
Sales at Auction: Carbon & Resource Calculator

Methodology Report by Anthesis Group

This report details how Anthesis Group developed and applied a methodology to estimate the potential ‘avoided carbon impact’ and ‘avoided resources consumed’ as a result of buying items second-hand at auction.

The methodology and resulting calculations draw on Life Cycle Assessment (LCA) expertise to give buyers and sellers an *estimation* of the *approximate* carbon dioxide equivalent impacts and resource consumption that is potentially *avoided* by buying at auction instead of purchasing a brand new item.

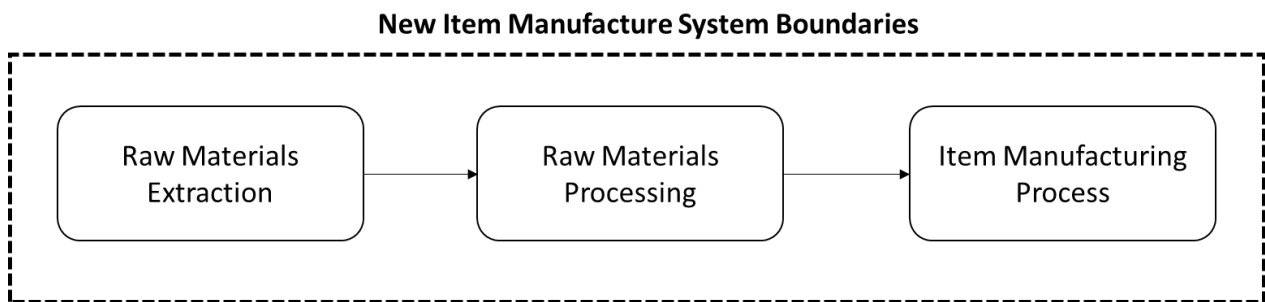
Report Overview

The work described in this report was developed and carried out by Anthesis Group, a sustainability consultancy.

This report details how the values for estimated carbon dioxide equivalents and resources consumed are calculated for items listed on TBAuctions websites.

The intention in providing these figures is to give buyers and sellers of second-hand goods an indication of the carbon dioxide equivalents and resources that may be avoided from being emitted or consumed by buying and selling a second-hand item at auction compared to buying an equivalent brand new item.

The scope of the calculator is cradle-to-gate meaning calculations cover the manufacturing impacts of producing an equivalent new item up to the point of distribution. The calculator assumes that purchasing a second hand item avoids the production, and associated environmental impacts, of a brand new item.



To balance the range of items sold, with data availability and modelling time, different sub-categories of items from the websites are grouped together into modelling groups. The selection of sub-categories for each modelling group is based on the material composition and functional characteristics of the items within the sub-categories. The modelling groups are described later in this report.

The values calculated using these modelling groups are not exact values and should not be taken or reported as such. The values should be treated as best guess estimates for an average product within the modelling group. This gives an approximate indication of the carbon dioxide equivalent emissions and resource consumption that may be avoided by buying a second hand item at auction.

In this initial phase of the carbon and resource calculator, modelling groups were produced for key range of sub-categories, described later in this report. As this calculator develops, there is scope to expand to a wider range of sub-categories and items sold.

Methodology Description

The methodology used in this carbon and resource calculator was developed using Life Cycle Assessment (LCA) expertise combined with analysis of other second hand sales calculators.

The over arching methodology is as follows:

- ⇒ The sub-categories of items are reviewed and grouped into modelling groups. This grouping is based on material and functional similarities across the sub-categories. More information on the sub-category grouping logic is given later in this report
- ⇒ A search is carried out to identify public cradle-to-gate LCA studies, which include carbon dioxide equivalent emissions, as well as material composition data for the items that sit within each sub-category included in the modelling group.
- ⇒ If LCA data is found for carbon dioxide equivalent emissions then these values are scaled to calculate the CO₂ equivalent per kg of sub-category item. Depending on the number of studies found the mean average is taken to calculate a final average value of CO₂ equivalent per kg for an average item within the modelling group.
- ⇒ If material composition data is found the materials are sorted into ferrous metal, non ferrous metal, polymers & rubber, glass and all other materials. The percentage split across these groups is taken. Depending on the number of studies found the mean average is taken to calculate a final average percentage split of materials for an average item within the modelling group.
- ⇒ If no public data is found, subcategory manufacturers/suppliers are contacted for LCA or EPD data
- ⇒ If no public data is found and no companies can provide LCA or EPD data then alternative methods, such as using material compositions to create LCAs are used.
- ⇒ If no data is found or the model created using data found is deemed to be low quality then the modelling group is put on hold until more data can be sourced. More information on data quality can be found later in this report.
- ⇒ Once final values have been calculated, the data and model quality is scored using a data quality matrix. This matrix assesses the coverage of the data found for each modelling group plus the range of results. More information on the data quality matrix can be found later in this report
- ⇒ Finally the assumptions, limitations and improvements for the modelling group are highlighted.

An individual methodology discussion for each of the modelling groups can be found later in this report.

Methodology Details

Allocation

A 100:0 allocation approach is taken for this carbon and resource calculator. This assumes that all the carbon and resource impacts associated with the raw materials and manufacture of item sit with the first owner. This allocation method is commonly used when comparing the impacts of new and second hand items^{1, 2, 4}.

As the second hand market develops, new recommended approaches for second hand allocation may emerge. This methodology will be updated should recommendations or policy change.

Additional Life

Some second-hand reports include additional life within the calculation of potential avoided emissions. Additional life accounts for the fact that second-hand items may have a shorter life span than a brand new item.³

Additional life is not currently included in this calculator as the current modelling groups are industrial and commercial equipment. The life span of these item types is dependent on age, usage and maintenance schedule both in the first use and second-hand use phase. These factors are highly variable and are therefore difficult to predict reliably.

As this calculator is expanded to other items sold at auction, additional life may be included where appropriate.

Displacement Rate

Some second-hand reports include displacement rate within the calculation of potential avoided emissions. Displacement rate is a measure of how many second-hand sales directly replace the purchase of a brand new item.^{1 3 4}

It is assumed that the purchase of a second-hand item at auction for all sub-categories included in the modelling groups covered in this initial phase of the carbon and resource calculator will displace the purchase of a new item.

In effect, the assumption is that were a second-hand option unavailable, the buyer would buy a new item. The main reason for this is that there is currently a lack of data around displacement rate for second-hand purchases of the large equipment items covered in this calculator.

This gap in data can be addressed via buyer engagement and included in future updates to the calculator.

References

1. Vinted: Second-Hand Impact Report: https://press-center-static.vinted.com/Vaayu_x_Vinted_Full_Climate_Impact_Report_2021_045f9e5c4b.pdf
2. Auction Technology Group: 2022 Impact Report <https://www.auctiontechnologygroup.com/media/rc4msb0b/atg-carbon-impact-report-2022-2.pdf>
3. eBay Methodology to Calculate the Environmental and Financial Benefits of Recommerce: <https://static.ebayinc.com/assets/Uploads/Documents/eBay-2021-Circular-Commerce-Methodology-Report.pdf>
4. Depop: <https://news.depop.com/download/docs/DepopDisplacementResearch2022.pdf>

Data Quality Matrix

The purpose of the data quality matrix is to critically assess the quality of the estimated carbon dioxide equivalent impacts and the estimated resource consumption for each of the modelling groups created.

This supports identification of possible limitations and scope of improvement in future iterations of the methodology and the modelling groups.

The models are scored according to number of references available (category representation) and the standard deviation (SD) (data representation) of the average scores calculated for each reference. A total score is calculated by adding these two scores together and the total score corresponds to a grade from A to C. With A representing the best grade.

It should be noted that grades B and C are still considered of sufficient quality for use. No result is included in this calculator for which the data and results were deemed low quality. Any model groups which did not meet the passing grade criteria were excluded from the calculator until such a time that better data becomes available.

Carbon Footprint

Sub-Category Representation	Score	Data Representation	Score
Multiple LCAs for each sub-category	5	SD less than 1	5
At least one LCA for each sub-category	4	SD greater than or equal to 1 less than 2	4
At least one LCA for $\geq 50\%$ of sub-category	3	SD greater than or equal to 2 less than 3	3
At least one LCA for $< 50\%$ of sub-category	2	SD equal or greater than 3	2
No LCAs found. Alternative method used to create an LCA	1	No SD (1 dataset or no data)	1

Resource Consumption

Sub-Category Representation	Score	Data Representation	Score
Multiple material compositions for each sub-category	5	SD less than 0.01	5
At least one material compositions for each sub-category	4	SD greater than or equal to 0.01 less than 0.02	4
At least one material compositions for $\geq 70\%$ of sub-category	3	SD greater than or equal to 0.02 less than 0.03	3
At least one material compositions for $\geq 50\%$ of sub-category but $< 70\%$	2	SD equal or greater than 0.03	2
Material compositions for fewer $< 50\%$ of sub-category	1	No SD (1 dataset)	1

Total Points Grading System

Scores	Grades
1-3	C
4-7	B
8-10	A

Individual Model Descriptions

Earth Moving Vehicles

Disclaimer:

The results calculated for this modelling group are based on publicly available carbon and material footprints for the included sub-categories. The results are not specific to each piece of equipment sold in the sub category but give an average, estimate of all the equipment in this category. The value shown on the website give as an approximate value to show the potential carbon emitted and resources used if the item were purchased brand new and thus shows the potential avoided impact of from buying second hand equipment.

Sub-categories included	LCA Data Found & Included?	Material Composition Found & Included?
Wheeled Excavators	Yes	Yes
Tracked Excavators	Yes	Yes
Midi-Excavators	Yes	Yes
Mini-Excavators	Yes	Yes
Dumper Trucks	No	No
Wheeled Loaders	Yes	Yes
Compact Loaders	Yes	Yes
Trenchers	No	No
Bulldozers	No	No
Compactors	No	Yes
Backhoe Loaders	No	No

Data Quality

Carbon Footprint:

Sub-Category Representation = 3/5 (6 of 11 categories represented)

Data Variability = 5/5 (Standard deviation of the LCAs values included is less than 1.)

GRADE A (Score 8/10)

Resource Footprint:

Sub-Category Representation = 3/5 (7 of 11 categories represented)

Data Variability = 3/5 (Standard deviation of the material compositions included is greater than or equal to 0.02 less than 0.03)

GRADE B (Score 6/10)

Limitations; Assumptions & Scope for Improvement

A total of 19 LCA studies were included in the model. Material composition data was found for 6 of 9 of the sub-categories included in this category model.

The main area of improvement that could be achieved in this model is the inclusion of the missing 3 categories. The assumption was made that these equipment types are similar enough in material composition and functionality that the values calculated here still cover the missing sub-categories.

Small Vehicles

Disclaimer:

The results calculated for this modelling group are based on publicly available carbon and material footprints for the included sub-categories. The results are not specific to each piece of equipment sold in the sub category but give an average, estimate of all the equipment in this category. The value shown on the website give as an approximate value to show the potential carbon emitted and resources used if the item were purchased brand new and thus shows the potential avoided impact of from buying second hand equipment.

Sub-categories included	LCA Data Found & Included?	Material Composition Found & Included?
Motorcycles	Yes	Yes
Quads	No	No
Moped	Yes	Yes
Scooters	Yes	Yes
Bikes	Yes	Yes

Data Quality

Carbon Footprint:

Sub-Category Representation = 3/5 (4 of 5 sub-categories represented)

Data Variability = 2/5 (Standard deviation of the LCAs values included is greater than or equal to 3.)

GRADE B (Score 5/10)

Resource Footprint:

Sub-Category Representation = 3/5 (4 of 5 sub-categories represented)

Data Variability = 2/5 (Standard deviation of the material compositions included is greater than or equal to 0.03.)

GRADE B (Score 5/10)

Limitations; Assumptions & Scope for Improvement

A total of 4 LCA studies were included in the model. Material composition data was found for 4 of 5 of the sub-categories included in this model.

The main area of improvement that could be achieved in this model is the inclusion of the quads category. The assumption was made that these equipment types are similar enough in material composition and functionality that the values calculated here still cover the missing LCA and material composition data.

A further point for improvement is the separation of the sub categories into vehicles with internal combustion engines from electric vehicles. Both types of small vehicle were included in this model, with some variation seen, which drove the SD scores.

Medium Vehicles

Disclaimer:

The results calculated for this modelling group are based on publicly available carbon and material footprints for the included sub-categories. The results are not specific to each piece of equipment sold in the sub category but give an average, estimate of all the equipment in this category. The value shown on the website give as an approximate value to show the potential carbon emitted and resources used if the item were purchased brand new and thus shows the potential avoided impact of from buying second hand equipment.

Sub-categories included	LCA Data Found & Included?	Material Composition Found & Included?
Cars	Yes	Yes
Vans	Yes	Yes
Motorhomes	Yes	No

Data Quality

Carbon Footprint:

Sub-Category Representation = 4/5 (3 of 3 sub-categories represented)

Data Variability = 3/5 (Standard deviation of the LCAs values included is greater than or equal to 2 but less than 3.)

GRADE B (Score 7/10)

Resource Footprint:

Sub-Category Representation = 3/5 (6 of 9 sub-categories represented)

Data Variability = 2/5 (Standard deviation of the material compositions included is greater than or equal to 0.03.)

GRADE B (Score 5/10)

Limitations; Assumptions & Scope for Improvement

A total of 9 LCA studies were included in the model. Material composition data was found for 2 of 3 of the sub-categories included in this category model.

The main area of improvement that could be achieved in this model is the inclusion of the material composition data of motorhomes. Motorhomes contain a combination of caravan-style internal furnishings, such as kitchen appliances and bathroom parts. However, motorhomes also contain engines that are found in cars and vans and thus cannot be modelled with caravans. It was decided that due to the similarity in terms of material composition (engine, wheels, plus soft furnishings which are also found in cars and vans) along with the vehicle functionality the values calculated here for cars and vans are still a good enough approximate estimate for the material composition of motorhomes.

Agricultural Vehicles

Disclaimer:

The results calculated for this modelling group are based on publicly available carbon and material footprints for the included sub-categories . The results are not specific to each piece of equipment sold in the sub category but give an average, estimate of all the equipment in this category. The value shown on the website give as an approximate value to show the potential carbon emitted and resources used if the item were purchased brand new and thus shows the potential avoided impact of from buying second hand equipment.

Sub-categories included	LCA Data Found & Included?	Material Composition Found & Included?
Tractors	Yes	Yes
Harvesters	Yes	Yes
Ride-on Mowers	Yes	Yes

Data Quality

Carbon Footprint:

Sub-Category Representation = 4/5 (at least one LCA found for each sub-category)

Data Variability = 4/5 (standard deviation is greater than or equal to 1 but less than 2)

GRADE A (Score 8/10)

Resource Footprint:

Sub-Category Representation = 4/5 (At least one material compositions for each sub-category)

Data Variability = 2/5 (Standard deviation of the material compositions included is greater than or equal to 0.03.)

GRADE B (Score 6/10)

Limitations; Assumptions & Scope for Improvement

A total of 11 LCA studies and 11 material compositions were included in this model.

These models cover a range of different types of tractor, harvester and mower to account for the wide range of different vehicle types and applications possible within these sub-categories.

Caravans

Disclaimer:

The results calculated for this modelling group are based on publicly available carbon and material footprints for the included sub-categories. The results are not specific to each piece of equipment sold in the sub category but give an average, estimate of all the equipment in this category. The value shown on the website give as an approximate value to show the potential carbon emitted and resources used if the item were purchased brand new and thus shows the potential avoided impact of from buying second hand equipment.

Sub-categories included	LCA Data Found & Included?	Material Composition Found & Included?
Caravans	Yes	Yes

Data Quality

Carbon Footprint:

Sub-Category Representation = 5/5 (LCA Data for multiple caravans found and included.)

Data Variability = 5/5 (Standard deviation of the LCAs values included is less than 1.)

GRADE A (Score 10/10)

Resource Footprint:

Sub-Category Representation = 4/5 (At least one material compositions for caravans included.)

Data Variability = 1/5 (No standard deviation due to single dataset used.)

GRADE B (Score 5/10)

Limitations; Assumptions & Scope for Improvement

A total of 2 LCA studies were included in the model. Material composition data was found for the lone caravan sub-category.

The main area of improvement that could be achieved in this model is the addition of more than one LCA study that features the material composition of caravans. This will improve the range of the data available and account for the variability that may be seen across the internal furniture within caravans.

Freight Trucks

Disclaimer:

The results calculated for this modelling group are based on publicly available carbon and material footprints for the included sub-categories. The results are not specific to each piece of equipment sold in the sub category but give an average, estimate of all the equipment in this category. The value shown on the website give as an approximate value to show the potential carbon emitted and resources used if the item were purchased brand new and thus shows the potential avoided impact of from buying second hand equipment.

Sub-categories included	LCA Data Found & Included?	Material Composition Found & Included?
Trucks	Yes	Yes

Data Quality

Carbon Footprint:

Sub-Category Representation = 5/5 (LCA Data for freight trucks found and included.)

Data Variability = 3/5 (Standard deviation of the LCAs values included is greater than or equal to 2 but less than 3.)

GRADE A (Score 8/10)

Resource Footprint:

Sub-Category Representation = 5/5 (Multiple data for material composition of freight trucks.)

Data Variability = 2/5 (Standard deviation of the material compositions included is greater than or equal to 0.03.)

GRADE B (Score 7/10)

Limitations; Assumptions & Scope for Improvement

A total of 6 LCA studies were included in the model. Material composition data was found for the lone truck sub-category.

Most weights of trucks provided in the LCA studies are based on gross vehicle weight, or the weight of the tractor or truck and the load it carries. Since the tare weight of the tractor, the weight of the tractor excluding the load, is used to calculate the carbon footprint in kgCO₂e/kg, the tare weight is estimated via linear interpolation with respect to the range of the gross vehicle weight and its corresponding range of the tare weight. The ranges of the gross vehicle weight and the tare weight are defined by the class of the vehicle (i.e. class 1 for small vehicles up to class 8 for tractor-semi-trailer combination vehicles).

Tractors with trailers attached to them are excluded in the study since tractors and trailers are typically sold separately on the second-hand market. If the material composition and carbon footprint of tractor and trailer are reported separately, then the information is split between this freight trucks model group and trailer model group.

The main area of improvement that could be achieved in this model group is the addition of more LCA studies that provide the empty weight of the vehicle. This lessens the reliance on estimating the empty weight from the gross vehicle weight.

Towed Trailers

Disclaimer:

The results calculated for this modelling group are based on publicly available carbon and material footprints for the included sub-categories. The results are not specific to each piece of equipment sold in the sub category but give an average, estimate of all the equipment in this category. The value shown on the website give as an approximate value to show the potential carbon emitted and resources used if the item were purchased brand new and thus shows the potential avoided impact of from buying second hand equipment.

Sub-categories included	LCA Data Found & Included?	Material Composition Found & Included?
Towed Semi-Trailers	No	Yes
Towed Car Trailers	No	No

Data Quality

Carbon Footprint:

Sub-Category Representation = 1/5 (LCA Data for towed trailer was not found. Models were created in SimaPro using estimates from material composition)

Data Variability = 3/5 (Standard deviation of the LCAs created is greater than or equal to 2 but less than 3.)

GRADE B (Score 4/10)

Resource Footprint:

Sub-Category Representation = 2/5 (material compositions found for semi trailers)

Data Variability = 1/5 (Standard deviation of the material compositions included is greater than or equal to 0.03.)

GRADE C (Score 3/10)

Limitations; Assumptions & Scope for Improvement

A total of 2 material composition datasets were included in this model group. Both of these datasets correspond to semi-trailers. However, it was assumed that car trailers are similar enough in material composition that this data can be applied to all sub-categories within the group. Additionally, one of these material compositions excluded tyres, while the other included tyres, meaning only one material composition estimate is available for tyres.

No public LCA studies could be found for either type of towed trailers within this category. However, using the two material composition dataset two LCA models were approximated using the LCA software SimaPro and ecoinvent 3.8. A final model was added using an ecoinvent factor (Agricultural trailer production). This allowed for the creation of three models with an average carbon dioxide equivalent value calculated as per the general methodology approach.

The data quality scores for this model group reflect the use of secondary models in place of primary data plus the amount primary data that could be found. However, this model is still a high quality model that can be used to get an estimate for an average trailer in this model group.

To improve the data quality score a future iteration of this modelling group, primary LCA studies for both semi-trailers and car trailers should be found, either via public or industry studies. In addition, material composition data for car trailers should be found.