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Product databases: the environmental benefits of reuse

The climate benefits of reusing IT products and the method for creating data bases

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Preface

This report is divided into two sections.

The first section explains a method for the creation of databases showing the environmental benefits from reuse, which covers a limited number of product groups. The idea is that this section of the report could be followed to create a useful database for any specific product group, or several product groups within a common field of work.

Databases that are created are intended to operate within a well-defined area, with a specific purpose. Examples are the climate benefits from reusing products that are part of ventilation systems in an office environment, or the climate benefits from reusing IT products.

The second section is a case study and describes a database for the climate benefits of reusing IT products, produced according to the method in part 1. The database contains a number of different categories and sub-categories of IT products, as well as calculated data on the climate benefit of reusing them in Sweden. The idea is that this database could be used by companies that work with the reuse of IT products, to calculate the climate benefits of reusing for their customers, or by organisations that want to investigate the potential climate benefit of their current or future internal reuse of IT products.

The advantage of producing distinct databases is that they are relatively simple to create, and they can be adapted to the purpose and made quite easy to work with, which increases the likelihood that they are actually used to their full potential. The disadvantage is that it is generally not possible to compare results between different databases without first analysing the differences between the databases and assumptions.

The case study in this report only looks at “climate benefits”, but it is quite possible to develop a database that looks at another, or several other, environmental aspect(s). It is up to the person who creates each database to investigate and choose which environmental benefits to include, depending on what is relevant in the context and what is possible given the availability of data.

The words “environmental benefit” and “climate benefit” are often used in this report when perhaps using “environmental impact” and “climate impact” would be more accurate. This is because reusing is not always a “benefit”, given the impact of the whole system. For example, reusing a product that travels a long way to its new user can cause such a lot of emissions that the “climate benefit” of reuse becomes negative, making it a “negative climate impact”. However, the choice of words is intentional, as these databases are often about quantifying the benefits. Another reason for the choice of words is that “environmental impact” is normally seen as “negative” and therefore must be defined as “negative” or “positive”, but it is not clear what these words mean when we talk about savings in general. In contrast, “environmental benefit” and “climate benefit” are positive words by nature, and we therefore assume that they are easier for a non-expert to assimilate.

The author would like to thank their partner Inrego AB for its commitment and constructive cooperation throughout the project leading up to this report.

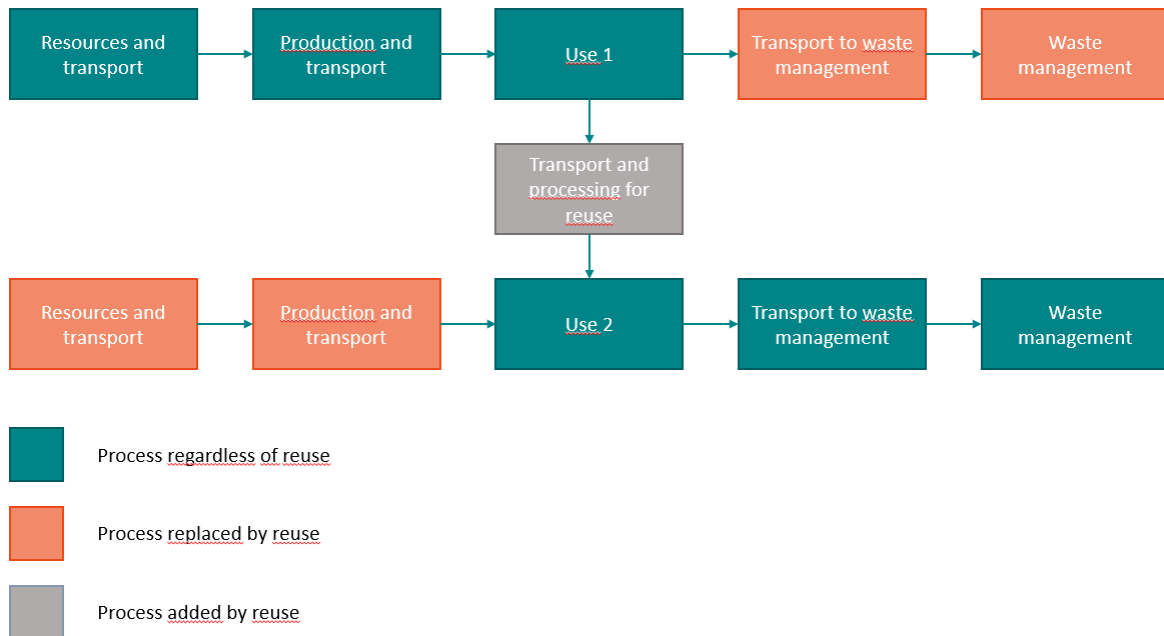
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Summary

This report contains two sections. The first section contains a method for the creation of databases for the environmental benefits from reuse, customised for a specific stakeholder and application. The second section is an implementation of the method from section one and it contains a database of the climate benefits of the reuse of IT equipment, created for use by a company facilitating the reuse of IT equipment. This database can be found on page 21.

The impact of “environmental benefits from reuse” is, in this report, defined as the difference between a product being reused or a similar product being bought new. This means that the production of one new product is avoided, along with its transport to the customer, waste handling, and the transport to waste handling. However, the process of reconditioning the reused product is added, as well as the transport to, and from, the reconditioning.



A “database for the environmental benefits of reuse” created using this method is a table of product categories that are reused in some specific context and that contains data on the potential environmental savings for different parts of the life cycle. All databases created following this method has the same basic equation defining the included parts of the life cycle, but they can be calculated in different ways for different databases, which means that the results should generally not be used outside their specific context. The various included parts of the life cycle are shown in the equation below.

$$Environmental\ benefits = PROD_u + TRP_{up} + AVF_u + TRP_{ua} - TRP_{re} - RECOND \quad (1)$$

$PROD_a$ = Environmental impact from the avoided new production; TRP_{ap} = Environmental impact from the avoided transport from production; $WASTE_a$ = Environmental impact from the avoided waste handling (of the product that was not produced); TRP_{aw} = Environmental impact from the avoided transport to waste handling; TRP_{re} = Environmental impact from the added transport to and from reconditioning; $RECOND$ = Environmental impact from the reconditioning of the product.

Included with the database is documentation meant to help a user to understand where the data comes from and how the calculations are made. It also contains details of what conditions need to be met for the results to be applicable, and if any limited conclusions can be drawn if they are only partially met.

The first section of the report describes how to create a database, how it should be designed and what the documentation should include. The description is meant to be able to be used to create databases, for environmental benefits from reuse, within all sorts of different product ranges.

Every database that is produced following this description is meant to have a specific purpose, e.g. to be used to measure the environmental benefit of reuse at one or several reuse processes within a specific industrial branch. The user group of such a database is thought to be within industry, where there is a need of a credible, easy-to-use database that has been made for the purpose, and that can be commonly used within the community.

The second section of the report contains a database of the “climate benefits of reuse of IT products”. This database is primarily made to be used by a reconditioning company, within Sweden, to help its clients calculate the climate benefit of their reuse of IT products. The database can be found again on page 21 and is preceded by documentation describing aspects including usability and data sources.

The database is mostly composed of publicly available material from some of the large computer companies: HP; DELL; Lenovo; and Apple. The results are presented for different categories, e.g. “laptops”, “desktops”, “monitors”, “mobile phones”, “tablets”, “servers” and “printers”. Some of the categories also have subcategories, and there are also a few not mentioned here.

The results in the database have a few conditions that need to be met for them to be applicable. The most important of these is the condition: “acquiring a reused product leads to not acquiring a similar newly produced product”. If this condition is not met, then the results are not valid.

The results in the database are dominated, almost completely, by the avoided impact from the production. This production data is taken from the producers’ PCF-files (Product Carbon Footprint) and they are regarded as having high credibility. Most categories use data that is no older than three years (2016-2018).

A reused IT product is here assumed to have the same potential performance as a new product in the same category. The use phase is not included since the reused product is assumed to be used in the same way as a new product would have been used, and the energy use is assumed to be the same. The assumption of equal energy use of newer and older products could potentially be incorrect, and for products that use a lot of energy when used, this could potentially lead to incorrect conclusions, but the project has not studied this.

1 Methods for creating the database

1.1 Reuse

The term “reuse” here refers to when a product that’s no longer needed by its owner (“user 1”) is taken over by a new user (“user 2”) who has a need for it, instead of it becoming waste.

Reusing is the second most desirable way to reduce our waste, right after “avoid production”, according to the EU Waste Framework Directive (directive 2008/98/EC)[1]. Reuse is thus the most desirable option for a product that has already been manufactured, rather than material or energy recycling or disposing of it to landfill.

Individuals, organisations and companies reuse products by buying, selling, exchanging, donating and receiving used products.

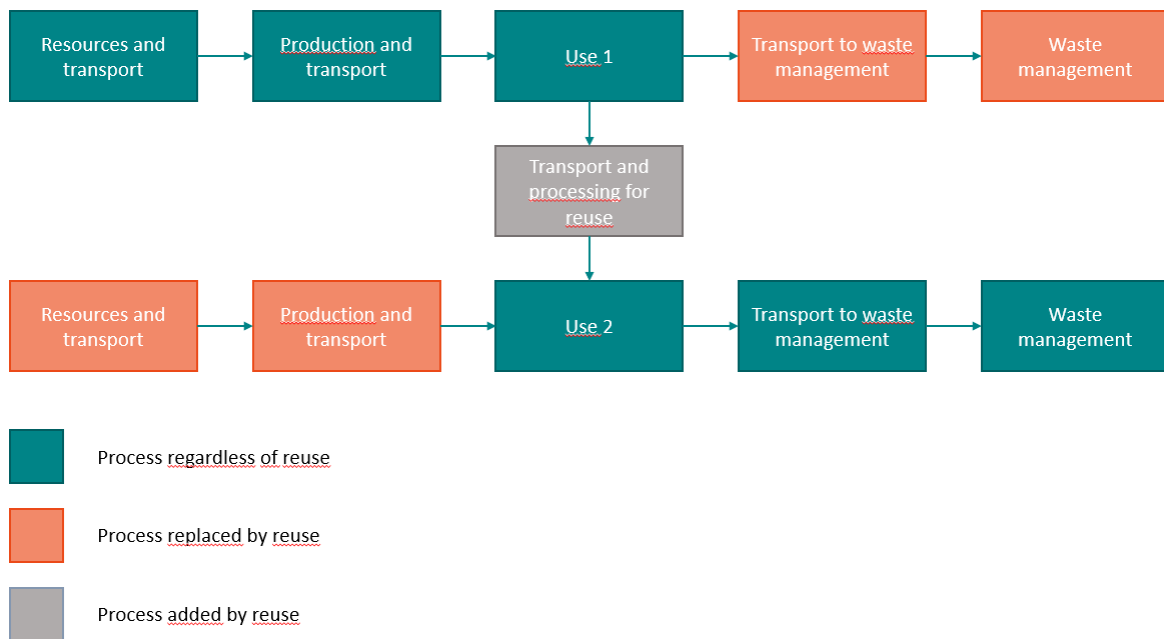


Image 1: Schematic diagram of reuse, as calculated in this report

1.2 Database

One way to promote reuse is to emphasise the environmental benefits of it, but it is also useful to be able to compare the environmental benefits across various products in order to know which products provide the most benefits when reused. As there are lots of stakeholders in the same industry, everyone is required to use similar results for the same things if credibility is to be maintained. In the absence of a compulsory calculation standard, the different calculations run the

risk of arriving at different results, and expert knowledge is usually required to understand the differences.

One solution to this is to develop a database containing the products of interest to the stakeholder in question, as well as values showing the environmental benefits associated with their reuse and make that database available to all of the stakeholders in the industry. In order to suit an industry stakeholder, the database needs to be useful even for people who do not have in-depth expert knowledge, while also being credible. Exactly what this means can differ from case to case, and it is also one of the reasons why different databases, produced according to this method, may need to be constructed in different ways. For example, they may have different types of data and focus on different types of environmental problems.

By creating a customised database, tailored to the industry and the stakeholder in question, it is possible to make the results for the various products in the database more comparable than would have been possible in a more general database. But this also has the consequence of the comparability between two different databases possibly being so poor that comparisons of results from different databases should generally be avoided, unless an in-depth review is made of how the calculations are done in each database.

As comparisons between different databases should be avoided, it is important to think about which additional stakeholders may be interested in using it, so that their interests can be safeguarded in the database. This is to avoid the creation of multiple databases with more or less the same products in them, which are calculated in different ways.

1.2.1 Designation and naming of databases

A database that takes a holistic approach to the environmental impact of the products in question should be called a “product database for the environmental benefits of reuse”, or similar. If the database focuses on a specific environmental impact category, such as climate impact, then it should not use the word “environmental benefits”, in this case the word “climate benefits” should be used instead.

1.3 The environmental benefits of reuse

When a buyer chooses to buy a reused product instead of a new one, it means that a new product of this kind does not need to be manufactured, which is generally an environmental benefit since in principle all production uses materials and energy, which in turn always has an environmental impact. When a new product does not need to be manufactured, all transportation that would otherwise have occurred to transport the product to the customer, as well as waste handling including transport, are also avoided.

However, there are generally a number of extra processes that occur when reusing a product which have an additional environmental impact. These include the transport that occurs to move the product from user 1 to user 2, and the reconditioning of the product where it may be stored, repaired or refreshed, and these processes have an impact that encumbers the actual reuse.

These parts are described in detail in the next section.

1.3.1 Equation

The equation for calculating the environmental benefit of recycling a product is as follows:

$$\text{Environmental benefits} = \text{PROD}_u + \text{TRP}_{up} + \text{AVF}_u + \text{TRP}_{ua} - \text{TRP}_{re} - \text{RECOND} \quad (1)$$

- PROD_a = Environmental impact from the avoided new production
- TRP_{ap} = Environmental impact from the avoided transport from production
- WASTE_a = Environmental impact from the avoided waste handling (of the product that was not produced)
- TRP_{aw} = Environmental impact from the avoided transport to waste handling
- TRP_{re} = Environmental impact from the added transport to and from reconditioning, or more generally: all transport between user 1 and user 2
- RECOND = Environmental impact from the reconditioning of the product

It is entirely possible that TRP_{re} and RECOND , which contribute negatively to the calculation, can be larger overall than the other four, normally positive, parts. In this case, the environmental benefit becomes negative, and is therefore more of a negative environmental impact. If this occurs for any of the products in a database, then the database needs to be extra clear about what positive and negative values mean, and in some cases it may be better to use the word “environmental impact” instead of “environmental benefit”. This needs to be determined for each specific database where the problem occurs. The goal is to reduce the risk of misunderstandings for all of the likely users.

It is also possible that one or more of the other four (PROD_a , TRP_{ap} , WASTE_a and TRP_{aw}) may be negative, which means that this part is counted as contributing to the equation as a negative environmental impact. This can also contribute to the environmental benefit becoming a negative environmental impact and is also managed by using the word “environmental impact” instead of “environmental benefit” consistently in that database.

1.3.2 Calculating the various parts of the equation

The way in which the six parts included in the calculation of the environmental benefit are calculated is described in detail in each individual database. There are no specific limitations on how they can be calculated, but it is of course important to include all aspects that are considered important for the products in the specific database.

It should be possible to understand from the description how the calculation is done; what important assumptions have been made; which parts are included and excluded; and a description and references for all of the data used.

It is important that the products’ environmental benefits are calculated in the same way, and that data of the same quality and origin are used, in one and the same database. In cases where this is not possible, for example due to a lack of data, this needs to be noted and justified. Potential problems with comparisons that may arise from different methods of calculation or data should also be analysed and discussed.

1.3.3 Data quality and traceability

All of the data used must be listed and described with the description of the calculation, for each part of the calculation where that data is used. The more important a piece of data is for the end result, the more important it is that it is well described. It should be possible to read where important data is taken from or exactly how it is calculated, and it should be shown how less important data was produced.

It is not necessary for all information to be available to accurately reproduce the whole, or parts of, the calculation. The goal is for a reader to be able to understand how the calculation is done, so that if they have thorough subject knowledge, they should be able to determine whether it is a reasonable calculation method.

There are no specific data quality requirements, as in some cases high quality data is not available. However, the quality of the data should always be discussed in the documentation, partly in general terms based on the purpose of the database, and partly for all data that is considered important, so that the user can make their own assessment of the credibility.

1.3.4 Allocation of the environmental benefits between users 1 and 2

Several stakeholders are often involved in reuse, and since potentially all of them are interested in knowing exactly how much of the calculated environmental benefit they can count as their own, sometimes the environmental benefit needs to be allocated between them. This is done to avoid counting the same benefit twice. However, it is not clear how the division should then be made between these stakeholders. The obvious stakeholders are users 1 and 2, but any intermediaries can also be seen as stakeholders.

The equation calculates the total environmental benefit from the entire reuse and that is the perspective that should be used primarily, whenever possible. This is because allocation between stakeholders can often be managed in a variety of ways, based on different motivations, leading to different results. All stakeholders have also contributed to the total environmental benefit, and in general contexts where the total benefit of reuse is presented, the total figure should be used.

How allocation is managed is decided and described in each individual database, but the recommendation is to use the 50/50 method [2], where the environmental benefit is shared equally between users 1 and 2 (meaning any intermediaries do not get their own cut of the environmental benefit). The reason for this recommendation is that the 50/50 method is easy to understand, and that it provides a benefit for both users 1 and 2, on the assumption that both of these must make direct choices for reuse to occur. If more complex allocation methods are used, they should be well motivated in the database documentation, under the allocation section.

The total environmental benefit should always be reported in the database. The database documentation should also always describe how the environmental benefit should be allocated between different stakeholders, where this is needed.

1.4 Method for producing a database

The checklist below outlines the things that need to be done to create a product database showing the environmental benefits of reuse.

1.4.1 Checklist, producing the database

1. Identify the need for the database – who will use it and why?
2. Identify additional stakeholders – are there additional stakeholders who may be affected, and whose perspectives should be taken into account?
3. Complete an inventory of the products – what products, or product categories, should be included?
4. Analyse the products – which environmental aspects are important to capture?
5. Complete an inventory of the data – what data is available?
6. Create a calculation model – develop a calculation that works for the products/product categories, for all the components of equation 1.
7. Create a database for the products and their environmental benefits (see the list of requirements below).
8. Create the documentation for the database (see the list of requirements below).

1.4.2 Requirements list, database and documentation

For each product or product category a database should contain:

- The product name or product category name (unique)
- A defining description of the product or category (this may be included in the name)
- Possibly multiple levels of categories
- The product unit for which the result applies (for example “piece” or “kg” or “m²”) (if the same unit is used for all products/product categories then it is sufficient to specify the unit somewhere next to the calculated result, for example in the result heading together with environmental impact unit).
- Estimated results for each included environmental benefit/impact, for each part of the equation and the total sum, including units for these
- Any other data that is considered relevant for usability, such as product weight.

The database documentation shall contain the following sections, with the content described, in the following order:

- General information about the database
 - o Contents
 - The name of the database
 - Who produced it
 - Who funded its production
 - When it was produced
 - Which environmental impact categories are included
 - o (Other information of a general nature may be included here).
- The aim and use of the database
 - o Text that clearly states how the database is intended to be used, by whom and why

- A presentation of the product categories
 - o A description of the group of product categories
 - o A description of each product category
- The calculation and equation
 - o A presentation of the equation used, and an explanation of what this means in the current database
- Conditions
 - o A description of which conditions need to be met for the database results to be applicable. Discuss how well the results can be assumed to work if the various conditions are not met.
- Allocation indications
 - o A description of how the result should be allocated between the various stakeholders involved in the reuse, when allocation is desirable.
- The general data quality of the database
 - o A discussion of the general quality of the database, with regard to how fair the results are considered to be, based on the data and calculations that they are based on.
- Review of the calculation and data
 - o A comprehensive review of the calculation/equation, where the important aspects in relation to size are identified, and important data sources are presented.
 - o A review of all of the important exceptions, such as from the overall description of the calculation/equation and common data sources, as well as comments on how each exception may conceivably affect comparability to other results.
 - o A detailed review of each part of the equation, with a description of the calculation and each input data. For important data and important parts of the calculation, data quality and any data gaps should be described.
- (Any) Other documentation

2 The climate benefits of reusing IT products

2.1 Documentation, database

2.1.1 General information about the database

Name: Product database to show the climate benefits of reusing IT products

Produced by: IVL Swedish Environmental Research Institute in 2019

Produced on behalf of: Inrego AB

Produced with funding from: Inrego AB and the Foundation for IVL (SIVL)

Environmental impact categories included: Climate impact (GWP100)

2.1.2 The aim and use of the database

Please note that the results in this database are produced for a specific purpose and are designed to ensure good comparability within the database. It is not possible to assume that comparability is good when comparing these results with other results outside the database, regardless of the context.

The purpose of the database is to enable a stakeholder dealing with the reuse of IT products to calculate the climate benefit of reuse.

The stakeholder is primarily intended to be a reuse company, which acts as an intermediary and collects IT products that are no longer used, checks that they work and then sells them to companies or private individuals. Alternatively, the stakeholder may be a company that reuses its IT products within its company, or a private person who buys used IT gadgets or sells their own used IT gadgets.

In addition to common IT products, the database also contains a number of components or peripherals, such as RAM memory, keyboards and power adapters. A reuse company that uses the database may want to use the data for components in order to partly attribute the benefit of saving components from products that would otherwise have to be disposed of. The company can also use the component data to calculate, at a highly detailed level, the impact of reconditioning a product where a certain part has to be replaced. For components, the impact of reconditioning and their transport has been set to zero, as they are normally counted as part of the more complete products (all other categories in the database) and they weigh relatively little.

A company that reuses its own IT products, or a private person who purchases used goods, can completely disregard the effects of reconditioning (RECOND), and also disregard the transport to and from reconditioning (TRP_{re}), unless the products in question have been transported across countries. The RECOND value in the database corresponds to the impact of energy required for the operating and heating of the reuse company's premises which is emitted per recycled product, and the TRP_{re} value corresponds to two transports within Sweden for the product in question. Both of these impacts are small in this context for all of the IT products in the database.

2.1.3 A presentation of the product categories

The group of product categories is “IT products”, and the aim was to include the categories that create large flows for the companies that manage IT waste, focusing on the categories that are widely reused.

List of the product categories included:

- Notebook (average all subcategories)
- Notebook: Screen below 14 inches
- Notebook: Screen 14+ inch
- Notebook: Hybrid
- AIO: (average all subcategories) (All-in-one desktop)

- AIO: Screen below 24 inches
- AIO: Screen 24+ inch
- Desktop (average all subcategories)
- Desktop: USDT (Ultra Small Desktop)
- Desktop: SFF (Small Form Factor)
- Desktop: Tower
- Monitor (average all subcategories)
- Monitor: Screen below 33 inches
- Monitor: Screen 33+ inch
- Printer: Desk
- Server: Rack
- Handheld (average all subcategories)
- Handheld: Tablet-big
- Handheld: Smartphone
- Handheld: Tablet-Small
- Projectors: mid-size
- Network equipment (average all subcategories)
- Network equipment: Small
- Network equipment: Rack mounted (blade)
- Network equipment: Rack mounted (large)
- Components (average all subcategories)
- Components: SSD
- Components: HDD
- Components: RAM memory
- Components: Processor
- Components: Laptop battery
- Components: Laptop screen
- Components: Tablet screen
- Components: Smartphone screen
- Components: Keyboard
- Components: Power adaptor, laptop
- Components: Docking station
- Components: Network card
- Components: Fan
- Components: DVD
- Components: Mouse pad
- Components: Smartphone/tablet charger

2.1.4 The calculation and equation

The equation for calculating the environmental benefit of recycling a product is as follows:

$$\text{Environmental benefits} = \text{PROD}_u + \text{TRP}_{up} + \text{AVF}_u + \text{TRP}_{ua} - \text{TRP}_{re} - \text{RECOND} \quad (1)$$

- PROD_a = Climate impact from the avoided new production
- TRP_{ap} = Climate impact from the avoided transport linked to new production
- WASTE_a = Climate impact from the avoided waste handling (of the product that was not produced)
- TRP_{aw} = Climate impact from the avoided transport to waste handling

- TRP_{re} = Climate impact from the added transport to and from reconditioning, or more generally: all transport between user 1 and user 2
- RECOND = Climate from the reconditioning of the product

The climate benefit here is defined as the consequence of someone buying a used IT product, instead of a new one. It is then assumed that a similar product does not need to be manufactured ($PROD_a$), and since it is not manufactured, it does not need to be transported to buyers (TRP_{ap}), nor to waste disposal ($WASTE_a$) or waste handling (TRP_{aw}). However, it is assumed that the used product will pass through a reuse company, which transports the product (TRP_{re}) and reconditions it (RECOND), thereby contributing to added impact that reduces the climate benefit.

2.1.5 Conditions

The results in this database are produced for a specific purpose and are designed to ensure good comparability within the database. It is not possible to assume that comparability is good when comparing these results with other results outside the database, regardless of the context.

The following conditions must be met for the results in the database to be valid:

1. The reuse occurs in Sweden.
2. The buyers of the used product would have bought a new product, within the same category, if they had not bought the used one.
3. The new product is assumed to have been manufactured in Asia.
4. Reuse occurs within three years of the last update to the database.

If all or part of the reuse does not occur in Sweden, the calculation could potentially be wrong in all parts except for $PROD_a$. However, since $PROD_a$ is generally the dominant part of the equation, it is still possible to draw conclusions based on the value of the total climate savings.

If condition 2 is not met, the database results are not applicable. This is because the result is dominated by the impact of manufacturing a new product being avoided.

If condition 3 is not met, $PROD_a$ is not correct, and as $PROD_a$ is generally the dominant part of the equation, it is possible that no conclusions can be drawn based on the results of the database.

If condition 4 is not met, the results may still be applicable depending, however, on how quickly technology has developed, both in terms of the product in question and the production methods used by the manufacturer.

2.1.5.1 Alternative uses of the database results

Alternative uses are not recommended. For example, if the database is to be used to extract values for the manufacture and/or use of IT products, it is recommended that the user goes straight to the background data instead (see references 3–7) to gain a better understanding that conforms with what they are looking for.

2.1.6 Allocation indications

The results in the database apply to the total reuse. If the climate benefits need to be divided among different stakeholders, they should be divided equally between user 1 and user 2. In this

case user 1 is the organisation or person who sold/donated the product for reuse, and user 2 is the organisation or person who bought or received the product for the purpose of reusing it.

2.1.7 The general data quality of the database

The data quality of the database is considered to be relatively high, given that it is largely based on calculations performed by the product producers where they have used a common calculation method, and that many of the major producers, such as HP, Dell, Lenovo and Apple, are included in the data. It is worth noting that Apple does not use exactly the same calculation method as the others, but our assessment is that the results are sufficiently comparable.

The documentation of this database does not include an in-depth analysis of the calculation method used by producers to calculate the climate impact of their products. This method is called the Product Attribute to Impact Algorithm (PAIA) and is a tool for calculating life cycle analysis (LCA) results, developed by the Materials System Laboratory at the Massachusetts Institute of Technology (MIT) in the USA. The general assessment is that the method is reliable, and that the producers use it correctly. This assessment is based on studies of the results used in this database as well as experience with similar calculations.

2.1.8 Calculations and data

Overview, important aspects

The equation for calculating the environmental benefit of recycling a product is as follows:

$$\text{Environmental benefits} = \text{PROD}_u + \text{TRP}_{up} + \text{AVF}_u + \text{TRP}_{ua} - \text{TRP}_{re} - \text{RECOND} \quad (1)$$

PROD_a , the influence of the avoided new production, completely dominates the calculated climate benefit. The data for PROD_a is largely taken from the producers' (HP, DELL, Lenovo and Apple) own calculated results, which are published for individual products. The result presented in the database is the average of a number of products. See the detailed description below for more info.

Overview, important exceptions

The data set for the following categories is of poorer quality for PROD_a – i.e. the influence of the avoided new production – which is the dominant part in the calculation of the database result.

- Printer
- Server
- Projectors
- Network equipment
- Components

As a consequence of this poor data quality, users should be extra cautious when drawing conclusions that are largely influenced by results from these categories.

Detailed review of data and calculations

Below is a description of the data used for the different parts of the calculation.

- PROD_a = Climate impact from the avoided new production

- Data: Results are generally taken directly from the producers' "Product Carbon Footprint" (PCF) files, which are published for a variety of products in most of the categories included in this database. Sub-totals, in the files, from the use, transport and waste handling phases have been calculated. These results are then averaged, for each product category, for the results published over the last three years (2016–2018). All of the published PCF files are not included in the background data to this database, but in some cases a selection has been made, with the goal of getting a good representation in all categories and from all producers. The number of data sets (PCF files) behind the results for each category are presented below.
 - Desktop: USDT (Ultra Small DeskTop): 15 data sets (PCF files)
 - Desktop: SFF (Small Form Factor): 16 data sets (PCF files)
 - Desktop: Tower: 10 data sets (PCF files)
 - AIO: Screen below 24 inches (All-in-one desktop): 11 data sets (PCF files)
 - AIO: Screen 24+ inch (All-in-one desktop): 12 data sets (PCF files)
 - Monitor: Screen below 33 inches: 41 data sets (PCF files)
 - Monitor: Screen 33+ inch: 4 data sets (PCF files)
 - Notebook: Screen below 14 inches: 22 data sets (PCF files)
 - Notebook: Screen 14+ inch: 37 data sets (PCF files)
 - Notebook: Hybrid: 8 data sets (PCF files)
 - Handheld: Tablet-big: 7 data sets (PCF files)
 - Handheld: Smartphone: 11 data sets (PCF files)
 - Handheld: Tablet-Small: 5 data sets (PCF files)
- Exception 1: For the Printer and Server categories, there was only isolated carbon footprint data from the producers, and it was also more than three years old. These results are therefore considered to be of lower quality, yet comparable within the database.
- Exception 2: For the Network components and Projector categories, data from the producers is missing, so the result is calculated from specially developed models based on material and component content. These results are therefore considered to be of lower quality, yet comparable within the database.
- Exception 3: For the Components category, the result is partly calculated based on disaggregated information from the producers' PCF files, and partly from specially developed models based on material and component content. These results are therefore considered to be of lower quality, yet comparable within the database.
- TRP_{ap} = Climate impact from the avoided transport linked to new production
 - Data: These results are calculated based on the general impact of transport, using data from the EcoInvent database (v3.5), based on the weight of the product, plus one (1) kg for packaging, and the assumption that transport is via container vessels from Asia, and then via lorries within Sweden. For the Components category and its subcategories, the packaging is assumed to weigh 50 g. The quality of these results is considered to be relatively low, but they are still considered to be acceptable since they generally account for a relatively small part of the total impact.
 - Comments: In many cases, this data could instead be taken directly from the producers' PCF files. But the potential risk considered was that the impact of transport differed between the products in a way that was difficult to understand and justify, as there is no information in the PCF files on all of the assumptions on transport modes and transport distance.
- $WASTE_a$ = Climate impact from the avoided waste handling (of the product that was not produced)

- Data. These results are taken directly from the producers' PCF files, where they are included as a percentage of the total impact. The product categories, where impact is not based on information from PCF files, have been assumed to have the same percentage as the average of the product categories with this information. The quality of the data is generally considered to be high because it comes directly from the producers, but these figures should be used with great caution as it is unclear exactly what they include.
- Comments: It is unclear exactly how this section is calculated in the PCF files, and, in general, the impact of waste handling can vary greatly depending on the assumptions made. The contribution of waste handling in the PCF files does not vary much and is not very large, relatively speaking. This, coupled with the fact that it is difficult to calculate such data, led to the assessment that this was the best way to include the impact of waste handling in this model/database.
- TRP_{aw} = Climate impact from the avoided transport to waste handling
 - Data: These results are calculated based on standard transport within Sweden, with an estimated distance based on the product weight in each product category. Background data for the impact of truck transport is taken from Ecoinvent [8].
- TRP_{re} = Climate impact from the added transport to and from reconditioning, or more generally: all transport between user 1 and user 2
 - Data: These results are calculated based on two standard transportations within Sweden, one from user 1 to the reuse company, and one from the reuse company to user 2. The calculation uses an estimated distance corresponding to transport within southern Sweden, as well as the product weight in each product category. Background data for the impact of truck transport is taken from Ecoinvent [8].
- RECOND = Climate from the reconditioning of the product
 - Data: The RECOND value in the database corresponds to the impact of energy required for the operating and heating of the reuse company's premises which is emitted per recycled product. The energy usage data per recycled product is taken from reuse company Inrego AB [9], who work with the reuse of IT products, and the impact of fuel and (Swedish) electricity is taken from the LCA database Ecoinvent [8].

2.2 Database

Produktdatabas för klimatfördelar med återbruk av IT-produkter, version 1.0 (2019)								
<i>This database needs to be used together with its documentation! (All numbers rounded to two significant digits)</i>								
Sub category	Avoided total (sum) (kg CO2-eq)	New production	Transport from new production	Refurbishment	Transport to and from refurbishment	Waste handling	Transport to waste handling	Weight (kg)
<i>Notebook (average all sub categories)</i>	280	280	1,2	-0,4	-0,5	1,6	0,1	1,6
Notebook: Screen below 14 inch	250	250	1,1	-0,4	-0,4	1,5	0,1	1,4
Notebook: Screen 14+ inch	300	300	1,5	-0,4	-0,6	1,6	0,1	2,1
Notebook: Hybrid	280	280	1,0	-0,4	-0,4	1,6	0,1	1,2
<i>AIO (average all sub categories) (All-in-one desktop)</i>	470	460	4,4	-0,4	-1,7	10,0	0,4	8,4
AIO: Screen below 24 inch	420	410	3,8	-0,4	-1,4	7,3	0,3	7,0
AIO: Screen 24+ inch	520	500	5,1	-0,4	-1,9	14,0	0,5	9,8
<i>Desktop (average all sub categories)</i>	470	460	4,3	-0,4	-1,6	9,1	0,4	8,2
Desktop: USDT (Ultra Small DeskTop)	290	290	1,6	-0,4	-0,6	3,4	0,1	2,4
Desktop: SFF (Small Form Factor)	380	370	3,6	-0,4	-1,3	8,7	0,3	6,7
Desktop: Tower	750	730	7,7	-0,4	-2,9	15,0	0,7	15,0
<i>Monitor (average all sub categories)</i>	520	510	5,6	-0,4	-2,1	8,4	0,5	11,0
Monitor: Screen below 33 inch	440	430	3,6	-0,4	-1,3	6,4	0,3	6,6
Monitor: Screen 33+ inch	620	600	7,5	-0,4	-2,8	10,0	0,7	15,0
Printer: Desk	180	170	12,0	-0,4	-4,7	0,0	1,2	26,0
Server: Rack	400	390	13,0	-0,4	-4,8	0,0	1,2	26,0
<i>Handheld (average all sub categories)</i>	98	97	0,7	-0,4	-0,3	0,7	0,0	0,4
Handheld: Tablet-big	140	140	0,8	-0,4	-0,3	1,0	0,0	0,7
Handheld: Smartphone	55	55	0,5	-0,4	-0,2	0,5	0,0	0,2
Handheld: Tablet-Small	95	94	0,6	-0,4	-0,2	0,7	0,0	0,3
Projectors: mid size	21	20	1,4	-0,4	-0,5	0,0	0,1	2,0
<i>Network equipment (average all sub categories)</i>	340	330	6,8	-0,4	-2,6	2,6	0,7	14,0
Network equipment: Small	8,7	9	0,7	-0,4	-0,3	0,1	0,0	0,5
Network equipment: Rack mounted (blade)	200	200	3,2	-0,4	-1,2	1,6	0,3	5,9
Network equipment: Rack mounted (large)	800	780	17,0	-0,4	-6,2	6,3	1,7	35,0
<i>Components (average all sub categories)</i>	22	22	0,1	0,0	0,0	0,2	0,0	0,2
Components: SSD	94	93	0,0	0,0	0,0	0,7	0,0	0,1
Components: HDD	71	70	0,4	0,0	0,0	0,6	0,0	0,8
Components: RAM memory	5,1	5	0,0	0,0	0,0	0,0	0,0	0,0
Components: Processor	50	50	0,0	0,0	0,0	0,4	0,0	0,0
Components: Laptop battery	7,9	8	0,2	0,0	0,0	0,1	0,0	0,3
Components: Laptop screen	61	60	0,1	0,0	0,0	0,5	0,0	0,1
Components: Tablet screen	32	32	0,1	0,0	0,0	0,3	0,0	0,2
Components: Smartphone screen	14	14	0,0	0,0	0,0	0,1	0,0	0,1
Components: Keyboard	3,7	3	0,4	0,0	0,0	0,0	0,0	0,8
Components: Power adaptor, laptop	3,5	3	0,1	0,0	0,0	0,0	0,0	0,2
Components: Docking station	8,4	8	0,4	0,0	0,0	0,1	0,0	0,8
Components: Network card	1,9	2	0,1	0,0	0,0	0,0	0,0	0,2
Components: Fan	0,3	0	0,0	0,0	0,0	0,0	0,0	0,0
Components: DVD	3,4	3	0,1	0,0	0,0	0,0	0,0	0,2
Components: Mouse pad	0,1	0	0,1	0,0	0,0	0,0	0,0	0,1
Components: Smartphone/tablet charger	1,3	1	0,1	0,0	0,0	0,0	0,0	0,1

References

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- 3: Website: Lenovo Product Carbon Footprints (URL: https://www.lenovo.com/us/en/social_responsibility/datasheets_notebooks/). Visited in June 2019.
- 4: Website: Dell Product Carbon Footprints (URL: https://www.dell.com/learn/us/en/uscorp1/corp-comm/environment_carbon_footprint_products). Visited in June 2019.
- 5: Website: HP Product Carbon Footprints (URL: <http://h22235.www2.hp.com/hpinfo/globalcitizenship/environment/productdata/ProductCarbonFootprintnotebooks.html>). Visited in June 2019.
- 6: Website: Huawei Product Carbon Footprints (URL: <https://consumer.huawei.com/en/support/product-environmental-information/>). Visited in June 2019.
- 7: Website: Apple Product Environmental Reports (URL: <https://www.apple.com/environment/reports/>). Visited in June 2019.
- 8: Ecoinvent v3.5, lifecycle inventory database. Accessed through the LCA modelling tool GaBi ts.
- 9: Inrego AB. Personal communication with Erik Petterson at Inrego, spring 2019.



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