Applied Science 261 Sustainability Project: An Investigation into the UBC Pharmaceutical Sciences Impact Media Wall and possible alternatives

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Abstract

On September 18, 2012, the Pharmaceutical Sciences Building unveiled an Impact Media Wall (IMW) portraying pharmacy's contribution to healthcare in the form of an exhibit called "The Story of Medicines" (SOM). Since its implementation, the IMW has encountered high operational and maintenance costs, namely the constant replacement of projector bulbs and excessive power consumption. Other problems posed by the current media wall include uneven light distribution, restrictive back-end proprietary software, and limitations in display content.

Using a triple bottom line analysis, the current IMW installed by NGX Interactive was assessed along with a proposed alternative using Christie MicroTiles, a video display system produced by Christie Digital, an industry leader in digital signage. The investigation on the comparison of these two products is evaluated based on economic, environmental, and social impacts. Data and sources for an analytic investigation was obtained mainly through manufacturers' websites and datasheets, a group of UBC graduate students conducting an ongoing life cycle analysis on the current media wall, and primary data in the form of an unbiased survey.

While Christie MicroTiles require a large up-front cost of implementation from an economic standpoint, the overall effectiveness of the microtile system addresses many of the current issues and presents many unique features, such as touch-screen interactivity. Furthermore, the microtile alternative has appreciably lower recurring annual costs, which would help offset the initial capital costs of the installation. Due to the absence of replaceable consumable parts like bulbs, the operational costs and the total cost of ownership (TCO) is minimized, providing a viable alternative in the long term.

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Glossary and List of Abbreviations

CDI: Creation, Distrubtion, Installation

DLP: Digital Light Processing

EMS: Environmental Management System

GHG: Greenhouse Gases

IMW: Impact Media Wall

LEDs: Light Emitting Diodes

RoHS: Restriction of Hazardous Materials

SEER: Seasonal Energy Efficiency Rating

SOM: Story of Medicines

TCO: Total Cost of Ownership

UBC: University of British Columbia

1 Introduction

Digital signs are becoming increasingly ubiquitous, and are used for purposes such as advertising, providing information, and image enhancement (Dennis et al., 2012). At its most basic level, a digital sign is composed of a display device and a display controller. Since their inception, digital signage technologies have gained popularity because of their advantages over conventional signage, namely: support of dynamic multimedia presentations and a reduced cost in the "creation, distribution, and installation (CDI)" cycle (Harrison & Andrusiewicz, 2004). Another oft-cited benefit of digital signage is that it reduces environmental costs associated with printed signage, which in turn can have long-term financial benefits. Various papers have also studied the social uses of digital signage as retail or advertising tools (Dennis et al., 2012) or as a learning media (Dale et al., 2011), as well as the general effects of digital media (Coyne, 2010).

Figure 1: Photo of the Impact Media Wall at the UBC Pharmaceutical Sciences Building

The UBC Faculty of Pharmaceutical Sciences Impact Media Wall (IMW), constructed in 2012 and situated in the UBC Pharmaceutical Sciences Building, falls under the digital signage category (see Figure 1). Installed by NGX Interactive, the 26 by 7 foot glass media wall, one of the largest in North America, tells part of the "Story of Medicines" (SOM), a collective display that conveys the contribution of pharmacy to health care. During its hours of operation, the IMW projects pharmacy and health care related "Twitter style facts" (UBC Pharmaceutical Sciences, 2013). The stakeholders of the IMW include Phil Chatterton, Director of Digital Media Technologies from UBC IT, Mike Coughtrie, the Dean of the Faculty of Pharmaceutical Sciences and all students, staff and visitors of the UBC Pharmaceutical Sciences building.

Since its installation however, the IMW has incurred high operational costs due to the frequent and costly replacement of the projector bulbs and the high power consumption of the projectors. Moreover, there is uneven light distribution on the display, diminishing the overall aesthetic of the IMW. Finally, the back-end software is proprietary, which adds a dimension of difficulty with regards to software updates and ongoing support. At the moment, the IMW only runs for four hours a day due to the expensive cost of operation.

2 Current Media Wall

The IMW is a large 26 by 7 foot rear-projected media wall powered by six projectors. Images are reflected off of a set of large mirrors and thrown onto a thin film that covers the back of the glass wall. The IMW was designed by NGX Interactive for the UBC Pharmaceutical Sciences building and is one of the largest displays of its type in North America. Currently, the wall is running from 10AM to 2PM during the weekdays. It displays rotating "Twitter-style facts" conveying "Story of Medicines" (SOM) (UBC Pharmaceutical Sciences, 2013).

2.1 Components

Below is a summary of the hardware and software components of the IMW (See Figure 2). This data was provided by NGX Interactive, the developers of the IMW.

Digital Exhibit Name		Hardware			Software	
Name	Abbrev.	Hardware	Quantity	Make and Model	Resolution	Description
Impact Media Wall	IMW	Projectors	6	PT-DW6300ULS	4800x1280	Flash application plus CMS
		Computer	1	Dell T3500		
		Video Card	1	Matrox M9188		
		Edge Blending Device	4	TV-One C2-2450A		
		Mirror Assembly	6	Millenium		
		Rear-Projection Film	6	EOS-procured film		
		AV Rack	1	Toten TOC22UD		
		AV Rack Drawer	1	Toten TODWR2U		

Figure 2: Impact Media Wall Component Reference Sheet
(NGX Interactive, 2010)

The current IMW hardware setup is composed of the following components:

- Six (6) PT-DW6300ULS projectors
- One (1) Dell T3500 computer
- One (1) Matrox M9188 video card
- Four (4) TV-One C2-2450A edge blending devices
- Six (6) Millenium mirror assemblies
- Six (6) EOS-procured rear-projection films
- One (1) TOC22UD AV rack
- One (1) Toten TODWR2U AV rack drawer

The basic configuration of the hardware components is shown below (See Figure 3):

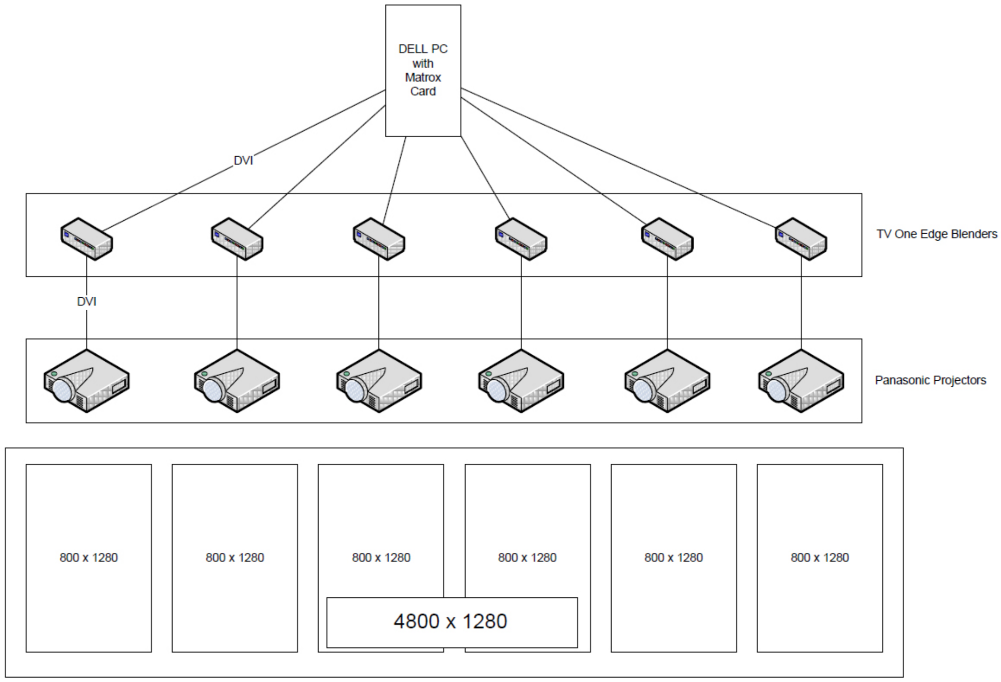

Figure 3: Impact Media Wall Hardware Diagram
(NGX Interactive, 2010)

Altogether, the display sits behind large glass panels with a rear projection film that allows for the projection to be displayed against the glass panels. Below is a photo showing the internal setup of the IMW (See Figure 4).

Figure 4: Photo of the hardware behind the IMW

2.2 Power Consumption

Based on electrical meter data taken from October 7 to October 16, 2013, the power consumption of the media wall can be summarized in the table below (See Table 1).

Unit	Power Consumption (W)	Energy per functional unit** (kWh)
per projector when on	757 W*	2006.05 kWh
per projector when off	7 W	42.812 kWh
6 projectors when on	4542 W	12036.3 kWh
6 projectors when off	42 W	256.872 kWh
6 projectors (total)	4584 W	12293.17 kWh

Table 1: Power Consumption of Impact Media Wall Projectors

* Comparable to power rating of 780 W on PT-DW6300ULS data sheet (Panasonic, 2009)

** Note: The functional unit used in this calculation for the on state of the projectors is 2650 hours per year, while the functional unit for the off state of the projectors is 6116 hours per year (total hours per year subtracted by on state functional unit).

3 Triple Bottom Line Assessment of Current Media Wall

The current IMW represents a significant investment by the UBC Faculty of Pharmaceutical Sciences. In order to fully assess the IMW, an analysis of the economic, environmental and social aspects was conducted as part of a triple bottom line assessment. According to the project stakeholders, the main issues with the current IMW are its high operational costs due to frequent and costly replacement of projector bulbs, uneven light distribution on the display (See Figure 5), and proprietary back-end software.

Figure 5: Photo of the uneven light distribution on the IMW

The assessment of the economic and environmental aspects of the current IMW was aided by an ongoing life cycle analysis conducted by a group of UBC graduate students: Eric Paice, Joshua Power, and Wendy Lee. Direct inquiries to the Faculty of Pharmaceutical Sciences resulted in a referral to the aforementioned group, as significant resources had already been expended by the faculty to compile the data, and any further inquiries were not possible. This group of graduate students completed cost of ownership analyses, as well as energy usage and greenhouse gas emission estimates from the manufacture, transport, and end operation of the current media wall. In line with the stakeholder's estimate of the ideal run-time of the IMW, used also by Eric Paice et. al, the functional unit used for the analysis of the IMW display is 2,650 hours per year.

With regards to the social assessment of the current IMW, primary data in the form of a survey was collected, specifically on the social implications of the media wall, and how changing it may or may not improve public opinion of the Pharmaceutical Sciences building.

3.1 Environmental Considerations

The manufacture and transportation of all the individual components of the IMW has significant environmental impact. Often, computer and electrical components are manufactured overseas and shipped to North America, as was the case with the many of the pieces of the media wall. Since these procedures have already taken place, the analyses of the greenhouse gas (GHG) emissions and electrical consumption data are incidental to the main assessment of the environmental impact of the current IMW; the aforementioned data is included in Table 2. The salient aspects of the environmental impact assessment involve the ongoing operation of the IMW and replacement part production and transportation. Both electrical energy consumption and GHG emissions have been examined. Table 3 outlines the ongoing environmental effects of running and maintaining the IMW.

Component	Number of Units	Electrical Consumption per unit (MJ)	GHG Emissions per unit (kg CO_2 equivalent)
Projector	6	29.08	7.5
Computer	1	5058.12	504.38
Video Card	1	16.52	1.17
Edge Blender	4	13.55	0.96
Mirror Assembly	6	379.32	4.17
Glass Assembly	6	729.71	8.03
Rear-Projection Film	6	10.21	0.72
AV Rack	1	66.29	5.00
AV Rack Drawer	1	132.99	10.03
	TOTAL	**12,218.04**	**646.94**

Table 2: Environmental effect of manufacture and transportation of the IMW components

* The data for these analyses was provided by Eric Paice et. al, who obtained the numbers directly from the department of Pharmaceutical Sciences. Note that some of the assembly and transportation data (specifically of the rear-projection film, glass assembly, and mirror assembly) were unavailable, so educated approximations were made based on similar products.

From Table 2 above, it is evident that the energy required and GHGs emitted for the manufacture and transportation of the computer running the display are by far the largest portion of the respective totals, making up 41.4% of all the energy required, and 78.0% of all the GHGs emitted. Fortunately, the computer already in use would be compatible with our proposed alternative wall, so those environmental impacts would not have to be replicated.

Electrical consumption of the current IMW totals 12,293.16 MJ per year, as noted in Table 3 below. This is the collective total of all of the electrical components involved in running the media wall, obtained from a single power meter installed between the power supply and IMW circuitry. Individual device consumption is unknown, however we were able to use precise readings from times when the wall was running and times when it was off to extrapolate one functional unit's worth of overall power consumption for the wall.

Component	Number of Units	Electrical Consumption per unit per year (MJ)	GHGs Produced to Generate Power per unit per year (kg CO_2 eq.)
Projector	6	2048.86*	21.34*
Computer	1		
Video Card	1		
Edge Blender	4		
Mirror Assembly	6	0	N/A
Glass Assembly	6		
Rear-Projection Film	6		
AV Rack	1		
AV Rack Drawer	1		
	TOTAL	**12,293.16 MJ**	**128.05 kg CO_2 eq.**

Table 3: Ongoing Environmental Effect of Operating the Impact Media Wall

* The electrical consumption and consequent GHG emissions of all the electrical components have been grouped together, as power consumption information was only available for the IMW as a whole.

According to the BC Hydro website (BC Hydro, 2013a), 90% of BC Hydro's power generation comes from hydroelectric means. The only significant portion of BC Hydro's electricity generation occurs at the Burrard Thermal Generating Station, which burns natural gas to produce 7.5% of BC Hydro's generated electricity. Using an average GHG emission of 1100 lbs CO2 eq. per megaWatt hour of electricity generation by natural gas combustion (Jaramillo et al., 2007), it was calculated that since the IMW is being run in BC, 128.05 kg CO2 eq. are produced each year to generate the power used by the wall (see Appendix A for the calculation). This number would increase dramatically if the IMW was being operated in a part of the world where 90% of the generated power was not hydroelectric.

Since each projector has 2 bulbs and they are only lasting about 1100 hours each, the IMW as a unit should go through 28.8 bulbs per functional unit (per year), on average. According to Amazon.com (2013), the shipping weight of one of these Panasonic ET-LAD60 lamps is 2 lbs, however we assumed that if they were shipped in bulk, the weight would be closer to 1.5 lbs each. To ship these from the Chinese factory requires another 10.71 kg CO_2 eq.

The total environmental impact of running the media wall and shipping in replacement bulbs, then, comes to the equivalent of 138.76 kg CO_2 eq. per year. It should be noted that the electrical consumption total and GHG emission total in Table 3 each individually represent the same environmental impact (that of running the media wall), just expressed in different units. The electrical consumption and GHG emission totals from Table 2, however, are separate pieces of the total environmental impact of manufacture and transportation, and should be considered together to evaluate the total impact of these processes.

3.2 Economic Considerations

The IMW represents a substantial part of the Story of Medicines digital media display. Aside from high initial capital costs (See Table 4), the IMW also requires high operation and maintenance costs which are a major concern of the project stakeholders. The total capital costs associated with the hardware and software components, as well as the shipping, handling and installation of the media wall are listed below:

	Components	**Cost**
Hardware	Projectors	$155,850
	Computer	
	Video Card	
	Edge Blending Devices	
	Mirror Assembly	
	Rear-projection Film	
	AV rack	
	AV rack drawer	
Software	Software development and design	$40,850
	Project management and consulting	$24,800
	Installation Services – Set Up, Testing and Configuration	$30,045
TOTAL		$251,545

Table 4: Capital Cost Breakdown of the Impact Media Wall*

*Note: Capital cost calculations do not include: content development and copywriting, video multimedia development, and exhibit design and fabrication (Paice et al., 2013).

In comparison, the capital cost of the the media wall at McCarran International Airport, the largest in the world measuring 33ft by 19ft cost $570,000, and is almost four times the size of our wall. This media wall, developed by Samsung, has a similar function to the IMW (O'Reiley, 2011). Scaled to the size of the current wall, the cost of the media wall at McCarran International would be approximately $160,000. Note that this price does not include software development and maintenance. Overall, the capital cost of the IMW is higher than the relative cost to create a larger LCD display wall.

The capital costs by percentage of total cost can also be seen in the chart below (See

Figure 6).

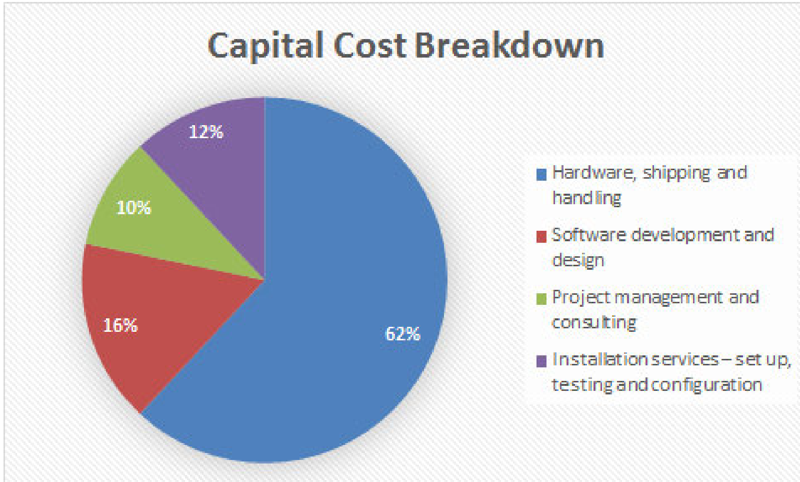

Figure 6: Capital Cost Breakdown of Impact Media Wall

As mentioned earlier, the most concerning costs are the ongoing operation and maintenance costs associated with the IMW (see Table 5).

Activity	**Unit Cost**	**Cost relative to functional unit**
Cleaning IMW	$500/year	$500
Dual projector lamps	$590/projector	$7,818
Projector replacement costs	$11,500/projector per estimated 8 year lifetime*	$8,625
Power consumption	$0.0928/kWh**	$1140
Lamp shipping costs	$55/shipment	$121
UBC IT labour for lamp replacement	$325/replacement	$718
	TOTAL	$18,922

Table 5: Operation and Maintenance Costs of IMW

* Lifetime of 8 years based on a similar DLP projector with a lifespan corresponding to about 7 years (TARR, 2009). The projector cost was estimated from a recognized seller of the particular Panasonic PT-DW6300 ULS projector model (Projector Zone, 2013).

** Based on BC Hydro Small General Service Rate (BC Hydro, 2013a).

The table above (See Table 5) shows that the IMW represents a significant yearly cost for the UBC Faculty of Pharmaceutical Sciences. The total cost is $18,922 per annum. The most significant costs however are given by the lamp replacement of the six dual projectors (45.6%), which are composed of: dual replacement lamp costs (41.3%), shipping costs (0.6%) and labour costs (3.7%), as well as the replacement of the projectors themselves (46%). See Figure 7 for more details. This $18,922 per annum is 7.5% the capital cost of the wall, and the majority of that maintenance is going towards replacing the projector bulbs and the projectors. After ten years of the current set up, the equivalent of three quarters of the entire capital cost would be spent on replacement of lamps and projectors alone.

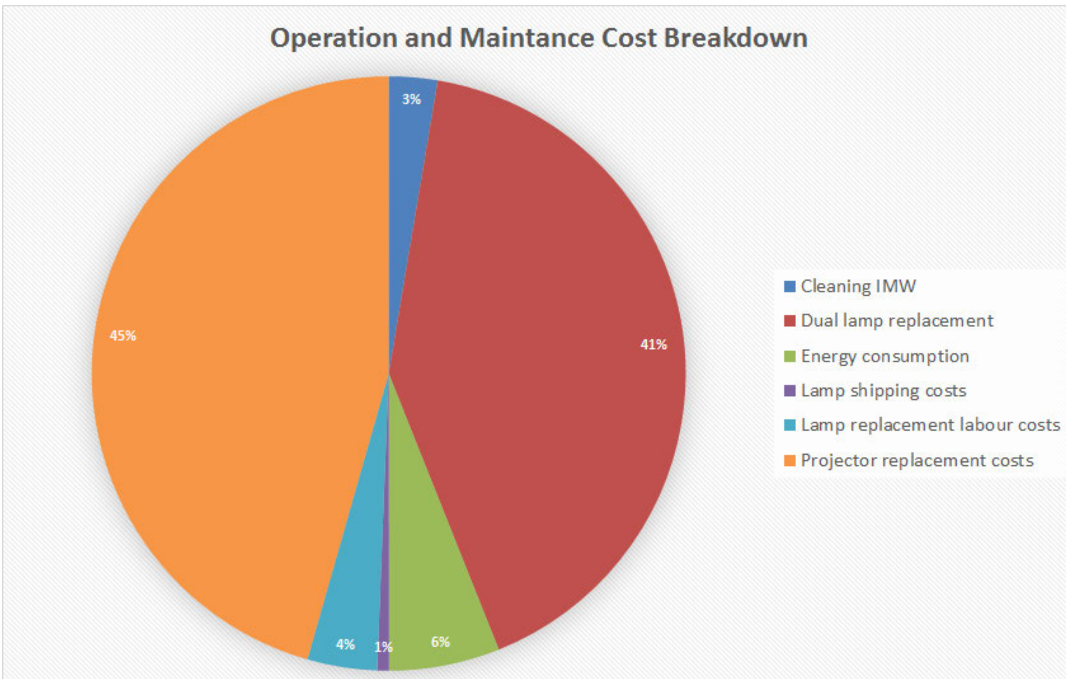

Figure 7: Operation and Maintenance Costs Breakdown

The cost associated with lamp replacement costs currently represents 76 percent of total operation and maintenance costs. These high costs are due mainly to the fact that the dual PT-DW6300 Panasonic projector lamps last only an estimated 1200 hours, as opposed to the 2000 hour rating (Pureland Supply, 2013). According to the data sheet for the Panasonic projectors used in this application, the lamp replacement cycle is shortened if the projector is repeatedly operated for short periods of time (Panasonic, 2009). Since the IMW and its rear-projectors are currently operated roughly between 10 am and 2 pm only, or about four hours daily, the replacement cycle is expectedly reduced.

3.3 Social Considerations

A survey was conducted in the Pharmaceutical Sciences building to gauge public interest in the wall and to investigate how building visitors and users think the wall can be improved. Fifty (50) students and faculty were surveyed in the foyer of the Pharmaceutical Sciences building, near the wall itself. A concerted effort was made to ensure the survey was unbiased to leave considerable room for free thinking, without influencing the public's feedback. A template of the conducted survey can be seen below in Figure 8. Tabulated results of all the survey data can be found in Appendix B.

Pharmaceutical Sciences Impact Media Wall Survey

Please check the box that most applies to you.

☐ I am a frequent visitor to the Pharmaceutical Sciences building

☐ I have been to the Pharmaceutical Sciences building before but do not visit regularly

☐ This is my first time to the Pharmaceutical Sciences building

What changes to the Impact Media Wall, if any, would improve your opinion of the Wall? How would any changes you propose affect your opinion of the Pharmaceutical Sciences Building as a whole (please circle)?

Your Proposed Change		How much would this change improve your opinion of the Wall and the building?		
____________________	=	Only Slightly	Moderately	Significantly
____________________	=	Only Slightly	Moderately	Significantly
____________________	=	Only Slightly	Moderately	Significantly

Figure 8: Pharmaceutical Sciences IMW Survey Template

Analysis of our survey responses yielded varied and interesting results. It should be noted that every survey respondent indicated that they are frequent visitors to the Pharmaceutical Sciences building, and are therefore familiar (to some extent) with the IMW and its usual operations. The vast majority of respondents were most concerned with the content of the wall. Of the received responses, 73.8% of the public's suggestions involved the content of the IMW display: either integrating news into the display (36.3% of suggestions), updating the factual content more regularly or making it more interesting (27.5% of suggestions), or including pictures, videos, or more graphic content (10.0% of suggestions). Of these suggestions, it was reported that inclusion of news updates and updating the wall's facts would on average have a moderately positive effect on the public opinion of the Pharmaceutical Sciences building. The respondents who suggested greater inclusion of graphics reported (on average) that it would have a moderate to significant positive impact on their opinion of the building.

Empirical studies have shown that interactivity increases the appeal of digital media overall (Exeler et al., 2009). However, only 12.0% of respondents suggested wall interactivity; but, that full twelve per cent all reported that this feature would have a significantly positive impact on their opinion of the space. 14.0% of respondents reported that, although they may have had other suggestions also, they were happy with how the wall is currently being run. Surprisingly, even though the IMW is currently operating on reduced hours, only 6.0% of respondents expressed interest in the wall being operational for more time each day. In fact, 8.0% of respondents indicated that the wall was currently running too much considering the small fraction of visitors that actively use it. On average, it was reported that all suggestions about running hours would have a slight to moderate effect on the respondents' opinion of the Pharmaceutical Sciences building if they were implemented.

4 Alternative Media Wall

A suitable alternative to the IMW would ideally have a low total cost of ownership (TCO), address the main problems of the current IMW, and present an advantage over the current wall environmentally, financially, and socially. Christie Digital, an industry leader in digital signage, produces a product known as Christie MicroTiles that meets these criteria and could present a viable alternative to the current IMW installed by NGX Interactive.

4.1 Implementation

To fully replace the current IMW with a Christie MicroTiles solution would require that we cut the glass panel display out of the current wall and create a pseudo wall to install the microtiles. In the housing space of the current projectors, a single computer would be stored along with four control units that power a maximum of 140 tiles. Each tile has physical specifications as shown in the table below (See Figure 9).

Physical specifications		Display unit with screen	ECU
	height	• 306mm (12.05")	• 50mm (1.97")
	width	• 408mm (16.06")	• 259mm (10.20")
	depth	• 260mm (10.24")	• 191mm (7.52")
	weight	• 9.2kg (20.3lbs)	• 1.6kg (3.5lbs)

Figure 9: Christie MicroTiles Physical Specifications

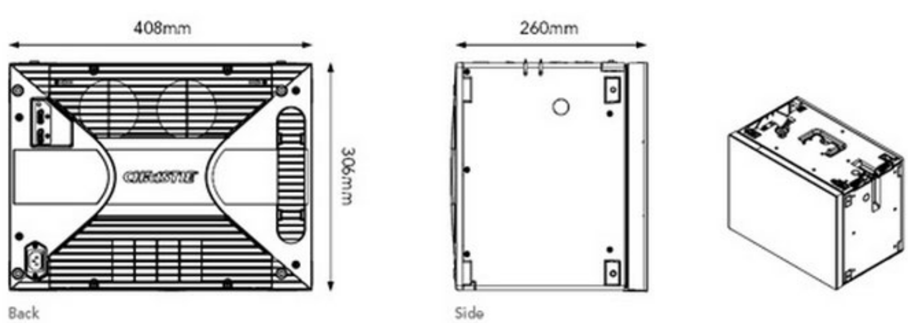

Figure 10: Dimensions of Christie MicroTiles

Each tile has a height of 12 inches and a width of 16 inches (See Figure 10). As the current media wall is 26ft by 7ft, which corresponds to an area of 182 square feet, the proposed wall is 19 tiles by 7 tiles, which gives dimensions of 7.03 ft by 25.4 ft and a display area of 178.73 square feet. The width of the new wall is about 6 inches shorter than that of the original IMW; but given a wall of this size, this difference is negligible. Thus, for all subsequent calculations and assessments of the proposed Christie MicroTiles display wall, a unit of 133 tiles will be used. However, the number of tiles can be scaled down because it is impractical to have a wall the size of the IMW to be made of touch-enabled microtiles.

Christie MicroTiles have a matte surface with a spacing of 1mm around all the edges of a tile. They are virtually seamless and are automatically calibrated to the same brightness level. Given the 133 tile setup, the resolution of the display using microtiles would be 13680 by 3780 pixels, almost triple the resolution of the current IMW. A microtile display would have three times the pixel density. The actual display system is made of LEDs in an array similar to that of an LED television set (See Appendix C).

5 Triple Bottom Line Assessment of Alternative Media Wall

To investigate the validity of using Christie MicroTiles as an alternative to the current IMW set-up, a triple bottom line assessment was conducted, with specific emphasis on the features that set the microtiles apart from our current wall, namely: an advertised low TCO, environmental friendly production and operation, claimed lower power consumption, and an interactivity option. The extent to which the alternative media wall addresses the current problems of the media wall will also be determined. Data for the economic, environmental, and social assessments was gathered mainly from Christie website and Christie MicroTile datasheets, which contained data regarding the production of materials, energy consumption, and interactivity options.

5.1 Environmental Considerations

As a whole, Christie MicroTiles implements both a green and sustainable design that is recognized for meeting environmental and energy standards. In the production of Christie MicroTiles, the materials used are in line with the Restriction of Hazardous Materials (RoHS) compliant, a directive implemented by the European Union to limit certain hazardous substances in electrical and electronic equipment. These hazardous substances include cadmium (Cd), lead (Pb), mercury (Hg), hexavalent chromium (Cr^{6+}), polybrominated biphenyl (PBB), and polybrominated diphenyl ether (PBDE), all of which must contain concentrations less than their associated maximum limit value, shown in Figure 11. Unless otherwise exempted, all parts and components are manufactured to satisfy the RoHS directive (Christie Digital, 2013a).

Compared to projector-based digital media walls, a Christie MicroTiles display consumes a comparable amount of energy. However, as Christie MicroTiles are built with light emitting diodes (LEDs), turning specific parts of the wall off when not in use is much more efficient. Christie MicroTiles are also extremely durable compared to projector technology. As a result of combining both digital light processing (DLP) projection and LEDs, the benefits of each technology are able to create a sustainable solution for implementing in the IMW. The LED components of the Christie MicroTiles have an extremely long lifespan and are rated at 65,000 hours. The microtiles also contain no consumable parts, are able to instantly turn on, and operate 24 hours a day without overheating or causing screen burn-in. At typical,

Substance	Maximum Limit
Cadmium (Cd)	100 ppm (0.01% by weight)*
Lead (Pb)	1,000 ppm (0.1% by weight)*
Mercury (Hg)	1,000 ppm (0.1% by weight)*
Hexavalent Chromium (Cr^{6+})	1,000 ppm (0.1% by weight)*
Polybrominated Biphenyl (PBB)	1,000 ppm (0.1% by weight)*
Polybrominated Diphenyl Ether (PBDE)	1,000 ppm (0.1% by weight)*

*Does not apply to applications for which exemptions have been granted to the RoHS directive

*Products listed in this document do not contain Deca-BDE in amounts greater than allowed limit of 1,000 ppm

Major categories of components breakdown is shown below:

主要零件分类 Major Classification	有毒有害物质或元素 Hazardous Substances or Elements					
	铅 Lead (Pb)	汞 Mercury (Hg)	镉 Cadmium (Cd)	六价铬 Hexavalent Chromium (Cr^{6+})	多溴联苯 Polybrominated biphenyl (PBB)	多溴二苯醚 Polybrominated diphenyl ether (PBDE)
Electronics (PCBs)	X	O	O	O	O	O
Electrical (harnesses, connectors, etc.)	X	O	O	O	O	O
Power Supply	X	O	O	O	O	O
Optical	X	X	X	O	O	O
Mechanical Chassis/Other	X	O	O	O	O	O

Note:

O: 表示该有毒有害物质在该部件所有均质材料中的含量均在SJ/T 11363-2006标准规定的限量要求以下。

O: Indicates that this toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in SJ/T 11363-2006

X: 表示该有毒有害物质至少在该部件的某一均质材料中的含量超出SJ/T 11363-2006标准规定的限量要求。

X: Indicates that this toxic or hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement in SJ/T 11363-2006

Figure 11: Christie MicroTiles RoHS Component Breakdown (Christie Digital, 2013a)

calibrated settings, DLP projection technology allows Christie MicroTiles to operate at 1.4 candelas per Watt. This provides and outputs more light, more efficiently as very little light is absorbed. Since the most light possible is being emitted per one Watt of energy consumption, very little energy is consumed to produce heat, which provides a cool surface conducive to touch-screen interactivity. Per tile, the typical power consumption is 70W with a design limit of 110W and a standby power consumption of 16W. A energy saving feature included in Christie MicroTiles is the built-in ecopower energy consumption modes, allowing minimal energy consumption while adequately displaying digital media (Digital, 2013). Further discussion on power usage will be provided in the economic analysis.

In the production of Christie MicroTiles, the components and parts are designed such that they can be reused or recycled to prevent an accumulation of electronic waste. In addition, the microtiles are extremely versatile and can be easily transported, reassembled, and reconfigured after their initial implementation. Of the metal and internal components, 80% of the material can be recycled and 90% is produced from recoverable materials (Christie Digital, 2013a).

5.2 Economic Considerations

To conduct an economic assessment of the Christie MicroTiles alternative, the power consumption, capital cost, and operational costs of a full implementation were factored into relevant calculations. Assessments of the microtile implementation without the interactivity option and with the interactivity option were conducted separately in order to provide a more comprehensive assessment. Calculations were mainly done using resources from Christie Digital.

5.2.1 Power Consumption

Using the power consumption ratings presented in Figure 12 below, calculations of a full implementation were made and summarized in Table 6 that follows.

Power	input rating	• Display unit: 100-240 VAC; 50/60Hz; 1.3A-0.54A • ECU: 100-240 VAC; 50/60Hz; 0.20A
	power consumption per tile	• 70W typical, 16W standby, 110W design limit[1]
	power consumption per ECU	• 8.5W typical
	heat load per tile	• 239 BTUs/hr typical, 375 BTUs/hr design limit[1]

Figure 12: Christie MicroTiles Power Consumption Data

	Unit	**Power Consumption***	**Energy Consumption per functional unit**
without interactivity	per tile (on)	70W	185.5kWh
	per tile (standby)	16W	97.856 kWh
	per tile (total)		283.356 kWh
	Total of all tiles		37686.348 kWh
with interactivity	per tile (on)	16W	97.856kWh
	per tile (standby)	16W	97.856 kWh
	per tile (total)		325.756 kWh
	total of al tiles		43325.548 kWh

Table 6: Christie MicroTiles Power Consumption

* Note: For power consumption calculations, totals can only be done per functional unit since on and standby times are not identical.

Overall, Christie MicroTiles use quite a significant amount of energy, especially considering there are around 133 units that each consume the same energy as a light bulb. Even if operating at a low brightness, a full implementation of a microtile based wall uses a significantly larger amount of energy than the current projector setup. Below is a discussion of the cost associated with the energy usage of a full microtile system as well as the costs to implement it.

5.2.2 Capital, Operation, and Maintenance Costs

	Cost		Cost (with interactivity features)	
	Total	Relative to Functional Unit	Total	Relative to Functional Unit
Upfront Hardware and labour	$279,300	$34,912,50	$518,700	64,837.50
Operating and Cooling	$13,989	$1,748.65	$15,082.48	$2,010.31
Replacement and Maintenance	$29,880	$3735.00	$56,116	$7,014.50
Salvage Value (Return after operation)	-$18,614	-$2,326.75	-$35,366.00	-$-4,420.75
Total	$304,551.20	$38,068.90	$555,532,48	$68,441.56

Table 7: Christie MicroTiles Capital Cost and Installation

Calculations of the capital cost of a Christie MicroTile solution used the total cost of ownership (TCO) calculator retrieved from the company website (Chrisite Digital, 2013). Calculations used the following parameters (see Appendix D for more details):

- Price per tile
  - Without interactivity: $2000
  - With interactivity: $3800
- Operating information

  - Operating hours per day: 8
  - Operating days per year: 330
  - Operating hours per year: 2640 (approximate functional unit)
  - Operating lifetime (years): 8
- Energy Costs (per kilowatt-hour): $0.0298
- Cooling Costs
  - Air conditioner SEER rating*: 16
  - Watts of cooling per kW: 213
- Installation and maintenance costs per hour
  - Full burdened labour rate: $100

* The SEER or seasonal energy efficiency rating (or ratio) is a measure of the efficiency of central air conditioners (Natural Resources Canada, 2013).

The overall cost of a Christie MicroTile solution was calculated to be $302,551 without the interactivity option, and $551,532 with the interactivity option. Note that this calculation does not include any labour associated with removing the current IMW.

As mentioned earlier, the microtiles use an LED-based digital light processing (DLP) optical system technology, with an LED lifespan rating of 65,000 hours at 50% brightness (Digital, 2013). This rating alone represents 24.5 functional units or even 7.4 years if operated continuously (i.e. 24/7), which precludes the need for high-capital replacement costs. In addition, the microtile technology has the added advantage of cutting out scheduled maintenance or replacement costs, owing to its lack of consumables or moving parts. However, because it takes over 100 tiles to replace the current IMW with a complete MicroTile solution, the maintenance costs of Christie MicroTiles still remain quite high, approximately $8000 per year. Replacement cost was calculated assuming a 2% failure rate of the tiles per year as indicated in manufacturing specifications. The possibility of failure within the tiles adds significantly to the operational costs because of the high cost of each tile.

5.3 Social Considerations

One of the most promising aspects of the microtile option is that it potentially addresses two of the major improvements suggested by the surveyed visitors of the UBC

Pharmaceutical Sciences building: dynamic content and interactivity. Since the content of the current IMW is both read-only and static, repeated viewing or use of the display, especially by regular users, is unlikely. Various studies have identified the importance of (real-world) context when it comes to human computer interaction (Schmidt, 2000). In line with these findings, the microtile technology would allow for updated dynamic content in the form of news or current information which would engage users of the IMW.

The microtile option also allows for the inclusion of interactivity using a Christie Interactivity Kit, which uses Baanto Shadowsense technology, alongside the implementation of the Christie MicroTiles (Baanto, 2013). With this kit, one can change an existing Christie MicroTile displays to a touch-enabled display with suitable sensitivity for a large scale wall. With only an additional 16W of power needed for an interactivity function, this interactivity kit is a practical addition to the wall, provided that a Christie MicroTile display is implemented. However, the interactivity kit can only be scaled to a wall the size of 16 by 6 feet and also requires an unbroken rectangular perimeter. Hence, different design changes, such as interactive sections of panels as opposed to an entirely interactive wall, would be needed in order to work around these limitations (Christie Digital, 2013b).

Even with these limitations, the microtile option still remains an extremely viable possibility because of the added social engagement it provides. According to Phil Chatterton of the UBC IT department, the inclusion of interactivity would be an ideal addition to the current IMW which is also in line with survey suggestions from regular visitors to the IMW that indicated the advantages of touchscreen interactivity.

A variety of empirical studies have also shown the increased appeal of interactive digital signage to users compared to pure one-way information (Exeler et al., 2009). Hence, the possible inclusion of an interactivity function coupled with updated dynamic content could significantly increase usage of the wall. Visitors would be able to personally interact with the IMW and discover content suited to their interests. With the inclusion of interactivity, the wall could also be programmed to have games, social feeds, and RSS feeds from health and pharmacy-related news websites. Overall, these additions to the media display would offer increased engagement to both first-time users and frequent visitors.

6 Comparative Assessment

In order to determine recommendations concerning the UBC Pharmaceutical Sciences IMW, a comparative assessment of the current IMW and the proposed microtile alternative was conducted. The assessment weighs the costs and benefits of each aspect, environmental, economic and social, as well as the extent to which the alternative addresses the current issues with the IMW.

Christie MicroTiles do seem to address all of the major issues with the current IMW. The microtile technology, with its internal LED technology as well as its self-calibrating display (which automatically adjusts brightness and color during set-up and continuously during the display duration) ensures that there will be no uneven light distribution across the display area. Furthermore, the microtile technology has an ultra-thin seam of 1mm between tiles, ensuring that media wall presents a near seamless display.

6.1 Environmental Comparison

In terms of energy consumption, which comes with associated environmental impacts, the Christie MicroTiles consume a larger amount of energy per functional unit. Using a scaling factor of 6 metric tonnes per gigawatt hour of CO2 (or 6 grams per kilowatt hour), the corresponding GHG emissions were determined and summarized in Figure 13 below. The scaling factor is taken by the 2010 measurement of GHG intensity per calendary year conducted by BC Hydro (BC Hydro, 2013b).

Figure 13 above shows that compared to the current IMW, the microtile alternative has a 53.2% and 76.2% higher gross GHG emission rate per year for the options with and without interactivity respectively. While this is a large comparative increase, the raw quantitative increases of 39.3 kg CO2 and 56.2 kg CO_2 are not as significant when considering the relative contribution of energy resources that do not utilize BC Hydro electricity rates. As a benchmark, the relative intensity of energy from fossil fuels is almost 100 times larger than that of electricity provided by BC Hydro (BC Hydro, 2013b).

It is worth noting however, that despite the higher energy costs of the microtiles, they also allow for much more flexibility during implementation. The estimates of power consumption used in the assessment assume a continuous high level of brightness during the on period of the functional unit. In line with this, the current wall runs at full conditions whether or not

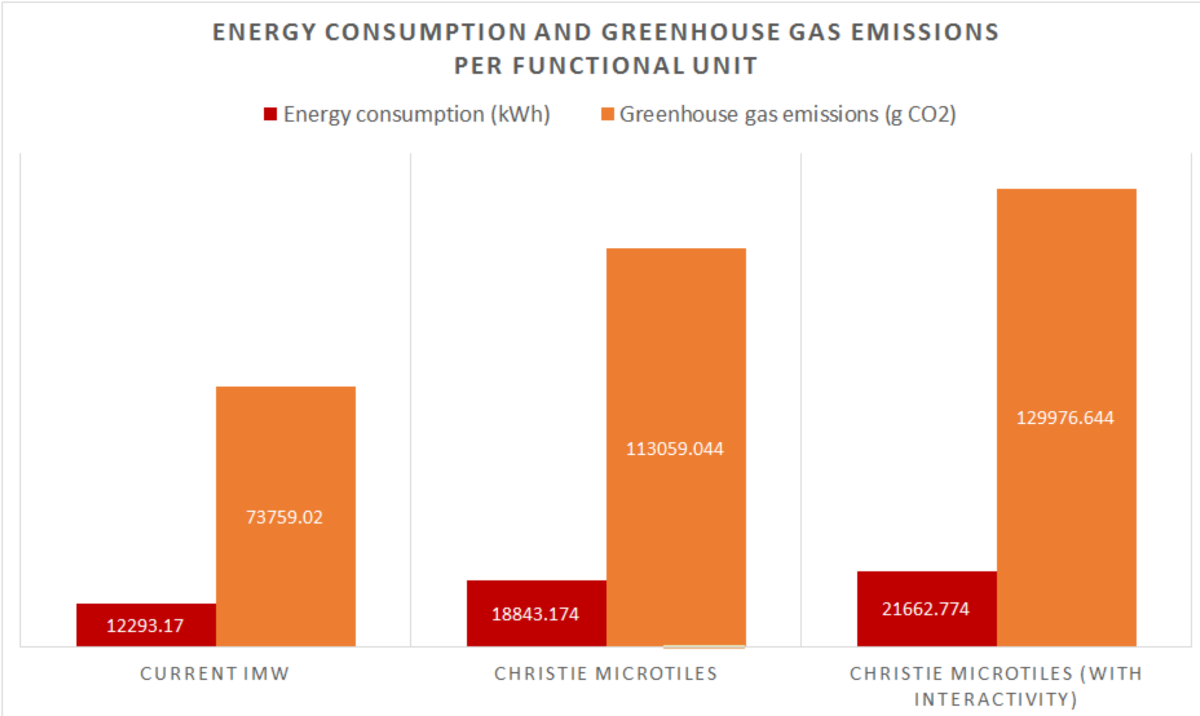

Figure 13: Comparison of Yearly Energy Consumption and Greenhouse Gas Emissions

users are viewing the display, which wastes both energy and potential user engagement due to the limitations of the technology. With the interactivity option of the microtiles, significant power savings could occur if a majority of the wall was on standby mode when not in use and would only fully engage when approached by a user. This would not only cut power consumption costs, but also increase user engagement, display usage, and prolong the lives of the tiles due to the diminished run time.

In the context of electronic waste, the Christie MicroTile option is much more advantageous as there are no consumable parts that require replacing, unlike the dual lamps of the projector currently being replaced more than twice per functional unit. The LED technology of the microtiles is rated at 65,000 hours, while the documented projector bulb lifespan is only 2000 hours, with an actual lifespan estimated at 1200 hours. Furthermore, the materials in the microtile system are RoHS compliant and composed of 80% recyclable materials, which allows for safe and easy disposal of the Christie MicroTiles after its lifespan and ensures that the tiles will not contribute to the addition of cadmium, lead, mercury, and other restricted substances in electronic waste landfills. Unlike the projector lamps, the Christie MicroTiles also have a salvage option once the tiles have expired past their lifetime, which would allow for the return and repurpose of the expended tiles to the manufacturing company, thereby reducing waste and the accompanying environmental impact.

6.2 Economic Comparison

One of the major issues with the current IMW is the high operation and maintenance costs of about $19,000, 86% of which come from the replacement of the projectors and projector lamps. This cost would only continue to increase throughout the lifespan of the display as the projector hardware deteriorates over time. A full microtile implementation on the other hand, expectedly comes with high initial capital costs: about $300,000 without interactivity and $555,000 with interactivity. Furthermore, the microtile option would still have replacement costs due to the documented 2% failure rate of the tiles as well as the increased power consumption costs. In terms of yearly operation and maintenance costs however, the microtile option presents a much cheaper alternative, as summarized in Figure 14 below.

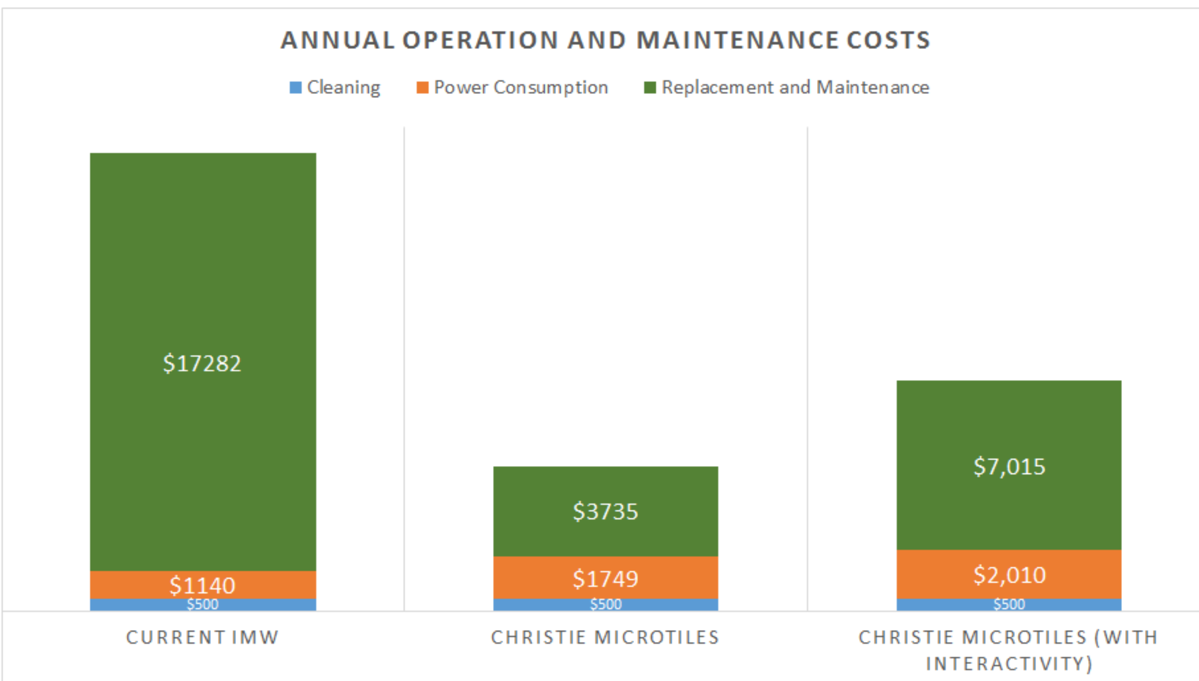

Figure 14: Comparison of Annual Operation and Maintenance Costs

The annual cost for a microtile implementation (without interactivity) is about $5,983.65 a year, about 68 percent less than the annual IMW costs of $18,922. Over the estimated lifetime of 8 years used in the calculation, this amounts to $103,506.80 in savings, already about 34% of the entire capital costs of implementation which would help offset the implementation costs of the microtile option.

With interactivity, the operational cost advantages of the microtile implementation are expectedly diminished since the implementation has a yearly cost of $9524.81, about 50 percent less than the current IMW. It should be noted that despite the noticeable difference in power consumption costs per year, the difference is marginal compared to the dual projector lamp, projector and microtile replacement costs respectively. Furthermore, despite the higher power costs initially, the microtiles have a more consistent energy use over long periods compared to the projectors which degrade much more noticeably over time, thus presenting an appealing alternative.

6.3 Social Comparison

Microtiles can potentially fix many of the content related issues of the wall noted by the people we surveyed. Currently, the display content of the IMW is limited to a static set of read-only information as part of the collective SOM display. With the proprietary software of the current wall however, implementing changing content also presents a challenge for the media display. The current IMW is bound to the same limitations as traditional paper-based media in that it is both read only and non-contextual (Schmidt, 2000) and does not take advantage of the potential of digital signage and the reduced CDI cycle (Harrison & Andrusiewicz, 2004). Visually and practically, having an interactive microtile display would be attractive to all stakeholders alike. However, a microtile system would also require new and more complex display graphics to be created on top of implementing interactive functionality, which would create additional costs. Despite these concerns, the social benefits of the microtile technology far outweigh the incidental costs, which would also be notably marginal compared to the initial capital costs. Consequently, the microtile alternative would increase the usage and overall impact of the media display for users in all sectors.

Another aspect to consider are the respective companies involved in each media wall option: NGX Interactive, a local Vancouver-based company responsible for installing the current IMW, and Christie Digital Systems Canada, Inc., which produces the Christie MicroTiles for the possible alternative media wall. Despite the benefits of contracting a local company, it should be noted that the current concerns with the IMW are outside the scope of NGX Interactive. Thus, contracting Christie Digital, an Ontario-based company, for the alternative option is extremely viable in that respect.

7 Conclusion and Recommendations

From the comparative assessment of the current IMW and the alternative Christie MicroTile implementation, there are a number of recommendations that could rectify the current issues with the media wall, as well as increase its overall usage and impact. The proposed microtile display presents numerous benefits: economic, social and environmental. Aside from fixing the edge-blending and light distribution issues, and significantly reducing yearly replacement and maintenance costs, the proposed wall not only improves functionality, but would likely increase the overall usage of the wall display. However, the initial capital costs, particularly for an interactive display, are not negligible. Hence, a full Christie MicroTile display with integrated partial interactivity would likely be the most viable recommendation.

With this option, the advantages of interactivity would be obtained at reduced cost, maximizing both the social and economic benefits. Furthermore, the savings from yearly maintenance and operations costs over eight years already offset about a third of the initial capital costs, making the option rather affordable. An initial two-year warranty would also temporarily negate early maintenance and replacement costs for the microtile technology. The versatility of the interactive touchscreen technology would also allow for more power saving options if the wall was placed on standby mode when not in use and only activated when desired by approaching users. This would decrease energy consumptions costs and increase the lifetime of each individual tile, consequently reducing replacement costs and the overall failure rate. By extension, the associated environmental costs from electronics production waste and power consumption would also be reduced.

Without the implementation of new hardware, however, the easiest and potentially the most efficacious change to increase the overall public interest in the wall is to introduce dynamic content into the current IMW display in the form of news and videos. This change would increase the overall public interest in the wall without incurring significant costs. Implementing dynamic content would increase the overall functionality of the IMW and also actively convey the ever-changing Story of Medicines. However, as this solution does not address the other issues of the IMW, this recommendation is best implemented in conjunction with the microtile alternative.

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Appendices

Appendix A - Greenhouse Gase Emissions Calculation

GHG Emissions from BC Hydro electricity generation to supply the current IMW with power:

$$kg\ CO_2\ eq. = 1100 * \frac{lbs\ CO_2\ eq.}{MWh} * \frac{1MWh}{3600MJ} * \frac{1kg}{2.2lbs} * 2048.86MJ * 7.5\%$$
$$= 21.34\ kg\ CO_2\ eq.$$

Appendix B - Impact Media Wall Survey Results

The survey was completed by 50 students and faculty on the main floor of the Pharmaceutical Sciences building, in the seating area in front of the media wall. All 50 respondents indicated that they were frequent visitors to the Pharmaceutical Sciences building.

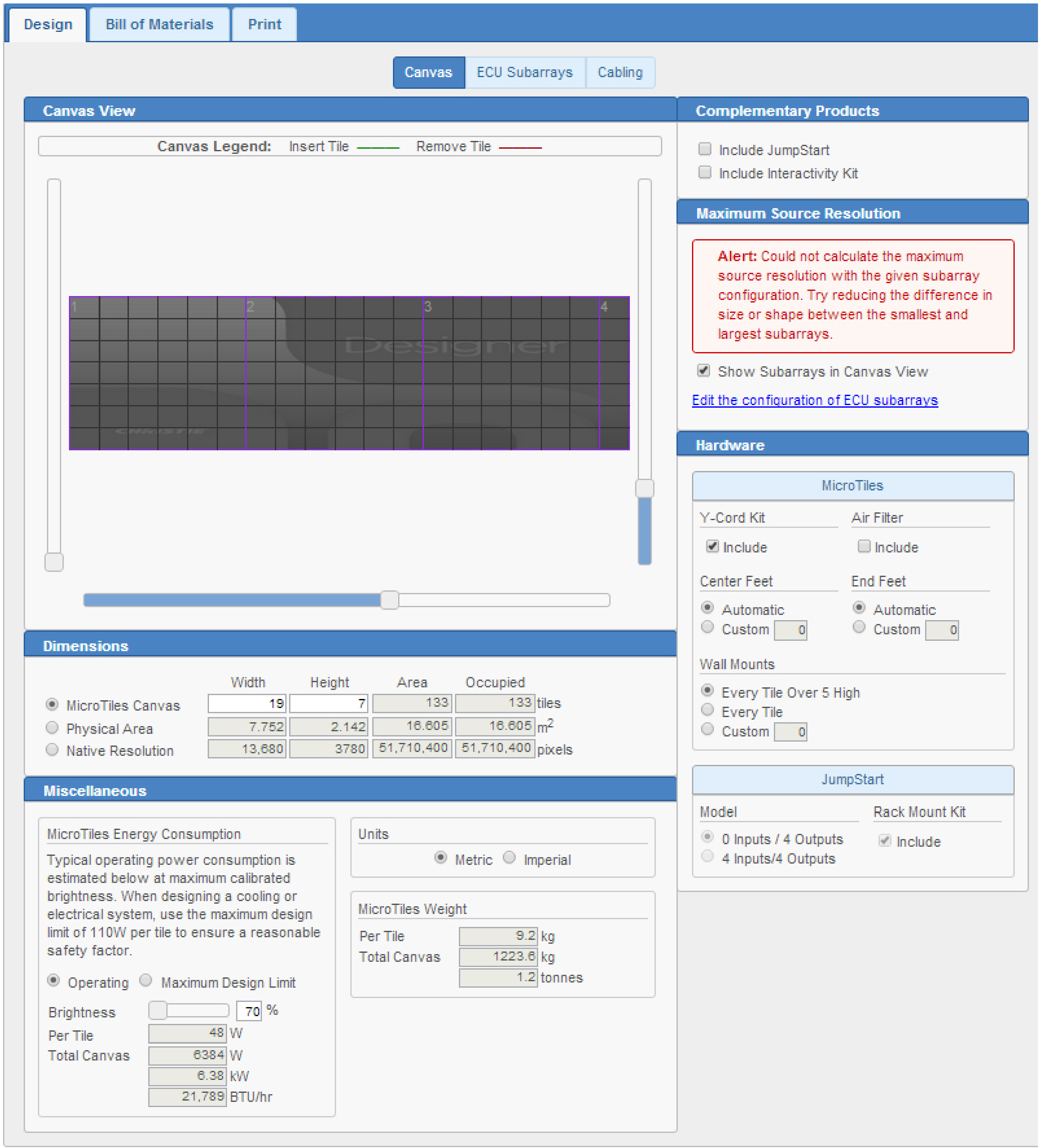
Proposed Change	Number of times the suggestion appeared	Size of set A	Size of set B	size of set C	Average Social Impact [0(slight) - 3(significant)]
Display news on the wall	29	5	18	6	2.03
Increase variety of dispalyed facts	22	4	16	2	1.90
Include pictures and/or videos	9	0	4	5	2.55
Do nothing	7	N/A	N/A	N/A	N/A
Make the wall interactive	6	0	0	6	3.00
Reduce operating time	4	2	2	0	1.50
Increase operating time	3	1	2	0	1.67

Table 8: Tabulated Survey Results

For each proposed change we encountered, Set A is the group of people who said the modification would only slightly improve their opinion of the IMW and the Pharmaceutical Sciences building, Set B is the group of people who said the modification would moderately improve their opinion of the IMW and the Pharmaceutical Sciences building, and Set C is the group of people who said the modification would significantly improve their opinion of the IMW and the Pharmaceutical Sciences building. Note that the calculated Average Social Impact index is a value between 0 and 3 indicating the average magnitude of improvement that respondents reported their opinions of the wall and building would undergo if the change was implemented. It is calculated by the following formula:

$$Average\ Social\ Impact\ Index = \frac{(1*A)+(2*B)+(3*C)}{Number\ of\ time\ the\ suggestions\ appeared}$$

Appendix C - Christie MicroTile Designer



Appendix D - Christie MicroTiles TCO

CHRISTIE®

Total Cost of Ownership (TCO) Calculator

Output on 24-Nov-2013

Total cost of ownership (TCO) is a financial measure of all the relevant costs associated with a particular asset. There is no "right" way to calculate TCO; it should include all the direct and indirect costs which you consider to be incremental and relevant to your particular situation.

The following calculator is provided as a reference only. Although every effort has been made to be fair, complete, and up to date, the methodology and variables used in this calculator are not guaranteed to be error free and are subject to change without notice. Users can make adjustments to the inputs and the calculation method, and should take care to ensure any resulting analysis is fair and reasonable.

*Please note that the results of the calculations are formatted for easy printing.

	Benchmark	Comparison Products	
	MicroTiles	50" Cube	LPD
Notes for user-defined products (optional)			
Details about the installation and product options			
Number of units	133	25	86
Square meters per unit	0.125	0.666	0.194
Square meters of display area	16.60	16.65	16.65
Estimated total system hardware cost	505,400	0	0
Total system hardware cost divided by number of units	3,800	required!	required!
Salvage value at end of operating lifetime	15%	10%	10%
Amortized hardware replacement costs per year	2%	2%	6%
Warranty (years)	2	2	2
Installation labor, person-minutes per unit	60	180	240
Maintenance labor, person-minutes per service event	30	90	120
Average power consumption at max brightness	70	230	30
Average operating brightness level	80%	100%	100%
Total cost of ownership calculation			
Upfront hardware and labor costs	518,700		
Lifetime operating and cooling energy costs	11,724		
Lifetime replacement and maintenance costs	72,265		
Salvage value	-29,228		
Total cost of ownership	573,461		
Compared with benchmark			

Calculation notes

Operating for 10 years at 8 hrs/day and 240 days/yr.

Currency in CAD. Future costs and salvage value discounted to present value using a 10% discount rate.

Energy costs included at 0.11 CAD per kWh.

Cooling costs included at 213 watts of cooling energy per kW of energy used.

Installation and maintenance costs included, utilizing a fully burdened labor rate of 100 CAD per hr.

Annual energy requirements			
kWh for operation	19,663	15,180	6,811
kWh for cooling	4,188	3,233	1,451
Total kWh/yr	23,851	18,413	8,262
Annual energy costs			
Year 1	2,213	1,709	767
Year 2	2,213	1,709	767
Year 3	2,213	1,709	767
Year 4	2,213	1,709	767
Year 5	2,213	1,709	767
Year 6	2,213	1,709	767
Year 7	2,213	1,709	767
Year 8	2,213	1,709	767
Year 9	0	0	0
Year 10	0	0	0
Discounted total operating and cooling energy cost	11,808	9,116	4,090
Annual replacement and maintenance costs			
Year 1	0	0	0
Year 2	0	0	0
Year 3	13,313	98	1,342
Year 4	14,337	105	1,445
Year 5	15,362	113	1,548
Year 6	16,386	120	1,651
Year 7	17,410	128	1,754
Year 8	18,434	135	1,858
Year 9	0	0	0
Year 10	0	0	0
Discounted total replacement and maintenance co	56,116	411	5,655