

Environmental Impacts of Rental Service with Reconditioning – A Case Study

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Abstract

This paper presents a combination of selling service and life time extension strategy which has previously been proposed by others but with no supporting environmental impact assessment. It aims at evaluating rental service with reconditioning using a photocopier as a case study. Life Cycle Assessment was employed to provide a quantitative comparison of rental service with reconditioning and traditional product selling. The findings indicate that the reconditioning is potentially a promising way for improving the environmental performance of the rental service. However, it is premature to draw the general conclusion with further environmental impact measurement being required since the approach is very dependent on specific environmental impact factors.

Keywords:

Product service systems, Rental service, Reconditioning, Life cycle assessment

1 INTRODUCTION

Over the past years, the global trend of environmental awareness is widely recognised. A growing number of businesses have consequently started providing integrated solutions of products and services. The concept of the Product Service System (PSS) has emerged as one of the elements of such solutions. A PSS has been defined as a system of products, services, supporting networks and infrastructure that is designed to be: competitive, satisfy customer needs and have a lower environmental impact than traditional business models [1]. It aims to provide companies with higher value adding process and to meet specific customer requirements, with reduced overall environmental impacts [2], [3].

Among types of PSS, the rental service is one of the possible strategies for a product-oriented company to move towards service-oriented company. Its underlying principle is that the remainder of the product ownership stays with manufacturers and provides the rightfulness for the usage of a product over a given period of time to the customer [4]. Thus the customer pays only for the use of the product when needed and need not be concerned about maintenance, repair or disposal of the product. In terms of the environmental perspective, the service provider who has the effective control of the product can extend its life span and improve the product utilisation [5].

However, the transition to the rental service can not automatically lead to the reduction in environmental impacts [6]. It requires further consideration of the environmental aspects for the whole life cycle. From the life cycle perspective, a product will be analysed in each phase along its life cycle, from material acquisition, component manufacturing, product assembly, customer use, and disposal. In general, the main source of the environmental impacts of the product life cycle will be from the material consumption or energy use [7]. However, in regard to the rental service, another source of

environmental impacts may come from the transportation during the service period. Some kind of rental service such as the machine tool or photocopier requires the maintenance during the rental period which involves transportation between service provider and customer site. In an attempt to reduce the environmental impacts which occur during the life cycle, reconditioning is one of the strategies employed to reduce the end-of-life waste. The reconditioning is defined as the process of rebuilding or replacing major components of a product and returning it with a normal working condition [8]. Reconditioning can also be considered as a potential to extending the product life time and reducing the amount of material consumed [9].

Although the reconditioning was referred as a strategy for the improvement of the environmental performance, there have been limited quantitative measurements performed for this strategy. This paper aims at investigating the advantages and disadvantages of reconditioning in the rental service. The methodology starts by identifying the sources of environmental impacts in the general rental service. Subsequently, the case study of a photocopier rental service with reconditioning is evaluated and the Life Cycle Assessment is employed to quantify the environmental performance of the rental service.

2 THE RENTAL SERVICE AND ENVIRONMENTAL ISSUES

2.1 Product Service System and Rental Service

The Product Service System (PSS) approach was launched in Europe in the mid- 1990's and focuses on delivering value to the customer throughout the product life cycle in an economically profitable, environmentally efficient and socially responsible manner [10]. An underlying principle of the PSS approach is the transfer of product ownership and responsibility to manufacturers,

and it provides the value of function or utility to the customer. There are three main categories of PSS; 1. Product oriented PSS, 2. Use oriented PSS, and 3. Result oriented PSS [11]. Rental service fits the second type of PSS i.e. use oriented PSS. In this category, the product ownership remains with the manufacturer who provides the usage of a product over a given period of time to the customer. Thus the customer pays only for the use of the product when needed and need not be concerned about maintenance, repair or disposal of the product. Although there are many rental services that exist in current businesses, not all of them consider the principles of PSS because the PSS oriented rental system takes environment into account in order to reduce the environmental impact.

2.2 Rental Service and Environmental Factors

It is necessary to understand the environmental impacts of the rental system in order to find the appropriate method to improve their environmental performance. There are three generic types of services which effect environmental impacts [12].

1. Type Alpha Services: In this type a service is provided in a fixed location and the customer travels to the service.
2. Type Beta Services: The service goes to the customer. In this type of service, a service provider performs the service at a customer location.
3. Type Gamma Services: Remote Provisioning. This group of service are provided without either the customer travelling to the service or their service travelling to the customer. Rather, the service is provided by electronic means such as internet, telephone.

Most of rental services are drawn into the Alpha and Beta categories. Examples of product rental in Alpha type include laundrettes, computer cafes and video rentals. On the other hand, manufacturing machines, photocopiers, TVs, refrigerators and furniture rentals are examples of the Beta group. From the environmental perspective, Type Alpha and Beta service are relevant to the transportation in the rental service. There are two types of transportation which is the crucial source of environmental impacts. There are the transportation of delivering service and the transportation of maintenance. The following describes the environmental impacts of both types of transportation.

1. Transportation of delivering service.

Transportation of service between service provider and customer is one of the main drivers of environmental impacts. The distance, frequency, and type of transportation are the factors which make the difference of environmental impacts of each rental service. The term of frequency of delivering service in the rental service means the frequency of change in customers. This frequency is usually determined by the term of the rental periods which are short and long terms. In short term rental periods, the product is allotted to many customers in sequential periods which make transportation high due to number of changes in customers. Therefore, in some situations, the short term rental makes more environmental impacts than long term rental.

2. Transportation for maintenance

In general, technical maintenance is usually part of both Alpha and Beta types of services. The maintenance in Alpha type can be done in-house at the service provider's site. However, the Beta service type requires service provider travel to do maintenance at the customer's place.

In some circumstances, the environmental impacts of the rental service in the Beta type are higher than those in the Alpha type. There are two types of maintenance, preventive and corrective. The corrective maintenance includes activities pertaining to fixing the product which become out of order or broken. Preventive maintenance on the other hand, relates to actions of keeping equipment working and/or extends the life of the equipment. Some rental contracts require both preventive and corrective maintenance while some contracts need only corrective maintenance. Although the maintenance depends on the rental contract, it also relies on the characteristic of the products. Some complex machines such as airplanes or machine tools require experts or technicians to do both preventive and corrective maintenance. While some common machines such as TVs, furniture, or refrigerators only require corrective maintenance. The product which requires both maintenance activities generates the environmental impacts from the transportation between the service provider and customer site.

2.3 Rental Service and Reconditioning

In order to reduce the environmental impact, the life cycle is an effective way to reduce environmental impacts during the product's lifetime. Among numerous methods, strategies of repair, reconditioning, remanufacturing, and recycling of products are proposed to increase the product's life. Figure 1 provides an illustration of ways for closing the material loop. Loop 2 in the figure is concerned with the recycling of materials, while loop 1 relates to the extension of the product life time. When the service provider controls the entire product life cycle, they can close loops and achieve reductions in waste. Loop 1 includes product reuse, repair, recondition, and upgrading hence is preferred because less energy is needed and the product life is extended. Therefore, the rental service with life cycle option with loop 1 is promoted to improve the environmental performance of service economy [13].

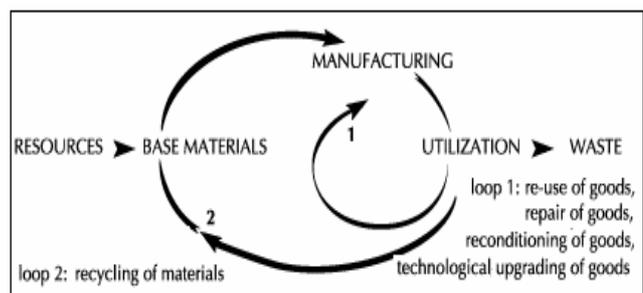


Figure 1: Closing the material loops of material recycling and product life extension [13].

Although the business models of product rental service with life time extension strategies are proposed [14], [15], [16], [17], there is no environmental assessment in this business model. This study aims at investigating the advantages and disadvantages of the reconditioning in the rental service. This is achieved by comparing of the rental service with reconditioning and traditional product selling. The photocopier rental service with reconditioning in Thailand was selected as the case study in this paper. Firstly, the photocopier rental service is classified in the Beta type of service where the service provider performs the service and both preventive and corrective maintenances are provided at the customer's location. Secondly, reconditioning is preferred as a life time extension strategy. The next section explains the

methodology for the environmental assessment of the case study.

3 METHODOLOGY

The photocopier case study was used as a case study to investigate the environmental impacts incurred during the life cycle of the rental service with reconditioning as shown in Figure 2. This environmental assessment was also emphasised on the resource efficiency and the environmental impacts during the reconditioning and maintenance phases. The Life Cycle Assessment (LCA) was used as a tool to quantify the environmental impacts of the service system using the Eco-Indicator 99 H/A method from the SimaPro 7.1 software. The environmental performance indicator is expressed in terms of a single score value which has a unit of points.

In order to evaluate the efficiency of the reconditioning, the rental service with reconditioning scenario was also compared with the traditional selling product scenario. The functional unit of the two scenarios was the life cycle of a photocopier usage during 9 years as shown in Figure 3. The first scenario is the rental service with reconditioning, after the first use at USA of 3 years. The used photocopier is shipped to Thailand and reconditioned. Subsequently, the reconditioned photocopier is rented to a customer for the next 6 years under a rental contract of 2 years as shown in Figure 3. The second was the traditional selling product which the customer replaces anew photocopiers every three year during 9 years period. The expected outcome was to quantify the difference in material consumption of the two scenarios which reveals the efficiency of the reconditioning process. Moreover, the difference in the environmental impacts of the transportation involved during the maintenance of both scenarios can be

compared and analysed. As a consequence, the background of case study of photocopier rental service and the input data are given in the following section in order to provide the basis of this analysis.

3.1 Background of the company

The company which provides the photocopier rental service in Thailand was selected as a case study in this research. In general, this rental service company is an organisation which has more than 5000 customers around Thailand. It imports second-hand photocopiers from USA and reconditions them in Thailand before providing the rental service to the customer. A rental contract of a copier is approximately 2-3 years. During the rental contract, the preventive maintenance and corrective maintenances are done to support the customer.

The life cycle of photocopiers in this case study is presented in Figure 2 in order to explicitly illustrate different phases which can be briefly described as follows.

Phase 1: First use at USA

The customer at USA buys brand new photocopiers from manufactures. However, the copiers are normally replaced at three year intervals to avoid excessive breakdown of the equipment and high cost maintenance. After the end of first life, the photocopier will be sold in second-hand markets.

Phase 2: Shipping

The second-hand photocopiers from USA are shipped to the photocopier rental service in Thailand by shipping which takes approximately four weeks.

Phase 3: Reconditioning

The second-hand photocopiers are reconditioned in the

Phase 1 First use at USA		Phase 2 Shipping	Phase 3 Recondition	Phase 4 Rental service
Photocopier is produced	Photocopier is first used at USA (3 years)	Photocopier is shipped from USA to Thailand	Photocopier is reconditioned	Photocopier is rented by customers (6 years)

Figure 2: The life cycle of photocopiers in the rental services with reconditioning.

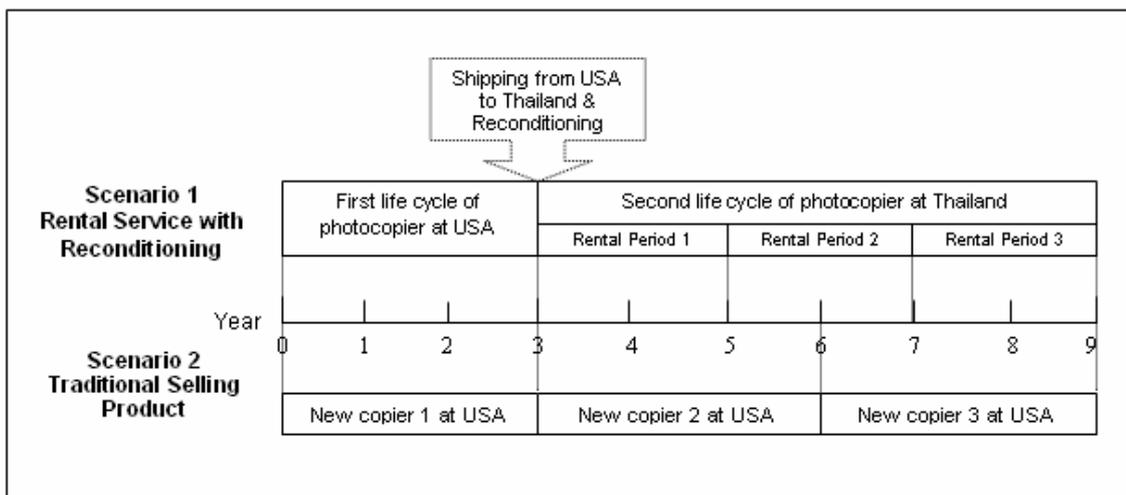


Figure 3: Comparison between the rental service with reconditioning and the traditional selling products.

factory. In addition to this, the reconditioning process involves with an intensive inspection of the copiers where the major components that fail or have bad conditions are rebuilt or replaced. For instance, the covers of copiers are disassembled and repainted. Subsequently, the cleaning process and quality tests are made to the copiers in order to ensure that the copiers meet the standard requirements.

Phase 4: Rental service

After recondition process, the photocopiers are ready for providing the rental service to the customer. However, they are normally replaced at six year intervals to avoid high cost maintenance.

3.2 Input data

The life cycle input data of the case study for the four phases as stated previously was collected on the basis of the company's historical record. The input data of phase 1 includes the materials, manufacturing and transportation for the distributing and maintenance of a photocopier and the electricity consumption for the 3 years.

Then, the input data of phase 2 was merely on the estimation of the distance in terms of tkm (tonne kilometre) of water transportation for the shipment from the USA to Thailand. Subsequently, the input data of phase 3 was focused on the materials for the replaced parts and the electricity consumption of the remanufacturing of the photocopier. Lastly, the input data of phase 4 included the materials of the spare parts, electricity during the usage of 6 years and the travel distance for the transportation involved in all trips of the preventive and corrective maintenance during the 2 years rental contract.

The next section presents the comparison of the LCA results between the two scenarios.

4 LIFE CYCLE ASSESSMENT RESULTS

4.1 The results from LCA analysis

The results from LCA analysis on the case study are concluded into following four key points.

Firstly, Figure 4 presents the single score of the two mentioned scenarios in terms of material consumption, transportation, energy consumption during the usage life cycle stage and the total single score for the entire life cycles. As it can be seen, the total single score results show that the rental service contributes 25% less environmental impacts than the traditional selling product. This was due to the significantly high environmental impacts from the material consumption of the traditional

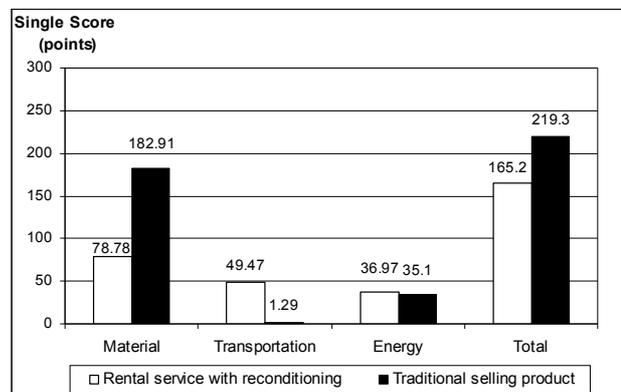


Figure 4: Environmental impacts of traditional product selling and rental service with reconditioning in terms of material, transportation, and energy.

selling product which is 43.07% higher than the material consumption by the rental service scenario with the figure of 78.78 points.

Secondly, the environmental impacts of the transportation for the rental service as shown in Figure 4 produces 49.47 points whilst, the traditional selling product scenario generates only 1.29 points. This result shows although, the rental service with the reconditioning gains the environmental benefit from the material reduction as discussed previously; but its environmental impacts from the transportation are significantly high.

Thirdly, Figure 5 illustrates the environmental impacts of transportation in the rental service with reconditioning scenario. It can be clearly seen that the transportation during the rental period has the largest environmental impacts of 31.43 points. The second highest contribution was the 17.29 points of the copier shipment from the USA to Thailand. Moreover, 0.42 points of the environmental impacts of transportation during the first life cycle at USA is substantially less than the rental service in Thailand which has a figure of 31.43 points. Therefore, the substantial amount of the environmental impacts for the rental service scenario was found from the transportation activities during the rental period in Thailand. This was due to the increasing of the transportation involved in the preventive and corrective maintenance during the rental service.

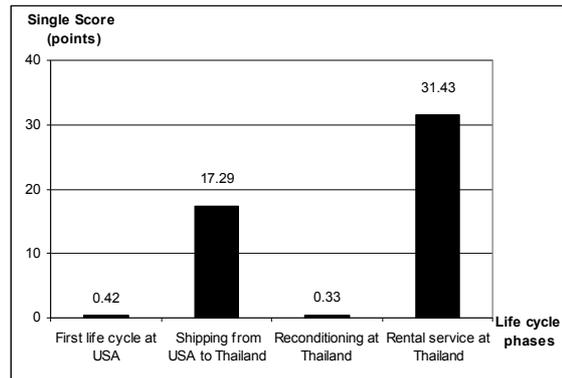


Figure 5: Environmental impacts of transportation during the life cycle phases of the rental service.

Finally, the comparison of environmental impacts between preventive and corrective maintenance is presented in Figure 6. The environmental impacts of transportation in the corrective maintenance are 14.39 points whereas 17.05 points were produced by the preventive maintenance. Similarly, the environmental

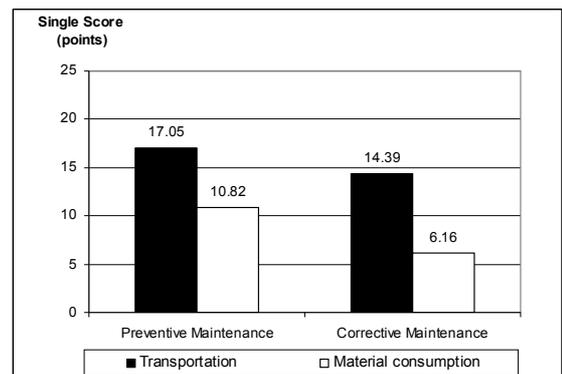


Figure 6: Environmental impacts of transportation of the preventive and corrective maintenance in rental service.

impacts of the corrective maintenance for the material consumption aspect are 6.16 points while 10.82 points was found in the preventive maintenance. Therefore, Environmental impacts from transportation of the corrective maintenance contribute almost as high as those from the preventive maintenance.

5 DISCUSSION

The reconditioning in the case study of photocopier rental service presents the improvement in environmental performance in terms of a reduction in material consumption. The rental service with reconditioning generates only 43.07% of the environmental impact of traditional product selling. Therefore, reconditioning provides benefits in terms of material consumption for the rental service in the case study.

The case study also shows that the environmental impact from transportation in the rental service are significant, compared with those in traditional product selling. Reconditioning resulted in a reduction of 54.1 points while the increase in transportation due to maintenance service resulted in an increase of 31.01 points. Therefore, even with the impact of transportation in service, reconditioning still has the potential for improving the environmental performance of the rental service.

However, the result presents that the environmental impacts from shipping the photocopier from USA to Thailand are considerable due to the long distance of transportation. The huge environmental impacts negate all improvements from the reconditioning. Although there is a possibility of the searching for new suppliers from nearby countries, other factors such as the availability, condition of the products and policies should be taken into account prior to such making decisions.

Another important aspect from this case study is that it is not enough to rest the environmental improvement only with the reconditioning. The optimization of all environmental aspects in every life cycle phase is also significant. For example, the product in the case study is in the product group which consumes energy during the use phase. Thus, the energy saving technology is also important for the reduction in environmental impacts during the use phase. It implies that reconditioning can not extend to the product's life cycle indefinitely. It should be limited by upcoming new energy saving technologies. The product replacement with new technologies or the component upgrading is more suitable in such situations. In addition, factors of deterioration of components which affects the increase in energy consumption over time should be taken into account.

A final point of discussion centres around maintenance during the rental service. This case study shows that the environmental burdens of corrective maintenance are almost as high as those from preventive maintenance. Although the maintenance is quoted in the rental agreement, the corrective maintenance can be reduced. One possible way to decrease the environmental impacts from corrective maintenance is the effective management of preventive maintenance. The principles of preventive maintenance such as the components replacement before the failure should be applied. Furthermore, preventive maintenance scheduling should consider incorporating the transportation of many machines at the same time.

6 CONCLUSION

The rental service is one of the various types of the Product Service System. Combining rental service and reconditioning is proposed as a means for improving

environmental impacts. This paper presented the environmental impacts of the photocopier rental service with reconditioning. The results show that the reconditioning is a promising way of improving the environmental performance of the rental service, despite the high environmental impact caused by the transportation from maintenance. However, it is too early to draw the general conclusions that the reconditioning has potential to reduce the environmental impacts. This is because there are other factors that cause environmental impacts such as product type, component characteristics and usage of customer. Therefore, it requires more examples and further research to generalise such conclusions. Another finding in this paper is that the transportation for maintenance between service provider and customer is a significant source of environmental impacts. The rental services such as machine tools and photocopiers require both preventive and corrective maintenance from the service provider. The distance, frequency, and the type of transportation are main factors of the environmental burdens in the maintenance service. Therefore, it is important that all of the environmental factors in every phase of the product life cycle should be considered in order to improve the environmental impacts of the rental service.

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8 REFERENCES

- [1] UNEP, 1997, Sustainable Service Design, United Nations Environment Programme, New York: UN Publications.
- [2] Mont, O., 2000, Product Service-Systems, Final Report, IIIEE, Lund University.
- [3] Wong, M., 2004, Implementation of Innovative Product Service Systems in the Consumer Goods Industry, PhD Thesis, Cambridge University.
- [4] Tukker, A., and Tischner, U., 2006, New Business for Old Europe, Sheffield, UK, Greenleaf Publishers.
- [5] Lamvik, T., 2001, Improving Environmental Performance of Industrial Products through Product Service Systems, Norwegian University of Science and Technology,
- [6] Mont, O., 2004, Product Service-Systems: Panacea or Myth? PhD Thesis, Lund University, Sweden.
- [7] Kaebnick, H. and Soriano, V., 2000, An Approach to Simplified Environmental Assessment by Classification of Products, Proceedings of the 7th International Seminar on Life Cycle Engineering, The University of Tokyo.
- [8] King, A.M., Burgess, S.C, 2005, the Development of a Remanufacturing Platform Design: A Strategic Response to the Directive on Waste Electrical and Electronic Equipment, Proceedings of the MECH E Part B, Journal of Engineering Manufacture: 623-632.
- [9] Parkinson H J, 2003, Thompson G, Analysis and Taxonomy of Remanufacturing Industry Practice,

Proceedings of the MECH E Part E, Journal of Process Mechanical Engineering, 217(3): 243-256.

- [10] Mont, O., 2002, Clarifying the Concept of Product Service Systems, Journal of Cleaner Production, 10(3): 237-245.
- [11] Tukker, A., 2004, Eight Types of Product Service System: Eight Ways to Sustainability? Experiences from SusProNet, Journal of Business Strategy and the Environment, 13(4): 246-260.
- [12] Graedel, T E., 1998, Life-Cycle Assessment in the Service Industries, Journal of Industrial Ecology, 1(4), 57-70.
- [13] Stahel, W R., 1997, the Service Economy: 'Wealth without Resource Consumption'? Philosophical Transaction: Mathematical, Physical and Engineering Sciences, 355(1728): 1309-1319.
- [14] Mont, O, Dalhammar, C, Jacobsson, N, 2002, A New Business Model for Baby Prams Based on Leasing and product remanufacturing, Journal of Cleaner Prod., 10(3): 237- 245.
- [15] Sundin, E., and Bras, B., 2005 Making Functional Sales, Environmentally and Economically Beneficial through Product Remanufacturing, Journal of Cleaner Production, 10(3): 913- 925.
- [16] Besch, K, 2005, Product Service Systems for Office Furniture: Barriers and Opportunities on the European Market, Journal of Cleaner Production, 10(3): 1083-1094.
- [17] Williams, A., 2007, Product Service Systems in the Automobiles Industry: contribution to System Innovation? Journal of Cleaner Production, 15(11): 1093-1103.