Environmental Life Cycle Assessment of 93PM Uninterruptible Power Supplies

Authors: Sagar Ghonge, Engineer – Sustainability, Safety Reliability and Sustainability CoE, Eaton India Engineering Center
Kirsi Hakalahti, Eco Design Project Coordinator / Project Manager – EMEA 3ph Engineering, Eaton

Abstract – The paper deals with the environmental life cycle assessment study of Eaton 93PM uninterruptible power supplies (UPSs). The study was commissioned to understand the impacts from different phases of life cycle of the product and proactively communicate the environmental profile of product to customers, underlining Eaton's commitment to sustainability. It was found that the in-use phase is the most impactful phase, making between 62% and 90% contribution to the overall lifetime impacts. Since the impacts of the in-use phase are tied to the efficiency of the UPS, ESS mode presents an important opportunity for reducing the environmental footprint of the product. In practice, ESS mode was found to reduce the impact by between 43 and 62 percent compared to double conversion mode.

Keywords – uninterruptible power supply (UPS), life cycle assessment (LCA), ecodesign

I. Introduction

The 93PM uninterruptible power supply (UPS) by Eaton features industry leading efficiency of greater than 96 percent and world class intelligent software. The Eaton 93PM UPS is an all-in-one solution that minimizes the total cost of ownership. It has two operational modes – double conversion mode (DCM) and Energy Saver System (ESS) mode, the second of these provides efficiency greater than 99 percent.

The study was commissioned to understand the lifetime environmental impacts of a product and communicate this information to potential customers.

A. Life Cycle Assessment (LCA)

A Life Cycle Assessment (LCA) approach was used to quantify the environmental impacts. LCA is an environmental assessment method that addresses the potential environmental impacts of products throughout their life cycle, from raw material acquisition through production, use and end-of-life including recycling (cradle-to-grave). Figure 1 shows the LCA framework in line with ISO 14040.

II. Goal and Scope Definition

A. Goal of the Study

First goal of the study was to obtain LCA-based environmental information to better understand the environmental impacts of 93PM UPS. This knowledge will assist the company in eco-design of the products. The intended audience for this goal is internal Eaton customers.

The second goal of the study was to quantify the life cycle environmental performance of 93PM UPS. The purpose was to justify and communicate environmental claims in a detailed critically reviewed LCA report to potential customers. The intended audiences for this goal are both internal and external customers.

The study was carried out in accordance with ISO 14040 and 14044 guidelines on LCA.

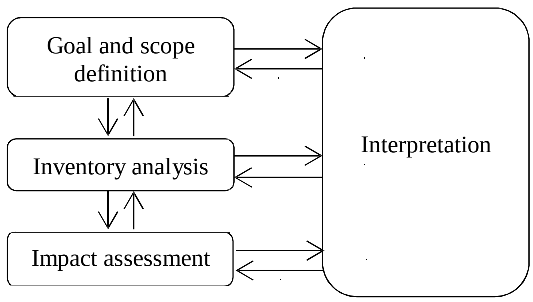

Figure 1. LCA framework [1] [2]

B. Scope of the Study

The Functional Unit for the study was defined as a device that would "over a lifetime of 13 years, ensure continuous and reliable power for critical applications, following a defined typical load profile, with 30 minutes of load on the batteries per year, assuming no redundancy."

A 93PM UPS was chosen for the study. A typical load profile for the study was defined by in-house engineers with many years of experience working with UPS units.

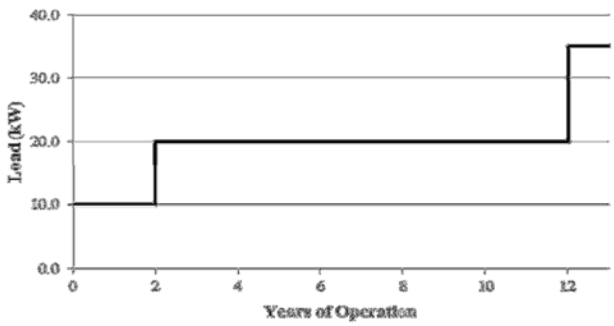

Figure 2. Typical load profile of 93PM UPS

III. Inventory Analysis

The product life cycle can be divided into six main stages – production, assembly and testing, packaging, delivery, in use and end of life. The production phase was modeled using the detailed bill of materials (BOM) provided by product teams. Figure 3 shows the weight contribution analysis of various components from BOM. Batteries were found to contribute 75% of weight of the product followed by frame and metal parts (19%).

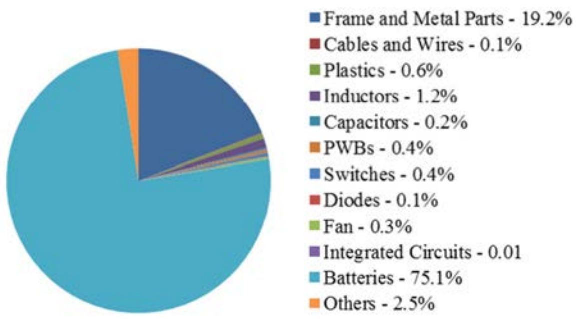

Figure 3. Weight contribution of 93PM UPS components

The UPS in-use phase involves electricity consumption associated with energy loss in the UPS system itself; the cooling of heat produced by the energy loss in the UPS; the servicing of the UPS and electricity consumption for battery charging. It was assumed that 100% of the UPS is ultimately collected and sent for waste treatment, in line with the WEEE directive.

The principal primary data used for this LCA was a detailed bill of materials (BOM) for the UPS units, provided by the 93PM UPS team, and efficiency data for the UPS, which allowed the calculation of energy losses during the use phase. In terms of secondary data, by far the most used source of life cycle inventory (LCI) data was the ecoinvent 2.2 LCI database [3], which contains detailed LCI data for most processes and materials used in this LCA, including electrical component production and end-of-life management. Relevant data from open literature [4] [5] [6] was used to plug data gaps where necessary.

IV. Life Cycle Impact Assessment

This step involves processing the inventory to quantify environmental impacts over the life cycle of product. The impact assessment method used here was Impact 2002+ (biogenic) [7].

A. Impacts Across Life Cycle Stages

Figure 4 shows the contribution of life cycle stages to the overall impacts from product life cycle. Contribution of impacts from the in-use phase is found to be highest (62% to 90%) followed by impacts from production (10% to 38%). The combined contribution from the other phases is in the range of 1% to 2%.

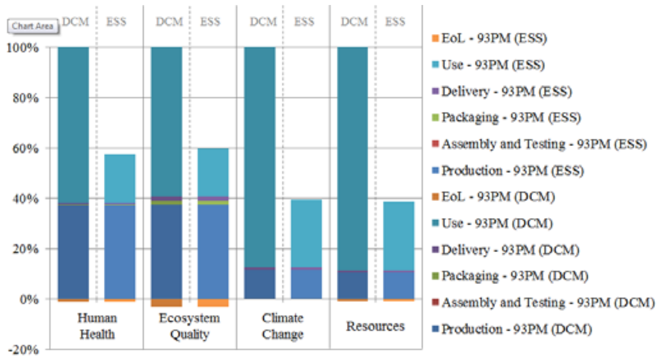

Figure 4. Stacked comparison of 93PM operating modes – DCM versus ESS

B. Analysis per Life Cycle Stage

In order to understand the source of the environmental impacts, the in-use phase and the production phase were analyzed in more detail. It was found that the in-use phase impacts accrued from the power losses (74%) and energy consumption for cooling purposes (26%).

As one of the goals for this study was to obtain LCA-based environmental information that will enable Eaton to better understand the environmental impacts of the 93PM UPS, a detailed contribution analysis of the various components of the production stage was performed (Figure 5). Impacts from battery production were found to be highest (41% to 75%) followed by frames and metal parts (9% to 22%).

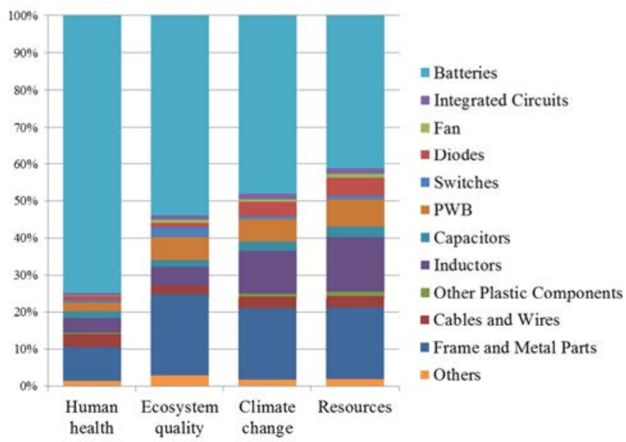

Figure 5. Contribution of components to production stage

C. Analyzing Impact Intensities by Component Group

In order to understand the higher contribution to impacts from certain components with lower overall weights, a comparative analysis of the impact intensities of each component was done. Impact intensity can be defined as the impact of the component production divided by the weight of the component in the product. Figure 6 shows the impact intensities for different components for the climate change damage category. Integrated circuits are found to have highest impact intensity followed by diodes, then cables and wires.

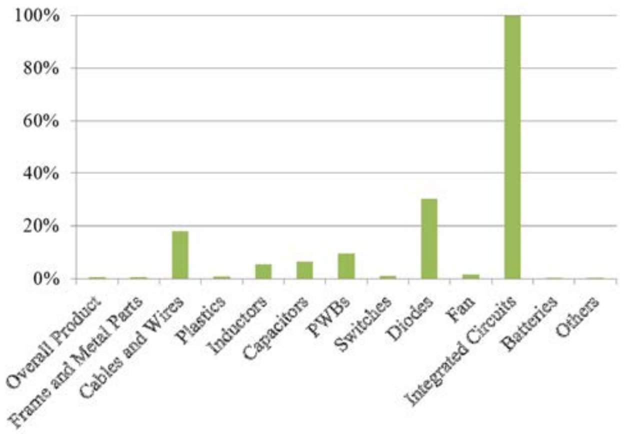

Figure 6. Impact intesities of different components for climate change damage category

D. Comparison of Operating Modes – DCM versus ESS

In ESS, the load is powered securely through a static bypass line. Double conversion is available on demand with typical 2 ms transition time, in the event of any abnormality on supply source. When operating in ESS mode, load is protected with inherent surge suppression. Impacts from the in-use phase were found to be substantially reduced due to the greater efficiency of ESS mode. The overall reduction was between 43% and 62%. Impacts from all other lifecycle phases remain same.

V. INTERPRETATON AND DISCUSSION

The study shows that the most impactful phase of the UPS life cycle is the in-use phase and that the impacts are mainly attributable to power losses and cooling requirements. Since the impacts during the in-use phase are tied to the efficiency of the UPS, ESS mode presents an excellent opportunity for reducing environmental footprint of the product and was found to reduce the impact by between 43 and 62 percent compared to double conversion mode. The production phase has the second highest environmental impacts, mostly as a result of lead acid battery production. The end-of-life phase has positive impacts attributed to material recycling. Other phases – assembly and testing, packaging and delivery – have minimal impacts over the life cycle of the product.

The purpose of this LCA was to quantify the lifetime environmental burdens and to identify the most impactful phase of the 93PM UPS lifecycle. This has been achieved.

Another objective was to proactively convey the environmental profile of product to potential customers and underline Eaton's commitment to sustainability. The report presents in detail the environmental footprint of 93PM UPS in each life cycle phase. It was critically reviewed and can be used to make any environmental claims in product brochures.

The results of this study will be used as benchmark for environmental design and development of products in future.

ACKNOWLEDGMENT

The authors would like to thank Lily Gan and Rex Yang for their support during data collection for the study.

REFERENCES

[1] ISO 14040, "Environmental Management - Life Cycle Assessment - Principles and Framework," International Organization for Stadardization, Geneva, Switzerland, 2006.

[2] ISO/TR 14049, "Environmental management — Life cycle assessment — Examples of application of ISO 14041 to goal and scope definition and inventory analysis," International Organization for Standardization, Geneva, Switzerland, 2000.

[3] Ecoinvent, "Ecoinvent Database v2.2," The Ecoinvent Centre, Dubendorf, CH, 2009.

[4] M. Rantik, "Life Cycle Assessment of Five Batteries for Electric Vehicles under Different Charging Regimes," Kommunikations Forsknings Beredningen, Stockholm, 1999.

[5] Friends of the Earth Europe, "Gone to Waste - The valuable resources that European countries bury and burn," Friends of Earth Europe, Brussels, Belgium, 2009.

[6] USEPA, "Municipal Solid Waste Generation, Recycling and Disposal in the United States: Facts and Figures for 2010," 2010.

[7] O. Jolliet, M. Margni, S. Humbert, J. Payet, G. Rebitzer and R. Rosenbaum, "IMPACT 2002+: A New Life Cycle Impact Assessment Methodology," International Journal of Life Cycle Assessment, vol. 8, no. 6, pp. 324-330, 2003.