UBC Faculty of Pharmaceutical Sciences Media Wall: A Life Cycle Assessment

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UBC Faculty of Pharmaceutical Sciences Media Wall

A Life Cycle Assessment

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Executive Summary

This LCA report was written and compiled for the UBC Pharmaceutical Building Media Wall stakeholders and is intended to be used as a benchmark for other comparative technologies in addition to showing the true environmental, energy, and economical cost of the media wall system.

LCA data was taken from various literature, nationally compiled databases, and measured directly from the system. The study included manufacturing, transportation and end-use values for energy use and greenhouse gas (GHG) emissions. Economical analysis included capital cost expenditures as well as operating and maintenance (O&M) costs over the life of the system. A functional unit of 2,650 hours and a lifetime of 20,000 hours of display were used in calculations.

Table 1 - Summary of LCA study based on functional units

	Mnfg.	Transportation	End Use	Total
Total Energy Use Based On Func. Unit (MJ) =	5149	82.3	46,269	51,500
Total GHG Emissions Based On Functional Unit (kg. CO2 eq.) =	108	6.1	10,284	10,398

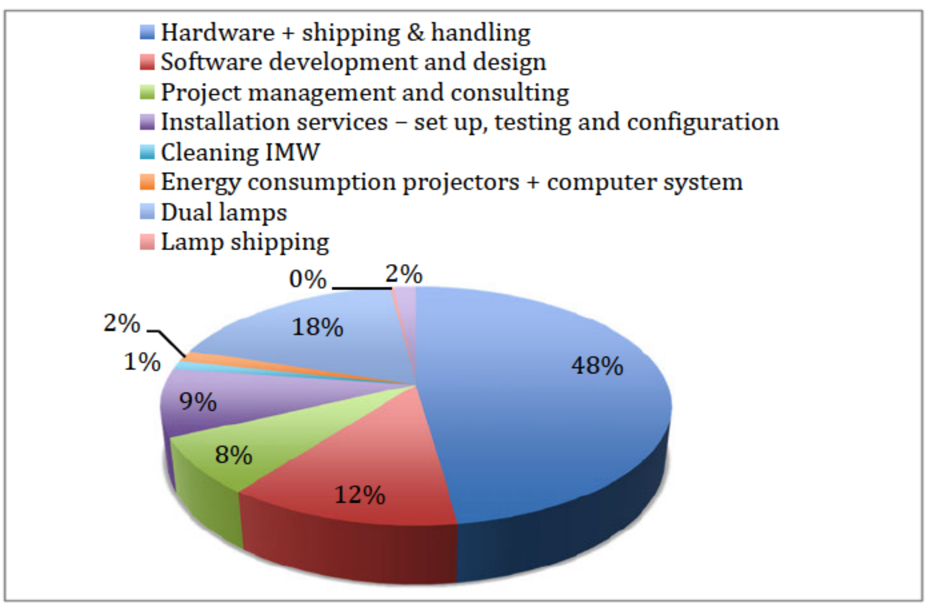

Figure 1 - Summary of costs

Introduction

The University of British Columbia's (UBC) Social Ecological Economic Development Studies (SEEDS) program was approached by UBC's Pharmaceutical Science's program about the alarming energy usage of the newly built impact media wall (IMW). The Pharmaceutical Science's building officially opened on Sept 8, 2012 and houses state of the art digital displays including the 7ft x 26ft media wall under review.

According to the building maintenance, the IMW's primary purpose was to display information about UBC's Pharmaceutical Science program. Additionally, it could be used as a large display screen during special events and activities. Unfortunately, due to the extraordinary energy costs and low life-span of the projector lamps, the maintenance staff can only run the IMW for limited amounts of time during the day.

This report identifies the true energy usage, greenhouse gas emissions, and costs of the IMW using a life-cycle assessment (LCA) analysis. Values from this report may be used as a benchmark when comparing future alternatives to the IMW.

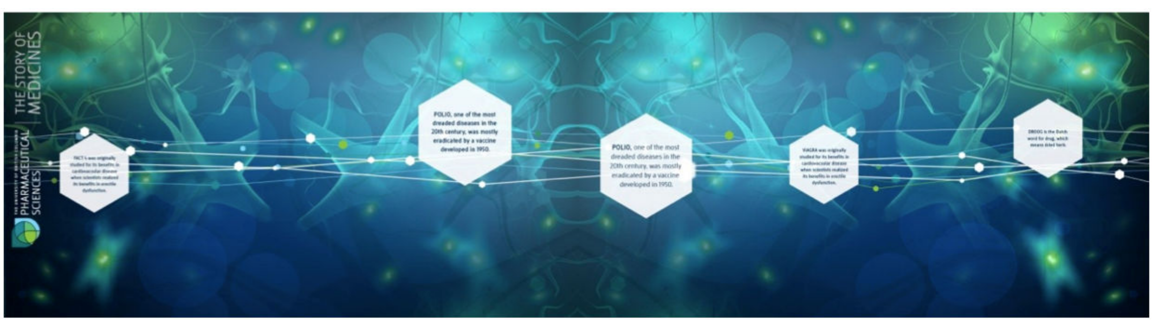

Figure 2 - "The Story of Medicine" currently displayed on the IMW

Goal and Scope

The LCA team's scope includes the hardware components of the IMW as listed in Table 2.

Table 2 - IMW Component List

Hardware	Quantity	Make and Model
Projectors	6	PT-DW6300ULS
Computer	1	Dell T3500
Video Card	1	Matrox M9188
Edge Blending Device	6	TV-One C2-2450A
Mirror Assembly	6	Millenium
Rear-Projector Film	6	EOS-procured film
AV Rack	1	Toten TOC22UD
AV Rack Drawer	1	Toten TODWR2U
Glass Assembly	6	n/a

The system comprises of a centralized computer drawer that includes the edge blending device, video card, and the controls for each of the projectors. Each of the six projectors is connected to this centralized control. The projectors and mirrors are mounted on steel frames behind the glass assembly. Figure 3 shows a diagram of the system.

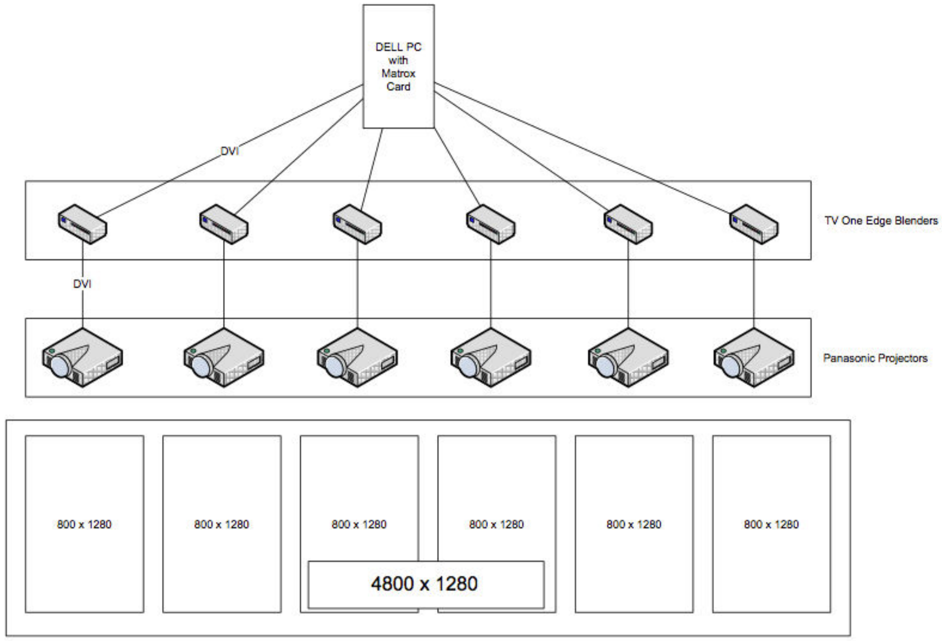

Figure 3 - IMW hardware components

Functional Unit

According to the IMW stakeholders, the ideal run-time for the IMW is 2,650 hours/year which this report uses as a functional unit. This calculation is based on optimal operating hours from 8:00am to 6:00pm Monday through Friday for an average of 50 weeks per year. Additional hours from events and promotions 3 times per month averaging 4 hours per event are also included.

The lifetime of the projectors and thereby the entire system was assumed to be 20,000 hours. According to the manufacturer the projectors require a factory overhaul after 20,000 hours of use. This overhaul procedure is a preventative maintenance recommendation. The Director of Operations and Facilities Management of the Faculty of Pharmaceutical Sciences has stated that it is unlikely that the projectors will undergo this overhaul process, and consequently the service life of the IMW for this report was assumed to be 20,000 hours of display.

System Boundary

The boundaries for the LCA start from manufacturing and stop at end-use. Disposal and recycling were not taken into account due to the wide variation of re-use and recycling methods of the systems depending on the display hours. Emissions, energy usage, and costs are included in all stages of the LCA.

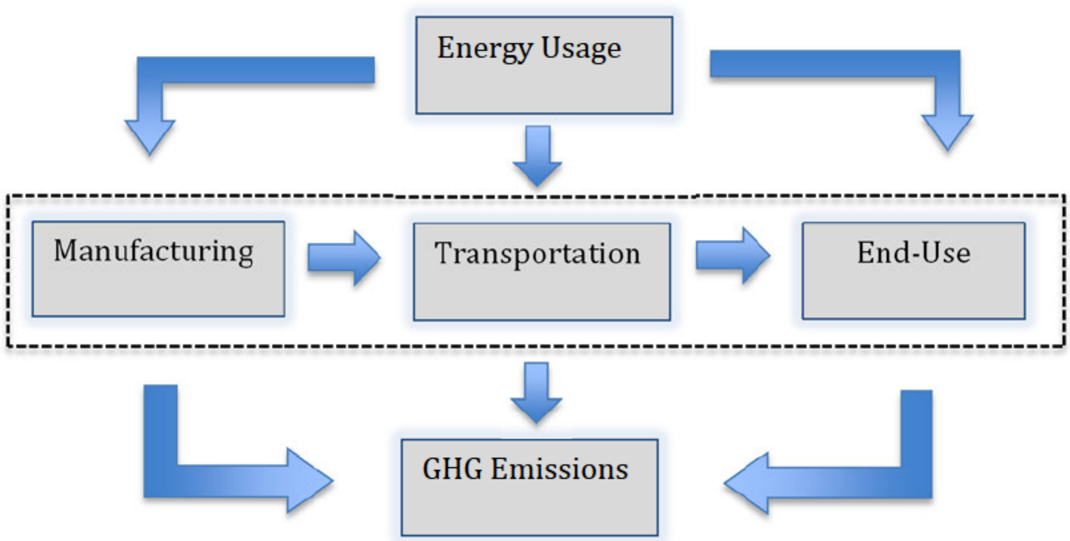

Figure 4 - System Bounadry

Life Cycle - Energy Analysis

Methodology

According to the system boundaries, energy usage was analyzed at three stages: the energy required for manufacturing each component, the energy required for transporting each component from the manufacturing plant to UBC, and the energy required to operate the media wall at its final location.

The team used the following three chronological methods in determining energy usage:

1. Directly measure electrical usage
2. Contact manufacturers directly for LCA energy usage data
3. Research similar products via the UBC library or other manufacturer's websites in order to find estimated energy usage data

The following table shows the method number and sources of each of our inputs.

Table 3 - Data collection methodologies

		Method		
Hardware	**Source**	**Mnfg**	**Transport-ation**	**End Use**
Projector	Casio XJ-S30 LCA	3	3	1
Computer	"Sources of variation in LCA of Desktop Computers", Teehan, Kandlikar (2012)	3	3	1
Mirror and Glass Assembly	"LCA of clear float glass for building applications"	3	3	3
AV Rack and Drawer	University of Bath Study for Steel Production	3	3	n/a

Due to limited data availability for electronics, the video card and edge-blending device were assumed to be included in the computer data. The rear-projection film was also assumed to be included as part of the glass assembly.

The energy requirements for transporting each component of the media wall were a significant source of energy use. In order to determine the transportation energy data for each component, the team utilized "Table 9 – Transportation Sector – Energy Use Analysis" from the National Resources Canada website. 2010 Marine Freight Energy Use and Heavy Truck Energy Use values were 0.53 MJ/T.km and 2.43 MJ/T.km, respectively. Transportation distances were calculated using Google maps. Additional information on LCA data sources and calculations are available in the Appendix.

Energy Usage Results

The following Table 4 shows a summary of data collected for Energy Usage for the system.

Table 4 - Energy usage results summary

			Electrical Use (MJ)			
Component	Model	Quantity	Mnfg.	Transportation	End Use	Total
Projector	Panasonic PT-DW6300ULS	6	26,000	174.48	328,320	354,494
Computer	Dell T3500	1	5000	58.12	20,880	25,938
Video Card	Matrox M9188	1	N/A	16.52	0	16.52
Edge Blending Device	TV-One C2-2450A	6	N/A	81.30	0	81.30
Mirror Assembly	Millenium	6	2,265.6	10.32	N/A	2,275
Glass Assembly	N/A	6	4,358.4	19.86	N/A	4,378
Rear-Projection Film	EOS-Procured Film	6	N/A	61.24	N/A	61.24
AV Rack	Toten TOC22UD	1	411.32	66.29	N/A	477.61
AV Rack Drawer	Toten TODWR2U	1	825.19	132.99	N/A	958.18
		TOTAL ENERGY REQ. (MJ) =	**38,861**	**621.12**	**349,200**	**388,682**
		TOTAL ENERGY BASED ON FUNCTIONAL UNIT (MJ) =	**5,149**	**82.30**	**46,269**	**51,500**

The electrical use for one projector was recorded over the period of October 8 to October 16, 2013 using a Wattsup electrical logger. It was found that the total electrical requirement for the projectors peaked at 4.56 kW, using approximately 91,200 kWh over the lifetime of the system (assumed to be 20,000 hrs). Using a conversion of 3.6 MJ per kWh, this yields a lifetime usage of 328,320 MJ. Similarly the computer peaks at .29 kW and uses 5,800 kWh or 20,880 MJ over its lifetime. Figure 5 and Figure 6 show week-long results of direct energy usage.

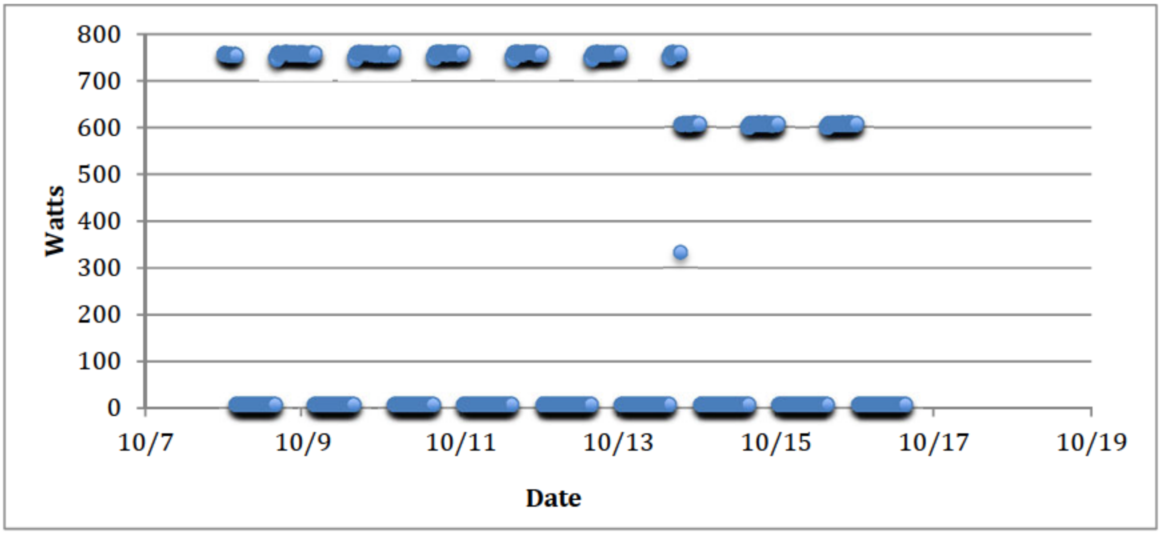

Figure 5 - Week long trended data for one projector

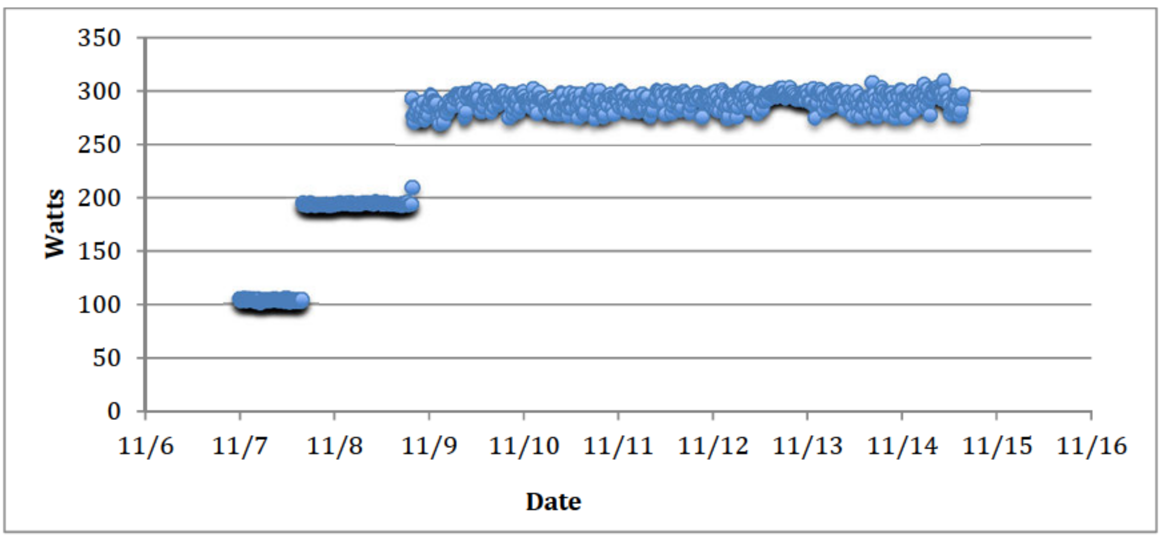

Figure 6 - Week-long trended data for computer

Life Cycle Impact Assessment (LCIA) – GHG Emissions

Methodology

Greenhouse gas emissions (GHG) are an important component of this study. With the manufacture, transport, and use of the media wall components, greenhouse gases, considered in this study as equivalent carbon dioxide emissions, are released in the atmosphere. Carbon dioxide emissions contribute to a system's global warming potential - global warming is responsible for a variety of impacts, including extreme weather conditions, and loss of habitat.

For this study, the LCA team conducted research on each component's manufacturing, transportation, and usage carbon footprint. The equivalent kilograms of carbon dioxide emitted into the atmosphere have been determined for each component's three product stages.

For transportation GHG emission data, the team used "Table 10 – Transportation Sector – GHG Emissions" from the National Resources Canada website. The LCA team has used the 2010 values for Marine Freight and Heavy Trucks, at 75.46 tonnes CO_2/TJ and 70.77 tonnes CO_2/TJ, respectively.

GHG Emission Results

The following table summarizes data collected for GHG emissions for the system.

Table 5 - Summary of GHG emission results

			Greenhouse Gas Emissions (kg CO2 Eq.)			
Component	Model	Quantity	Mnfg.	Trans.	End Use	Total
Projector	Panasonic PT-DW6300ULS	6	152.84	13.16	72,960	73,126
Computer	Dell T3500	1	500	4.38	4,640	5,144
Video Card	Matrox M9188	1	N/A	1.17	0	1.17
Edge Blending Device	TV-One C2-2450A	6	N/A	5.75	0	5.75
Mirror Assembly	Millenium	6	24.31	0.73	4.72	29.76
Glass Assembly	N/A	6	46.76	1.41	9.08	57.25
Rear-Projection Film	EOS-Procured Film	6	N/A	4.33	0	4.33
AV Rack	Toten TOC22UD	1	30.28	5.00	0	35.28
AV Rack Drawer	Toten TODWR2U	1	60.76	10.03	0	70.79
		TOTAL GREENHOUSE GAS EMISSIONS (kg. CO2 eq.) =	**814.95**	**45.96**	**77,614**	**78,475**
		TOTAL GHG EMISS. OVER FUNCTIONAL UNIT (kg. CO2 eq.) =	**107.98**	**6.09**	**10,284**	**10,398**

Additional information on sources and calculations are available in the Appendix.

Economics Analysis

The costs for the IMW were evaluated in terms of the capital costs and operation and maintenance (O&M) costs. The total cost breakdown of the IMW relative to the functional unit of 2,650 hours of display can be seen in Table 6 and Figure 7.

Table 6 - Summary of IMW costs for 2,650 hours of display

Capital Costs	
Considerations	**Cost**
Projectors	$20,650
Computer	
Video-card	
Edge blending devices	
Mirror assembly	
Rear-projector film	
AV rack	
AV rack drawer	
Software development and design	$5,412
Project management and consulting	$3,286
Installation Services – Set Up, Testing and Configuration	$3,981
Total Capital Cost	**$33,329**
O&M Costs	
Considerations	**Cost**
Cleaning IMW	$500
Energy consumption projectors and computer system	$700
Dual lamps	$7818
Lamp shipping costs	$121
UBC IT labour for lamp replacement	$718
Total O&M Cost	**$9,857**
Total Cost	**$43,186**

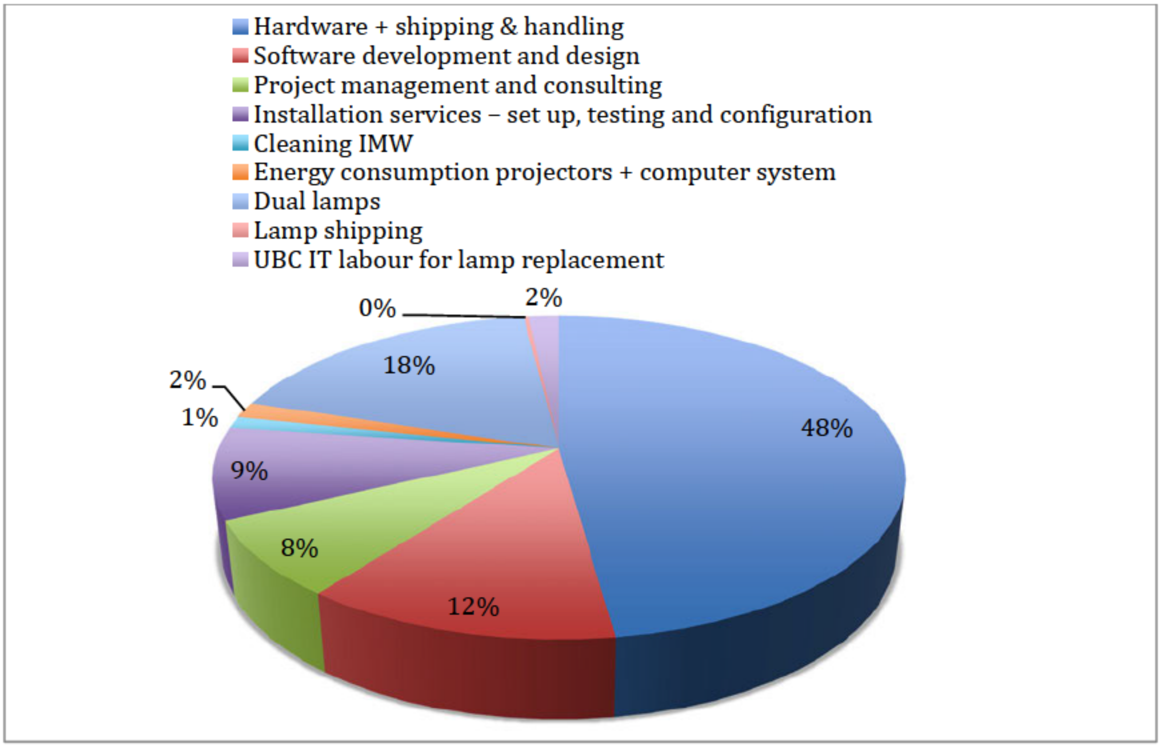

Figure 7 - Summary of costs

Capital Costs

The capital costs of the project were calculated relative to the functional unit by dividing the total costs for each consideration by the 20,000-hour service life of the system, and multiplying by the optimal operating hours. These calculations can be seen in the Appendix.

The capital costs of the project were obtained from UBC Properties Trust. The Vancouver based consultant, NGX Interactive, is responsible for the following IMW major components: master-planning, interactive lead & project management, research & content, development, content writing, concept development, interface design, animation design, software development, audio & video production, hardware consulting, installation & QA, training, and maintenance & support.

Note that some of the capital costs not taken into account include: content development and copywriting, video multimedia development, and exhibit design and fabrication.

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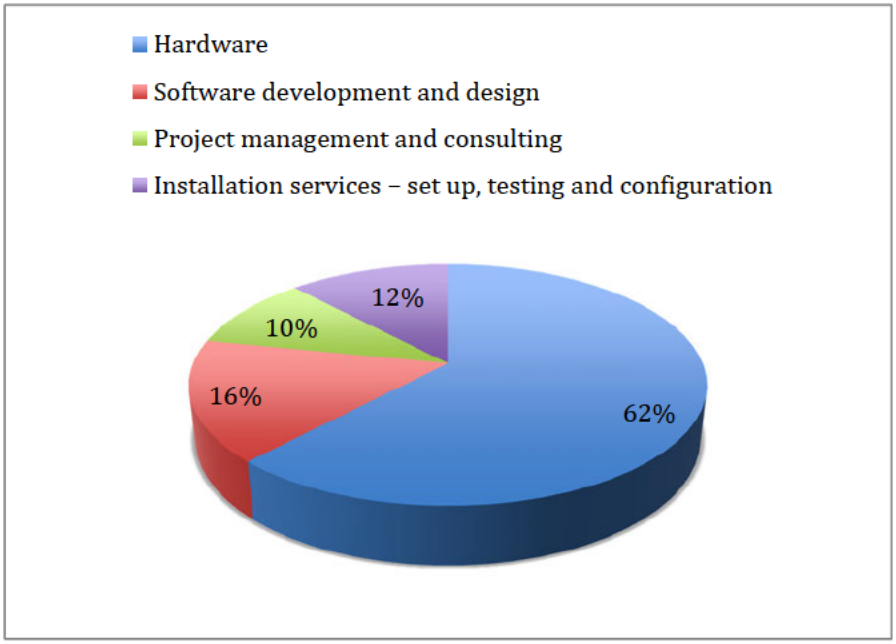

Figure 8 - Capital cost breakdown

Operational and Maintenance Costs

The O&M costs of the project were calculated relative to the functional unit by dividing the costs by the actual time the lamps are lasting (assumed to be 1,200 hours based on conversations with IMW stakeholders), and multiplied by the optimal operating hours.

Cleaning of the IMW is considered an extra cost, as it is not included in the Faculty's custodial budget. According to the SOM Operations and Maintenance Manual, monitors should only be cleaned with a non-scratch cloth. If there is heavier soiling on the screens, then a lightly damp cloth may be used. No cleaners (Windex, liquid or any other type) should be used to clean the screens.

The cost of the energy consumption of the IMW takes into account the energy consumed from the 6 projectors and the computer system. This is based off of the logged primary data for both pieces of hardware, assuming the maximum power in both cases, and the cost of electricity for UBC.

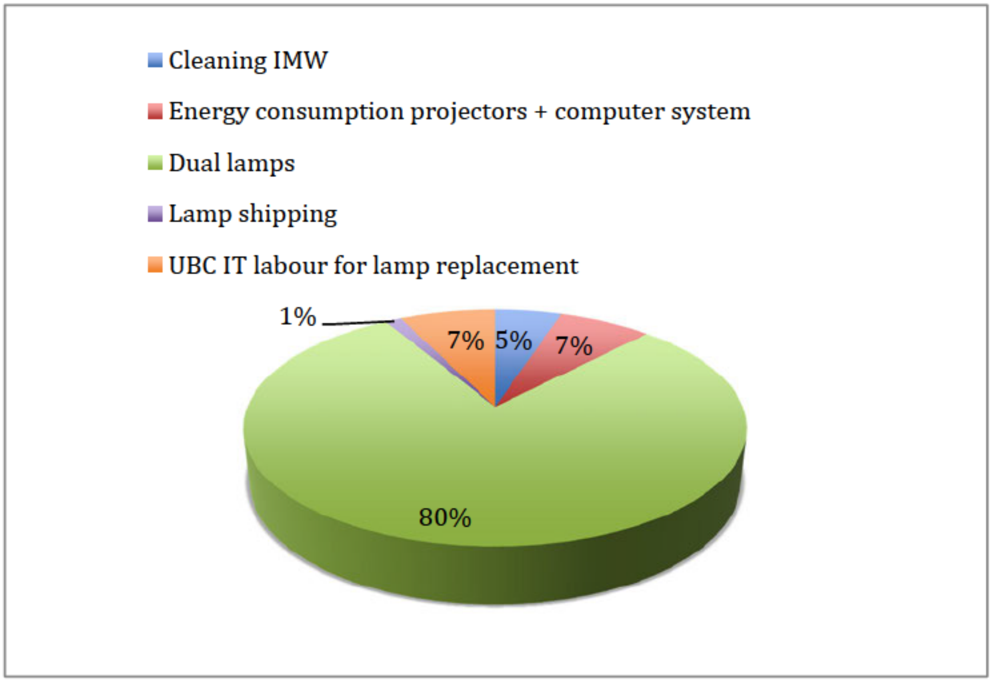

Figure 9 - O&M Cost breakdown

The cost of the dual lamps, lamp shipping and labour for installation are calculated based on figures obtained from UBC AV services. The labor for installation includes the time associated with replacement, cleaning, and edge blending alignment. Note that when one of the dual lamps burns out, all 6 need to be replaced in order to maintain the desired brightness of the display.

One of the key concerns addressed in the project proposal was the high cost of the projector lamps. The operating budget of the IMW is based off of the technical specifications of the dual lamps that has them rated at 2,000 hours; however, the lamps are only lasting for approximately 1,200 hours. Our analysis shows that 88%

of the O&M costs of the IMW are associated with projectors lamps (replacement, shipping, labour).

In initial discussions with IMW stakeholders, the general perception was that large portions of the IMW costs were coming from excessive power consumption of the projectors. Our analysis shows that approximately 7% of the O&M costs, which translates to 2% of the total costs, are from power consumption of the projectors and computer system. The hardware, and shipping and handling costs account for 48% of the total cost of the IMW.

Conclusion and Further Analysis

The following table shows the final results of the three key areas of study in this LCA: energy usage, GHG emissions, and costs. These values can be used in comparison with future technologies being considered to replace the IMW. Additionally the LCA team has provided the stakeholders with an excel assessment tool in order for future data to be normalized using this study's functional unit.

Table 7 - Summary of final results

	Mnfg.	Transportation	End Use	Total
Total Energy Use Based On Functional Unit (MJ) =	5149	82.3	46,269	51,500
Total GHG Emissions Based On Functional Unit (kg. CO2 eq.) =	108	6.1	10,284	10,398

	Capital	Operation & Maintenance	Total
Total Costs ($) =	$33,329	$9,852	$43,181

Stakeholders should note that the values of this LCA may change if a different functional unit was used. Due to lack of time to fully monitor the IMW, the lifetime of the lamps in the report are assumed to be 1,200 hours, based on initial meetings with stakeholders; however, to improve the accuracy of the results, it would be beneficial to track the exact time the lamps are lasting before burning out and take an average to acquire a more accurate lamp service life.

Another area of improvement would be to incorporate the raw materials and end-of-life life cycle stages in this analysis. In terms of energy requirements and GHG production, these phases could significantly increase the overall environmental impacts of the product system.

In terms of cost, the cost of raw material acquisition is already embodied in the capital and O&M costs, but the costs associated with end-of-life considerations are not. This analysis could be improved by incorporating the costs of recycling and/or disposing of the continuous flow of lamps throughout the IMW's service life, and the hardware components at the end of their service life. In the event that an alternative system replaces the IMW, the IMW's components might still be within their useful service life and may be reused within the Faculty of Pharmaceutical Sciences or somewhere else on campus.

Lastly, the analysis would be more complete if the capital costs of content development and copywriting, video multimedia development, and exhibit design and fabrication were included.

Appendix

Functional Unit Calculation

- The functional unit is based on the optimal operating hours of the IMW as expressed by IMW stakeholders
- 8am – 6pm, Monday – Friday → 10 hours/day
- Assume system is run for 50 weeks/year
- 4 hour events ~ 3 times/month

$$10\,\frac{hours}{day} * 5\,\frac{days}{week} * 50\,\frac{weeks}{year} = 2{,}500\ hours/year$$

$$4\,\frac{hours}{event} * 3\,\frac{events}{month} * 12\ months = 144\,\frac{hours}{year} \approx 150\ hours/year$$

$$\boldsymbol{Total = 2,650\ hours\ of\ display/year}$$

Energy Usage Data and Calculation

References for each of the components are listed below:

"LCA Evaluation of the Super Slim Projector XJ-S30/S35, a Casio Green Product", Casio Corporate Report, 2006.

"Sources of Variation in Life Cycle Assessments of Desktop Computers" by Paul Teehan and Milind Kandlikar (2012)

"Life Cycle Assessment of clear float glass for building applications", http://www.glassforeurope.com/en/issues/life-cycle-analysis.php.

"Inventory of Carbon & Energy (ICE) version 1.6a", University of Bath, Hammond and Jones, 2008.

Using the same electrical meter, the LCA team recorded the electrical use for operation of the computer. The recording period was from November 7-14, 2013. It was found that the total electrical requirement for the system peaked at 4.85 kW using a total of 97,000 kWh or 349,200 MJ over the lifetime of the system (20,000 hrs)

Table 8 - Projector logged data (six projectors)

Date	Day	kWh	Avg kW	MJ	$/day
08-Oct	Tues	55	2.292	198.072	5.105856
09-Oct	Wed	55	2.292	198.072	5.105856
10-Oct	Thurs	55	2.292	198.0288	5.104742
11-Oct	Fri	42	1.728	149.4504	3.852499
12-Oct	Sat	41	1.728	149.2992	3.848602
13-Oct	Sun	37	1.524	131.6304	3.393139
14-Oct	Mon	33	1.392	120.096	3.095808
15-Oct	Tues	33	1.392	120.204	3.098592

Table 9 - Computer logged data

Date	Day	kWh	Avg kW	MJ	$/day
07-Nov	Wed	3	0.13	11.52	0.29696
08-Nov	Thurs	5	0.21	18.0	0.464
09-Nov	Fri	7	0.29	25.2	0.6496
10-Nov	Sat	7	0.29	25.2	0.6496
11-Nov	Sun	7	0.29	25.2	0.6496
12-Nov	Mon	7	0.29	25.2	0.6496
13-Nov	Tues	7	0.3	25.2	0.6496
14-Nov	Wed	5	0.19	16.2	0.4176

Table 10 - Energy usage calculations

				Distance from Manufacturer to Site		Energy Requirements		Transportation Energy		
Component	**Manufacturing Location**	**Quantity**	**Total Approx. Weight (Tonne)**	**Marine Shipping (km)**	**Truck Shipping (km)**	**Marine Shipping (MJ/T.km)**	**Truck Shipping (MJ/T.km)**	**Marine Shipping (MJ)**	**Truck Shipping (MJ)**	**Total (MJ)**
Projector	Osaka, Japan	6	0.0408	8000	15	0.53	2.43	172.99	1.49	174.48
Computer	Xiamen, China	1	0.011	9900	15	0.53	2.43	57.72	0.40	58.12
Video Card	Dorval, Quebec	1	0.00136	0	5000	0	2.43	0.00	16.52	16.52
Edge Blending Device	Erlanger, KY, USA	6	0.00816	0	4100	0	2.43	0.00	81.30	81.30
Mirror Assembly	N/A (Assuming Vancouver)	6	0.1416	0	30	0	2.43	0.00	10.32	10.32
Glass Assembly	N/A (Assuming Vancouver)	6	0.2724	0	30	0	2.43	0.00	19.86	19.86
Rear-Projection Film	N/A (Assuming Cynthiana, KY, USA)	6	0.006	0	4200	0	2.43	0.00	61.24	61.24
AV Rack	Shenzhen, China	1	0.0113	11000	15	0.53	2.43	65.88	0.41	66.29
AV Rack Drawer	Shenzhen, China	1	0.02267	11000	15	0.53	2.43	132.17	0.83	132.99
							TOTAL ENERGY FOR TRANSPORTATION (MJ) =			**621**

GHG Emissions Calculations

The LCA team has used a total kg CO_2 equivalent value of 210 kg, and the same use phase value of 44 kg for the Panasonic projector. This value comes from the Sustainable Energy BC website which states that for every kWh of energy which is provided in BC, 0.8 kg of CO_2 equivalent emissions are released. The computer manufacturing GHG emissions were found to be approximately 500 kg CO_2 equivalent, with a transportation value of 4.38 kg and a usage value of 5.6 kg. For the video card, a transportation value of 1.17 kg CO_2 equivalent was determined. This study determines a manufacturing CO_2 equivalent value of 1.03 kg CO_2/kg glass produced, and an end use rate of 0.2 kg CO_2/kg glass produced. For the AV Rack and Rack Drawer, a value of 2.68 kg CO_2 equivalent per kg steel was used.

Table 11 - GHG emission calculations

		Transportation Energy			Transportation GHG Emissions, CO_2 Eq.				
Component	**Total Approx. Weight (Tonne)**	**Marine Shipping (MJ)**	**Truck Shipping (MJ)**	**Total (MJ)**	**Marine Shipping (Tonne/TJ)**	**Truck Shipping (Tonne/TJ)**	**Marine Shipping (Tonne)**	**Truck Shipping (Tonne)**	**Total (kg CO_2 Eq.)**
Projector	0.0408	172.99	1.49	174.48	75.46	70.77	0.013053976	0.000105246	13.16
Computer	0.011	57.72	0.40	58.12	75.46	70.77	0.004355325	2.83752E-05	4.38
Video Card	0.00136	0.00	16.52	16.52	75.46	70.77	0	0.001169403	1.17
Edge Blending Device	0.00816	0.00	81.30	81.30	75.46	70.77	0	0.005753465	5.75
Mirror Assembly	0.1416	0.00	10.32	10.32	75.46	70.77	0	0.000730533	0.73
Glass Assembly	0.2724	0.00	19.86	19.86	75.46	70.77	0	0.001405348	1.41
Rear-Projection Film	0.006	0.00	61.24	61.24	75.46	70.77	0	0.004333672	4.33
AV Rack	0.0113	65.88	0.41	66.29	75.46	70.77	0.004971229	2.91491E-05	5.00
AV Rack Drawer	0.02267	132.17	0.83	132.99	75.46	70.77	0.009973254	5.84788E-05	10.03

TOTAL GHG EMISSIONS FOR TRANSPORTATION (kg CO_2 eq.) = 45.97

Capital Cost Calculations

Hardware

- Projectors, Computer, Video-card, Edge blending devices, Mirror assembly, Rear-projector film, AV rack, AV rack drawer
- Figures from UBC Properties Trust
- Total cost of $155,850
- Includes shipping and handling costs

$$\frac{\$155{,}850}{20{,}000\ hours\ of\ display} * 2{,}650\ hours\ of\ display = \$20{,}650$$

Software development and design

- Figures from UBC Properties Trust
- Total cost of $40,850

$$\frac{\$40{,}850}{20{,}000\ hours\ of\ display} * 2{,}650\ hours\ of\ display = \$5{,}412$$

Project management and consulting

- Figures from UBC Properties Trust
- Total cost of $24,800

$$\frac{\$24{,}800}{20{,}000\ hours\ of\ display} * 2{,}650\ hours\ of\ display = \$3{,}286$$

Installation services – set up, testing and configuration

- Figures from UBC Properties Trust
- Total cost of $30,045

$$\frac{\$30{,}045}{20{,}000\ hours\ of\ display} * 2{,}650\ hours\ of\ display = \$3{,}981$$

O&M Cost Calculations

Cleaning the IMW

- $500/year average – source: Jamal Kurtu, Director of Operations & Facilities Management
- The cost of cleaning is not dependent on display hours (functional unit) so the cost relative to the functional unit is the same as the yearly cost ($500)

Energy consumption of the projectors and the computer system

- Max combined power of projector and computer of 4.85 kW obtained from power loggers

- Cost of electricity for UBC of 5.4 cents/kWh, including peak demand charges

$$4.85\ kW * 2650\ hours\ of\ display * \frac{\$0.054}{kWh} = \$700$$

Dual Lamps

- $590/dual-lamp – source: Ken Watanabe UBC AV Services

$$\frac{\$590}{dual\ lamp} * \frac{1\ dual\ lamp}{projector} * 6\ projectors\ \div 1{,}200\ hours\ of\ display * 2{,}650\ hours\ of\ display = \$7{,}818$$

Lamp Shipping

- $55/replacement – source: Ken Watanabe of UBC AV Services
- Assume average of $20-$90/shipment (from varying invoices)
- Assume all 6 dual bulbs are delivered in one shipment

$$\frac{\$55}{replacement} \div \frac{1{,}200\ hours\ of\ display}{replacement} * 2{,}650\ hours\ of\ display = \$121$$

UBC IT labour for lamp replacement:

- Assume 2 hours for replacement and cleaning
- Assume 4-5 hours for alignment of edge blending devices
- Assume an hourly rate of $50/hour
- Source: Ken Watanabe of UBC AV Services

$$6\ hours * \frac{\$50}{hour} = \$300$$
$$7\ hours * \frac{\$50}{hour} = \$350$$

Therefore assume average cost of $325/replacement

$$\frac{\$325}{replacement} \div \frac{1{,}200\ hours\ of display}{replacement} * 2{,}650\ hours\ of\ display = \$718$$