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Report

CRADLE to GATE CARBON FOOTPRINT ANALYSIS for DOUBLE-SIDED TAPES

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Prepared for:

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Executive Summary

Incorporated in 2011, GTG Manufacturing Sdn. Bhd. (GTG Manufacturing) is one of the leading manufacturing and supplier of adhesive tapes and stretch films in Malaysia. They strive to offer high quality products marketed worldwide such as in Americas, Africa, Asia, the Caribbean, Europe, the Ocean, and Middle East at competitive prices. The company is interested in assessing carbon emissions associated with its wide range of product as a key step towards a more cohesive environmental sustainability initiative.

GTG Manufacturing Sdn. Bhd has identified one of their products known as ***Double-sided tapes*** to undergo carbon emissions assessment related to the use of materials and energy consumption as well as transportation during the production process. The ***Double-sided tapes*** are manufactured by applying a thin adhesive layer to each side of a carrier material. Its physical and chemical properties make ***Double-sided tapes*** a versatile tape in a wide range of applications in different industries. The scope of the study is from cradle-to-gate and the production inventory data is collected and provided by GTC Manufacturing.

The ***Double-sided tapes*** produced by GTG Manufacturing at the Semenyih manufacturing plant with Double-sided PE Foam tape, Double-sided Tissue tape, Double-sided Polyester tape, Double-sided Acrylic Foam tape, and Double-sided EVA Foam tape have the carbon emissions of 5.942 $kgCO_2e/kg$, 0.861 $kgCO_2e/kg$, 0.830 $kgCO_2e/kg$, 0.586 $kgCO_2e/kg$, and 0.986 $kgCO_2e/kg$ respectively. Most of the carbon emission was emitted from the Winding process, contributing to an average of 82% of the total emissions which comes mostly from materials consumption.

At the same time, it should be noted that the product has a CFP value of 25.670 $kgCO_2e/CTNS$ and 0.178 $kgCO_2e/roll$ for Double-sided PE Foam tape, 9.177 $kgCO_2e/CTNS$ and 0.032 $kgCO_2e/roll$ for Double-sided Tissue tape, 31.79 $kgCO_2e/CTNS$ and 0.110 $kgCO_2e/roll$ for Double-sided Polyester tape, 8.439 $kgCO_2e/CTNS$ and 0.059 $kgCO_2e/roll$ for Double-sided Acrylic Foam tape, and 5.252 $kgCO_2e/CTNS$ and 0.036 $kgCO_2e/roll$ for Double-sided EVA Foam tape.

1. Introduction

GTG Manufacturing Sdn. Bhd. (GTG Manufacturing) was established on 15 November 2011 with the aim of supplying superior quality adhesive tape to their customers at competitive prices. Among the various types of self-adhesive tape that they provide to their customers in the form of jumbo rolls, log rolls or finished rolls include single sided tape such as OPP Packing Tape, Masking Tape, PVC Black Protection Tape, PVC Floor Marking Tape, PVC Insulation Tape, PE Protective Film, Cloth Duct Tape, Aluminium Foil Tape, Filament Tape, Teflon Tape, and others. They also supply double sided tape, acrylic foam tape, and protective film for application on various surfaces such as electronic device, injection moulding, automotive, construction glass, carpet, aluminium profiles, ceramic tiles etc.

SIRIM has been approached by GTG Manufacturing to conduct Carbon Footprint (CFP) analysis for their product namely ***Double-sided tapes.*** The ***Double-sided tapes*** are manufactured by applying a thin adhesive layer to each side of a carrier material. Its physical and chemical properties make ***Double-sided tapes*** a versatile tape in a wide range of applications in different industries. The CFP assessment for ***Double-sided tapes*** has been conducted based on lifecycle inventory data from GTG Manufacturing's product manufactured in Semenyih, Selangor. The details information of the manufacturing plant is provided herewith.

Name of company and address	:	GTG MANUFACTURNG SDN. BHD. NO 1, JALAN PLUMBUM 1/1, KAWASAN PERINDUSTRIAN SUNGAI PURUN, 43500 SEMENYIH, SELANGOR, MALAYSIA
Production site and address	:	Same as above
Name of contact person	:	Mr. Steve Ong
Contact no	:	+603-8725 9988, +6012-3246 908
Regulatory requirements for the operation	:	Environment Quality Act 1974 Environmental Quality (Scheduled Wastes) Regulations 2005 Occupational Safety and Health Act (Use and Standards of Exposure of Chemicals Hazardous to Health) Regulations 2000
Information on environmental management system	:	ISO 9001:2015 (Quality Management Systems) ISO 14001: 2015 (Environmental Management Systems)

2. General Description of Quantification Methodology

The carbon emissions quantification in this assessment adopts the general principle for product carbon foot-printing approach although it did not cover the complete life cycle phases. This assessment is tailored to the intention of GTG Manufacturing in focusing on the effect of different types of material used in product components to carbon emissions value.

ISO I4044: Life Cycle Assessment (LCA) as the over-arching principle to evaluate the environmental burdens associated with a product, process or activity which includes the identification of energy, raw materials and substances used, emissions and wastes released to the environment over its life cycle. Riding on the principles of LCA, carbon foot-printing is introduced as method to assess single environmental impact category over a product's life cycle stages associating with raw materials used, design, production, transportation, use and its end-of-life (ISO 14067: 2018). Carbon-equivalent emission comprises of greenhouse gases (GHGs) emissions. The GHGs, mainly carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) are accounted to derive the carbon equivalent emission factors using 100-year GWP coefficients, IPCC Fourth Assessment Report: Climate Change 2007.

The carbon quantification considers the first two phases of the LCA concept, i.e., goal and scope definition and life cycle inventory (LCI) analysis and excludes the life cycle impact assessment (LCIA) and results interpretation phases. The quantification coverage is specified through a system boundary from where the assessment indicates whether it is a segmented quantification, a partial-life cycle, or a complete life cycle quantification. This assessment is a segmented carbon emissions measurement based on the system boundary set to meet the intended goal of the assessment. Within the set boundary, there are two (2) different sources of data required, primary data and secondary data. In principle, primary data shall be collected as site specific data or foreground data. Whereas secondary data are data gathered from published sources (LCI databases, LCA journals, web-publication, etc) for related environmental emissions coefficients (emission characterisation factors) as well as measures to fill data gaps in primary data. The quantified carbon value also depends on the availability of the LCI datasets and options available to choose from. Any data gaps, limitations and assumption are reported as quantification barriers.

3. Goal and Scope of Study

3.1. Goal

The goal of this assessment is to quantify the carbon emissions associated with double-sided tape manufactured by GTG Manufacturing at their manufacturing facility at Semenyih, Selangor. The assessment aims to support GTG Manufacturing's initial exercise in product's environmental performance evaluation. The results will be used for future planning, strategy, and environmental sustainability initiatives in GTG Manufacturing's business activities.

3.2. Scope

The scope of this assessment is determined from cradle-to-gate.

Details of the assessment's scope are described further in each section below.

3.3. Function of the product

The function of this product is to unite two surfaces together, often in a way which is not visible in the end product, due to it being in between the objects rather than overlaying them.

3.4. Functional unit

The functional unit for the study is defined as quantity of greenhouse gases (GHGs) generated per kilogram of product.

3.5. Product System Assessed

Five double-sided tape models have been selected by GTG Manufacturing for this GHG assessment. Brief product information for selected double-sided model is provided below.

Table 1: Specification for selected model of Double-sided tape for GHG assessment

	**Double sided PE Foam tape** Double sided PE foam coated with synthetic rubber adhesive or solvent acrylic based adhesive. Typically used for mounting of lightweight materials, bonding,vibration dampening, splicing, laminating, permanent fastener, etc. Size: 12mm x 5m Weight: 30 gram
	**Double sided Tissue tape** Double sided sided tissue tape coated with hotmelt, solvet acrylic based and acrylic emulsion adhesive. Typically used for mounting of lightweight products, splicing of paper and joining of 2 lightweight surfacesuch as sealing documents. Size: 18mm x 30m Weight: 37 gram

	**Double sided EVA Foam tape** Double sided EVA foam coated with synthetic rubber adhesive or solvent acrylic based adhesive. Typically used for mounting of lightweight poster, name plate, automotive industry such as door sealing, mounting stripp, pedal, metal board, etc. Size: 10mm x 8.8m Weight: 37 gram
	**Double sided Acrylic Foam tape** Double sided acrylic foam coated with silicone rubber adhesive. Typically used for mounting of sign and dsiplay, maounting of badge and fixing of vehicle panel. Widely applied on metal, glass, plastic, composite, sealed wood, paint etc. Size: 10mm x 8m Weight: 100 gram
	**Double sided Polyester tape** Double sided cloth or OPP coated with synthetic rubber adhesive. Typically used for carpet fixing of outdoor advertising, exhibition, mold, printinghote, meeting room, carpet induster decorative suture, etc. Size: 30mm x 10m Weight: 133 gram

3.6. Process Map and System boundary for Quantification

GTG Manufacturing's ***Double-sided tapes*** are manufactured through a winding process. The unit processes involved are shown in Figure 2.

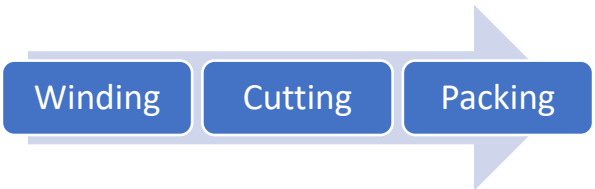

Figure 1: Process flow within the manufacturing plant of GTG Manufacturing

The description of the three (3) main unit processes are stated below:

i. Winding process
The bulk jumbo rolls are winded to form log rolls.

ii. Cutting process
The log rolls are cut into specific sizes of rolls as per customer requirement.

iii. Packing process
The specific sized products are wrapped and packed into cartons to be stored in the warehouse

The process map together with its system boundary for the life cycle of ***Double-sided tapes*** is illustrated in Figure 3 below. Since the scope of the study is from cradle-to-gate, only raw material extraction phase and product manufacturing phase were involved in the CFP study. Whereas, use phase and end-of-life phase were excluded in this study. The process map of the Double-sided tape is summarized and presented in Figure 2. The red dotted indicates the system boundary for this CFP analysis based on cradle-to-gate approach.

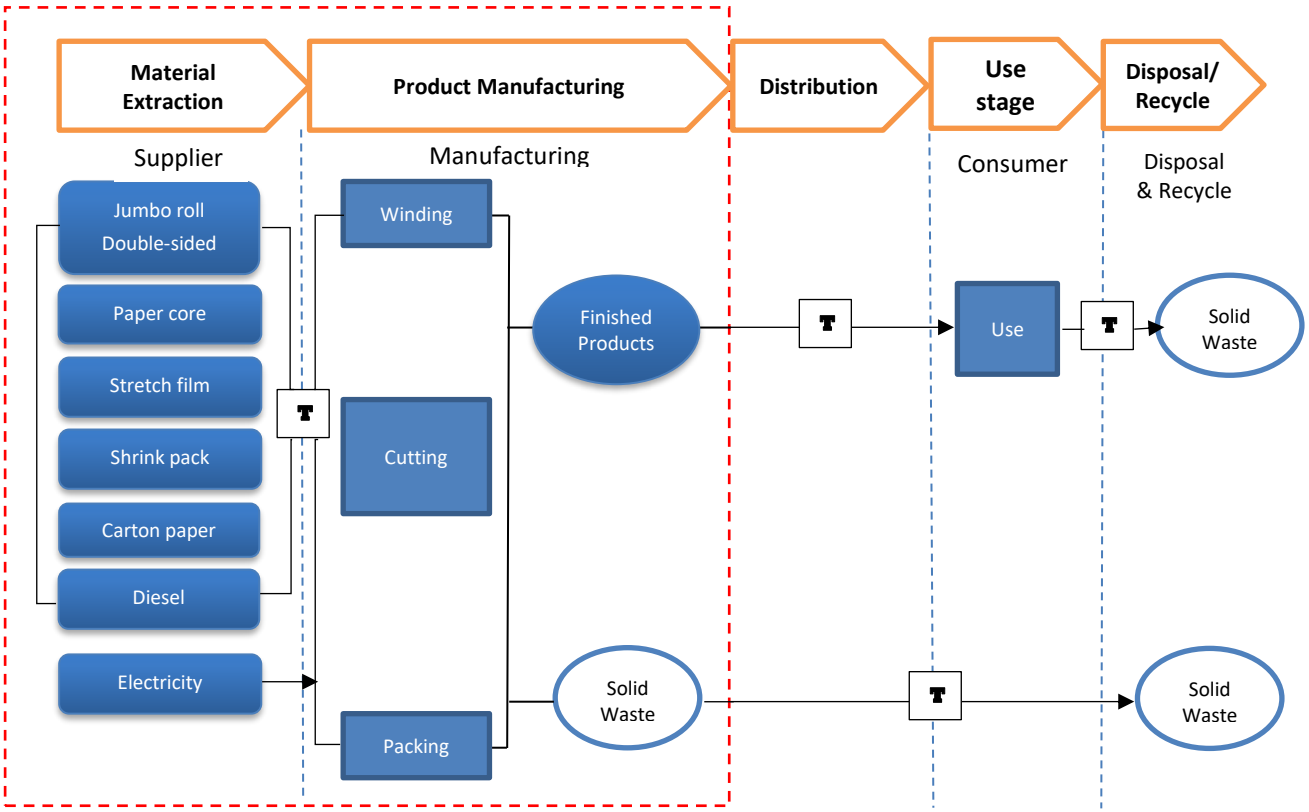

Figure 2: Process map together with its system boundary for Double-sided tape

3.7. Data coverage period

The site-specific data covers from 1 January 2020 – 31 December 2020 (12 months' reference for the inventory data collection).

3.8. Cut-off Rules

Cut-off rules are not applied in this assessment because GTG Manufacturing has provided sufficient primary data and the associated background data used for calculation are available in the database.

3.9. Allocation Procedures

According to ISO 14044:2006 (E), allocation is defined as a procedure of partitioning the input or output flows of a process to the product system under study.

GTG Manufacturing plant produces a variety of tape models by sharing the process flow and energy consumption. The energy consumption i.e., electricity and diesel for a particular model of ***Double-sided tapes*** have been partitioned for each model based on the product output mass ratio.

3.10. Data Requirement and Data Quality

Primary /Foreground Data: Site data as primary data source relevant to the products, appropriately collected and compiled by data owner. Site data are actual data obtained from various data owner in the product's life cycle phases. In cases where actual measured data are not available or too complex for collection, substitutes data through theoretical calculation and estimates are acceptable with consideration on their level of accuracy. Details on the site-specific data are further incorporated in the section onwards.

Secondary / Background Data: Secondary data are data information of characterisation factors (carbon emission factors, EFs) as well as product related data deemed appropriate for filling in any possible data gaps found in primary data. For the characterization factors, the data information normally is sourced from the following:

- Malaysia Life Cycle Inventory Database (MYLCID)
- Commercial databases (GaBi, EcoInvent, etc.)
- Published journals and articles

Available EFs used in the carbon quantification are tabulated herein. Wherever there are no EFs listed for data items, it is understood that no carbon emissions being accounted for in association with the respective data items. This data gap(s) therefore would affect the quantified results; i.e reduced carbon

value due to data gaps. This data gap situation is further addressed under the 'Limitations and Assumptions' section.

Table 2: Summary of carbon emission factors and sources

Data Item	*Material Type*	*Emission Factor, EF ($kgCO_2e$ per kg item, unless otherwise specified)*			
		Value	*unit*	*EF Source*	*EF Description*
Double-sided jumbo roll	Polyethylene	2.306	kg	ecoinvent	Polyethylene granulate (PE)
	Adhesive: synthetic rubber resin	2.644	kg	ecoinvent	Synthetic rubber, at plant
	Acrylate polymer	4.335	kg	ecoinvent	Butyl acrylate, at plant
	Tissue paper	0.971	kg	GaBi	Kraft paper bleached
	Silicone coated paper	0.969	kg	GaBi	Kraft paper one-sided coated
	Foam carrier	4.824	kg	ecoinvent	Polyurethane, flexible foam, at plant
	EVA foam	2.094	kg	ecoinvent	Ethylene vinyl acetate copolymer (EVA), at plant
Paper core	Paper core board	0.485	kg	ecoinvent	Paper core board, at plant
PE core	Polyethylene	2.306	kg	ecoinvent	Polyethylene granulate (PE)
Shrink pack	PVC	2.384	kg	GABI	polyvinylchlorides granulate mix (S-PVC)
Stretch film	LDPE	2.690	kg	ecoinvent	Packaging film, LDPE, at plant
Carton paper	Paper board	1.383	kg	ecoinvent	Corrugated board (technology mix | production mix, at factory | 18% primary fibre, 82% recycled fibre)
Electricity	-	0.89	kWh	MYLCID	Electricity grid mix (Peninsular Malaysia)
Diesel	Diesel	0.3711	kg	MYLCID	Diesel (from crude oil | consumption mix, at refinery | 500 ppm sulphur)
Diesel	Diesel	3.186	kg	IPCC	Gas/ diesel oil
Lorry	Transportation	0.184	t.km	ecoinvent	Lorry 16-32t EURO 3/RER
Lorry	Transportation	0.483	t.km	ecoinvent	Lorry 3.5-7.5t EURO 3/RER
Ship	Transportation	0.0106	t.km	ecoinvent	Transoceanic freight ship/OCE

3.11. Limitations and Assumptions

It is inevitable that some limitations and assumptions need to be made to address data gaps or irregularities (involving both primary and secondary data) to close the quantification process. Listed below are the limitations and assumption observed in the assessment.

Limitations:

- The carbon emissions from the manufacturing of Double-sided jumbo role at the supplier factory are not considered in the calculation due to the difficulty of obtaining the inventory data of the process.

Assumptions:

- Density of diesel was assumed at 0.85 kg/L for the conversion of diesel from L to kg.
- Mode of marine transport were assumed as transoceanic freight ship/OCE for the marine transportations of jumbo rolls from China, Singapore, and India to Port Klang.
- Port of departure in China, Singapore and India were assumed as Port of China (Shanghai), Port of Singapore (Jurong) and Port of India (Calcutta) for the marine transportations of jumbo rolls to Port Klang. Port distances are measured in nautical miles (nm), where 1nm equals to 1.852km.
- Diesel is sourced from a supplier in Semenyih, the same district as the factory, the distance for transportation is assumed as 10km.

4. Life Cycle Inventory Analysis

The site-specific inventory data for CFP quantification purposes are provided in this section. All on-site data is collected and compiled by GTG Manufacturing using a Product data sheet (PDS) template provided by SIRIM. The summary of input output data for production of Double-sided tape is shown in Table 3.

Table 3: Input-output flow of Double-sided tapes

Input – Output Flow					
Input			*Output*		
Material	*Quantity*	*Unit*	*Material*	*Quantity*	*Unit*
Polyethylene	332.1	kg	DS EVA Foam Tape	449	CTNS
Adhesive: Synthetic Rubber Resin	413.65	kg	DS PE Foam Tape	37	CTNS
Acrylate polymer	319.24	kg	DS Tissue Tape	229	CTNS
Tissue paper	67.5	kg	DS Acrylic Foam Tape	31	CTNS
Silicone coated paper	303.75	kg	DS Polyester Tape	3	CTNS
EVA Foam	397.88	kg	Plastic waste	55	kg
Natural Rubber Adhesive	1.95	kg	Paper waste	33	kg
Foam Carrier	12.68	kg			
Paper core	772	pcs			
Electricity	219.5	kWh			
Shrink pack (PVC)	12	roll			
Stretch film (LDPE)	30	roll			
Carton paper	749	CTNS			
Diesel	14.65	L			

Information on the transportation of materials from the source location to the manufacturing site or disposal location is shown in Table 4.

Table 4: Information on the transportation of materials

Material	*Source location*	*Transport mode*	*Manufacturing/ disposal location*
Double-sided jumbo roll	China (80%), India (10%), India (10%)	Ship 30-tonne lorry	GTG Manufacturing
Paper core	Sungai Buloh	20-tonne lorry	GTG Manufacturing
Diesel	Semenyih	3-tonne lorry	GTG Manufacturing
Stretch film	Batu Pahat	30-tonne lorry	
Shrink pack	China	Ship 30-tonne lorry	GTG Manufacturing
Carton paper	Kajang	30-tonne lorry	GTG Manufacturing
Plastic waste	GTG Manufacturing	26-tonne lorry	Kajang
Paper waste	GTG Manufacturing	26tonne lorry	Kajang

5. Results and Discussion

The detailed of CFP profiles for each selected ***Double-sided tapes*** model are summarized in Table 5.

Table 5: Summary of CFP profiles for Double-sided tapes

Model/ Unit Process	**kgCO_2e/CTNS**	**KgCO_2e/roll**	**KgCO_2e/kg**	**%**
Double-sided PE Foam tape	**25.670**	**0.178**	**5.942**	**100**
Winding	*24.946*	*0.173*	*5.775*	*97.18*
Cutting	*0.036*	*0.0003*	*0.008*	*0.14*
Packing	*0.688*	*0.005*	*0.159*	*2.68*
Double-sided Tissue tape	**9.177**	**0.032**	**0.861**	**100**
Winding	*7.390*	*0.026*	*0.694*	*80.54*
Cutting	*0.090*	*0.0003*	*0.008*	*0.98*
Packing	*1.696*	*0.006*	*0.159*	*18.48*
Double-sided Polyester tape	**31.790**	**0.110**	**0.830**	**100**
Winding	*25.369*	*0.088*	*0.662*	*79.80*
Cutting	*0.323*	*0.001*	*0.008*	*1.02*
Packing	*6.097*	*0.021*	*0.159*	*19.18*
Double-sided Acrylic Foam tape	**8.439**	**0.059**	**0.586**	**100**
Winding	*6.025*	*0.042*	*0.418*	*71.40*
Cutting	*0.122*	*0.001*	*0.008*	*1.44*
Packing	*2.292*	*0.016*	*0.159*	*27.16*
Double-sided EVA tape	**5.252**	**0.036**	**0.986**	**100**
Winding	*4.359*	*0.030*	*0.818*	*83.00*
Cutting	*0.045*	*0.0003*	*0.008*	*0.86*
Packing	*0.848*	*0.006*	*0.159*	*16.15*

**Note: All processes have accounted the transportation data.*

Based on the functional unit identified in this CFP study, it is noticeable that Double-sided PE Foam tape has the highest CFP value with 5.942 kgCO_2e/kg, followed by Double-sided EVA tape, Double-sided Tissue tape, Double-sided Polyester tape, and Double-sided Acrylic Foam tape with carbon emission of 0.986 kgCO_2e/kg, 0.861 kgCO_2e/kg, 0.830 kgCO_2e/kg, and 0.586 kgCO_2e/kg respectively. In general,

winding process is the major contribution to the total CFP profile for the manufacturing of all models of ***Double-sided tapes***, followed with packing and cutting. With respect to the winding process, most of the CFP value is contributed by material consumption, and only a small portion of the CFP value is contributed by electricity and transport.

Based on the tabulated figures above, the CFP value information can also be translated as:

- 25.670 $kgCO_2e$/CTNS and 0.178 $kgCO_2e$/roll for Double-sided PE Foam tape.
- 9.177 $kgCO_2e$/CTNS and 0.032 $kgCO_2e$/roll for Double-sided Tissue tape.
- 31.79 $kgCO_2e$/CTNS and 0.110 $kgCO_2e$/roll for Double-sided Polyester tape.
- 8.439 $kgCO_2e$/CTNS and 0.059 $kgCO_2e$/roll for Double-sided Acrylic Foam tape.
- 5.252 $kgCO_2e$/CTNS and 0.036 $kgCO_2e$/roll for Double-sided EVA tape.

The summary of the CFP profiles for each ***Double-sided tapes*** model is illustrated in Figure 3.

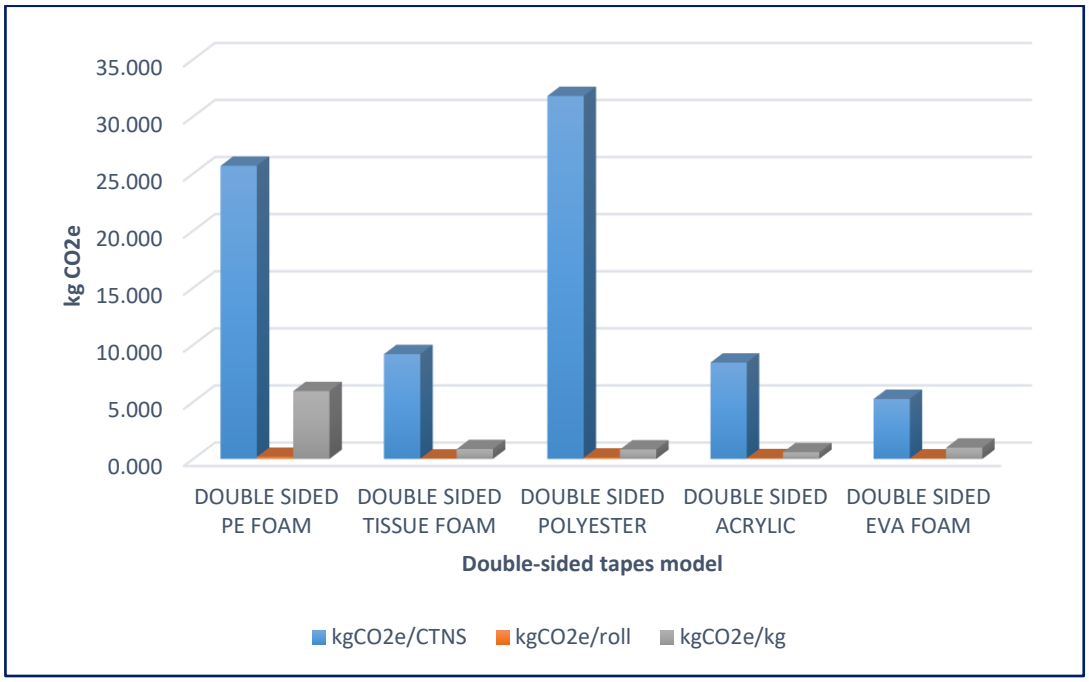

Figure 3: CFP profiles for Double-sided tapes model

6. Conclusion

The ***Double-sided tapes*** produced by GTG Manufacturing at the Semenyih manufacturing plant with Double-sided PE Foam tape, Double-sided Tissue tape, Double-sided Polyester tape, Double-sided Acrylic Foam tape, and Double-sided Acrylic Foam tape have the carbon emissions of 5.942 $kgCO_2e$/kg, 0.861 $kgCO_2e$/kg, 0.830 $kgCO_2e$/kg, 0.586 $kgCO_2e$/kg, and 0.986 $kgCO_2e$/kg respectively. Most of the carbon emission was emitted from the Winding process which comes mostly from materials consumption.

At the same time, it should be noted that the product has a CFP value of 25.670 $kgCO_2e$/CTNS and 0.178 $kgCO_2e$/roll for Double-sided PE Foam tape, 9.177 $kgCO_2e$/CTNS and 0.032 $kgCO_2e$/roll for Double-sided Tissue tape, 31.79 $kgCO_2e$/CTNS and 0.110 $kgCO_2e$/roll for Double-sided Polyester tape, 8.439 $kgCO_2e$/CTNS and 0.059 $kgCO_2e$/roll for Double-sided Acrylic Foam tape, and 5.252 $kgCO_2e$/CTNS and 0.036 $kgCO_2e$/roll for Double-sided EVA foam tape.

7. References

[1] International Standard ISO 14067: 2018; Greenhouse gases - Carbon footprint of products - Requirements and guidelines for quantification-Principles and Framework.

[2] Intergovernmental Panel on Climate Change, 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

For more information, please contact:

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