UBC Social Ecological Economic Development Studies (SEEDS) Student Report

LCA Study of Hennings

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University of British Columbia

CIVL 498C

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PROVISIO

This study has been completed by undergraduate students as part of their coursework at the University of British Columbia (UBC) and is also a contribution to a larger effort – the UBC LCA Project – which aims to support the development of the field of life cycle assessment (LCA).

The information and findings contained in this report have not been through a full critical review and should be considered preliminary.

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Alex Biczok

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CIVL 498

LCA Study of Hennings

Executive Summary:

This report contains the results of a life-cycle assessment (LCA) performed on the Hennings Building on the University of British Columbia's Vancouver Campus. This report was constructed as part of the University of British Columbia (UBC) CIVL 498 class, under the supervision the the course instructor, Rob Sianchuk, in the Fall 2013 semester. Approximately 20 other students took part in the class, each examining a different UBC building in the context of an LCA. UBC is a hundred-year old institution, and the engineering and architectural practices involved in creating its infrastructure have naturally evolved over time. One of the main goals of this project was to compare the different campus buildings with regards to their environmental impact, and in so doing provide more context for future construction projects. The results of this project will provide clear insight into which construction practices result in the lowest environmental impact, and this context can easily inform university policy.

A number of tools and methods are available for performing an LCA. This study relied upon the Athena Sustainable Materials Institute's Impact Estimator. This software is a publicly available tool that correlates the materials used in construction to their environmental impacts. The Impact Estimator uses data from TRACI, a database which is managed by the United States Environmental Protection Agency. The impact estimator is a useful tool as it can take individual components of the building as inputs, then compile them and output a series of environmental impacts. The other tool used in this analysis was On-Screen Takeoff, which is able to quantify individual building elements and provide dimensions that can be input into the Athena Impact Estimator.

The purpose of a Life Cycle Assessment (LCA) is to quantify the material and energy inputs into a product or product system, and then correlate those inputs to their overall environmental impact. LCA will typically account for the creation, use and disposal of a product or service, including the acquisition of of raw materials used. This differs from more traditional life-cycle costing, in that it is not primarily concerned with a financial assessment; it's goal is to promote sustainable business decisions by providing reliable data.

The results of this LCA show that, were the Hennings building to be constructed today, it would have a

quite significant environmental impact. The building was constructed almost entirely with concrete, a carbon-intensive material that requires significant energy to extract, transport and use in construction. The results of this LCA show that the environmental footprint of Hennings is much greater than most UBC buildings. Architectural practices have greatly improved since Hennings was created, but it is still useful to examine it as a lesson in how unsustainable certain practices are.

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1.0 General Information on the Assessment.

Purpose of Assessment

This report describes the Life Cycle Assessment (LCA) that has been performed on the Hennings building, with the goal of examining the material and energy inputs used in its construction and determining what environmental emissions this would have resulted in. This report assumes that modern construction practices in the city of Vancouver are being used; if Hennings were to be built today, this report models the expected environmental footprint.

This report was created as part of UBC's CIVL 498C class, under the instruction of Rob Sianchuk. All students in the class examined a different building on the UBC campus, with the intent of creating a comparative model. The results of this LCA will be compared to a class benchmark.

This report is intended to be used by current and future students of the CIVL 498 class. This report will demonstrate the methods used in the LCA process and the results that have been obtained. Additionally, all LCA reports created in this class will be compared for the purpose of informing future building decisions at UBC. It is the hope of this class that with clear results and data available, new construction projects on campus will be able to prioritize sustainability in their design and construction.

As this is a student project, their are limits to the data and methods that are available. That said, the reports created in this class should be able to clearly demonstrate the general trends in construction, including the impacts of materials used, in a way that should provide a meaningful comparison.

Identification of Building

The Hennings building, originally referred to simply as the Physics building, was designed and constructed in 1945 for the purpose of teaching physics-related courses and laboratory experiments. The building's address is 6224 Agricultural Road, on UBCs Vancouver campus. The building is two storeys tall with a basement, and contains several lecture halls and teaching laboratories. The largest hall in the building has a capacity of 257 students, and two other halls have capacities of 155 and 150 students. These halls are located in the centre of the building's first floor. Additionally, each floor has about 20 smaller rooms which are used for teaching space, laboratories, workshops, a library and office space, as well as bathrooms and other facilities.

Other Assessment Information

Additional information on this LCA is summarized in Table A.

Client for Assignment	Completed as coursework for the University of British Columbia's CIVL 498C class.
Name and Qualification of Assessor	Alex Biczok, Environmental Engineering major. Previous report by Robyn Edgar.
Impact Assessment Method	Athena Impact Estimator
Point of Assessment	68 years after building construction.
Period of Validity	5 years
Date of Assessment	Completed December 2013
Verifier	Student work, not verified.

Table A: Assessment Information

2.0 General Information on the Object of Assessment

Functional Equivalent

All LCA work requires the selection of an appropriate functional unit. The functional unit is a means of relating the environmental impact of a product's life to an easily quantifiable measure of that product. Functional units make it possible to compare different product systems that produce similar products. This life cycle assessment examines both the separate components of the building and the building as a whole, and each of these has a different functional unit. In this case, the functional unit of the studied buildings will be the area of the building, in square meters.

More information on this LCA is summarized in Table B.

Aspect of Object Assessed	Construction of Hennings Building
Building Type	Institutional building used for teaching space and laboratory work.
Technical Requirements	Able to accommodate the required number of students,
Pattern of Use	Sees daily use in a variety of functions. Main functions are lectures given to 100+ students, laboratory use, classes taught to smaller groups of students.
Required Service Life	UBC requires buildings to last for at least 100 years.

Table B: Building description

Reference Study Period

LCA will usually strive to examine the entire life of a product; however, this report will concern itself only with the acquisition of raw materials and the construction of the building. This is due to the limitations of the Athena Impact Estimator tool, and the unreliability of data concerning building usage patterns in the far future.

Object of Assessment

The Hennings building mainly constructed with concrete, from its foundations to walls to its roof. The components of the building were separated in accordance with the CIQS standards. This LCA report is interested only in the structure and envelope of the building, to keep the focus on building materials and construction practices.

Reference Study Period

LCA will ideally study the entire life cycle of a building, including its construction, use, and end-of-life. However, this project is concerned only with the construction practices involved, and the production of raw materials used. Because the use of the building may change over time, or certain aspects of its use may change, an LCA of this scope would not provide a reliable result. For that reason, this LCA will study only the period of construction and the use of raw materials in construction.

Object of Assessment Scope

The components of the building were separated according to the Canadian Institute of Quantity Surveyors (CIQS)-defined Level 3 elements. This was done to identify key construction phases of a project and identify where the greatest environmental impacts came from. Table C shows each of these elements, what they encompass, and how they have been quantified for the Hennings building.

The building's foundations consist of the concrete slab, the columns, and load-bearing walls. The concrete slab was modelled as the entire basement floor, and according to the construction design was 4 inches thick. The load-bearing walls were approximated as tall strip footings due to limitations of the Impact Estimator. Columns were identified in the architectural design, including their dimensions.

The second and third floor were modelled as a suspended slab above grade. This is a fair assumption as concrete was used throughout their construction. Due to limited data in the impact estimator, the concrete bearing load was over-estimated; this will lead to a more conservative model. The second-floor light-well was simply treated as empty space. The design documents specified the use of joist-slab in certain areas; as this is not supported by the Impact Estimator, they were assumed as concrete slab.

Exterior walls were modelled as solid concrete with a natural stone exterior. This is less than ideal, as the stone exterior only partially covers the Hennings' walls; but this is beyond the capability of the impact estimator. Additionally, there was no data available on the specific thickness of the walls; 10-inch walls were approximated as 12-inch, and 6-inch walls were approximated as 8-inch. This will lead to greater-than-actual results. The architectural drawings also showed that there was a wood stud interior to exterior walls, which was included in the model.

Walls below grade were modelled separately from walls above grade. Windows were approximated as double-pane, and insulation was taken as 2-inch Rockwool.

Partition walls were counted separately from exterior walls, and were grouped by their material type and width. Most partition walls were of uniform material, so they could be approximated as a single long wall. Glass partitions were also included, and were counted separately, approximated as 100% clear glass curtains.

CIVL 498 Level 3 Elements	Description	Quantity	Unit
A11 Foundations	Concrete Slab, Columns, Support Walls	4000	m^2
A21 Lowest Floor Construction	Concrete Slab		
A22 Upper Floor Construction	Supported Concrete Slab, Columns Supporting Second floor	4000	m^2
Roof Construction	Area of the roof (concrete slab)	4000	m^2
Walls Below Grade	Area of all walls below the ground surface	900	m^2
Walls Above Grade	Area of all walls above the ground surface	1800	m^2
Partitions	Area of interior walls	3800	m^2

Table C: CIQS Element Description

3.0 Statement of Boundaries

System Boundary

The system boundary of an LCA defines which aspects of the product life will be included in the analysis. Ideally, an LCA would study all possible sources of environmental impact; however, this is impractical as product systems will change over time as construction practices evolve or change. This is especially true of buildings, which have a long service life and may be modified over time. For this reason, the system boundary of this analysis will be limited to the first two stages of building life cycle assessment as defined by EN 15798 reference. This will include the production, transportation and manufacturing associated with the raw materials to be used in construction, and the transportation and construction practices involved with creating the building. This report will not examine the environmental impacts associated with the long-term use of the building, or the building's decommission and demolition.

Product Stage

The Athena Impact Estimator relies on certain assumptions when calculating environmental impacts. As the Hennigs building is primarily constructed from concrete, it is important to note where Athena has acquired it's data on this material.

The Athena Impact Estimator uses data acquired from the Cement Association of Canada, last updated in 2004. This data is a compilation of the energy used to create cement in various geographic regions of Canada, and examines the extraction and transportation of raw materials, and the manufacture and transport of the refined product. Included in this analysis is an examination of what type of electricity was used in each stage of production, and the associated emissions from producing that electricity.

The impact of the product stage is greatly dependent on the type of electricity available. Electricity generated by coal-fire plants produces a emissions to a greater degree than hydro power, for example, and the product stage will therefore be greatly region-dependent.

*Athena SMI. Cement and Structural Concrete Products, 2005.

Certain other aspects of the product stage may be taken into account by the estimator. Any ancillary inputs will have their own associated emissions that the estimator may take into account. Additionally, all aspects of packaging, transportation and disposal may have an impact on the environmental footprint of the product stage.

Construction Stage

The construction stage of a product will include the transport of materials to the construction site, and the energy and material requirements for installing the material. This stage does not include any ongoing maintenance or retrofits after the building has opened for use. The Athena Impact Estimator accounts for a number of energy-intensive factors in the construction stage. It first determines how the power used in the construction was likely generated, and accounts for those emissions. It also accounts for what construction equipment was likely used and what type of fuel is associated with them. The estimator makes assumptions about how far material likely needed to be transported to reach the site, and how many workers were likely involved in the project and what their transportation requirements were.*

EUPave. Milachowski et al. Life Cycle Assessment for Road Construction and Use. 2011

4.0 Environmental Data

The Athena Impact Estimator, the primary tool used in developing this LCA, is managed by the Athena Sustainable Materials Institute. This institution's stated goal is to provide reliable and easy-to-use data and tools to assist in the construction of LCA. The Institute adhere's to the International Organization for Standardization, which provides an international framework for managing environmental impact. The Athena Institute has a number of tools available, including the EcoCalculator, the Impact Estimator for Buildings, and the Impact Estimator for Highways. This report modelled its results using the Impact Estimator for Buildings. Advantages to this tool include being able to input exact dimensions of building elements, and having access to data from across North America, allowing one to select a specific region and generate more specific results.

The data that Athena uses to calculate the environmental impact of a product is based on the TRACI database, which is managed by the United States Environmental Protection Agency. TRACI examines a variety of environmental impact categories, which include possible negative impacts associated with a product, such as climate change, acid rain, or cancer risk. This can be used to correlate the expected chemical emissions of a product system with their environment impact. The final output of the Athena Impact Estimator corresponds to these impact categories, and will provide quantifiable data on criteria such as global warming potential, ozone depletion, and smog.

Data Adjustments and Substitutions

The Athena Impact Estimator does not have data on all possible types of building materials. Material type, material thickness and a number of other factors vary from building to building, and in the event that the Impact Estimator does not account for them, there exists a source of uncertainty. Other databases may exist that account for missing materials. Although some inadequacies were noted in the impact estimator for this project, there was no supplementary data available to account for it. Such inaccuracies were noted in Section 2.0.

Data Quality

The quality of data in this project will be limited to what the Athena Impact Estimator can account for, what other sources of data exist to supplement the Impact Estimator, and the reliability of original building measurements and dimensions.

One potential source of poor data quality was the age of the structural building designs that was available. As the plans were developed in 1945, the drawings were created by hand often had poor annotations. Generally, the main concept for each aspect of the building was made clear, and so the overall result of the study should be viable; however, smaller, more specific aspects of the building had to be estimated or approximated due to this uncertainty.

Due to limitations in the Impact Estimator, some aspects of the building design had to approximated to accommodate the available options. For instance, walls in the building were generally either 6 inches or 10 inches, neither dimension of which is included in the estimator; these had to be approximated as 8 inch and 12 inch, respectively. Generally speaking, such inaccuracies could be fairly approximated to within a reasonable range from the true value.

5.0 LIST OF INDICATORS

The end goal of an LCA is to quantify the environmental impacts of a product or system. Typically this is done by examining the physical and energy outputs of a system and relating them to their effects on the environment. This report produced results in the following impact categories:

Fossil fuel consumption: The amount of fossil fuel, such as oil or natural gas, that was consumed as a result of this process.

Global Warming: The potential of the released air emissions to contribute to global warming, which would raise global temperatures. Expressed as the equivalent mass of carbon dioxide.

Acidification: The potential to lower the pH of local water, which would cause health effects in humans and damage biodiversity. Expressed as moles of H+ produced.

Human Health, Respiratory: The potential of emissions to impact the respiratory functions of the human body, which may results in acute or chronic sickness. Expressed as mass of Particulate Matter.

Eutrophication: The potential for an emission to cause an increase in plant growth in local water systems. This will typically result in severe damage to biodiversity. Expressed as equivalent mass of Neq.

Ozone Depletion: The ability of a chemical to degrade the earth's ozone layer, which will increase the risk of skin cancer and other health effects. Expressed as equivalent mass of CFC-11.

Smog: The potential of an emission to result in smog, which typically correlates with human respiratory health effects. Expressed as equivalent mass of ozone.

6.0 MODEL DEVELOPMENT

The original data for this model came from the original construction plans for the building. Using On-Screen Takeoff as an aid, the components of the building, such as the walls, interior partitions, foundations, floors, and roof, were carefully measured and sorted by their material type and location in the building. Using the CIQS sorting method, these elements were grouped together and then input into the Athena Impact Estimator, which produced a summary of construction materials and their associated environmental impacts.

Refer to Annex D for more details on the inputs into the Impact Estimator.

Figures 1-7 show the bill of materials created by the Impact Estimator for each CIQS element.

Table 1: A11 Foundation

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Table 2: A23 Roof Construction

Material	Quantity	Unit
#15 Organic Felt	9150.88	m2
6 mil Polyethylene	4257.43	m2
Ballast (aggregate stone)	84281.64	kg
Concrete 20 MPa (flyash av)	22.94	m3
Concrete 30 MPa (flyash av)	210.7	m3
Galvanized Sheet	4.78	Tonnes
GluLam Sections	141.96	m3
Hollow Structural Steel	10.8	Tonnes
Laminated Veneer Lumber	133.89	m3
MW Batt R11-15	21086.42	m2 (25mm)
Nails	2.07	Tonnes
Precast Concrete	369.04	m3
Rebar, Rod, Light Sections	9.35	Tonnes
Roofing Asphalt	54001.77	kg
Small Dimension Softwood Lumber, kiln-dried	7.43	m3

Table 3: A21 Lower Floor Construction

Material	Quantity	Unit

Table 4: A22 Upper Floor Construction

Material	Quantity	Unit
Concrete 20 MPa (flyash av)	1223.47	m3
Hollow Structural Steel	2.7	Tonnes
Laminated Veneer Lumber	66.95	m3
Rebar, Rod, Light Sections	68.67	Tonnes
Small Dimension Softwood Lumber, kiln-dried	1.86	m3

EPDM membrane (black, 60 mil)	34.65	kg
Mortar	17.06	m3
Nails	0.18	Tonnes
Rebar, Rod, Light Sections	6.82	Tonnes
Screws Nuts & Bolts	0.29	Tonnes
Small Dimension Softwood Lumber, Green	13.34	m3

T
Grade

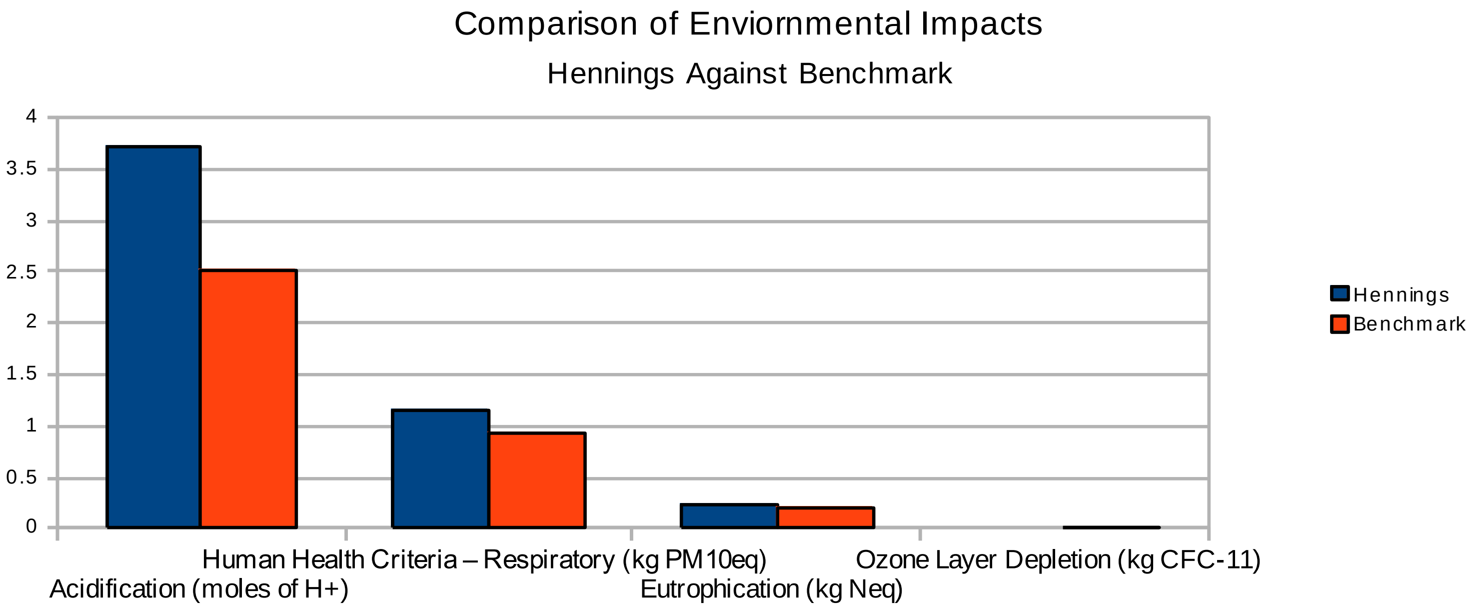
Material	Quantity	Unit
#15 Organic Felt	31.51	100sf
1/2" Regular Gypsum Board	3223	sf
Aluminum	3.88	Tons (short)
Aluminum Clad Wood Window Frame	2512.8	lbs
Cold Rolled Sheet	0.06	Tons (short)
Concrete 20 MPa (flyash av)	217.95	yd3
Double Glazed No Coating Air	3958.37	sf
EPDM membrane (black, 60 mil)	531.43	lbs
Expanded Polystyrene	210.22	sf (1")
Galvanized Sheet	0.41	Tons (short)
Joint Compound	0.33	Tons (short)
Mortar	4.33	yd3
MW Batt R11-15	6049.77	sf (1")
Nails	0.49	Tons (short)
Natural Stone	2902.2	sf
Paper Tape	0	Tons (short)
Rebar, Rod, Light Sections	4.33	Tons (short)
Screws Nuts & Bolts	0.44	Tons (short)
Small Dimension Softwood Lumber, Green	12.9	Mbfm small
Softwood Plywood	7.95	msf (3/8")
Solvent Based Alkyd Paint	0.47	Gallons (us)

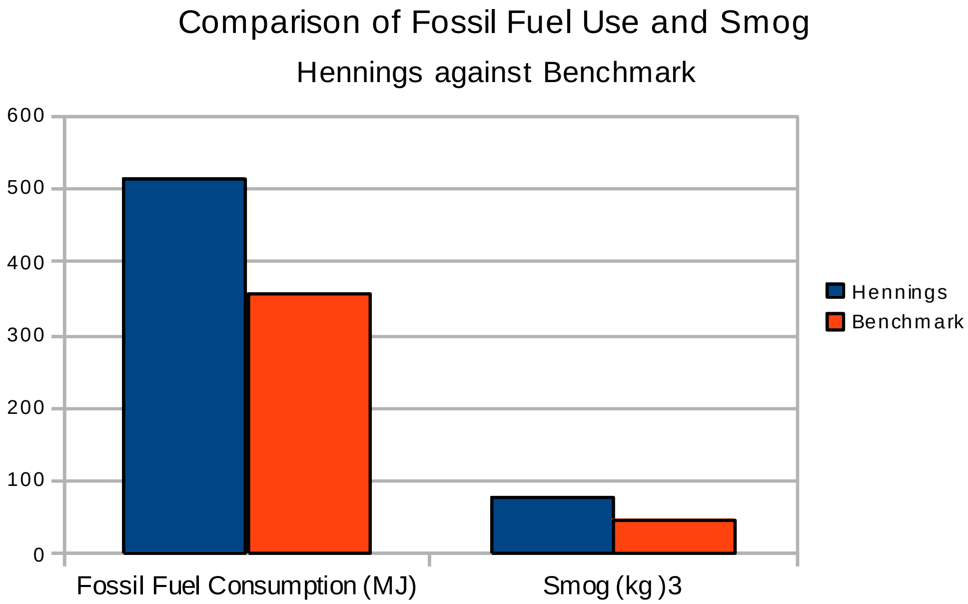
y	Unit
8	m2
	Tonnes
1	m3
	m2
	kg
	Tonnes
	Tonnes
	Tonnes
6	m2 (25mm)
	Tonnes
	Tonnes
	Tonnes
	Tonnes
	m3
	m3

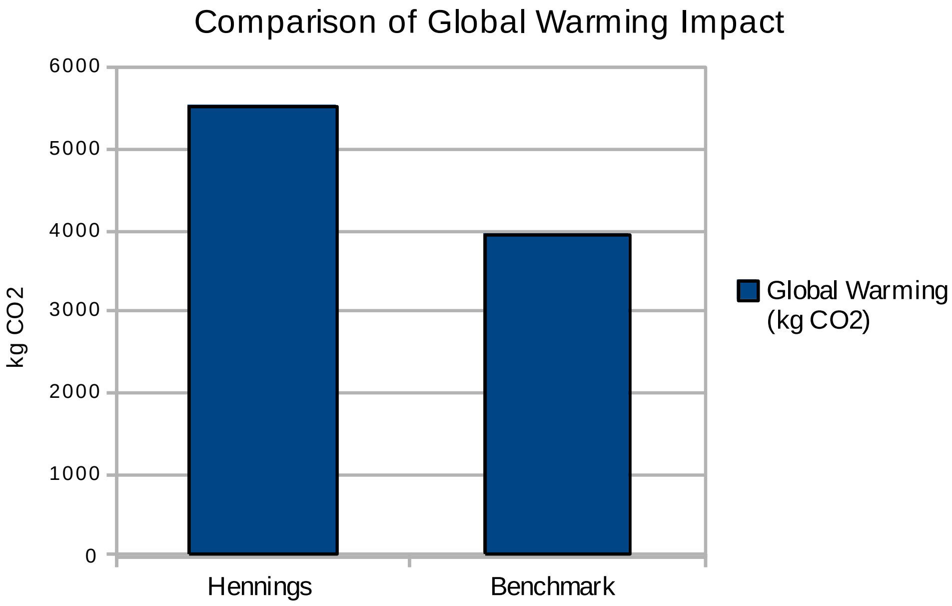
7.0 COMMUNICATI

ON OF ASSESSMENT

The results of the whole-building assessment are summarized in Figures 1-3. Note that units of each element vary and are specified in the data label. All results are per square meter of constructed floor space (i.e., for Human Health Criteria, Hennings construction produces 1.2 kg of PM equivalent per square meter of construction).


Comparison of Enviornmental Impacts
Hennings Against Benchmark
4
3.5
3
2.5
2
1.5
1
0.5
0
Acidification (moles of H+)
Human Health Criteria – Respiratory (kg PM10eq)
Eutrophication (kg Neq)
Ozone Layer Depletion (kg CFC-11)
Hennings
Benchmark


Comparison of Fossil Fuel Use and Smog
Hennings against Benchmark
600
500
400
300
200
100
0
Fossil Fuel Consumption (MJ)
Smog (kg)3
Hennings
Benchmark



It is apparent from these comparisons that the Hennings building under-performs compared the class benchmark in every respect. This was not unexpected; since the Hennings building relied on concrete so heavily, a higher-than-average environmental impact was likely. It should be noted that no smog potential was found in either the benchmark or Hennings construction. The largest contributor to the environmental footprint is the walls and floors of the building. These structures are enormous in volume and constructed almost entirely with concrete, resulting in them representing the majority of all emissions. While conducting this study, it was determined that most other aspects of a building are small in comparison; the walls and floors of a building should always be subjected to the most thorough review possible as they have the greatest sensitivity to the overall result.

For more details on the creation of this LCA study, please refer to the following Annexes.

ANNEX A: Benchmarking

As part of this project, a benchmark was developed by all students of the CIVL 498 class, using the average impact results from all studied buildings. This benchmark was an important tool, and benchmarking in general is a key part of LCA. Reliable benchmarks allow one to compare their product to the industry average, and determine whether their product is more or less sustainable than existing products.

One of the goals of this project was to compare individual buildings and determine which construction methods produce the most sustainable results. A reliable benchmark is key for this, as future construction projects may be subjected to Life Cycle Assessment and assessed by their potential environmental impact. This benchmark was shown in the results section of the report.

Hennings has a very poor environmental performance when compared to other buildings. As was communicated in the results section, all key environmental indicator categories show that the construction practices used to create Hennings have a poorer environmental performance than the average UBC building, as defined by the used benchmark. In particular , this was due to the reliance on concrete in constructing the walls and floors of the building. The buildings thick walls and low ceilings reduce the overall amount of floorspace, meaning that available space was inefficiently used.

ANNEX B: Recommendations for LCA Use

LCA is a powerful tool to model the environmental cost of creating a product. Without LCA, it is difficult to accurately determine the full impact of a product; aspects such as the production of individual product components and transportation effects require extensive research to accurately model and is generally beyond the scope of interest of construction planners. LCA greatly simplifies this process by using existing software tools and databases.

While this particular study did not include the use of the building in its scope, it is important to recognize that this is where a substantial portion of a building's impact comes from. Heat, power, ventilation, and maintenance are a few such aspects of the use phase of a building, and these can be optimized by using LCA.

As with any engineering practice, LCA will evolve and improve as more data and research becomes available. For that reason, it is preferable for UBC to incorporate LCA into its policy decisions as soon as possible.

Its important to recognize that many elements of LCA are subjective. In interpreting the results of LCA, one must decide which environmental impacts have the greatest value to them. This may be influenced by a number of factors, such as the region of the product being assessed. Often this is quantified by assigning a rank to each impact category; if one feels that mitigating climate change is the most important goal, then they may rank that more highly than the other categories. Note that this ranking does not affect the results of LCA in any way; it is just a way of assigning value to each element.

If UBC is interested in incorporating LCA into future decisions, then it should first develop a way of standardizing the LCA process, and determining who should be responsible for constructing an LCA model. This should include selecting which software tools and databases are to be used, how building elements are to be sorted, and compiling supplementary data for the software tools. One of the limitations of this report was being restricted to the inputs that were allowed by the Impact Estimator; if UBC develops a standardized database, it would be a much simpler process to improve LCA models and provide more accurate data.

Annex C: Personal Reflections

Before undertaking this project, I had had some experience with LCA. As an environmental engineering major, this was a topic that had been raised a few times in various green design courses. One past project used several elements of LCA to examine the most and least efficient way that commercial fishing vessels could harvest fish. However, I have still learned a lot about the subject through this class, such as the types of software tools that are available, the various ISO standards, and how widely LCA might be used.

I have had very little exposure to buildings and construction in the past, so it was both challenging and interesting to take on this kind of project. The course showed me how LCA may be applied to almost any industry, which I will keep in mind throughout my professional career. I became aware of the state of LCA in the world; where and how it is used, what its limitations are, and what it is capable of. Doing this LCA study showed me how important it is to be familiar with both LCA and the field it is being applied to to acquire the best results; given the complexities behind something as large as a construction project, one would need to have a keen awareness of what assumptions may be valid, and how to overcome the limits of the software tools.

I feel that by doing this project I improved in several of the CEAB attributes. Problem analysis was certainly important, as this was a great undertaking that required several different tasks to complete. Dividing up the project into different stages was certainly important for making sure that I understood each part of the project before creating the final report. Also important was using engineering tools, as this study relied heavily on the Athena Impact Estimator and On Screen Take Off. Being able to understand and use these effectively was essential to succeeding here. Life-long learning was another key attribute; this project required me to learn outside of my regular field, and apply skills I already had to topics I knew little about. As a result, I have obtained a greater understanding of LCA, LCI, and civil engineering.

Annex D: Impact Estimator Inputs

Assembly Name	Input Fields	Assembly Type	
		A11 Foundations	
		1.2 Concrete Footing	
1.2.1 - 10" exterior wall - basement	Length (ft) Width (ft) Thickness (in) Concrete (psi)		
		1.1 Concrete Slab on Grade	
1.1.1 - Basement Slab	Length (ft) Width (ft) Thickness (in) Concrete (psi) Concrete Flyash %		
1.1.2 - East Stairway Slab	Length (ft) Width (ft) Thickness (in) Concrete (psi) Concrete Flyash %		
1.1.3 - West Stairway Slab	Length (ft) Width (ft) Thickness (in) Concrete (psi) Concrete Flyash %		
1.1.4 - Main Stairway Slab	Length (ft) Width (ft) Thickness (in) Concrete (psi) Concrete Flyash %		
		5.1 Suspended Slab	
5.1.1 - 1st Floor	Floor Width (ft) Span (ft) Concrete (psi) Concrete Flyash % Live Load (psf)		145.5 271.5
		A22 Upper Floor Construction	
3.1.3 - 2nd Floor Beams and Columns	Number of Beams Number of Columns Floor to Floor Height (ft) Bay Sizes (ft) Supported Span Live Load (psf)	3.1 Concrete Column and Concrete Beam	
5.1 2 - 2nd Floor	Floor Width (ft) Span (ft) Concrete (psi) Concrete Flyash % Live Load (psf)	5.1 Suspended Slab	145.5 271.5
3.1.2 - 1st Floor Beams and Columns	Number of Beams Number of Columns Floor to Floor Height (ft) Bay Sizes (ft) Supported Span Live Load (psf)	3.1 Concrete Column and Concrete Beam	
		A23 Roof Construction	
		4.1 Concrete Precast Double T	
4.1.1 - Roof	Number of Bays Bay Sizes (ft) Span (ft) Live Load (psf) Topping		

A31 Walls Below Grade			A31 Walls Below Grade	Known/Measured (Metric)
2.1 Cast-in-Place			2.1 Cast-in-Place	
	2.1.1 - 10" Exterior Wall - basement			
		Length (ft)		0
		Height (ft)		0
		Thickness (in)		300
		Concrete (psi)		20
		Concrete Flyash %		average
		Rebar		15
	Window Opening	Number of Windows		0
		Total Window Area (ft2)		0.0
		Frame Type		Aluminum
		Glazing Type		Standard
	Envelope	Envelope Category		Gypsum board
		Envelope Material		Gysum Regular 1/2"
		Thickness		-
		Envelope Category		0
		Envelope Material		0
		Thickness (in)		-
	2.1 2 - 10" Exterior Wall Front - basement			
		Length (ft)		0
		Height (ft)		0
		Thickness (in)		300
		Concrete (psi)		20
		Concrete Flyash %		average
		Rebar		15
	Window Opening	Number of Windows		0
		Total Window Area (ft2)		0 0
		Frame Type		Aluminum
		Glazing Type		Standard
	Envelope	Envelope Category		Gypsum board
		Envelope Material		Gysum Regular 1/2"
		Thickness		-
		Envelope Category		0
		Envelope Material		0
		Thickness (in)		-
	2.1.3 - 8" Exterior Wall - basement			
		Length (ft)		0 0
		Height (ft)		0
		Thickness (in)		200
		Concrete (psi)		20
		Concrete Flyash %		average
		Rebar		15
	Envelope	Envelope Category		Gypsum board
		Envelope Material		Gysum Regular 1/2"
		Thickness		-
		Envelope Category		0
		Envelope Material		0
		Thickness (in)		-
2.3 Wood Stud	2 3.1 - Architectural Basement Walls		2.3 Wood Stud	
		Wall Type		Interior
		Length (ft)		0
		Height (ft)		0
		Sheathing		none
		Stud Thickness		100
		Stud Spacing		400
		Stud Type		Green
	Envelope	Category		Gypsum board
		Material		Gysum Regular 1/2"
		Thickness		-
	Envelope	Category		Gypsum board
		Material		Gysum Regular 1/2"
		Thickness		-

A32 Walls Above Grade			A32 Walls Above Grade	
	2.1.9 - 10" Exterior Wall - 1st Floor			
		Length (ft)		0
		Height (ft)		0
		Thickness (in)		300
		Concrete (psi)		20
		Concrete Flyash %		average
		Rebar		15
	Window Opening	Number of Windows		0
		Total Window Area (ft2)		0
		Frame Type		Aluminum
		Glazing Type		Standard
	Envelope	Envelope Category		Gypsum board
		Envelope Material		Gysum Regular 1/2"
		Thickness		-
		Envelope Category		0
		Envelope Material		0
		Thickness (in)		-
	2.1 91 - 10" Exterior Wall - 1st Floor			
		Length (ft)		0
		Height (ft)		0
		Thickness (in)		300
		Concrete (psi)		20
		Concrete Flyash %		average
		Rebar		15
	Window Opening	Number of Windows		0
		Total Window Area (ft2)		0
		Frame Type		Aluminum
		Glazing Type		Standard
	Envelope	Envelope Category		Gypsum board
		Envelope Material		Gysum Regular 1/2"
		Thickness		-
		Envelope Category		0
		Envelope Material		0
		Thickness (in)		-
	2.1 92 - 10" Exterior Wall - 1st Floor			
		Length (ft)		0
		Height (ft)		0
		Thickness (in)		300
		Concrete (psi)		20
		Concrete Flyash %		average
		Rebar		15
	Window Opening	Number of Windows		0
		Total Window Area (ft2)		0
		Frame Type		Aluminum
		Glazing Type		Standard
	Envelope	Envelope Category		Gypsum board
		Envelope Material		Gysum Regular 1/2"
		Thickness		-
		Envelope Category		0
		Envelope Material		0
		Thickness (in)		-
	2.1.11 - Exterior Wall - 2nd Floor			
		Length (ft)		0
		Height (ft)		0
		Thickness (in)		300
		Concrete (psi)		20
		Concrete Flyash %		average
		Rebar		15
	Window Opening	Number of Windows		0
		Total Window Area (ft2)		0.0
		Frame Type		Aluminum
		Glazing Type		Standard
	Envelope	Envelope Category		Gypsum board
		Envelope Material		Gysum Regular 1/2"
		Thickness		-
		Envelope Category		0
		Envelope Material		0
		Thickness (in)		-
	2.1.111 - Exterior Wall - 2nd Floor			
		Length (ft)		0
		Height (ft)		0
		Thickness (in)		300
		Concrete (psi)		20
		Concrete Flyash %		average
		Rebar		15
	Window Opening	Number of Windows		0
		Total Window Area (ft2)		0.0
		Frame Type		Aluminum
		Glazing Type		Standard