

**An Investigation into Remanufactured Toner
Cartridges vs. OEM Cartridges**
Hao Chun Liao, Jui Feng Chung, Trevor Yu, Yilun Song
University of British Columbia
APSC 261
November 28, 2013

Disclaimer: "UBC SEEDS provides students with the opportunity to share the findings of their studies, as well as their opinions, conclusions and recommendations with the UBC community. The reader should bear in mind that this is a student project/report and is not an official document of UBC. Furthermore readers should bear in mind that these reports may not reflect the current status of activities at UBC. We urge you to contact the research persons mentioned in a report or the SEEDS Coordinator about the current status of the subject matter of a project/report".

An Investigation into Remanufactured Toner Cartridges vs. OEM Cartridges

Jui Feng Chung

Hao Chun Liao

Yilun Song

Trevor Yu

UBC - APSC 261

November 28, 2013

Tutorial Instructor: Ms. Saloome Motavas

ABSTRACT

Across the University of British Columbia (UBC) toner cartridges are utilized by over 16,000 faculty and staff in over 400 departments. The sheer amount of toner cartridges on campus plays a major role on the economy and has a huge impact on the environment. As a leader in sustainability, UBC wants to perform a detailed analysis on the type of toner cartridge that would contribute the most to a sustainable future. The two main choices for toner cartridges are Original Equipment Manufacturer (OEM) cartridges and remanufactured cartridges. Throughout the analysis, each cartridge was compared based on its economic, environmental, and social impacts.

This paper utilizes a wide range of primary and secondary sources. The primary sources came in the form of a departmental survey and a discussion with a representative from Digitech (a local cartridge remanufacturer currently partnered with UBC). The secondary sources came through online databases such as Google Scholar and the UBC library databases, including both peer-reviewed articles and online websites. The triple bottom line analysis was utilized in this report to determine the recommended cartridge. In addition to the sources, there were several constraints and assumptions made regarding the usage of toner cartridges on campus. One of these assumptions was made while analyzing the survey. The survey yielded only 11 out of the 400 university departments responses as many departments were either unwilling or too preoccupied to respond. However, the departments surveyed were arbitrarily chosen, allowing for an assumption to be made that the responses were an accurate representation of the entire campus. Another assumption made was during the research and discussion of secondary sources. Peer-reviewed sources were assumed to be unbiased, while non-peer-reviewed sources (e.g. an article from HP - an OEM company) were assumed to be biased.

To help evaluate the more sustainable cartridge, this paper uses various indicators for economic, environmental, social impacts. For economic comparisons, the total cost of remanufactured cartridges was found to be cheaper than the total cost of OEM cartridges. The environmental comparison showed that remanufactured cartridges have a lower toll on the environment than OEM cartridges. And in the

social comparison, it was found that there was no noticeable difference in quality between remanufactured and OEM cartridges. However, the use of remanufactured cartridges can potentially increase sustainability awareness and the possibility of new job opportunities. Based on the findings in this report, it is recommended that remanufactured cartridges be implemented. In addition, it was found that many departments across campus are in a contract with Xerox, a cartridge remanufacturing firm. Through the course of this analysis, details about the contract with Xerox were not found, thus placing restrictions on the types of recommendations made. With the existence of this contract, several criteria were developed for future and existing contracts to ensure the sustainable usage of toner cartridges on campus. These criteria are the following: the company must supply remanufactured cartridges, the company must be local to the Lower Mainland, and the contract should involve the majority of the university departments. By following these criteria, UBC can be sure that the sustainable usage of toner cartridges on campus.

TABLE OF CONTENTS

ABSTRACT.....	2
LIST OF ILLUSTRATIONS	5
GLOSSARY	6
LIST OF ABBREVIATIONS	7
1.0 INTRODUCTION	8
2.0 METHODOLOGY	10
3.0 ECONOMIC INDICATORS	11
3.1 LIFE SPAN OF ONE TONER CARTRIDGE	12
3.2 MONETARY VALUES	12
4.0 ENVIRONMENTAL INDICATORS.....	14
4.1 MATERIAL RESOURCES	14
4.2 ENERGY CONSUMPTION.....	14
4.3 GREENHOUSE GAS EMISSIONS.....	15
4.4 WASTE GENERATION	17
4.5 ENVIRONMENTAL DISCUSSION AND SUMMARY.....	18
5.0 SOCIAL INDICATORS.....	19
5. 1 EMPLOYMENT OPPORTUNITIES	19
5.2 CONSUMER SATISFACTION.....	19
5.3 SUSTAINABILITY AWARENESS	20
5.4 SOCIAL DISCUSSION AND SUMMARY	21
6.0 CONCLUSION & RECOMMENDATIONS	22
REFERENCES.....	24
APPENDIX A - SURVEY QUESTIONS	26
APPENDIX B - SURVEY RESULTS	28

LIST OF ILLUSTRATIONS

Illustration	Description	Page Number
Figure 1:	The Life Cycle of an HP cartridge and a remanufactured cartridge.	11
Figure 2:	Emissions of CO ₂ , NO _x from OEM and re-used toner cartridges without emissions from paper	16
Figure 3:	Emissions of CO ₂ and NO _x from OEM and re-used toner cartridges with emissions from paper	17
Table 1:	Price Comparison of OEM cartridges and Non-OEM cartridges	13
Table 2:	The comparisons of environmental effects between OEM cartridges and re-used toner cartridges with paper.	15
Table 3:	The composition of toner in waste toner cartridges	18

GLOSSARY

Compatible Cartridge	Cartridges that are made by third-party companies and are illegal to use.
Micro-economics	Microeconomics is a branch of study of economics. More precisely, the study of causes and consequences of resource allocation as it is affected by the workings of the price system (Ragan & Lipsey, 2011).
Monopoly	A market controlled by one single firm in which this firm has absolute market power. This market structure presents the other end of the spectrum in the theory of microeconomic market model.
OEM Cartridge	Cartridges that are made by the Original Equipment Manufacturer.
Perfect Competition	A market structure in which all firms in an industry are price takers (Ragan & Lipsey, 2011). In other words, all firms have equal market power in which the price of the product of interest is not subjected to change by each individual firm. This market structure sits on one end of the spectrum depicted in the theory of microeconomic market model.
Remanufactured Cartridge	Cartridges that are fixed and refilled with new and working parts.
Toner	Powder used in printer cartridges.

LIST OF ABBREVIATIONS

APSC	Faculty of Applied Science (Engineering)
GHG	Greenhouse Gas
OEM	Original Equipment Manufacturer
PPS	Payment & Procurement Services
UBC	University of British Columbia

1.0 INTRODUCTION

As the world becomes more reliant on technology, the amount of waste produced increases. If this trend were to continue, the growth in waste production will eventually result in devastating environmental issues. One of the largest contributors to waste production is electronic waste (e-waste). When thrown into landfills, e-wastes are left to decompose. This decomposition releases toxic chemicals into the atmosphere. Referring to the case of our study, toner cartridges are comprised of at least 62%-84% high toxicity materials. Drawing on research through primary and secondary sources, it is obvious that if the waste generated by toner cartridges is neglected, there will be detrimental effects to our environment.

When the cartridges run out of toner, users have several purchasing options: Original Equipment Manufacturer (OEM) cartridges, remanufactured cartridges, and compatible cartridges. This report will analyze the benefits and drawbacks of OEM cartridges and remanufactured cartridges. OEM cartridges are toner cartridges built by the original equipment manufacturer (i.e. if your printer is HP, the cartridge would also be made by HP). Remanufactured toners are built by companies that repair and reuse OEM cartridges. Each cartridge will be evaluated based on their economic, environmental, and social impacts. Compatible cartridges will briefly be mentioned throughout the paper, but the main goal is to evaluate the better choice between OEM and remanufactured cartridges. As requested by our stakeholder, Faiza Wilson, the focus of the report is on the usage of OEM and remanufactured cartridges in photocopier machines. By limiting the analysis to only photocopier toner cartridges, it will reduce the number of variables due to the different types and brands of printers and will result in a more accurate analysis.

Based on a survey and various enquiries around UBC, many UBC faculty members are unaware of the recycling process regarding toner cartridges. In general, most departments surveyed said they recycle their toner cartridges. While speaking to the various departments, many explained that they did not know the details of the recycling process as their printer cartridges were currently in a contract. The

report will provide several recommendations for UBC based on the findings in order to increase the campus' sustainability.

2.0 METHODOLOGY

The strategy used in finding information to develop the analysis was performed over the course of six weeks and involved several steps. These steps included: meeting with the stakeholder (Faiza Wilson), performing preliminary research, surveying departments, performing secondary research, and discussing the data. During the meeting with the stakeholder, a representative from Digitech provided basic statistics about UBC's current toner recycling process and explained how toners are remanufactured throughout the printer industry. Following the meeting, preliminary research was performed by finding online sources through UBC library and Google Scholar. This research helped lay the groundwork for the entire analysis.

After the preliminary research, a survey was asked amongst various departments across the UBC campus. Some of these departments included: UBC libraries, Computer Science, Sauder Undergraduate Office, Pharmaceutical Sciences, and Payment and Procurement Services. In order to produce more accurate results, the surveyed departments were arbitrarily chosen with the exception of Pharmaceutical Sciences, Faculty of Medicine, and Payment and Procurement Services as they were suggested by the stakeholder. The questions in the survey allowed for a deeper look into some of the ongoing toner programs across campus. Three additional questions were added to the survey after Pharmaceutical Sciences, Faculty of Medicine, and Payment and Procurement Services submitted their responses. These questions were added in order to learn insight into the social aspects. A spreadsheet with all the survey results and the corresponding departments can be found in Appendix B.

In addition to the survey a second, less formal round of research was performed in order to learn more about other recycling programs and to better understand the perspective from OEM manufacturers. Once the survey and research was completed, a formal discussion was held to determine the optimal toner cartridge and develop additional recommendations.

3.0 ECONOMIC INDICATORS

The goal of this section is to estimate the gross financial cost of OEM toner cartridges and remanufactured toner cartridges over their lifetime. In order to estimate the gross financial costs, this section will quantify the economic cost of all potential parts throughout a toner’s lifecycle. This includes: the cost of purchase and the recycling fee. This section discusses and analyzes the various pros and cons of OEM cartridges and remanufactured cartridges from an economic perspective.

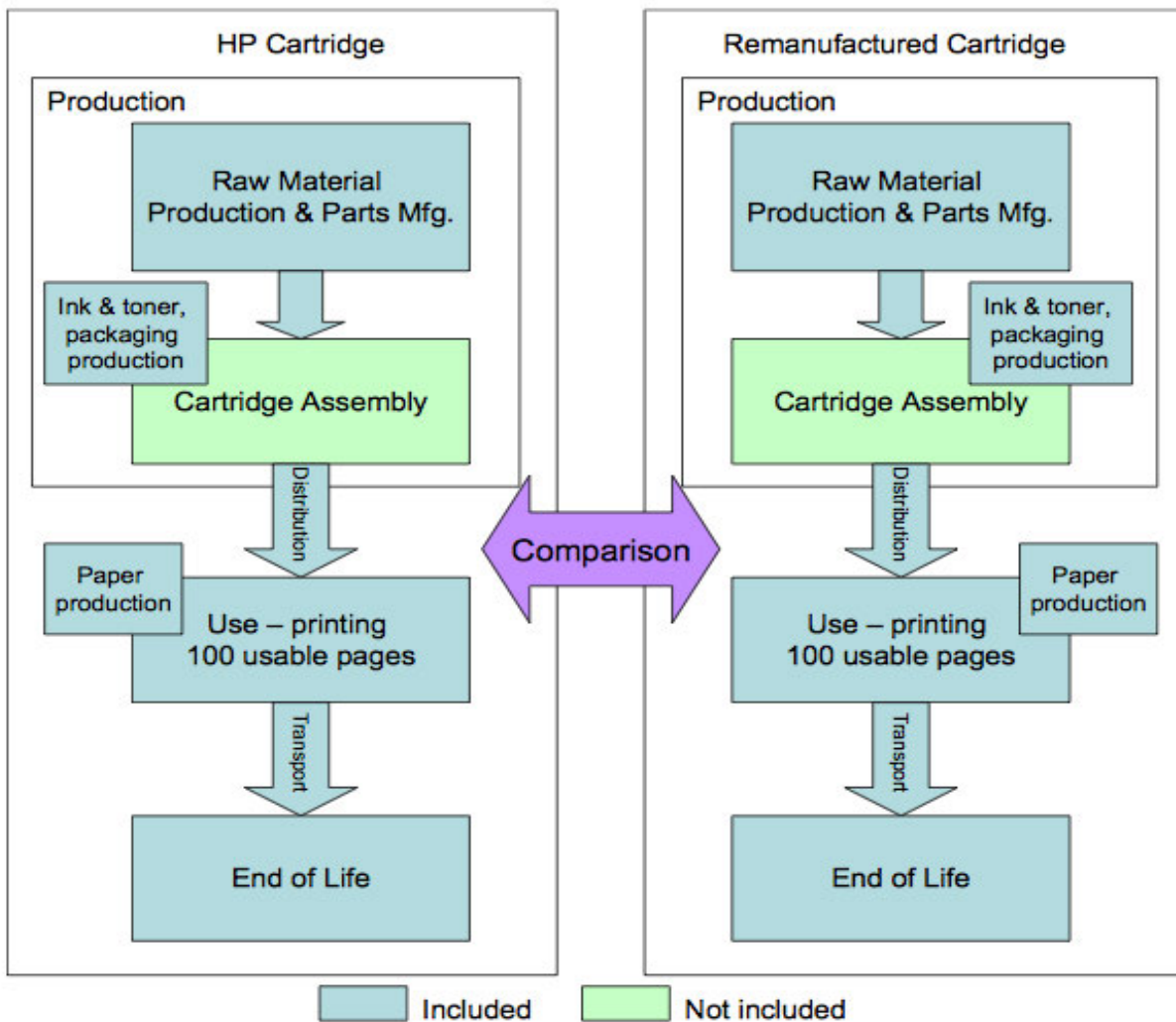


Figure 1: This diagram illustrates the life-cycle of an OEM cartridge (HP) and a remanufactured cartridge. As seen, they both undergo the same life-cycle.

Source: Four Elements Consulting, 2008

3.1 LIFE SPAN OF ONE TONER CARTRIDGE

Several factors contribute to the life span of each toner cartridge, including: effective page yield, frequency of usage, and notably, its print quality. Based on our survey results of eleven faculties within UBC, almost all of the faculty staff found the quality of their prints to be satisfactory or excellent. This result directly affects the lifespan of the cartridge, since a non-satisfactory print requires a reprint, hence reducing the actual page yield and shortening the lifespan. Our gathered data also demonstrates that for standard, office usage, the majority of photocopier toner cartridges last approximately four months (one academic term). Highly used cartridges, such as the photocopiers open for public usage, only last for a single month, effectively increasing the need to replace used toners.

3.2 MONETARY VALUES

The economical cost of the different types of toner cartridges play crucial roles when the buyers decide which option to choose. First, an OEM cartridge can cost from \$70 to \$100 apiece, while guaranteeing superb print quality and high page yield. On the other hand, a recycled cartridge can cost only 30% to 50% of the OEM cartridge. Companies like Xerox guarantee their remanufactured cartridge to be equal or have better performance than OEM cartridges, with no risk to the consumer's warranty. A third party (compatible) cartridge costs approximately 50% of OEM cartridges, and remanufactured cartridges cost about 33% (at best) of OEM cartridge. OEM companies such as HP and Lexmark now manufacture cartridges with computer programmed chips that prohibit third-party manufacturers from creating compatible cartridges, further restricting buyers' options. It is important to note that the smaller economic burden of compatible cartridges and remanufactured cartridges comes with a trade-off as non-OEM cartridges can void the printer's warranty. Warranty voiding introduces another huge variable into the analysis as each printer warranty is non-identical and costs different. For the remainder of this report, the potential cost of a printer's warranty will not be discussed in order to provide simplification and clarity.

Only solely taking the cartridge’s cost into consideration cannot sufficiently yield a complete economical analysis. Another area that needs to be taken into account is the amount of paper used. According to *Remanufactured and Energy Saving*, an OEM cartridge produces, on average, 100 good copies with 101 sheets, whereas a remanufactured one requires 114 sheets. From the equation below, one can see that remanufactured cartridges need 11.4% more paper to accomplish the same task. With 13 extra pages, the user has to sustain an additional cost of \$0.30 (data acquired from Office Depot), which is negligible when compared to the far larger price discrepancy between the two different cartridges.

$$\frac{114 \text{ pages} - 101 \text{ pages}}{114 \text{ pages}} \times 100\% = 11.4\%$$

Equation 1: Equation demonstrating the percentage of paper required to print 100 good copies.

3.3 ECONOMIC CONCLUSION

Table 1 below summarizes the different types of cartridges discussed above. The percentage shown for the remanufactured cartridges is the percentage of its cost when compared to the cost of an OEM cartridge. Although OEM cartridges are able to use approximately 11% less paper, it is still reasonable to neglect this slight advantage when compared to the vast cost (at least 50% less in monetary value) saved by remanufactured cartridges, given that the print quality of the good prints are about the same. From the data gathered through surveys and Xerox’s website, it is clear that remanufactured cartridges perform on par with OEM cartridges, and the users are content with the quality of their prints. Therefore, from an economic standpoint, it is recommended to purchase remanufactured toner cartridges as opposed to buying OEM cartridges for reliability and cost savings.

Table 1: Cost analysis of OEM vs. Non-OEM cartridges.

OEM Cartridges		Non-OEM Cartridges		
		Recycled	Third-Party (Compatible)	Remanufactured
Price (per unit \$)	70 – 100	30%-50%	50%	33% at best

4.0 ENVIRONMENTAL INDICATORS

OEM toner cartridges and remanufactured toner cartridges have various effects on the environment. This section analyzes and compares the differences in environmental effects between OEM toner cartridges and remanufactured toner cartridges. In order to qualify and quantify the comparisons, the environmental analysis focuses on material resources, energy consumption, greenhouse gas (GHG) emissions, and waste generation.

4.1 MATERIAL RESOURCES

The materials within a cartridge can be traced throughout the cartridge's entire life cycle. Before comparing the effects of material resources between OEM and remanufactured toner cartridges, the following lists the general environmental issues involved in the life cycle of toner cartridges.

“The typical used toner cartridge weighs about three pounds and is composed of 40% plastic, 40% metal, and smaller percentages of rubber, paper, foam, and toner” (LaserCycle, 2013). Materials, such as steels, aluminums, plastics, and magnets, can be recovered and reused as raw industrial materials. The main component of toner, organic macromolecular compounds, has the potential to pollute the environment once it is been released. Pollution can also be produced by a slow decomposition rate in the environment and the residual toner leaking out.

A typical toner cartridge can be remanufactured up to four times, and the cartridges are usually 97% recyclable (LaserCycle, 2013). This indicates that the remanufactured toner cartridges use about 30% of the materials used in producing OEM toner cartridges over the course of their life cycle. When toner cartridges are reused, fewer new materials are needed and fewer cartridges end up in the landfills. Based solely on the amount of the materials that is being used, remanufactured toner cartridges have a lower footprint on the environment than OEM cartridges.

4.2 ENERGY CONSUMPTION

This section evaluates and discusses the amount of energy consumed in the production and recycling processes of toner cartridges and the corresponding effects on the environment.

As analyzed in *Life Cycle Assessment of Toner Cartridge HP C4127X*, the researchers measured that the electrical consumption for toner is approximately 5 kWh/kg. The component manufacturing processes consumes 30 kWh per toner cartridge, the assembly and packaging consumes about 10 kWh per toner cartridge, the restoration and refilling takes about 2.02 kWh per toner cartridge, and the recycling takes 2 kWh per cartridge (Berglind & Eriksson, 2002, pp. 12-20). In comparison, the production of OEM toner cartridges consumes more energy than the production of remanufactured cartridges. However, remanufactured cartridges use more energy to recycle and remanufacture than OEM cartridges. Taking the total amount of energy consumption into account, as shown in Table 2, the amount of energy can be preserved by 20% using remanufactured toner cartridges than OEM toner cartridges.

Table 2: The comparisons of environmental effects between OEM cartridges and re-used toner cartridges with paper.

Data category	Original	Re-used	Difference in percents, original/re-used (%)
CO2 (kg)	87	77	13
NOx (kg)	0,62	0,55	13
Energy (MJ)	3060	2540	20
Waste (kg)	35,1	30,3	16

Source: Jonas Berglind and Henric Eriksson, 2002, p.24.

4.3 GREENHOUSE GAS EMISSIONS

Greenhouse gases (GHG) are gases that allow sunlight to freely enter the atmosphere. As the amount of GHG increases, the corresponding temperature across the Earth also increases. These gases are composed of CO₂, CO, SO_x, and NO_x. This section analyzes and compares the amount of GHG emissions that are released from OEM toner cartridges and remanufactured toner cartridges.

The main contributor of GHG emissions occurs during the production and remanufacturing stages. Choosing to remanufacture cartridges reduces the emissions of GHG from production processes. The GHG emissions from the production of a single toner cartridge are about 4.8 kg of CO₂ (eco-facts, 2013). Excluding effects from the toner inside, the GHG emissions are about 16 metric tons per 1 metric ton toner produced (eco-facts, 2013). For toner cartridges, roughly 3.2 kg of CO₂ is released by using 200 g of toner to print 5000 pages. Even though remanufacturing toner cartridges cannot reduce the GHG emissions from toner, the emissions from the production stage can be prevented. Figure 2 illustrates a comparison of emissions between CO₂ and NO_x between OEM and remanufactured toner cartridges without emissions from paper.

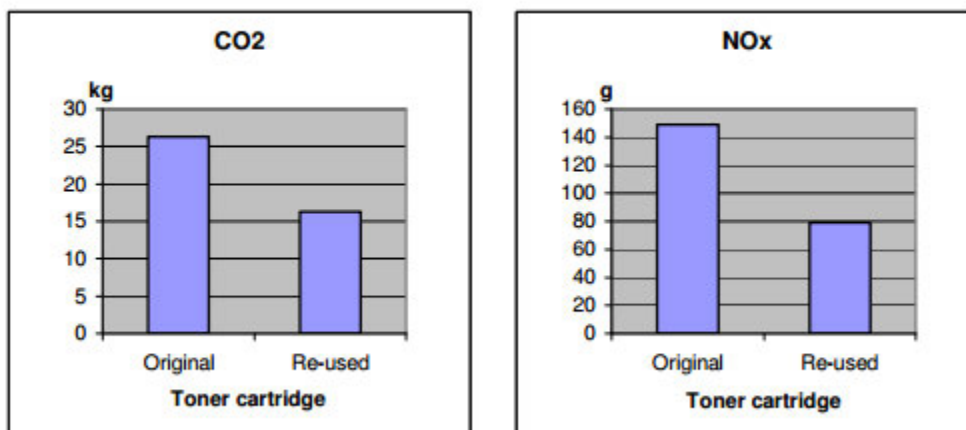


Figure 2: Emissions of CO₂, NO_x from OEM and re-used toner cartridges without emissions from paper

Source: Jonas Berglind and Henric Eriksson, 2002, p.26

As mentioned in Section 3.2, remanufactured toner cartridges may require more paper to accomplish the same task than OEM toner cartridges. If taking the emission of paper into account, more emissions will be released from paper using remanufactured toner cartridges. Figure 3 below compares the emissions of CO₂ and NO_x between OEM and remanufactured toner cartridges with emissions from paper. As seen in Figure 3, remanufactured toner cartridges release 13% less GHG emissions than the OEM ones. Therefore, compared to OEM cartridges, remanufactured cartridges produce lower amounts of GHG emissions that contribute to climate change.

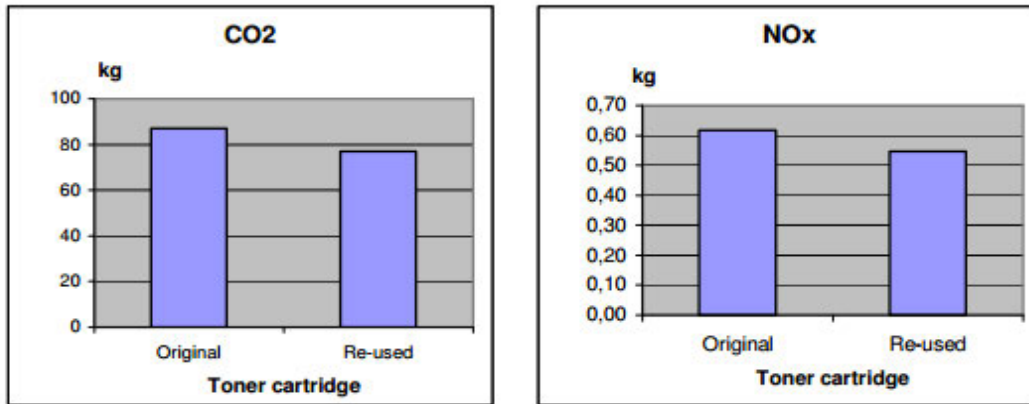


Figure 3: Emissions of CO₂ and NO_x from OEM and re-used toner cartridges with emissions from paper

Source: Jonas Berglind and Henric Eriksson, 2002, p.24

4.4 WASTE GENERATION

Over the life cycle of OEM and remanufactured toner cartridges, a certain amount of waste is generated and sent to landfills. This section focuses on comparing the waste generated from OEM and remanufactured toner cartridges.

As mentioned in Section 4.1, remanufactured cartridges require on average 70% fewer materials than OEM cartridges. Therefore the amount of the materials being left in environment is significantly lower. Another waste produced from toner cartridges is toner. Toner can be very harmful for the environment and unhealthy for any living creatures and planets. Table 3 analyzes the composition of toner in waste toner cartridges. The toxicity level indicates the degree of which the component within the toner may affect the environment. In Table 3, it is shown that at least 62% to 84% of the toner contributes to high toxicity. Remanufacturing toner cartridges reduces the chance of letting toner leak out in environment as fewer cartridges are thrown into landfills. Based on the material and toner waste described above, remanufactured toner cartridges generate a lower amount of waste than OEM cartridges.

Table 3: The composition of toner in waste toner cartridges

Composition	Material	Function	Proportion (wt%)	Size (μm)	Toxicity ^b
Carbon black	Polyacrylate-styrene copolymer	Imaging material	50–60	8–12	High
Magnetic powder	Fe_3O_4	Transporting toner	20–30		None
Resin ^a	Polyethylene/polypropylene paraffin wax	Controlling the melting point of toner	2–4		High
Charge control agent	Hydroxyl-aromatic-acid and the derivatives	Controlling the charge of toner	10–20		High
Additive	SiO_2	Improving the fluidity of toner	1–3		None

a Refined from oil.

b Inhaled into human body due to the small size.

Source: Ruan J, Li J, Xu Z, ShangHai JiaoTong University, 2010

4.5 ENVIRONMENTAL DISCUSSION AND SUMMARY

In summary, remanufactured toner cartridges use, on average, 70% less material than OEM cartridges. Despite the fact that remanufactured toner cartridges use more paper than OEM cartridges, remanufactured cartridges preserve 20% of the energy consumed by OEM cartridges in the entire life cycle. Using remanufactured toner cartridges also reduces the GHG emissions by at least 13%, and has the potential to generate lower amounts of waste compared to the OEM toner cartridges. Based on the above analysis, the environmental impacts of remanufactured toner cartridges have a lower footprint than that of OEM cartridges.

5.0 SOCIAL INDICATORS

Choosing to use OEM toner cartridges or remanufactured toner cartridges can result in a variety of social effects. In order to qualify and quantify the social impacts of each cartridge, the following sections will compare and contrast the benefits and drawbacks from a social perspective.

5.1 EMPLOYMENT OPPORTUNITIES

With the introduction of remanufactured toner cartridges, the number of jobs available in the cartridge market has increased. The monopoly that the OEMs once held is threatened by the rise of remanufactured cartridges. This impact is justified and seen through the strategic contracts that OEMs establish with consumers to prevent third-parties from obtaining used cartridges (Gutowski, 2010; Sahni, 2010; Boustani & Graves, 2010). By adapting the use and purchase of remanufactured cartridges, competitions are created in the market. Based on knowledge of micro-economics, the structure of the cartridge market will shift toward the perfect competition end of spectrum as opposed to the monopoly end of spectrum (refer to Glossary). This causes the total revenue of a competitive market to be greater than the total revenue of a non-competitive market. Through the usage of remanufactured cartridges, the employment opportunities available in the cartridge market are likely to increase. In order to maintain sustainability, the job opportunities should be local to the Lower Mainland. If the jobs were located outside of the Lower Mainland, cartridge costs would increase due to labour and shipping, and there would be a larger toll on the environment due to transportation. By having staff members utilize remanufactured cartridges, UBC will effectively be allowing the creation of new jobs in the marketplace.

5.2 CONSUMER SATISFACTION

When it comes to consumer satisfaction, getting the best quality and value is essential. As detailed in the economic analysis section (Section 3.0), OEM cartridges generally outperform the remanufactured cartridges. OEM cartridges are safe to use and provide quality prints (Goldsborough, 2003). In addition, OEM cartridges need about 101 sheets of paper to produce 100 quality prints;

remanufactured cartridges require about 114 sheets to achieve the same result (Gutowski, 2010; Sahni, 2010; Boustani & Graves, 2010). That being said, the difference in quality between OEM cartridges and remanufactured cartridges is minor. Currently, many remanufactured cartridge firms have performance guarantees. Xerox, a major supplier of remanufactured toner cartridges for heavy-duty photocopiers offers Total Performance Warranty as their products are tested three times prior to sale. Digitech, a local remanufactured cartridge supplier, holds a 96% success rate for their assembly process (Digitech, Oct. 2013, interview). Furthermore, based on our survey results in Appendix B, campus staff who have used both types of cartridges said there was little or no difference in terms of performance. Through this response, it should be safe to conclude that performance disparity is within consumer tolerance. Although OEM cartridges generally provide better quality prints, with guarantees and warranties, performance is a minor concern as faculty who have used both types of cartridges said they could not notice a difference.

5.3 SUSTAINABILITY AWARENESS

The existence of remanufactured cartridges can potentially raise sustainability awareness directly and indirectly. With a rising demand for remanufactured cartridges, OEMs are at risk of losing a monopoly over cartridge sales. Therefore, OEMs may establish recycling programs to secure cartridge shells from falling into the hands of remanufacturing firms. In response, remanufacturing firms are forced to strengthen their recycling contracts and deals. For example, Digitech and Xerox offer free pick-up for used cartridges of any type (Digitech, Oct. 2013, interview; CPSC Department, Nov. 2013, interview). As a result, recycling programs in the cartridge industry are enhanced, as all firms are struggling to collect used cartridges. This trend can also be seen from our survey results. All eleven departments surveyed recycle their used cartridges; and most of the departments indicate that they are forced to recycle under contracts from the suppliers. By starting sustainable efforts with the suppliers themselves, sustainability awareness will slowly trickle down to the end user, thus making everyone more aware.

5.4 SOCIAL DISCUSSION AND SUMMARY

By adapting the use of remanufactured toner cartridges, employment opportunities are potentially created through the expansion of the remanufacturing market. On the other hand, OEM cartridges are known to produce slightly better quality prints than remanufactured cartridges. However, the difference between OEM and remanufactured cartridges may lie within an acceptable range based on surveyed results. Finally, sustainability awareness is promoted from increased numbers of remanufactured cartridge purchases. As a competition to gather cartridge shells is started, firms are forced to enhance and advocate recycling programs. Through these three sections, it is recommended that remanufactured cartridges be used as opposed to OEM cartridges.

6.0 CONCLUSION & RECOMMENDATIONS

Over the course of this paper, two different types of photocopier toner cartridges were analyzed: OEM cartridges and remanufactured cartridges. Each cartridge has their benefits and drawbacks. In the above sections, both cartridges were evaluated for their economic, environmental, and social impacts. Each category (i.e. economic, environmental, and social) can be ranked differently based on importance. The most important feature in determining the cartridge of choice was the environmental aspects. This feature should be the most important as the portion of the world affected by the environment is much greater than that of the economic and social aspects. Following the environmental aspects is the economic section as it impacts the local economy and possibly some outside companies. The least important category is the social aspects as it only affects the UBC campus.

Throughout each section, an analysis was performed to determine which cartridge was the most optimal choice. In the economics section, it was found that remanufactured cartridges cost significantly less than OEM cartridges. The environmental section showed that remanufactured cartridges impose a smaller toll on the environment than OEM cartridges based on material resources, greenhouse gas emissions, and waste generation. Although negligible, the social section showed that users who have used remanufactured cartridges and OEM cartridges could not notice a difference in quality. In addition, other aspects such as sustainability awareness and employment opportunities support remanufactured cartridges. Based on these results, it is recommended that remanufactured cartridges be utilized throughout the UBC campus.

In addition to these findings, it was found that in a large number of the campus departments, there is already an existing contract with Xerox for cartridge recycling and replacing used cartridges with new units. While developing this paper, our group was unable to find information regarding the current contract with Xerox. That being said, our group developed several criteria either that Xerox or the company UBC decides to partner with must follow. The first of these criteria is that the company must be able to provide remanufactured cartridges. The second criterion is that the company must be local to the

Lower Mainland. By having a local company, UBC will be helping strengthen the local economy and provide more jobs to the people. In addition, UBC will save on transportation fees and the corresponding environmental effects that come with shipping. The third and final criterion is that the contract must involve most of the departments at UBC. Currently each department is either under a contract or free to make their own purchases. By instituting a contract with the majority of UBC's departments, the university can be sure that they are both saving the most money and contributing to a sustainable future. In addition, contracting departments will free up the time individuals within the departments spend looking for and finding replacement cartridges. Once the contract is in place, the company should actively be showing the ways they contribute towards a sustainable future. Regardless of the decisions the university makes, the most important piece is that remanufactured toner cartridges should be used rather than OEM cartridges.

REFERENCES

1. Berglind, J., & Eriksson, H. (2002). Life cycle assessment of toner cartridge HP C4127X. *Environmental impact from a toner cartridge according to different recycling alternatives*. Retrieved from <http://www.etira.org/images/content/2003%20LCA%20Toner%20Cartridge%20Swedish%20University.pdf>
2. Clolery, P. (1994). Recycling that toner cartridge. *The Practical Accountant*, 27(8), 12. Retrieved from <http://search.proquest.com.ezproxy.library.ubc.ca/docview/208245477>
3. Four Elements Consulting. (2008). *LaserJet Cartridge Life Cycle Environmental Impact Comparison Refresh Study*. Retrieved from http://www.hp.com/hpinfo/globalcitizenship/environment/productdesign/suppliesLCA_EMEA.pdf
4. Goldsborough, R. (2003). The savings, and controversy, of printer cartridges. *Teacher Librarian*, 31(2), 40. Retrieved from <http://search.proquest.com/docview/224877583>
5. Gutowski, T. G., Sahni, S., Boustani, A., & Graves, S. C. (2013). Remanufacturing and energy savings. *Environmental Science & Technology; Environ.Sci.Technol.*, 45(10), 4540-4547. Retrieved from <http://pubs.acs.org/doi/abs/10.1021/es102598b>
6. *HP bright white ink jet paper 203000*. (2013). Retrieved November 15, 2013, from <http://www.officedepot.ca/Inkjet-Paper/HP-Bright-White-Ink-Jet-Paper-203000.asp>
7. Jujun, R., Jia, L., & Zhenming, X. (2013). Improvements of the recovery line of waste toner cartridges on environmental and safety performances. *Environmental Science & Technology; Environ.Sci.Technol.*, 47(12), 6457-6462. Retrieved from <http://pubs.acs.org.ezproxy.library.ubc.ca/doi/pdfplus/10.1021/es305311k>
8. Pollock, D., & Coulon, R. (1996, May). Life cycle assessment: of an inkjet print cartridge. In *Electronics and the Environment, 1996. ISEE-1996., Proceedings of the 1996 IEEE International Symposium on* (pp. 154-160). IEEE. Retrieved from <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=501870&isnumber=10831>
9. Ragan, C. T., & Lipsey, R. G. (2011). *Microeconomics*. Toronto, ON: Pearson Education Canada Inc.
10. Remanufactured Toner Cartridges: High Quality Standards. (n.d.). *LaserCycle USA RSS*. Retrieved from <http://www.lasercycleusa.com/toner-cartridges/remanufactured-cartridges/>
11. Replacement printer cartridges: Replacement printer cartridges. (2013). Retrieved November 15, 2013, from <http://www.xerox.ca/printer-supplies/compatible-cartridges/enca.html>

12. Ruan, J., Li, J., & Xu, Z. (2011). An environmental friendly recovery production line of waste toner cartridges. *Journal of Hazardous Materials*, 185(2–3), 696-702. Retrieved from <http://dx.doi.org/10.1016/j.jhazmat.2010.09.074>
13. Save the Environment AND Save Money!. (n.d.). *Eco-facts about laser printer toner cartridges & inkjet printer cartridges*. Retrieved November 23, 2013, from <http://www.mrcartridge.com/eco-facts-laser-printers-inkjet-printers-cartridges.html>
14. Williams, J., & Shu, L. (2000). Analysis of toner-cartridge remanufacturer waste stream. 260-265. doi:10.1109/ISEE.2000.857659. Retrieved from <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=857659>

APPENDIX A - SURVEY QUESTIONS

1. What department do you represent? (Text response)
2. What brand of photocopier cartridge(s) is your department currently using? (HP/Other)
3. What type of photocopier cartridge(s) is your department currently using? (Ink/Toner)
4. On average, how long does a toner cartridge last before you have to refill/replace it? (Multiple choice)
 - a. Less than one month.
 - b. Between one to four months.
 - c. Between five to eight months.
 - d. Between nine months to a year.
 - e. More than one year.
5. Where do you go to buy your cartridges? (Text response)
6. When your cartridges run out of ink, what do you do with the cartridges? (Checkbox)
 - a. Buy a new cartridge.
 - b. Refill the cartridge.
 - c. Recycle the cartridge.
7. In your department, how do you find the quality of your prints?
 - a. Very Poor
 - b. Below Average
 - c. Average
 - d. Above Average
 - e. Excellent
8. If you buy new cartridges, what type of cartridge do you buy?
 - a. Remanufactured Cartridges - cartridges that are disassembled, repaired, and put back together.
 - b. OEM Cartridges - cartridges that are made by the Original Equipment Manufacturer.
 - c. Compatible Cartridges - cartridges that are made by third party manufacturers and made entirely of new parts.
 - d. Unsure. Please explain. (text response)
9. If you recycle the cartridges, do you utilize the UBC BuySmart program? (Yes/No)

10. If you refill the cartridges, where do you refill the cartridges? (Text response)
11. If you buy remanufactured cartridges, how is the quality of the prints compared to OEM cartridges?
 - a. Better
 - b. About the same
 - c. Worse
12. Would incentives such as discounts affect your purchasing decision? (Yes/No)

APPENDIX B - SURVEY RESULTS

Survey Results – Part I

	What brand of photocopier cartridge(s) is your department currently using?	What type of photocopier cartridge(s) is your department currently using?	On average, how long does a toner cartridge last before you have to refill/replace it?	Where do you go to buy your cartridges?
Pharmaceutical Sciences	HP	Toner	Between nine months to a year.	SNS Data
Faculty of Medicine	HP	Toner	Between five to eight months.	TLD
Payment and Procurement Services	Other	Toner	Between one to four months.	Xerox UBC global services
Computer Science	HP	Toner	More than one year.	Recycler/Reseller
Borrower Services (Koerner Library - Office Printer)	Other	Toner	Between five to eight months.	Xerox
Koerner Library - Public Printer	Other	Toner	Between one to four months.	Xerox
Electrical and Computer Engineering	Other	Toner	Between one to four months.	laser valley
Sauder Undergraduate Office	Other	Toner	Between one to four months.	staples
Education Library	Other	Toner	Between one to four months.	Xerox
Earth Ocean and Atmospheric Sciences	HP	Toner	Less than one month.	Ricoh
Law	HP	Toner	Between one to four months.	Xerox

Survey Results – Part II

In order to reduce the amount of paper used, the responses for the question “*If you buy new cartridges, what type of cartridge do you buy?*” are shortened. The full responses are listed as following:

- **Compatible Cartridges** – cartridges that are made by third party manufacturers and made entirely of new parts
- **OEM Cartridges** – cartridges that are made by the Original Equipment Manufacturer
- **Remanufactured Cartridges** – cartridges that are disassembled, repaired, and put back together

	When your cartridges run out of ink, what do you do with the cartridges?	In your department, how do you find the quality of your prints?	If you buy new cartridges, what type of cartridge do you buy?	If you buy new cartridges, what type of cartridge ... [other]
Pharmaceutical Sciences	Buy a new cartridge. Recycle the cartridge.		Compatible Cartridges	
Faculty of Medicine	Recycle the cartridge.		Remanufactured Cartridges	
Payment and Procurement Services	Recycle the cartridge.		OEM Cartridges	
Computer Science	Recycle the cartridge.	Excellent	Compatible Cartridges	
Borrower Services (Koerner Library - Office Printer)	Recycle the cartridge.	Average	Unsure. Please explain.	Xerox
Koerner Library - Public Printer	Recycle the cartridge.	Average	Unsure. Please explain.	Xerox
Electrical and Computer Engineering	Recycle the cartridge.	Above Average	Remanufactured Cartridges	
Sauder Undergraduate Office	Buy a new cartridge. Recycle the cartridge.	Excellent	Unsure. Please explain.	xerox sends them
Education Library	Recycle the cartridge.	Average	Unsure. Please explain.	Xerox takes care of it
Earth Ocean and Atmospheric Sciences	Recycle the cartridge.	Above Average	OEM Cartridges	
Law	Refill the cartridge.	Average	Remanufactured Cartridges	

Survey Results – Part III

	If you recycle the cartridges, do you utilize the UBC BuySmart program?	If you refill the cartridges, where do you refill the cartridges?	If you buy remanufactured cartridges, how is the quality of the prints compared to OEM cartridges?	Would incentives such as discounts affect your purchasing decision?
Pharmaceutical Sciences	No			
Faculty of Medicine	No			
Payment and Procurement Services	No	We get the toners manufactured from Xerox and send them back for recycling.		
Computer Science	No	n/a	About the same	Yes
Borrower Services (Koerner Library - Office Printer)	No			No
Koerner Library - Public Printer	No			No
Electrical and Computer Engineering	No	dont do that	About the same	No
Sauder Undergraduate Office	No			Yes
Education Library	No			No
Earth Ocean and Atmospheric Sciences	No			Yes
Law	No		About the same	Yes