

# Summary Report of the process LCA results

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## 1. Introduction

This document summarises the main aspects of the deliverable document "Report of the process LCA results" corresponding to phase I of the B.1 action, part of the Life+2011 project: Demonstration of a WEEE reuse process which seeks to propose regulatory policies pursuant to European Community legislation.

The work corresponds to the Life Cycle Analysis (hereinafter "LCA") for the computer equipment reuse process. The project features four examples which analyse the processing of computer waste elements with a view to using them in new applications. The requirements for each of the examples are covered by two modules featuring disassembly, checking, verification and assembly lines at Universidad de Vigo and Revertia facilities. In order to tackle the challenge that LCA poses, four calculation models were designed, corresponding to each of the programme's four examples.

The LCA study was carried out using SimaPro software. This program, developed by Pré Consultants, allows complete Life Cycle Analysis to be carried out using multiple methods to assess the impact levels to be calculated based on the recommendations contained in international ISO regulations 14040 and 14044 and the ILCD Handbook directives. The impact assessment methodology selected for this study is known as ReCiPe, created by RIVM, CML, PRé Consultants, Radboud Universiteit, Nijmegen and CE Delft.

## 2. Life Cycle Analysis

An LCA study has been carried out in order to demonstrate the environmental efficiency of the four examples, whose reuse process consists of the analysis and processing of computer equipment for new purposes.

- Example I: Central Units in Data Acquisition and Mechanism Control in a distributed system. (UCAC)
- Example II: Standard Distributed Computer Equipment (CLUSTER)
- Example III: Perimeter Security Systems for the protection of an organisation's intranet. (ASP)
- Example IV: New complete IT work stations for office use.

### 2.1 Scope and objective

This study establishes an initial approach to analysis of the environmental development of the preparation process for reuse for industrial ends (Example I, II and III) and office use (Example IV), in order to quantitatively assess the importance of the environmental impact of the final provision process for office equipment within its own life cycle.

This analysis represents a tool that can be used to quantify the environmental impact of reuse, allowing new products to be identified in the sector and the reuse preparation process to be optimised, highlighting the advantages and disadvantages of the various types of reuse impact as well as providing verified life-cycle data of reuse processes.

The scope of this study has been defined in accordance with the main aim, in other words, to carry out LCAs of the four examples which consist of obtaining and operational processes - a UCAC, a CLUSTER, an ASP and a complete office IT system respectively, obtained from conventional office IT components with reuse potential, with a "cradle to grave" focus.

In order to be able to compare the recycling process in future work, the initial computer equipment should be the same for the analysis of all examples. The final destination of these and how they will be managed once used, will be the determining factor in the results obtained from the corresponding analysis for each example. The product system for each example will therefore cover all the unit processes required in order to manufacture conventional office computer equipment, its distribution, use and, when it reaches the end of its useful life, the preparation for its reuse and the assembly of the resulting reused product in each case (UCAC, CLUSTER, ASP or office computer equipment), its distribution, its use and, when necessary, its subsequent recycling.

For each variant, a functional unit in time terms has been defined, which will ensure full servicing of the resulting product for each example, bearing in mind the spatial, temporal and technological context in each case.

The system limits have been established, as has its function and the functional unit, in accordance with the future aim of making comparisons with a scenario in which all office computer equipment is recycled at the end of its life. Initially we will be analysing the manufacture of office computer equipment from virgin raw materials, assessing impact during production (from the extraction of the material to final assembly), distribution (from the production site to the place of use) and use (the energy consumed during its working life). After this first working life, the environmental impact of the manufacture of the corresponding product based on reused components for each of the examples is assessed, as is its use during the defined period within the functional unit and the final treatment at the end of said period.

## 2.2 Life cycle inventory

In the inventory stage the material and energy flows are assessed for each of the phases into which the systems covered by this study can be divided. The relevant data is collected and the pertinent calculations made in order to best evaluate the input and output for each process based on the functional unit described for each example variant.

As far as the stages in which there is no access to specific data (manufacture, use, recycling and distribution) are concerned, generic data will be used from a third-party life-cycle inventory database or from another source that meets quality standards.

The inventory from the corresponding reuse preparation process phase in order to assemble different products (corresponding to each example variable) will be based on specific data, given that it will be carried out on two work islands specifically designed and built for this purpose, which will be installed in the Universidad de Vigo and Revertia and which will reproduce the processes on a smaller scale.

The reuse preparation process consists of three main phases: the removal phase, the treatment phase and the issue phase. Each of these phases is in turn sub-divided into different activities and tasks which offer the greatest level of process detail. Due to the differing needs of certain hardware elements for each of the examples, the unit processes that make up each of the phases have been individually designed.

The phases into which the life cycle with reuse has generally been divided are as follows: manufacture of conventional office computer equipment, distribution, use during its first useful life, recycling of non-reusable components (common to the LCAs for all examples) and the preparation process for the reuse of office computer equipment in order to obtain the reused product, its use during its second useful working life and recycling, with these latter factors specific to each variant.

### **Inventory of the manufacturing process.**

This process takes into account the manufacture of a CPU, screen, keyboard and optical mouse. The environmental impact and emissions associated with the manufacturing processes of the four elements have been determined based on the inventory of materials of which each element is comprised and on SimaPro, Ecoinvent 2.2 (2010) databases. In order to take capital goods (machinery, vehicles, infrastructure etc.) into full account, a straight-line depreciation system will be used, taking into consideration the expected useful life of the capital goods in question.

### **Inventory of the distribution process**

During this stage, the transportation of the office computer equipment from the manufacturing plant to the end user must be considered. Depending on the results presented in scientific publications regarding the European Distribution Network and the project's own estimates, a distribution chain which takes surface transport from the production centre to the airport, air

transport from China to Spain and road and car transport to retail outlets and end users have all been studied.

### **Inventory of the use phase**

During the use phase of the LCA, two key areas are considered. Firstly, the use corresponding to conventional office computer equipment (common to all example variants) and secondly, the use corresponding to the product resulting from the reuse process.

The energy consumed by office computer equipment during its first useful life is determined by considering operational model and the power consumption as published by Energystar, establishing first useful life as lasting 5 years.

In the event that the products resulting from the preparation process for the reuse of examples I, II and III do not have representative data relating to the use of similar products. The data relating to the use stage of these products has been determined through an estimate that is based on the three parameters that potentially determine electricity consumption: the estimated useful life, the expected use model and the operating power required in each case.

The product resulting from the example IV reuse preparation process is a conventional piece of office computer equipment, equivalent to a brand new unit, with a second useful life estimated at 24 months.

### **Inventory of the end of useful life phase**

As far as the end of useful life phase is concerned, two stages have been identified in the systems studied: the initial reuse of conventional office computer equipment process and the recycling of the product resulting from the reuse process at the end of its useful life.

#### Reuse phase

As a part of the aims of this project, four specific preparation processes have been designed and started up which focus on integrated reuse through three main phases - the removal phase, the treatment phase and the issue phase, as set out earlier.

Inventory data from this period represents empirical data from the start-up of the work islands, built according to the specifications set out in the process design for each of the examples located at Revertia (removal, issue and treatment at Example IV) and the Universidad de Vigo (treatment Example I, II and III). Data from the Ecoinvent database will also be used. In those cases in which there is no compatibility with certain specific materials, data from similar cases will be assigned.

The environmental impact of all these processes will be assigned to the various co-products in accordance with the system limit extension assignment rule. The alternative method that has been employed is that of mass assignment.

#### Recycling phase

The recycling phase includes the non-reusable components from conventional office computer equipment, in other words, the parts which cannot be utilised in the reuse process, and the product components resulting from the reuse preparation process (UCAC, CLUSTER, ASP and office computer equipment) at the end of its useful life.

This part of the LCA takes into account the treatment of electronic waste and the subsequent treatment of the various classification types of the recycling companies on a European level, using the Ecoinvent database as the point of reference.

### **3. Conclusions**

Four example variants which represent different reuse product component preparation process scenarios are being studied. The aim is for this study to serve as a benchmark for computer equipment LCAs, outlining different end-of-life scenario options.

LCA models for each example have been prepared in order to assess the environmental impact of the various reuse preparation process, with a main focus on comparison with the recycling process. In each case, all the parameters required for analysis have been established: objective, scope, system limits, functional unit etc. Furthermore, for the inventory stage, the relevant data has been collected and the pertinent calculations made in order to best evaluate the input and output for each process based on the functional unit described for each example variant.

Start-up of the work islands and assembly of the prototypes will allow validation of the representative nature of the estimates and the reference data based on similar processes, as well as obtaining specific data. Based on this , we can draw up highly accurate impact assessment for the corresponding life cycle which we will be including in a second version of this deliverable.