Life Cycle Analysis of
The Civil and Mechanical Engineering Building

University of British Columbia, Vancouver BC, Canada

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Submitted to:

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CIVL 498c: Life Cycle Bldg

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ABSTRACT

This study is a Life Cycle Analysis (LCA) of the structural envelope of the Civil and Mechanical Engineering (CEME) Building at the University of British Columbia (UBC) in Vancouver, Canada. The analysis entailed a cradle-to-gate assessment using the architectural and structural drawings to develop a material takeoff that was modeled in the Athena Impact Estimator. The building model is explain in detail, with all pertinent data necessary to replicate the study. When compared with the five other institutional buildings at UBC that underwent the same analysis, it was shown that CEME had less of an environmental impact than the average and the building assemblies that were the source of this were demonstrated. The study also included a basic energy performance modeling that showed that a thermally improved CEME building envelope would recover the energy invested in additional insulation within less than two years.

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1.0 INTRODUCTION

The Civil and Mechanical Engineering (CEME) Building is located at 2324 Main Mall, at the University of British Columbia (UBC), in Vancouver, Canada. It was constructed from 1974-76 at a cost of $6.7 Million. The building is the home of both the Civil and Mechanical Engineering departments, and their respective offices. It contains a wide range of facilities in five sections (as defined in the architectural and structural drawings) of the building.

CEME is approximately a 111,159 sq.ft building that contains a large variety of facilities including offices, classrooms, student and graduate student study space, foyers, mechanical laboratories, soil laboratories, environmental laboratories, and computer labs. While the exact number is difficult to estimate due to multipurpose spaces, CEME contains roughly eight large workspaces, nine classrooms, twenty nine labs, and seventy two offices.

Each of the five sections has a unique layout and elevation. Some sections, like that on Main and East Mall, have only one story with elevated ceilings and contain labs. Other areas have two-stories and this is where most of the offices and actual classrooms can be found. There is also a small basement under one section, and on several there are steel “penthouses” that appear to serve a mechanical purpose. The primary structural components of the building are described below in Table 1.

Table 1: CEME Building Characteristics

Building System	Specific Characteristics
Structure	Concrete columns supporting concrete beams supporting concrete precast T-Beam joists.
Floors	Predominantly precast T-beam joists resting on beams resting on columns - all concrete.
Exterior Walls	Predominently precast concrete panels with some concrete block walls. Penthouse: Currugated Steel Sheeting.
Interior Walls	Mix of concrete block walls, wood stud walls, and steel stud walls.
Windows	Window glazing not specified but assumed to be standard. Window frames are aluminum and include panels that are insulated steel stud walls with asbestos panels.
Roof	Drawings lack detail on roof. Consists of built up system on top of precast concrete T-beam or open web still joist coverd with corrugated steel. All has 1" rigid insulation with some sort of asphalt roofing.

2.0 GOAL AND SCOPE

2.1 Goal of Study

This life cycle analysis (LCA) of the Civil and Mechanical Engineer Building (CEME) at the University of British Columbia was carried out as an exploratory study to determine the environmental impact of it's design. This LCA of CEME is also part of a series of twelve others being carried out simultaneously on respective buildings at UBC with the same goal and scope.

The main outcomes of this LCA study are the establishment of a materials inventory and environmental impact references for CEME. An exemplary application of these references are in the assessment of potential future performance upgrades to the structure and envelope of CEME. When this study is considered in conjunction with the twelve other UBC building LCA studies, further applications include the possibility of carrying out environmental performance comparisons across UBC buildings over time and between different materials, structural types and building functions. Furthermore, as demonstrated through these potential applications, this CEME LCA can be seen as an essential part of the formation of a powerful tool to help inform the decision making process of policy makers in establishing quantified sustainable development guidelines for future UBC construction, renovation and demolition projects.

The intended core audience of this LCA study are those involved in building development related policy making at UBC, such as the Sustainability Office, who are involved in creating policies and frameworks for sustainable development on campus. Other potential audiences include developers, architects, engineers and building owners involved in design planning, as well as external organizations such as governments, private industry and other universities whom may want to learn more or become engaged in performing similar LCA studies within their organizations.

2.2 Scope of Study

The product system being studied in this LCA are the structure, envelope and operational energy usage associated with space conditioning of CEME on a square foot finished floor area of academic building basis. In order to focus on design related impacts, this LCA encompasses a cradle-to-gate scope that includes the raw material extraction, manufacturing of construction materials, and construction of the structure and envelope of CEME, as well as associated transportation effects throughout.

2.2.1 Tools, Methodology and Data

Two main software tools are to be utilized to complete this LCA study; OnCenter's OnScreen TakeOff and the Athena Sustainable Materials Institute's Impact Estimator (IE) for buildings.

The study will first undertake the initial stage of a materials quantity takeoff, which involves performing linear, area and count measurements of the building's structure and envelope. To accomplish this, OnScreen TakeOff version 3.6.2.25 is used, which is a software tool designed to perform material takeoffs with increased accuracy and speed in order to enhance the bidding capacity of its users. Using imported digital plans, the program simplifies the calculation and measurement of the takeoff process, while reducing the error associated with these two activities. The measurements generated are formatted into the inputs required for the IE building LCA software to complete the takeoff process. These formatted inputs as well as their associated assumptions can be viewed in Annexes A and B respectively.

Using the formatted takeoff data, version 4.0.51 of the IE software, the only available software capable of meeting the requirements of this study, is used to generate a whole building LCA model for CEME in the Vancouver region as an Institutional building type. The IE software is designed to aid the building community in making more environmentally conscious material and design choices. The tool achieves this by applying a set of algorithms to the inputted takeoff data in order to complete the takeoff process and generate a bill of materials (BoM). This BoM then utilizes the Athena Life Cycle Inventory (LCI) Database, version 4.6, in order to generate a cradle-to-grave LCI profile for the building. In this study, LCI profile results focus on the manufacturing and transportation of materials and their installation in to the initial structure and envelope assemblies. As this study is a cradle-to-gate assessment, the expected service life of CEME is set to 1 year, which results in the maintenance, operating energy and end-of-life stages of the building's life cycle being left outside the scope of assessment.

The IE then filters the LCA results through a set of characterization measures based on the mid-point impact assessment methodology developed by the US Environmental Protection Agency (US EPA), the Tool for the Reduction and Assessment of Chemical and other environmental Impacts (TRACI) version 2.2. In order to generate a complete environmental impact profile for CEME, all of the available TRACI impact assessment categories available in the IE are included in this study, and are listed as;

- Global warming potential
- Acidification potential
- Eutrophication potential
- Ozone depletion potential

- Photochemical smog potential
- Human health respiratory effects potential
- Weighted raw resource use
- Primary energy consumption

Using the summary measure results, a sensitivity analysis is then conducted in order to reveal the effect of material changes on the impact profile of CEME. Finally, using the UBC Residential Environmental Assessment Program (REAP) as a guide, this study then estimates the embodied energy involved in upgrading the insulation and window R-values to REAP standards and calculates the energy payback period of investing in a better performing envelope.

The primary sources of data for this LCA are the original architectural and structural drawings from when CEME was initially constructed in 1975. The assemblies of the building that are modeled include the foundation, columns and beams, floors, walls and roofs, as well as the associated envelope and openings (ie. doors and windows) within each of these assemblies. The decision to omit other building components, such as flooring, electrical aspects, HVAC system, finishing and detailing, etc., are associated with the limitations of available data and the IE software, as well as to minimize the uncertainty of the model. In the analysis of these assemblies, some of the drawings lack sufficient material details, which necessitate the usage of assumptions to complete the modeling of the building in the IE software. Furthermore, there are inherent assumptions made by the IE software in order to generate the bill of materials and limitations to what it can model, which necessitated further assumptions to be made. These assumptions and limitation will be discussed further as they energy in the Building Model section and, as previously mentioned, all specific input related assumption are contained in the Input Assumptions document in Appendix B.

3.0 BUILDING MODEL

3.1 Takeoffs

As described earlier, a software tool named OnScreen TakeOff version 3.6.2.25 was used to generate a material takeoff that would be the subject of the assessment. OnScreen makes use of the architectural and structural building drawings in PDF format to allow the user to make manual measurements. Numerous, but not all, of the CEME structural and architectural drawings were used to do the takeoffs, and these were purchased from the UBC LBS Facilities and Capital Planning Records Department. The drawings, listed using the Records Department nomenclature, include:

- 306-06-007
- 306-06-008
- 306-06-009
- 306-06-010
- 306-06-011
- 306-06-012
- 306-06-013
- 306-06-014
- 306-06-015
- 306-06-016
- 306-06-017
- 306-06-018
- 306-06-019
- 306-06-020
- 306-06-021
- 306-06-022
- 306-06-023
- 306-06-025
- 306-06-026
- 306-06-028
- 306-06-029
- 306-07-002
- 306-07-003
- 306-07-004
- 306-07-005
- 306-07-006
- 306-07-007
- 306-07-008
- 306-07-009

The interpretation of CEME drawings posed numerous challenges to the quantity takeoff process, with the primary challenge being a lack of material detail in the drawings. This lack of detail resulted in the need for assumptions to be made about assembly characteristics such as an assumed average amount of flyash and #4 gauge rebar in concrete assemblies; the live loads, which were assumed to be 75psf based on other buildings; assumptions made about the type of insulation used; and virtually all details about the roofing assembly. Some elements of the building envelope were also either beyond the scope of this assessment to model or beyond the capacity of the Impact Estimator to model. Some significant omissions or simplifications in the CEME model including not modeling the underside of overhangs due to complexity and the inability of the Impact Estimator to model plaster, and treating foundations as if it had a constant thickness while in reality it has a complex array of dimensions to accommodate lab equipment. Furthermore, small "penthouses" sit on the top of the roof of the major section of the building. These structures are enclosed by corrugated metal sheeting around a frame of columns and open webbed steel joists. While the columns were modeled, this unique wall envelope had to be omitted because the Impact Estimator does not have the capacity to model it. Other challenges in modeling CEME including a blurriness of the drawings, which reduced accuracy, and the absence of data such as the live loads that floors were expected to carry.

OnScreen uses three types of "conditions" to do takeoffs: linear, area, and count conditions. How these three condition types were used for each assembly group is detailed in the next section.

3.2 Assembly Groups

3.2.1 Foundations

Foundation slabs were modeled using the *area condition* in OnScreen by enclosing the floor plan of the ground floor. On-grade slabs are named based on the thickness of the slab where, for example, a four-inch slab was named "OnGradeSlab1-4". In the Impact Estimator the length and width was inputted as the square root of the total area, except where one dimensions was increased to get the correct volume because of limited thickness options.

Three types of footings were present in CEME: column footings, strip footings (under exterior walls), and basement walls. Due to being underground, the exteriors walls that comprise the small basement were modeled as large strip footings.

Column footings were quantified by using the OnScreen *count condition*, with specified length, width, and height dimensions that produced a volume. The naming followed a simple format of “f.#”, where the number corresponded to how the footings were labeled in the drawings. The total summed volume of column footings was then divided into the most common thickness of the footings (18”) and the area square-rooted to get equal length and width dimensions to be input into the Impact Estimator. It is important to note that the column-footing model does not include the section of column that extends below ground to the footing, which was left out due to insufficient drawing detail.

Strip footings were measured in OnScreen using the *linear condition*, with specified width and height. Naming tried to follow that of the drawings with names like “f.A”, which would be strip footing “A”. However, footing names changed from one drawing to the next, with footings with different dimensions given the same letter designation and footings with the same dimension given new letter designation. In the takeoff process the same condition was used as long as the dimension fit, and where a letter designation was applied again to a footing with different dimensions in the drawings, it was differentiated in OnScreen by naming it with double letters, such as “f.JJ”. The structural drawings exhibited surprisingly little detail about the dimensions of strip footings and where one type ended and a different type began. As many separate conditions were created as the drawings had details for, and these generated volumes in cubic-feet of the footing. The volumes were summed and broken down, for the sake of the input fields of the Impact Estimator, into a two-foot thick slab with length and width equaling the square root of the area, adjusted for limited input field options.

Lastly the basement walls were modeled using the same process as strip footings with the nomenclature changed to the system used for a wall, which is detailed below. In all cases flyash had to be assumed to be average because the drawings did not specify it. A large range of rebar was used ranging from #4 to #8 and inside each footing several types were often combined. This was simplified to the most common rebar used, #4, because of the limit to one type in the Impact Estimator.

3.2.2 Floors

Many of the floor sections were modeled in the foundations, as they are slabs on grade. Other sections of floor were of two types: suspended slab and precast concrete T-beams, and these were modeled using the *area condition* of OnScreen. One suspended slab exists in the building overtop the small basement area, however, the stairwells were modeled as footing by approximated the thickness to achieve the closest volume possible and then measured linearly at an angle over the stairwell drawings. In OnScreen these were named using a short form of what they represent, such as “SuspSlab” or “staircase slab”.

The other floor sections that were not either slab on grade or suspended slabs were precast T-beam floors. The area calculated in OnScreen was divided into a long length and a much small span to ensure the span wasn’t too large for the Impact Estimator. The length was then divided into the bay size, as per the drawings, and the number of bays needed to make up the approximated length. The modeling of T-Beam floors was all an approximation as the Impact Estimator only has double-T beam assemblies, which is what the T-beams were inputted as.

3.2.3 Walls

Walls represent the bulk of the model, as there was a large number of walls with different parameters that had to be modeled independently instead of combining like the foundations and floors were. Walls were quantified in OnScreen using the *linear condition*, and were named to indicate the wall parameters. The nomenclature used for walls is illustrated below.

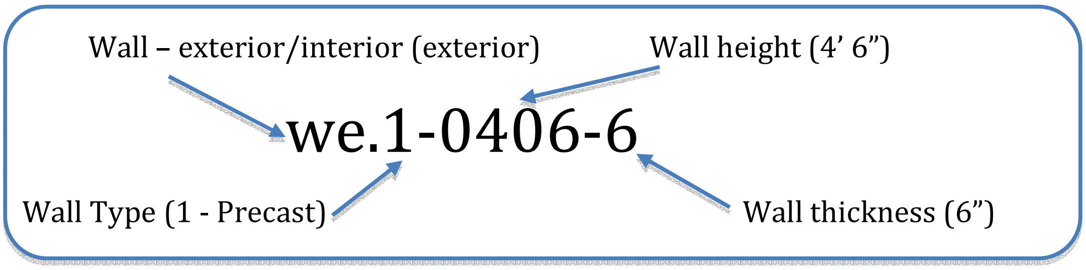


Figure 1: Wall Takeoff Nomenclature

Where wall types correspond to the following:

1. Precast Concrete Wall
2. Concrete Block Wall
3. Poured Concrete Wall
4. Wood Stud Wall
5. Concrete Block Fire Wall
6. Partial Height Wood Stud Wall (not used because only height was the difference - #4 used instead)
7. Wood Stud Wall with Sound Insulation (Type 1)
8. Wood Stud Wall with Sound Insulation (Type 2)
9. Steel Stud Wall
10. Steel Stud Partition Wall
11. Steel Stud Partition with Fiberglass Insulation

The assumptions about concrete, such as flyash content, were also used in the wall assemblies. Not all wall heights were given and were assumed based on to be the same as other walls enclosing rooms with similar purposes. Concrete block walls in the Impact Estimator have a thickness of 200mm, which was not consistent with the two types of thicknesses of blocks, 6in and 8in, used in CEME. To compensate for this, extra length was calculated to achieve the same volume of wall.

The characteristics of the studded walls had to be assumed because of the lack of drawing detail. Wood studs were modeled as kiln-dried, due to the age of the building, and steel studs were modeled as lightweight because they are not structural walls and mostly are used in CEME to divide space into offices. Assumptions about the envelope of walls also had to be assumed because the type of drywall was not specified, nor was most of the insulation beyond being “fiberglass”. Furthermore, the exterior of the building is insulated by a one-inch thick layer of “rigid insulation”, but the details of what that insulation is cannot be found in the drawings and was modeled as “Extruded Polystyrene”.

Doors were counted manually and recorded in the notes of each wall type in OnScreen. The material type of each door was not specified, and based on inspection of the building it was assumed that all doors in exterior walls were best approximated by a “steel exterior” material type; interior doors in concrete walls were best approximated by “steel interior”; and other doors such as in the wood stud walls were “Hollow Wood Core Interior” doors.

Windows posed a modeling challenge, as most windows in CEME are comprised of an assembly of windows in a frame similar to what is depicted below.

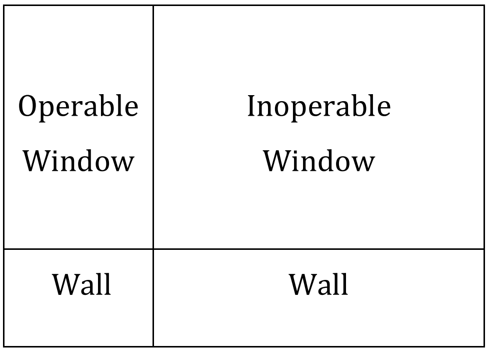


Figure 2: Common CEME Window Layout

The “wall” sections consist of an insulated steel stud wall with a “backing board forced with Glasweld asbestos”. This part of the window could not be modeled using the Impact Estimator because each wall assembly can only have one window input. Instead this portion was neglected in the wall assemblies, and the materials in the wall were added in extra basic materials, described in the section sub-section. This approximation, though necessary to make the model work, will also lead to more concrete than is actually present, which will hopefully be partially offset by the concrete not included in the model from the column footings. Because windows are not well represented on the plan-view drawings, the section-view drawings were used to determine the window inputs for each wall. The nomenclature used in OnScreen to differentiate walls was written on a hardcopy of the section-views and then an *area condition* for each window within a frame was created. A basic window unit like the one above was used to determine the area of inoperable, operable, and wall sections and was noted in the correspond wall notes along with the number of times that window unit repeated itself. The number of windows is one of the parameters that is needed in the Impact Estimator wall models, and by multiplying the area by the number of windows, the total area of windows in a wall was found. During the process of modeling CEME it was determined that approximating all windows as inoperable was the most effective way to proceed with the model due to the large amount of work involved in dividing up walls so that both operable and inoperable windows could be inputted.

3.2.4 Columns and Beams

CEME has columns throughout it that support beams upon which rest the precast T-beam flooring and roofing systems. Columns were counted using the OnScreen *count condition*, and named "c.#" or "c.#.#" with the first number corresponding to the number given to each building section in the drawings and the second number corresponding to the level. To each of these areas, the *area conditions* were used to find the area supported by the columns. Because in the Impact Estimator one floor to floor height can be inputted for assemblies, those columns and areas that had the same height were combined. The assemblies were simplified into a square model with the area supported by a group of columns square-rooted to determine a bay-size and span. The number of beams was approximated by using one less than the number of columns. Once again the live load was to be assumed, due to lack of information, to be 75psft based on other buildings at UBC.

3.2.5 Roofs

The roofing systems are arguably the least detailed aspect of the CEME building envelope. What is on the drawings is a roof envelope of steel decking, rigid insulation, and some sort of built up asphalt roofing. This vague assemblage was approximated by an envelope of "Ply Built-up Asphalt Roof System" with extruded polystyrene and glass felt, asphalt roofing, and commercial steel roofing system.

The envelope was built on two types of roof: the precast T-beam system described earlier and an open web steel joist system. In both cases the area of roof was determined using the *area condition* in OnScreen. T-beam system was modeled the same way as the floor T-beam systems, and the steel joists area was broken down into a reasonable width and corresponding span. Live load was, again, assumed to be 75psf as per earlier.

3.2.6 Extra Basic Materials

As mentioned earlier, the wall part of the window units was beyond the capacity of the Impact Estimator to model. Instead, a bill of materials of the steel stud wall envelope was generated by separately modeling the wall in the Impact Estimator as a one-foot height and long wall. This bill of materials per square foot was multiplied by the area of wall calculated when quantifying the windows in OnScreen to determine a list of extra basic materials that was used to compensate for this missing aspect of the wall assemblies.

The results of the OnScreen takeoffs and how that model was translated and approximated into EIE inputs can be found in Appendix A. The specific assumptions made in each of the input translation and approximation can be found in Appendix B.

3.3 Bill of Materials

Once the above assemblies are modeled in the Impact Estimator, the Impact Estimator software generates a *Bill of Materials*, which is show in Table 2.

Table 2: Bill of Materials - CEME Building Envelope LCA

Material	Quantity	Unit
#15 Organic Felt	99182.33031	ft2
1/2" Regular Gypsum Board	133567.2116	ft2
5/8" Regular Gypsum Board	1699.59993	ft2
Aluminium	10.39365	Tons
Ballast (aggregate stone)	187099.4876	pounds
Batt. Fiberglass	90716.40713	ft2
Concrete 20 MPa (flyash av)	2274.87927	yd3
Concrete 30 MPa (flyash av)	2427.518168	yd3
Concrete 60 MPa (flyash av)	802.6149798	yd3
Concrete Blocks	41257.9014	Blocks
EPDM membrane	1664.623591	pounds
Expanded Polystyrene	840.87668	ft2
Extruded Polystyrene	125427.5425	ft2
Galvanized Decking	38.51618754	Tons
Galvanized Sheet	30.35038317	Tons
Galvanized Studs	5.803083457	Tons
Glazing Panel	4.386394223	Tons
Joint Compound	11.21523724	Tons
Modified Bitumen membrane	8674.143368	pounds
Mortar	171.923013	yd3
Nails	3.823673177	Tons
Open Web Joists	37.06049604	Tons
Oriented Strand Board	15189.8151	ft2
Paper Tape	0.128707473	Tons
Rebar, Rod, Light Sections	206.8500522	Tons
Roofing Asphalt	128789.7391	pounds
Screws Nuts & Bolts	0.49623579	Tons
Small Dimension Softwood Lumber, kiln-dried	92.5418552	yd3
Softwood Plywood	20399.11719	ft2
Solvent Based Alkyd Paint	89.34512	US gallons
Standard Glazing	6658.03832	ft2
Type III Glass Felt	198363.7995	ft2
Water Based Latex Paint	23.69049972	US gallons
Welded Wire Mesh / Ladder Wire	12.41024849	Tons

By far the most dominant material is concrete, which makes sense as this is a concrete structure that has concrete foundations, floors, columns, beams, and T-beam joists as well as most of the walls being concrete. Aforementioned assumptions in modeling the column foundations, where only the footing was modeled and not the column that extends below grade to the footing, results in an under estimation of concrete. Meanwhile, those assumptions made for modeling the complex window systems, where wall panels were added using extra basic materials but there absence from the wall assemblies means an overestimation of concrete. Concrete may have further be over or under estimated due to the simplification of the foundations, which in reality have some areas that are thicker and some areas where trenches exist. Another dominant material related to concrete, rebar, is likely an underestimate as the approximation of #4 gauge was used while in reality a range was used and mixed within the concrete assemblies going as high as #8 gauge.

Other dominant materials include gypsum, wood studs, and steel studs. The *quantities* of these materials should be relatively accurate as very few assumptions were made in modeling these wall assemblies. The biggest source of quantity error for these will be several small wall sections that did not have heights specified on the drawings, and thus could be under or overestimated depending upon how accurate the assumption is. The major source of error for these is really the *type* of material, as *standard* gypsum, *kiln-dried* wood studs, and *lightweight* steel studs were not specified but assumed.

It is also important to note that significant amounts of material in the list are attributed to the roof of the building, which is quite large. As mentioned earlier, the major assumptions in terms of the very assemblies comprising the roof means that, while the quantities should be accurate, the materials could be incorrect.

4.0 SUMMARY MEASURE

The eight environmental impact categories investigated in the CEME model are made significantly easier to interpret by comparing the resultant data to that of a baseline, as all buildings have an impact. Thus in the following sections the CEME summary measures are compared to the results of six other LCA investigations of institutional buildings at UBC with the same goal and scope. This comparison is done by relating each of the buildings in terms of square-foot area academic building.

4.1 Energy Consumption

According to the Impact Estimator, energy consumption, or *primary energy*, includes all forms of energy, direct and indirect, that used to process the raw materials into the building product and transport it. Energy consumption is measured in mega-joules (MJ) (Athena Insitute, 2008). The energy consumption of CEME is shown below in Figure 3, broken up by life-cycle stage.

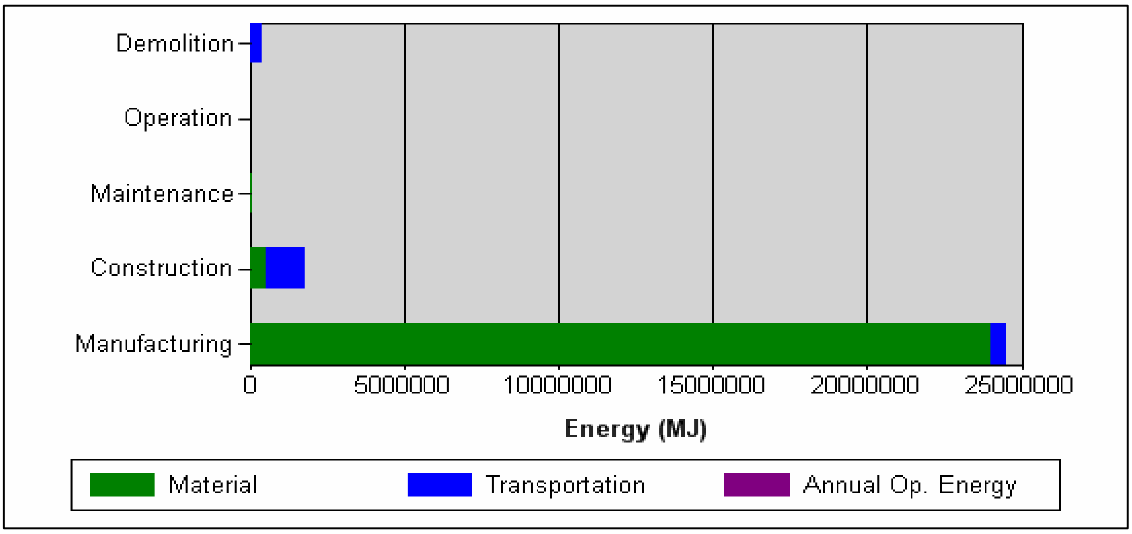


Figure 3: Energy Consumption Summary Measure Chart By Life Cycle Stages

The total energy amounts to 26,324,569.64MJ, and the graph indicates that this is almost exclusively from the manufacturing of materials. How this compares to other buildings, on a per square-foot comparison, is shown below in Table 3.

Table 3: Building Comparison of Primary Energy Consumption

Impact Category	Year	Primary Structural Component	Primary Energy Consumption
Units			**MJ**
Geography	1925	Wood	76.27
Hennings	1945	Concrete	143.08
Buchanan	1958-1960	Concrete	493.05
HRMacMillan	1967	Concrete	481.71
CEME	1976	Concrete	236.82
FSC	1998	Concrete/Wood	387.30
AERL	2004	Concrete	362.90
Average			**298.97**

CEME has a below average embodied energy, and has the second lowest energy of the concrete structure buildings. The source of the energy consumption can be better seen below in Figure 4.

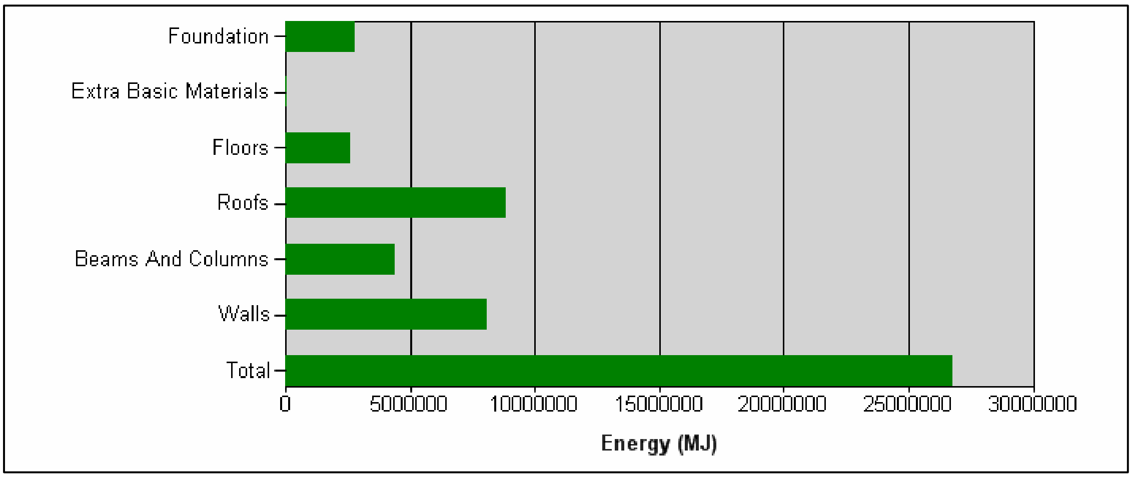


Figure 4: Energy Consumption Summary Measure Chart By Assembly Groups

The majority of the primary energy is consumed in the production of the roof and walls. This comparison is based on impacts per square-foot of building and CEME is a low building with a very large roof as the building does not have many levels. Most of the walls in the building are concrete, which will also be a major source of energy in the manufacturing.

4.2 Acidification Potential

The *acidification potential* is expressed as a hydrogen ion equivalency based on mass balance calculations. Acidification is a predominately regional impact that can affect human health when NO_X or SO_2 reach high concentrations (Athena Insitute, 2008). The acidification potential of CEME is shown below in Figure 5 broken up by life-cycle stage.

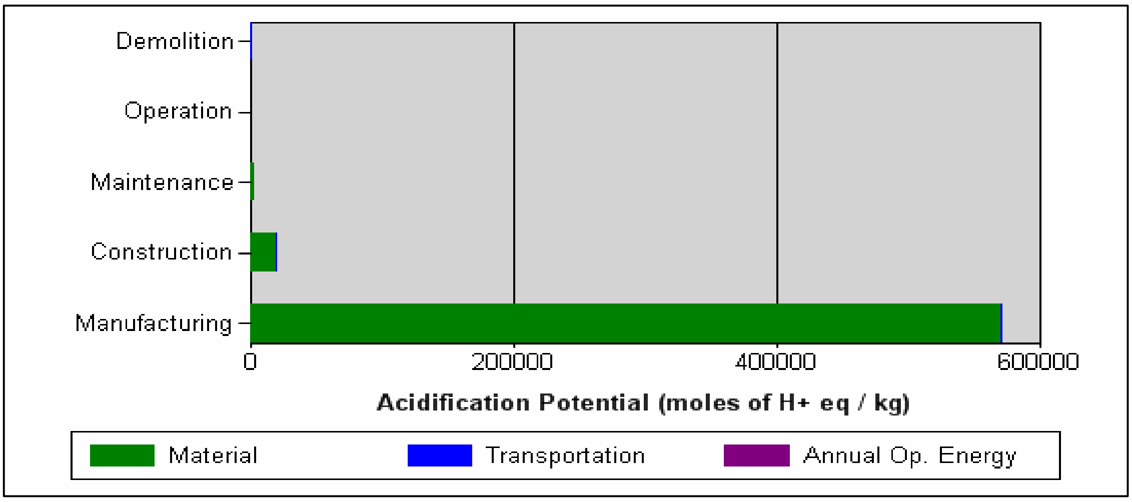


Figure 5: Acidification Potential Summary Measure Chart By Life Cycle Stages

As with primary energy, most of the NO_X or SO_2 is produced in the manufacturing process, and virtually exclusively due to the material production. Table 4 demonstrates how CEME compares, by square-foot of building to other buildings with regard to acidification potential.

Table 4: Building Comparison by Acidification Potential

Impact Category	Year	Primary Structural Component	Acidification Potential
Units			**(moles of H+ eq / kg)**
Geography	1925	Wood	1.45
Hennings	1945	Concrete	4.53
Buchanan	1958-1960	Concrete	13.40
HRMacMillan	1967	Concrete	13.85
CEME	1976	Concrete	5.311
FSC	1998	Concrete/Wood	7.60
AERL	2004	Concrete	9.06
Average			**7.93**

CEME once again is having nearly double the impact of the average of the five buildings. Figure 6 below shows where this impact is coming from.

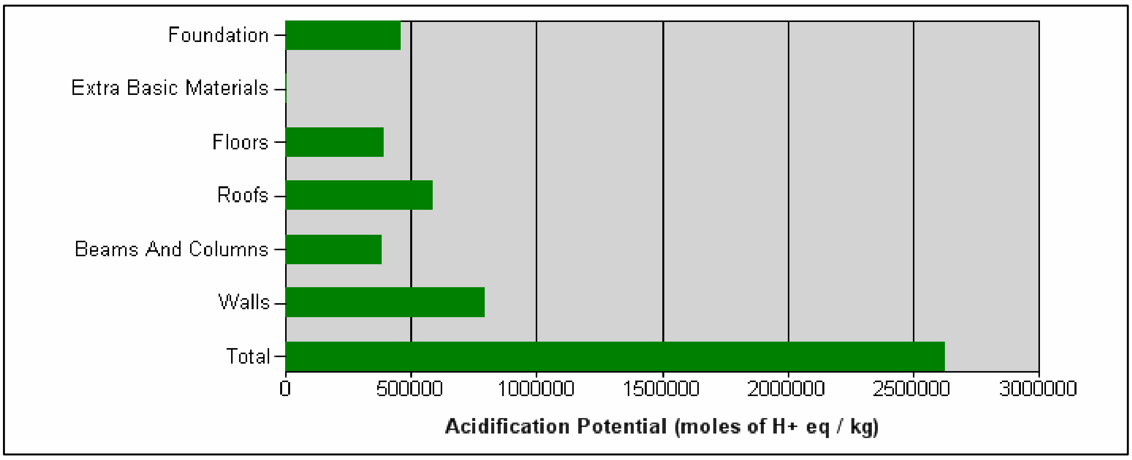


Figure 6: Acidification Potential Summary Measure Chart By Assembly Groups

According to the model the total acidification potential is 590,310.32 moles of H+ eq / kg. The sources of NO_X or SO_2 are coming from mix of all the assembly groups, except extra basic materials, with the walls being the closest thing to the dominant assembly. As the walls and roofs have the highest quantities, it perhaps can be interpreted that the thing these two envelopes have in common, extrude polystyrene, is the major source of this environmental impact.

4.3 Global Warming Potential

Global Warming Potential is expressed in terms of CO_2 equivalence by weight, because carbon dioxide is the most common reference point for greenhouse gas effects. The CO_2 equivalence for other greenhouse gases is a ratio of the heat trapping potential to CO_2, affected by a time horizon as different compounds have different reactivity in the atmosphere. The time horizon used in TRACI is one hundred years based on the Intergovernmental Panel on Climate Change (IPCC). The sources of greenhouse gas modeled include combustion for energy as well as processing of some raw resources such as in the production of concrete (Athena Insitute, 2008). The global warming potential of CEME is shown below in Figure 7 broken up by life-cycle stage.

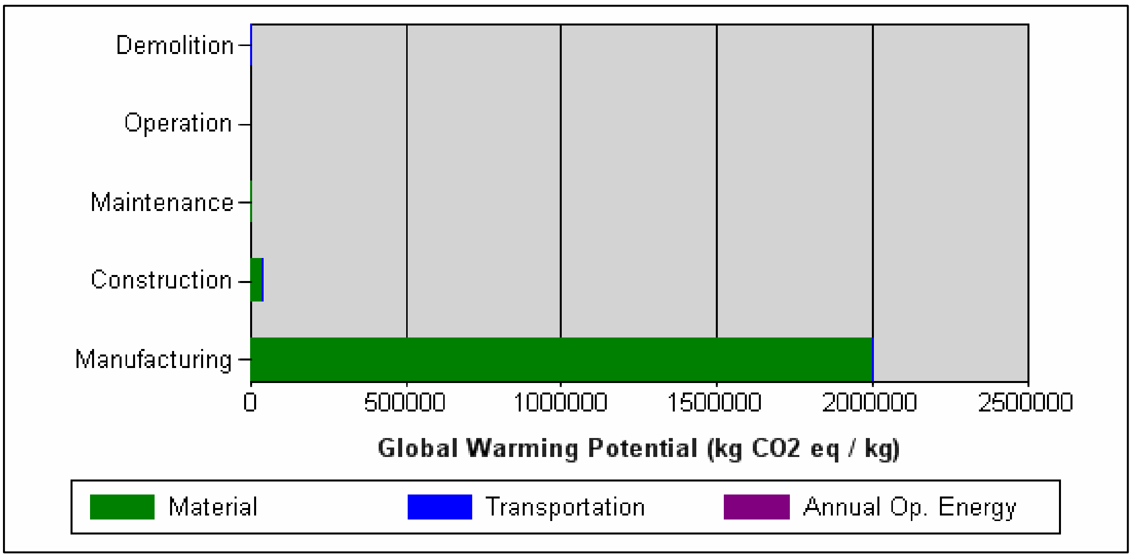


Figure 7: Global Warming Potential Summary Measure Chart By Life Cycle Stages

The global warming potential of CEME is located overwhelmingly in the manufacturing phase of it's life, at a value of 2,043,066.84kg CO2 eq/kg. This is compared to the other buildings that have been studied in Table 5.

Table 5: Building Comparison of Global Warming Potential

Impact Category	Year	Primary Structural Component	Global Warming Potential
Units			(kg CO2 eq / kg)
Geography	1925	Wood	3.87
Hennings	1945	Concrete	13.07
Buchanan	1958-1960	Concrete	46.60
HRMacMillan	1967	Concrete	42.72
CEME	1976	Concrete	18.38
FSC	1998	Concrete/Wood	29.83
AERL	2004	Concrete	28.60
Average			**25.54**

CEME proved to be below average in terms of its global warming potential. This is a key feature because, as mentioned earlier, this criterion was one of the most commonly used indicators of environmental impact. The distribution of how much each assembly is contributing is shown below in Figure 8.

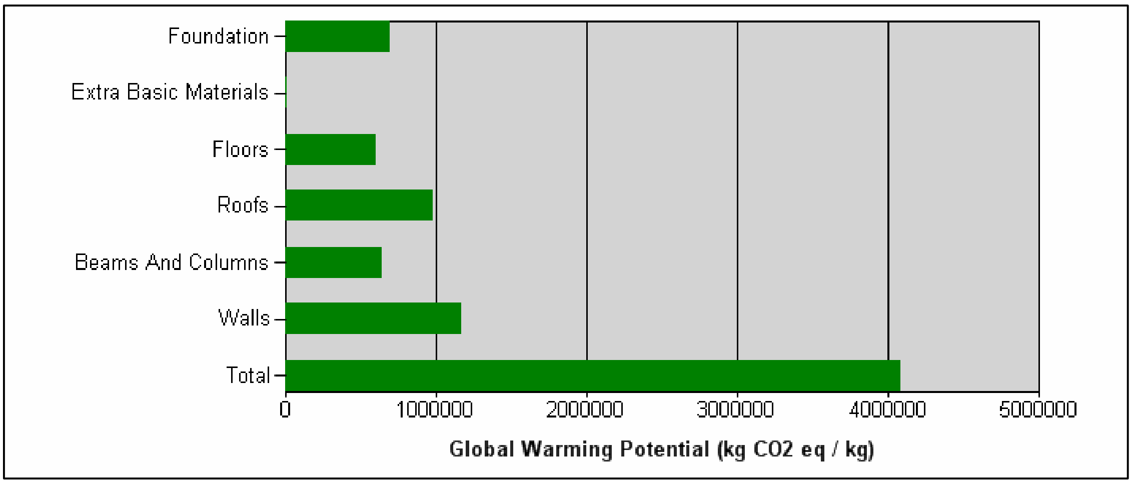


Figure 8: Global Warming Potential Summary Measure Chart By Assembly Groups

Like acidification potential, there is a fairly even contribution of the different assemblies with roofs and walls somewhat more dominant. This could be interpretted as extrude polystyrene also have a significant contribution to the emission of green house gases, as well as concrete manufacturing which is involved in every assembly.

4.4 HH Respiratory Effects Potential

According to the United States Environmental Protection Agency (EPA), particulates, especially from diesel fuel combustion, can have a dramatic affect on human health due to respiratory problems such as asthma, bronchitis, and acute pulmonary disease. The Impact Estimator uses TRACI's "Human Health Particulates from Mobile Sources" characterization factor to account for the mobility of particles of different sizes, thus equivocated them to a single size: $PM_{2.5}$ (Athena Insitute, 2008). The human health respiratory effects potential of CEME is shown below in Figure 9, broken up by life-cycle stage.

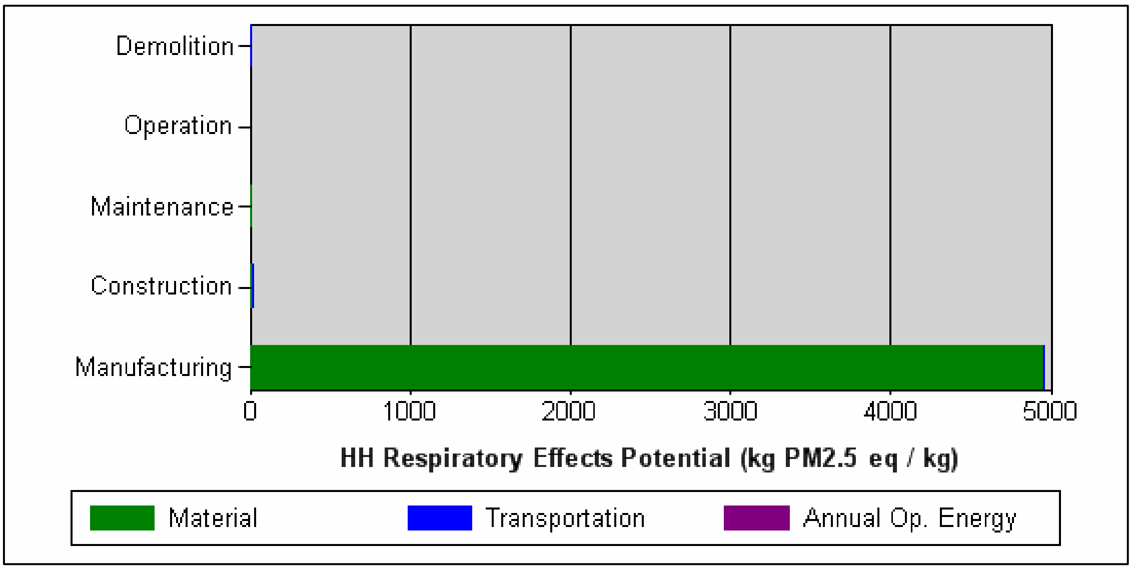


Figure 9: HH Respiratory Effects Potential Summary Measure Chart By Life Cycle Stages

The total HH Respiratory Effects Potential for CEME is estimated to be 4,971.65kg PM2.5 eq/kg. Below, the respiratory effect potential of CEME is compared to the other buildings in Table 6.

Table 6: Building Comparison of HH Respiratory Effects Potential

Impact Category	Year	Primary Structural Component	HH Respiratory Effects Potential
Units			**(kg PM2.5 eq / kg)**
Geography	1925	Wood	0.01
Hennings	1945	Concrete	0.05
Buchanan	1958-1960	Concrete	0.11
HRMacMillan	1967	Concrete	0.11
CEME	1976	Concrete	0.04
FSC	1998	Concrete/Wood	0.07
AERL	2004	Concrete	0.10
Average			**0.07**

The potential affects of all buildings are very small on a per square-foot basis, with all potential impacts being less than 1kg PM2.5 eq/kg. CEME, in this impact category, also is projected to have less than the average impact of buildings on campus. Below in Figure 10 the contribution of each assembly is shown.

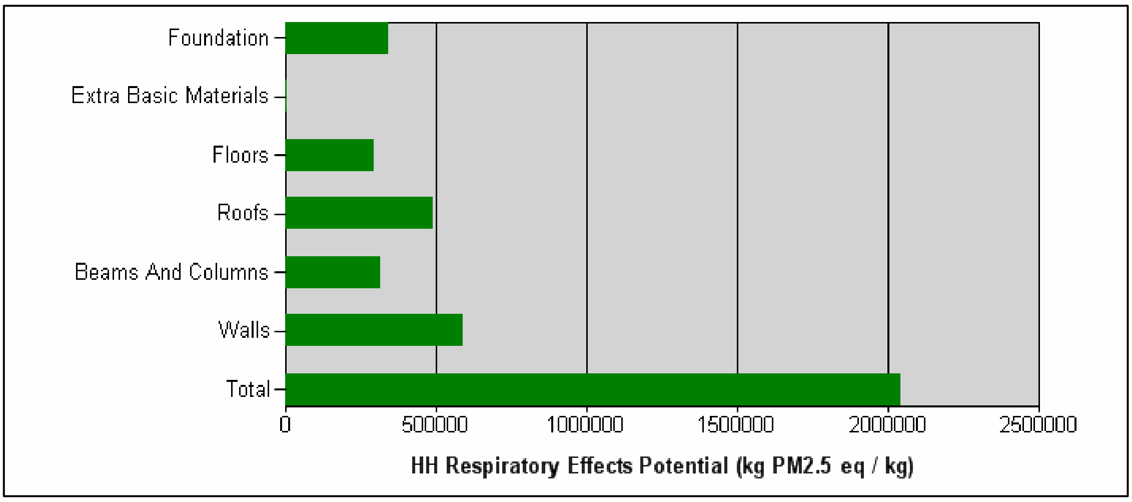


Figure 10: HH Respiratory Effects Potential Summary Measure Chart By Assembly Groups

The exact same profile seen before in the other impact categories is seen in the distribution of respiratory effect potential.

4.5 Ozone Depletion Potential

Ozone depletion has been a cause for global concern in the past. The *ozone depletion potential* is expressed in mass equivalence of CFC-11, based on their relative capacity to damage ozone in the stratosphere (Athena Insitute, 2008). The ozone depletion potential of CEME is shown below in Figure 11, broken up by life-cycle stage.

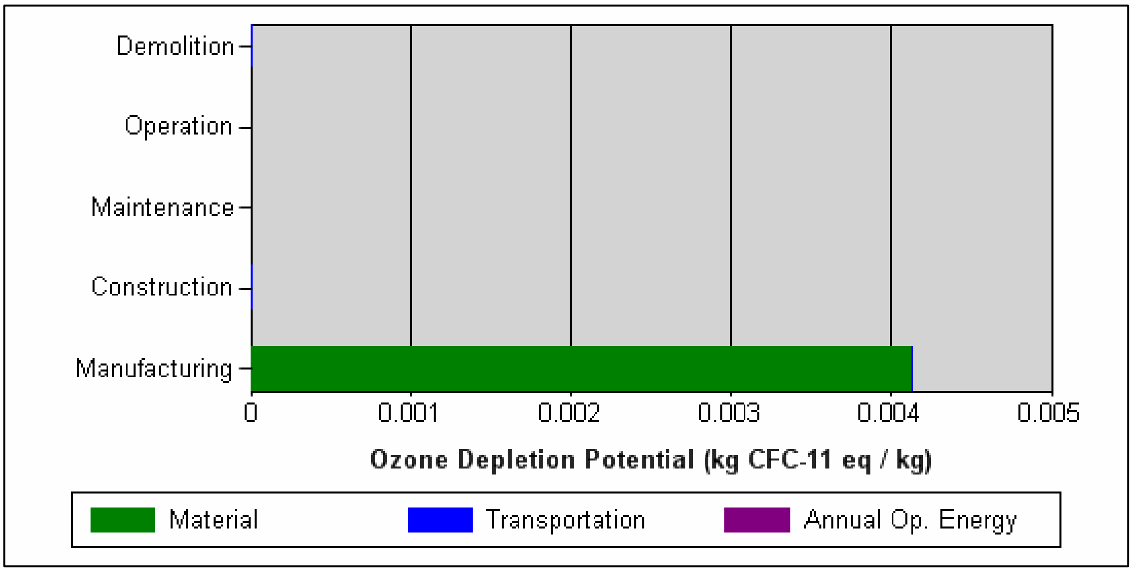


Figure 11: Ozone Depletion Potential Summary Measure Chart By Life Cycle Stages

So little ozone depletion is produced that in the summary measure *tables* the estimated values have all be reduced to zero. If rounding is prevented, 0.0041 kg CFC-11 eq/kg is the potential ozone depletion for CEME. Below in Table 7 is the comparison from building to building.

Table 7: Building Comparison of Ozone Depletion Potential

Impact Category	Year	Primary Structural Component	Ozone Depletion Potential
Units			(kg CFC-11 eq / kg)
Geography	1925	Wood	0.00
Hennings	1945	Concrete	0.00
Buchanan	1958-1960	Concrete	0.00
HRMacMillan	1967	Concrete	0.00
CEME	1976	Concrete	0.00
FSC	1998	Concrete/Wood	0.00
AERL	2004	Concrete	0.00
Average			**0.00**

CEME is not unique in its low potential impact for ozone depletion as all have the same insignificant potential. The graph showing the distribution of the extremely small potential ozone show the same distribution and magnitudes as in Figure 10.

4.6 Smog Potential

Smog, or *photochemical ozone creation potential*, takes place under certain climate conditions when air emissions are trapped at ground level and are exposed to sunlight. The effect is actually a result of the interaction of volatile organic chemicals (VOCs) and nitrogen oxides and expressed in terms of mass of ethylene equivalence (Athena Insitute, 2008). The smog potential of CEME is shown below in Figure 12, broken up by life-cycle stage.

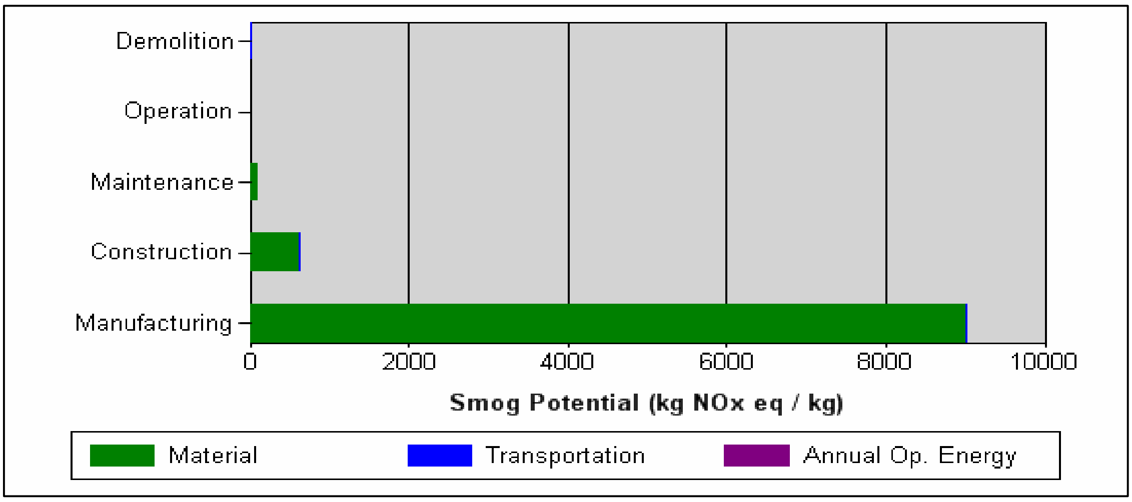


Figure 12: Smog Potential Summary Measure Chart By Life Cycle Stages

A more significant percentage of the total 9,646.78 kg NO_x eq/kg is contributed by the construction phase than other impacts, however it is still very small relative to the impacts of construction. The building comparison is illustrated below in Table 8.

Table 8: Building Comparison of Smog Potential

Impact Category	Year	Primary Structural Component	Smog Potential
Units			(kg NOx eq / kg)
Geography	1925	Wood	0.01
Hennings	1945	Concrete	0.07
Buchanan	1958-1960	Concrete	0.22
HRMacMillan	1967	Concrete	0.19
CEME	1976	Concrete	0.09
FSC	1998	Concrete/Wood	0.11
AERL	2004	Concrete	0.17
Average			**0.11**

The smog potential of CEME is consistent with the impact pattern that has emerged over the other impact categories of being less than the average. Smog potential is a bit higher, where most impacts CEME is just over 50% of the average it is closer to

75% of the average smog potential per square-foot. The source of this potential is shown in more detail in Figure 13.

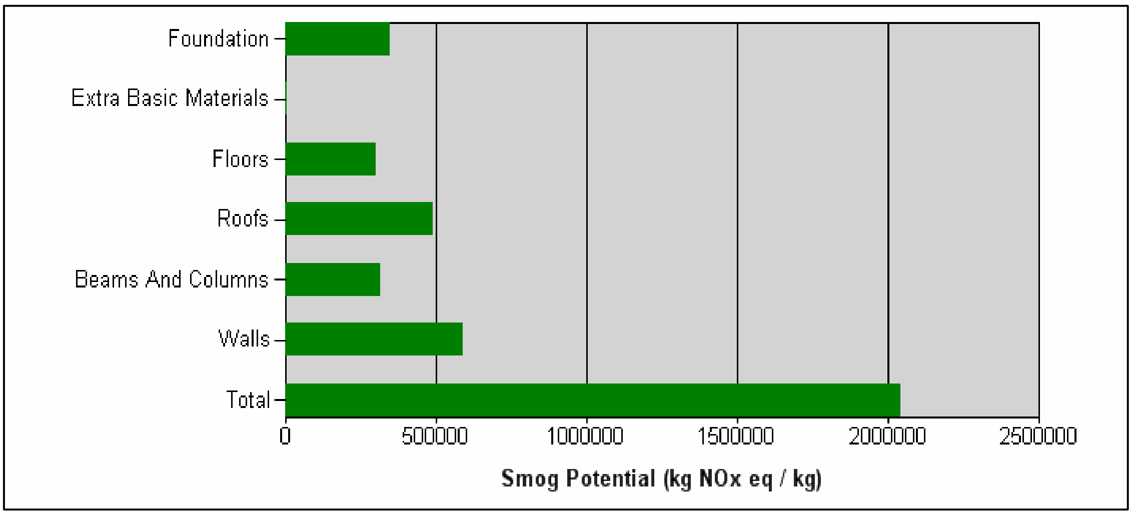


Figure 13: Smog Potential Summary Measure Chart By Assembly Groups

The impact distribution continues to follow the same pattern as with the other impact categories with the roof and walls the largest contributors.

4.7 Eutrophication Potential

When nutrients previously absence in an aquatic environment are introduced, photosynthetic plant life proliferate, potentially choked out other aquatic life and/or producing other effects such as foul orders. Eutrophication potential is expressed in terms of mass equivalence of nitrogen (Athena Insitute, 2008). The eutrophication potential of CEME is shown below in Figure 14, broken up by life-cycle stage.

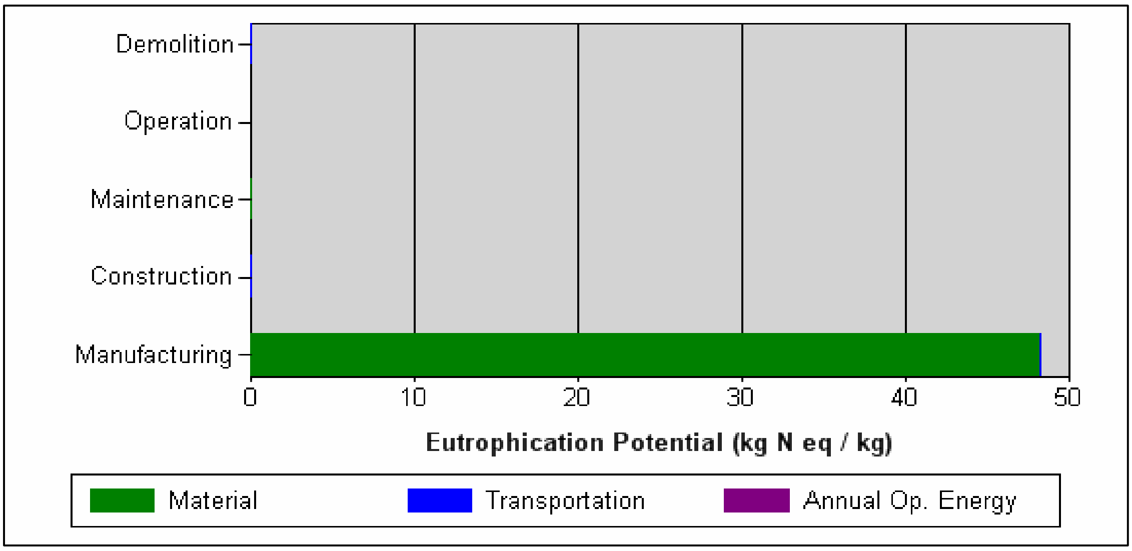


Figure 14: Eutrophication Potential Summary Measure Chart By Life Cycle Stages

The 48.25 kg N eq/kg of estimated eutrophication potential came exclusively from manufacturing. Below this value is compared with other buildings in Table 9.

Table 9: Building Comparison of Eutrophication Potential

Impact Category	Year	Primary Structural Component	Eutrophication Potential
Units			(kg N eq / kg)
Geography	1925	Wood	0.00004
Hennings	1945	Concrete	0.00034
Buchanan	1958-1960	Concrete	0.00182
HRMacMillan	1967	Concrete	0.00069
CEME	1976	Concrete	0.00043
FSC	1998	Concrete/Wood	0.00129
AERL	2004	Concrete	0.00057
Average			**0.0006**

CEME is less resource intensive than the other buildings on average, with a square-foot potential of less than 66% of the average. The eutrophication potential is an imporant factor in Vancouver where there is a great deal of aquatic environments. The contributions of the assemblies to the potential of eutrophication is demonstrated below in Figure 15.

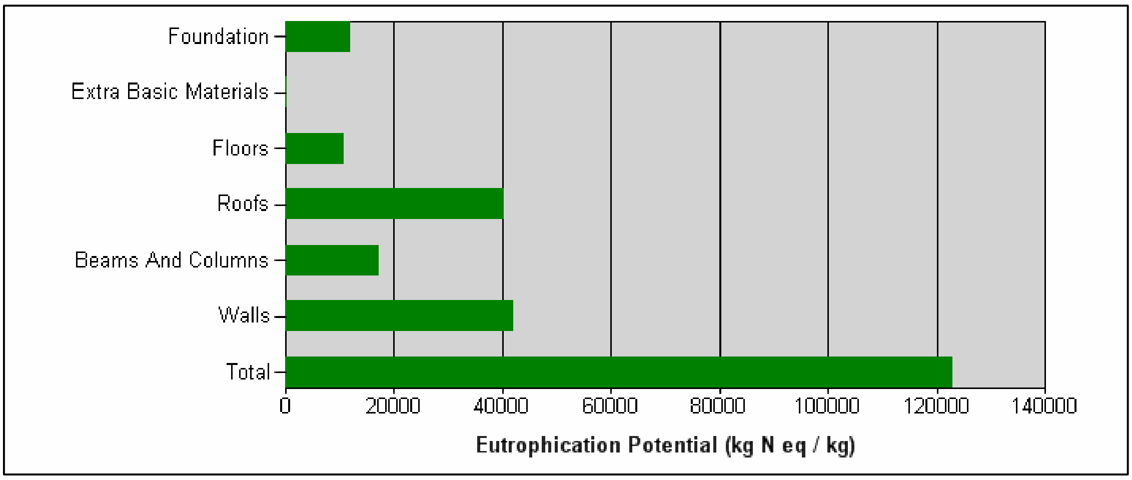


Figure 15: Eutrophication Potential Summary Measure Chart By Assembly Groups

Here we see a deviation from the usual profile as the roof and walls contribute more than double of any other assembly. It can be interpretted that perhaps the insulation in the envelope of both of these is contributing significantly.

4.8 Weight Resource Use

Raw resource use is the most challenging environmental impact to equate to a single, numerical scale. Not only does each resource have different affects, but the carrying capacity of the environmental from which it was taken also plays a major role in terms of the scope of impact. Subjective weighting was developed in consultation with resource extraction and environmental experts from across Canada for the use of this software. These weighted factors were combined into a set of resource-specific index numbers that are applied to the weight of resources in the Impact Estimator's Bill of Materials. The results are expressed what can be thought of as "ecologically weighted kilograms" that represent relative levels of environmental impact based on expert opinion. The weighted resources include limestone, iron ore, coal, and woodfiber, but exclude energy feedstocks used as raw materials (Athena Insitute, 2008). The weighted resource use of CEME is shown below in Figure 16, broken up by life-cycle stage.

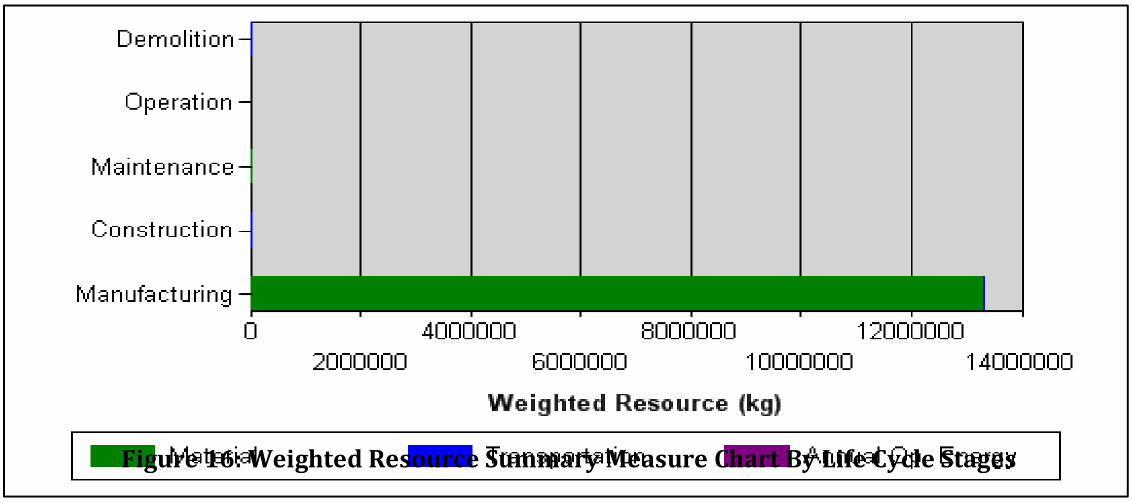


Figure 16: Weighted Resource Summary Measure Chart By Life Cycle Stages

The 13,369,455.30kg of weighted resource use comes exclusively form the manufacturing phase, which is to be expected, as this impact category is a measure of the raw resources processed. Below, the intensity of each building's resource requirements to build is compared in Table 10.

Table 10: Building Comparison of Weighted Resource Use

Impact Category	Year	Primary Structural Component	Weighted Resource Use
Units			**kg**
Geography	1925	Wood	35.12
Hennings	1945	Concrete	123.94
Buchanan	1958-1960	Concrete	390.86
HRMacMillan	1967	Concrete	294.62
CEME	1976	Concrete	120.27
FSC	1998	Concrete/Wood	270.84
AERL	2004	Concrete	144.03
Average			**184.81**

As in all the other categories, CEME is estimated to be below average in terms of resource consumption. What assemblies those resources are going to is illustrated below in Figure 17.

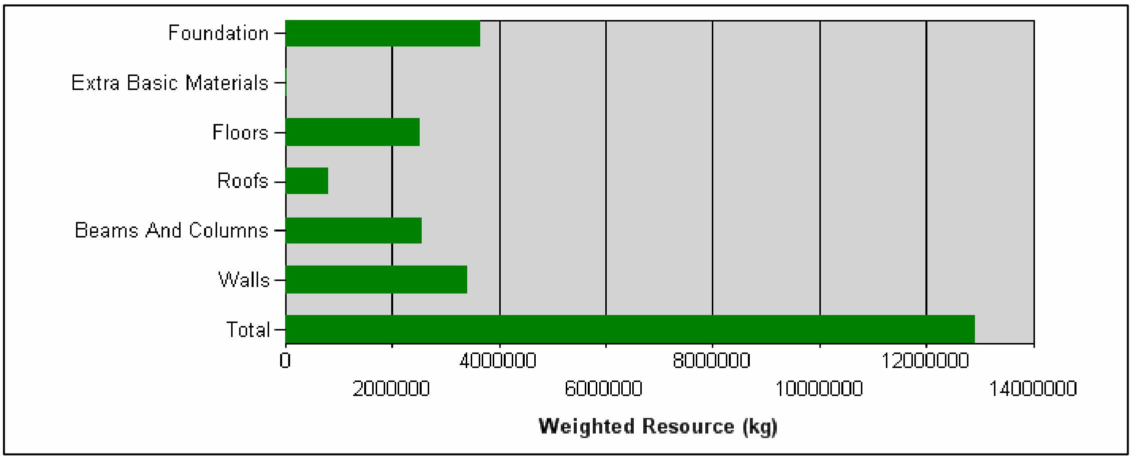


Figure 17: Weighted Resource Summary Measure Chart By Assembly Groups

The roof assembly has a much less significant contribution to resource consumption than in other categories of impact. This could be explained by the large section of roof that have an open webbed steel joist assembly while most of the other assemblies are concrete, and that the steel joist is much less resource intensive than the concrete and rebar in the other assemblies.

4.9 Complete Summary Measures

For ease of reference, the complete Summary Measures are collected below in Table 11.

Table 11: Overall CEME Summary Measures

		Total Effects (Man. + Constr.)	
Impact Category	**Units**	**Overall**	**Per Sq. Ft**
Primary Energy Consumption	MJ	26,324,569.64	236.82
Weighted Resource Use	kg	13,369,455.30	120.27
Global Warming Potential	(kg CO2 eq / kg)	2,043,066.84	18.38
Acidification Potential	(moles of H+ eq / kg)	590,310.32	5.31
HH Respiratory Effects Potential	(kg PM2.5 eq / kg)	4,971.65	0.04
Eutrophication Potential	(kg N eq / kg)	48.25	0.00
Ozone Depletion Potential	(kg CFC-11 eq / kg)	0.0041	0.00
Smog Potential	(kg NOx eq / kg)	9,646.78	0.09

4.10 Sensitivity Analysis

4.10.1 Sensitivity Analysis Purpose and Method

A sensitivity analysis was conducted on for five dominant materials to provide further information to help interpret the impact data. The Bill of Materials was used to determine what ten percent of these five materials were, and then summary measures were modeled for a ten-percent increase in extra basic materials for each material. To clearly illustrate the affect this ten-percent change had on the summary measures, the following graphs show the percent change in impact – being the increased level of impact less the original, all divided by the original.

4.10.2 Sensitivity Analysis of 30MPa Concrete

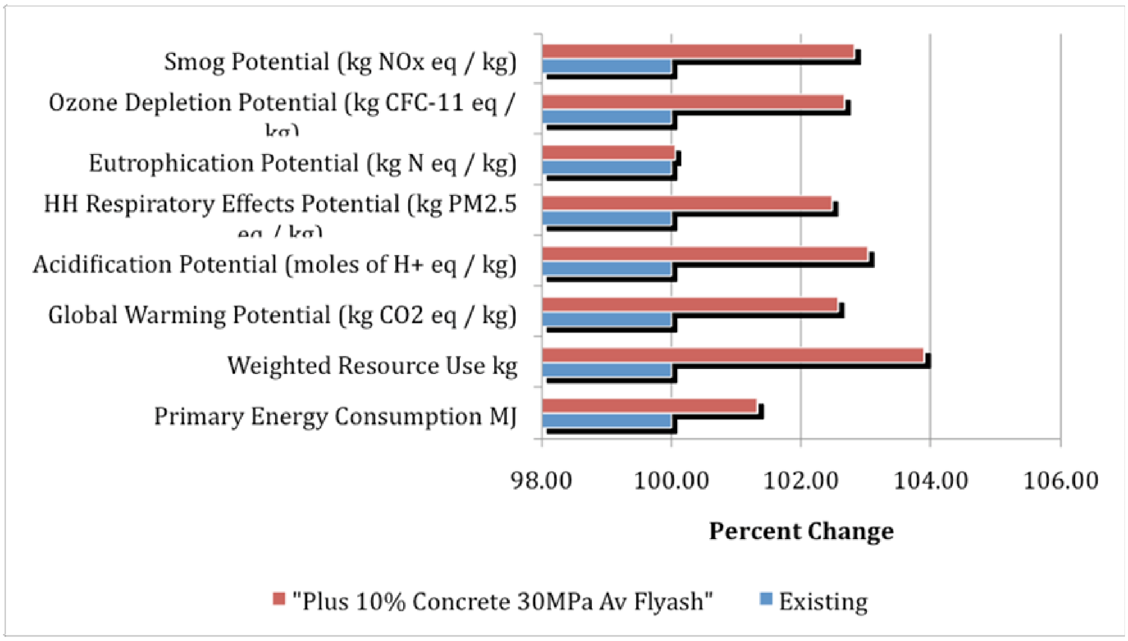


Figure 18: Sensitivity of Concrete (30MPa Av-flyash)

Changing the amount of 30MPa concrete by 10-percent results in one to four percent change in all impact categories except eutrophication. This is just one type of concrete, and other materials also contribute to the impact categories yet the influence suggests that the 30MPa concrete is one of the most dominant specific materials in the Bill of Materials. Errors made with regards to the concrete assumptions will thus have a bigger affect on the model.

4.9.3 Sensitivity Analysis of Gypsum

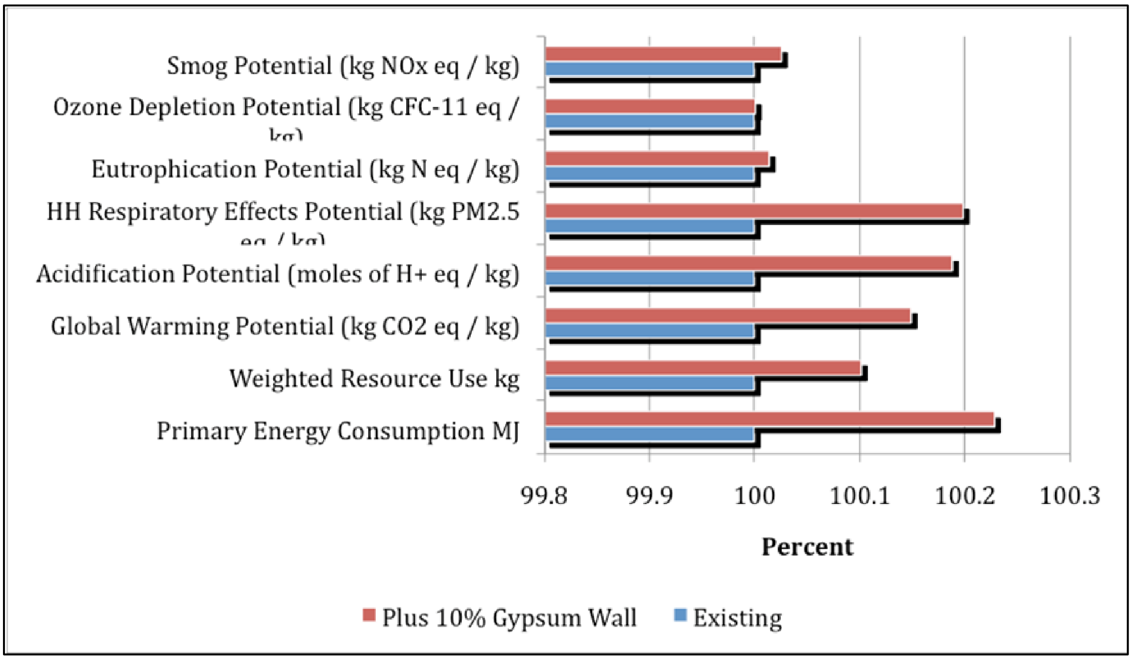


Figure 19: Sensitivity of Standard Gypsum

Gypsum affects the impact of the building much less than the concrete, which is to be expected as the volume of gypsum is a great deal less than concrete. Gypsum has almost no affect on the smog, ozone, or eutrophication potential, so we know that these impacts will not be affected much if additional drywall was installed in a renovation. Even the most significant change, primary energy consumption, did not break a 0.3% increase when gypsum was increased by ten-percent, so it would not be unreasonable to assume that approximations with gypsum had little affect on the model.

4.9.4 Sensitivity Analysis of Steel Studs

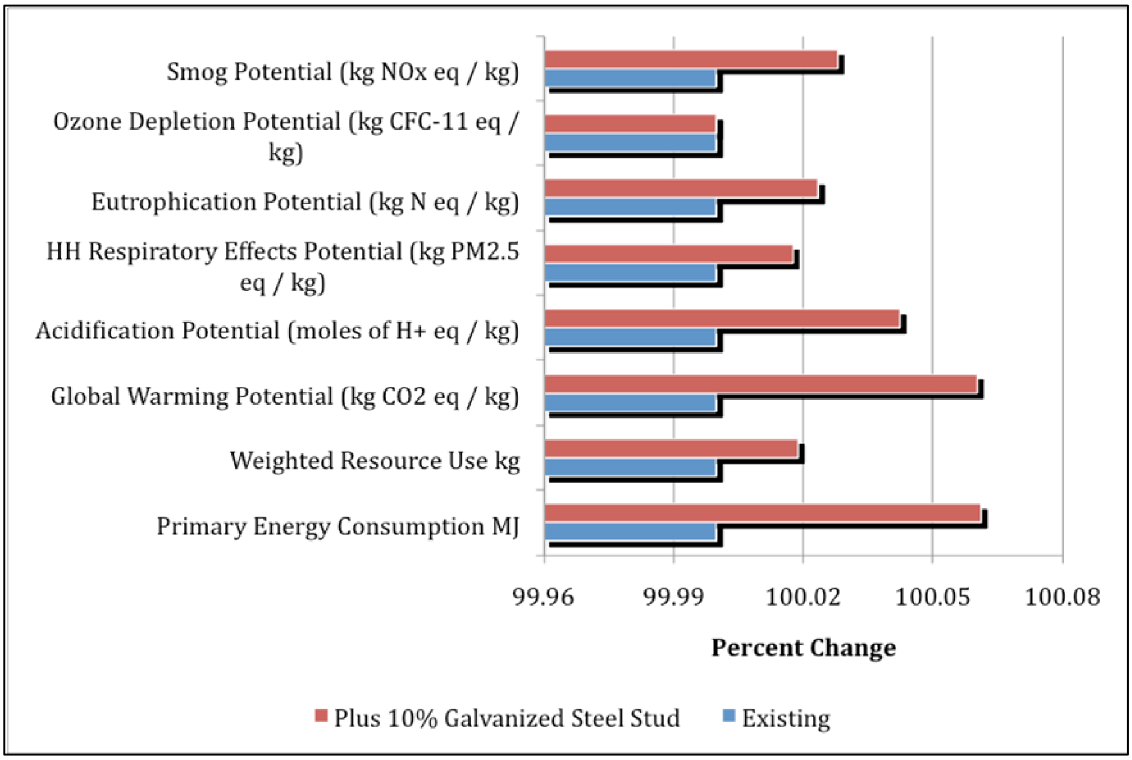


Figure 20: Sensitivity of Steel Studs

Steel studs, like gypsum, had a very marginal affect on the overall building. No impact was changed more than 0.07% by the ten-percent change in steel studs, thus assumptions made regarding steel studs are unlikely to have contributed to a significant error in the model.

4.9.5 Sensitivity Analysis of Extruded Polystyrene

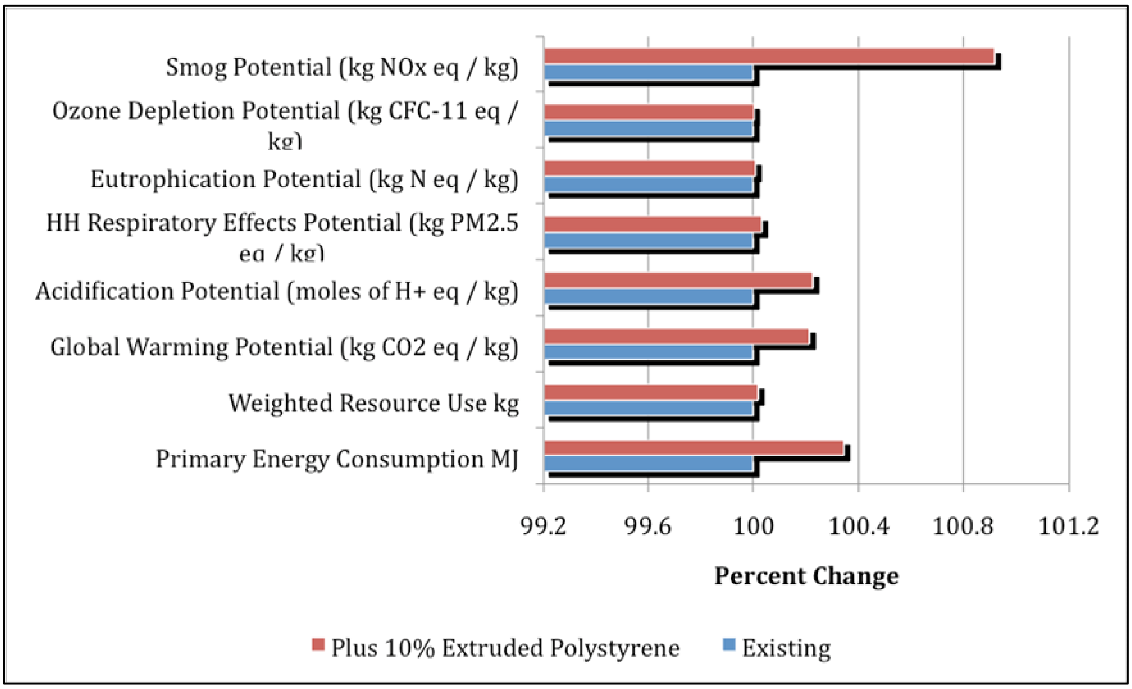


Figure 21: Sensitivity of Extruded Polystyrene

Despite the extensive use of extruded polystyrene throughout the entire exterior envelope of the building, it did not prove to have to be able to affect any impact category even one-percent with a ten-percent increase. As expected earlier, it does have a significant impact on smog, relative to the other impact categories.

4.9.6 Sensitivity Analysis of Wood Studs

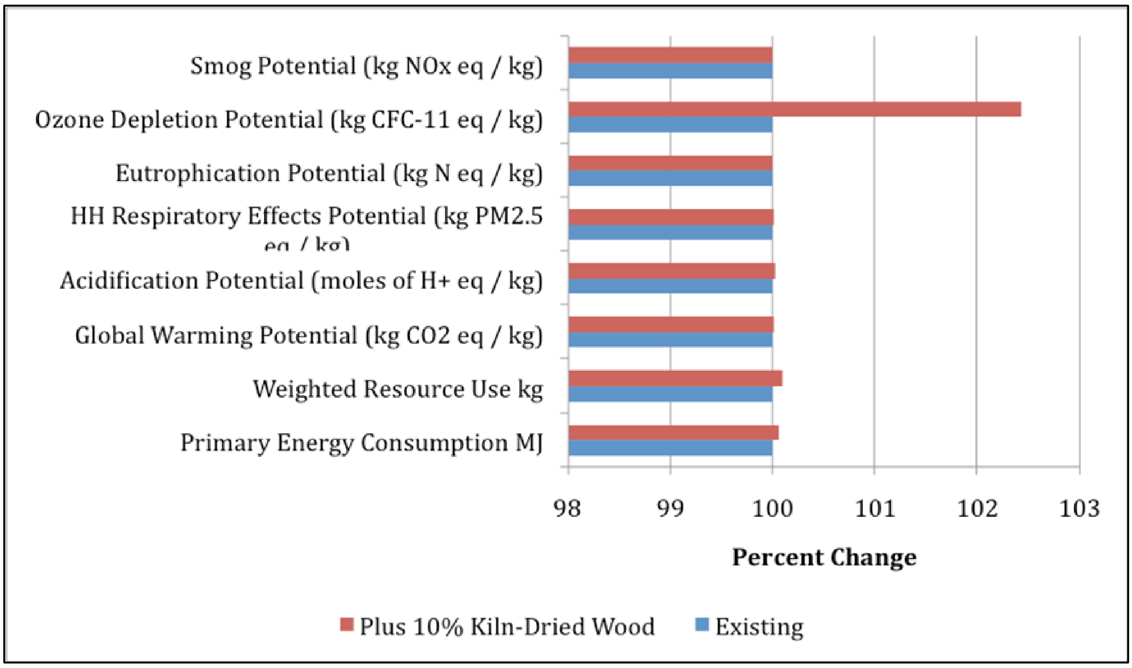


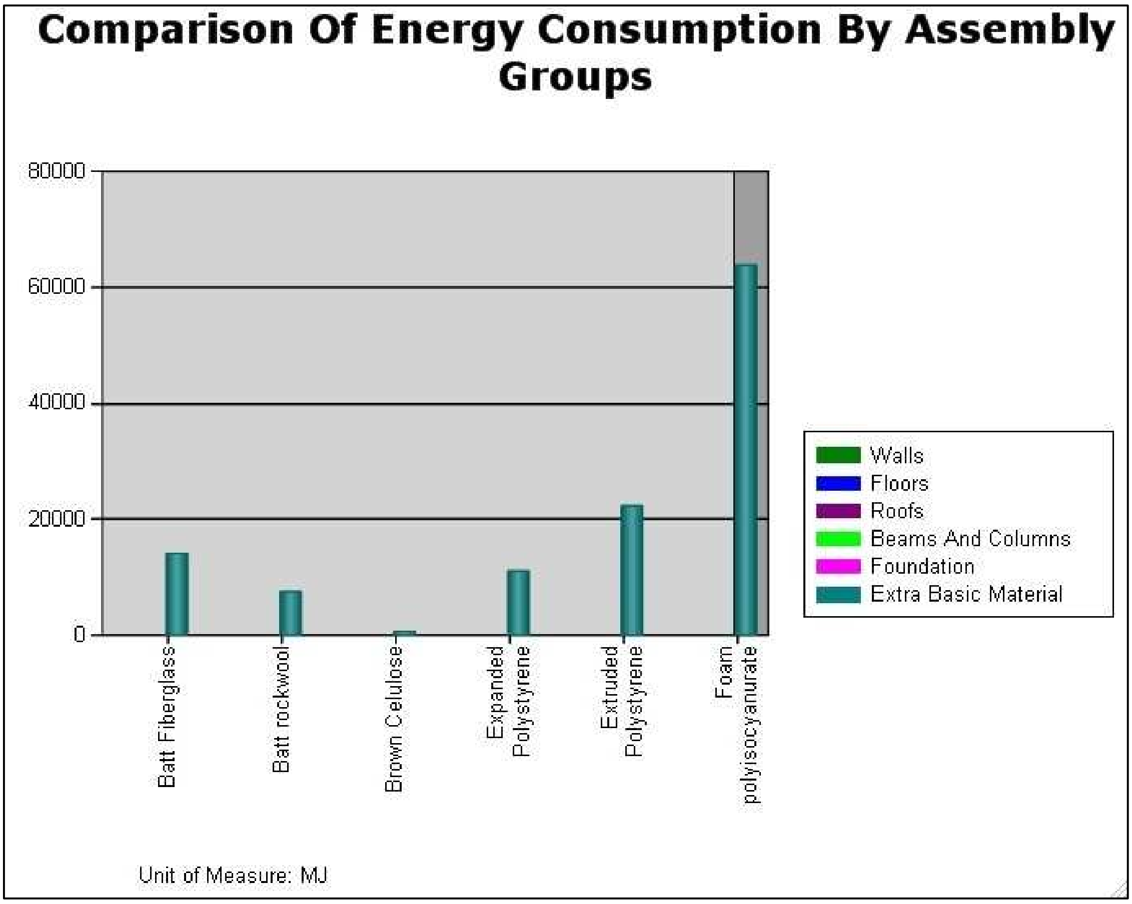
Figure 22: Sensitivity of Wood Studs

Changing the wood stud volume by ten-percent had almost no effect on the environmental impact categories despite having many interior wood walls. The only category it did affect was the impact category with the smallest magnitude of impact, ozone depletion.

5.0 BUILDING PERFORMANCE

A great deal of the energy consumed by the building goes to maintain a temperature, whether hotter or colder, different from the external environment. Improving the building envelope's resistance to heat transfer can thus greatly reduce the operating energy consumed by a building. Furthermore, there is the potential to have a better energy performance for a building and a lower embodied energy by choosing correctly. The Impact Estimator contains six types of insulation, and the embodied energy of each is shown below for a piece 1in thick and 1ft^2 in Figure 23.

Figure 23: Comparison of Embodied Energy of 1in-thick 1sq.ft Insulation



The *Primary Energy* being compared in Figure 23 "…includes all energy, direct and indirect, used to transform or transport raw materials into products and buildings, including inherent energy contained in raw or feedstock materials that are also used as common energy sources."[1] In the CEME Model, it was assumed that the "1in Rigid Insulation" could be approximated by extruded polystyrene. It is clear from the above graph that using any other type of insulation, besides foam polyisocyanurate, would have reduced the embodied energy of the insulation portion of the building envelope. However, each insulation type has unique properties in terms of resisting heat transference and this needs to be taken into account. A basic energy performance calculation is outlined in the following sections, followed the application of this method to the CEME building.

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[1] Athena Insitute. (2008). Athena Impact Estimator for Buildings v.4.0.51.

5.1 Basic Energy Performance of Building Envelope[2,3]

A basic energy model can be conducted to calculate the performance of the insulation of a building by using the R-values of different types of insulation. In short, the R-values are an indication of how *resistant* the material is to the transfer of energy, per inch. These will be discussed in more detail in the next section when different alternatives for CEME are compared.

The R-values are used in an equation to determine the heat loss, Q:

$$Q = (1/R) \times A \times \Delta T$$

Where,

R = Calculated R-Value in ft2 ºF h/BTU (Imperial units)
A = Assembly of interest ft2
ΔT = Inside Temperature – Outside Temperature in ºF

This simple equation can be used to find the average heat loss for a building by finding an average R-value. Because different parts of the building, such as the walls, windows, and roof have different R-values, it is necessary to create a weighted average where each assembly's area is multiplied by it's R-value and then summed with the other's and divided by the total area. Historical data can be used to determine the average temperature difference for a given time interval, such as days or months.

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[2] Future Stone. (n.d.). *Frequently Asked Questions*. Retrieved from The Future of Building: http://www.futurestone.com/faq.php#RSIvR

[3] Penn State University. (n.d.). *Chapter 10: HEAT LOSS CALCULATIONS*. Retrieved from Fayette, The Eberly Campus: http://www2.fe.psu.edu/~dxm15/aet121/Ch10HeatLoss.htm

5.2 CEME and Improved-CEME Energy Performance Comparison

The R-values for the insulation and windows modeled in the Impact Estimator are summarized below in Table 12.

Table 12: R-Values [4]

Insulation		R-value/Inch	R-value/Type
	Batt. Fiberglass	3.14	
	Batt. Rockwool	3.14	
	Blown cellulose	3.42	
	Expanded polystyrene	4	
	Extruded polystyrene	5	
	Foam polyisocyanurate	7.2	
Windows			
	Low E silver argon filled glazing (3mm glass with 1/2" airspace)		3.75
	Low E tin argon filled glazing (3mm glass with 1/2" airspace)		3.45
	Low E tin glazing (double panes, 1/2" airspace)		2.81
	Low E tin glazing (single pane)		1.68
	Standard glazing (double panes, 1/2" airspace)		2.04
	Standard glazing (single pane)		0.91
Other			
	Air Space (12mm)		0.22
	Double Pane Glass (12mm airspace)		2.04
	Double Pane Glass (Low E 0.2, 12mm airspace)		3.13

While foam polyisocyanurate had a much higher embodied energy, it also has a much higher R-value. Rockwool batt has an R-value over 60% of that of extruded polystyrene, yet the embodied energy is well below half. Thus we can see that in the

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[4] CertainTeed. (n.d.). *Bright Ideas: Vinyl Windows*. Retrieved from http://mouleselkgroveglass.com/AUBIdata_SliderspgsCto15.pdf

Colorado Energy. (n.d.). *R-Value Table*. Retrieved from Colorado Energy: http://www.coloradoenergy.org/procorner/stuff/r-values.htm design phase if rockwool batt had been chosen it could have reduced the embodied energy of the CEME building, while at the same time increasing it's R-value.

Applying the basic energy performance calculations using monthly historical climate data for UBC and the average room temperature of 68ºF (20ºc), we can determine a monthly and subsequently annual energy consumption. The R-value for 1in of extrude polystyrene, which is the approximation made in the CEME model and extends over all exterior walls and the roof, is R5, and the assumed standard glazing (single pane) windows have an R-value of 0.91.

To illustrate the value of increasing the R-value, a second energy analysis will be done with a higher R-value representing a different envelope. For the purpose of this example, building's R-value to the minimum Residential Environmental Assessment Program's (REAP's) insulation requirements;

- Roof – minimum R-40
- Exterior Wall Insulation – minimum R-18
- Energy Star Windows – minimum R-3.2

To meet these requirements an extra 3in of extrude polystyrene would need to be applied to the exterior walls; an extra 7in of extrude polystyrene would need to be applied to the roof; and all windows would need to be replaced with Low-E, silver argon filled glazing windows. The decision to simply apply the extra layers of extruded polystyrene is that any improvement involves the logistics of actually renovating the building and the simplest way is to add, rather than replace, to the insulation with that which is already in use.

The model of the "Improved" CEME has an embodied energy of 30,940,000,000,000J compared to the current CEME embodied energy of 26,370,000,000,000J. However, the resulting annual energy loss for the "Improved" CEME is only 686,313,568,172.83J relative to the current CEME losses of 4,255,039,360,361.96J. The results are shown below in Figure 24 where the cumulative energy consumed is graphed against the number of years the building is in operation. The "Year 0" indicates the embodied energy, which will be higher for the improved building.

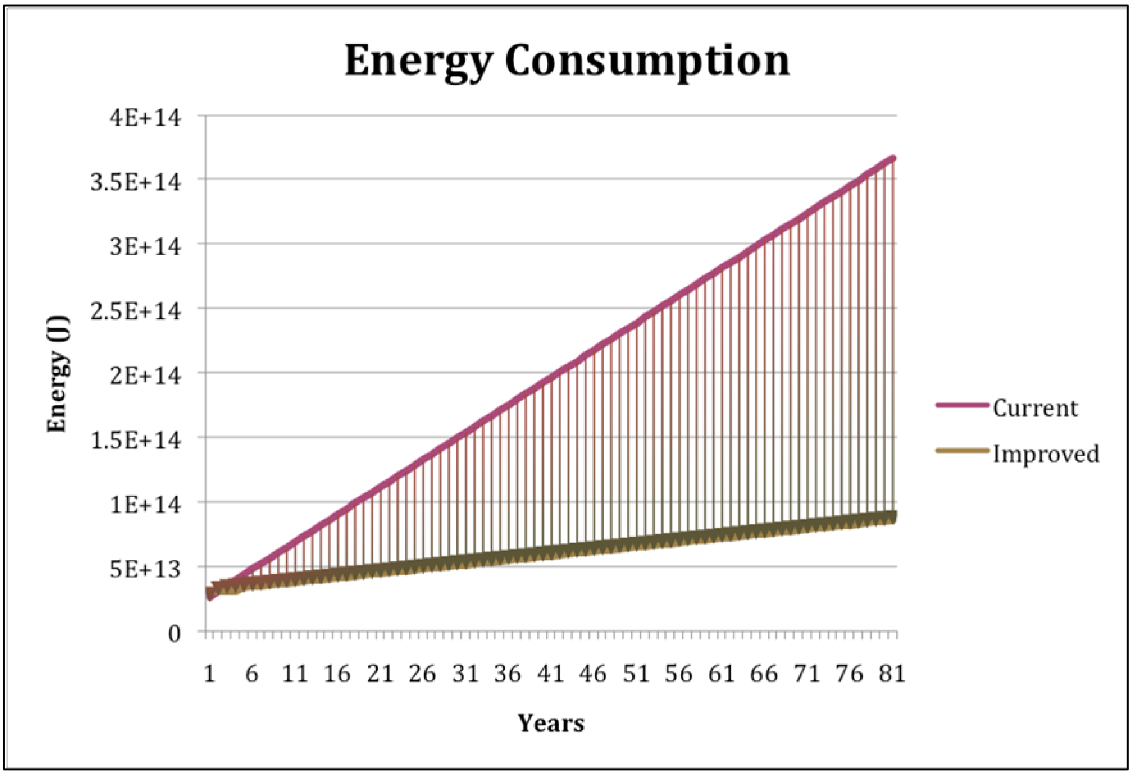

Figure 24: Cumulative Energy Consumption of CEME vs Improved CEME

Figure 24 clearly illustrates the vast quantity of energy that would be saved by the improvements in the building envelope, denoted by the pinstriped area between the two plots. This energy performance model is very basic and does not include other important factors such as the window frame type, which has its own rate of heat loss; the opening of doorways and windows; possible changes in the internal temperature of the building; and the insulation provided by the building envelope itself.

It was mentioned earlier that the improvements would result in a higher embodied energy as more materials were used in the envelope, and this is difficult to see on Figure 24. A closer look at when the cumulative energy of the improved building is surpassed by the cumulative energy of the current building is necessary to determine the *Energy Payback Period*.

5.3 Payback Period

The energy payback period is the time it takes for the energy invested in the improvements to be returned in energy savings. Figure 25, a close-up of Figure 24, shows this value to be roughly 1.25 years, or twenty-one months.

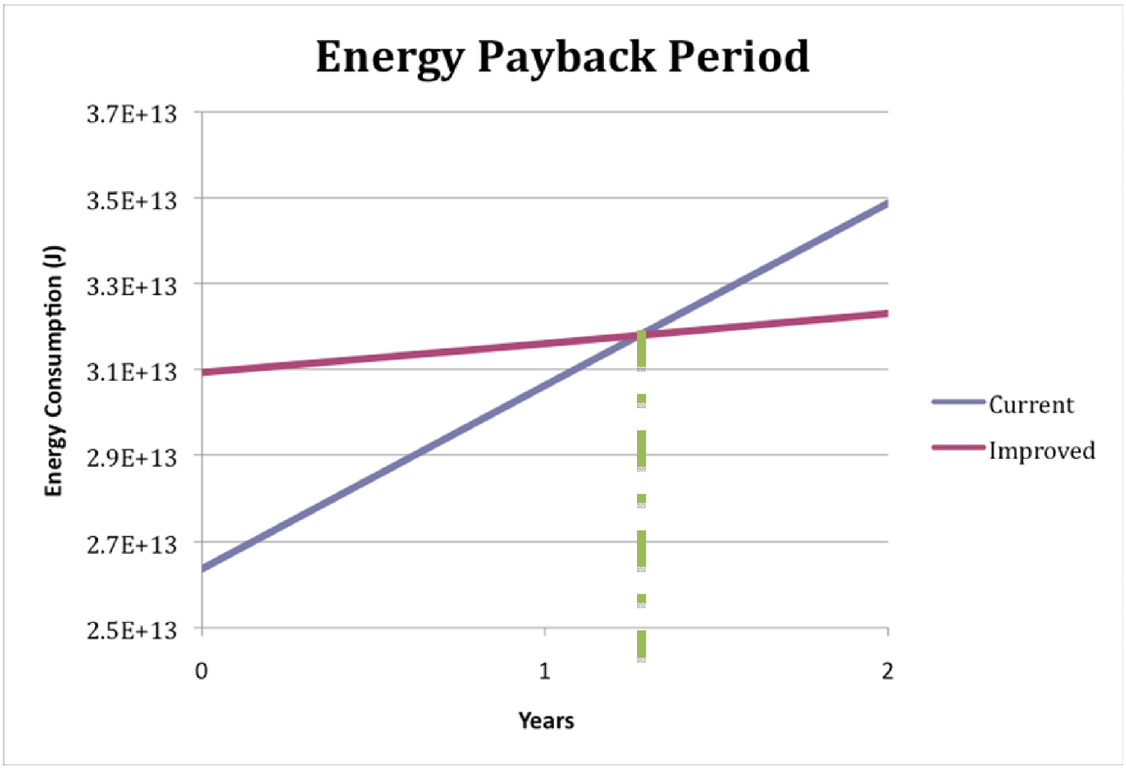

Figure 25: Energy Paback Period of Current vs Improved CEME

The results of this calculation indicate that even a considerable increase in insulation such as quadrupling the exterior wall insulation, twice over quadrupling the roof insulation, and replace all the windows will be worth the investment, in energy consumption terms, in less than two-years. Even if this simple energy performance calculation was inaccurate by an order of magnitude the results still support the decision to improve the building.

However, tradeoffs still exist as there will be additional impacts from the increase in materials beyond just the energy consumption, and in this example there would be a lot of waste generated from the old windows. These other factors would have to be addressed in the design decision-making process or the decision to renovate an existing building such as CEME. The use of thermal imaging could show where an existing building is losing most of its energy and those areas targeted to get the maximum reduction with the least intensive renovation.

6.0 CONCLUSIONS

This study illustrated an LCA of the CEME structural envelope from cradle to gate. The structural envelope of CEME, a mostly concrete structure, posed significant challenges to modeling including the limitations of the Impact Estimator to model some aspects of the building; the complexity of the building that demanded simplification for the model; and the poor quality of the drawings. Despite these challenges, a model was produced using reasonable approximations and assumptions, and the impact of this model was assessed using non-regionalized TRACI version 2.2.

The results of the impact assessment showed that CEME, compared to other institutional buildings at UBC, has less impact per square-foot of building than average. An investigation of how sensitive the environmental impacts are to changes of some of the main building materials showed that only concrete had a large effect on the overall impact of the building. This is not surprising, as the building is mostly comprised of concrete.

A simple energy calculation to assess the buildings energy performance showed that an investment in more resistant thermal conductivity for the envelope is worth the embodied energy investment as its embodied energy is paid back within less than two years. However, this simple assessment did not address other factors in deciding to upgrade the building envelope, as there will be additional environmental impacts from doing so as well as economic and renovation feasibility to consider.

Several different next steps would be appropriate for the LCA of CEME. Significant elements of the building were not modeled due to the limited assembly types in the Impact Estimator. One continuation of this project could be a more detailed look at those elements to determine an approximate Bill of Materials for them that could be added in extra basic materials. Similarly, accuracy of the LCA could be increased by modeling the building closer to its true form, instead of using approximations for the calculation of columns and beams or foundations.

Alternatively, an appropriate next step would be moving the model beyond cradle-to-gate by duplicating the model and making the adjustments from renovations. Each version of the building would have its own lifespan corresponding from its beginning to the beginning of the next “version” of the building, with the maintenance costs looked at more in depth.

APPENDIX A: EIE INPUTS

ATHENA® Environmental Impact Estimator

General Description				Key:	
	Project Name		CEME		Assumption
	Project Location		Vancouver		Calculation
	Building Life Expectancy		1 year		(to make values fit into Athena input fields or to approximate building)
	Building Type		Institutional		
	Operating Energy Consumption		-TBA-		
Assembly Group	**Assembly Type**	**Assembly Name**	**Input Fields**	**Input Values**	
				Known/Measured	EIE Inputs
1 Foundation					
	1.1 Concrete Slab on Grade				
		1.1.1 - OnGradSlab1-4			
			Length (ft)	-	230.1
			Width (ft)	-	230.1
			Thickness (in)	4.0	4.0
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
		1.1.2 - OnGradSlab2-5			
			Length (ft)	-	70.5
			Width (ft)	-	88.1
			Thickness (in)	5.0	4.0
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
		1.1.3 - OnGradSlab3-8			
			Length (ft)	-	84.9
			Width (ft)	-	84.9

			Thickness (in)	8.0	8.0
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
		1.1.4 - OnGradSlab4-10			
			Length (ft)	-	46.1
			Width (ft)	-	57.6
			Thickness (in)	10.0	8.0
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
	1.2 Concrete Footing				
		1.2.1 - Column Footings (F.1-31, f.Str, f.ramp)			
			Length (ft)	-	79.0
			Width (ft)	-	79.0
			Thickness (in)	-	18.0
			Concrete (psi)	4000.0	4000.0
			Concrete flyash %	-	Average
			Rebar	#4, #5,#6, #7, #8	#4
		1.2.2 -Strip Footing (f.A, f.B, f.B/C/E/F, f.B/C/E/F-2, f.C, f.D, f.G, f.J, f.JJ, f.JJJ)			
			Length (ft)	-	60.0
			Width (ft)	-	80.0
			Thickness (in)	24.0	18.0
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	#4, #5,#6, #7, #8	#4
		1.2.3 - Basement Walls (wf.1-0600-8, wf.1-1306-100, wf.1-1700-100)			
			Length (ft)	-	71.0
			Width (ft)	-	71.0
			Thickness (in)	-	12.0
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#4
2 Custom Wall					
	2.1 Concrete Tilt-up				
		2.1.1 - we.1-0406-6			

		Envelope	Wall Type	Exterior	Exterior
			Length (ft)	109.0	118.9
			Height (ft)	4.5	4.5
			Thickness (in)	6.0	5.5
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#4
			Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	
			Category	Insulation	Insulation
			Material	Rigid	Polystyrene Extruded
			Thickness (in)	1.0	1.0
		2.1.2 - we.1-0600-6			
		Envelope	Wall Type	Exterior	Exterior
			Length (ft)	110.0	120.0
			Height (ft)	6.0	6.0
			Thickness (in)	6.0	5.5
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#4
			Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	
			Category	Insulation	Insulation
			Material	Rigid	Polystyrene Extruded
			Thickness (in)	1.0	1.0
		2.1.3 - we.1-0700-6			
			Wall Type	Exterior	Exterior
			Length (ft)	200.0	218.2
			Height (ft)	7.0	7.0
			Thickness (in)	6.0	5.5
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#4
		Window Opening	Number of Windows	40.0	40.0
			Total Window Area (ft2)	740.0	740.0

		Envelope	Frame Type	Aluminium	Aluminium
			Glazing Type	-	Standard Glazing
			Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	
			Category	Insulation	Insulation
			Material	Rigid	Polystyrene Extruded
			Thickness (in)	1.0	1.0
		2.1.4 - we.1-0707-6			
		Envelope	Wall Type	Exterior	Exterior
			Length (ft)	279.0	304.4
			Height (ft)	7.6	7.6
			Thickness (in)	6.0	5.5
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#4
			Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	
			Category	Insulation	Insulation
			Material	Rigid	Polystyrene Extruded
			Thickness (in)	1.0	1.0
		2.1.5 - we.1-0906-6			
		Envelope	Wall Type	Exterior	Exterior
			Length (ft)	202.0	220.4
			Height (ft)	9.5	9.5
			Thickness (in)	6.0	5.5
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#4
			Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	
			Category	Insulation	Insulation
			Material	Rigid	Polystyrene Extruded
			Thickness (in)	1.0	1.0
		2.1.6 - we.1-1000-6			
			Wall Type	Exterior	Exterior

		Envelope	Length (ft)	73.0	79.6
			Height (ft)	10.0	10.0
			Thickness (in)	6.0	5.5
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#4
			Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	
			Category	Insulation	Insulation
			Material	Rigid	Polystyrene Extruded
			Thickness (in)	1.0	1.0
		2.1.7 - we.1-1400-6			
		Window Opening	Wall Type	Exterior	Exterior
			Length (ft)	70.0	76.4
			Height (ft)	14.0	14.0
			Thickness (in)	6.0	5.5
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#4
			Number of Windows	22.0	22.0
			Total Window Area (ft2)	396.0	396.0
			Frame Type	Aluminium	Aluminium
			Glazing Type	-	Standard Glazing
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	
			Category	Insulation	Insulation
			Material	Rigid	Polystyrene Extruded
			Thickness (in)	1.0	1.0
		2.1.8 - we.1-1407-6			
			Wall Type	Exterior	Exterior
			Length (ft)	477.0	520.4
			Height (ft)	14.6	14.6
			Thickness (in)	6.0	5.5
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average

			Rebar	-	#4
		Window Opening	Number of Windows	78.0	78.0
			Total Window Area (ft2)	1388.0	1388.0
			Frame Type	Aluminium	Aluminium
			Glazing Type	-	Standard Glazing
		Door Opening	Number of Doors	2.0	2.0
			Door Type	-	Steel Exterior
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	
			Category	Insulation	Insulation
			Material	Rigid	Polystyrene Extruded
			Thickness (in)	1.0	1.0
		2.1.9 - we.1-1506-6			
			Wall Type	Exterior	Exterior
			Length (ft)	71.0	77.5
			Height (ft)	15.5	15.5
			Thickness (in)	6.0	5.5
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#4
		Window Opening	Number of Windows	12.0	12.0
			Total Window Area (ft2)	222.0	222.0
			Frame Type	Aluminium	Aluminium
			Glazing Type	-	Standard Glazing
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	
			Category	Insulation	Insulation
			Material	Rigid	Polystyrene Extruded
			Thickness (in)	1.0	1.0
		2.1.10 - we.1-1600-6			
			Wall Type	Exterior	Exterior
			Length (ft)	426.0	464.7
			Height (ft)	16.0	16.0
			Thickness (in)	6.0	5.5
			Concrete (psi)	3000.0	3000.0

			Concrete flyash %	-	Average
			Rebar	-	#4
		Window Opening	Number of Windows	24.0	24.0
			Total Window Area (ft2)	387.0	387.0
			Frame Type	Aluminium	Aluminium
			Glazing Type	-	Standard Glazing
		Door Opening	Number of Doors	7.0	7.0
			Door Type	-	Exterior Steel
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	
			Category	Insulation	Insulation
			Material	Rigid	Polystyrene Extruded
			Thickness (in)	1.0	1.0
		2.1.11 - we.1-1606-6			
			Wall Type	Exterior	Exterior
			Length (ft)	42.0	45.8
			Height (ft)	6.5	6.5
			Thickness (in)	6.0	5.5
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#4
		Window Opening	Number of Windows	2.0	2.0
			Total Window Area (ft2)	28.0	28.0
			Frame Type	Aluminium	Aluminium
			Glazing Type	-	Standard Glazing
		Door Opening	Number of Doors	2.0	2.0
			Door Type	-	Exterior Steel
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	
			Category	Insulation	Insulation
			Material	Rigid	Polystyrene Extruded
			Thickness (in)	1.0	1.0
		2.1.12 - we.1-1700-6			
			Wall Type	Exterior	Exterior

			Length (ft)	283.0	308.7
			Height (ft)	17.0	17.0
			Thickness (in)	6.0	5.5
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#4
		Window Opening	Number of Windows	48.0	48.0
			Total Window Area (ft2)	862.0	862.0
			Frame Type	Aluminium	Aluminium
			Glazing Type	-	Standard Glazing
		Door Opening	Number of Doors	2.0	2.0
			Door Type	-	Exterior Steel
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	
			Category	Insulation	Insulation
			Material	Rigid	Polystyrene Extruded
			Thickness (in)	1.0	1.0
		2.1.13 - we.1-1800-6			
			Wall Type	Exterior	Exterior
			Length (ft)	389.0	424.4
			Height (ft)	18.0	18.0
			Thickness (in)	6.0	5.5
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#4
		Window Opening	Number of Windows	42.0	42.0
			Total Window Area (ft2)	903.0	903.0
			Frame Type	Aluminium	Aluminium
			Glazing Type	-	Standard Glazing
		Door Opening	Number of Doors	1.0	1.0
			Door Type	-	Exterior Steel
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	
			Category	Insulation	Insulation
			Material	Rigid	Polystyrene

					Extruded
			Thickness (in)	1.0	1.0
		2.1.14 - we.1-1900-6			
			Wall Type	Exterior	Exterior
			Length (ft)	344.0	375.3
			Height (ft)	19.0	19.0
			Thickness (in)	6.0	5.5
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#4
		Window Opening	Number of Windows	18.0	18.0
			Total Window Area (ft2)	315.0	315.0
			Frame Type	Aluminium	Aluminium
			Glazing Type	-	Standard Glazing
		Door Opening	Number of Doors	2.0	2.0
			Door Type	-	Exterior Steel
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	
			Category	Insulation	Insulation
			Material	Rigid	Polystyrene Extruded
			Thickness (in)	1.0	1.0
		2.1.15 - we.1-2100-6			
			Wall Type	Exterior	Exterior
			Length (ft)	273.0	297.8
			Height (ft)	21.0	21.0
			Thickness (in)	6.0	5.5
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#4
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	
			Category	Insulation	Insulation
			Material	Rigid	Polystyrene Extruded
			Thickness (in)	1.0	1.0
		2.1.16 - wi.1-1300-6			
			Wall Type	Interior	Interior

Envelope	Length (ft)	11.0	12.0
	Height (ft)	13.0	13.0
	Thickness (in)	6.0	5.5
	Concrete (psi)	3000.0	3000.0
	Concrete flyash %	-	Average
	Rebar	-	#4
	Category	Gypsum board	Gypsum board
	Material	Gysum Regular 1/2"	Gysum Regular 1/2"
	Thickness	-	
	Category	Insulation	Insulation
	Material	Rigid	Polystyrene Extruded
	Thickness (in)	1.0	1.0
2.1.17 - wi.1-1500-8			
Envelope	Wall Type	Interior	Interior
	Length (ft)	73.0	77.9
	Height (ft)	15.0	15.0
	Thickness (in)	8.0	7.5
	Concrete (psi)	3000.0	3000.0
	Concrete flyash %	-	Average
	Rebar	-	#4
	Category	Gypsum board	Gypsum board
	Material	Gysum Regular 1/2"	Gysum Regular 1/2"
	Thickness	-	
	Category	Insulation	Insulation
	Material	Rigid	Polystyrene Extruded
	Thickness (in)	1.0	1.0
2.1.18 - wi.1-1506-6			
	Wall Type	Interior	Interior
	Length (ft)	222.0	242.2
	Height (ft)	15.5	15.5
	Thickness (in)	6.0	5.5
	Concrete (psi)	3000.0	3000.0
	Concrete flyash %	-	Average
	Rebar	-	#4
Door Opening	Number of Doors	2.0	2.0
	Door Type	-	Exterior Steel
Envelope	Category	Gypsum board	Gypsum board
	Material	Gysum Regular 1/2"	Gysum Regular 1/2"

		Thickness	-	
		Category	Insulation	Insulation
		Material	Rigid	Polystyrene Extruded
		Thickness (in)	1.0	1.0
	2.1.19 - wi.1-1700-6			
	Envelope	Wall Type	Interior	Interior
		Length (ft)	19.0	20.7
		Height (ft)	17.0	17.0
		Thickness (in)	6.0	5.5
		Concrete (psi)	3000.0	3000.0
		Concrete flyash %	-	Average
		Rebar	-	#4
		Category	Gypsum board	Gypsum board
		Material	Gysum Regular 1/2"	Gysum Regular 1/2"
		Thickness	-	
		Category	Insulation	Insulation
		Material	Rigid	Polystyrene Extruded
		Thickness (in)	1.0	1.0
2.2 Concrete Block Wall	Conversion Factor=	0.762	6in/Athena	1.016
	2.2.1 - we.2-1506-6			8in/Athena
	Window Opening	Wall Type	Exterior	Exterior
		Length (ft)	321.0	244.6
		Height (ft)	15.5	15.5
		Number of Windows	12.0	12.0
		Total Window Area (ft2)	177.0	177.0
		Frame Type	Aluminium	Aluminium
		Glazing Type	-	Standard Glazing
	Door Opening	Number of Doors	2.0	2.0
		Door Type	-	Exterior Steel
	2.2.2 - wi.2-0900-6			0.0
		Wall Type	Interior	Interior
		Length (ft)	125.0	95.3
		Height (ft)	9.0	9.0
	Door Opening	Number of Doors	1.0	1.0
		Door Type	-	Steel Interior
	2.2.3 - wi.2-0900-6			0.0
		Wall Type	Interior	Interior
		Length (ft)	343.0	261.4

			Height (ft)	-	9.0
		Door Opening	Number of Doors	16.0	16.0
			Door Type	-	Steel Interior
		2.2.4 - wi.2-1000-6			0.0
			Wall Type	Interior	Interior
			Length (ft)	47.0	35.8
			Height (ft)	10.0	10.0
		Door Opening	Number of Doors	2.0	2.0
			Door Type	-	Steel Interior
		2.2.5 - wi.2-1000-8			0.0
			Wall Type	Interior	Interior
			Length (ft)	9.0	9.1
			Height (ft)	10.0	10.0
		Door Opening	Number of Doors	2.0	2.0
			Door Type	-	Steel Interior
		2.2.6 - wi.2-1300-8			0.0
			Wall Type	Interior	Interior
			Length (ft)	24.0	24.4
			Height (ft)	13.0	13.0
		Door Opening	Number of Doors	2.0	2.0
			Door Type	-	Steel Interior
		2.2.7 - wi.2-1206-6			0.0
			Wall Type	Interior	Interior
			Length (ft)	605.0	461.0
			Height (ft)	12.5	12.5
		Door Opening	Number of Doors	25.0	25.0
			Door Type	-	Steel Interior
		2.2.8 - wi.2-1506-6			0.0
			Wall Type	Interior	Interior
			Length (ft)	595.0	453.4
			Height (ft)	15.5	15.5
		Door Opening	Number of Doors	29.0	29.0
			Door Type	-	Steel Interior
		2.2.9 - wi.2-1606-6			0.0
			Wall Type	Interior	Interior
			Length (ft)	194.0	147.8
			Height (ft)	16.5	16.5
		Door Opening	Number of Doors	5.0	5.0
			Door Type	-	Steel Interior
		2.2.10 - wi.2-1800-6			0.0
			Wall Type	Interior	Interior
			Length (ft)	884.0	673.6
			Height (ft)	18.0	18.0

	Door Opening	Number of Doors	36.0	36.0
		Door Type	-	Steel Interior
	2.2.11 - wi.5-1000-8			0.0
		Wall Type	Interior	Interior
		Length (ft)	24.0	24.4
		Height (ft)	10.0	10.0
	Door Opening	Number of Doors	1.0	1.0
		Door Type	-	Steel Interior
	Envelope	Category	Gypsum board	Gypsum board
		Material	Gysum Regular 1/2"	Gysum Regular 1/2"
		Thickness	-	-
		Category	Gypsum board	Gypsum board
		Material	Gysum Regular 5/8"	Gysum Regular 5/8"
		Thickness	-	-
	2.2.12 - wi.5-1300-8			0.0
		Wall Type	Interior	Interior
		Length (ft)	107	108.7
		Height (ft)	13.0	13.0
	Door Opening	Number of Doors	5.0	5.0
		Door Type	-	Steel Interior
	Envelope	Category	Gypsum board	Gypsum board
		Material	Gysum Regular 1/2"	Gysum Regular 1/2"
		Thickness	-	-
		Category	Gypsum board	Gypsum board
		Material	Gysum Regular 5/8"	Gysum Regular 5/8"
		Thickness	-	-
2.3 Cast-in-Place				
	2.3.1 - we.3-1300-6			
		Wall Type	Exterior	Exterior
		Length (ft)	93.0	69.8
		Height (ft)	13.0	13.0
		Thickness (in)	6.0	8.0
		Concrete (psi)	3000.0	3000.0
		Concrete flyash %	-	Average
		Rebar	-	#5
	Door Opening	Number of Doors	1.0	1.0
		Door Type	-	Steel Exterior
	2.3.2 - we.3-1600-6			
		Wall Type	Exterior	Exterior

			Length (ft)	113.0	84.8
			Height (ft)	16.0	16.0
			Thickness (in)	6.0	8.0
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#5
		Window Opening	Number of Windows	2.0	2.0
			Total Window Area (ft2)	48.0	48.0
			Frame Type	Aluminium	Aluminium
			Glazing Type	-	Standard Glazing
		Door Opening	Number of Doors	3.0	3.0
			Door Type	-	Steel Exterior
		2.3.3 - we.3-1700-6			
			Wall Type	Exterior	Exterior
			Length (ft)	41.0	30.8
			Height (ft)	17.0	17.0
			Thickness (in)	6.0	8.0
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#5
		Window Opening	Number of Windows	2.0	2.0
			Total Window Area (ft2)	62.0	62.0
			Frame Type	Aluminium	Aluminium
			Glazing Type	-	Standard Glazing
		2.3.4 - we.3-1800-6			
			Wall Type	Exterior	Exterior
			Length (ft)	60.0	45.0
			Height (ft)	18.0	18.0
			Thickness (in)	6.0	8.0
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#5
		Door Opening	Number of Doors	2.0	2.0
			Door Type	-	Steel Exterior
		2.3.5 - wi.3-1300-6			
			Wall Type	Interior	Interior
			Length (ft)	92.0	69.0
			Height (ft)	13.0	13.0

			Thickness (in)	6.0	8.0
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#5
		Door Opening	Number of Doors	3.0	3.0
			Door Type	-	Steel Interior
		2.3.6 - wi.3-1300-8			
			Wall Type	Interior	Interior
			Length (ft)	49.0	49.0
			Height (ft)	13.0	13.0
			Thickness (in)	8.0	8.0
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#5
		Door Opening	Number of Doors	1.0	1.0
			Door Type	-	Steel Interior
		2.3.7 - wi.3-1600-6			
			Wall Type	Interior	Interior
			Length (ft)	47.0	35.3
			Height (ft)	16.0	16.0
			Thickness (in)	6.0	8.0
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#5
		Door Opening	Number of Doors	1.0	1.0
			Door Type	-	Steel Interior
		2.3.8 - wi.3-1700-6			
			Wall Type	Interior	Interior
			Length (ft)	40.0	30.0
			Height (ft)	17.0	17.0
			Thickness (in)	6.0	8.0
			Concrete (psi)	3000.0	3000.0
			Concrete flyash %	-	Average
			Rebar	-	#5
		Door Opening	Number of Doors	2.0	2.0
			Door Type	-	Steel Interior
		2.3.9 - wi.3-1800-6			
			Wall Type	Interior	Interior
			Length (ft)	140.0	105.0
			Height (ft)	18.0	18.0

		Thickness (in)	6.0	8.0
		Concrete (psi)	3000.0	3000.0
		Concrete flyash %	-	Average
		Rebar	-	#5
	Door Opening	Number of Doors	3.0	3.0
		Door Type	-	Steel Interior
	2.3.10 - wi.3-1800-8			
		Wall Type	Interior	Interior
		Length (ft)	151.0	151.0
		Height (ft)	18.0	18.0
		Thickness (in)	8.0	8.0
		Concrete (psi)	3000.0	3000.0
		Concrete flyash %	-	Average
		Rebar	-	#5
	Door Opening	Number of Doors	3.0	3.0
		Door Type	-	Steel Interior
2.4 Wood Stud				
	2.4.1 - wi.4-0700-6			
		Wall Type	Interior	Interior
		Length (ft)	238.0	238.0
		Height (ft)	7.0	7.0
		Sheathing	-	-
		Stud thickness	2 x 6	2 x 6
		Stud Spacing	16 o.c.	16 o.c.
		Stud Type	Kiln dried	Kiln dried
	Envelope	Category	Gypsum board	Gypsum board
		Material	Gysum Regular 1/2"	Gysum Regular 1/2"
		Thickness	-	-
	2.4.2 - wi.4-0900-6			
		Wall Type	Interior	Interior
		Length (ft)	9.0	9.0
		Height (ft)	9.0	9.0
		Sheathing	-	-
		Stud thickness	2 x 6	2 x 6
		Stud Spacing	16 o.c.	16 o.c.
		Stud Type	Kiln dried	Kiln dried
	Envelope	Category	Gypsum board	Gypsum board
		Material	Gysum Regular 1/2"	Gysum Regular 1/2"
		Thickness	-	-
	2.4.3 - wi.4-1206-6			

			Wall Type	Interior	Interior
			Length (ft)	70.0	70.0
			Height (ft)	12.5	12.5
			Sheathing	-	-
			Stud thickness	2 x 6	2 x 6
			Stud Spacing	16 o.c.	16 o.c.
			Stud Type	Kiln dried	Kiln dried
		Door Opening	Number of Doors	2.0	2.0
			Door Type	-	Hollow Wood Core Interior Door
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	-
		2.4.4 - wi.4-1300-6			
			Wall Type	Interior	Interior
			Length (ft)	1333.0	1333.0
			Height (ft)	13.0	13.0
			Sheathing	-	-
			Stud thickness	2 x 6	2 x 6
			Stud Spacing	16 o.c.	16 o.c.
			Stud Type	Kiln dried	Kiln dried
		Door Opening	Number of Doors	68.0	68.0
			Door Type	-	Hollow Wood Core Interior Door
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	-
		2.4.5 - wi.4-1506-6			
			Wall Type	Interior	Interior
			Length (ft)	175.0	175.0
			Height (ft)	15.5	15.5
			Sheathing	-	-
			Stud thickness	2 x 6	2 x 6
			Stud Spacing	16 o.c.	16 o.c.
			Stud Type	Kiln dried	Kiln dried
		Door Opening	Number of Doors	6.0	6.0
			Door Type	-	Hollow Wood Core Interior Door
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	-
		2.4.6 - wi.4-1600-6			

			Wall Type	Interior	Interior
			Length (ft)	27.0	27.0
			Height (ft)	16.0	16.0
			Sheathing	-	-
			Stud thickness	2 x 6	2 x 6
			Stud Spacing	16 o.c.	16 o.c.
			Stud Type	Kiln dried	Kiln dried
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	-
		2.4.7 - wi.4-1800-6			
			Wall Type	Interior	Interior
			Length (ft)	376.0	376.0
			Height (ft)	18.0	18.0
			Sheathing	-	-
			Stud thickness	2 x 6	2 x 6
			Stud Spacing	16 o.c.	16 o.c.
			Stud Type	Kiln dried	Kiln dried
		Door Opening	Number of Doors	15.0	15.0
			Door Type	-	Hollow Wood Core Interior Door
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	-
		2.4.8 - wi.4-506-6			
			Wall Type	Interior	Interior
			Length (ft)	30.0	30.0
			Height (ft)	5.5	5.5
			Sheathing	-	-
			Stud thickness	2 x 6	2 x 6
			Stud Spacing	16 o.c.	16 o.c.
			Stud Type	Kiln dried	Kiln dried
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	-
		2.4.9 - wi.7-1300-6			
			Wall Type	Interior	Interior
			Length (ft)	440.0	440.0
			Height (ft)	13.0	13.0
			Sheathing	3/8" Backing Board	OSB
			Stud thickness	2 x 6	2 x 6

			Stud Spacing	16 o.c.	16 o.c.
			Stud Type	Kiln dried	Kiln dried
		Door Opening	Number of Doors	13.0	13.0
			Door Type	-	Hollow Wood Core Interior Door
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	-
			Category	Insulation	Insulation
			Material	Fiberglass	Fiberglass Batt
			Thickness	2 1/2"	2 1/2"
		2.4.10 - wi.7-1506-6			
			Wall Type	Interior	Interior
			Length (ft)	20.0	20.0
			Height (ft)	15.5	15.5
			Sheathing	-	OSB
			Stud thickness	2 x 6	2 x 6
			Stud Spacing	16 o.c.	16 o.c.
			Stud Type	Kiln dried	Kiln dried
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	-
			Category	Insulation	Insulation
			Material	Fiberglass	Fiberglass Batt
			Thickness	2 1/2"	2 1/2"
		2.4.11 - wi.7-1800-6			
			Wall Type	Interior	Interior
			Length (ft)	25.0	25.0
			Height (ft)	18.0	18.0
			Sheathing	-	OSB
			Stud thickness	2 x 6	2 x 6
			Stud Spacing	16 o.c.	16 o.c.
			Stud Type	Kiln dried	Kiln dried
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	-
			Category	Insulation	Insulation
			Material	Fiberglass	Fiberglass Batt
			Thickness	2 1/2"	2 1/2"
		2.4.12 - wi.8-1300-6			
			Wall Type	Interior	Interior

			Length (ft)	658.0	658.0
			Height (ft)	13.0	13.0
			Sheathing	-	OSB
			Stud thickness	2 x 6	2 x 6
			Stud Spacing	16 o.c.	16 o.c.
			Stud Type	Kiln dried	Kiln dried
		Door Opening	Number of Doors	5.0	5.0
			Door Type	-	Hollow Wood Core Interior Door
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	-
			Category	Insulation	Insulation
			Material	Fiberglass	Fiberglass Batt
			Thickness	2 1/2"	2 1/2"
	2.5 Steel Stud				
		2.5.1 - we.9-1206-4			
			Wall Type	Exterior	Exterior
			Length (ft)	64.0	64.0
			Height (ft)	12.5	12.5
			Sheathing	-	-
			Stud thickness	1 5/8 x 3 5/8	1 5/8 x 3 5/8
			Stud Spacing	16 o.c.	16 o.c.
			Stud Weight	-	Light
		Window Opening	Number of Windows	12.0	12.0
			Total Window Area (ft2)	198.0	198.0
			Frame Type	Aluminium	Aluminium
			Glazing Type	-	Standard Glazing
		Door Opening	Number of Doors	2.0	2.0
			Door Type	-	Hollow Wood Core Interior Door
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	-
			Category	Insulation	Insulation
			Material	Batt insulation	Batt insulation
			Thickness (in)	3 1/2"	3 1/2"
		2.5.2 - we.9-1300-4 - NB			
			Wall Type	Exterior	Exterior
			Length (ft)	278.0	278.0

			Height (ft)	13.0	13.0
			Sheathing	-	-
			Stud thickness	1 5/8 x 3 5/8	1 5/8 x 3 5/8
			Stud Spacing	16 o.c.	16 o.c.
			Stud Weight	-	Light
		Window Opening	Number of Windows	52.0	52.0
			Total Window Area (ft2)	884.0	884.0
			Frame Type	Aluminium	Aluminium
			Glazing Type	-	Standard Glazing
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	-
			Category	Insulation	Insulation
			Material	Batt insulation	Batt insulation
			Thickness (in)	3 1/2"	3 1/2"
		2.5.3 - we.9-2000-4			
			Wall Type	Exterior	Exterior
			Length (ft)	77.0	77.0
			Height (ft)	20.0	20.0
			Sheathing	-	-
			Stud thickness	1 5/8 x 3 5/8	1 5/8 x 3 5/8
			Stud Spacing	16 o.c.	16 o.c.
			Stud Weight	-	Light
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	-
			Category	Insulation	Insulation
			Material	Batt insulation	Batt insulation
			Thickness (in)	3 1/2"	3 1/2"
		2.5.4 - wi.9-1506-4			
			Wall Type	Interior	Interior
			Length (ft)	84.0	84.0
			Height (ft)	15.5	15.5
			Sheathing	-	-
			Stud thickness	1 5/8 x 3 5/8	1 5/8 x 3 5/8
			Stud Spacing	16 o.c.	16 o.c.
			Stud Weight	-	Light
		Door Opening	Number of Doors	2.0	2.0
			Door Type	-	Hollow Wood Core Interior Door
		Envelope	Category	Gypsum board	Gypsum board

			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	-
			Category	Insulation	Insulation
			Material	Batt insulation	Batt insulation
			Thickness (in)	3 1/2"	3 1/2"
		2.5.5 - wi.10-1000-4			
			Wall Type	Interior	Interior
			Length (ft)	156.0	156.0
			Height (ft)	10.0	10.0
			Sheathing	-	-
			Stud thickness	1 5/8 x 3 5/8	1 5/8 x 3 5/8
			Stud Spacing	16 o.c.	16 o.c.
			Stud Weight	-	Light
		Door Opening	Number of Doors	7.0	7.0
			Door Type	-	Hollow Wood Core Interior Door
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	-
			Category	Insulation	Insulation
			Material	Batt insulation	Batt insulation
			Thickness (in)	2 1/2"	2 1/2"
			Category	-	Gypsum board
			Material	-	Gysum Regular 1/2"
			Thickness	1/2"	-
		2.5.6 - wi.10-1300-4			
			Wall Type	Interior	Interior
			Length (ft)	556.0	556.0
			Height (ft)	13.0	13.0
			Sheathing	-	-
			Stud thickness	1 5/8 x 3 5/8	1 5/8 x 3 5/8
			Stud Spacing	16 o.c.	16 o.c.
			Stud Weight	-	Light
		Door Opening	Number of Doors	8.0	8.0
			Door Type	-	Hollow Wood Core Interior Door
		Envelope	Category	Gypsum board	Gypsum board
			Material	Gysum Regular 1/2"	Gysum Regular 1/2"
			Thickness	-	-
			Category	Insulation	Insulation
			Material	Batt insulation	Batt insulation

			Thickness (in)	2 1/2"	2 1/2"
			Category	-	Gypsum board
			Material	-	Gysum Regular 1/2"
			Thickness	1/2"	-
3 Mixed Columns and Beams	3.1 Concrete Column and Concrete Beam				
		3.1.1 - c.1.p, c.2.p, c.3.2, c.3.p, c.4.2			
			Number of Beams	-	119.0
			Number of Columns	120.0	120.0
			Floor to floor height (ft)	10.0	10.0
			Bay sizes (ft)	-	17.6
			Supported span	-	17.6
			Live load (psf)	-	75.0
		3.1.2 - c.1-Low, c.3, c.5			
			Number of Beams	-	65.0
			Number of Columns	66.0	66.0
			Floor to floor height (ft)	12.5	12.5
			Bay sizes (ft)	-	17.8
			Supported span	-	17.8
			Live load (psf)	-	75.0
		3.1.3 - c.2			
			Number of Beams	-	22.0
			Number of Columns	23.0	23.0
			Floor to floor height (ft)	13.5	13.5
			Bay sizes (ft)	-	22.6
			Supported span	-	22.6
			Live load (psf)	-	75.0
		3.1.4 - c.2.b			
			Number of Beams	-	9.0
			Number of Columns	10.0	10.0

			Floor to floor height (ft)	14.0	14.0
			Bay sizes (ft)	-	22.3
			Supported span	-	22.3
			Live load (psf)	-	75.0
		3.1.5 - c.1-High			
			Number of Beams	-	30.0
			Number of Columns	31.0	31.0
			Floor to floor height (ft)	17.0	17.0
			Bay sizes (ft)	-	19.2
			Supported span	-	19.2
			Live load (psf)	-	75.0
	3.2 Concrete Column and No Beam				
		3.2.1 - c.2.2, c.5.p			
			Number of Beams	0.0	0.0
			Number of Columns	40.0	40.0
			Floor to floor height (ft)	10.0	10.0
			Bay sizes (ft)	-	17.2
			Supported span	-	17.2
			Live load (psf)	-	75.0
		3.2.2 - c.4			
			Number of Beams	0.0	0.0
			Number of Columns	36.0	36.0
			Floor to floor height (ft)	14.5	14.5
			Bay sizes (ft)	-	22.6
			Supported span	-	22.6
			Live load (psf)	-	75.0
4 Roofs	4.1 Open Web Steel Joist				
		4.1.1 - Steel-Joist			
			Roof Width (ft)	-	30.0
			Span (ft)	-	1338.0
			With/Without Concrete Topping	Without	Without
			Live load (psf)	-	75.0
		Envelope	Category	Ply Built-up Asphalt Roof System	Ply Built-up Asphalt Roof System

		Material	-	Extruded Polystyrene, Glass Felt
		Thickness (in)	1 1/2"	1 1/2"
		Category	Roofs	Roofs
		Material	Roof Envelope	Roof Envelope
		Thickness (in)	-	Roofing Asphalt
		Category	Steel Roof System	Steel Roof System
		Material	-	Commercial
		Thickness (in)	-	-
	4.1.2 - Steel-Joist-Pent			
		Roof Width (ft)	-	15.0
		Span (ft)	-	402.6
		With/Without Concrete Topping	Without	Without
		Live load (psf)	-	75.0
		Category	Steel Roof System	Steel Roof System
		Material	-	Commercial
		Thickness (in)	-	-
4.2 Concrete Precast Double T				
	4.2.1 - Precast-T-Slab-R-4			
		Number of bays	-	14.0
		Bay sizes (ft)	10.0	10.0
		Span (ft)	-	24.0
		Live load (psf)	-	75.0
		Topping	Included	Included
	Envelope	Category	Ply Built-up Asphalt Roof System	Ply Built-up Asphalt Roof System
		Material	-	Extruded Polystyrene, Glass Felt
		Thickness (in)	1 1/2"	1 1/2"
		Category	Roofs	Roofs
		Material	Roof Envelope	Roof Envelope
		Thickness (in)	-	Roofing Asphalt
		Category	Steel Roof System	Steel Roof System
		Material	-	Commercial
		Thickness (in)	-	-

5 Floors	5.1 Suspended Slab				
		5.1.1 - SuspSlab1, staircase slab, staircase intermediate slab			
			Floor Width (ft)	-	36.8
			Span (ft)	-	20.0
			Concrete (psi)	4000.0	4000.0
			Concrete flyash %	-	Average
			Live load (psf)	-	75.0
	5.2 Concrete Precast Double T				
		5.2.1 - Precast-T-Slab-F-4			
			Number of bays	-	209.0
			Bay sizes (ft)	10.0	10.0
			Span (ft)	-	30.0
			Live load (psf)	-	75.0
			Topping	Included	Included
6 Extra Basic Materials	6.1 Gypsum Board				
		6.1.1 - Win Asbestos			
			1/2" Regular Gypsum Board (m2)	-	161.3
	6.2 Insulation				
		6.2.1 - Win Asbestos			
			Extruded Polystyrene (m2 (25mm))	-	228.8
	6.3 Steel				
		6.3.1 - Win Asbestos			
			Galvanized Studs (Tonnes)	-	2.1
		6.3.2 - Win Asbestos			
			Screws Nuts & Bolts (Tonnes)	-	0.3
	6.4 Wood				
		6.4.1 - Win Asbestos			
			Oriented Strang Board (m2 (9mm))	-	204.7

APPENDIX B : INPUT ASSUMPTIONS

ATHENA® Environmental Impact Estimator

General Description			
	Project Name		CEME
	Project Location		Vancouver
	Building Life Expectancy		1 year
	Building Type		Institutional
	Operating Energy Consumption		-TBA-
Assembly Group	**Assembly Type**	**Assembly Name**	**Assumptions and Calculations**
1 Foundation			
	1.1 Concrete Slab on Grade		
		1.1.1 - OnGradSlab1-4	
			Fly ash concentration was not detailed in drawings, therefore the flyash percentage was assumed to be average. Length & Width = Sqrt (Area) = Sqrt (52946.01) = 230.1ft
		1.1.2 - OnGradSlab2-5	
			Fly ash concentration was not detailed in drawings, therefore the flyash percentage was assumed to be average. Adjustments to the slab dimensions were necessary to make them fit the inputs into the Impact Estimator - the same area was achieved. Length = Sqrt (area) = sqrt (4969) = 70.5 Width = 70.5 / new width x old with = 70.5/4*5 = 88.1
		1.1.3 - OnGradSlab3-8	
			Fly ash concentration was not detailed in drawings, therefore the flyash percentage was assumed to be average. Length = width = sqrt (area) =sqrt (7215) = 84.9
		1.1.4 - OnGradSlab4-10	
			Fly ash concentration was not detailed in drawings, therefore the flyash percentage was assumed to be average. Adjustments to the slab dimensions were necessary to make them fit the inputs into the Impact Estimator - the same area was achieved. Length = sqrt (area) = SQRT(2127) = 46.1 Width = length / 8 * 10 = 57.6

	1.2 Concrete Footing		
		1.2.1 - Column Footings (F.1-31, f.Str, f.ramp)	
			Fly ash concentration was not detailed in drawings, therefore the flyash percentage was assumed to be average. Consist of a variety of rebar. The most common grade was chosen length = width = sqrt (6421) = 79 Thickness approximated as 18inches based on common thickness
		1.2.2 -Strip Footing (f.A, f.B, f.B/C/E/F, f.B/C/E/F-2, f.C, f.D, f.G, f.J, f.JJ, f.JJJ)	
			Fly ash concentration was not detailed in drawings, therefore the flyash percentage was assumed to be average. Consist of a variety of rebar. The most common grade was chosen Length = sqrt (area) = 60 Width = length /18in * 24in Adjustments to the dimensions were necessary to make them fit the inputs into the Impact Estimator - the same area/volume was achieved.
		1.2.3 - Basement Walls (wf.1-0600-8, wf.1-1306-100, wf.1-1700-100)	
			Fly ash concentration was not detailed in drawings, therefore the flyash percentage was assumed to be average. Consist of a variety of rebar. The most common grade was chosen Thickness assumed to be 12 to get the correct volume length = width = sqrt (area) = sqrt (5041) = 71
2 Custom Wall			
	2.1 Concrete Tilt-up		
		2.1.1 - we.1-0406-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #4 Dimensions were adjusted to account for limited thickness options Type of "1in Rigid Insulation" not specified in drawings and assumed to be "Polystyrene Extruded" Insulation EIE Length =Length / EIE Thickness * Actual Thickness EIE Length = 109 / 5.5 * 6 = 118.9
		2.1.2 - we.1-0600-6	
			Concrete flyash percentage not specified and assumed to be

			average Rebar not specified in drawings and assumed to be #4 Dimensions were adjusted to account for limited thickness options Type of "1in Rigid Insulation" not specified in drawings and assumed to be "Polystyrene Extruded" Insulation EIE Length =Length / EIE Thickness * Actual Thickness EIE Length = 110 / 5.5 * 6 = 120
		2.1.3 - we.1-0700-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #4 Dimensions were adjusted to account for limited thickness options Type of "1in Rigid Insulation" not specified in drawings and assumed to be "Polystyrene Extruded" Insulation Glazing not specified for windows in drawing and assumed to be "Standard Glazing" EIE Length =Length / EIE Thickness * Actual Thickness EIE Length = 200 / 5.5 * 6 = 218.2
		2.1.4 - we.1-0707-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #4 Dimensions were adjusted to account for limited thickness options Type of "1in Rigid Insulation" not specified in drawings and assumed to be "Polystyrene Extruded" Insulation EIE Length =Length / EIE Thickness * Actual Thickness EIE Length = 279 / 5.5 * 6 = 304.4
		2.1.5 - we.1-0906-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #4 Dimensions were adjusted to account for limited thickness options Type of "1in Rigid Insulation" not specified in drawings and assumed to be "Polystyrene Extruded" Insulation EIE Length =Length / EIE Thickness * Actual Thickness EIE Length = 202 / 5.5 * 6 = 220.4
		2.1.6 - we.1-1000-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #4

			Dimensions were adjusted to account for limited thickness options Type of "1in Rigid Insulation" not specified in drawings and assumed to be "Polystyrene Extruded" Insulation EIE Length =Length / EIE Thickness * Actual Thickness EIE Length = 73 / 5.5 * 6 =79.6
		2.1.7 - we.1-1400-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #4 Dimensions were adjusted to account for limited thickness options Type of "1in Rigid Insulation" not specified in drawings and assumed to be "Polystyrene Extruded" Insulation Glazing not specified for windows in drawing and assumed to be "Standard Glazing" EIE Length =Length / EIE Thickness * Actual Thickness EIE Length = 70 / 5.5 * 6 = 76.4
		2.1.8 - we.1-1407-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #4 Dimensions were adjusted to account for limited thickness options Type of "1in Rigid Insulation" not specified in drawings and assumed to be "Polystyrene Extruded" Insulation Glazing not specified for windows in drawing and assumed to be "Standard Glazing" Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length =Length / EIE Thickness * Actual Thickness EIE Length = 477 / 5.5 * 6 = 520.4
		2.1.9 - we.1-1506-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #4 Dimensions were adjusted to account for limited thickness options Type of "1in Rigid Insulation" not specified in drawings and assumed to be "Polystyrene Extruded" Insulation Glazing not specified for windows in drawing and assumed to be "Standard Glazing" EIE Length =Length / EIE Thickness * Actual Thickness EIE Length = 71 / 5.5 * 6 = 77.5

		2.1.10 - we.1-1600-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #4 Dimensions were adjusted to account for limited thickness options Type of "1in Rigid Insulation" not specified in drawings and assumed to be "Polystyrene Extruded" Insulation Glazing not specified for windows in drawing and assumed to be "Standard Glazing" Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length =Length / EIE Thickness * Actual Thickness EIE Length = 426 / 5.5 * 6 = 464.7
		2.1.11 - we.1-1606-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #4 Dimensions were adjusted to account for limited thickness options Type of "1in Rigid Insulation" not specified in drawings and assumed to be "Polystyrene Extruded" Insulation Glazing not specified for windows in drawing and assumed to be "Standard Glazing" Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length =Length / EIE Thickness * Actual Thickness EIE Length = 42 / 5.5 * 6 = 45.8
		2.1.12 - we.1-1700-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #4 Dimensions were adjusted to account for limited thickness options Type of "1in Rigid Insulation" not specified in drawings and assumed to be "Polystyrene Extruded" Insulation Glazing not specified for windows in drawing and assumed to be "Standard Glazing" Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door"

	EIE Length =Length / EIE Thickness * Actual Thickness EIE Length = 283 / 5.5 * 6 = 308.7
2.1.13 - we.1-1800-6	
	Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #4 Dimensions were adjusted to account for limited thickness options Type of "1in Rigid Insulation" not specified in drawings and assumed to be "Polystyrene Extruded" Insulation Glazing not specified for windows in drawing and assumed to be "Standard Glazing" Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length =Length / EIE Thickness * Actual Thickness EIE Length = 389 / 5.5 * 6 = 424.4
2.1.14 - we.1-1900-6	
	Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #4 Dimensions were adjusted to account for limited thickness options Type of "1in Rigid Insulation" not specified in drawings and assumed to be "Polystyrene Extruded" Insulation Glazing not specified for windows in drawing and assumed to be "Standard Glazing" Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length =Length / EIE Thickness * Actual Thickness EIE Length = 344 / 5.5 * 6 = 375.3
2.1.15 - we.1-2100-6	
	Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #4 Dimensions were adjusted to account for limited thickness options Type of "1in Rigid Insulation" not specified in drawings and assumed to be "Polystyrene Extruded" Insulation EIE Length =Length / EIE Thickness * Actual Thickness EIE Length = 273 / 5.5 * 6 = 297.8
2.1.16 - wi.1-1300-6	

			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #4 Dimensions were adjusted to account for limited thickness options Type of "1in Rigid Insulation" not specified in drawings and assumed to be "Polystyrene Extruded" Insulation EIE Length =Length / EIE Thickness * Actual Thickness EIE Length = 11 / 5.5 * 6 = 12
		2.1.17 - wi.1-1500-8	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #4 Dimensions were adjusted to account for limited thickness options Type of "1in Rigid Insulation" not specified in drawings and assumed to be "Polystyrene Extruded" Insulation EIE Length =Length / EIE Thickness * Actual Thickness EIE Length = 73 / 5.5 * 6 = 77.9
		2.1.18 - wi.1-1506-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #4 Dimensions were adjusted to account for limited thickness options Type of "1in Rigid Insulation" not specified in drawings and assumed to be "Polystyrene Extruded" Insulation Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length =Length / EIE Thickness * Actual Thickness EIE Length = 222 / 5.5 * 6 = 242.2
		2.1.19 - wi.1-1700-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #4 Dimensions were adjusted to account for limited thickness options Type of "1in Rigid Insulation" not specified in drawings and assumed to be "Polystyrene Extruded" Insulation EIE Length =Length / EIE Thickness * Actual Thickness EIE Length = 19 / 5.5 * 6 = 20.7
	2.2 Concrete Block Wall		
		2.2.1 - we.2-	

		1506-6	
			The Impact Estimator assumes 200mm thick block. Length of 6" thick block wall multiplied by 0.762 to achieve correct volume Glazing not specified for windows in drawing and assumed to be "Standard Glazing" Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length = Actual Length * 0.762 (200mm/6in) 244.6 = 321 * 0.762
		2.2.2 - wi.2-0900-6	
			The Impact Estimator assumes 200mm thick block. Length of 6" thick block wall multiplied by 0.762 to achieve correct volume Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length = Actual Length * 0.762 (200mm/6in) 95.3 = 125 * 0.762
		2.2.3 - wi.2-0900-6	
			The Impact Estimator assumes 200mm thick block. Length of 6" thick block wall multiplied by 0.762 to achieve correct volume Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" Walls assumed to be 9ft tall based on other walls the area EIE Length = Actual Length * 0.762 (200mm/6in) 261.4 = 343 * 0.762
		2.2.4 - wi.2-1000-6	
			The Impact Estimator assumes 200mm thick block. Length of 6" thick block wall multiplied by 0.762 to achieve correct volume Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length = Actual Length * 0.762 (200mm/6in) 35.8 = 47 * 0.762
		2.2.5 - wi.2-1000-8	
			The Impact Estimator assumes 200mm thick block. Length of 8" thick block wall multiplied by 1.016 to achieve correct volume Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood

			Frame Door" EIE Length = Actual Length * 1.016 (200mm/8in) 9.1 = 9 * 1.016
		2.2.6 - wi.2-1300-8	
			The Impact Estimator assumes 200mm thick block. Length of 8" thick block wall multiplied by 1.016 to achieve correct volume Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length = Actual Length * 1.016 (200mm/8in) 24.4 = 24 * 1.016
		2.2.7 - wi.2-1206-6	
			The Impact Estimator assumes 200mm thick block. Length of 6" thick block wall multiplied by 0.762 to achieve correct volume Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length = Actual Length * 0.762 (200mm/6in) 461 = 605 * 0.762
		2.2.8 - wi.2-1506-6	
			The Impact Estimator assumes 200mm thick block. Length of 6" thick block wall multiplied by 0.762 to achieve correct volume Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length = Actual Length * 0.762 (200mm/6in) 453.4 =595 * 0.762
		2.2.9 - wi.2-1606-6	
			The Impact Estimator assumes 200mm thick block. Length of 6" thick block wall multiplied by 0.762 to achieve correct volume Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length = Actual Length * 0.762 (200mm/6in) 147.8 = 194 * 0.762
		2.2.10 - wi.2-1800-6	
			The Impact Estimator assumes 200mm thick block. Length of 6" thick block wall multiplied by 0.762 to achieve correct volume Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls

			except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length = Actual Length * 0.762 (200mm/6in) 673.6 = 884 * 0.762
		2.2.11 - wi.5-1000-8	
			The Impact Estimator assumes 200mm thick block. Length of 8" thick block wall multiplied by 1.016 to achieve correct volume Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length = Actual Length * 1.016 (200mm/8in) 24.4 = 24 * 1.016
		2.2.12 - wi.5-1300-8	
			The Impact Estimator assumes 200mm thick block. Length of 8" thick block wall multiplied by 1.016 to achieve correct volume Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length = Actual Length * 1.016 (200mm/8in) 108.7 =107 * 1.016
	2.3 Cast-in-Place		
		2.3.1 - we.3-1300-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #5 Dimensions were adjusted to account for limited thickness options Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length = actual length / EIE thickness * actual thickness 69.8 = 93 / 8 * 6
		2.3.2 - we.3-1600-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #5 Dimensions were adjusted to account for limited thickness options Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" Glazing not specified for windows in drawing and assumed to be

			"Standard Glazing" EIE Length = actual length / EIE thickness * actual thickness 84.8 = 113 / 8 * 6
		2.3.3 - we.3-1700-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #5 Dimensions were adjusted to account for limited thickness options Glazing not specified for windows in drawing and assumed to be "Standard Glazing" EIE Length = actual length / EIE thickness * actual thickness 30.8 = 41 / 8 * 6
		2.3.4 - we.3-1800-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #5 Dimensions were adjusted to account for limited thickness options Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length = actual length / EIE thickness * actual thickness 45 = 60 / 8 * 6
		2.3.5 - wi.3-1300-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #5 Dimensions were adjusted to account for limited thickness options Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length = actual length / EIE thickness * actual thickness 69 = 92 / 8 * 6
		2.3.6 - wi.3-1300-8	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #5 Dimensions were adjusted to account for limited thickness options Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls

			except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door"
		2.3.7 - wi.3-1600-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #5 Dimensions were adjusted to account for limited thickness options Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length = actual length / EIE thickness * actual thickness 35.3 = 47 / 8 * 6
		2.3.8 - wi.3-1700-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #5 Dimensions were adjusted to account for limited thickness options Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length = actual length / EIE thickness * actual thickness 30 = 40 / 8 * 6
		2.3.9 - wi.3-1800-6	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #5 Dimensions were adjusted to account for limited thickness options Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" EIE Length = actual length / EIE thickness * actual thickness 105 = 140 / 8 * 6
		2.3.10 - wi.3-1800-8	
			Concrete flyash percentage not specified and assumed to be average Rebar not specified in drawings and assumed to be #5 Dimensions were adjusted to account for limited thickness options Door type not specified in the drawings and assumed to be

			"Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door"
	2.4 Wood Stud		
		2.4.1 - wi.4-0700-6	
			None
		2.4.2 - wi.4-0900-6	
			None
		2.4.3 - wi.4-1206-6	
			Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door"
		2.4.4 - wi.4-1300-6	
			Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door"
		2.4.5 - wi.4-1506-6	
			Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door"
		2.4.6 - wi.4-1600-6	
			Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door"
		2.4.8 - wi.4-506-6	
			None
		2.4.9 - wi.7-1300-6	
			Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" "Backing Board" not specified and assumed to be Oriented Strand Board Fiberglass Insulation type not specified but based on usage and thickness assumed to be Batt Insulation
		2.4.10 - wi.7-1506-6	
			"Backing Board" not specified and assumed to be Oriented Strand Board Fiberglass Insulation type not specified but based on usage and thickness assumed to be Batt Insulation
		2.4.11 - wi.7-1800-6	
			"Backing Board" not specified and assumed to be Oriented Strand Board Fiberglass Insulation type not specified but based on usage and

			thickness assumed to be Batt Insulation
		2.4.12 - wi.8-1300-6	
			Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" "Backing Board" not specified and assumed to be Oriented Strand Board Fiberglass Insulation type not specified but based on usage and thickness assumed to be Batt Insulation
	2.5 Steel Stud		
		2.5.1 - we.9-1206-4	
			Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" Stud Weight not specified in the drawings and assumed to be Light. Glazing not specified for windows in drawing and assumed to be "Standard Glazing"
		2.5.2 - we.9-1300-4 - NB	
			Stud Weight not specified in the drawings and assumed to be Light. Glazing not specified for windows in drawing and assumed to be "Standard Glazing"
		2.5.3 - we.9-2000-4	
			Stud Weight not specified in the drawings and assumed to be Light.
		2.5.4 - wi.9-1506-4	
			Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" Stud Weight not specified in the drawings and assumed to be Light.
		2.5.5 - wi.10-1000-4	
			Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" Stud Weight not specified in the drawings and assumed to be Light. Additional layer clearly visible on drawings but not specified. Assumed to be an additional 1/2" Drywall based on thickness in drawing

		2.5.6 - wi.10-1300-4	
			Door type not specified in the drawings and assumed to be "Steel Exterior" for exterior walls, "Steel Interior" for interior walls except Wood Stud walls assumed to have "Hollowed Core Wood Frame Door" Stud Weight not specified in the drawings and assumed to be Light. Additional layer clearly visible on drawings but not specified. Assumed to be an additional 1/2" Drywall based on thickness in drawing
3 Mixed Columns and Beams	3.1 Concrete Column and Concrete Beam		
		3.1.1 - c.1.p, c.2.p, c.3.2, c.3.p, c.4.2	
			Column Bay and Span determined by taking floor area that columns were in, divided by the number of columns, and square-rooted to get each dimension Live load not specified in drawings. Assumed 75 psf based on other institutional building in vicinity of CEME Number of beams = number of columns -1 = 120 - 1 = 119 Span = Bay size = sqrt (supported area) Span = Bay size = sqrt (309.8) = 17.6
		3.1.2 - c.1-Low, c.3, c.5	
			Column Bay and Span determined by taking floor area that columns were in, divided by the number of columns, and square-rooted to get each dimension Live load not specified in drawings. Assumed 75 psf based on other institutional building in vicinity of CEME Number of beams = number of columns -1 = 66 - 1 = 65 Span = Bay size = sqrt (supported area) Span = Bay size = sqrt (316.8) = 17.8
		3.1.3 - c.2	
			Column Bay and Span determined by taking floor area that columns were in, divided by the number of columns, and square-rooted to get each dimension Live load not specified in drawings. Assumed 75 psf based on other institutional building in vicinity of CEME Number of beams = number of columns -1 = 23 - 1 = 22 Span = Bay size = sqrt (supported area) Span = Bay size = sqrt (510.8) = 22.6
		3.1.4 - c.2.b	
			Column Bay and Span determined by taking floor area that columns were in, divided by the number of columns, and square-rooted to get each dimension Live load not specified in drawings. Assumed 75 psf based on other institutional building in vicinity of CEME Number of beams = number of columns -1 = 10 - 1 = 9

			Span = Bay size = sqrt (supported area) Span = Bay size = sqrt (497.3) = 22.3
		3.1.5 - c.1-High	
			Column Bay and Span determined by taking floor area that columns were in, divided by the number of columns, and square-rooted to get each dimension Live load not specified in drawings. Assumed 75 psf based on other institutional building in vicinity of CEME Number of beams = number of columns -1 = 31 - 1 = 30 Span = Bay size = sqrt (supported area) Span = Bay size = sqrt (368.6) = 19.2
	3.2 Concrete Column and No Beam		
		3.2.1 - c.2.2, c.5.p	
			Column Bay and Span determined by taking floor area that columns were in, divided by the number of columns, and square-rooted to get each dimension Live load not specified in drawings. Assumed 75 psf based on other institutional building in vicinity of CEME Span = Bay size = sqrt (supported area) Span = Bay size = sqrt (295) = 17.2
		3.2.2 - c.4	
			Column Bay and Span determined by taking floor area that columns were in, divided by the number of columns, and square-rooted to get each dimension Live load not specified in drawings. Assumed 75 psf based on other institutional building in vicinity of CEME Span = Bay size = sqrt (supported area) Span = Bay size = sqrt (510) = 22.6
4 Roofs	4.1 Open Web Steel Joist		
		4.1.1 - Steel-Joist	
			Drawings contain virtually no specifics on the Open Web Steel Joist roofing systems. Live load not specified in drawings. Assumed 75 psf based on other institutional building in vicinity of CEME Roof consists of 1 1/2" built up asphalt roof, but not specified. Approximated by "Extruded Polystyrene, Glass Felt" Roof is topped with asphalt but not specified. Approximated with Impact Estimator's "Roofing Asphalt" Above Open Web Steel Joist is corrugated steel that the drawings do not detail - assumed to be a commercial steel roof system. Roof width assumed 30 to fit input parameter, span = area / roof with 40140 / 30 = 1338
		4.1.2 - Steel-	

		Joist-Pent	
			Drawings contain virtually no specifics on the Open Web Steel Joist roofing systems. Live load not specified in drawings. Assumed 75 psf based on other institutional building in vicinity of CEME Above Open Web Steel Joist is corrugated steel that the drawings do not detail - assumed to be a commercial steel roof system. Roof width assumed to be 15ft, span = area / width 6039 / 15 = 402.6
	4.2 Concrete Precast Double T		
		4.2.1 - Precast-T-Slab-R-4	
			Drawings contain virtually no specifics on the Open Web Steel Joist roofing systems. Live load not specified in drawings. Assumed 75 psf based on other institutional building in vicinity of CEME Roof consists of 1 1/2" built up asphalt roof, but not specified. Approximated by "Extruded Polystyrene, Glass Felt" Roof is topped with asphalt but not specified. Approximated with Impact Estimator's "Roofing Asphalt" Above Open Web Steel Joist is corrugated steel that the drawings do not detail - assumed to be a commercial steel roof system. Span chosen to be 24ft, number of bays = area / span / bay size 14 = 3360 / 24 / 10
5 Floors	5.1 Suspended Slab		
		5.1.1 - SuspSlab1, staircase slab, staircase intermediate slab	
			Concrete flyash percentage not specified and assumed to be average Live load not specified in drawings. Assumed 75 psf based on other institutional building in vicinity of CEME Span chosen to be 20ft, width = area / span 736 / 20 = 36.8
	5.2 Concrete Precast Double T		
		5.2.1 - Precast-T-Slab-F-4	
			Concrete flyash percentage not specified and assumed to be average Live load not specified in drawings. Assumed 75 psf based on other institutional building in vicinity of CEME Span chosen to be 30ft, number of bays = area / span / bay size

			62700 / 30 / 10 = 209
6 Extra Basic Materials	6.1 Gypsum Board		
		6.1.1 - Win Asbestos	
			Many window frames in the building contain panels that are steel stud walls with solid insulation and backing board forced with asbestos. This was approximated by finding the materials in a square foot wall with the steel studs, extruded polystyrene insulation, and OSB. The Impact Estimator can not model asbestos. See end of Assumption table for calculations
	6.2 Insulation		
		6.2.1 - Win Asbestos	
			Many window frames in the building contain panels that are steel stud walls with solid insulation and backing board forced with asbestos. This was approximated by finding the materials in a square foot wall with the steel studs, extruded polystyrene insulation, and OSB. The Impact Estimator can not model asbestos. See end of Assumption table for calculations
	6.3 Steel		
		6.3.1 - Win Asbestos	
			Many window frames in the building contain panels that are steel stud walls with solid insulation and backing board forced with asbestos. This was approximated by finding the materials in a square foot wall with the steel studs, extruded polystyrene insulation, and OSB. The Impact Estimator can not model asbestos. See end of Assumption table for calculations
		6.3.2 - Win Asbestos	
			Many window frames in the building contain panels that are steel stud walls with solid insulation and backing board forced with asbestos. This was approximated by finding the materials in a square foot wall with the steel studs, extruded polystyrene insulation, and OSB. The Impact Estimator can not model asbestos. See end of Assumption table for calculations
	6.4 Wood		
		6.4.1 - Win Asbestos	
			Many window frames in the building contain panels that are steel stud walls with solid insulation and backing board forced with asbestos. This was approximated by finding the materials in a square foot wall with the steel studs, extruded polystyrene insulation, and OSB. The Impact Estimator can not model asbestos. See end of Assumption table for calculations

Total Asbestos	1578	SF

	1 sq.ft of Asbestos Wall:		**Total:**	
Material	Quanitity	Unit	Quanitity	Unit
1/2" Regular Gypsum Board	0.1022	m2	161.2716	m2
Extruded Polystyrene	0.145	m2 (25mm)	228.81	m2 (25mm)
Galvanized Studs	0.0013	Tonnes	2.0514	Tonnes
Oriented Strang Board	0.1297	m2 (9mm)	204.6666	m2 (9mm)
Screws Nuts & Bolts	0.0002	Tonnes	0.3156	Tonnes