthen customer relationships and gain a competitive edge.

3. Conclusion and Recommendations (cont'd)

Green Purchasing and Procurement/Sourcing

This involves the selection and acquisition of products and services to minimise any negative impacts over product life cycles associated with manufacturing, transportation, usage, and recycling. Research on sourcing or purchasing materials with higher reusability/recyclability has shown to reduce costs associated with products and increase environmental and financial performance with positive reputation obtained in the market.

Green Manufacturing

This includes production processes that have relatively low environmental impacts, are highly efficient, and generate little waste or pollution. Green manufacturing can result in lower raw material costs, gains in production efficiency, reduced environmental and occupational safety expenses, and an improved corporate image.

Another recommendation is to consider investing in solar panels or renewable energy projects within the supply chain to power manufacturing facilities, which will help in the overall reduction of the carbon footprint.

Implementing Lean Management practices will reduce waste and increase efficiency in the production process. It is also recommended to consider innovative manufacturing methods such as the 'Dancing Module' Concept, which is when a production line team member is not limited to one machine, skill or process but a cluster or combo of machines where a group of processes are managed individually. This enables them to move around ("dance") and complete a product, whilst ensuring the quality of the work that they perform.

3. Conclusion and Recommendations (cont'd)

Green Distrubution

Packaging characteristics (such as size, shape, and the materials used) have an impact on distribution and transportation. Better packaging can result in a reduction in the quantity of materials used, better use of space, and less handling requirements. It is therefore recommended to assess the technical and financial feasibility of introducing a 'Green Fleet', comprised of hybrid/electric vehicles for land transport of raw materials and finished products, and the usage of packing materials made of recycled materials.

Efficient Packaging and Handling

Packaging characteristics (such as size, shape, and the materials used) have an impact on distribution and transportation. Better packaging along with rearranged loading patterns can result in a reduction in the quantity of packaging materials used, better use of space, and less handling requirements.

3. Conclusion and Recommendations (cont'd)

Reverse Logistics

This is the process by which manufacturers accept previously shipped products from the point of consumption for recycling and remanufacturing where possible and also reduce waste. Smart strategies to reuse, refurbish, and recycle products and raw materials not only benefit the environment, but also save money and increase profits. It is important therefore, to truly understand the impact of the products from raw material extraction until end use.

According to the Reverse Logistics Association (RLA), a trade organisation focused on educating retailers, manufacturers, and third-party logistics providers about the benefits of reverse logistics claims that there may be savings of 3-15% from implementing such practices within the operations of a company. Considering collaborative opportunities within the supply chain and long-term Return on Investments (ROIs) are also important when implementing Reverse Logistics

Reverse Logistics (cont'd)

It is also recommended to use Carbon Neutral transport service providers to transport raw materials as well as finished products to customers. As the emissions from this component of the supply chain would already be quantified and offset, this will also contribute to the overall reduction of the carbon footprint.

4. PCF Benchmarking

4. PCF Benchmarking

Table 17: PCF Benchmarking

Product	kgCO2e/unit	Description	Reference
Nitrile Glove - Malaysia	0.0260 $kgCO_2e$/single glove	• Synthetic rubber • “Cradle to Grave” assessment • Functional unit – single piece of nitrile glove (3.23 g) • The effect of eighteen midpoint impact categories were evaluated including Global Warming using ReCiPe Midpoint Hierarchist Method • Disposal Method - Incineration	Rizan, C., Reed, M., & Bhutta, M. F. (2021). Environmental impact of personal protective equipment distributed for use by health and social care services in England in the first six months of the COVID-19 pandemic. Journal of the Royal Society of Medicine.
Non-sterile Latex Free Glove - China	0.0680 $kgCO_2e$/pair	• Nitrile Butadiene Rubber • “Cradle to Grave” assessment • Functional Unit – an individual clinician using one pair of non-powdered, medium-sized gloves for a healthcare procedure • The effect of Climate Change using the International Panel of Climate Change (IPCC) methodology • Disposal Method - Incineration	Jamal, H., Lyne, A., Ashley, P. and Duane, B., 2021. Non-sterile examination gloves and sterile surgical gloves: which are more sustainable?. Journal of Hospital Infection, 118, pp.87-95.

5. References

References

- Dstech.com.my. 2021. The Importance of Measuring Fillers Brightness In Rubber Gloves – Color, Appearance, Light & Display Measurement | DS Technology & Services Sdn Bhd | Malaysia. [online] Available at: <https://dstech.com.my/the-importance-of-measuring-fillers-brightness-in-rubber-gloves/> [Accessed 21 December 2021].

- Eia.gov. 2022. Energy conversion calculators - U.S. Energy Information Administration (EIA). [online] Available at: <https://www.eia.gov/energyexplained/units-and-calculators/energy-conversion-calculators.php> [Accessed 18 December 2021].

- IPCC (2006). Revised IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual. Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

- IPCC (2007). IPCC Fourth Assessment Report: Climate Change 2007. Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

- Jamal, H., Lyne, A., Ashley, P. and Duane, B., 2021. Non-sterile examination gloves and sterile surgical gloves: which are more sustainable?. Journal of Hospital Infection, 118, pp.87-95.

- Kumar, H., Azad, A., Gupta, A., Sharma, J., Bherwani, H., Labhsetwar, N. and Kumar, R., 2020. COVID-19 Creating another problem? Sustainable solution for PPE disposal through LCA approach. Environment, Development and Sustainability, 23(6), pp.9418-9432. https://doi.org/10.1007/s10668-020-01033-0

- Patrawoot, S., Tran, T., Arunchaiya, M., Somsongkul, V., Chisti, Y. and Hansupalak, N., 2021. Environmental impacts of examination gloves made of natural rubber and nitrile rubber, identified by life-cycle assessment. SPE Polymers, 2, pp.179–190.

- Poh, G. K. X., Chew, I. M. L., & Tan, J. (2019). Life Cycle Optimization for Synthetic Rubber Glove Manufacturing. Chemical Engineering and Technology, 42(9), 1771–1779. https://doi.org/10.1002/ceat.201800476

References (cont'd)

- Rizan, C., Reed, M. and Bhutta, M., 2021. Environmental impact of personal protective equipment distributed for use by health and social care services in England in the first six months of the COVID-19 pandemic. Journal of the Royal Society of Medicine, 115(5), pp.250 - 263. https://10.1177/01410768211001583
- Vidanagama, J., Lokupitiya, E., and Kulatunga, A., 2016. "Cradle-to-Gate Product Life Cycle Greenhouse Emissions from Rubber Industry in Sri Lanka". https://www.researchgate.net/publication/312376797_Cradle-to Gate_Product_Life_Cycle_Greenhouse_Emissions_from_Rubber_Industry_in_Sri_Lanka
- Weerasinghe,N., Kulatunga, A., (2014), Carbon footprint of Latex Dipped Products in Sri Lanka.
- Wijesinghe, H., Gamage, W., Jayasinghe, H. and Weerawansha, A., 2016. Optimization of calcium carbonate (CaCO3) loading in Natural rubber latex based disposable gloves. International Journal of Scientific and Research Publications, 6(3), pp.266-269.
- WRI/ WBCSD. (2010). GHG Protocol. Retrieved October 2010, from The Greenhouse Gas Protocol Initiative: http://www.ghgprotocol.org
- Usubharatana, P., & Phungrassami, H. (2018). Carbon footprints of rubber products supply chains (Fresh latex to rubber glove). Applied Ecology and Environmental Research, 16(2), 1639–1657. https://doi.org/10.15666/aeer/1602_16391657

6. Annexures

Annex 1: Main Assumptions and Exclusions in the Calculation & Detailed GHG Emissions of Cradle to Gate Assessment

Process/Unit	Detail	Main Assumptions and Exclusions in the Calculation
Raw Materials	Raw material (e.g.: compounds, chemicals, etc.)	It was assumed that the weights of a single 100% Latex Glove and a 100% Nitrile Glove is the same as the weight of the assessed product, TD 02 (Neo 03). It was assumed that the chemical formulation except for the latex types used in compound dipping, other input raw material including packaging, energy utilisation, waste, and monthly glove production quantities of the 100% Latex Glove and 100% Nitrile Glove were the same as that of TD 02 (Neo 03). It was assumed that the weight of latex formulation in compound dipping of the 100% Latex Glove and 100% Nitrile Glove is similar to the weight of latex formulation of TD 02 (Neo 03) Glove, which is a blend of Latex, Nitrile and Neoprene. The local supplier of the 60% Centrifuged NR latex (Dry) was considered as Lalan Rubbers (Pvt) Ltd, Warakapola, due to the unavailability of data. Filler for the latex compound was taken as precipitated $CaCO_3$ based on published studies, due to unavailability of Material Safety Data Sheets of the filler (45% Tuflack). Global average factors were taken for the manufacturing of materials/chemicals due to the absence of Sri Lankan-specific characterisation factors.

Annex 1: Main Assumptions and Exclusions in the Calculation & Detailed GHG Emissions of Cradle to Gate Assessment (cont'd)

Process/Unit	Detail	Main Assumptions and Exclusions in the Calculation
		Certain materials/chemicals were excluded from the calculation as there were no accurate/relevant characterisation factors available. This was done to avoid an over/underestimation of the final impact values of each glove by using inaccurate emission factors.
Manufacturing	End product	Global average factors available in the 'ecoinvent' database were considered for the calculation.
Transport	Upstream transport - International	It was assumed that raw material transportation from the location of the manufacturer to the port of the manufacturer is done using 20-foot containers.
Waste	Material Waste	It was assumed that the waste quantities of 100% Latex Glove and 100% Nitrile Glove is the same as that of TD 02 (Neo 03). Separate waste amounts for separate processes were not recorded. Therefore, separation was done based on the production quantities of the factory for the month of June 2021.
	Wastewater	It was assumed that the wastewater quantities of the 100% Latex Glove and 100% Nitrile Glove is the same as that of TD 02 (Neo 03). It was assumed that the density of wastewater is equal to the density of water.

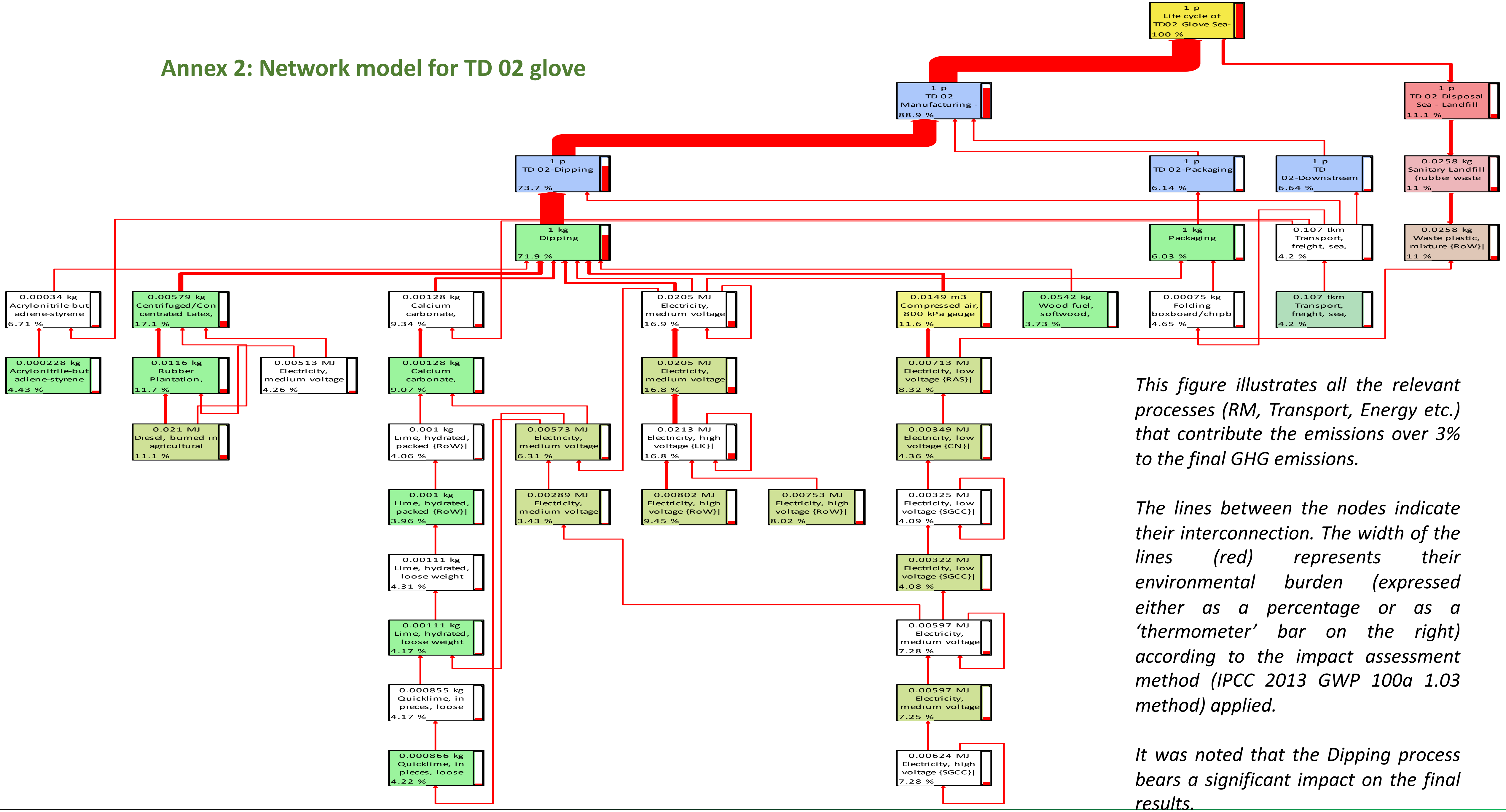
Annex 1: Main Assumptions and Exclusions in the Calculation & Detailed GHG Emissions of Cradle to Gate Assessment (cont'd)

Process/Unit	Detail	Main Assumptions and Exclusions in the Calculation
Waste	Wastewater	The wastewater generation and the water treatment chemical consumption were allocated based on the production ratio of the TD 02 glove variant over the total production of gloves of the factory for the month of June 2021.
Elementary Flows	Electricity	It was assumed that the energy utilisation of the100% Latex Glove and 100% Nitrile Glove is the same as that of TD 02 (Neo 03). The electricity consumption of the wastewater treatment plant for three types of gloves was allocated based on the production ratio of the TD 02 Glove variant over the total production of gloves of the factory for the month of June 2021.
	Compressed Air	As the compressors were used by two lines, it was assumed that both lines have similar production capacities with power equally shared, as per the expert opinion of the Lalan Team.
	Chiller	It was assumed that the chiller valves were fully opened during the production period. It was assumed that the cooling requirement for the 7 lines are equal, therefore, the flow rate is the same for each line.
	Biomass	The ‘Designed Heat Requirement’ developed by the Lalan Team for production line 7 was also considered for the calculation of biomass emissions. Rubber woodchips were considered as the type of biomass used. It was assumed that the moisture content of woodchips is less than 20%.

Annex 1: Main Assumptions and Exclusions in the Calculation & Detailed GHG Emissions of Gate to Grave Assessment (cont'd)

Process/Unit	Detail	Main Assumptions and Exclusions in the Calculation
Transport	Downstream Transport	As there was a countrywide distribution of the final product from the warehouse to the first customers/retailers, an average distance was taken in the calculations.
Warehousing	Electricity	Since there were no separate meter readings for the warehouse, it was taken as 40% of the share of the monthly electricity consumption of the warehouse according to client-provided data. The average product storage period of a glove was taken as 9 months.
Use Phase	Transport	The average distance was taken as 20km from the first customer/retailer to the end user (commercial users or industrial users) and mode of transport was taken as a box lorry. As this is a single-use examination glove, there were no emissions during the use stage.
Disposal	End-product Disposal	The disposal method was considered as landfill sites located within a 10 km radius from the locations of end-users and mode of transport for waste was taken as a truck.

Annex 2: Network model for TD 02 glove



This figure illustrates all the relevant processes (RM, Transport, Energy etc.) that contribute the emissions over 3% to the final GHG emissions.

The lines between the nodes indicate their interconnection. The width of the lines (red) represents their environmental burden (expressed either as a percentage or as a 'thermometer' bar on the right) according to the impact assessment method (IPCC 2013 GWP 100a 1.03 method) applied.

It was noted that the Dipping process bears a significant impact on the final results.

Figure 18: SimaPro 9.0.0 Software-generated Network Model of Analysis for a TD 02 glove with a 3% Node Cut-off