

# Environmental Impact Report

## Introduction

The purpose of this report is to outline the main contributions of carbon emissions of Rugged Interactive products. The data in this report is based on the Freestyle Duo with the intention of deriving a way to estimate the carbon equivalent value based on the weight of other similar products.

## High-Density Polyethylene (HDPE) Casing

The HDPE casing makes up the majority of the final products weight and therefore the source of the majority of the emissions. The casing uses pellets produced in Belgium, of which 0% is from recycled material, further increasing the carbon equivalent value of this part. The manufacturing process uses LPG fuel to heat the material to roughly 166 degrees Celsius, with no information available for the quantity of fuel used for the process. To overcome this, the following equations can be used to estimate the fuel required:

Specific heat capacity of HDPE (SHC) = 2000 J/ kg.K  
Forming temperature ( $T_F$ ) = 439 Kelvin  
Thermal efficiency ( $\eta$ ) ~ 40%  
Combustion energy of LPG ( $E_F$ ) = 50MJ/kg  
HDPE mass ( $m_c$ ) = 22kg

$$(1) \quad m_F = (SHC \cdot (T_F - 291) \cdot m_c) / (\eta \cdot E_F) = 0.326kg$$

Density of LPG is roughly 0.5 kg/L which results in the volume of fuel used in the process to be 0.652 Litres.

## PCB

Due to data regarding the CO2 equivalent of PCBs not being available from the suppliers, estimations have been made from a publication by Tobias Kupka et. al. [2] based on typical PCB design.

Relative to its mass, the emissions from PCB production are very high when compared to other parts. Subsequently, this could create issues when creating estimates for other products that have a much higher proportion of PCB mass, such as Freedom Gaming.

## Freight

Much like the emissions of the raw materials, the contribution of the HDPE casing dominates the emissions from logistics due to its mass and the inefficient transport methods. The efficiency of freight depends largely on the capacity utilisation. It is assumed that the raw materials are delivered by road in lorries at full capacity, whereas the moulded products are delivered in lorries operating at much lower capacity. As a result, the emissions of the transit from Belgium to Somerset are roughly equal to those of the transit from Somerset to Bodmin, despite the latter being over three times shorter.

Parts produced in China contribute a small proportion of the weight of the final product and are delivered via a very efficient transport method that contributes very little to the final value.

## Data Table

Category	Item	Measure		Specific Carbon Equivalent (Kg CO2/ unit ) [1]	Total Carbon Equivalent (Kg CO2)
		Quantity	Unit		
Materials	HDPE case	22	kg	1.9	41.8
	PCB	0.06	m <sup>2</sup>	100.82	6.05
	Copper	0.2	Kg	2.77	0.554
Frieght	HDPE case (RM)	608 x 0.022	km.t	0.25 (35t lorry full)	3.344
	HDPE case	177 x 0.022	km.t	0.82 (20t lorry 1/2 full)	3.2
	Electronics	21700 x 0.001	km.t	0.01	0.271
Manufacturing	LPG fuel	0.652	L	1.7	1.11
				<b>Total</b>	<b>56.33</b>

*Table 1: Summary of equivalent carbon emissions of production and delivery.*

## Carbon Offset

It is widely agreed that the average carbon capture of a British tree is 1000kg in its lifetime [3][4]. When divided by the total carbon equivalent of a single Freestyle Duo, this equates to **17.8 items** offset by a single tree.

A specific value of emissions per kg of Rugged products can be found by dividing the total CO2 value by the weight of a completed Freestyle Duo (2.17 kg CO2/kg). By multiplying the mass of completed products by **2.17**, this can produce a reasonable estimate for the value for that specific product.

## Other Considerations

The value for the number of products offset by a single tree is an overestimate due to multiple factors being neglected. These include:

- International delivery of the final product,
- The energy usage of the products of their lifespan,
- Various parts not included.

Parts that weren't included can be considered to have negligible impact. However, the international delivery and power use of the products lifetime are both considerable factors. The former is something that will differ between orders, it could be calculated as an average of international delivery distances, however an accurate value would be hard to achieve. It can be argued that the latter is not the responsibility of Rugged, but that of the customer.

## References

[1] "MODULARIZATION OF PRINTED CIRCUIT BOARDS THROUGH EMBEDDING TECHNOLOGY AND THE INFLUENCE OF HIGHLY INTEGRATED MODULES ON THE PRODUCT CARBON

FOOTPRINT OF ELECTRONIC SYSTEMS": *Tobias Kupka, Gernot Schulz, Thomas Krivec, Wolfgang Wimmer*; AT&S AG, Fabrikgasse 13, 8700 Leoben, Austria.  
TU Vienna, Institute for Engineering Design and Logistics Engineering, Austria.

[2] [https://www.winnipeg.ca/finance/findata/matmgt/documents/2012/682-2012/682-2012\\_Appendix\\_H-WSTP\\_South\\_End\\_Plant\\_Process\\_Selection\\_Report/Appendix%207.pdf](https://www.winnipeg.ca/finance/findata/matmgt/documents/2012/682-2012/682-2012_Appendix_H-WSTP_South_End_Plant_Process_Selection_Report/Appendix%207.pdf) *Winnipeg 2012*.

[3] <https://granthaminstitute.com/2015/09/02/how-much-co2-can-trees-take-up/>

[4] <https://www.viessmann.co.uk/heating-advice/how-much-co2-does-tree-absorb>