An Investigation into Waste Stream Tracking in the New Student Union Building (SUB) Building

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ABSTRACT

This report employs the triple bottom line analysis to determine the feasibility of placing an advanced waste station in the new SUB, and ultimately provides two options for the waste station design. The purpose of the waste station is to provide both instant feedback and observable data to promote environmentally responsible waste management behaviour in users. In the body of this report, both the consequences and advantages of the waste station implementation are explored, in regards to the environmental, social, and economic aspects as prescribed by the triple bottom line analysis model. Key considerations analysed are installation costs, maintenance costs, longevity of design, the expected effect of the waste station feedback on users, and the expected effect of the waste station on the labour force involved. The explorations and considerations outlined above are broken down by section and analysed. The first step is the gathering of information through primary sources, such as surveys and interviews, and secondary sources, such as scholarly articles and statistics. The information gained is then analysed qualitatively and discussed if deemed reliable. Information is then analysed further in a quantitative manner in order to give a numerical representation of our findings as accurately as possible.

Through the aforementioned analysis technique, the results of the triple bottom line analysis are clear. The implementation of the advanced waste station will result in a diversion of nearly 31,340 tonnes of eCO_2 annually, an increase in waste recycling activity from 51% (currently at UBC) to an estimated 75% (for those that use this waste station), and an estimated savings of $1250 per year for a single waste station. In light of these findings, it is recommended that this waste station is implemented in the new SUB. An advanced waste station that provides waste stream data as well as instant feedback for bin users would make an immediate impact on the environment, the UBC society, and cost of waste disposal. Two options for such a waste station are explored and discussed in this report.

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GLOSSARY

Android:	An operating system used by a multitude of tablet and phone manufacturers
Arduino:	A pre-assembled microcomputer
Bluetooth:	A method of short range wireless data transmission
Coke:	A solid fuel made by heating coal in the absence of air so that the volatile components are driven off
e2,4-Ds:	Compounds with a similar effect to 2,4-D such as DDT and other insecticides and pesticides
eCO_2 :	Compounds with a similar environmental effect to CO_2 such as methane
eToluene:	Compounds with a similar health effect to Toluene
HDMI:	High definition video input, connected via a cable
Raspberry Pi:	A pre-assembled microcomputer
Strain Gauge:	An electronic sensor comprised of thin foil resistors that, once installed, sense mechanical deflection in the material they are attached to
Toluene:	A colourless liquid hydrocarbon present in coal tar and petroleum and used as a solvent and in organic synthesis
Triple Bottom Line Analysis:	A feasibility analysis which considers the environmental, social, and economic factors of a given project or consideration

LIST OF ABBREVIATIONS

SUB: Student Union Building

LCA: Life Cycle Analysis

GHG: Greenhouse Gas(es)

UBC: University of British Columbia

AMS: Alma Mater Society

BC: British Columbia

App: Android application

CO_2 : Carbon dioxide

UAE: United Arab Emirates

1.0 INTRODUCTION

The purpose of this report is to conduct a triple bottom line analysis on possible products to be used to weigh, track and display data relating to the multiple streams of waste in the new SUB at UBC. It will consider the environmental, social, and economic implications of the creation of an interactive waste station designed to encourage students to recycle and compost waste instead of using the garbage receptacle. The report will discuss the different options available for this system and will detail the importance of waste diversion, the effect an instant feedback system could have on the UBC community, and the costs associated for the design and maintenance of the new waste station.

2.0 ENVIRONMENTAL IMPACT

2.1 PURPOSE

In order to give an accurate assessment of the environmental effects of a waste station tracking system in the new SUB at UBC, the factors to be considered included the weight of reduced waste and increased recycling and composting, as well as the eCO_2 emissions related to these numbers. Further indicators were the health benefits of the reduced waste from the receptacle for all living organisms, which can be measured by eToluene and e2,4-D levels in the atmosphere.

2.2 METHOD

As the environmental effects of a small project such as this cannot easily be measured, only secondary sources were used to collect relevant data. This method ensured that all of information gathered was accurate and well tested. To find these sources, Google Scholar and Summon (the UBC library main database) were used and yielded many small articles, however the main research investigation used was a large study conducted by an Olympia, Washington group on the impacts of recycling and composting programs in Vancouver and Burnaby for the Recycling Council of British Columbia (Sound Research Management Group Inc., 2009). This report explained in detail how these systems work and what effects they have on both the atmosphere and the human population. As it was only conducted a few years ago and agrees with the smaller sources, this document was deemed by the group to be accurate and trustworthy information.

2.3 RESULTS

Information from the sources used all yielded very similar information on the effects of recycling and composting versus garbage disposal on the environment. This section will be broken into two main parts, the GHG emission reduction from diverted waste, and the biological health benefits of this diminution.

As is commonly known and often discussed, humans are currently producing more CO_2 emissions than ever before, and this increase is said to be causing the phenomenon known as 'Global Warming'. Though research on this topic is not definitive, it is widely believed by professionals in the field that these emissions are toxic to the atmosphere at high levels and thus should be decreased. CO_2 is produced by the combustion of nearly all of the fuel sources used in the modern world (i.e. wood, coal, petroleum, natural gas, etc.) and the increase in this gas has changed the concentration of the GHGs in our atmosphere, the network which controls the temperature of the planet. Research conducted by the Sound Research Management Group of Olympia, Washington discusses the effect of recycling of different materials and composting on the emissions produced by Vancouver and Burnaby on a per tonne basis. In figure 2.3.1, information on the left side of the graph indicates diversion of emissions when a given quantity of waste is diverted from the garbage into a recycling facility. Information on the right side indicates production of emissions.

Product / Material	kg eCO2 / Tonne Recycled or Composted
Aluminum	(9,827)
Newspaper	(3,666)
Mixed Paper	(3,236)
Wood	(2,753)
Cardboard	(2,236)
Electronics	(2,220)
PET	(1,638)
HDPE	(1,258)
Re-refined Lubricating Oil	(1,133)
Recycling/Composting Average (MSW & DLC)	(1,152)
Ferrous	(900)
Compostables	(757)
Glass	(181)
Asphalt/Concrete	(14)

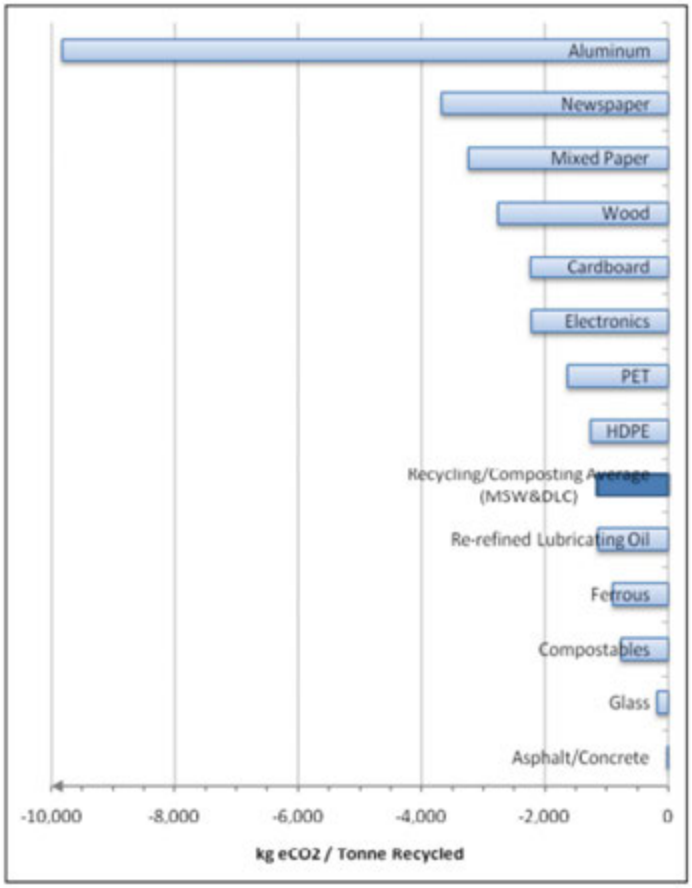

Figure 2.3.1: GHG Emissions per Tonne - Select Recyclables

Sound Research Management Group, Inc. (2009). *Environmental Life Cycle Assessment of Waste Management Strategies with a Zero Waste Objective.* Retrieved from Recycling Council of British Columbia website: http://www.rcbc.ca/files/u7/ement_for_ZeroWaste_Objective_ReportJune2009.pdf

As seen above, the main source of CO_2 diversion is the recycling of aluminum products, including soda cans, and of paper products, such as newspaper and cardboard. Composting, although still diverting CO_2 from the atmosphere, does not have nearly as big an impact on the situation. This information makes it clear that the positive feedback on the design of the new SUB Waste Station is much more important for recycling than for composting. Furthermore, as seen in the graph, many products divert much more emissions than the amount of material being recycled (eg: 1 tonne of recycled aluminum diverts 9.8 tonnes of eCO_2). This is due to the fact that this study takes into account the transportation, production, and disposal emissions of

products and therefore this information could be an interesting point to display in the final design.

The health and toxicity effects of recycling and composting are also discussed in the RCBC report and show similar effects to that of the last discussion. First, however, it is useful to discuss the effects of these by-products of waste disposal. Toluene is a solvent which naturally occurs in small amounts in crude oil. However, the production of coke from coal and the distillation of gasoline produce this compound. Toluene is used as paint thinner and other solvents, but is also used by some as a drug via huffing, or inhalation. As use as a drug indicates intoxicating effects, and therefore health concerns, the constant production of this chemical in common processes increasing the Toluene concentration in the atmosphere creates human health concerns in addition to that of other organisms. As well as chemicals created accidentally, compounds such as 2,4-D and DDT are released into the atmosphere when waste is disposed of, rather than recycled. Though these are not created by chemical processes in material production, these compounds are used as pesticides and herbicides on natural resources which later become products, and then waste. When released into the atmosphere, these compounds which are specifically created to kill insects and plants are able to do their job again, however they are now free to seep into streams, farms, and groundwater undetected. Higher concentrations of these chemicals can potentially kill off many plants, insects, and even animals in a region without being detected first. Figures 2.3.2 (a) and 2.3.2 (b) again show the diversion of both eToluenes and e2,4-Ds from the atmosphere via recycling and composting.

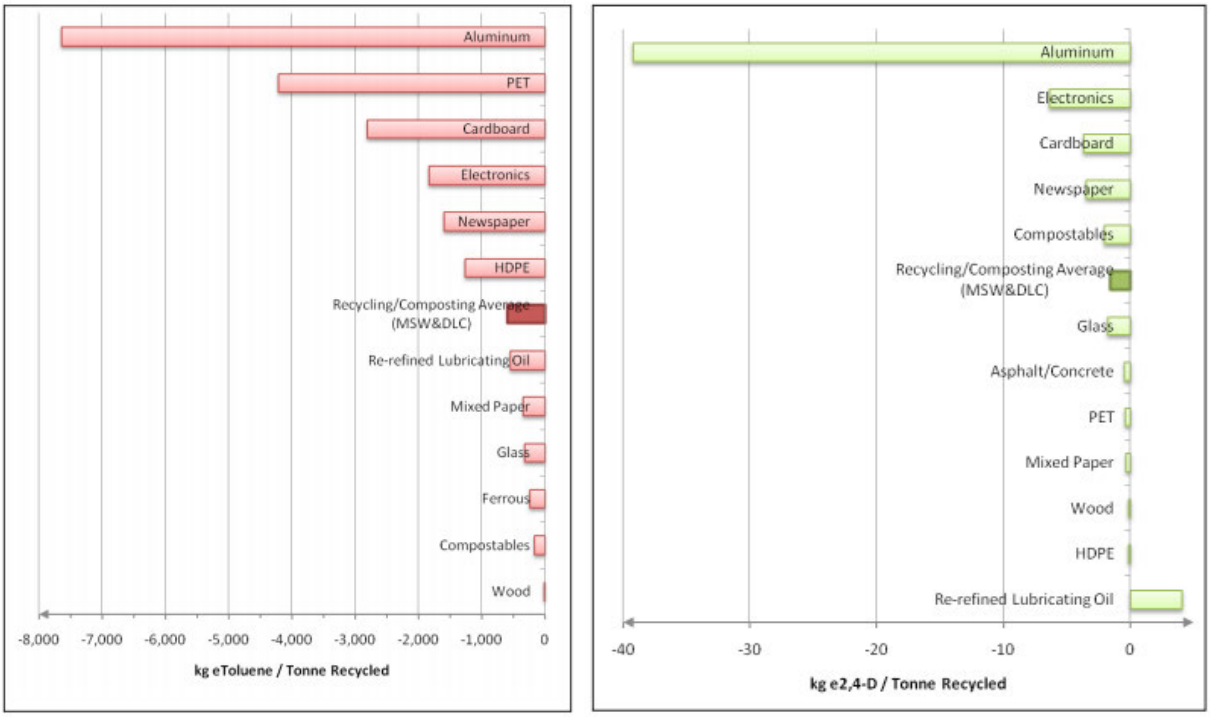

Figure 2.3.2: (a) Human Health Emissions per Tonne - Select Recyclables
(b) Ecosystem Toxicity Emissions per Tonne - Select Recyclables
Sound Research Management Group, Inc. (2009). *Environmental Life Cycle Assessment of Waste Management Strategies with a Zero Waste Objective.* Retrieved from Recycling Council of British Columbia website: http://www.rcbc.ca/files/u7/ement_for_ZeroWaste_Objective_ReportJune2009.pdf

As shown above, the effects of recycling aluminum products and paper not only have the highest diversion of eCO_2, but also of eToluenes and e2,4-Ds, and thus it is environmentally vital to encourage recycling of these materials. In addition to this, it is clear that composting has a large effect on ecosystem toxicity levels although not a great effect on the other two sections. This indicates that relating positive composting feedback to not just the environment, but flora and fauna wellbeing is a true and impactful way to address the issue in the waste station.

Using the estimations for reduced waste found in both the Social and Economic sections of this report, a 24% increase in the recycling rates of this bin can be assumed. This corresponds to a diversion of 8,787 kg in recyclables alone. Assuming plastics make up roughly 40% of this,

paper and cardboard are 40%, and aluminum cans 20%. This corresponds to the emission diversion savings in figure 2.3.3 below.

	Recycled Material (tonnes)	eCO_2 diverted (tonnes)	eToluene diverted (tonnes)	e2,4-Ds diverted (tonnes)
Paper/Cardboard	3515	9,620	5,270	14.1
Aluminum	1760	17,300	13,550	68.6
Plastic	3515	4,420	4,570	1.76
Total	8790	31,340	23,390	84.5

Figure 2.3.3: Emissions diverted by the proposed Waste Station.

2.4 CONCLUSION

Considering all of the environmental and ecological impacts of recycling and composting for waste diversion, it is clear that these processes are extremely important for preventing damages to the GHG balance, human health, and the natural chemical balance of all living things. Assuming some type of visual feedback is selected as the design for the new SUB waste station, and that this system does change the behaviour of students towards recycling and composting in the expected ways, the environmental impact of this change could be the start of the shift at UBC from producers of harmful substances (CO_2, Toluene, 2,4-D, etc.) to diverters of these harmful waste by-products.

3.0 SOCIAL IMPACT

3.1 PURPOSE

For this investigation, the social factors which were most heavily considered were the public opinion of the waste station design, the effect of the waste station on the users, and the effect of the waste station on the labour force. A positive reception of the new waste station would cause people to want to use it more, increasing the amount of exposure to the feedback loop, which in turn would cause those users to successfully separate their recyclable materials more consistently.

3.2 METHOD

As a basis for deciding which type of feedback to incorporate in the new waste station, both primary and secondary data was gathered. In order to gauge the effectiveness of the different possible feedback methods, it is necessary to investigate past studies, and report on what has been determined up to the present. The results of three such studies performed in 1992, 2005, and 2013 are detailed below. Furthermore, a survey was conducted for the purposes of this investigation, which was distributed through the use of social media.

The effect of the waste station on the labour force was also observed. The factors considered were the amount of maintenance required, difficulty of installation and repair, and how the design would affect waste collection. These factors largely depend on the individual components and architecture of the proposed design, and so the information was gathered through data sheets and parts specifications.

3.3 RESULTS

There have been several studies and tests conducted by reputable sources to determine the relationship between feedback loops and recycling. For instance, a study was conducted in South Korea by Sungbum Kim, a master's student of psychology, and Shezeen Oah and Alyce Dickinson, both professors of psychology, to gauge the effectiveness of both written and graphic feedback. Before any type of feedback was posted, the percentage of correctly separated aluminum cans was 62.4%, and separated paper cups was 43.5%. The conductors of the study then posted written feedback for several days which provided the weight of recycled paper and the percentage of separated materials (cans and paper cups) from the previous day. The percentage of successfully separated materials increased considerably due to the feedback, reaching 75.5% for cans, and 64.8% for paper cups. When graphic feedback was introduced, plotting the percentages of separated materials at regular intervals, the percentage slightly rose again to 78.5% for cans and 69.9% for paper cups (Kim et al, 2005).

A very similar test was performed in 1992 by Richard Katzev, and Henry Mishima in Portland Oregon. The study also used written feedback in order to encourage people to recycle their paper products more often, and showed that after written feedback was posted, there was a 76.7% increase in the weight of paper recycled each day (Katzev & Mishima, 1992). These studies are very useful in showing that the mindset of the public towards recycling can be significantly improved when they are able to see their level of success or failure. Through witnessing the stats of their previous actions, they seem to be driven toward progress and better performance.

Aside from written and graphic feedback, there have been recent tests of recycle bins which incorporate an animation and sound when a person uses it. One such recycle bin is called the Emo-bin. The Emo-bin was designed by Jose Berengueres, Fatma Alsuwairi, Nazar Zaki,

Tony Ng in 2013 at the United Arab Emirates University, and was used to test human responsiveness to emoticons. Very simply, a screen is used to regularly display a neutral face as seen in figure 3.3.1 (a), but when an object is placed in the Emo-bin, the screen displays a happy face as seen in figure 3.3.1 (b), and a quick, positive sound is emitted. Although the average for recycled bottles at UAE is about 10%, this form of feedback was found to be extremely effective, tripling the amount of recycled plastic bottles (Alsuwairi et al, 2013). The animation acts as a sort of reward for the user, and so encourages good recycling habits.

Figure 3.3.1(a): Neutral Face on the Emo-bin
(b): Happy Face on the Emo-bin
Alsuwairi, F., Berengueres, J., Ng, T., Zaki, N. (2013, March 3-6). *Emo-bin: How to Recycle more by using Emoticons.* Paper presented at 8th International Conference on Human-Robot Interaction, Tokyo, Japan.

In addition to the primary data received in the mentioned articles, a survey was created for the purposes of this report. The survey consisted of five questions, which helped to gauge the effectiveness of feedback when associated with recycling. The survey questions are provided in Appendix A. As displayed in the results for Question 1 (figure 3.3.2) most people are moderately concerned about recycling, but only 4% of respondents described themselves as being passionate about it. This would suggest that there is certainly room for improvement of

people's recycling habits. Figure 3.3.2 and figure 3.3.3 show that the majority of respondents believe that each of the forms of feedback (statistics about CO2 emissions, the amounts and trends of previously recycled materials, and immediate animations) would cause them to recycle more. Finally, figure 3.3.4 indicates that the most popular method of feedback is the positive and negative animations.

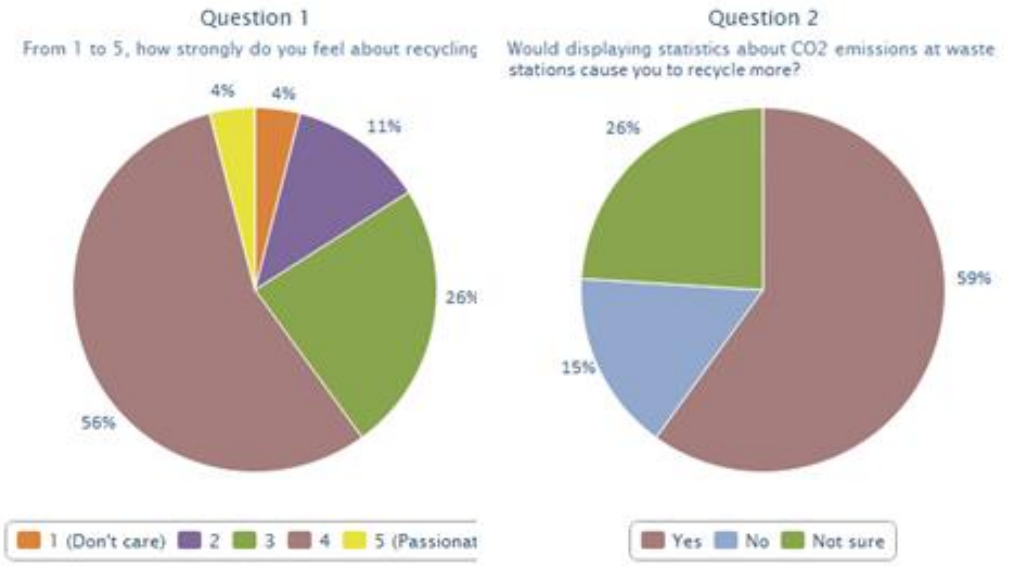

Figure 3.3.2: Survey Questions 1 and 2 Results

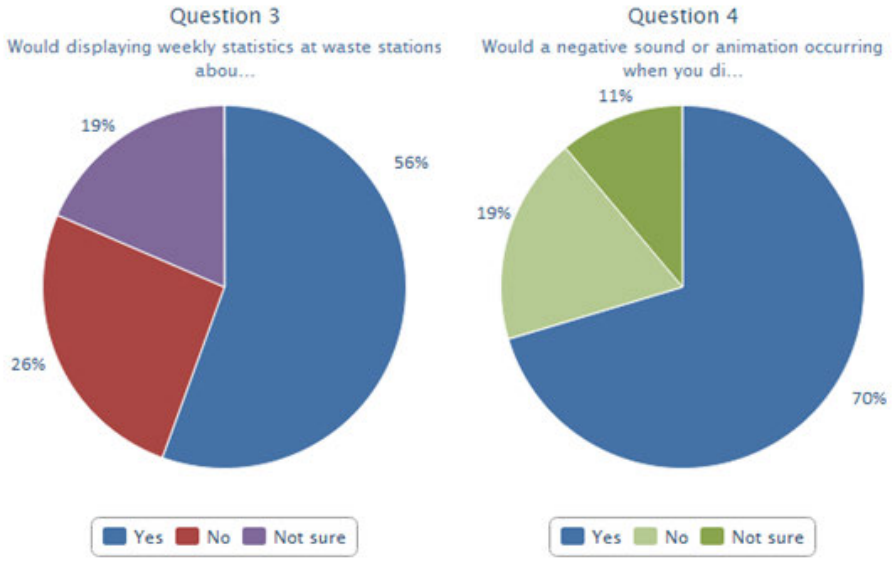

Figure 3.3.3: Survey Questions 3 and 4 Results

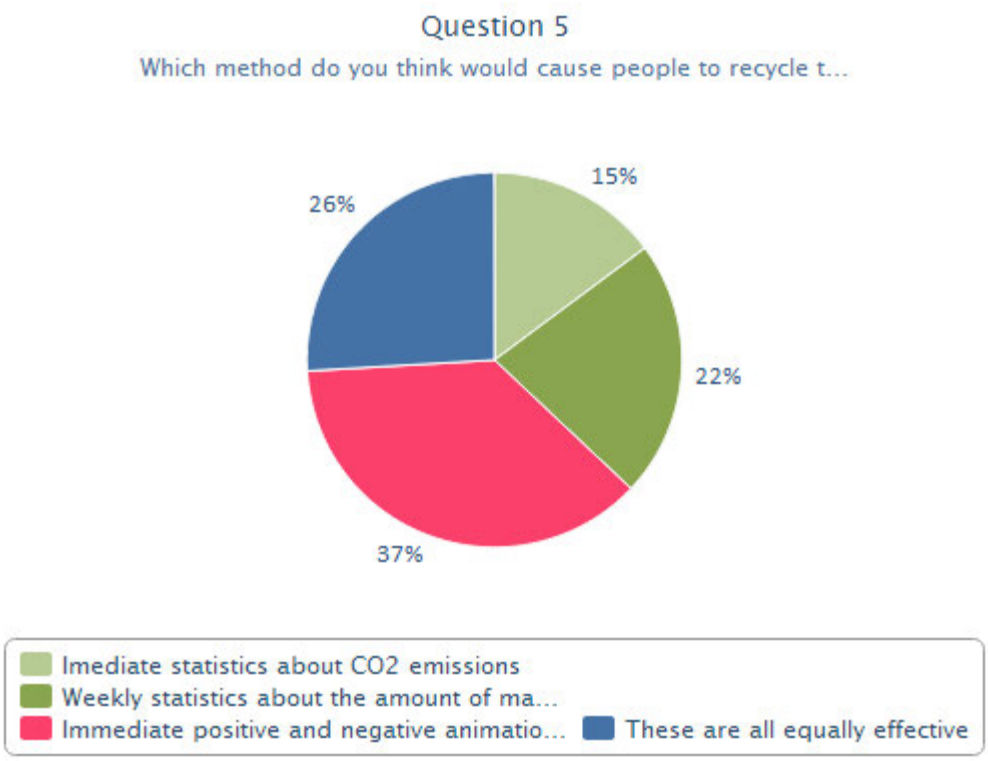

Figure 3.3.4: Survey Question 5 Results

For the proposed design, the components used should have a very minor effect on waste collection. Both of the options, outlined in Conclusions and Recommendations, are supplementary to the existing bins, and do not require any changes to the bins themselves. The only extra step involved in collection would be recording the weights of each material for that specific waste station, and entering the information into the app to be analysed and displayed. As with all electronic devices, the proposed design is expected to require maintenance, and the strain gauges will need to be replaced every so often. It is difficult to determine a consistent life expectancy for these parts, but strain gauges can function well for up to several years. Regardless, the maintenance should be a minor issue, as the installation and uninstallation of the entire design is fairly simple. Some work will need to be done initially, in order to develop an app with which to display the feedback, and the AMS may also wish to regularly update the app

and add additional features, which will be up to their discretion. This development and programming could be performed by students and/or faculty members at UBC, further increasing student involvement, or could be outsourced from third party companies.

3.4 CONCLUSION

Considering all of the gathered data, it is clear that feedback is very effective in encouraging people to recycle. All of the forms mentioned (written, graphic, and animation) seem to be useful, and each may also motivate different types of people. For this reason, an app which can regularly alternate between written and graphic feedback, and which also executes an animation when the bins are used, is sure to be relevant to a wide array of users. Furthermore, the design will not only cause people to behave more appropriately regarding recycling, but will help to raise awareness and change the long-term mindset of the users. As a result, an attitude of sustainability will be greatly encouraged. According to UBC's waste audit for 2009, 51% of generated waste was correctly recycled (MJ Waste Solutions, 2010). Based on the data discussed above, an appropriate estimate for correctly recycled materials after the proposed feedback system is implemented is approximately 75%.

The low amount of maintenance required, and the ability to continually improve the app and to set up additional such waste stations make the proposed system very promising. Also, the prospect of incorporating student involvement with the app is a definite benefit, as it could provide an interesting and relevant project, as well as yield increased awareness of environmental issues and participation in the new waste station.

4.0 ECONOMIC IMPACT

4.1 PURPOSE

Although the main aspects of this waste station are the environmental and social changes that it will make, this section will cover the costs associated and the possible paybacks. The potential hardware/software combinations and their respective costs will be outlined in the following section. The cost of running and maintaining the bin, as well as an approximate lifespan will be analysed. The savings will be compared to the investment cost to see how long of a payback period there is for the waste station.

4.2 METHOD

To determine the cost of the hardware/software combinations for the bin, two options will be compared. There are also two options for the installation and programming of the station, both of which will be outlined and compared. To determine the ongoing costs of running the station, the electricity costs will be calculated with both possible units consuming roughly 10 Watts of power. The lifespan will be evaluated by looking at the parts most likely to fail in the two options and this will also show the possible maintenance associated with the station. Savings from the station will be calculated by looking at the amount of material that could be diverted from the garbage to the respective recycle bin, as garbage costs much more to dispose of than recyclables. These calculations will be based on the assumption that the waste station would account for 10% of the post consumer garbage, compost, and recyclables in the Student Union Building (SUB).

4.3 RESULTS

The two options will be described in detail in Conclusions and Recommendations; both are similar in cost with option 2 being slightly cheaper. Allowing students the opportunity to design the software makes use of the many talented students at UBC, and also reduces the initial investment cost. For the following calculations, assume both options cost $650 for the components. If students are used for the programming and installation the total cost would be approximately $1000. Should a contractor or third party be hired for the installation and programming, the total cost would be raised to approximately $3000. The actual cost could be higher or lower depending on who is used for the programming and installation, but these estimates will help with determining the payback period.

The cost for electricity in BC for the use of over 550 000 kWh/year is $0.096/kWh (www.bchydro.com). Assuming the waste station will be operating at all times, the station will use roughly 87.6kWh annually and cost just $8.41 in electricity per annum. Out of all the parts in the two options, the strain gauges and the tablet or LCD screen are the most likely parts to fail. Although it is difficult to give a consistent lifespan for these parts, it can be approximated at 4 years each. The rest of the components are not likely to fail for many years. For maintenance it is recommended to do an overall inspection of the unit yearly and whenever problems are reported. The annual maintenance costs are estimated to be $20.

According to the AMS waste audit that took place in 2009, The Student Union Building disposed of roughly 58,000kg worth of post-consumer garbage in that year (MJ Waste Solutions, 2010). Of that 47% could be composted and 6% could be easily recycled in a paper or a beverage container bin, as seen in figure 4.3.1 below. In Metro Vancouver it costs $107 per metric tonne, as a tipping fee, to dispose of garbage (Metro Vancouver, 2011). This leaves a very big payback

for diverting more of the recyclables and compost from the garbage into the correct bins. To offset the initial investment cost, the new waste station would only have to divert 9 tonnes of compost and recyclables from the garbage in the case that students design and implement the station, and 27 tonnes if a 3rd party was brought in. In 2009 51% of the waste generated was correctly recycled. As concluded in the previous section, different forms of feedback have been shown to be able to increase correct waste diversion significantly. It is expected that correctly recycled materials will rise to approximately 75% after the implementation of the proposed waste station. For the sake of cost estimates, assume the new station accounts for roughly 10% of the post consumer waste in the SUB. That is an extra 8,787kg worth of recyclables that could be diverted by installing the new waste station. Annually this would save the university almost $950 in tipping fees alone.

The audit also stated that around 1581 kg worth of beverage containers were put in the garbage that year. If the waste diversion rate was increased from 51% to 75% there would be the possibility of an extra 890 kg of beverage containers being recycled annually in the SUB. Assuming each container weighs around 15g, this comes out to 59,333 containers. Using the same assumption that the new station would account for 10% of the post consumer waste, the university would save another $300 annually on recyclable container deposits.

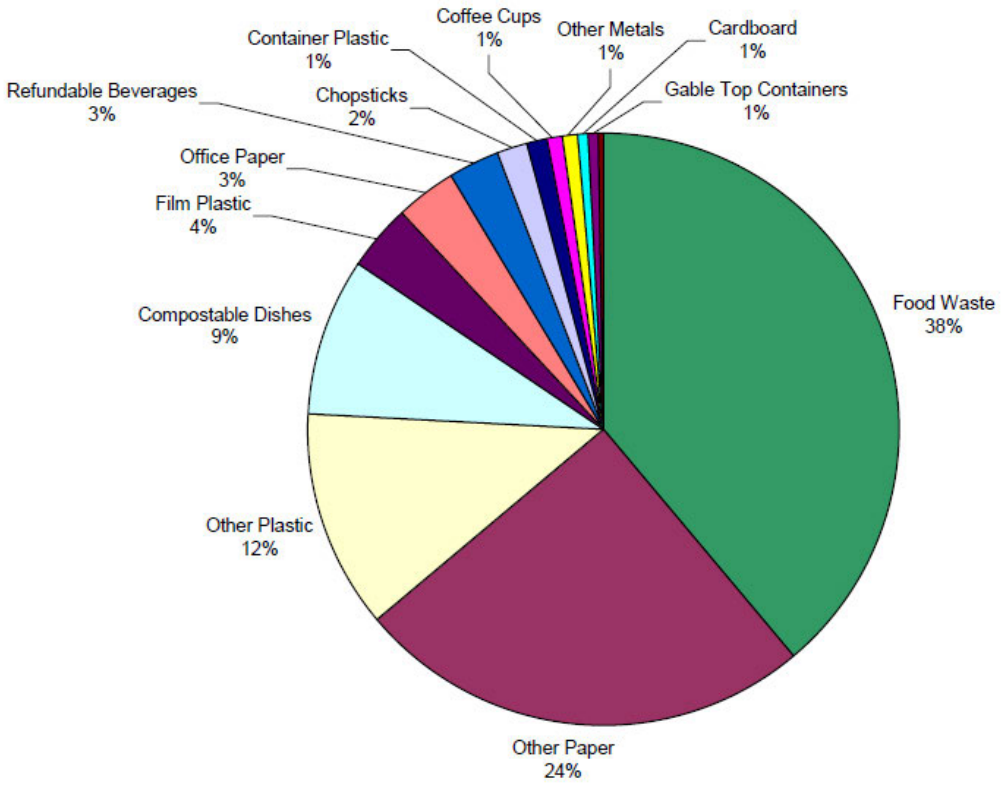

Figure 4.3.1: Post Consumer Garbage Composition
MJ Waste Solutions. (2010, April 22). *Phase 2 Waste Audit Results and Waste Management Plan.*

4.4 CONCLUSION

From an economic standpoint both options are equally viable. If the proposed waste station works as expected it would save the university approximately $1250 annually. If students were used to design and implement the station the initial investment would be paid off in just over 10 months and the university would see savings within the first year. If a third party was hired to do this the initial investment would be paid off in 29 months. These savings would be more than enough to cover any possible maintenance costs, as well as the cost of electricity to run the station. From this section it is clear that the waste station is economically feasible and there is the opportunity to save a significant amount of money by diverting waste from the

landfill. If the SUB changed out all of its waste stations for the options proposed, the university would save roughly $12,500 annually with a similar payback period.

5.0 CONCLUSIONS AND RECOMMENDATIONS

As discussed above, the environmental impact of the advanced waste station would be entirely positive and immediate. The negatives of energy consumption and occasional part replacement and repair would be far outweighed by the positives of the reduction of waste and the increase in percentage of correctly recycled materials. Considering the social implications, it is clear that the introduction of the advanced waste station will result in an immediate increase in environmental awareness in individuals, possibly up to a 75% increase. With positive feedback and graphical data display, users of the waste station will become stewards of their portion of the environment, and strive to live in a more sustainable manner. This awareness will move society one step closer to realizing the full value of environmental preservation. Economically, the proposed waste station will actually result in profit due to savings in waste disposal fees as soon as ten months after installation, eventually resulting in a savings of $1250 per year as discussed above. Due to the overall favorable results determined from the triple bottom line analysis, it is certainly recommended to go ahead with the installation of the advanced waste station. As requested, two hardware/software configurations have been outlined, discussed and designed. A parts breakdown and price list can be found in Appendix B, and a description of the two options will be outlined below.

Both options will utilize strain gauges to sense the weight of the waste in the separate bins. The strain gauges will be attached to steel flat bar that will span the waste station area, configured in such a way that the weight of the individual waste bins will end up directly above the sensing area, thus maximizing sensitivity (see Appendix C for dimensioned AutoCAD drawings). The advanced waste station designs will also incorporate proximity sensors that will enable the detection of any objects that enter the waste bins which will allow for immediate

feedback when an action is sensed. Both of the designs have wifi capability and can be configured to transmit data to the main building control system. The two designs mainly differ in how the data is processed and displayed.

Option one will incorporate a Raspberry Pi microcomputer that will acquire data and display the preferred output to an LCD screen mounted above the bins via HDMI cable. This configuration is electronically the most stable as it is a standalone design with a minimum number of parts. The second option uses an Arduino microcomputer with an attached Bluetooth shield to transmit data via Bluetooth to an Android tablet located above the bins. The data would then be interpreted by an onboard app, and would output the desired display. This option allows for more portability and functionality. Ultimately, the Android tablet's touch screen could be incorporated to achieve a more interactive experience. There is also the potential for a sister app to be developed that could be installed on a student's or faculty member's mobile device, enabling an interaction with the project and a real time look at the results. Should there be a desire to incorporate additional waste stations at UBC, the Android app could be easily installed on any Android device. Overall, the second option which uses the Arduino in conjunction with the Android tablet is the design recommended for the advanced waste station. It is recommended that the display screens are used to show past and future waste generation numbers to encourage improvement while no input to the bins has been detected, as well as instant feedback in the form of popular culture gifs, animations, and sound loops when input has been detected.

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APPENDIX A: Recycling and Feedback Survey

From 1 to 5, how strongly do you feel about recycling?

- 1 (Don't Care)
- 2
- 3
- 4
- 5 (Passionate

Would displaying statistics about CO2 emissions at waste stations cause you to recycle more?

- Yes
- No
- Not sure

Would displaying weekly statistics at waste stations about the amount of materials recycled at UBC cause you to recycle more?

- Yes
- No
- Not sure

Would a negative sound or animation occurring when you did not recycle, and a positive sound or animation occurring when you did recycle cause you to recycle more?

- Yes
- No
- Not sure

Which method do you think would cause people to recycle the most?

- Immediate statistics about CO2 emissions
- Weekly statistics about the amount of materials recycled
- Immediate positive and negative animations
- These are all equally effective.

APPENDIX B: Parts List and Cost Breakdown of Options 1 & 2

Option 1:

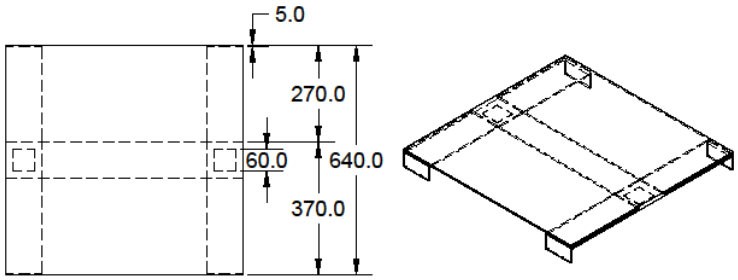
Item	Part Number	Qty	Cost
Weight Sensors	SGD-2/350-X411 Strain Gauges	12 (4 per bin)	$312.00
Circuit Board - Amplifiers, Filters, Temp Compensators, Adders, Quad ADC Converter, Proximity Sensor	ADC: DS2450, to be designed and tested	1	Approx $25.00
Raspberry Pi	Raspberry Pi Model B	1	$40.00
Raspberry Pi WiFi	PiroBoxx Adapter	1	$13.00
SparkFun LCD Monitor	LCD-11612	1	$150.00
Structure	5mm steel	-	$100.00
TOTAL	-	-	**$640.00**
Power Consumption	-	-	10W

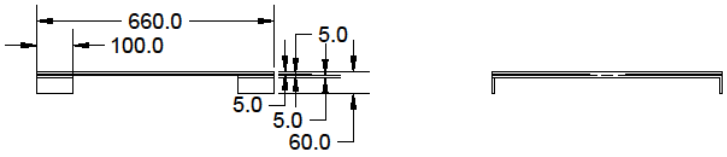
Option 2:

Item	Part Number	Qty	Cost
Weight Sensors	SGD-2/350-X411 Strain Gauges	12(4 per bin)	$312.00
Circuit Board - Amplifiers, Filters, Temperature Compensators, Adders, Proximity Sensor	To be designed and tested	1	Approx $25.00
Arduino Uno	Arduino Uno	1	$30.00
Arduino Bluetooth Module	Arduino BT	1	$13.00
Le Pan II Andriod Tablet	Le Pan II	1	$170.00
Structure	5mm Steel	-	$100.00
TOTAL	-	-	**$650.00**
Power consumption	-	-	10W

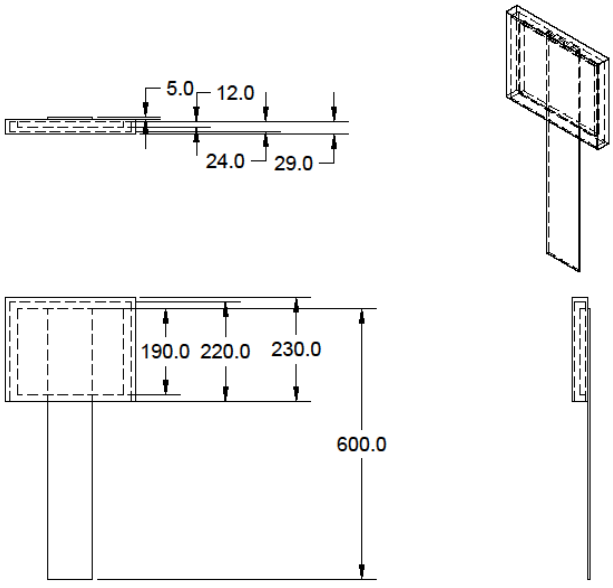
APPENDIX C: Dimensioned Structural Drawings

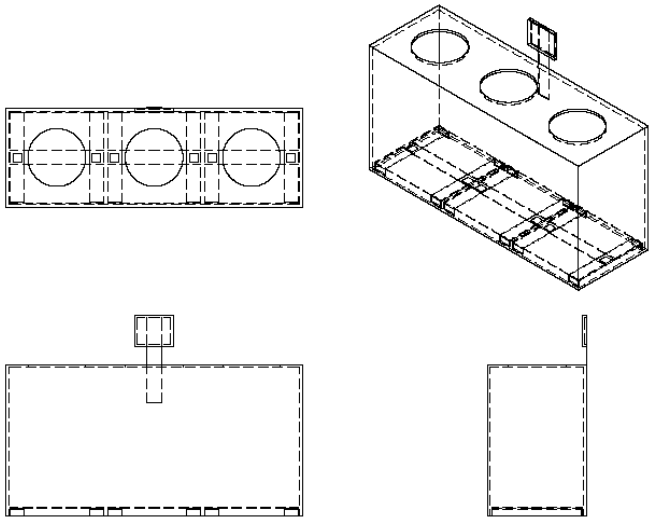
Scale Below Each Bin:





Screen Assembly:





Expanded View of Scale: