

# A FRAMEWORK FOR DEVELOPING SUSTAINABLE VALUE PROPOSITIONS FOR INDUSTRIAL PRODUCT-SERVICE SYSTEMS

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*The 29<sup>th</sup> IMP 2013 Conference, Atlanta*

## ABSTRACT

This study examines the process of developing sustainable value propositions for product-service systems (PSS). By integrating the literature on customer value propositions with life cycle assessment methodologies, we build a process framework that can be employed to demonstrate the economic, environmental and social value delivered by PSS. The framework comprises 1) value potential identification, 2) baseline assessment, 3) life cycle modelling, and 4) life cycle value calculation for PSS. Through participatory action research, we explore the development of value propositions in two industry sectors: metallurgical and automotive. The results highlight the value provided to customers, through the combination of direct economic value and the derivative value of lower environmental and social impacts. This research contributes to the knowledge on PSS by presenting a framework through which industrial suppliers of PSS can demonstrate sustainable value provided to the customer, which is vital for more widespread business acceptance of PSS.

**Keywords:** Customer value proposition, sustainability in marketing, life cycle assessment, life cycle profit assessment

## PAPER TYPE

Competitive

## TRACK

Managing Sustainability in Global Networks

## INTRODUCTION

Businesses are increasingly encouraged to help solve rather than cause social, environmental and economic problems (Kotler, 2011; Porter and Kramer, 2011). As a result, sustainability is considered a new strategic imperative (Connelly et al., 2011; Kotler, 2011; Porter and van der Linde, 1995; Porter and Reinhardt, 2007) and a potential source of major competitive advantage (Berns et al., 2009). This shift is reflected, for example, in the provision of sustainable product-service systems (PSS) (Bauren, 2013; Mont, 2002), which aim to advance sustainability through integrated offerings that combine products and services.

The idea that customers purchase expectations of benefits and solutions to particular problems instead of product functions is at the core of PSS (Boehm and Thomas, in press). Despite growing research and practical interest on PSS, their application and use is at a relatively early stage. The extant literature suggests that PSS research needs to integrate environmental and marketing perspectives to facilitate more widespread adoption (Boehm and Thomas, 2013; Lee et al., 2012; Tukker and Tisher, 2006). This article aims to integrate these perspectives by examining the development of a *sustainable value proposition* through which suppliers can demonstrate to potential customers the life cycle value that results from the economic, environmental and social impacts of PSS.

The adoption of sustainable PSS requires potential and realised benefits to be demonstrated convincingly to potential adopters. We propose that ambiguity relating to the value of PSS is an obstacle to their wider adoption. Value ambiguity refers to the doubts and concerns of potential adopters regarding their actual realisation of value from PSS offerings (Anderson and Wynstra, 2010). To tackle the problem of value ambiguity and facilitate the adoption of PSS, researchers and practitioners must focus attention on the creation of sustainable value propositions.

Firms need to evaluate and credibly demonstrate the social, economic and environmental benefits that resonate with potential customers. However, the benefits of PSS are often assessed with the focus purely on their environmental benefits, and with a lack of approaches that consider all three dimensions of sustainability (Lee et al., 2012). There is also a lack of research on assessing the value elements of PSS offerings. The purpose of this research is to address this gap by developing and illustrating an integrative framework with which to deliver sustainable value propositions for industrial PSS.

Specifically, we address the question: How can firms that offer PSS develop sustainable value propositions? We answer this question by integrating the literature on customer value propositions with the literature on sustainable life cycle tools to develop an operational framework for developing sustainable value propositions. We illustrate the framework through a case study that involves two different industrial technologies targeted at improving the efficiency of industrial production processes. The paper contributes to the literature on PSS by suggesting a systematic approach to the evaluation and demonstration of industrial PSS benefits, with a focus on how impacts of the three dimensions of sustainability deliver value to the customer over the life cycle of a system.

# LITERATURE REVIEW

## INTEGRATING PRODUCT-SERVICE SYSTEMS AND CUSTOMER VALUE PROPOSITIONS RESEARCH

Research on product-service systems (PSS) and related concepts such as solutions and hybrid offerings is dispersed across various disciplines including marketing and service (Tuli et al., 2007; Ulaga and Reinartz, 2011), operations research (Pawar, 2009), engineering and design (Baines et al., 2007) and information systems (Geum et al., 2011). Drawing from a multidisciplinary systematic literature review, Boehm and Thomas (in press) define PSS as “an integrated bundle of products and services which aims at creating customer utility and generating value.” The underlying premise of PSS is that they have the potential to advance sustainability through dematerialisation. PSS aim at providing the same utility as existing products through an increased service component, decreasing environmental impacts in the process (Mont, 2002). Instead of product efficacy and technical functionality, PSS focus on improving the efficiency and effectiveness within an end-user’s process (Pawar et al., 2009). Therefore, PSS form a specific type of value proposition that a supplier offers to (or co-creates with) its customers (Tukker and Tisher, 2006).

The concept of value proposition originates from the marketing literature and refers to a scheme that communicates the value delivered by an offering to customers (Anderson et al., 2006; Ballantyne et al., 2011; Truong et al., 2012). Conventionally, customer value propositions have been defined as statements on benefits of a particular product or service (Lanning & Michaels, 1988; Rintamäki et al., 2007). For example, Anderson et al. (2006) suggest that suppliers can develop customer value propositions in three ways by identifying: 1) all benefits, 2) benefits that exceed the next best alternative or 3) the value of the selected key benefits their offerings deliver to customers. However, instead of focusing on benefits derived from particular products or services, service-dominated thinking emphasises that value is created in customers’ processes as value-in-use (e.g. Grönroos, 2011). This is in line with the PSS literature, which focuses on creating value by improving production processes (Boehm and Thomas, in press; Wang et al., 2011). Business models that are built around PSS emphasise taking responsibility for customers’ operations (Mont, 2002; Pawar et al., 2009). For example, Ulaga & Reinartz (2011) suggest that the value proposition of PSS can be grounded in a supplier’s promise to perform a deed (based on input) or achieve performance (based on output) on behalf of the customer.

However, the value perceived by customers from PSS is usually realised over a long period of time (Tuli et al., 2007) and depends on how well a customer is able to utilise the offering. Consequently, potential value-in-use that results from PSS is often difficult to assess, which can lead to value ambiguity (Anderson and Wynstra, 2010) and customers’ reluctance to adopt new PSS. To overcome this, suppliers need to develop customer value propositions that evaluate and quantify the potential and realised value of their offerings (Anderson et al., 2006; Töytäri et al., 2011).

Given that PSS are aimed at improving customers’ processes, their value proposition should convey the value received by customers over the lifetime of an offering (Pawar et al., 2009; Schweitzer & Aurich, 2010). From a marketing perspective, this requires *identifying the value potential* of a supplier’s offering, which defines the current and future benefits that represent

expected value-in-use for a customer (Grönroos and Voima, 2013; Möller and Törrönen, 2003). Considering an offering's value potential beyond customers to other stakeholders is particularly relevant in the context of PSS, which usually involve multiple stakeholders (Ballantyne et al., 2011; Cova and Salle, 2008; Morelli, 2006;). Due to their long life cycle and technologically complex nature, measuring realised value potential from PSS has special requirements in comparison to physical products (Schweitzer and Aurich, 2010). Key among these is the need for a *baseline assessment*, which evaluates a customer's process performance before implementing PSS. Baseline assessment enables a supplier to predefine key performance indicators that are employed to measure the impacts of PSS on customers' processes (see also Bertoni et al., 2013). Key performance indicators can relate either to input- or output-based outcomes, such as repair or downtime, quality of the end-product, amount of scrap material or productivity (Schweitzer and Aurich, 2010). As PSS are usually highly customised, defining key performance indicators for each customer and their relevant stakeholders is critical (Bertoni et al., 2013). Ultimately, baseline assessment aims at identifying specific process improvements after implementing PSS, and analysing their impact on customers' performance. In turn, this enables a supplier to *calculate the life-time value* that results from improved process performance (c.f. Schweitzer & Aurich, 2010).

#### LIFE CYCLE TOOLS IN ASSESSING THE POTENTIAL VALUE OF PRODUCT-SERVICE SYSTEMS

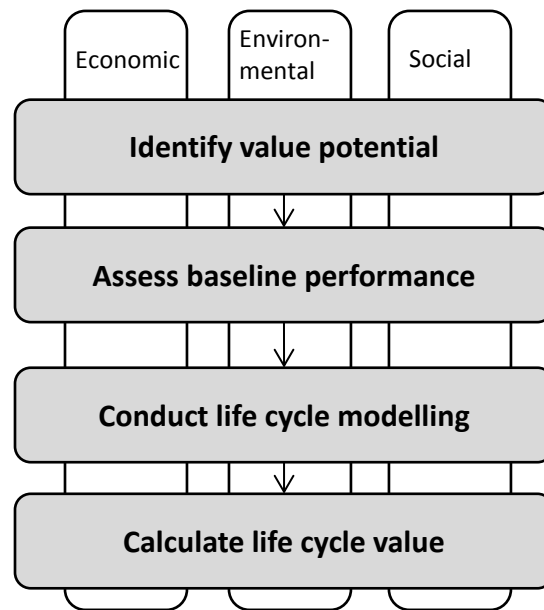
In the sustainability literature, life cycle assessment (LCA) tools have been widely employed to evaluate environmental impacts of PSS over their life cycles from inception to post-usage (e.g. Komoto, 2006; Lee et al., 2012; Rebitzer et al., 2004; Öberg et al., 2012). LCA studies also can be employed in marketing activities to verify environmental arguments and achieve environmental certifications or eco-labels (SFS, 2006, Thrane et al., 2009).

LCA is a systematic method that examines material flows relating to PSS, and considers a wide scope of effects that relate to the natural environment, human health and resource usage, and aims to determine environmental impacts and life cycle phases most relevant to them (Rebitzer et al., 2004; Soukka, 2007). LCA tools are typically employed to identify potential to improve environmental performance at various points over the life cycle of a PSS. For example, services such as training, repair, maintenance or the upgrading of physical equipment components result in a longer equipment life cycle (Aurich et al., 2004). PSS that do not include the transfer of ownership can lead to reduced equipment and material disposal. Thus, the effects of included services can be beneficial to the environment, but they might also have negative rebound effects (Bartolomeo et al., 2003). This indicates a need to analyse the potential for improved environmental performance of each PSS individually.

Key phases in the LCA process comprise goal and scope definition, inventory analysis, impact assessment and interpretation of results (SFS, 2006). Goal and scope definition involves *determining the potential* that PSS has to improve environmental performance within a selected application, and specific key performance indicators that are employed to measure results. Inventory analysis and impact assessment are often termed *life cycle modelling* (Guinee et al., 2011), which involves establishing a *baseline for the key performance indicators*, and analysing resultant environmental impacts over the life cycle of a PSS (Rebitzer et al., 2004).

While LCA standards are developed to assess environmental impacts, recent studies have focused on integrating *economic, environmental and social impacts* into a single multidisciplinary sustainability assessment framework (e.g. Guinee et al., 2011; Lee et al., 2012). Moreover, prior research indicates that overly focusing on environmental impacts can hinder the promotion of ecologically beneficial PSS (Sharma et al., 2010), and emphasising the economic benefits of PSS might facilitate their more widespread business acceptance (Tukker and Tischer, 2006). Consequently, modified life cycle tools, such as life cycle profits (LCP) (Soukka, 2007), life cycle costing (LCC) and societal LCA (Guinee et al., 2011) have been developed to interpret economic and social impacts, and *calculate the life cycle value* that PSS provide to customers. For example, profit analysis in LCP is based on overall equipment effectiveness analysis, which calculates the overall performance of a process based on three factors: availability, performance and quality. Availability refers to the amount of time that a production line is in use, compared to the amount of time that was planned. Performance rate is related to the production speed of the line, compared to the maximum speed attainable. Process disturbances can also cause slowed speed of production in the case that they don't cause actual downtime. Process disturbances can also cause losses in the desired quality of the end product. The quality rate is the ratio quantity of production that fulfills the quality criteria to the total quantity of production. LCP assigns life cycle costs to economic, environmental and social impacts relating to each factor, and ultimately integrates the direct and derivative economic values of environmental and social impacts to calculate the life cycle value delivered by an offering to a customer (Soukka, 2007).

Synthesizing the customer value proposition and life cycle assessment tools literature, Figure 1 presents a tentative framework of the key stages involved in developing sustainable value propositions for PSS: value potential identification, baseline assessment, life cycle modelling and life cycle value calculation. Value potential identification refers to defining the current and future key benefits from a specific PSS that represent expected value-in-use for a customer and relevant stakeholders. Baseline assessment refers to determining specific key performance indicators for the identified value potential and their current performance before implementing the PSS. Life cycle modelling refers to analyzing the improvements in the selected key performance indicators during the life-cycle of the implemented PSS. Life cycle value calculation refers to determining the total value-in-use that results from the improved key performance indicators during the life-cycle of the PSS (i.e. the total life cycle value realized for the customer). The framework takes into account all three dimensions of sustainability, and aims to integrate the economic, environmental and social impacts to calculate the life cycle value that a specific PSS delivers to a customer



**Figure 1. Tentative framework for developing sustainable value propositions**

We next demonstrate this framework for developing sustainable value propositions through two separate empirical cases. Both cases are focused on an industrial offering that improves the efficiency of a production process, and provide an interesting context to study the integration of economic, environmental and social aspects of value provided to a customer.

## METHODOLOGY

A recent multidisciplinary review on product-service systems (PSS) called for increased collaboration between researchers and practitioners to overcome the research-practice gap and encourage practical relevance (Boehm and Thomas, in press). To ensure a practically relevant approach to the development of value propositions, we engaged in participatory action research (Greenwood, 1998; Gummesson, 2000) on two industry sectors, the mining and automotive industries, and collected data from both developers and adopters of PSS.

The selected industry contexts were particularly suitable for examination as PSS have the potential to improve ecological performance, particularly in energy intensive and natural resource intensive industries such as power generation, minerals and mining, and the automotive industry. These mature industries consume scarce resources and face considerable pressure to restructure operations by developing and adopting environmental solutions. However, investing in new production processes and replacing existing technologies with PSS involves high risks and requires close co-operation, co-creation and new operation models between suppliers and adopters of PSS.

The data utilised for the research were collected during two separate projects that focused on developing value propositions for two industrial PSS; three of the authors were personally involved in these projects. The first project, completed in 2010, acted as a pilot case for employing the life cycle tools in developing value propositions. It provided background information with which to develop the conceptual, sustainable value proposition framework. The framework was then employed as a basis for conducting the second project, which was

completed in 2012. We employ the results of these projects as illustrative cases, demonstrating the utility of the framework (Siggelkow, 2007). In addition, the projects provided direct managerial contributions in the form of new value propositions for PSS.

### CASE DESCRIPTIONS

The case offerings were both PSS that provided environmental and/or social benefits, as well as economic value to their customers. Both offerings can be classified as input oriented PSS (Tukker, 2004; Ulaga and Reinartz, 2011), in which the supplier’s product formed the core of the offering with additional complementary services that included maintenance, updates, and remote support. Both PSS were designed to improve the efficiency of an industrial customer’s production process (providing economic value), while optimizing material usage (providing environmental value) and improving work safety (providing social value). However, neither of the firms providing these PSS’s had previously promoted the offerings as sustainable, but had focused on emphasizing the economic benefits of the value propositions. The details of the two cases are listed in Table 1.

Case company A is a supplier of advanced measurement systems for quality control in the automotive industry. The PSS examined in this study is an optical measurement system designed to enhance process efficiency in measuring welded assemblies in the production line of an automotive parts manufacturer. This particular PSS was selected, because it provides economic value by enhancing process efficiency through faster and more comprehensive measurements, environmental value by performing all the visual inspections in the production line and removing the need for several inspection systems, and social value by adjusting automatically to production changes and thus reducing response times and manual required from the operator.

Case company B is a global supplier of technology solutions for the metallurgical industry, with a key emphasis on the sustainable use of resources in these sectors. The PSS examined in this study is a monitoring system designed to enhance process efficiency in an electrolytic copper refining process, with applications also for nickel and zinc refining. This particular PSS was selected, because it provides economic value by enhancing process efficiency, environmental value by optimizing resource usage, and social value by improving the working conditions for the personnel operating the system.

**Table 1. Case descriptions**

	<b>Case A</b>	<b>Case B</b>
<b>Company description</b>	A supplier of measurement systems for quality control in automotive manufacturing.	A global supplier of technology solutions for minerals and metals processing, with a key emphasis on the sustainable use of resources in these sectors.
<b>Focus of the value proposition</b>	Optical measurement system for improving the process output of welded assemblies in the manufacture	A monitoring system designed to enhance process efficiency in the electrolytic refining process for

	of automotive parts.	copper, nickel and zinc
<b>Involved personnel in value proposition development</b>	12 experts from four organisations: measurement system supplier, line builder, parts manufacturer and an OEM	19 experts from the supplier and two customers firms.

## DATA COLLECTION

Data for conducting the analyses were gathered from multiple representatives to improve validity. For Case A, the data were obtained through interviews with altogether 12 representatives from four different organisations. Specifically, interviews were done with three representatives from the supplier of the optical measurement system, three representatives with the original equipment manufacturer (OEM) that assembles the final cars, four representatives with the parts manufacturer that produces parts for the OEM and two representatives with the line builder that delivers the production line to the parts manufacturer. The representatives included directors, production managers, salespeople and technical experts to ensure a broad view of the economic, environmental and social benefits provided by the system

For Case B, a total of 19 semi-structured interviews were conducted with representatives from the supplier and two of its customers. All representatives were chosen on the basis of their familiarity with the system. The supplier's representatives totalled 12 interviewees, comprising senior managers, salespeople and technical experts. The interview form for the supplier's representatives consisted of: 1) questions regarding economic, environmental and social benefits of the system, 2) questions concerning various customer segments and their value drivers, and 3) questions concerning suitable performance indicators with which to measure value provided by the system. Based on the supplier interviews, two suitable customer firms of the system were chosen for further analysis, and seven interviews were conducted with their representatives, comprising buyers, process experts and plant operators. They were asked to give their opinions on the economic, environmental and social value that had been provided by the system, as well as potential improvements for the PSS. Both examined cases also included secondary data sources such as technical documents, documented analyses from previous assessment projects and sales presentations.

## DATA ANALYSIS

For Case A, the interviews with the supplier were employed as the basis to assess benefits provided by the PSS, as well as suitable performance indicators to measure the value provided. The results were then validated through customer interviews. Additional data were gathered from the line builder organisation to provide data for a conventional mechanical gauge system that was employed as a benchmark for the baseline assessment. The interviews in Case B were transcribed and analysed through qualitative content analysis to determine which benefits were most important in generating value for the customer. Based on these findings, suitable performance indicators were chosen for baseline assessment. The next stage of data collection involved gathering data to quantify the value provided to the customer. These were obtained from a combination of conducted measurements, estimation by experts and the literature. The modelling phases were conducted by Excel and GaBi life cycle assessment software. Two of the

authors, who had the primary responsibility in conducting the life cycle analyses, had prior training on the application of these tools to ensure their correct usage in the action research projects. Following the new value propositions, the offerings were developed and then validated by the representatives of their respective suppliers to ensure accuracy.

## ILLUSTRATIVE CASES

Through the two case studies, this section will illustrate our framework for developing a sustainable value proposition. The empirical data which were gathered included the respondents' perspectives on benefits of the product-service systems (PSS) and suitable performance indicators for measuring the value provided by the benefits. After the data were gathered, calculations were conducted to determine the life cycle value of the offerings.

### OPTICAL MEASUREMENT SYSTEM

The first offering that was studied was an optical measurement system designed to enhance the efficiency of an automotive production line. Conventionally, product quality control in automotive manufacturing is through sampling inspection or conventional mechanical gauges. In sampling inspection, a typical sampling rate is one measured part out of a thousand produced parts. Thus, there is a high risk of unmeasured parts being sub-standard.

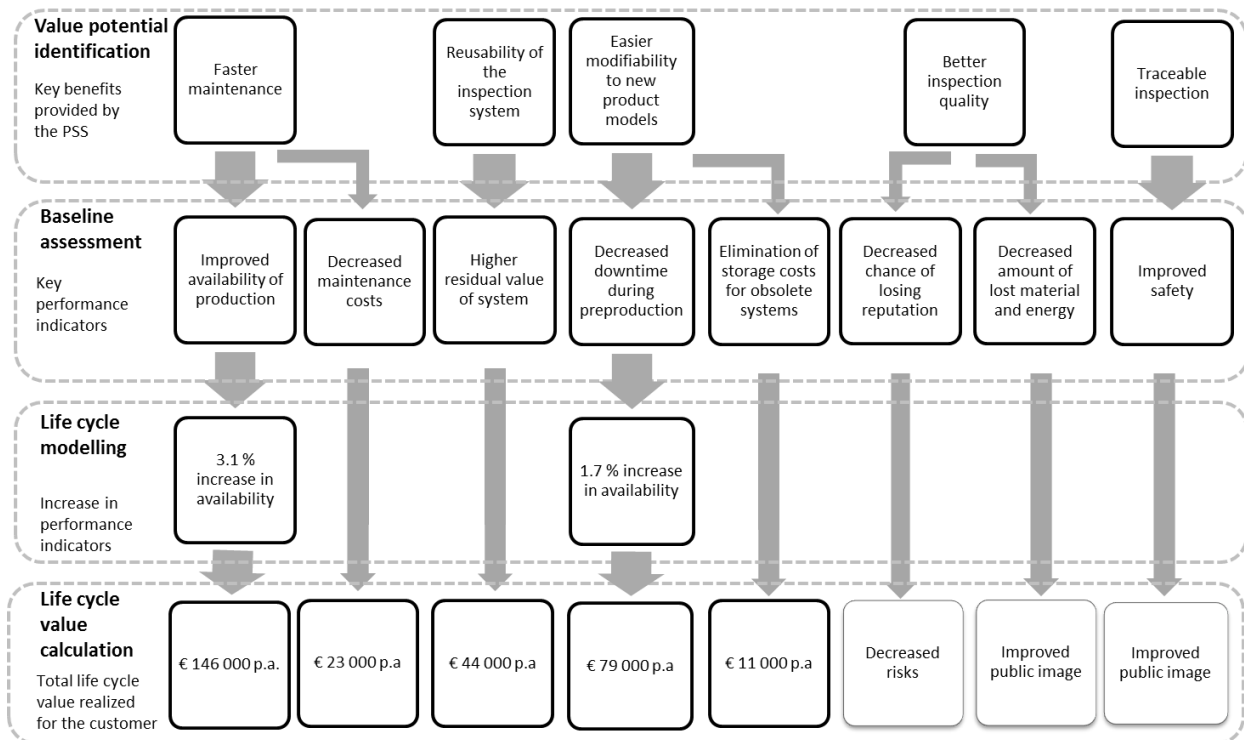


Figure 2. Sustainable value proposition development process for the optical measurement system

### *Value potential identification*

A conventionally employed mechanical gauge measures every part. The mechanical gauges have probes that measure a particular feature of the part, limiting the number of measured features. When the number of measured features is small, the structure of a mechanical measurement system is simple and the cost is low. However, when inspecting only a few features, there is a risk that uninspected features will cause problems. Therefore, a true 100% inspection is defined as measuring every feature of every part. A mechanical system requires a relatively large amount of maintenance and service, which halts the production line. Additionally, a mechanical system requires considerable reconfiguration for changes to produced parts.

An optical measurement system, which measures the product features employing several cameras from multiple viewpoints, addresses these issues. It requires significantly less maintenance, increases overall uptime of the process and also decreases direct maintenance costs. Additionally, most of the maintenance and support can be conducted via the internet as software tasks. Thus, response time and carbon footprint are reduced as a technician does not need to visit the site to perform the task. The same applies to changes caused by engineering modifications in the produced part or introduction of a new product. Modifications to the measurement system require only reprogramming of the software, instead of physical activity. These features combine to improve the overall efficiency of the process.

### *Baseline assessment*

The optical measurement system improves the efficiency of the customer's process through five mechanisms. First, true 100% inspection will eliminate the delivery of defective parts to an OEM. Only delivering satisfactory parts will eliminate penalty and recall costs caused by stopping an OEM's assembly line or the scrapping of nearly complete cars due to a defective part. Secondly, the comprehensive information from a true 100% inspection makes it easier, faster and cheaper to adjust a production process so that no defective parts are produced in the first place. As every produced part can be sold and not scrapped, this saves material, labour and energy costs. Thirdly, an optical measurement system requires considerably less corrective and preventive maintenance in comparison to a mechanical system. Also, all problematic situations can be solved via the internet by remote support with considerably faster response times. This increases the overall uptime of production, which leads to higher revenues. This also decreases the direct costs incurred as a result of maintenance activities. Fourthly, engineering modifications to the produced parts due, for example, to improvements or the introduction of new products are performed by software adjustments, not physical activity. This directly saves costs of the operations required by the change. The fast software tasks enable a faster ramp-up time, which shortens unproductive pre-production time of the new production line. Fifthly, as measurement of various products only requires different programs, the same system can be employed also to measure old products that are needed for spare part production. This eliminates the storage costs of conventional measuring systems and increases the residual value of the system due to its re-usability. These performance impacts of these benefits can be measured through a combination of availability rate and cost analysis.

The aforementioned features of measurement technology also deliver environmental benefits in the form of improved efficiency through two main mechanisms. First, the improved quality decreases the amount of overall waste generated by a production line. Also, only delivering satisfactory parts eliminates the scrapping of semi-finished cars on the final assembly line due to defective parts. Both of these mechanisms directly reduce material and energy loss. Secondly, the possibility of remotely conducting most of the support and maintenance tasks via the internet reduces the carbon footprint otherwise caused by travelling technicians. Additionally, the elimination of storage required for old measurement systems decreases energy usage. As with the other case offering, improved material efficiency can be a source of public image value for the case company. Especially in the automotive industry, environmental efficiency is a powerful marketing tool.

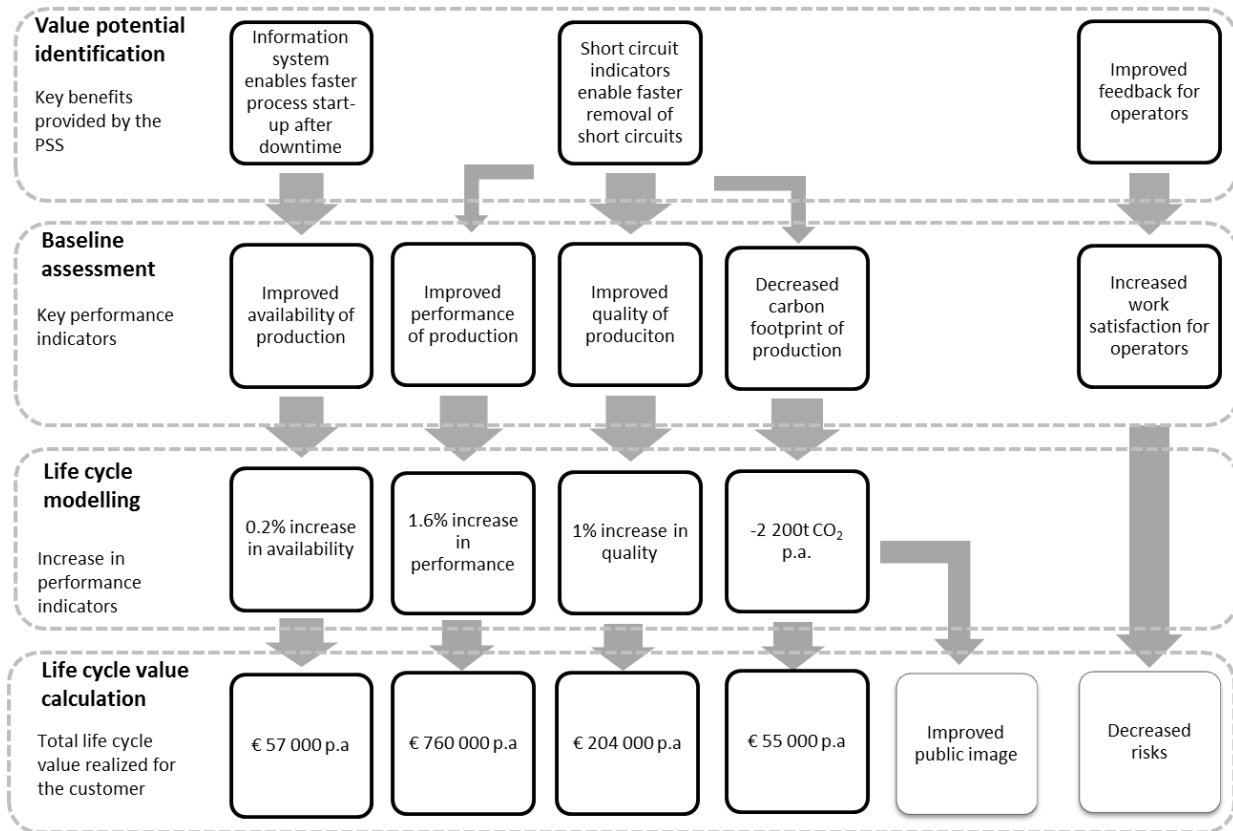
The fact that each produced part is completely inspected increases traceability in the event of safety issues. As well as being a tool for improving company image, it will directly impact recall cases. If an unpredicted major safety defect is found in a car, the stored data of the comprehensive inspection will enable the problem to be traced to specific vehicles and thus help in eliminating accidents or worldwide recall campaigns.

#### *Life cycle modelling and life cycle value*

Life cycle modelling was conducted to quantify the increased profitability resulting from improved production time, decreased maintenance costs, flexible adaptation to new product models and elimination of storage costs. The largest profitability potential was identified in the increased production time resulting from decreased maintenance and faster adaptation to new models, which increased the availability by 3.1 percent and 1.7 percent respectively. Total profitability impact was calculated to be over €300,000, or between 4.4 percent and 7 percent annually. The total *life cycle value* provided to the customer comprises improved annual profitability, decreased risks of losing reputation due to recalls, as well as an improved public image resulting from decreased environmental impacts and improved product safety.

#### *MONITORING SYSTEM*

Figure 3 shows the sustainable value proposition development process for the monitoring system. The data for the value potential assessment were gathered from the interviews with the supplier and two different customers. While the customer interviews provided insight on the customer-specific value drivers, the customers had not yet conducted tests to obtain verified data on the value provided. Therefore the modelling phase was conducted with numeric data, based on estimations from the supplier's and customers' experts. The modelling was conducted with an example case of a medium-sized customer in the copper refining segment, which represents the most typical customer of the monitoring system.



**Figure 3. Sustainable value proposition development process for the monitoring system**

### *Value potential identification*

The monitoring system is designed to enhance efficiency in the electrolytic refining processes of copper, nickel and zinc. It affects a customer's electrolysis process by providing two main benefits. First, it speeds up the removal of efficiency-decreasing short circuits from the process. The removal of short circuits is performed manually by plant operators who have to continuously monitor various sections of their plant for short circuits. The monitoring system enables easier detection and faster removal of short circuits. Secondly, the system provides continuous real-time process data that can be utilised to further develop the efficiency of the process, mainly by improving the start-up time of the process after mandatory process halts for harvesting the refined metal. The system also provides direct feedback on the removal of short circuits to the operators through an LED indicator, something which previously has been unavailable in process monitoring systems, although it is highly important for an operator's work efficiency. Additionally, the wireless nature of the system is highly advantageous in comparison to traditional wired systems, as the plant's structure requires hundreds of individual indicators.

### *Baseline assessment*

The interviews of the customers' representatives from the copper segment were employed as the basis to assess key performance indicators for the baseline assessment. The availability of the customer's process is improved through a faster start-up after downtime, due to accurate

information on the process parameters provided by the monitoring system. The wireless nature of the system provides the most value to the customer through ease of maintenance in comparison to competing systems. The performance rate of the process is improved through the faster removal of short circuits, leading to less wasted energy and, consequently, a higher total quantity of production. Short circuits are also a main cause of quality defects, so the monitoring system also improves the overall quality rate.

The decreased energy usage resulting from faster removal of short circuits also provides the primary environmental benefits of the system, as it decreases the amount of copper scrap that needs to be reprocessed. The environmental value in this case is provided by an increase in energy and material efficiency over the process, which both relate to the carbon footprint of production. The respondents described two mechanisms of value creation for the decreased carbon footprint. The first relates to employing the footprint as a tool to strengthen the company's public image. The mining industry, in particular, is known for having high environmental impacts and is often under public scrutiny for environmental hazards. Both customers mentioned that environmental impacts are highly important issues that affect the public image of their companies. However, while life cycle assessment provides the means to calculate the carbon footprint in physical units, this value creation mechanism is generally difficult to monetise. The second value creation mechanism mentioned by the respondents for decreased carbon footprint is risk management. Industrial firms are already partly responsible for their emissions through mechanisms such as the carbon emissions trading system, and such liabilities are likely to increase in the future. Thus, proactive reduction of emissions results in decreased risks of operation. If a manufacturer's environmental management is ahead of its competitors in its respective industry, tightening environmental regulations pose a considerably smaller threat. This value creation mechanism also provides a means of monetising the decrease in carbon footprint through the value of carbon emissions in the carbon trading system. This was employed as the basis for estimating the economic value of the reduced carbon footprint.

In addition, the faster removal of short circuits was also identified as providing social value through decreased health impacts on operators as they need to spend less time in potentially hazardous areas of the plant. However, this benefit was found to mostly relate to nickel refining, and thus is not included in further calculations as the assessment is conducted for a copper refinery. The final element of customer value is the social value provided through increased employees' work satisfaction, resulting from the effects of short circuit removal. The traditional method of removing short circuits involves significant wasted effort by operators on examining sections of the plant that are working normally. The monitoring system eliminates a large amount of this wasted effort, enabling operators to concentrate effort on problematic sections. In addition, the monitoring system provides direct feedback for the removal of short circuits, something which was previously unavailable. Together, these two effects were recognised to have a positive impact on the work satisfaction of operators. While this was recognised to be an important element of value, it was also difficult to quantify, and thus was not included in the modelling phase.

### *Life cycle modelling and life cycle value*

The main value elements included in the life cycle modelling phase were the increased revenue resulting from improved availability (0.2%), performance (1.6%) and quality (1%), as well as the decreased carbon footprint of production. The economic value for improved availability, performance and quality were calculated to be €57,000 p.a., €760,000 p.a. and €204,000 p.a. respectively. The decreased carbon footprint was calculated to be -2,200 tonnes CO<sub>2</sub> per year. The value of the carbon footprint can also be monetised through carbon emission prices. A mean value of €25/kg CO<sub>2</sub> was suggested by a study in 2008 (Maibach et al., 2008). This delivers a €55,000 annual cost decrease for the case refinery. In total, these elements add up to an estimated 4 percent increase in profitability for the plant during the life cycle of the offering. The *life cycle value* provided to the customer is the combination of this profitability increase, the public image improvement through decreased environmental impacts and the risk reduction resulting from employees' improved motivation.

## **DISCUSSION**

Our proposed framework is an operational tool for managers to employ when integrating sustainability into their value propositions for industrial product-service systems (PSS). While the results of our illustrative case studies are specific to their respective offerings, our framework is based on established methodologies for assessing sustainability and processes to develop value propositions, and thus is applicable to a wide range of industrial offerings.

In a wider context, employing life cycle-based tools can be perceived as information exchange between a supplier and its customer companies, increasing their relationship value and providing knowledge on opportunities for further improvements. As manufacturers are increasingly shifting their focus on their core production processes, it often falls to the technology suppliers to assess the performance of the processes. Technological expertise gained by the supplier from the assessments can uncover opportunities for further improvement that can suggest the development of new technological innovations.

We found supplier-customer cooperation to be vital in the value proposition development process, which is in line with the current perspective on value proposition as jointly crafted between supplier and customer (Terho et al., 2012; Ballantyne et al., 2011). At the value potential identification stage, customer's knowledge of their key value drivers is vital to determine the benefits that the offering can provide. However, at the same time, a supplier's knowledge of its own offering can include value potential that is unknown to the customer. The life cycle modelling phase depends on determining baseline values against which impacts resulting from the offering are compared, and this stage is also dependent on collaboration to accurately quantify these impacts.

Both our cases demonstrate the impacts of sustainable value on the public image of the customer firm, as well as reduced risks. As firms are increasingly required to communicate their value to a broader set of stakeholders, including environmentally and socially conscious customers, employees, governmental organisations and industry standard committees (e.g. Ballantyne et al.,

2011), environmental and social elements of value can play a large role. Some elements of sustainability (e.g. employee health and safety issues and regulations on emissions) can potentially present large risks to an industrial firm in the form of employee turnover or pollution prevention costs. The demonstration of positive impacts on these issues creates value in the form of risk reduction to the customer.

Our research contributes to the theoretical knowledge on PSS by focusing on the process through which a supplier of an industrial PSS can demonstrate the sustainable value provided to its customer. Studies have shown that promotion of ecologically beneficial offerings has often failed due to overly heavy focus on ecological aspects of the offering (Sharma et al., 2010), and the environmental dimension has been the primary focus of many assessments of PSS sustainability (Leet et al., 2012). Our framework and the illustrative cases demonstrate how the environmental and social aspects can complement the functional benefits provided to the customer. We also demonstrate how life cycle assessment (LCA) tools can be employed in the context of marketing sustainable PSS to industrial firms. Conventional applications of LCA in promoting environmentally friendly products, such as eco-labelling schemes, concentrate on the downstream environmental impacts of a supplier's offering throughout the supply chains of the product. Our approach takes a new perspective and focuses on how an offering impacts a *customer's* processes, thus demonstrating the value created for the customer.

Our research also adds to the extant theoretical knowledge on customer value propositions by proposing a framework to assess the economic, environmental and social impacts of industrial offerings. Previous research on value propositions has focused primarily on the economic dimension (e.g. Anderson et al., 2006; Terho et al., 2012), even though the importance of environmental and social dimensions has been acknowledged (c.f. Kowalkowski, 2011; Öberg et al., 2012). Sustainable value is an increasingly important concern in industrial buying decisions (Walker et al., 2012) and LCA and life cycle profit assessment tools provide a method to an industrial supplier with which to demonstrate the sustainable value of its offering. In addition to customers, value propositions are increasingly targeted at a wider network of stakeholders whose value drivers might place high emphasis on environmental and social value (Ballantyne et al., 2011).

## CONCLUSIONS

Skillful integration of product and service components has the potential to reduce environmental load while creating unique benefits for customers. However, more widespread application of product-service systems (PSS) requires that suppliers understand how value is created 'through the eyes of the customer' (Galbraith, 2002; Davies, 2004), and develop value propositions that credibly concretise potential and realised benefits of PSS.

By integrating the literature on customer value propositions and life cycle approaches, this paper proposed a process framework with which to develop sustainable value propositions for industrial PSS. The framework comprises 1) value potential assessment, 2) goal and scope definition, 3) lifecycle value modelling, and 4) life cycle value calculation. We demonstrated the framework through action-based research on two illustrative cases from the metallurgical and

automotive industries. The resulting value propositions demonstrate how the environmental and social benefits of an industrial offering can complement economic benefits to create value for the customer, for example by improving the public image of the firm and the work safety of employees.

While our research focused on a framework to develop sustainable value propositions for industrial offerings, we did not study the effectiveness of sustainable value propositions. Further research should be conducted to determine if sustainable value propositions are more effective in conveying the value provided to the customer in comparison with value propositions that focus purely on the functional benefits and economic value they provide. Both the studied cases also focused on input-based industrial PSS. Thus we do not suggest that the framework is directly applicable beyond this scope, such as with PSS offered to consumers. Further studies are also needed on the application of the framework with more service-oriented PSS that focus on functionality provided to the customers.

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