MKS PAMP – CARBON FOOTPRINTS OF 1kg GOLD BARS AND LARGE GOLD BARS (12.5kg)

Product Emissions Report

March 2024

Contents

1. Summary

1.1. Introduction

This report presents the footprinting study results calculated for MKS PAMP to measure the carbon footprints of their gold bars, namely 1kg and Large Bars. Footprint Expert v5 is a Carbon Trust developed and owned footprinting tool that was used to calculate the results.

This report conforms to the requirements for public disclosure of the life cycle GHG emissions of products laid out in the “Code of Good Practice for product GHG emissions and reductions”. It aims to provide the basis to allow consistent information for product GHG emissions and reduction, assessed in conformity with the ISO 14067 standard.

1.2. Background Information

Table 1: MKS PAMP Products Carbon Footprint - Background Information

Category	Description
Company name	MKS PAMP
Company contact information	Prom. de Saint-Antoine 10, 1204 Geneva, Switzerland
Product name(s)	Gold bars (1kg and Large Bars)
Boundary	Cradle-to- grave
Standards, specifications and/or other documents used for footprinting methodology against which the company has been assessed for conformity	ISO 14067 Standard Carbon Trust Product Carbon Footprint - Requirements for Certification v2.0
Name of the independent, third-party verifier	Carbon Trust Assurance Ltd
Level of assurance achieved	Reasonable
Date of certification	01/07/2023 - 30/06/2024
Functional unit	$kgCO_2e$ per kg of gold bar
Data period	01/07/2022 – 30/06/2023
Product consistency criteria (PCC)	Product Category Criteria Form for Precious Metals

1.3. Results

The overall emissions are reported in Table 2 below. Detailed emissions results are shown in **Section 1.11.**

Table 2: Footprinting results Large Bars and 1kg Gold Bar Results (Cradle-to-Grave) – Global Market

	Per SKU		per KG		Contribution per kgCO2e/kg	
	Gold Large Bar	1kg Gold Bar	Gold Large Bar	1kg Gold Bar	Gold Large Bar	1kg Gold Bar
Weight per SKU (kg)	**12.50**	**1.00**	**12.50**	**1.00**	**12.50**	**1.00**
Fossil emissions per SKU	10,617,934	324,233,388	2,718	2,719	95%	95%
Biogenic Emissions per SKU	58	740	0.01	0.01	0%	0%
Biogenic Removals per SKU	- 23	- 131	- 0.01	- 0.001	0%	0%
Land Use Change per SKU	523,674	15,983,918	134	134	5%	5%
Total annual production (kg)	3,906	119,236	3,906	119,236	100%	100%
Total fossil footprint (kgCO2e)	**10,617,934**	**324,233,388**	**2,718**	**2,719**		
Total Biogenic & LUC Emissions (kgCO2e)	**523,710**	**15,984,526**	**134**	**134**		
Total Emissions (kgCO2e)	**11,141,644**	**340,217,914**	**2,852**	**2,853**		

1.4. Data

The data quality assessments were carried out based on a key developed internally at Carbon Trust. The overall data quality for the project was good because of the granularity of the data received and its completeness.

1.5. Key Assumptions

Table 4 in Section 1.9.1 outlines the key assumptions that have been made.

1.6. Interpretation of results

An overall breakdown of the emissions associated with the various products and process steps for each product are reported in **Table 6: Large Bars and 1kg Gold Bar Results (Cradle-to-Grave) – Global Market.** This table demonstrates that the highest emission process is that of the raw material (raw gold) which account for 95% of the total footprint and land use change which accounts for 5% of the total footprint.

Land Use Change (LUC) emissions were not calculated in the previous product footprints but have been included for this product footprint in order to keep up with current standards and best practices, such as Land Sector and Removals Guidance from the Greenhouse Gas Protocol (GHGP) and World Resource Institute (WRI).

The LUC methodology follows the 2019 IPCC Guidelines for National Greenhouse Gas Inventories. The equations and default constants used in the methodology are revised for specific land and biomes. To calculate LUC emissions, direct LUC equations and methodology were used. Indirect LUC has not been accounted for due to the lack of internationally agreed procedure.

Further details are recorded in section 1.9.1 Methodological Choices.

1.7. Disclaimer on uncertainty

The emissions figures provided in this report have been calculated in accordance with the requirements of ISO 14067 standard, using the primary and secondary sources of data specified above. Based on ISO 14067 standard method of assessment, we believe that our assessment has identified 95% of the likely GHG emissions associated with the full life cycle of the products covered in this report. However, readers should be aware that even primary sources of data are subject to variation over time, and the figures given in this report should be considered as our best estimates, based on reasonable cost of evaluation.

1.8. Boundary

The process map for the gold bars (1kg and Large Bars) are as follows:

Figure 1: Life Cycle Stages

1.8.1. Raw materials

Gold inputs come from both virgin and recycled sources. The activity data provided by MKS PAMP was the total mass of the raw material inputs for each footprinted product over the reporting year.

The largest emission source within the raw materials was the gold input. The emission factors used for the gold were calculated using the EU Product Environmental Footprint Circular Footprint Formula (PEF CFF). The virgin emission factor for gold was calculated for specific suppliers provided by MKS PAMP. Recycled emission factors for gold were taken from literature, including academic journal articles, research[1] and EcoInvent 3.9.1, and averaged.

The Product Environmental Footprint (PEF) is a life cycle assessment (LCA) based method to quantify the environmental impacts of products established by the EU. The overarching purpose of PEF is to enable to reduce the environmental impacts of goods, accounting for supply chain activities (from extraction of raw materials, through production and use and to final waste management). This purpose is achieved through the provision of detailed requirements for modelling the environmental impacts of the flows of material/energy and the emissions and waste streams associated with a product throughout its life cycle.

The Circular Footprint Formula (PEF CFF) provides the approach that shall be used to estimate the overall emissions associated to a certain process involving recycling and/or energy recovery. These moreover also relate to waste flows generated within the system boundary.

The emission factor applied to the input gold material was calculated using the following two formulae which have been derived from PEF CFF below. An adaptation has been made in multiplying it with EvLUC to account for land use change from mining,

Pr = R2 x (1−A)MQL+R1A

EF = Pr x Er + (1-Pr) x Ev + Pr x Er + (1-Pr) x EvLUC

With respect to both the virgin gold and recycled gold, a 3-year rolling average emission factor has been applied and implemented into the PEF CFF. This allows MKS Pamp to obtain a supplier specific EF from each of their mines which may have varying yields over the years.

Pr is derived by calculating an average of the mine emission factors over the 3-year period.

Table 3: Explanation of PEFCFF formula

Parameter	Definition
Pr	The portion of the emission factor which can use Er (the recycled content)
Ev	Specific emissions and resources consumed (per functional unit) arising from the acquisition and pre-processing of virgin material, 3-year rolling average applied to this figure.
Ev LUC	Specific emissions and resources consumed (per functional unit) arising from land use change emissions caused by extraction of the virgin material.
Er	Specific emissions and resources consumed (per functional unit) arising from the recycling process of the recycled (reused) material, including collection, sorting and transportation process.

1
Medium (Harvey- Walker, 2019)
Academic Journal (Fritz,2020)

Er LUC	Specific emissions and resources consumed (per functional unit) arising from land use change emissions caused by the recycled material
R1	Proportion of material in the input to the production that has been recycled from a previous system. A three year rolling average has also been applied to R1.
R2	Proportion of the material in the product that will be recycled (or reused) in a subsequent system. R_2 shall therefore take into account the inefficiencies in the collection and recycling (or reuse) processes. R_2 shall be measured at the output of the recycling plant.
A	Allocation factor of burdens and benefits (jointly: "credits") between supplier and user of recycled materials. *For metals, this value is 0.2.*
MQL	The recycling process shall account for material quality loss during recycling, which is pre-defined for most materials. *For metals, this value is 1.*

Definitions from: PowerPoint-Präsentation (europa.eu)

For other chemical inputs, emission factors were taken from the FPX v4.7 database, BEIS 2022 and EcoInvent 3.9.1. In the cases when the emission factors were not available in either database, an emission factor of a similar chemical was applied from EcoInvent.

1.8.2. Manufacturing

The raw materials were transported to MKS PAMP's manufacturing facility in Switzerland.

The activity data provided by MKS PAMP included the distance and mode of transport for each of the raw materials, as well as supplier location. Using these distances, the air freight, road freight and sea freight FPX v4.7 calculators were used to find the emission factors for each ingredient's upstream transport.

For manufacturing, electricity was the main energy source and 100% of the electricity was derived from hydroelectric power. Other energy sources used at the plant were natural gas and propane. This activity data was provided by MKS PAMP in MWh / year (for electricity) and m^3 / year (for natural gas and propane) for each process step. IEA 2022 emission factor was used for electricity as they use renewable energy. Emission factors from BEIS 2022 were used for natural gas and propane. For each process step a specific amount of $kgCO_2e$ emissions were associated with them, namely for example the first melting or the anode casting.

There were the following waste streams: black water, white water, non-precious metal waste, used crucibles. Waste activity data was derived from input data provided by MKS PAMP and BEIS 2022 was used for waste treatment emission factors.

1.8.3. Packaging

Packaging was carried out at MKS PAMP's facility in Ticino, Switzerland.

1kg gold bars are individually packaged in protective plastic rolls with a paper certificate each. 25 bars are packaged in one plastic box for shipping.

Large Bars are packaged in wooden pallets, separated by a cardboard sheer. Each pallet contains 500kg of gold (40 large bars at 12.5kgs each).

In terms of activity data, the mass of materials for one box or pallet was provided. These masses were then scaled up to account for the total production output for each product. Emission factors applied to these packaging materials came from the Carbon Trust's FPX v4.7 database.

1.8.4. Downstream Distribution

Finished products are transported by road from MKS PAMP in Switzerland to Zurich airport or to the final customers in Switzerland. For the 1kg gold bar, the products are flown to France, India, Jordan, Saudi Arabia, Turkey, United Arab Emirates, United States, and Switzerland. From here, the products are transported to the end customer, by air and/or road. The large gold bars are distributed by road to their final destinations within Switzerland.

For each country, the activity data was calculated using the specific mode and distance of the type of transport used. Emission factors were applied to these activity data which derive from Carbon Trust FPX v4.7 transportation calculator.

1.8.5. End of life

For the gold bars it is assumed 100% of the metal is recycled. The End-of-Life profile for packaging was calculated using BEIS 2022 disposal emission factors and the disposal method percentages of the different countries of the sold products.

1.9. Methodology

1.9.1. Methodological choices

Significant methodological choices for calculating the product footprint of MKS PAMP's SKUs are listed below:

- Calculation models were based on templates available in Footprint Expert Multi SKU and Footprint Expert 4.7 (FPX). These were set out in the different life cycle stages of gold bar, from the raw materials entering the facility and going through the first round of the foundry, to the grain entering the bullion department, packaging, and sent to retailers.
- Global warming potential (GWP) factors were taken from the FPX Reference Database and EcoInvent 3.9.1.
- Materiality methodology and cut-off criteria: any process that constituted less than 1% of total emissions was excluded from the assessment. This includes upstream packaging of the raw material

inputs, namely the chemicals and gold, and land use change for 2% of procured gold where the mine source could not be verified and accurately calculated.

- Land use change calculation tool follows the 2019 IPCC Guidelines for National Greenhouse Gas Inventories. Equations and default constants used in the methodology are revised for specific land and biomes.
- A 3-year rolling average has been applied to the virgin gold emissions factor and the percentage of recycled gold procured.

Table 4 outlines the key assumptions that have been made.

Table 4: List of Assumptions

Process Step	Key assumption
Entire process	400oz = large
Grouping	Grouping has been done for the different finesses, ie 995+ and 999.9 gold large bars have been grouped as large bars. This is because the differences lie in downstream distribution and end of life, the rest of the processes remain the same. The two are less than 1% of the total footprint and hence have been aggregated
Water	No water input data was provided; therefore, it was assumed that the sum of black and white water was that of input water.
End of Life	Where specific packaging disposal data could not be provided, assumptions were made based on the percentage of gold sold in each geographical region and applied to each SKU to calculate end of life emissions per country.
Inbound transportation	To calculate exactly how much gold was transported per different supplier, looked at total amount transported, and then calculated the percentage per supplier and applied that to the total amount of gold used. This percentage split is included in the model.
SKUs	For the large bars, the LBMA and Swiss are the same finesse and hence product, the only difference is the engraving on the product, for it to be sold in specific areas.
Emission factors	For the raw materials where emission factors were not found, a generic Ecoinvent organic chemical emission factor was applied.
Input allocation	The data received was for the family group of the product and not per different SKU, essentially it was for all the gold large bars produced, hence an allocation key was created which was then used to determine the amount of gold produced and consequently the amount of materials/utilities is used.
Raw Materials	Only 10 months of data for the raw materials were available, made calculation to uplift to 12 months' worth of data
Raw materials	The virgin emission factor for gold was provided by MKS PAMP for all its suppliers, where there were none, an emission factor taken from the world gold council study was used.
Raw materials	Potassium fluoroborate EF was not reported in Ecoinvent 3.9.1 so the EF for sodium fluoroborate was used instead
Raw materials	For trimercaptotriazine and many chemicals in the minting department, a specific chemical could not be found in EcoInvent 3.9.1 so the 'chemical, organic//[GLO] chemical production, organic' was used instead
End of life	In terms of the PEF CFF, a 100% recycling rate of finished gold is assumed for finished gold products. Due to the nature of the value of the end product, we

	assume that this will not be disposed of through waste streams and will eventually be recycled. Furthermore, the products are sold branded and stored in vaults so unlikely that they are purchased for further processing.
Land Use Change	A 20-year life-cycle assessment period is used, despite the potential for a mines life cycle to surpass 20 years. This is based on the IPCC's Good Practice Guidance for Land Use, Land Use Change and Forestry default value of 20 years, such that land use data is collected from 2003. The linear discounting method is used to allocated emissions over this 20-year period.
Land Use Change	Using the gold procured by MKS Pamp, we calculated a percentage for the amount of gold MKS Pamp procures of total gold produced by each mine. The percentage is used to apportion the hectares of land use change of the mine for only the amount procured by MKS Pamp.
Land Use Change	If exact start date for the mine is unknown, a mid-period start date of 2013 during the 20-year period was assumed for the initial land-use change of developing the mine
Land Use Change	Assume no land use change where land type is rocky/ desert or where there have been no visible expansions or change to the land scape in the last 20 years.
Land Use Change	There are several mines where the source is not a mine, but a bank or aggregator. The amount of gold from these sources amounts to less than 2% of total gold. These mines have been excluded from the LUC calculation as there is not enough evidence to make appropriate assumptions and it is not deemed to be material to this overall footprint.
End of Life	Waste disposal percentages per each country were uplifted to ensure that the total added up to 100%
Waste	MKS Pamp inputs include raw metals, chemicals, and water. To balance the input and output materials, it is assumed that all chemicals are wasted as copper sulphates.

1.9.2. Allocation of inputs

MKS PAMP produce several products at their facility. Raw materials, outputs and utilities were provided for each process step for all products within project scope. When modelling the individual product footprints, a calculation was made to identify the production inputs and utilities required for 1kg of each product and the associated outputs for 1kg of product. This was then multiplied by the total output of the product to determine the total input emissions associated with each SKU.

The inbound transportation file included the transportation information for all inbound gold. In order to allocate only the emissions related to the large gold bars and the 1kg Gold Bars, an allocation factor was required. Using the percentage of gold procured from each mine of the total gold procured, an allocation was calculated to determine the input gold transported from each mine for both the large gold bar and the gold kilo bar. An additional adjustment was made to the inbound gold to remove the inbound gold related solely to the provenance gold bars and provenance gold grains. The client provided a percentage split of gold per product from each of these source mines.

The LUC emissions were also calculated using an allocation factor. The change in land use was calculated by drawing polygons on google earth of the developed land areas. The land use change in hectares was apportioned based on the percentage of gold procured by MKS Pamp for this product over the total metals production of the mine.

1.9.3. Allocation due to recycling

Recycling allocation allows products to use the generally lower, recycled material emissions factor, rather than exclusively using virgin material emissions factors, for a portion of some input materials — thereby reflecting the benefits of recycling in reducing GHG emissions. The methodology (PEF CFF) used, balances how much benefit is attributed to products that use recycled input materials and how much is attributed to products that are recycled and provided these materials.

It was assumed that gold had a 9recycling rate of 100% due to the high value of the end product. The end-of-life fates for packaging materials were found at a country level.

Please refer to section 1.8.1 where further information is provided on the PEF CFF.

1.9.4. Grouping

This footprint includes the grouping of four SKUs into two final products: Gold large bars and 1kg gold bars. The reasoning behind the grouping is due to the similarity of the products. The 995+ product contains traces of silver in the final product. The difference in the footprint which would arise from this is considered immaterial due to the emission factor for silver being considerably lower than the emission factor for gold.

Table 5: SKU list of footprinted products

Product Name	SKU	ID Number
Gold Large Bar	Finesse 999.9 LBMA	ZAULB00117
Gold Large Bar	Finesse 995+ LBMA	ZAULB00121
Gold Large Bar	Finesse 995+ Swiss	ZAULB00122
1 kg Gold Bar	Finesse 999.9	ZAUCB00211
1 kg Gold Bar	Finesse 995	ZAUCB00204

1.10. Data

1.10.1. Data Collection and Validation

MKS PAMP provided all activity data used for the analysis. All the input data drivers are summarised in the footprint model under their relevant process sheet. The main point of contacts for the data was MKS PAMP ESG team members. The Carbon Trust provided MKS Pamp with a data collection template to be used.

1.10.2. Data Quality

The data quality assessments were carried out based on a key developed internally at Carbon Trust.

Scores range from “Excellent” to “Lowest quality” with an excellent score representing data at the most granular level, in units which relate directly to the best available emission factors. An example of lower quality data would be data derived from proxies or uncalibrated assumptions. The table below provides some guidance and example data for the Carbon Trust scoring system. Note that the final data quality results, presented in **Table 5,** shows scores ranging between very good and excellent with an overarching score of **Good,** scores rated good and acceptable have an overarching score of **Medium** and the lower scores all fall under a **Low** score**.**

Data Quality Score	Data Quality Scoring Guidance	Example - Materials data
Excellent	Data at granular level (e.g. by product, supplier) in units that directly relate to the best available emission factors	Tonnes of "Steel grade XY… blast oxygen furnace" or "Alu grade Z extruded and anodized…"
Very Good	Data with some granularity (e.g. by country) in units that directly relate to the best available emission factors	Tonnes of "Steel BOF production" or "Aluminium extruded"
Good	Data in units that are a good proxy for emissions	Tonnes of "Steel" or "Aluminium"
Acceptable	Data in units that are a reasonable proxy for emissions	Tonnes of "Metals"
Low Quality	Data in units that are a low quality proxy for emissions	Spend on "Parts" or "Components"
Lower Quality	Data in units that are a lower quality proxy for emissions	Spend on "Goods"
Lowest Quality	Data from uncalibrated assumptions	Unknown

Generally, data quality for the project ranged between good and excellent with some acceptable scoring. Overall, the activity data was consistent with the boundary year, provided in some granularity and could be matched with the best available emission factors. In some cases, such as the land use change, assumptions were made around the mine data (see **Table 4** for full assumption list), which were appropriate and reasonable, such as the allocation of hectares based on the procured raw materials of total mine production and some proxies where mine data was unavailable. More primary data for the land use change emissions calculation would result in a higher data quality score. Similarly with inbound gold, some assumptions were made based on the outbound distribution and waste to calculate the input gold required for large gold bars and 1kg Gold Bars. **Table 5** summarises the data quality assessment of the most material data points.

Table 5: Data quality assessment for material data points (Scale; Low, Medium, Good)

Data point	Activity Data Quality Indicator	Emission Factor Data Quality Indicator	Application Data Quality Indicator
Raw Materials	Good	Medium	Medium
Packaging	Good	Good	Good
Manufacturing	Good	Good	Good
Downstream distribution	Good	Good	Good
End-of-Life	Medium	Medium	Medium
Land Use Change	Medium	Medium	Medium

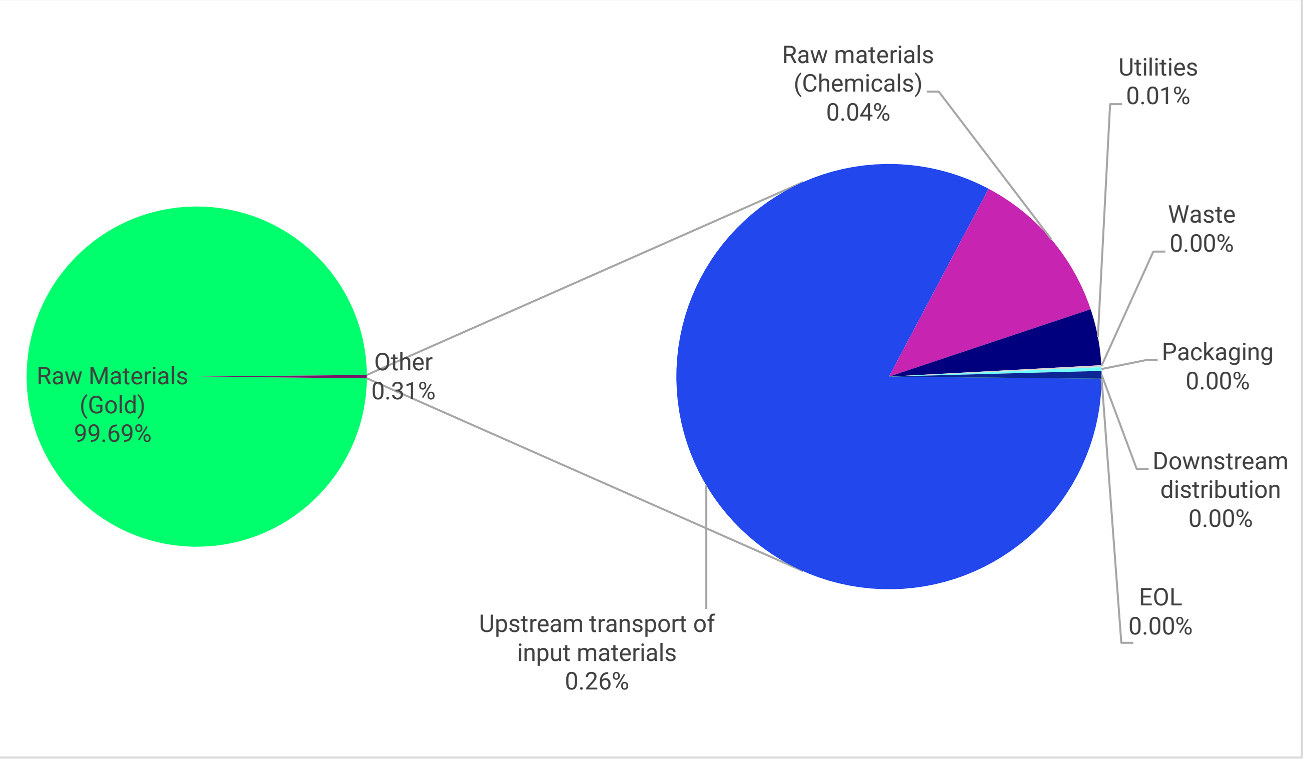
1.11. Detailed results

An overall breakdown of the emissions associated with the various products and process steps is reported in Table 6 below. Please refer to the complementary Excel file, [Phase 1 MKS PAMP FPX Multi SKU V5], for a full breakdown of all product carbon footprints.

Table 6: Large Gold Bar Total Carbon Footprint Results (Fossil, Biogenic & Land Use Change)

Life Cycle Stage	kgCO2e	kgCO2e/kg	Contribution per lifecycle stage
Upstream transport of input materials	28,511	7.3	0.26%
Raw Materials (Gold)	11,107,127	2,843	99.69%
Raw materials (Chemicals)	4,181	1.07	0.04%
Utilities	1,477	0.38	0.01%
Waste	50	0.01	0.0005%
Packaging	97	0.02	0.0009%
Downstream distribution	201	0.05	0.0018%
End of life	0.09	0.00	0.000001%
Total footprint (kgCO2e)	**11,141,644**	**2,852**	**100%**

Figure 2: Gold Large Bar Carbon Footprint

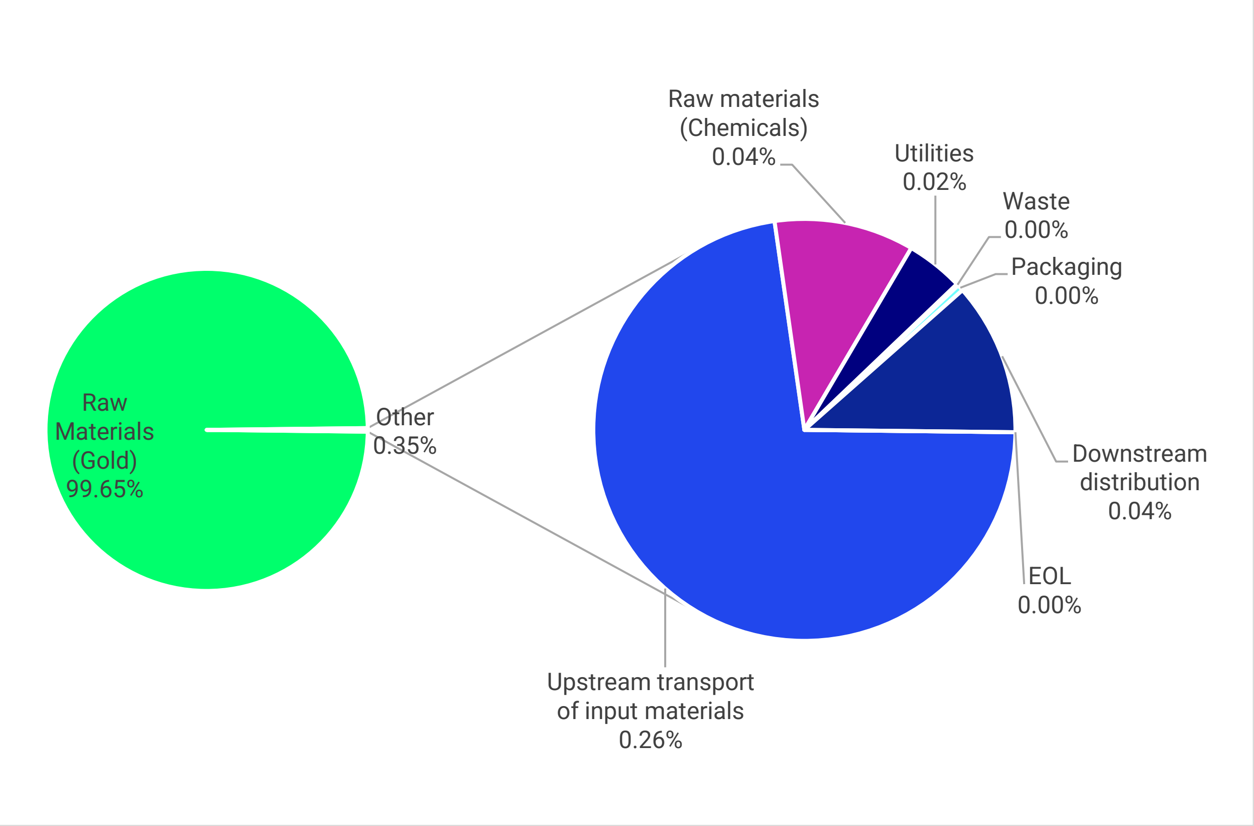


1kg Gold Bar

Table 7: 1kg Gold Bar Total Carbon Footprint Results (Fossil, Biogenic & Land Use Change)

Life Cycle Stage	kgCO2e	kgCO2e/kg	Contribution per lifecycle stage %
Upstream transport of input materials	870,270	7.30	0.26%
Raw Materials (Gold)	339,018,609	2,843	99.65%
Raw materials (Chemicals)	128,517	1.08	0.04%
Utilities	52,768	0.44	0.02%
Waste	1,624	0.01	0.0005%
Packaging	5,816	0.05	0.002%
Downstream distribution	140,309	1.18	0.04%
End of Life	0.25	0.000002	0.0000001%
Total footprint (kgCO2e)	**340,217,914**	**2,853**	**100%**

Figure 3: 1kg Gold Bar Carbon Footprint



1.12. Conclusions

The two main hotspots within the carbon footprint of both the large gold bar and the 1kg Gold Bar is that of the raw materials, namely the raw gold and the land use change, driven by the carbon intensity surrounding the emission factors.

1.13. Recommendations

1.13.1. Emissions reductions

The main emissions hotspot of both products is the gold raw material input and land use change from the source mines. Sourcing raw materials with a higher percentage of recycled content would be the most impactful way of reducing the product footprint.

Moreover, switching to the use of low-carbon methods of transport, both upstream and downstream (business to business transport), will decrease this further. This might include alternative fuels, electric vehicles, or even more efficient delivery routes. For third-party logistics, (retailer to consumer) it is recommend that MKS PAMP engage with suppliers in switching to more sustainable transport options.

In addition to the procurement of recycled gold, MKS Pamp could work more with mines to understand what land rehabilitation projects they are involved and see where they could lower LUC emissions by sourcing from mines that are in not in expansion or increasing emissions through land use change.

1.13.2. Data quality improvements

There are several recommendations to improve future recertification and results:

Raw materials (Gold): MKS PAMP provided the gold sourcing data of the used mines and the emission factors from these mines. Obtaining more visibility not only on Dore but also on the recycled gold sources would help to derive a more accurate recycled gold emission factor.

Other inputs: Obtaining supplier-specific emission factors would increase the accuracy of the footprint as generic emission factors would no longer be required.

Inbound transportation and downstream distribution: Attaining more clarity over the transportation stages could improve footprint accuracy. For example, it may be that the suppliers use electric vehicles, or particularly efficient logistical practices.

Mine Data: For the calculation of land use change, a large amount of data research was required by the delivery team as the client did not hold specific data on the mines. Challenges such as, some mines not exclusively mining gold, unknowns around how much land has actually been changed and the age of the mines, difficulty accessing reports which disclosed development or production resulted in a number of assumptions and a lower data quality score for the LUC emissions. Gaining visibility on the expansion of mines and land use change due to gold exploration will help with the calculation of the land use change emissions.

1.14. Disclaimer on potential uses of this report

The results presented in this report are unique to the assumptions and practices of MKS PAMP. The results are not meant as a platform for comparability to other companies and/or products. Even for similar products, differences in unit of analysis, use and end-of-life stage profiles, and data quality may produce incomparable results. The reader may refer to the ISO 14067 standard for additional insight into the GHG inventory process.

Annex 2: Certification Details (Third Party Sign-Off)

This product footprinting study has been subject to an independent critical review to verify whether the methodology used for this LCA is compliant with the ISO 14067 standard.

Category	Description
Name of the certifier	Rajul Shah
Date of certification	1st July 2023
Data valid until	30th June 2024

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