Available online at www.sciencedirect.com
ScienceDirect
Procedia CIRP 47 (2016) 300 – 304
www.elsevier.com/locate/procedia

Product-Service Systems across Life Cycle

Reference data architecture for PSSs Life Cycle Inventory

Donatella Corti[a]*, Alessandro Fontana[a], Federico Montorsi[a]

[a]SUPSI - University of Applied Sciences and Arts of Southern Switzerland, via Cantonale, 2C, 6928 Manno, Switzerland

* Corresponding author. Tel.: +41 58 666 66 90. *E-mail address:* donatella.corti@supsi.ch

Abstract

This paper focuses on the evaluation of the environmental impacts of a PSS based on the Life Cycle Assessment methodology. Since current LCA tools are mainly product-oriented, solutions that allow an easy integration of the service component are needed. A reference architecture guiding the execution of the LCI phase is proposed both considering how service and product information jointly contribute to data gathering in the lifecycle phases and providing a more detailed checklist of information categories. The proposed architecture in this version has been thought to be as general as possible in order to be applied to any type of PSS.

Peer-review under responsibility of the scientific committee of the 8th Product-Service Systems across Life Cycle

Keywords: Life Cycle Inventory (LCI); Life Cycle Assessment (LCA); Data architecture; Product-Service Systems (PSS)

1. Introduction

The link between the use of a PSS and its environmental impact has been clarified since the introduction of the concept itself. This was evident in the first formal definition of a PSS given in 1999 ([1]) that was: “A product-service system is a system of products, services, networks of players and supporting infrastructure that continuously strives to be competitive, satisfy customer needs and have a lower environmental impact than traditional business models”. More recently, [2] have investigated the relation between the type of PSS and its environmental impacts showing that impacts are closely related to the types of PSS and, depending on the type of contract reflecting the type of PSS, different results in term of environmental assessment, both positive and negative, can be achieved.

The widespread use of PSS in different sectors combined with the increasing importance of sustainability issues also in the customer’s eyes makes it necessary the development of tools able to reliably and easily assess the environmental and economic impacts of PSS. Tough the assessment of products is quite an established field and different solutions are available in the market, the assessment of services is not always taken into consideration and there are no standard for their inclusion. The sustainability measure of PSS thus calls for methods and tools able to seamlessly integrate product- and service-related aspects into the assessment tools.

Focus of this paper is on the evaluation of the environmental impact of a PSS by means of the Life Cycle Assessment (LCA) methodology. There is a lack on general procedures, applicable to any type of PSS to follow in order to effectively carry out the evaluation: the wide range of services that can be combined with a product and their different nature, in fact, makes it difficult the development of a unique and robust method to systematize the information collection. The main aim of the piece of research here presented is to provide a reference architecture to support the Life Cycle Inventory (LCI) phase of the LCA that could formalize in detail the integration of information related to the service part of the offer. First, categories of information and their positioning along the life cycle of the PSS are taken into consideration showing the backbone structure that is recommended to carry out the LCI for a PSS. Then, each category is detailed more by considering some PSS-related examples (from the more traditional technical assistance to the most advanced pay per use service contracts). Even though the paper is mainly of a conceptual nature and aims at providing a model that is as general as possible, the discussion is based on empirical

Peer-review under responsibility of the scientific committee of the 8th Product-Service Systems across Life Cycle
doi:10.1016/j.procir.2016.03.033

examples taken from the authors expertise in different sectors and relies on the work carried out within an European-funded project (Manutelligence project ID 636951, Horizon2020-FoF2014). In the next chapter a literature review about the use of LCA for PSS is presented (§2). Next, a high level architecture for supporting the data collection for the LCI phase of the LCA is proposed in §3. Such architecture is further detailed and explained using some practical examples (§4), before drawing some conclusions (§5).

2. LCA for PSS: a brief literature overview

In [3] different types of PSS are compared against the simple sale of the product and their relative environmental impact is qualitatively assessed. According to their study, the model of PSS that might lead to a radical reduction of environmental impacts is the functional result since, in this case, the provider has more degree of freedom for designing a low impact system.

More generally, the best results in environmental sustainability are achieved when the PSS provider retains the responsibility for physical products during the use phase, that matches with a better delivery of repair services and maintenance leading to a product lifetime extension ([2]).

In literature, the benefits of methodologies to perform the assessment of PSSs are frequently described (see for example [2]; [4] or [5]), whilst more rarely contributions describing how to effectively execute these evaluations can be found. Often, the sustainable design of solutions focuses mainly on the physical product and potential optimizations are directed towards its subsystems, whilst only later surrounding systems, which are the basements of the services, are paid attention. This procedure is not due to a lack of methodologies but rather due to lack of system thinking ([4]).

Many contributions dealing with sustainability assessment of PSS depict the maintenance as the only service to be evaluated, while all the other services included in the PSS are neglected ([6]) and, typically, LCA procedures are applied to a specific case so that it is difficult to identify a general procedure. For instance, [7] presents an LCA study to assess impacts for a leasing PSS type of a water filtration device. The product related impacts are evaluated using the Swiss-based Ecoinvent database, whilst for the service component a scenario simulation has been used to evaluate the use stage, developed thanks to the carrying out of a site survey.

A few contributions only introduce methodologies to be applied when assessing the environmental impact of PSSs. In particular, three methodologies have been analyzed, as they seem to be the most complete. They are briefly described in what follows.

A model proposed by [8] takes into account the three dimensions of sustainability (economic, environmental and social) when analyzing PSSs. It describes the steps a designer should follow in order to calculate a “final” indicator called Sustainability Indicator (SI) that could be used to compare different configurations of a PSS. The SI is computed to evaluate every aspect of a PSS and is composed by aggregating a list of more specific indicators. In order to allow the aggregation, each indicator is translated into an economic value and expressed as a monetary value.

The second model taken into consideration is the one proposed by [9] and is specific for product renting, share and product pooling PSSs. It describes a step-wise methodology, based on the computation of specific parameters to model the system, to optimize the PSS in term of intensified usage. It analyzes every phase of life cycle of the PSS and in particular the use phase, that is split into main activities and states (stand-by stage, use stage and maintenance stage), providing parameters to model the system. The calculation of these parameters is functional for the comparison of different scenarios and, hence for determining the strategy that optimizes the system in term of environment, economics and use. The Functional Unit, suggested within the model by [9] can be used to model all kind of PSSs in which the service is strictly linked to the delivery of the product. However, the methodology does not take into account Pay-per-use or the Functional results types but, taking in consideration every environmental aspect of the service, could be extended to set up an analysis for every type of PSS.

Finally, [10] introduce an approach useful for PSS developers looking for cost effective ways to get a quick overview of sustainability consequences of alternative choices. Their proposal relies on the use of three strategic tools that allow the early integration of the service component into the design process and the assessment of the sustainability impacts. They propose a procedure for including the sustainability evaluation, but they do not provide any specific indicator or method of calculation.

Even tough these methodologies adopt a wider perspective for assessing sustainability impact, a general model describing how to assess LCA adaptable to any kind of PSS has not been found.

3. A LCI high level architecture for PSS

The Life Cycle Inventory (LCI) is one of the four steps included in the LCA procedure, namely (i) goal and scope definition; (ii) Life Cycle Inventory (LCI); (iii) Life Cycle Impact Assessment (LCIA) and (iv) interpretation of results. In particular, the LCI is focused on the data collection: all the flows in terms of resources and emissions entering and leaving the system of interest have to be taken into account identifying the exchanged natural elements and their quantity. This step is highly complex and time consuming, since it involves several different processes and actors along the supply chain. The main considered reference procedure to carry out the LCI is the standard included in the ISO 14040:2006. According to this, the process of conducting an inventory analysis is iterative. As data are collected and more is learned about the system, new data requirements or limitations may be identified; this analysis may suggest a change in the data collection procedures so that the data characterizing the system are collected in a more precise way. Sometimes, after the LCI phase, also a review of the goal and scope of the LCA study is required.

The second step of LCI involves the calculation procedures that follow data collection, including validation of data