INTEGRATED ENERGY MASTER PLAN

FINAL REPORT DATED 02/16/2017

Prepared for:

HUMBER

Humber College Institute of Technology & Advanced Learning

ENERGY MASTERPLAN

Prepared by:

Garforth International llc

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ACKNOWLEDGEMENTS

The innovative Humber College Integrated Energy Master Plan could not have been developed without the enthusiastic support and constructive input from many people. Collectively they represented the College leadership, academic faculty, staff, the student body and a wealth of experience and expertise from Canada and beyond. Their invaluable contributions and their commitment to the future success of the plan are gratefully recognized.

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1 VISION

Humber's campuses embody our institutional value to be sustainable in everything we do. All campus development and operations begin by incorporating sustainability into the design and building process and connecting students to real-world learning opportunities. The IEMP represents Humber's long-term strategy of achieving significant reductions in energy, water and greenhouse gas emissions and being a college campus leader in this area nationally.

2 EXECUTIVE SUMMARY

The world's current energy and water picture presents opportunities and uncertainties. The Paris Climate Agreement underlines the urgency to reduce carbon emissions to limit the effects of climate change. Changing weather and water use are stressing rivers, lakes and aquifers. Energy use is growing and changing following patterns of economic and population growth, and in turn reshaping markets for major oil and gas suppliers like Canada. Older energy and water systems are being upgraded to improve flexibility and reliability. Technology is offering cleaner and more efficient energy and water supply choices.

Canada and Ontario have policies and plans in place that are targeted at improving the economic and environmental performance of their energy systems. A major focus of these plans is deep cuts in carbon emissions.

This global and local picture was the backdrop to Humber College's leadership decision to develop an Integrated Energy Master Plan (IEMP) to maximize opportunities and minimize risks from the College's use of energy and water for the coming two decades.

The College began the planning process by setting the challenge to develop an IEMP that by 2034 would double the College's energy and water efficiencies; drop total carbon emissions by at least 30%; and create economic returns that would be at least twice as attractive as typical municipal bonds. Recognizing that Humber's energy challenge is the same for communities and businesses across Canada, they also set the challenge do develop new academic offerings related to integrated energy planning and implementation.

In 2014, Humber College educated 33,000 students; a number expected to grow more than 30% by 2034. The College spent $5.4M in 2014 on utilities for its North and Lakeshore Campuses, creating a carbon footprint of 8,510 metric tons; roughly equivalent to emissions from 2,000 cars. Humber's baseline energy performance is a little better than the average for similar colleges in Ontario and North America. However, it is about twice as energy intensive as that found elsewhere in the world today.

In a business-as-usual scenario that combines anticipated student growth and new construction along with energy and water price uncertainty, utility costs increase by between 260% and 590%, or $14M to $32M, by 2034. The carbon footprint grows by 68% over a period where Provincial plans call for up to 70% reductions.

The IEMP solution comprises multiple elements which are designed to be implemented as an integrated whole to achieve the breakthrough results. The IEMP outlines a wide range of measures on both campuses that will dramatically reduce the energy and water needs of the current buildings, and ensure new buildings are as efficient as the best buildings found anywhere in the world.

Some key measures include upgrading the North Campus heating and cooling networks to 21st Century levels and extending to encompass all new and existing buildings; integrating the heating network for Lakeshore Campus into a campus-wide modern network; and implementing new Energy Centres that will supply competitive, clean, and reliable energy from efficient sources, including combined heat and power (CHP) generation and substantial rooftop solar power.

Another key part of the solution is to upgrade the College's energy and water metering and control capability to create a Smart Energy Network, supporting efficient day-to-day operations and long-term continuous improvement.

The IEMP solution calls for investing approximately $66M through the year 2034. About $3M focus on information and control; $37M in deep efficiency improvements in buildings; and the balance in efficient supply and distribution elements.

Humber College		Reference Scenario
Investment Group	Measure	$
Efficiency	Metering and Control	3,000,000
	Window Upgrade (Existing)	8,400,000
	Exterior wall insulation (Existing)	17,200,000
	Roof insulation (Existing)	5,700,000
	Lighting upgrade	400,000
	HVAC Upgrade	3,000,000
	Commissioning	600,000
	Water Efficiency	1,000,000
	Heat Recovery Data Center	300,000
Supply	DH Network	3,700,000
	Heating Substations	700,000
	CW Network	600,000
	CHP Engines	7,900,000
	Absorption Chiller	1,400,000
	Boilers	5,100,000
	Steam Conversion	3,900,000
Solar PV		3,100,000
Total Investment	$	66,000,000

Figure 2-1 IEMP Investments from 2017 to 2034

The Energy and Sustainability organization at Humber will add additional staffing, and management practices will be reinforced. This will provide the means to supervise the energy efficiency investments in buildings, distribution and supply; actively manage day-to-day operations for optimum performance; and engage the College faculty, staff, students and key stakeholders through a structured engagement process.

The entire solution will be configured to support a wide range of training and academic programmes. The Humber academic team will complete their recommendations during FY2016 /17 for a comprehensive world-class range of academic programmes, serving the integrated energy planning needs of communities and industry in Ontario and beyond.

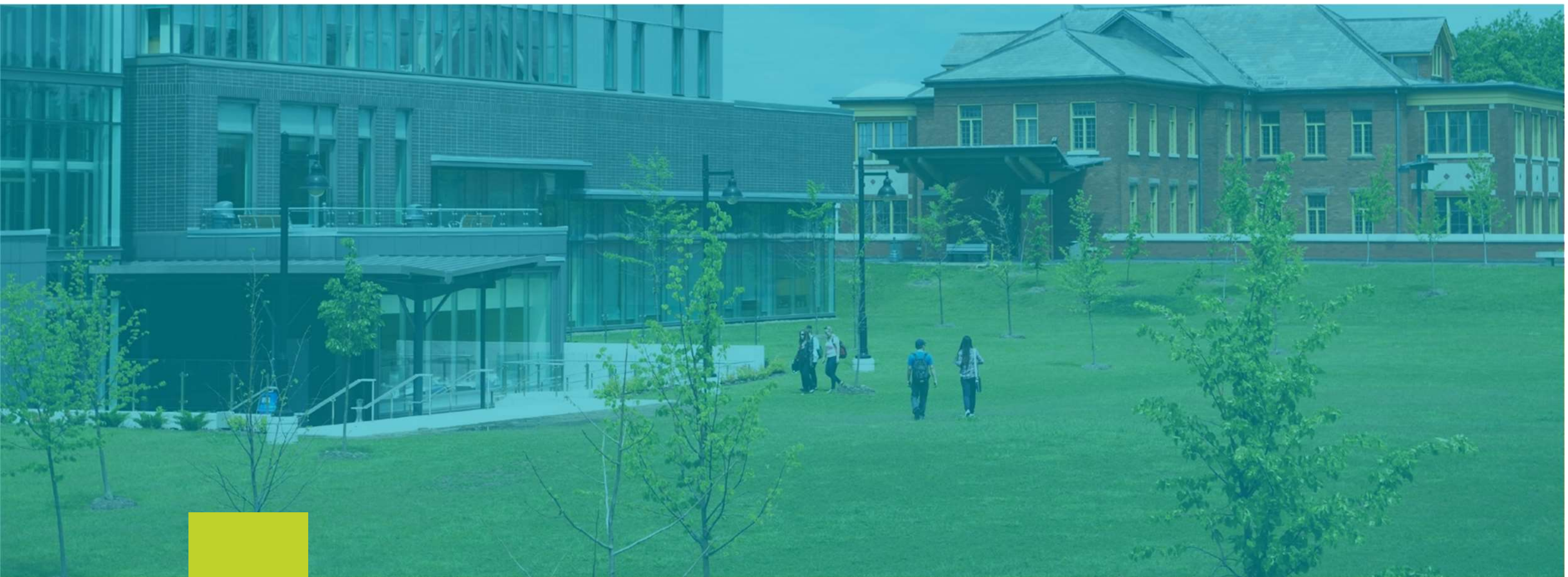
The IEMP was developed through a highly collaborative process over the last year. The results of the IEMP recommended solution, as detailed in the IEMP Final Report, substantially exceed the project objectives by:

- Increasing energy efficiency by 50%
- Increasing Water Efficiency by 54%
- Decrease of absolute carbon emission by 60%
- Achieving Internal Rate of Return of between 10% and 17%
- Becoming a North American Centre of Academic Excellence for Integrated Energy Solutions

The overall energy and climate performance of the College will be tracked and regularly reviewed over the coming decades to ensure the IEMP stays on track and that any necessary mid-course adjustments are made. Source and site energy efficiency will be tracked with Energy End Use Indexes (EEUI) measuring energy use per square metre of floor area. Water Efficiency will be tracked with a Water EUI based on potable water use per student. Similarly, energy and carbon cost and avoided costs will be tracked by function and source. These parameters will all be tracked at the College, Campus and Buildings levels. As importantly, the development and success of related academic programmes will be regularly reviewed.

In addition to monitoring the academic, cost, emissions and efficiency performances, the implementation of the key IEMP enablers will be regularly reviewed. These will include progress in identifying and teaming with implementation partners, creating new organization and management processes, and developing a campus-wide sustainability culture.

Through the rigorous implementation of the IEMP, Humber College will achieve world-class energy and climate performance and become an educational institution leader for Ontario and Canada, both operationally and academically.



3 INTEGRATED ENERGY MASTER PLAN (IEMP) BACKGROUND

3.1 Global, National and Provincial Energy and Water Priorities

Both opportunities and uncertainties surrounding Humber's current energy use are significant. They arise from a mix of major global influences, many of which directly impact North America, Canada and Ontario.

Growth in energy demand in the emerging economies of China, India, Brazil, Mexico and Indonesia, among others, continues to reshape global energy markets.

In North America, the rapid exploitation of new natural gas supply from shale has pushed prices to their lowest prices in decades. Many assume these low prices will be the new normal. However, the growing use of gas for power generation and transportation around the world, along with concern over the local impacts of shale gas could radically change the worldwide cost structure.

Electricity prices are on an upward trend as grids are upgraded to accommodate more renewable and other distributed generation, presenting both risks and opportunities. This is especially true in Ontario, where a combination of adding new sources and catching up on deferred investments looks set to continue for many years.

Globally, the drive to reduce the impact of human induced greenhouse gas emissions is accelerating. In November 2016, the Paris Treaty was ratified to cut emissions to the level necessary to limit global warming below two degrees Celsius. Canada is a partner to this Treaty with aggressive emission reduction targets and policies at both Federal and Provincial Levels. Further Details are in Appendix 13 : Federal & Ontario Energy and Climate Policy.

These sweeping global trends are calling for a rethink in the way energy decisions are made in the community at large. This in turn is changing the needs in the way energy planners, managers and technical staff are trained, creating new academic and training opportunities for institutions like Humber College.

Humber's Executive Team recognized the need for a thorough strategic response. They took this as an opportunity both to build expertise and new skills, and to create an institutional 20-year Integrated

Energy Master Plan. The IEMP summarized in this report mitigates energy risks to the College and seeks out areas of opportunity to enhance its operations and academic programming.

3.2 IEMP Scope

The Plan addresses the energy and water use, cost and environmental impact on the North Campus (including Carrier Drive) and the Lakeshore Campus[i].

Energy is limited to electricity and natural gas used in buildings operated by the College directly and consider the added energy used off the campus to generate and transport electricity. Greenhouse gas emissions caused by this energy use is the key quantified environmental indicator.

Energy used directly or indirectly for transportation related to college activities is excluded for the moment but is recognized as being a high probability follow on assessment to be added to the IEMP[ii].

Water is limited to its use within buildings for service hot water, other functions such as catering, and on the wider campus to support the heating supply and distribution networks. Water use for landscaping is a very minor aspect for the College and is excluded.

The opportunities for new curriculum subjects related to integrated energy solutions planning and implementation is included.

The time frame for the plan is from the Fiscal Baseline Year of 2014 to an end year of 2034.

3.3 IEMP Methodology and Process

3.3.1 Team Structure

The College formed a core team of sponsors, faculty, staff and students to develop the IEMP under the project management of the Director of Facilities Management. The team was developed based on the far-reaching attributes of an Integrated Energy Management Program for the overall college. The team was assembled by Humber Facilities Management reaching out to representatives from these departments inside the Humber organization. This core team has representatives from Facilities Management, Academic, Capital Development, Finance and Planning, Procurement and Sustainability. This sub-team of Humber facilities worked with the consulting team from Garforth International llc (GIL), providing internationally recognized energy expertise, to guide the process. The IEMP was developed under the overall senior co-sponsorship of Humber College: Rani Dhaliwal, Senior Vice-President of Planning and Corporate Services and CFO, and Laurie Rancourt, Senior Vice-President Academic. The membership and structure of the Team is included in Appendix 1 : IEMP Scope and Planning Team. Appendix: IEMP Scope and Planning Team

3.3.2 Overall Framework

The IEMP seamlessly addresses the entire energy value chain of the College on both campuses, starting from end-uses and continuing through all forms of primary fuel used both on and off the site. The IEMP includes recommendations that optimize investments and management measures between end-use efficiency, energy distribution on the campuses, and on-site and off-site energy supply choices, including fuels. The IEMP systematically addresses the following questions in a balanced way:

- Does the IEMP recommendation meet acceptable reliability standards?
- How much energy is really needed by the final end-uses?
- Does the solution meet acceptable financial returns?
- Are greenhouse gas emissions minimized?

3.3.3 Process

The IEMP was developed over a period of about a year following a highly collaborative process outlined in Appendix 2: IEMP Process Map and Milestones. The process was aimed at ensuring that energy related decisions on energy and water use and supply infrastructure involve all key stakeholders, consider multiple energy supply and demand options.

3.3.4 Framing Goals

The Framing goals that would guide the development of the IEMP were established at the Kick-off meeting. Challenging goals were established for energy and water efficiency, greenhouse gas reductions, economic returns and new academic programmes that combined would clearly represent world-class energy performance. The team was given the challenge to develop a plan that would meet all these goals by 2034:

- Energy efficiency will increase by 50%
- Water efficiency will increase by 50%
- Carbon footprint will reduce by 30%
- Investment return[iii] will be at least 7%
- College will offer world-class energy and climate academic programmes

These goals are addressed in more detail later in the report.

The IEMP must also clearly support the Vision of the existing Sustainability Plan:

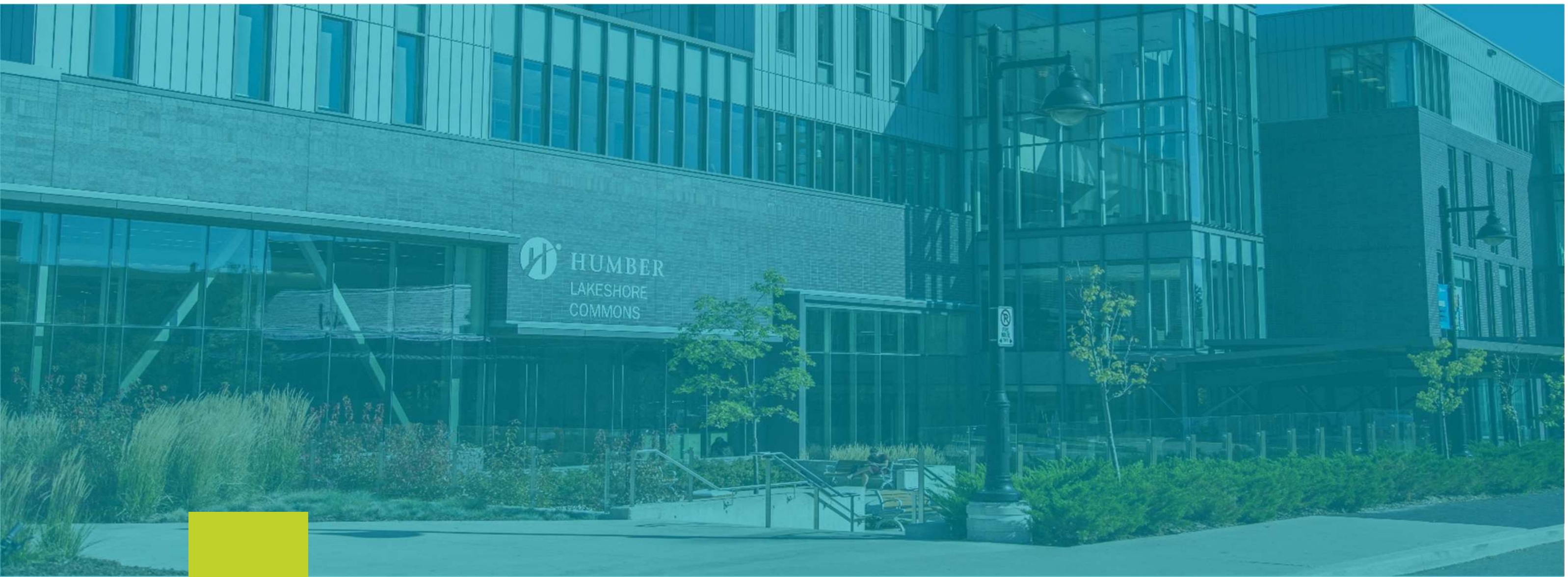
- *"The three pillars of sustainability require that we consider environmental stewardship, social equity and economic performance to provide true balance within our decision making and planning"*
- *"To demonstrate educational leadership by embedding sustainability into teaching and learning on campus"*
- *"To ensure sustainability is a learning outcome for all students"*
- *"To develop a culture of sustainability on campus which promotes engagement, health, social equity and wellbeing"*

3.4 Energy, Water and Carbon Pricing Outlook

Two energy pricing outlooks were developed for the IEMP to evaluate the range of financial impacts of future efficiency and supply measures; a Lower Risk (LR) and a Higher Risk (HR) Price Case. Both build on the 2014 Baseline conditions and the anticipated changes to 2034 outlined in Appendix 15: Utility Outlook Pricing Assumptions.

The Price Cases were established based on the 2013 Ontario Long Term Energy Plan[iv] (OLTEP) wherever possible. The OLTEP is primarily based on electricity and associated emissions. Team assessments were used for the natural gas pricing. The Lower Risk Case is based on business-as-usual, while the Higher Risk Case is driven by the following factors:

- Grid reliability issues caused by aging infrastructure and extreme weather require accelerated investments that must be recovered in electricity prices.
- Tougher GHG emissions reduction targets and regulation has a follow-on effect in the pricing of fossil fuels and electricity.
- Upgrading and reinforcing provincial electricity and gas networks to manage a larger portfolio of distributed clean and renewable generation.
- Closer scrutiny and regulation of shale gas will increase the future price of natural gas.
- Accelerating national and international demand for natural gas for both reducing carbon emissions and resulting from very low North American prices relative to the rest of the world will increase its future price.



4 BASELINE AND BASE CASE

4.1 College Overview and Growth Outlook

Humber College is one of the largest colleges in Canada offering a polytechnic education programme with a wide range of credentials including bachelor's degrees, diplomas, graduate certificates, certificates and apprenticeships. The College is located on two major campuses in Toronto. The largest is the North Campus located northwest of the city centre, and the Lakeshore Campus located to the west of the city, close to Lake Ontario.

In 2014 Humber College spent $5.4M on utilities summarized below, of which $3.9M is for electricity, $1M for gas and the balance for water. The carbon footprint[v] in 2014 was 8,510 metric tons, equivalent to the emissions of over 2,000 cars.

The North Campus has about 150,000 square metres of buildings with ages ranging from 1968 to 2014. The utility use accounts for about three quarters of the College total. Lakeshore Campus has about 73,000 square metres of buildings with ages from 1890 to 2014. Lakeshore includes ten heritage buildings, formerly the Lakeshore Psychiatric Hospital.

Since 2005, the student[vi] body has grown by over 50% to 33,000 full-time equivalents (FTEs) by 2014. North Campus hosts about 23,000 and Lakeshore about 10,000 FTEs.

Over the period covered by the IEMP from 2014 to 2034, the student body is expected to grow by 31% to 43,000. The North Campus will grow to 29,400 students and Lakeshore to 13,400. To accommodate this growth, projected new construction would add a further 90,000 square metres to the North Campus, and 44,000 square metres to Lakeshore. The timing and location of these new buildings are detailed in Appendix_4: Demolitions & New Buildings Supporting Growth.

4.2 Energy and Water Performance from 2005 to 2014

Prior to launching the IEMP, Humber College already had in place a Sustainability Plan which aimed to, by 2023, double energy efficiency, halve water use per student and cut greenhouse emissions by 50%.

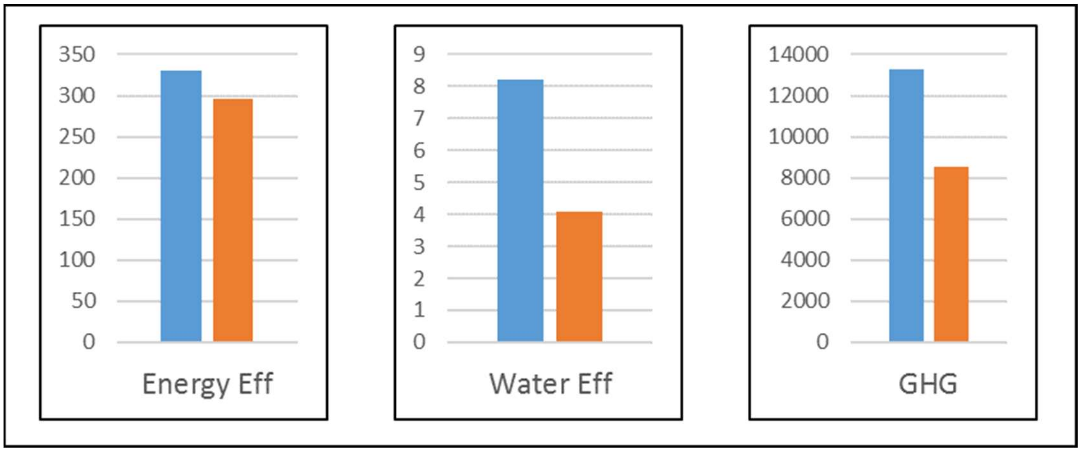


Figure 4-1 Energy, Water and Greenhouse Gas Performance 2005-2014

In the past ten years, water efficiency has increased 50% largely from the systematic installation of low-flow shower heads, low-flush toilets and other water efficient devices. By comparison, the modest increase in energy efficiency of 10% was below expectations and was one of the motivations to develop a comprehensive IEMP. During this decade, emissions have halved, largely resulting from Ontario's policy to shift to low carbon power sources. Going forward, the College's energy, water and emissions goals will be updated and incorporated into a future update of the College's Sustainability Plan. How these are related is explained in more detail in Appendix 6: Comparison of IEMP and Sustainability Plan Goals.

4.3 Energy Management Practices

An institution with above average energy performance will always have well-established and consistent energy management practices, encompassing both energy use and energy purchases. The Team evaluated current energy management practices against the ENERGY STAR Energy Management Assessment Matrix[vii], a well-recognized best-practice framework.

Today, energy use is managed by a professional, well-motivated Facilities Team. Their focus is on maintaining functional availability of the College's facilities with energy performance being a secondary concern managed on a sporadic basis. There is limited interaction with other departments, faculty or students. There are few activities related to the development of an energy culture inside the College.

The profile is not untypical for any organization making the transition from managing energy in a way that is reactive to pressing needs to an approach that maximizes energy productivity and engages the entire College population in the challenge.

Further details are in Appendix 5: Assessment of Current Energy Management Approach.

4.4 Metering and Control Systems

The campus utility metering is supported with some sub-metering for buildings measuring heating, cooling, electricity, natural gas and water. There are still significant gaps in the sub-metering coverage.

The College has a campus-wide Siemens Apogee control system currently in place controlling most building functions. With the appropriate extensions and upgrades, the system has the capability to manage data and control most major functions on both campuses and the college as a whole.

4.5 Building Energy Use

The different energy end uses for Humber campuses were modelled using both generalized and individual models. The College's 49 existing buildings were split between academic, office and residential buildings. These ranged in age from the late 1960s to 2015. Seventeen generalized energy models were used to represent the campus building stock.

Four individual energy models were completed for the N building and Carrier Drive on the North Campus, and I Building and L Building on the Lakeshore Campus. Two individual models were also available from prior work for the Learning Resource Commons on North and the Welcome Centre on Lakeshore.

To estimate the College's business-as-usual energy needs for the future buildings, the expected Ontario codes are assumed to be rigorously implemented. The current (2012) Ontario code is the most energy efficient in North America.

The modelling estimates the energy used in buildings for cooling, heating, fans, pumps, lighting, interior equipment and service hot water in total cost, use and energy use intensity (EUI). EUI is the energy use per floor area in kilowatt-hours per square metre (kWh/m^2). EUIs are a useful indicator of energy efficiency and facilitate benchmarking with other buildings and campuses. The building model categories used is in Appendix 7: Generalized Building Energy Demand Modelling.

The following figures summarize the end-use break-down of total cost, energy use and emissions for the College.

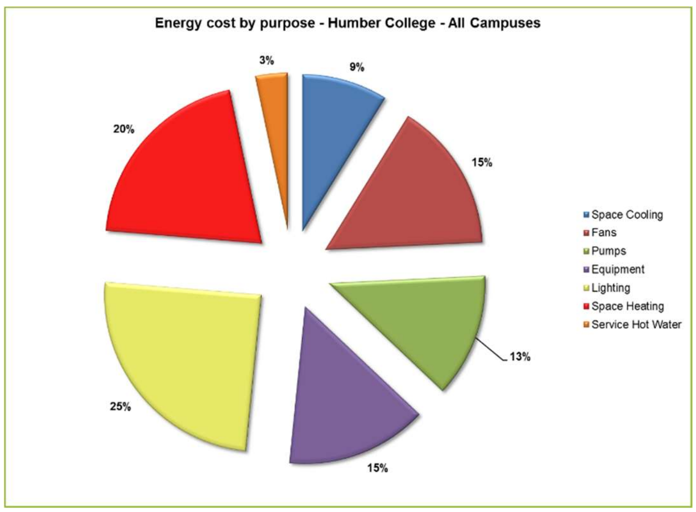


Figure 4-2 Humber College – 2014 Energy Cost by End Use

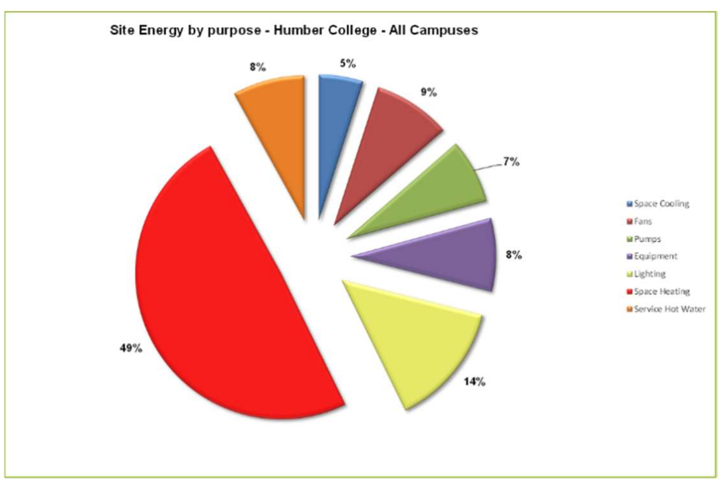


Figure 4-3 Humber College – 2014 Site Energy Use by End Use

Site energy is based on the energy as measured at the campus meters.

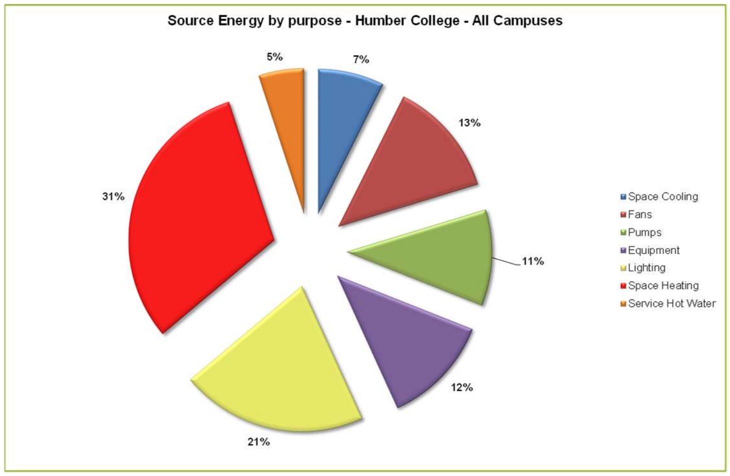


Figure 4-4 Humber College – 2014 Source Energy Use by End Use

Source energy includes additional energy needed to generate and transport electricity to the campus.

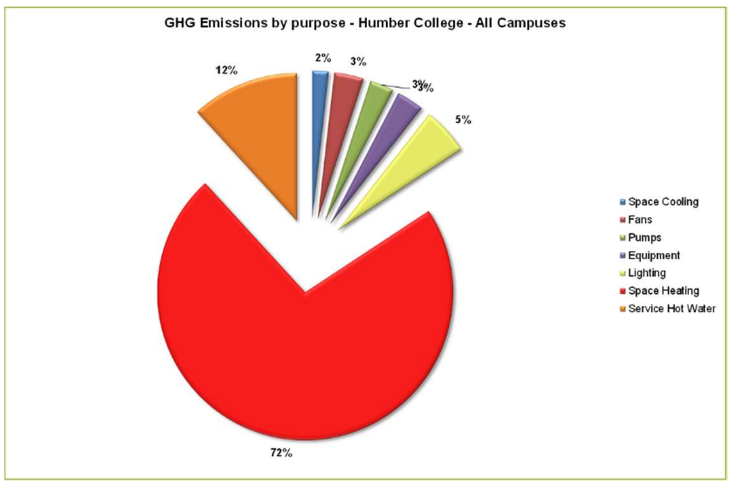


Figure 4-5 Humber College – 2014 Greenhouse Gas Caused by End-Use

The breakdown of these totals by modelled buildings, along with the associated end-use indexes are included in Appendix 9: Baseline Building Energy Demand Modelling Results.

The building-by-building total energy use is helpful in understanding which buildings have the highest total energy use on site. The building-by-building EUI perspective helps identify which buildings are the least efficient. Together, these will help guide implementation and prioritization in order to have the most impact on the total energy use.

For the IEMP, four buildings were modeled using their actual data, floor plans, internal loads, operating hours, mechanical schedules and controls. The conclusions are summarized below, with further details also in the Appendix 8 : Customized Building Energy Demand Modelling Results.

N Building - North Campus

Figure 4-6 Interior and Exterior Views of N-Building

This was chosen to be modelled as it was due for a façade upgrade. The individual model showed 11% higher than the College average, more than 2 times higher than current OBC and 3 times higher than a German A-rated building[viii].

Carrier Drive – North Campus

Figure 4-7 Interior and Exterior Views of Carrier Drive

Carrier Drive was chosen based on its age and size as a significant energy end-user. Again, this is 13% higher than the College average, more than 2 times higher than current OBC and 3 times higher than a German A-Rated building

I Building – Lakeshore Campus

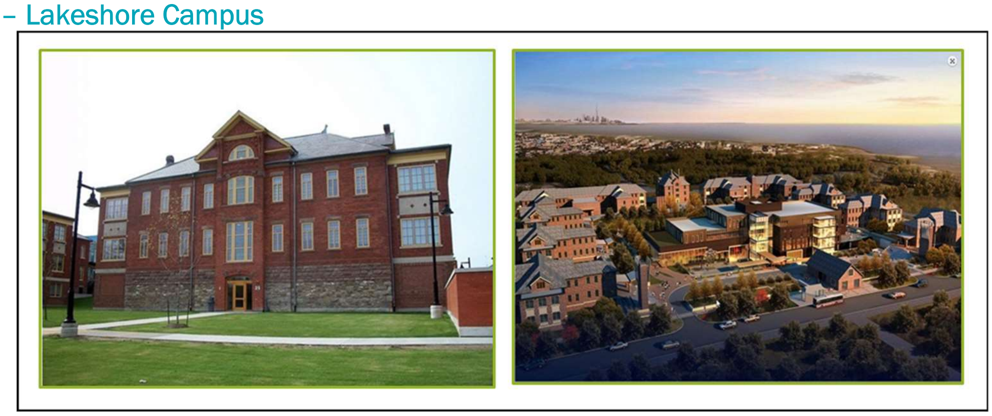


Figure 4-8 I Building and Campus Views of Carrier Drive

The I Building on Lakeshore Campus is one of the historic buildings from 1893 that form most of the east side of the Lakeshore Campus. It was chosen as it is representative of a significant number of buildings on the Lakeshore East Campus. The total energy is 35% lower than College average, exceeds current OBC and is 1.9 times greater than a new German A-rated building putting this close to a global best practice for historic renovation.

L Building – Lakeshore

Figure 4-9 Lakeshore L Building Views

While relatively new, L-Building on Lakeshore Campus, was chosen because of suspicions of poor energy performance. As suspected the total energy usage is 25% higher than the College average, well over double OBC and 3.5 times higher than a German A-rated building of this type.

4.6 Water Usage

The 139,000 cubic metres of potable water used in 2014 were assigned to each generalized and individual building model using available metered and modelling data, along with background on the fixtures in each actual building from a prior energy audit. Humber College has a wide mix of water fixtures and flushes. Many have been replaced with low flow fixtures and flushes. More details of the modelling and allocation results are in Appendix 10: Baseline Water Use Modelling.

4.7 Supply & Distribution

The following are a summary of the current energy supply and distribution on the two campuses. Further background is in Appendix 11: Baseline Energy Supply and Distribution.

4.7.1 North Campus

Central heating plant in Building I has three 450 HP natural gas steam boilers, replaced in 2008 generating steam for heating. The steam is distributed from the central plant to the campus buildings (exceptions being Buildings GH, R, S, T, U, W) via pipes in underground tunnels. Within the buildings, the high-pressure steam passes through pressure reducing stations. The low-pressure steam is used for various end uses including feeding steam/hot water to supply hydronic systems, for steam heating coils and humidifiers. The condensate is captured and recirculated to the boilers. Make-up water is a quarter of all water used by the College and represents a third of water used on the North Campus.

The central chilling plant, also in Building I, has four 550-ton variable speed centrifugal chillers, three chilled water pumps with Variable Frequency Drives (VFDs), four variable flow evaporative cooling towers, and three condenser water pumps with VFDs. The fourth chiller was added in 2015 to accommodate the LRC. Chilled water is distributed to the same buildings as the steam heating.

4.7.2 Lakeshore East Campus

Building N houses the central boiler plant and central chiller plant for the Lakeshore East Campus. Heating is supplied by three hot water boilers with fuel economizers fired with natural gas supplying heat to a warm-water[ix] distribution network fitted with primary, secondary and in-buildings pumps. Boilers were added as the East Campus expanded. The warm-water network runs in tunnels and connects all the East Campus buildings including the new L-Building.

The chiller plant consists of three chillers, each between 300 and 400-ton capacity in good condition with the most recent being installed in 2011. The condenser loop has glycol in it. This is a closed loop system with a heat exchanger. The chilled water is distributed from the central plant to the campus buildings via pipes in the tunnel system.

Both networks are in good condition.

4.7.3 Lakeshore Campus West

The heating water system for Buildings A and B is from two boilers in a single boiler room, distributed by circulation and distribution pumps. Cooling is provided by a mix of rooftop and window units. The condition is generally poor, and this is an area of the college slated for major renovation in the coming years.

The heating and cooling system in Residence Building R is a conventional islanded building solution supplied by boilers and chillers located in a penthouse.

4.8 Utility Supply

The College is supplied with electricity, natural gas from local distribution companies.

Electricity is supplied from the medium voltage grid operated by Toronto Hydro-Electric System Limited with the commodity procured on the Ontario spot market.

Natural Gas is supplied from the natural gas distribution network operated by Enbridge Gas Distribution, with the commodity contract being with Shell Energy North America (Canada) Inc. The pressure is at least 5 psi/340 mbar and adequate to support on-site cogeneration.

Water and waste water services are supplied by Toronto Water & Solid Waste Management Services.

4.9 2014 Baseline Summary

In fiscal year 2014, Humber College spent $5.45 M on electricity, gas and water on its two campuses. The total energy use on site is 66 gigawatt hours (GWh) equivalent to a total of 113 (GWh) when electricity conversion and energy distribution losses are included.

College	Cost	Cost increase	Unit cost	Unit Cost Increase	Usage of Water	Site Energy use	Source Energy use
Item	**M$/yr**	**2010 - 2014**	**$/kWh**	**2010 - 2014**	**m³**	**MWh/yr**	**MWh/yr**
Electricity	3.89	23%	0.127	15%		30,520	76,300
Natural Gas	1.03	38%	0.029	32%		35,270	37,000
			$/m³				
Water	0.53	44%	3.788	50%	139,000		
Total	***5.45***					***65,790***	***113,300***

Figure 4-10 Humber College – Baseline Utility Balance for Fiscal Year 2014

The carbon footprint is 8,510 mt CO_2, roughly equivalent to the annual emissions of over 2,000 cars.

North Campus spent $3.85M, used 82 GWh of energy and has a carbon footprint of 6,350 mtCO_2.

Baseline 2014C North Campus	Cost	Cost increase	Unit cost	Unit Cost Increase	Usage of Water	End Energy use	Source Energy use
Item	M$/yr	2010 - 2014	$/kWh	2010 - 2014	m³	MWh/yr	MWh/yr
Electricity	2.72	16%	0.126	14%		21,550	53,900
Natural Gas	0.77	34%	0.029	22%		26,610	27,900
			$/m³				
Water	0.37	36%	3.766	50%	98,000		
Total	***3.85***					***48,160***	***81,800***

Figure 4-11 North Campus – Baseline Utility Balance for Fiscal Year 2014

Lakeshore Campus spent $1.60M, used 32 GWh of energy and has a carbon footprint of 2,160 mtCO_2.

Baseline 2014 Lakeshore Campus	Cost	Cost increase	Unit cost	Unit Cost Increase	Usage of Water	End Energy use	Source Energy use
Item	M$/yr	2010 - 2014	$/kWh	2010 - 2014	m³	MWh/yr	MWh/yr
Electricity	1.17	41%	0.130	16%		8,980	22,500
Natural Gas	0.27	48%	0.031	64%		8,660	9,100
			$/m³				
Water	0.16	68%	3.843	51%	41,000		
Total	***1.60***					***17,640***	***31,600***

Figure 4-12 North Campus – Baseline Utility Balance for Fiscal Year 2014

The College's overall Baseline energy and water efficiency is shown in the following table.

Energy Index	2014 m²
Indexing Factor	222,000
Site Energy Index (kWh)	296
Source Energy Index (kWh)	510
Water Index	FTE
Indexing Factor	32,800
Water Index (m³)	4.2

Figure 4-13 Humber College – Energy and Water for Fiscal Year 2014

Humber College uses just over four cubic metres of water for each student. The metered energy use is just under 300 kWh per square metre, which translates to just over 500 kWh when the added energy needed to generate and transport electricity is included.

4.10 2014 Global and Local Performance Benchmarking

Humber's Baseline energy performance was compared with similar institutions in Ontario and beyond. This benchmarking included other educational institutions in Ontario and the USA, the Ontario Ministry of Education performance guideline, the current Ontario Code, and German A-rated.

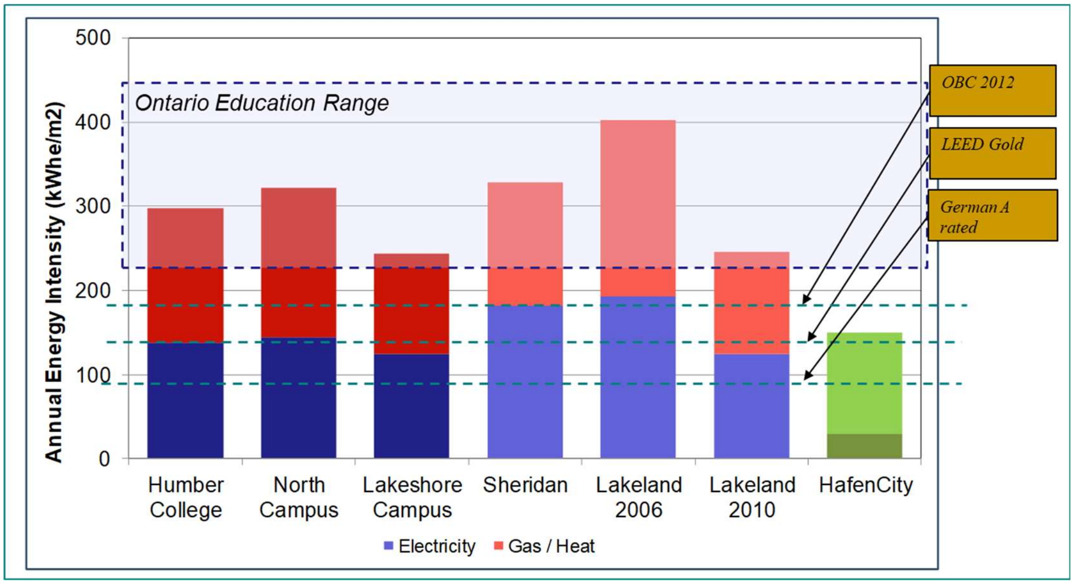


Figure 4-14 Humber College Benchmarking – Site Energy Efficiency

In terms of site energy use, the College, at 296 kWh/m², is somewhat more efficient than the mid-point of a sample of Ontario educational institutions. It is well above the energy level around 200 kWh/m² that would be expected from a new current Ontario Code Building.

There is a large difference between the North and Lakeshore Campuses, 323kWh/m² versus 242kWh/m², attributable to a combination of less efficient buildings and energy losses in the steam heating system on North.

Humber in 2013 was slightly more efficient than nearby Sheridan College was in 2010, a comparable institution also with two major campuses.

Lakeland[x] College in Ohio had a 2006 baseline energy efficiency of about 400 kWh/m² and launched an IEMP. Within four years this had dropped to 230kWh/m² and has continued to improve since with a 100kWh/m² strategic target. This indicates the achievable efficiency gains in a comparable institution in about the same climate.

To estimate a systematic global best practice, the site energy use of HafenCity University in Hamburg, as an example, is about 150 kWh/m² for the entire campus. In local terms this is above the level that would be expected from a typical new German A-rated academic building, about 90 kWh/m²

The energy benchmarking was also done in terms of source energy to establish a reasonable efficiency framing goal for the IEMP.

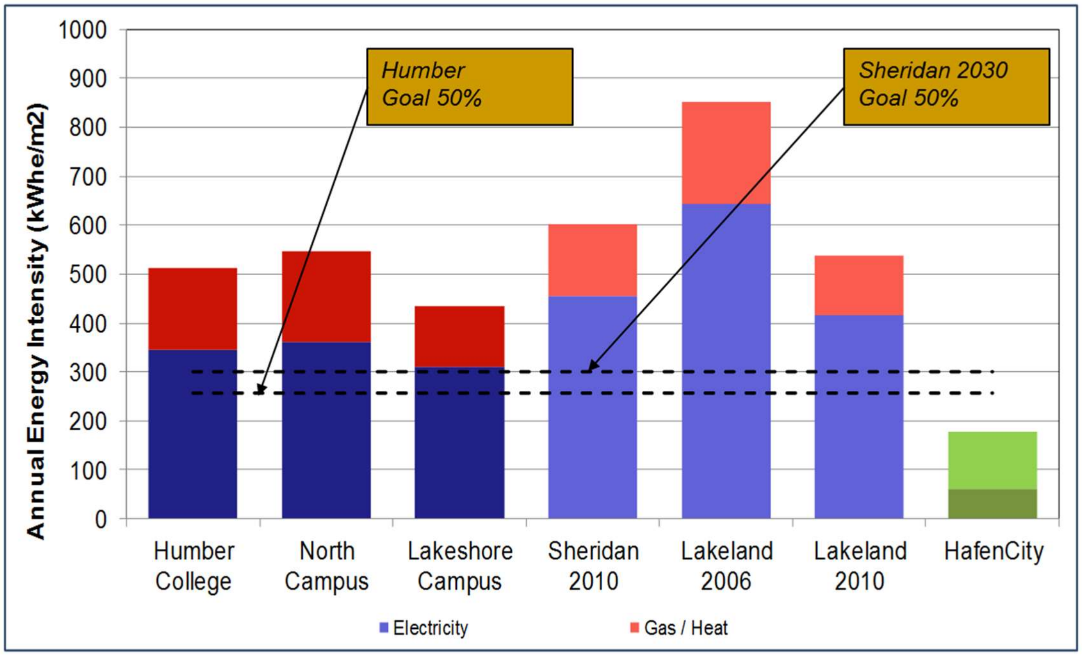


Figure 4-15 Humber College Benchmarking – Source Energy Efficiency

There are two noticeable differences. The energy efficient differences between Humber and Lakeland increase owing to the more fuel intensive Ohio power grid compared to Ontario. HafenCity is relatively more energy efficient mostly owing to the use of highly integrated heating and cooling systems. Two targets are indicated. Sheridan College's approved 50% relative to 2010, and Humber College's Framing Goal of 50% relative to 2014.

4.11 2034 Business-As-Usual Outlook

The IEMP Base Case is the picture of the future assuming business-as-usual from the 2014 Baseline through the 20 years to 2034. The Base Case is the starting point for all the scenarios assessed before making the final IEMP recommendation.

In the Base Case, the average energy efficiency of existing buildings remains the same as in the Baseline in 2014. New buildings are added based on the needs resulting from FTE growth anticipated in the Campus Development Plan and Land Use Plan. New buildings in the Base Case are fully compliant with the current 2012 Ontario Building Code.

Energy supply and distribution remain unchanged in configuration and efficiency. New buildings are assumed islanded in terms of heating and networked in terms of cooling.

Total FTE grows by the official College forecast to 2021 after which it grows by the demographic growth for the relevant catchment areas as forecast by Statistics Canada. Water efficiency remains the same as the 2014 Baseline.

The higher and lower price outlooks for natural gas, electricity and carbon are used to evaluate Base Case cost risks.

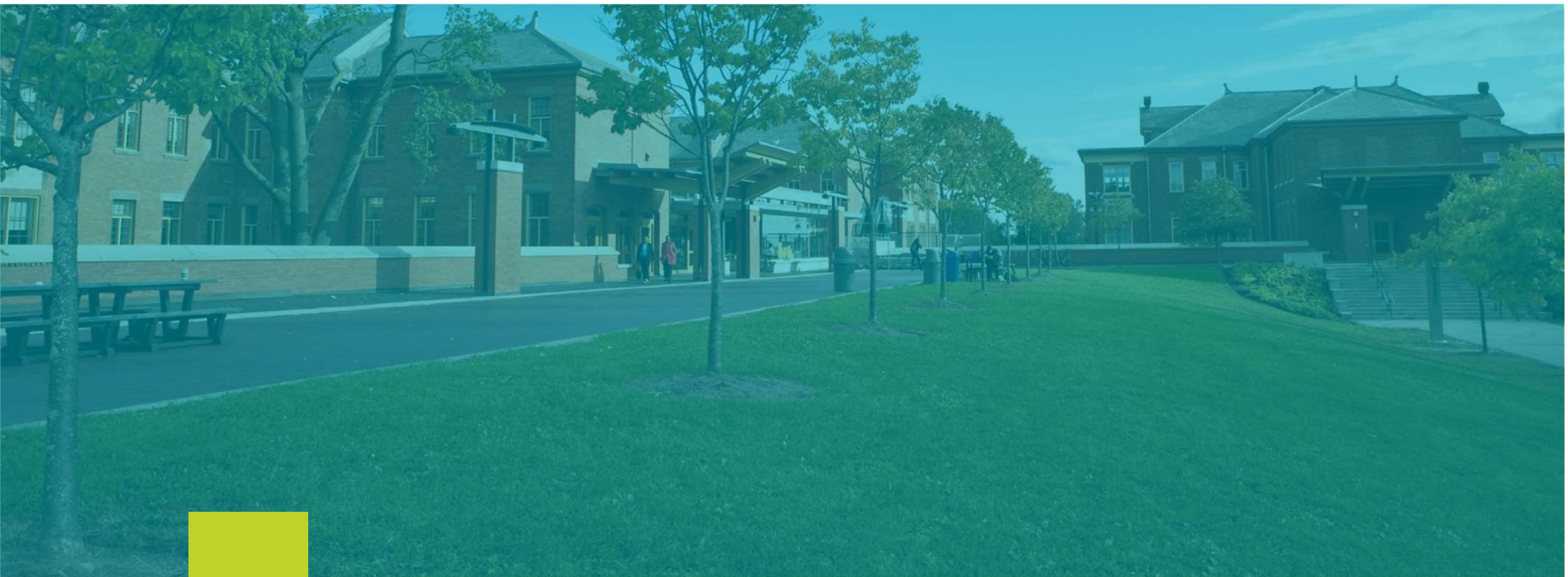
Detailed assumptions for College growth and utility price development are documented and described in Appendix 3: College Growth Assumptions; Appendix 4: Demolitions and New Buildings Supporting Growth; and Appendix 15: Utility Pricing Outlook and Assumptions.

The 2034 Business-as Usual picture relative to 2014 looks something like this:

- Total source energy grows by 46% driven by student growth
- Source energy efficiency improves by 9% through the addition of newer buildings

- Carbon footprint grows by 68% mostly through the addition of newer buildings
- Cost for energy, water and carbon increases at least by 260% to $20M per year
- Cost for energy, water and carbon could increase up to 588% to $37M per year

This picture represents major economic and environmental risks to the College's future, while the benchmarking indicates major opportunities to manage, or even benefit from these risks.



5 FUTURE COLLEGE ENERGY AND CLIMATE SOLUTION

5.1 Framing Goals

The Framing Goals for College were set early in the IEMP planning process. They address all five dimensions shown in Figure 4.1. The challenge of the IEMP was to create a plan that would meet or exceed all the Framing Goals set forth.

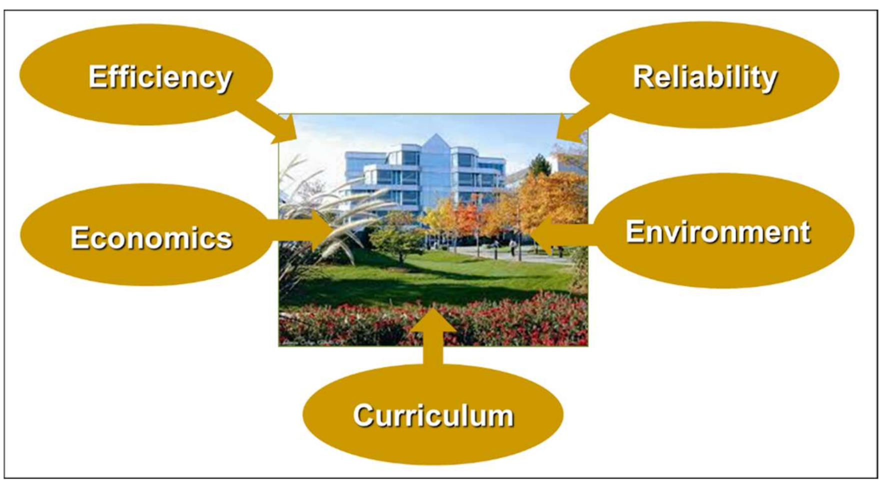


Figure 5-1 IEMP Framing Goals

Academic Offering

Humber College will offer world-class academic courses addressing integrated energy, water and climate solutions. The courses will cover the social, policy, economic and technical aspects and will meet the needs of Canada and beyond.

Energy Efficiency
Humber College will have energy efficiency[xi] levels that meet global-practices and will have achieved at least a 50% gain in source energy efficiency by 2034; measured in energy use per square metre.

Water Efficiency
Humber College will have water efficiency[xii] that meets global best practices and will have achieved a further 50% gain in efficiency by 2034, measured in potable water use per student.

Carbon Footprint
Humber College's total greenhouse gas emissions will be aligned with both the UN and Ontario Climate Change[xiii] recommendations and they will have achieved at least a 30% reduction by 2034.

Investment Returns
The total investments in the IEMP over time will deliver at least twice the return of typical 20-year municipal bonds and achieve an Investment Rate of Return of at least 7%.

Detailed background on the Framing Goals is shown in Appendix 6: Comparison of IEMP and Sustainability Plan Goals

5.2 IEMP Solution Overview
The Framing Goals are established for the entire College. Many different possible combinations of end-use efficiency, efficient distribution, along with clean and renewable supply mixes are possible.

Multiple combinations of efficiency, distribution and supply on both campuses were systematically evaluated. For each combination, critical technical and economic assumptions and future outlooks were assessed. Major categories of investment estimates were "stress tested" to judge the economic vulnerabilities. An interactive "Integration Workbook" (IW) allowed the combined economic, efficiency and environmental impact of hundreds of combinations to be rapidly tested. Further details on the IEMP Integration Workbook is given in Appendix 12: Integration Workbook

The IEMP recommended solution is the combination best fitting all the Framing Goals for the entire College, summarized in Figure 4.2.

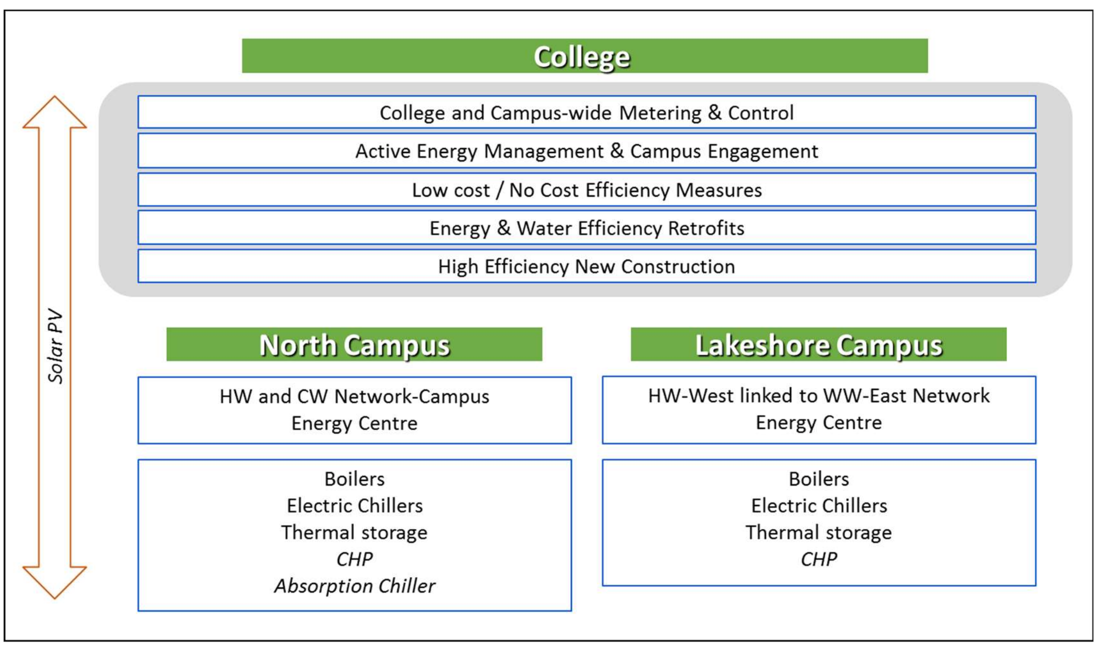


Figure 5-2 IEMP Recommended Solution

The IEMP solution calls for a wide range of measures on both campuses that will dramatically reduce the energy and water needs of the current buildings and ensure new buildings are as efficient as the best performing buildings anywhere in the world.

The existing North Campus heating network will be upgraded to 21st Century levels and extended to encompass all new and existing buildings. The existing heating network at Lakeshore will be integrated into a campus-wide modern network.

Both campuses will have new Energy Centres supplying clean, reliable efficient energy services, supplemented by substantial rooftop solar power generation throughout.

The College will upgrade its energy and water information and control capability to create a Smart Energy Network, supporting efficient day-to-day operation and long-term continuous improvement.

The entire solution will be configured to support a wide range of training and academic programmes.

5.3 Gain Control & Metering

Prerequisite for world-class energy management is comprehensive, up-to-date information on energy use supported by the ability to optimize energy use through integrated smart controls. The existing metering, sub-metering and control systems will be extensively updated. The combination of active energy management enabled by reliable information and controls alone will deliver energy savings of well over 10%.

Metering

A College-wide open-architecture sub-metering system that is interoperable with Siemens Apogee will be added. This will allow real-time metering at campus, building, end-use zones, and major sub-system levels. Heating, cooling, electricity, natural gas and water will be sub-metered at each level. In many cases the sub-metering function will be provided via information gathered in the control system and not necessarily a physical sub-meter.

The metering will be linked to energy management targets, utility pricing information, greenhouse gas emissions and indexes and site/source ratios to allow comprehensive mapping and reporting of energy and water use, utility costs and carbon footprint. A variety of graphic representations at each metering hierarchy level will be possible to guide energy management priorities and evaluation of IEMP measures as they are implemented.

Control

An interoperable College-wide open architecture control system will be implemented by upgrading the existing Apogee system to complete the control of all significant subsystems. In addition to extending and completing the reach of the current system, the capability to manage predictive control strategies for weather and scheduling college activities will be included.

5.4 Existing Building Energy Efficiency

There is a major potential to make all existing buildings substantially more efficient as shown in the Base Case benchmarking. The recommendation is to invest in retrofitting most existing buildings with a comprehensive set of energy efficiency measures (EEMs), the majority being completed between 2017 and 2022.

The priority focus will be to improve the passive efficiency by improving the envelope performance of most buildings through improved wall and roof insulation, windows and weatherproofing. The detailed prioritization of the buildings/facades/roofs to be retrofitted would ideally be combined with implementing other deferred maintenance.

Internal mechanical systems will be upgraded once envelope improvements are completed, or as a part of an integrated renovation project including significant energy efficiency retrofitting. The bias will be to convert the existing Variable Air Volume (VAV) reheat systems to operate as Dedicated Outdoor Air Systems (DOAS) with, wherever possible, ventilation heat recovery.

All lamps will be replaced with LEDs as part of the normal course of business, reducing both energy use and maintenance costs. As resources allow, deeper lighting renovation including replacing luminaires and enhanced programming could be possible with associated higher energy savings.

These EEMs were applied to each generalized building model to estimate their aggregate effect on the College energy use and estimate the overall level of investments. This approach is statistically valid for the College; however, each building's retrofit will be specific to the actual building and may deliver efficiency gains that are different from the generalized model.

Which Energy Model?	EEMS							
	Window Upgrade	Exterior Wall Insulation	Roof Insulation	Slab Insulation	Lighting Upgrade	HVAC upgrade	New HVAC	Cx
North – VAV reheat 2004 - Academic					X			X
North – CV no reheat 2004 - Academic					X			X
North – VAV reheat Post 1980s - Academic	X	X	X		X	X		X
North – VAV reheat pre 1980s - Academic	X	X	X		X	X		X
North – DOAS wFancoils 2004 - Residential								X
North – VAV electric reheat post 1980s - Office	X	X	X		X	X		X
North – VAV reheat post 1980s - Office	X	X	X		X			X
North – VAV reheat pre 1980s - Office	X	X	X		X			X
North – VAV reheat DX 1990s – N BUILDING	X	X	X		X		X	X
Lakeshore – VAV reheat 2004 - Academic					X			X
Lakeshore - CV no reheat 2004 – Academic					X			X
Lakeshore - VAV reheat post 1980s - Academic	X	X	X		X			X
Lakeshore – VAV reheat pre 1980s- Academic	X	X	X		X			X
Lakeshore DOAS w/fancoils post 1980s - Residential								X
Lakeshore – VAV reheat post 1980s - Office	X	X	X		X	X		X
Lakeshore – VAV reheat pre 1980s - Office	X	X	X		X	X		X
Historic Renovation – I Building								

Figure 5-3 Matrix of EEMs Applied to Generalized Models for the Existing Buildings

The aggregated energy needs and investments are integrated with the supply and distribution recommendations for the College. Obviously, no investments in EEMs were recommended for buildings planned for demolition. The Residences are relatively efficient and did not present a convincing economic case for specific EEMs under current circumstances and no immediate investments are recommended,

Investments above the Base Case are implemented. For the remaining buildings, these recommended EEM retrofits will achieve about 30% end-use energy savings.

The technical and investment assumptions for each major category of EEM are in Appendix 21: IEMP Solution Investment Assumptions.

To ensure all renovations meet acceptable energy efficiency levels, the IEMP is also recommending updating the relevant construction procurement guidelines, described in more detail in Section 7.2

5.5 New Building Energy Efficiency

There will be a significant number of new buildings between now and 2034 which will have a significant impact on the energy performance of the College.

It is recommended that new building projects form part of the Sustainable Procurement element of the IEMP. This requires all new construction to be close to current systematic global best practice. To estimate the impact of the IEMP recommendations, energy efficiency aligned with German A-Rated construction was used, which is roughly twice as efficient as OBC 2012.

Under the IEMP recommendations, Humber College would not accept any proposal that did not, at minimum, guarantee this level of performance.

This is described in more detail in Section 7.1 and Appendix 22: New Construction Procurement Guidelines.

Further background and examples of the modelling of the efficiency recommendations for new and existing Buildings is in Appendix 23: IEMP Existing and New Buildings Efficiency Background.

5.6 Heating and Cooling Distribution

The guiding principle for the IEMP solution is to maximize the cost-effective integration of heating and cooling distribution across all buildings on the respective campus. This reduces distribution inefficiencies, creates operating flexibility, and reduces the capacity and capital needed to supply the campuses.

5.6.1 Heating Distribution

As a rule, all buildings will be connected to campus-wide hot-water heating networks. Exceptions may be buildings across public streets or if internal systems would be too costly to upgrade. Pre-insulated pipes will be buried outside the buildings or in existing tunnels.

District energy pipes and associated accessories will follow the global standard (EN253 et al). To meet current Ontario safety regulations, the network will operate at a supply temperature of 95 deg C with a 65 deg C return[xiv]. If there is a possibility that the network could be extended beyond the campus boundary in future, pipe sizing will anticipate these extensions.

Building connections will be implemented using standardized, pre-constructed compact sub-stations to transfer heat to buildings and sub-systems. The sub-stations include heat exchangers between the distribution network and secondary building heating distribution. The sub-stations can also supply domestic hot water as needed.

The cost of the sub-stations and supply pipes linking to the campus network for new buildings is assumed to be included in the overall cost of the buildings and is not treated as an incremental investment.

North Campus

Implementing the hot water distribution system includes converting the existing steam network to hot water. The heating network will expand in line with new construction. The system will be supplied from a new Energy Centre which will be adjacent to Phase 1 of the new Centre for Technology Innovation (CTI)).

Lakeshore Campus

A new hot water network will be developed on the west of the campus as the major renovations and new construction proceeds. This new network will be linked to the existing warm-water network on the east of the campus to optimize operational and economic efficiencies. The system will be supplied from a new, co-located Energy Centre, to be located in the new Building A - Phase 1.

The Lakeshore Campus encompasses the site of the Father J Redmond Catholic High School, a 10,000 sq m. facility for 1,100 students. The heating network will be sized and structured for potential future integration of this facility.

5.6.2 Cooling Distribution

New integrated cooling networks create the opportunity to change cooling base load generation. The distribution will be implemented with pre-insulated pipes using the same routing as heat. Standard piping and building connection components will be used. Given the relatively small size of the cooling networks and the narrower temperature differentials, the recommendation is to direct connect to the building systems.

North Campus

The current central chilled water supply will be connected to the new Energy Centre. Some central chilling equipment in the new Energy Centre is required for expansion on the campus to the west. The existing chilling equipment in Building I will remain.

Lakeshore Campus

A chilled water network will be built on parts of the West Campus. It will be supplied from a new, co-located Energy Centre in the new Building A - Phase 1. The existing distribution on the East Campus will remain the same. No connection between the East and the West Campuses is recommended.

5.7 Energy Supply

Base load heating on both campuses will be supplied by natural gas-fired reciprocating Combined Heat and Power (CHP) engines. Two identical engines will be implemented in each Energy Centre, obviously sized to match the modelled thermal demand. On the North Campus, each engine would be about 800 kW_{el} and on Lakeshore about 400 kW_{el}.

The electricity generated by these CHPs will be used on the campus, replacing purchased electricity. This locally generated power is assumed to be net-metered, in effect valuing it at retail. Natural gas-hot-water boilers are used to supply peak heat needs and for redundancy.

The North Campus Energy Centre will be configured to be a teaching facility with a fully integrated supply portfolio. In support of this, a 230-ton absorption chiller sized appropriately to use the heat from the CHP units. Absorption chillers use the hot water recovered from engine exhaust and coolers to produce chilled water. No absorption chillers are recommended on Lakeshore Campus.

Heat storages will be built to optimize CHP operating hours and for decoupling of the heat and power requirements. Heat storages also help the generation of power at times of high tariffs[xv]. The size used on the North Campus is 150m^3 and 100m^3 on Lakeshore.

5.8 Solar Photo Voltaic

Ontario regulations and incentives support installing solar photovoltaic (PV) panels for renewable power generation. A conservative estimate of the available roof area indicated up to 4.7 MW of panels could potentially be included; on North 2.8 MW, Lakeshore 1.6 MW and 0.3 MW on Carrier Drive. The recommended solution assumes 25% of these potential capacities are installed.

The electricity generated by PV will be used on the campus and conservatively treated as net-metered as it is assumed the current more attractive incentive pricing levels will continue to decline. It may be worth the College accelerating the implementation to benefit from current incentives.

5.9 Other Renewables

Other renewable energy supply options were considered in the preparation of the IEMP. None was immediately recommended; many are recommended for future consideration.

Green power contracts could be concluded at any time to reduce the greenhouse gas from grid power to zero. Biogas may be added to the natural gas network as part of a wider national energy policy, an approach already being adopted in some other countries, and under study in Ontario. Both these would reduce the carbon footprint of the College.

The following are technically feasible but economically not justifiable and are recommended deferred:

- Small-scale wind
- Bio-digester for catering waste
- Ground-source heat pumps “geothermal”

- Extended heat recovery and reuse

The main reason to defer these options is the primary focus on efficiency measures combined with their relatively high investment costs. A good example is supplying heating and cooling from ground-source heat pumps also known as geothermal which requires costly conversion of the building internal systems to low temperatures in the range of 35 to 40°C.

Given the academic purpose of the College, any of these could be integrated into the recommended energy solution for teaching purposes.

Utility scale wind power is rejected due to lack of space for safety zones, poor wind quality and proximity to the airport.

5.10 Water Efficiency

To further increase the efficiency of service water use, the recommendation is that the fixtures in the existing buildings that had not already been converted to low flow be converted to low flow. A Table of the targeted flow rates and impact on the generalized modelling are in Appendix 20: IEMP Water Efficiency.

New buildings, like energy, will perform to systematic global best-practice in terms of service water efficiency. Where feasible, new buildings would use grey/rain water systems. Service water use is reduced 56% in the recommended solution.

When catering, laundry and other water using equipment needs to be replaced, water efficiency will be clearly included in the recommended procurement policy.

The biggest contribution to water efficiency targets is the conversion of the steam network on the North Campus to a hot water supply and distribution system. Hot water systems have minimal leakage which will be detected and removed through leakage control. The conversion will eliminate 32,000 m^3 of make-up water, or 25% of all water supplied by the City to the College in 2014.

5.11 Energy Management Organization

Immediately establishing an energy management organization is critical to the success of the IEMP. The IEMP will complete over $65M of sub-projects demanding high-levels of leadership and project management. The recommended functional structure and responsibilities are shown below.

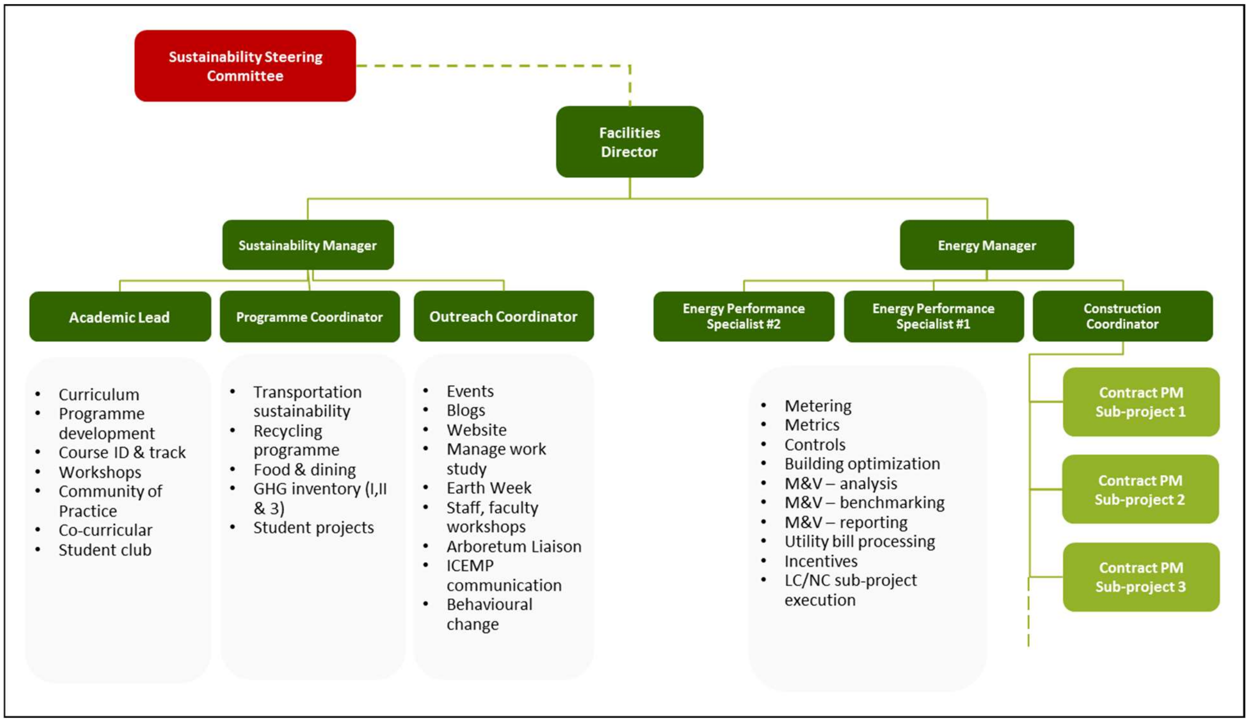


Figure 5-4 IEMP Implementation Organization

The IEMP will be implemented under the guidance of the Sustainability Steering Committee and the leadership of the Facilities Director. The Energy Manager will have a small team of energy management and control specialists, and a construction coordinator working with various sub-contractors and SIN (Strategic Implementation Network) partners to implement IEMP sub-projects.

The Sustainability Manager and team will lead the efforts to inform and engage staff, facility and students in the IEMPs goals and activities. This team will also be the key resource to ensure the academic programme recommended as part of the IEMP be implemented.

In addition to this formal organization, the recommendation includes the role of the "Energy Champion". This will be a senior level executive who has both a personal passion and commitment to see the IEMP succeed in all its goals. The Champion will be both a cheerleader and ambassador for the College's energy achievements; as well as a resource to remove unforeseen obstacles. The recommendation for Energy Champions is to have both of the IEMP Co-Sponsors; Rani Dhaliwal, Senior Vice-President of Planning and Corporate Services and CFO, and Laurie Rancourt, Senior Vice-President – Academic, fulfill that role.

5.12 Continuous Improvement

A key element of ensuring Humber College delivers ongoing continuous improvement in energy and climate performance will be to create an environment where energy efficiency and pride in energy and climate accomplishments become an irreversible part of the campus culture.

Industrial and commercial experience points to the effectiveness of "Low Cost / No Cost" programmes that actively engage all parts of the College community, and typically deliver up to a quarter of the overall potential energy saving, with the balance coming from improved sourcing and capital-based projects.

The IEMP includes recommendations to ensure facilities are operating as efficiently as possible early on, and that a systematic continuous improvement of between 0.5% and 1.5% per year energy saving is embedded in energy management practices.

5.12.1 Establishing Operation Frameworks

Upgrading the existing metering and control system of the College is an early priority. This enables flexible operating frameworks for each building and area within each building to be rigorously established.

The current operation of every significant building will be immediately assessed in detail. New operating frameworks will be established within the first year that optimize the energy use based on the planned daily schedule, predicted weather, desired comfort and air quality.

Other than optimizing the current usage of the buildings, the insights gained by a detailed building-by-building operating assessment invariably highlights collateral efficiency opportunities. This may include among other things, consolidating activity in smaller areas of the building or between buildings and retiming activity.

This will deliver immediate energy efficiency and other benefits even before more fundamental efficiency investments are made, which is reflected in the IEMP assumptions[xvi].

5.12.2 Energy & Water Treasure Hunts

The IEMP recommends structured staff and student engagement programmes, many of which will evolve over time under the leadership of the Sustainability Manager.

Toyota-style "Energy/Water Treasure Hunt" (ETH)[xvii] will be part of a disciplined programme underpinning low-cost/no-cost continuous improvement. These events involve cross functional teams with members typically from sustainability and energy management, facilities maintenance and operations, students, faculty and external support.

Participation of students and faculty are actively encouraged, both for valuable ideas and to underscore the energy culture of the College.

An ETH is a relatively formal process typically conducted over 2 days. Participants are briefed at the onset of the event as to what opportunities to look for. It is important to first develop standards for operations and maintenance procedures of existing equipment, and commissioning of new equipment.

During the ETH, the teams walk the campus and identify energy reduction opportunities. This takes place at different times during classes as well as non-class times. Teams should be asking questions as to why things are done in certain ways, and whether they could be done more efficiently.

The teams present findings and recommendations to the executive staff. Opportunities are prioritized, and an implementation plan prepared. An ETH should be done at least annually. A rigorous ETH process typically delivers annual efficiency improvement of between 0.5% to 1% per year

5.13 Deferred Maintenance

Humber College has a long list of deferred maintenance items. Many of these overlaps with the IEMP investment recommendations and can be retired as the IEMP is implemented. Others are no longer relevant due to changes in approach recommended by the IEMP and can also be retired.

The IEMP investments will allow about $17M Deferred Maintenance to be retired, of which about $12.3M comes from window and envelope measures, $1.5M from controls, $1.2M from lighting and $1.5M resulting from the steam to hot water conversion.

5.14 IEMP Investments

The IEMP recommended solution call for estimated total investments are $66M in the following categories:

- Metering and Control $ 3.0M
- Building Efficiency Measures $ 36.6M
- Thermal Distribution and Substations $ 5.0M

- Energy Generation and Conversion $ 21.4M

Investment assumptions are detailed in Appendix_21: IEMP Solution Investment Assumptions.

About $7M of these investments are already covered as part of a grant from the Post-Secondary Strategic Investment Fund (SIF) by the Federal Ministry of Industry during 2016 with the goal to invest in innovative infrastructure and repair for Colleges and Universities. Further breakdown of the IEMP investments and the SIF allocations are shown below.

Humber College			Reference Scenario	SIF funds to IEMP	Remaining IEMP
Investment Group	Measure		$	$	$
Efficiency	Metering and Control		3,000,000	2,415,000	585,000
	Window Upgrade (Existing)		8,400,000	3,476,000	4,924,000
	Exterior wall insulation (Existing)		17,200,000	2,872,000	14,328,000
	Roof insulation (Existing)		5,700,000		5,700,000
	Lighting upgrade		400,000	400,000	
	HVAC Upgrade		3,000,000	523,000	2,477,000
	Commissioning		600,000	250,000	350,000
	Water Efficiency		1,000,000	500,000	500,000
	Heat Recovery Data Center		300,000	300,000	
Supply	DH Network		3,700,000		3,700,000
	Heating Substations		700,000		700,000
	CW Network		600,000		600,000
	CHP Engines		7,900,000		7,900,000
	Absorption Chiller		1,400,000		1,400,000
	Boilers		5,100,000		5,100,000
	Steam Conversion		3,900,000		3,900,000
Solar PV			3,100,000		3,100,000
Total Investment		$	**66,000,000**	**10,736,000**	**55,264,000**
Deferred Maintenance (Avoided)		*$*			***17,069,000***
Net Investment (Cash & Avoided)		*$*			***38,195,000***

Figure 5-5 Humber College–Recommended Scenario Investment Summary

The impact of the avoided expense from current deferred maintenance items is also shown in Figure 4.5. Even though a large portion of this expense would be incurred in a business-as-usual scenario and is avoided in the IEMP scenario, the IRR calculation does not include any retired deferred maintenance.

5.15 Strategic Implementation Network

The initial implementation phase to upgrade existing buildings and supply systems takes place over about 6 years, during which time the College will maintain control of the implementation. This will ensure all elements meet the IEMP requirements and come together to deliver the plan's integrated College level performance targets.

Successful implementation of the IEMP solution demands a world-class range of skills, experience, and equipment, some of which may not be readily available in Canada or the U.S. The IEMP solution uses approaches that are more common in Europe and less in North America.

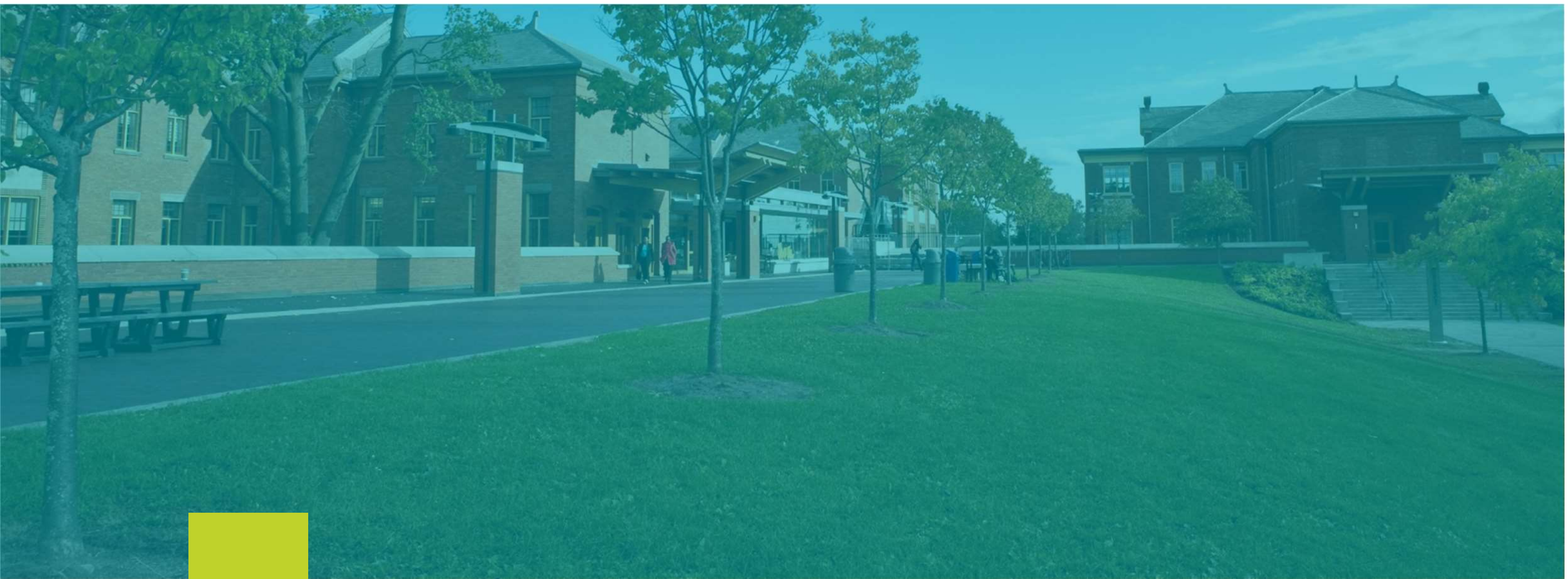
The College will create a Strategic Implementation Network of partners in some key areas. These partners will be competitively selected based on demonstrated large-scale, world-class expertise and a commitment to be priced consistent with global practices. Humber will work with this network throughout the implementation of the IEMP solution.

The key areas to identify IEMP SIN partners are:

- Strategic energy planning to track implementation alignment and course adjustments
- Energy efficient retrofitting of existing building envelopes – Insulation
- Energy efficient retrofitting of existing building envelopes – Windows
- Engineering design of district energy networks including thermal storage
- Engineering design of Energy Centres
- Construction of globally recognized Euro Norm (EN) compliant district energy networks
- Supply of district energy compact sub-stations
- Supply of CHP (Combined Heat and Power) engines and associated equipment
- Integrated controls and metering
- Integrated lighting systems
- Design and construction of new buildings with global best practice energy performance

Humber's energy solution will deliver breakthrough energy and climate performance. The College is currently among a handful of institutions in North America committing to a multi-year holistic energy plan. Given the scale of the benefits, this is likely to become more common over time, making it an attractive entry point for any SIN partner.

The implementation itself is also a living demonstration of capability and a potential training platform for SIN partner staff and customers, creating a collateral educational opportunity for Humber College.



6 RESULTS

The results of the recommended solution are shown for the recommended solution compared to the 2014 Baseline and the 2034 Base Case. The solution comprises:

- Restructured energy management organization and practices
- Advanced metering and control strategy
- Enhanced building efficiency measures
- Fully integrated heating and cooling supply on the North Campus and the Lakeshore Campus
- Gas-fired CHP on both the North Campus and the Lakeshore Campus
- Absorption chilling on the North Campus
- Solar PV electricity generation

6.1 Energy Efficiency Results

Site Energy Efficiency

By 2034, the annual site (metered) energy drops by 45% to 163 kWh/m^2 relative to 2014. This is 39% less than the 2034 Base Case.

Source Energy Efficiency

The solution includes significant electricity generation from CHP and solar PV. The CHP causes more gas to be used on the campus. However, by generating electricity and heat at the same time it is more fuel efficient than power plants in Ontario, it effectively reduces the total source (fuel) energy used by the College.

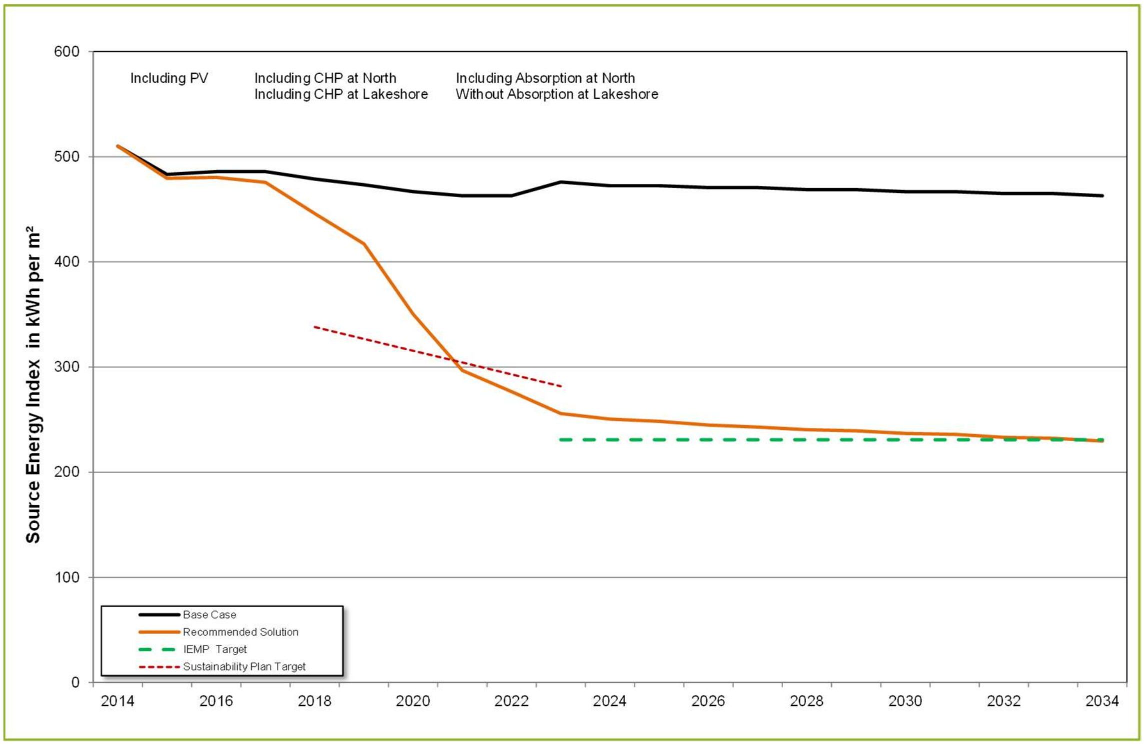


Figure 6-1 Source Energy Efficiency– Recommended Solution against Base Case

By 2034, annual source (fuel) energy drops by 50% relative to Base Case, achieving the 50% Framing Goal.

6.2 Water Efficiency Results

The reduction of water end-use intensity results from water efficiency measure in the buildings and the conversion of the steam supply on the North Campus to a hot water heat supply.

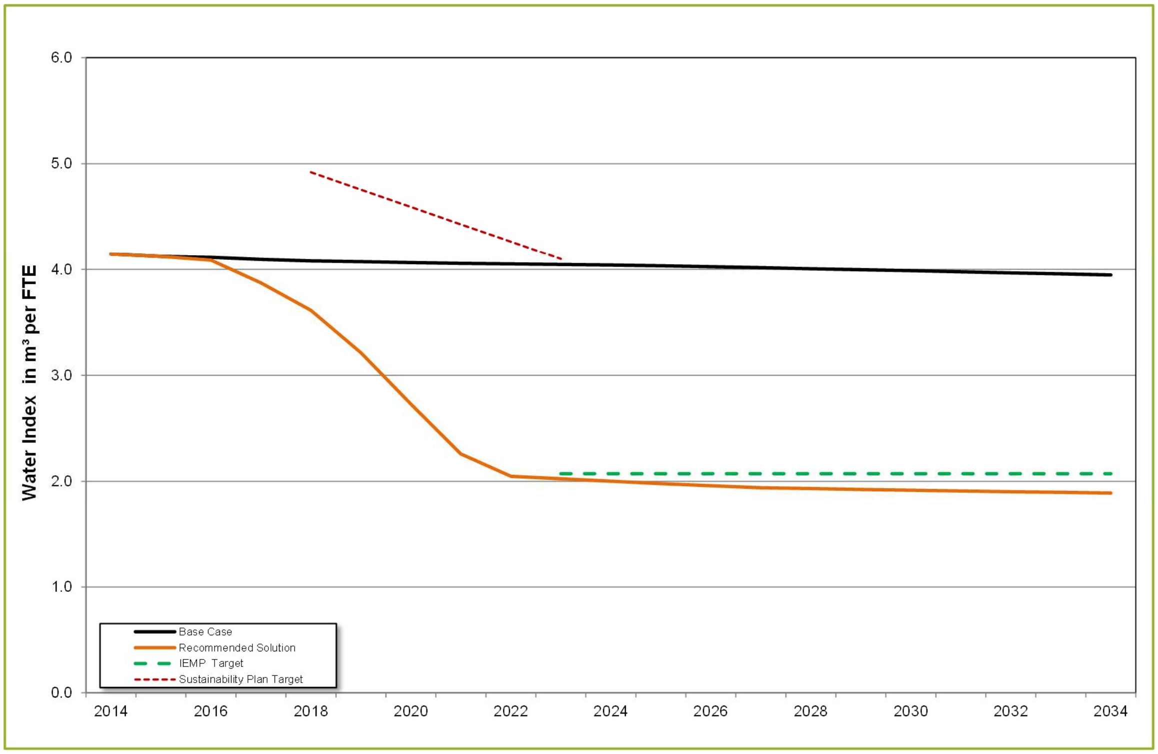


Figure 6-2 Water Use Intensity – Recommended Scenario against Base Case

By 2034, the water intensity will be reduced by 54% relative to Base Case exceeding the 50% Framing Goal. The Framing Goal is met by 2022. End-use efficiency measures represent 81% of this reduction and the remaining 19% is from the steam to hot water conversion on the North Campus.

6.3 Greenhouse Gas Performance

Total greenhouse gas emissions in 2034 are 60% lower than in 2014, which far exceeds the 30% Framing Goal, based on assuming electricity growth, efficiency and on-site generation as adding or avoiding marginal greenhouse gas emissions.[xviii] See Appendix 13 for more background.

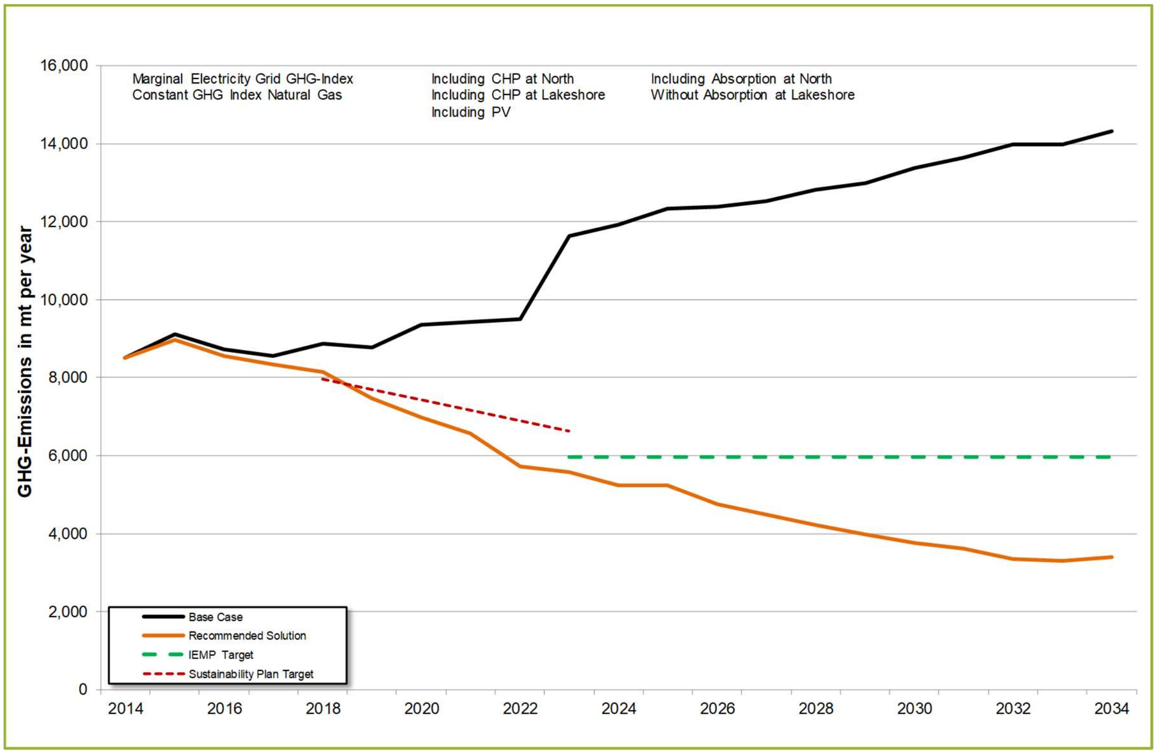


Figure 6-3 Emissions Reduction – Recommended Solution vs Base Case

6.4 Reliability

There was no explicit reliability goal for the IEMP. The long-term outlook for the reliability of the Ontario grid and gas networks was not deemed to be a major risk factor to the college's operations. However, the implementation of CHP in both campuses creates an additional energy back-up reserve to maintain critical functions and even some College routine operations.

6.5 Reduced Costs and Risks

The IEMP solution's combination of efficiency and reconfigured supply drive major cost avoidance and risk mitigation.

In the Lower price outlook, the energy cost of the College increases from $5.4M in 2014 to $8.1M in 2034, as opposed to $19.5M in the Base Case. This is a cost risk avoidance of $115 over the plan period. In the Higher price outlook, the energy cost increases from $5.4M in 2014 to $15.7M in 2034, as opposed to $37.4M in the Base Case. This is a cost risk avoidance of $182M over the plan period.

6.6 Investment Returns

The financial benefit of the IEMP is measured with the internal rate of return (IRR) calculated on the total savings and the total investments of the recommended solution.

In the Lower Price Outlook, the IRR is 10% and 16.4% in the Higher Price Outlook. Both comfortably exceed the 7% Framing Goal.

6.7 Federal and Provincial Incentives

The recommended solution was developed with a guiding principle that no future incentives or subsidies should be considered as part of the IEMP. This ensured the financial returns were based on an estimate of the market factors without the added uncertainty of future public policy at Federal or Provincial levels.

Notwithstanding, there is a high probability that many of the individual sub-projects of the IEMP will be eligible for current or future incentives, and these should aggressively be pursued. As things stand today (2016) the most likely incentive sources are summarized below. Further details are in Appendix_14: Federal and Provincial Incentives.

Ontario Power Authority - Solar FIT

This gives a guaranteed price for power from solar PV installations. The current programme could be slightly more attractive for Humber than the non-incentivized assumptions used in the plan. If this proves to be the case, the PV installation could be accelerated assuming it does not conflict with upgrading roofing insulation.

Independent Electricity System Operator – Combined Heat and Power Standard Offer Programme

The last version of this gave a 40% grant to cover investment costs of small to medium gas-fired CHP like the four units being recommended for Humber College. This would be worth about $3M for Humber and would add about 1% to the IRR.

The last approval on this programme was at the beginning for 2015, and the next iteration is in discussion. There are many positives for the Province for distributed heat and power generation, so the likelihood of continuing support is high. Humber should be an active voice in this next round of dialogue.

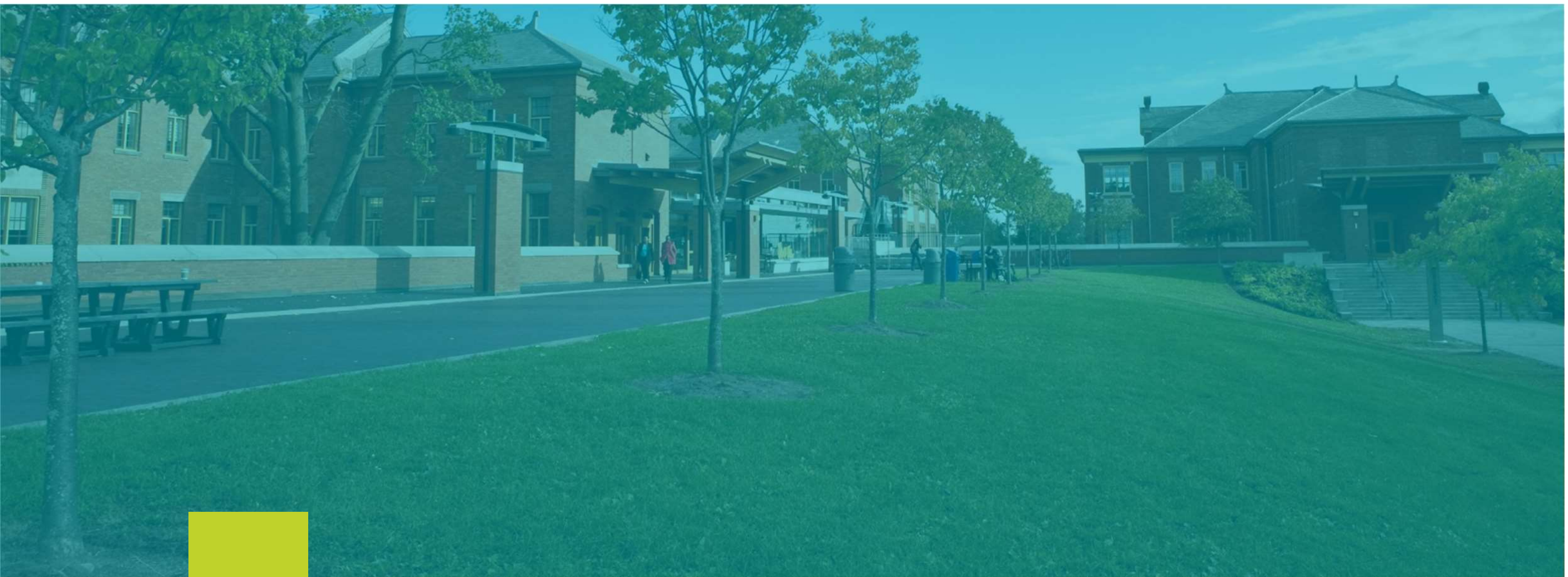
Toronto Hydro and Enbridge Gas Efficiency Incentives

Both Toronto Hydro and Enbridge Gas offer a wide range of standard incentives to encourage their customers to reduce gas and electricity use. These include grants on installation of new equipment, free consulting services and even engineering design costs. As the IEMP sub-projects roll out over the next decade, many of the elements will be eligible for support. This should be managed in a systematic way by the implementation team.

Utility programmes tend to be very standardized and based on the average state of the current market. Given the transformational nature of the IEMP, care should exercise that the incentive programme does not perversely drive non-transformational implementation. Senior level dialogue with the utilities may well result in customized incentives being possible.

Post-Secondary Institutions Strategic Investment Fund

Established by the Federal Ministry of Industry during 2016, this $2Bn fund had the goal to invest in innovative, sustainable infrastructure for Colleges and Universities. Humber College was successful with a proposal that anticipated about $10,7M of the estimated IEMP efficiency investments. As this was a “fait-accompli” prior to the completion of the plan it has been included in the IEMP. This is the one exception to the non-inclusion of incentives.



7 ENERGY AND CLIMATE CURRICULUM

The IEMP has a clear goal to offer world-class academic courses addressing integrated energy, water and climate solutions, covering the social, policy, economic, environmental and technical aspects. The courses should address the needs of key stakeholders as they navigate the dramatic changes in the energy landscape resulting from technical innovation, economic pressure, climate change commitments, regulation and public policy. These stakeholders include schools and colleges, industry, communities, property owners and developers, legislators at all levels of government, equipment and services suppliers among others.

7.1 Current Offering

In North America, energy has traditionally been taught as a series of specialty topics with limited focus as how all the pieces play together. Energy demand and energy supply are treated as two distinct territories. There is also a tendency to treat energy technology, economics and policy as distinct areas of study.

In recent years, Colleges and Universities have added many "clean energy" courses covering efficiency, various renewable energy supply opportunities, but again in narrow technical, environmental and economic silos.

Globally, energy is a market where major new business opportunities are being created and traditional energy businesses are being challenged. Despite this, there is limited focus from the business schools to focus on what is arguably one of today's biggest entrepreneurial possibilities.

Energy is also finding its way onto the decision-making agenda of many stakeholders who traditionally have had little or no need to understand the topics. Their educational and resource building needs are only just being recognized, with limited and sporadic educational tools available.

Like any transforming market, the balance between skills that are needed to drive the transformation, the supporting skills that will be needed to grow and sustain it, and the reality of skills needed in the current market is a challenge. At present the bulk of the education offerings focus on the status quo.

Some parts of the world, notably in parts of Europe, have somewhat more interdisciplinary and integrated education programmes around energy and climate, which may serve as partial models for North America.

Humber College through the School of Applied Technology (SAT) offers a range of energy related certificates and diplomas. The Sustainable Energy and Building Technology Advanced Diploma primarily focuses in creating, renovating and managing individual efficient buildings and some key aspects of renewable energy. The SAT also offers in-service training on building energy systems and energy modelling for industry. There are no specifically energy-related offerings by any of the other schools at Humber.

7.2 Market Needs – Industry

Managing energy is increasingly becoming a strategic management issue for many industries and commercial companies. There is a growing awareness that the systematic implementation of energy efficiency measures with the appropriate management encouragement and oversight should be embedded in all operational processes to ensure competitiveness and mitigate risks. There is also a growing awareness that the "big-picture" risks and opportunities from rapidly changing technology, climate change regulation, changing weather patterns, energy price uncertainty and supply reliability need to be managed as part of the overall business plans.

Humber has discovered, through the IEMP process, that creating multi-year integrated energy plans for key sites can deliver energy and climate productivity gains far higher than traditional incremental energy efficiency initiatives. Industry is at an early stage of recognizing this and this is creating new needs for programmes aimed at:

- Improving strategic energy literacy for board members and senior management
- Corporate energy planning
- Holistic site energy planning
- Corporate energy management
- Site energy management
- Managing government and regulatory relationships around energy and climate

To be effective these programmes must be interdisciplinary and cover technical, operational, human factors, economic and environmental aspects. There is also a growing awareness that the "big-picture" risks and opportunities from rapidly changing technology, climate change regulation, changing weather patterns, energy price uncertainty and supply reliability need to be managed as part of overall organizational business plans.

7.3 Market Needs – Communities

For the best part of the last hundred years, municipalities have had a relatively small role in establishing long-term energy policy and managing energy performance for their communities. This is beginning to change. Ontario is one of a handful of Canadian Provinces and US States that is challenging communities to develop long-term Municipal Energy Plans[xix]. This is the beginning of a trend that is likely to accelerate across Canada and the U.S. With over 70% of all energy used within the urban environment, Federal and Provincial governments are recognizing the clear need for "bottom up" energy and climate planning. Canadian cities use twice as much energy as their best-practice counterparts from Central and Northern Europe[xx], highlighting both the opportunities of successful energy plans, and the risks of inaction.

As in industry, municipal political leaders, and other stakeholders have an urgent need to become strategically energy literate. There will be a comparable range of Community Energy Planning, neighbourhood planning and implementation management. The diversity of stakeholders and the need for wider community engagement will put a higher emphasis on managing distributed decision making to achieve community goals. As an aside, the genesis of the integrated planning process used by Humber to develop the IEMP was the pioneering Community Energy Planning done by the City of Guelph (Ontario) in 2006.

On the technical side, there will be a high focus on energy mapping and visualization. Implementing solutions that combine efficiency, energy distributions and flexible supply across traditional ownership and institutional lines will require new training combinations covering technical, policy and business.

7.4 Market Needs – Colleges and Schools

Humber's own experience, along with a few other institutions of higher learning, will increasingly become the template for Canadian School Districts, Colleges and Universities as the understanding of the benefits of strategic energy planning grows. The same hierarchy of training needed for Industry and Communities will be relevant for School Districts, Colleges and Universities.

7.5 Market Needs – Strategic Implementation Network Partners

To implement the IEMP, Humber will create a Strategic Implementation Network, selected from companies representing global best practices. In many cases, these companies will be actively expanding their business in Canada and the USA. They will need to hire local employees to build their teams. They will also need to familiarize actual or potential clients with their capability and equipment.

Training on new or unfamiliar energy solution concepts and technology will be an essential part of building these teams and for end-users.

7.6 Recommendations

The development of a comprehensive integrated energy solution curriculum will be built on the following elements:

Use the IEMP as a Platform for Teaching and Engagement

- Configure the College as a "Living Laboratory" or "Classroom";
- Ensure efficiency and energy infrastructure measures are implemented to be suitable for teaching;
- Provide real time, online information connected to Control and Metering Data to support both structured education and community outreach; and

Develop intern and classroom facilities in the Energy Centres. Extend Existing Programmes

- Assign interns/coop students from relevant SAT programmes to IEMP sub-projects;
- Expand current "Sustainable Energy and Building Technology" program to include the basics of creating sustainable neighbourhoods; and,
- Structure IEMP sub-projects as Applied Research

Develop Restructured Integrated Energy Solution Curriculum

- Create a formal Curriculum Development Task Force including members representing most College schools, along with stakeholders from community and industry.
- Develop a new program: Building Optimization and Energy Management within the School of Applied Technology which will be directly linked to the IEMP

7.7 Current Status

Humber's Core IEMP Project Working Team (team) presented the IEMP and potential curriculum links to the Academic Operations Committee (AOC) in November 2016. The AOC includes all the Deans and Associate Deans at the College. The team is now meeting individually with all eight academic schools and some departments (Research, International) to begin brainstorming short and long-term goals for each academic school, and the various collaborative cross-curriculum opportunities. In the Spring of 2017, the IEMP team will take these ideas back to the AOC to further solidify the opportunities and complete an IEMP curriculum Action Plan.

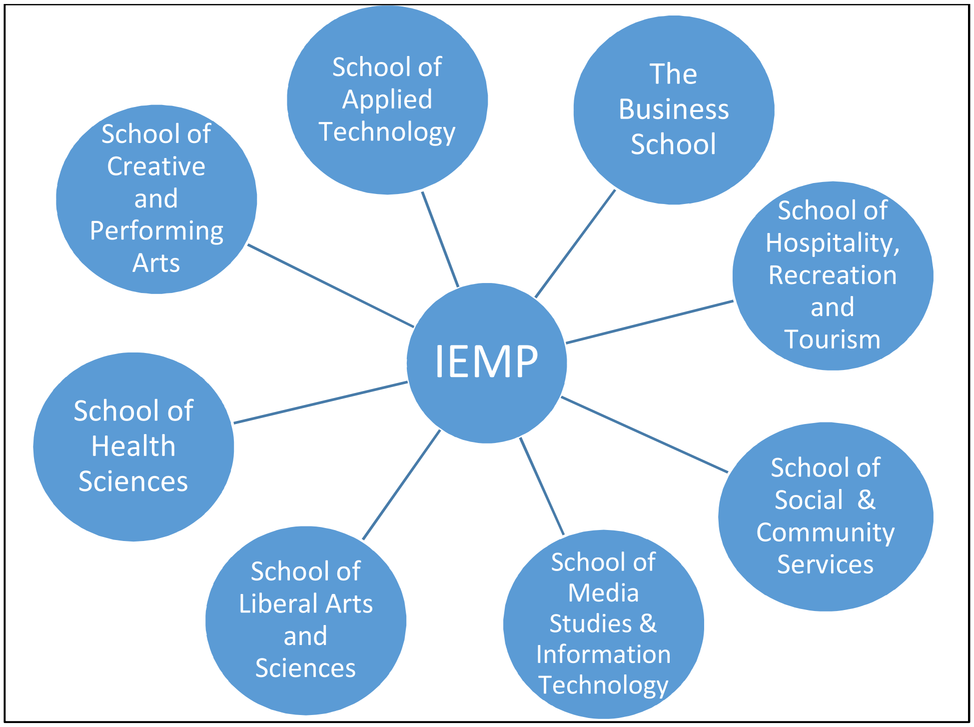


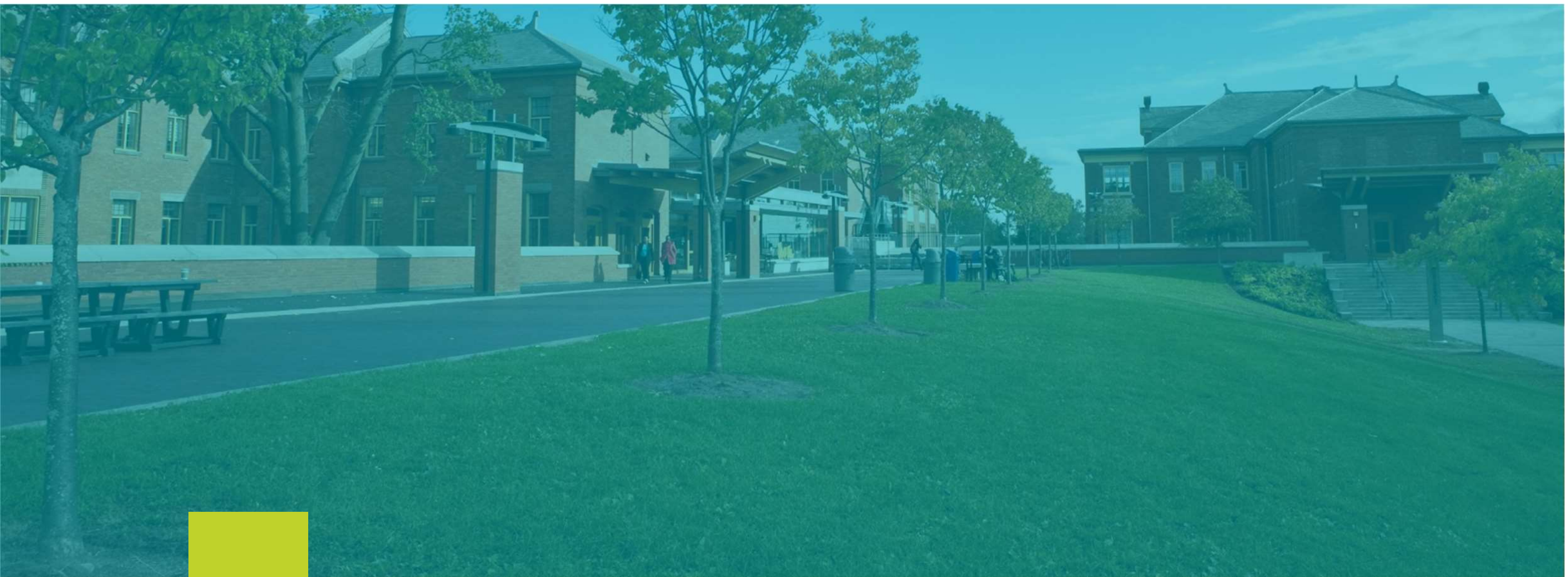
Figure 7-1 Academic Links to IEMP

School	Possible academic links to IEMP
School of Applied Technology	• Architectural Technology Program: N building re-skin design in parallel with architects (began Fall term 2016, continued into Winter term 2017)
The Business School	• Bachelor of Commerce – Marketing degree: Develop a strategy to communicate externally about Humber's leadership in energy efficiency. • Bachelor of Commerce - Finance: Assessment of individual IEMP project ROI's and financing.
School of Hospitality, Recreation and Tourism	• Humber should be an international destination exemplifying world-class energy efficiency. Prospective students should also be aware of Humber's leadership in energy efficiency. This will require the development of formal educational tours to inform individuals of IEMP progress and accomplishments. • Hospitality and Tourism Operations Management Graduate Certificate: integrate education on energy efficiency/consumption as energy is a rising operating cost for organizations. • Integrate more visible energy and water meters into culinary labs so students can monitor their consumption.
School of Social and Community Services	• Better indoor air quality, day-lighting, thermal comfort has been linked to enhanced productivity, learning, mental health and recovery.

	• Program links discussed: • Criminal Justice • Crime Prevention • Social Problems • Degree in Community Development (with the Business School) • Degree thesis research support • Center of Innovation for Health Sciences (with HRT)
School of Health Sciences	• Improved indoor air quality, day-lighting, thermal comfort will lead to enhanced productivity, learning, mental health and recovery.
School of Media Studies and Information Technology	• Marketing and branding of IEMP (began with IEMP logo development Winter term 2016) • Fundraising Management Graduate Certificate Program – Opportunities for students to use the IEMP as a real-world example of a project that requires fundraising, Potential opportunities for work study placements.
School of Liberal Arts	• Research Analyst Program: research design, data collection, analysis & interpretation, preparation & presentation of the research findings
School of Creative and Performing Arts	• There may be potential to integrate into the Arts Administration and Cultural Management program. They can use the IEMP as a case study for Corporate Social Responsibility in an organization.
Research	• Research will facilitate the many academic and research links to the IEMP.
International	• International has many global partnerships and often collaborates with other academic institutions. Potential opportunities include integrating sessions and tours of how Humber is integrating world class level design throughout the campus development (CTI, IEMP, LEED, etc.). • There could also be opportunities to do joint research with international academic partners (to be discussed with Research)

Figure 7-2 Possible Academic Links to IEMP

Humber will continue to advance discussions within the institution. It is envisioned that Humber's Sustainability Steering Committee (SSC), a cross-functional team of representatives from across the college, will continue to lead the direction of the academic linkages to the IEMP. SSC will also review progress at regular intervals. The Research department will facilitate, pitch and project manage research projects that evolve from the IEMP. The Office of Sustainability will act as the liaison between the SSC, research and the capital project implementation team to lead any coordination activities that may be required.



8 SUSTAINABLE PROCUREMENT

Humber College is a major customer for a wide range of items that have a significant impact on energy use, costs and carbon footprint. While there have been individual efforts to include energy and water efficiency a part of the procurement criteria, a consistent overall approach is absent.

A key recommendation of the IEMP is that all significant procurement includes clear energy, water and related requirements that accelerate the achievement of the IEMP Framing Goals and, as an influential public institution[xxi], influence the behaviour of others.

The following sections focus primarily on energy and water related aspects.

8.1 New Construction

The guiding requirement for all new buildings is that their energy and water performance will always meet systematic global best practices. This would challenge all designs to be at least as efficient as buildings that represent a significant portion of new construction somewhere in the world.

Humber College will include specific energy performance targets for all future buildings that must be met by the selected architectural, design and construction teams. The design must be supported by both detailed energy modelling and supporting background showing how best practices are achieved and sub-project goals are met before it can be accepted.

The construction team must commit to commissioning the building to the design performance levels before handing over to the College. They must provide reasonable contractual assurances that the building will operate at these levels in normal use.

By the standards of 2016, a new building meeting these criteria would be nearly twice as efficient as a building meeting current Ontario Building Code. This would have the performance level typical for an A-rated building in Germany; a level representing well over 20% of that country's new construction market.

All new construction must be designed to be connected to the heating and cooling networks and include the necessary substations and supply connection to the networks.

During 2016, a provisional set of new construction energy performance guidelines was developed for an actual procurement. A slightly adapted version of these is included in Appendix 22: New Construction Procurement Guidelines.

8.2 Building Renovation

The recommended solution includes significant renovation of most existing buildings within the first half of the plan period. Some renovations will also occur for reasons other than solely improving their energy efficiency. Ideally, most of the energy renovations would be planned to coincide with other needs including deferred maintenance, repurposing or functional upgrades.

As is the case for new construction, required energy and water criteria will be included as part of the renovation procurement, irrespective of the driving reasons for the procurement. Initially these will be aligned with the levels used for the generalized energy models in the IEMP. They will be refined and strengthened over time. Depending on the specifics of any renovation these could include:

- Insulation requirements for wall and roof renovation or repair- currently at least R22 for walls and R25 for roofs;
- Thermal properties of windows – at least 1.0W/m²/deg K;
- Combined thermal performance of renovated building envelopes supported by energy modelling;
- Lighting performance including control flexibility – a combined lighting/daylighting intensity of not more 7.5 Watts/m²;
- Connection to campus heating and cooling networks using standard compact sub-stations with costs competitive to Scandinavian and German markets;
- Right-sizing of heating, ventilation and air-conditioning systems because of other demand reduction measures supported by appropriate modelling.
- Water efficiencies that meet or exceed the IEMP criteria

In the case where a comprehensive whole-building renovation is being done, then the energy retrofit procurement requirements would be comparable to those for new construction where the College would establish an overall "Design Energy Target". The design and construction team would be expected to contractually confirm the performance supported by relevant energy modelling.

8.3 Material Purchasing

The recommendation is to develop material purchasing criteria to support the ongoing energy performance efficiency gains of the IEMP continuous improvement targets. These should be part of sustainability criteria. The priority will focus items with a significant impact on electrical plug loads.

Computer and Office Equipment

Equipment for data centres including servers should minimally be Energy Star and demonstrably meet the highest current standards available in the Canadian market. Data centre systems should be designed to operate at the highest possible temperatures to minimize unnecessary cooling energy.

Similarly, all computer equipment and peripherals should be minimally Energy Star listed, with deep stand-by as close as possible to the "one watt standby" initiatives[xxii] in North America and the EU.

Printers, monitors, TVs, copiers, smart boards and similar office and teaching equipment must have Energy Star rating and deep standby as a matter of policy. Where equipment is used for general information such as screens in public spaces, proximity/motion standby control should be considered.

The College should implement a comprehensive networked standby strategy to manage all networked devices to ensure items are in deep standby when not needed.

Catering Equipment

Commercial kitchens are energy and water intensive, and there is a body of resources[xxiii] to make them less so. From a procurement standpoint, again all equipment should be Energy Star with the maximum turn-down and stand-by capability. As this is a significant educational area for Humber, the Energy Team and the Faculty could also work closely to develop operating and control approaches to minimize energy use. This could also be the basis of a training module for students on running energy efficient kitchens.

Maintenance Repair/Parts

Any maintenance action requiring parts replacement should include material selection criteria to ensure the replacement item meets the best available efficiency.

If the replacement part is to extend the life of older equipment, the request should include an energy lifecycle-cost assessment of the alternative to replace the entire equipment. An IRR of 10% or higher should be grounds to replace the equipment with a more efficient modern version.

Transportation and Vehicles

Transportation energy use is beyond the scope of the current IEMP. The energy and carbon footprint of staff, student and transporting goods and services for the College is probably greater than for the campus buildings. Some immediate procurement actions are recommended. The College is developing a TDMP (Transportation Demand Management Plan). The combination of the current IEMP, which covers Scope 1 and 2 emissions, and the TDMP, which will cover a large part of Scope 3 emissions and will form the ongoing Climate Action Plan for the College.

Any major renovation or new construction projects including parking and upgrades will include criteria to favour access by mass-transit, ride share, e-ride, two-wheelers, and near-zero emissions vehicles.

Any vehicle purchased by, or on long-term lease to, the College should be as close to zero-emissions as possible consistent with a life-cycle cost assessment yielding at least at least a 10% IRR over the most efficient fossil alternative.

All transportation companies used directly or indirectly by the College should meet the Vendor Selection Criteria outlined in 7.7. Specifically, they will be required to spell out their approaches to:

- Energy and carbon efficient operations including vehicle selection and efficient audits
- Packaging to minimize weight and wasted volume
- Packaging reuse and recycling to minimize land-fill

Food Services

Any food service companies including on-campus franchisees should meet the Vendor Selection Criteria outlined in Section 7.7. Specifically, they will be required to spell out their approaches to:

- Reusable/returnable packaging, bags, pallets, trays to minimize landfill
- Reduction and handling of food waste to minimize aerobic emissions
- Energy and water efficient operations

Travel

Any travel companies recommended by the College for business travel, including hotels, airlines and car rental, should meet the Vendor Selection Criteria outlined in Section 7.4 below. Specifically, they will be required to spell out their approaches to how they select their fleets and manage operations to minimize emissions.

Any travel authorized by the College should meet some key criteria:

- Be placed with an approved vendor
- Be as efficient a choice as possible consistent with the goals of the event or trip, including type and size of vehicle/transportation option used

- “Walk the talk” by using energy efficient hotels, conference venues etc.
- Use e-meeting alternatives if professional effectiveness is not jeopardized

The College should consider including favourable terms for all College staff, faculty and students for personal travel as part of their procurement decision making. This would be a communication opportunity to underline the energy and carbon messages of the IEMP and could make for more attractive commercial terms for the College and the vendor.

To create visibility to the cost of carbon from business travel, Humber College could establish a green fund. This would have as revenue a carbon penalty placed on all business travel based on the estimated emissions. The fund would be used for recognitions and funding small sub-projects that reduce emissions from College activity

8.4 Vendor Selection and Engagement

Humber College’s impact on the environment goes far beyond its direct use of energy. Energy, water and carbon is embedded in everything it buys indirectly adding to the College’s environmental footprint. The supplier’s energy, water and carbon costs are also passed on to the College and all other customers.

As a major public institution, Humber can also influence its supply chain to meet certain criteria before contracts are placed. In addition to the sustainable procurement criteria already outlined for specific products and services, all major vendors will be expected to respond specifically as to the degree to which they meet the following criteria as far as their commitment to energy, water and climate are concerned:

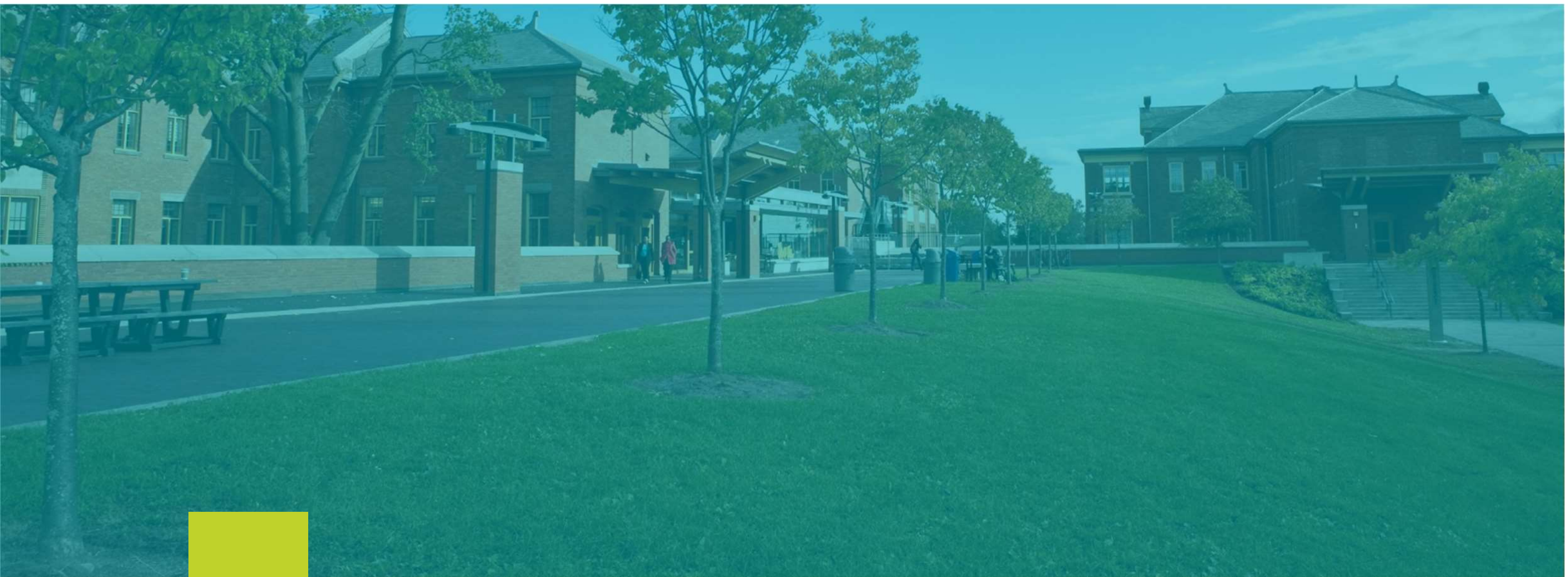
- Corporate Energy and Climate Policy approved and supported by Board, Trustees and Executive Leadership.
- Policy supported by written and approved energy, water and climate plans with targets that are aligned with Canadian National Climate Policy and Ontario Climate Action Plans, or comparable with senior level accountability.
- Governance and policies in place to ensure these plans are part of the supplier’s day-to-day operational priorities and that targets are achieved.
- Demonstrated energy and water efficiency gains in operation over the prior ten years.
- Willingness and ability to estimate energy, water and carbon content of products and services.

Ideally, Humber would only source from suppliers where the above criteria are currently in place with significant measurable results. Companies that meet these criteria will be acceptable as viable contenders for competitive procurement.

However, many potential vendors will fall short. Recognizing this, Humber will be open to source from companies that are committed to put energy and climate policy and plans in place within two years and to report progress on an annual basis.

Through the implementation of the IEMP, Humber is acting as an example of a large complex organization, simultaneously gaining significant economic advantage while reducing it environmental impact. Humber will be willing to formally and informally share its experience with potential vendors committed to meeting its energy and climate procurement criteria.

At least for the first years, these criteria would be required to be met for large procurements above $1M per year or in a single project. By the end of the plan period, all vendors should be compliant.



9 SUSTAINABILTY AS A WAY OF LIFE

9.1 Campus and Community Outreach

The commitment to fully implement the IEMP presents Humber College with a unique opportunity to engage staff, faculty and student in energy and water efficiency and climate change mitigation. Through this, the sustainable use of energy will become embedded in the College's culture and identity; in turn influencing students and their future relationships for the rest of their lives.

The planned involvement of representatives from all parts of the College population in the energy Treasure Hunts, along with the educational and intern opportunities, will be important pillars of this change. In addition, the Sustainability Manager will coordinate outreach to the entire College on a continuous basis. This role will include the following:

- Creating and sourcing energy and climate "stories" around College energy, water and climate performance, IEMP implementation, as well as other background stories and disseminating them through social media, College web-site and internal communication networks.
- Organizing and hosting events throughout the year aimed at raising awareness and understanding of energy and climate change drawing on internal and external resources.
- Hosting regular energy-related workshops for staff and faculty.
- Structuring student orientation on energy-related career opportunities.
- Enabling student-driven projects that support the Framing Goals of the IEMP.

The Sustainability Steering Committee will guide the IEMP sponsors, key staff and faculty to reach out to the College alumnae, prospective students, and College Trustees to further cement Humber's reputation as a committed energy and climate leader.

The Committee will further guide the College to establish links with the local community to be sources of orientation for elementary and high-school students, and to familiarize businesses with the potential benefits resulting from a deep focus on energy, along with the resources and example offered by the College. As Humber's reputation in this space grows, the definition of "local" will change.

9.2 Performance Reporting

The IEMP is laying out a 20-year plan for Humber College to have world-class energy and climate performance including academic programmes that meet the energy and climate challenges of the 21st Century. Effective and sustained reporting of results will be key to making sure the College leadership, entire College population and key stakeholders remain engaged for the long haul.

The Sustainability Manager, supported by the Energy Manager, will be accountable to develop, and roll-out a detailed communication and engagement plan as an early IEMP implementation action.

The Energy Manager will be responsible for extensive performance reporting, which will use data from the upgraded metering and control systems. A flexible data reporting tool capable of organizing cost, usage and emissions data at College, Campus, Building, Department, and sub system level is a prerequisite for effective reporting[xxiv].

Another pre-requisite will be to organize the detailed sub-project implementation and performance information using well recognized Kaizen approaches[xxv].

As the IEMP move forward through the finalization of the plan, decision and implementation, a structured approach will capture, create and store narratives around process and team activities.

All three of these sources will feed into the performance reporting which will be tailored for different audiences, at a minimum including:

- College Board
- Executive Committee
- Sustainability Steering Committee
- Deans and other Department Heads
- Facilities Team
- Student Organizations
- Campus users and visitors
- External Stakeholders
    - Strategic Implementation Network Partners
    - Government
    - Industry and Commerce Partners
    - Host Communities
    - Ontario Colleges

Simple monthly and year-to-date summaries of costs, emissions and usage for the College and Campuses against current year and long-term IEMP targets will be suitable for the board, executives, and steering committees. A similar breakdown by department would meet the needs of Deans and Departments.

To communicate to all campus users, the IEMP is recommending all buildings have electronic energy performance labels following an adapted version of the NRCan EnerGuide and EU Performance Labelling approaches. These should be clearly visible and show current performance, historical performance and target. Obviously, today's electric display and networks will allow explanatory background along with anecdotal success stories to be added.

Important performance reporting that cannot be overlooked is the achievement of process milestones. These will include major decisions to approve the IEMP, form and staff teams, select strategic implementation network partners, approve ongoing resources to continue IEMP implementation, capture incentives, launch academic programmes etc. These are as important as the reporting of current operational data, since they set the framework for the future.

The packaging of information to each stakeholder will ultimately be limited only by the creativity of the team and the College leadership. Key will be to maintain a high level of reporting quality, credibility and consistence for years to come.

9.3 Continuous Benchmarking

All good energy programmes contain a structured process to regularly benchmark progress. The benchmarking will address the following key questions:

- Has the implementation drifted from the original strategic intent?
- How does our performance progress compare with a respected peer?
- How does our energy management process compare with a respected peer?
- Have external factors moved to the point we should adapt our targets?
- Are we missing collateral opportunities?

The continuous benchmarking at a minimum will comprise regular sharing with four distinct benchmark entities:

- Trusted strategic advisor to challenge the depth and consistency of the IEMP implementation.
- A comparable academic institution delivering world-class energy performance including education programmes, probably from somewhere in Europe.
- A peer Canadian or U.S. academic institution committed to transforming its energy performance to world-class and working through comparable implementation challenges.
- An industrial company with a proven global reputation for consistent and sustained excellence in global energy management; companies such as Toyota and BASF would fit this profile.

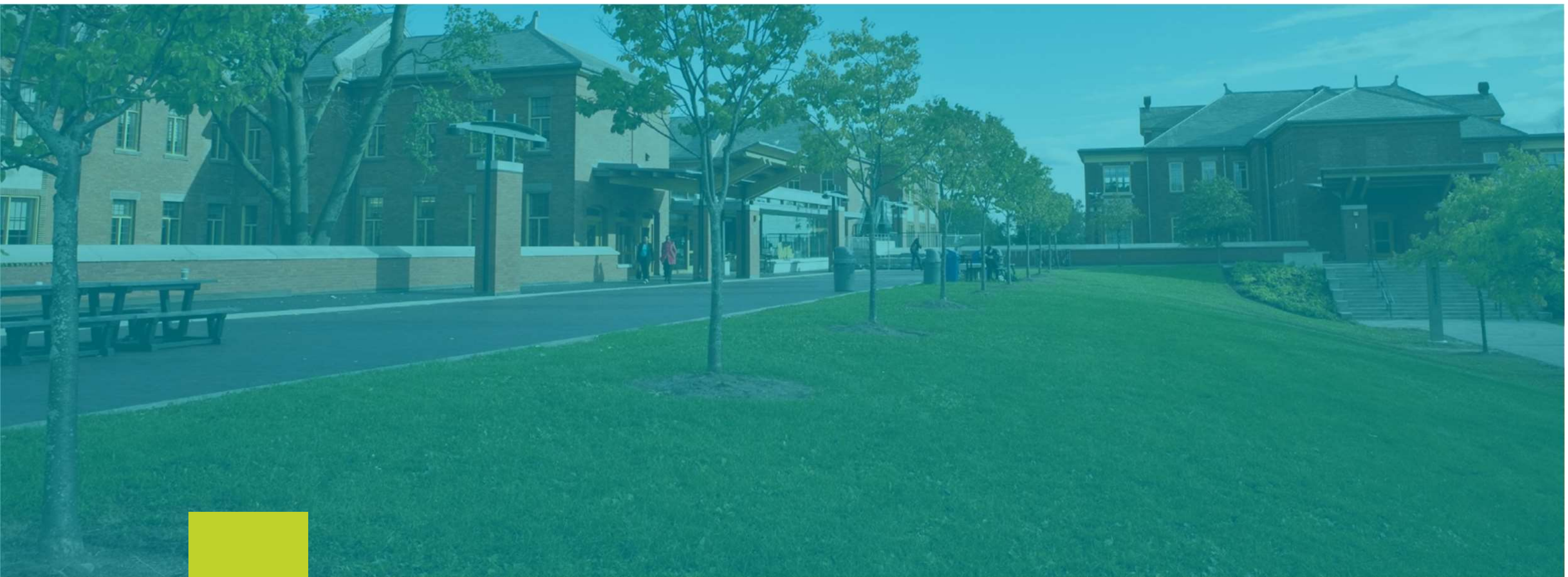
The Energy Manager will also have the accountability to scan the global market for changes in technology or proven performance that may require adjusting the IEMP goals and modifying the implementation emphasis. The Energy Manager would be expected to summarize Humber's benchmarked performance and progress about every six months.

9.4 Government Engagement

The Federal Government and the Ontario Provincial Government are clearly committed to meeting Canada's commitment under the Paris Climate Accords. This will require Canada's urban infrastructure to at minimum meet the kind of energy and climate performance goals embraced by Humber through the IEMP. There will also be a need for transformational energy planners and implementers. Humber will be well placed as an example of successful energy transformation and a resource to create capacity for the wider community.

Humber's government affairs team, supported by the Facilities Director and the Sustainability Steering Committee, will proactively and regularly brief all government levels of their intent and progress to both further the public policy agenda and to potentially gain support to accelerate or deepen their energy transformation and associated educational programmes.

This role will also include advising the government agencies on policy areas where adjustments could accelerate the wider policy achievement. As an example, these currently include the treatment of CHP for emissions assessment and the treatment of district energy relative to assessing building efficiency. In the future, other items will be added to this list.



10 NEXT STEPS

To be successful, the IEMP will require a multi-facetted, well-orchestrated implementation process. This must successfully deliver the initial phases of deep retrofits while building the management processes that will continuously improve the energy and climate performance of the College for decades to come.

At the same time as the IEMP is proceeding through the formal approval process by the Executive Team, the following implementation frameworks should be also considered and approved through the proper channels.

10.1 Implementation Timeline

The IEMP implementation process will address management structure and process, operational measures and construction. The timeline from the IEMP approval is summarized in these three categories – Management (M), Process (P) and Operational (O).

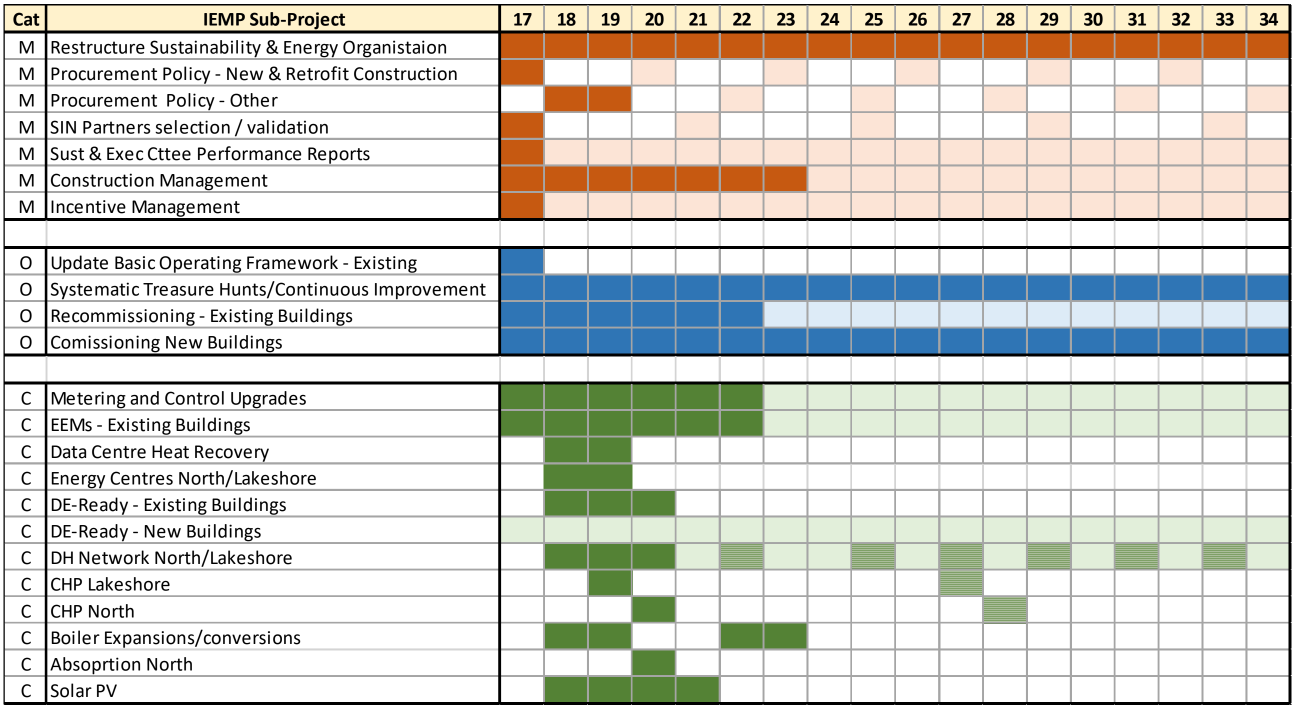


Figure 10-1 IEMP Solution Implementation Timeline

The numbers on the top axis represent the years of IEMP implementation from 2017-2034. Items in dark colours refer to IEMP sub-projects where there is a specific investment or cost assumption in the IRR calculation. This includes the striped items which are provisions for future costs associated with the measure. The lighter colours indicate activities that have become embedded in normal course of business.

This is a very challenging timeline. However, the sooner that energy waste can be eliminated, the more rapidly positive cash flow is freed up to finance investments and positive returns for the College. Additionally, this minimizes the upside risks from uncertain energy and carbon prices.

10.2 Organization and Governance

Section 4.11 outlines the organizational roles and accountabilities for the Energy and Sustainability teams. Staffing these roles should be an immediate priority. A reasonable cost provision has been included in the IEMP.

The recommendation is for Humber to keep design control up to the level of procurement grade designs for all sub-projects, and to ensure contracts include energy performance commitments consistent with the IEMP.

As outlined in various parts of the IEMP, many of the elements of the IEMP solution are not currently widespread practice in Canada. This will make it essential for Humber to be an “informed customer” to insist on global best practice performance and competitive pricing.

All construction estimates in the IEMP include design, management and contingency assumptions. Depending on the measure, some allowance should be allocated to the costs of the Energy and Sustainability teams, and to consultants who are contracted to act as customer representatives.

Early in the implementation process, the various outreach and engagement processes and the formalization of basic operating frameworks and continuous improvement protocols should be finalized and set in motion. Again, the IEMP has included reasonable cost provisions for these.

Monthly performance summaries should become the "norm" by no later than the middle of 2017, along with regularly scheduled Sponsor and Sustainability Steering Committee action reviews. This will enable Humber to rapidly implement a data tracking, mapping and reporting tool that can grow and adapt as the IEMP implementation rolls out.

Section 5.6 indicates there is a high probability that many of the IEMP measures would be eligible for standard or customized incentives. There should be an early and clear role assignment to identify and manage these opportunities, and complete the various proposals and applications required in a timely manner. As a reminder, the IEMP pricing assumes no incentives will be applied, so every incentive gained improves the IRR.

Section 8.4 emphasizes the importance of engaging Federal and Provincial Government in the IEMP process. The necessary orientation and assignments for the College Government Affairs Team should be put in place as soon as the IEMP is formally approved. Ensuring this happens is a combined accountability for the IEMP Sponsor and the Facility Director.

10.3 Financial Structuring

The estimated investments for the IEMP recommended solution are summarized for the first 6 years using the interest rate in the lower price scenario. This accounts for all but $3M of total investments.

IEMP Humber College	Total		2017	2018	2019	2020	2021	2022
Investments by year	Including PV							
	$		$	$	$	$	$	$
Recommended Solution excluding PV	**62,900,000**		4,400,000	7,600,000	16,500,000	16,700,000	7,900,000	7,200,000
Solar PV	**3,100,000**		0	775,000	775,000	775,000	775,000	0
Total Solution	**66,000,000**		**4,400,000**	**8,375,000**	**17,275,000**	**17,475,000**	**8,675,000**	**7,200,000**

Figure 10-2 Financing Needs from 2017 to 2022

As a reminder, $10.7M of this required funding has already been sourced from the SIF programme.

An immediate assignment will be for the College Facilities and Finance teams to develop a detailed multi-year financing plan, for approval by the Executive Committee well before the end of 2017.

This should identify the sources of funds needed to finance the implementation of the IEMP recommended solution, which could come from some combination of the following:

- College Cash Reserves
- College guaranteed loans/bonds
- Private sector loans/bonds
- Strategic Investment Partner in-kind investments
- Federal and Provincial Incentives
- Utility Incentives
- Redirected capital budgets
- Redirected deferred maintenance budgets

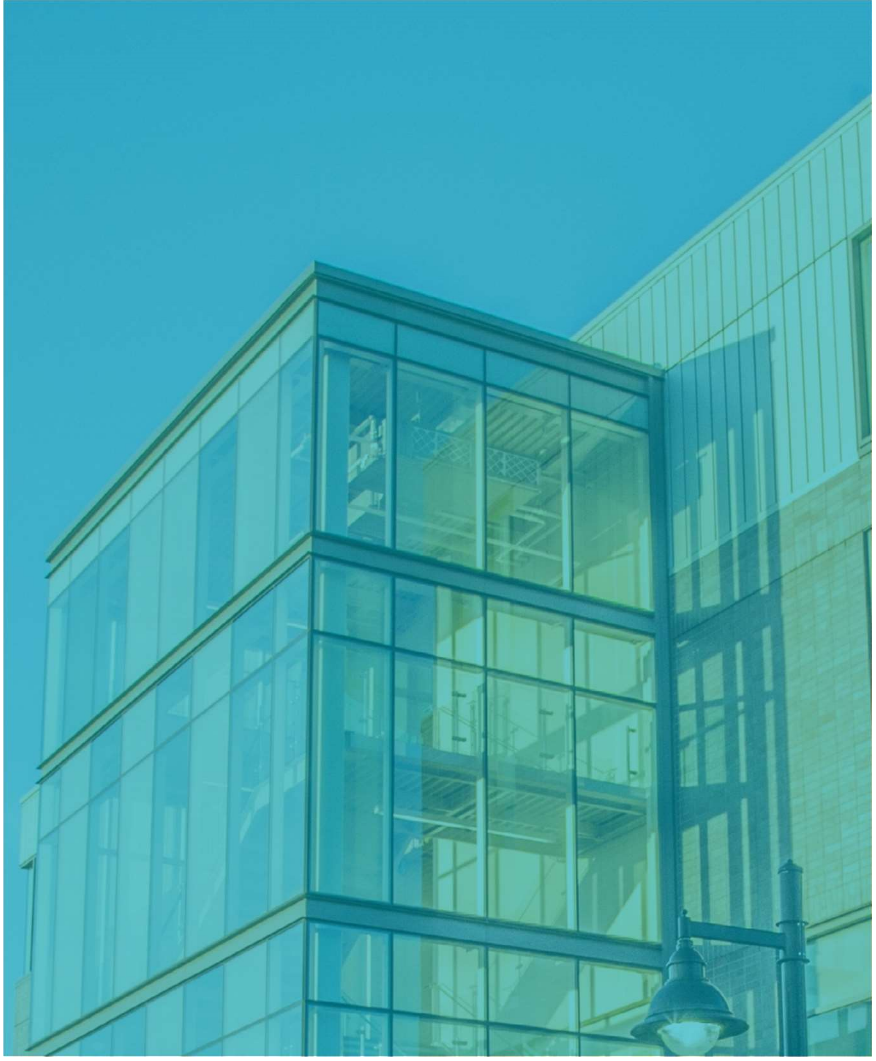
The financing plan should include a structured approach which could result in a $5M upside investment risk over the recommended solution estimates. This upside risk will mostly be applied to areas where the IEMP is recommending moving into elements that are not yet part of the Canadian market norm.

10.4 SIN Partners Selection

Section 4.15 highlights the importance of making an early selection of Strategic Implementation Partners. That section highlights nine areas of expertise necessary for the successful implementation of the IEMP. These could be fulfilled by a single SIN partner or a mix of partners, with some of the necessary expertise coming from Canadian companies, while some is likely to come from outside of Canada.

Within the first six months of the implementation process, Humber should develop a Request for Qualifications (RFQ) procedure to gain information that would lead to the selection of highly-qualified SIN partners. This should be a transparent, competitive process with at least three players being invited to apply in each category. ***As a reminder, only companies with demonstrated global leading capability at globally competitive costs will be invited to participate in the SIN selection process.***

In addition to transforming its own energy performance, Humber College is motivated to contribute to a wider transformation in the Canadian market. To this end, the RFQ and SIN selection process could logically be a teamed effort with other Canadian colleges or universities having similar goals and objectives.



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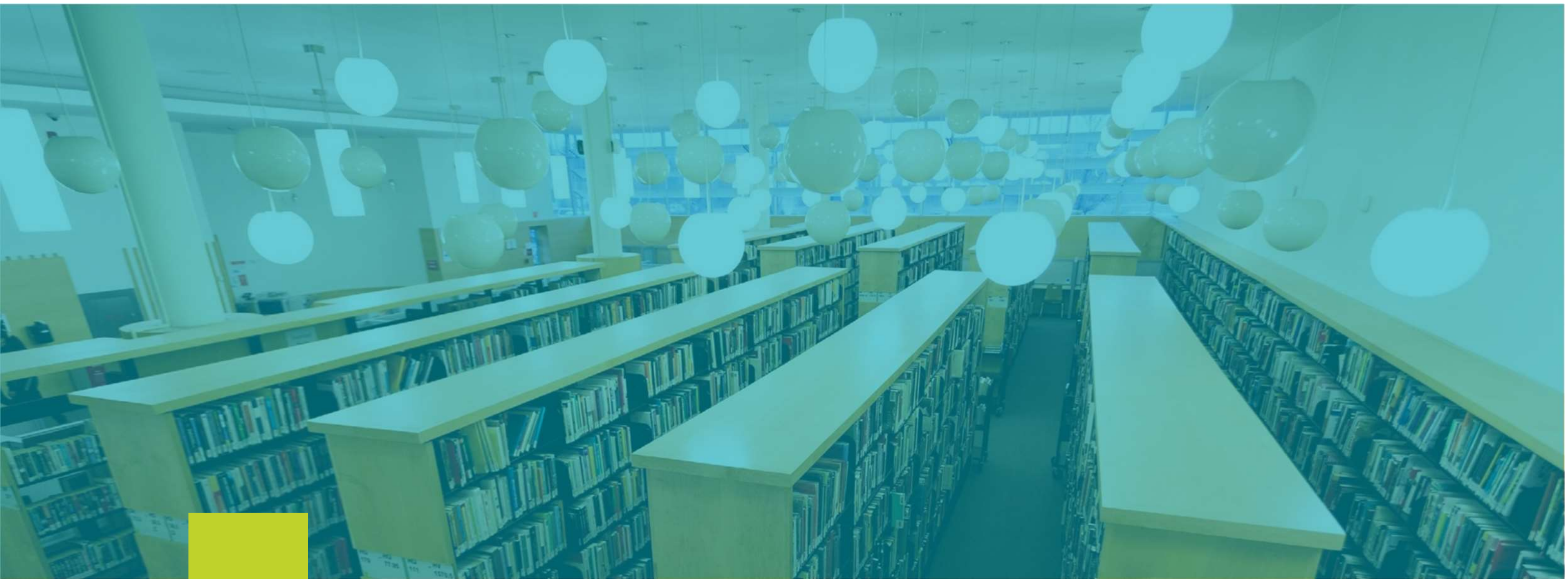


1 Appendix: IEMP Scope and Planning Team

The energy- and climate-related items that would be included in the final IEMP scope were clarified and confirmed during the Kick-off Meeting in December 2015 and are summarized per the following.

Item	Scope
Baseline Year	2014 2005 included as indicative baseline for the Humber Sustainability Plan 2014-2019
IEMP End Year	2034
Geography	North Campus Lakeshore Campus
Public utilities	Electricity Natural Gas Water
Energy Uses	All normal building uses All special uses inside buildings Campus street lighting Use for on-site distribution Use for on-site conversion
Buildings	All current buildings with selected exceptions All anticipated future buildings or expansions All anticipated future demolitions
On-site primary energy	Baseline: None Future: All reasonable alternatives assessed
Greenhouse gas emissions[xxvi]	Scope 1: On-site stationary combustion sources Scope 2: On-site use of grid electricity

Figure 1A- 1 IEMP Scope Assumptions

The overall project team is shown below:

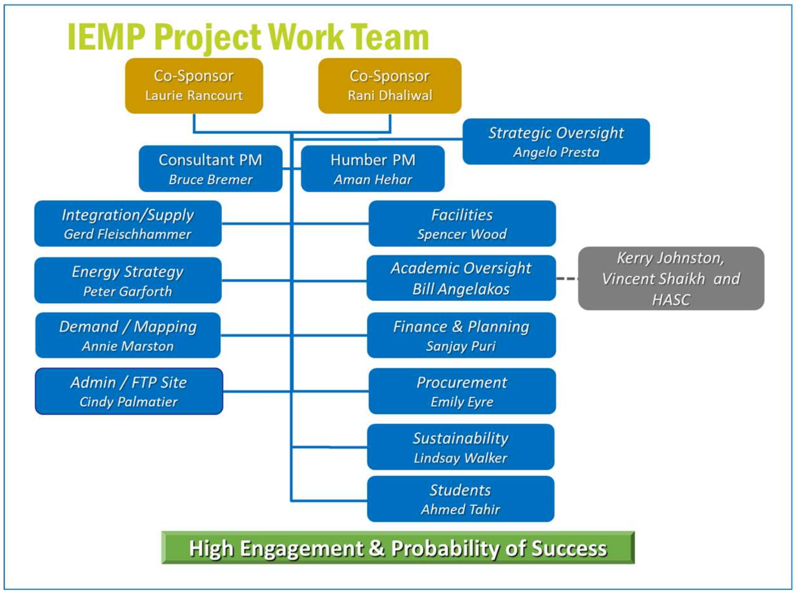


Figure 1A- 2 IEMP Project Work Team

2 Appendix: IEMP Process Map and Milestones

The IEMP was launched at a Project Kick-off Meeting in December 2015 with the participation of the Humber Team, Mentors and senior leadership including the Sponsors. The scope of energy-related activities included in the IEMP was clarified and confirmed.

Alignment was also reached between all stakeholders on the Framing Goals, all of which would ideally be met by the completed IEMP (Step 2). These Framing Goals establish the preconditions for the Team prior to starting on detailed analysis. To be effective the Framing Goals should meet the following criteria:

- Must encompass the entire energy use of the College
- Must balance often conflicting outcomes
- Must establish pathways to achieving goals, even if these are not clear at start of IEMP process
- Must highlight quantitative indicators which are easily derived from readily available data
- Must include non-quantitative goals which are 'core' to final recommendations and build on Humber's "living laboratory" initiatives
- Must aim high, motivate change and, if achieved, lead to significant institutional successes

Following the Kick-off, a detailed analysis of the energy use, emissions and costs for the Baseline year on each campus was developed (Step 3). A team gathered detailed information on 4 buildings (N Building, Carrier Drive, I Building and L Building) across Humber's campuses and created detailed computer energy models of each. The other building on the campuses used a general modelling concept.

Any existing plans that would affect the future energy profile were confirmed (Step 4). This includes planned expansions, repurposing or demolition of buildings. It also includes overall activity growth and the general sustainability goals of the College.

The final IEMP includes recommendations based on future risks around energy pricing, environmental legislation and any other uncertainties that are relevant. A key step was to gain agreement with all stakeholders on these risk profiles (Step 5).

The Base Case representing a "business-as-usual" view of energy use from the Baseline year to 2034 was then developed (Step 6), incorporating existing activity and infrastructure plans, along with the cost impacts of the various risk profiles. The Base Case highlights energy vulnerabilities of the College, and the degree to which the Framing Targets would be missed if no significant energy-related actions were implemented by the College.

Since the IEMP takes a "service-to-fuel" perspective for a large, complex College, there could be an unwieldy number of possible combinations of efficiency, energy distribution and supply choices. Using the insights from the Base Case analysis and the experience of the Team, the scenarios to be analyzed in-depth were selected (Step 7). This was completed for the Base Case and Scenario Review Meeting with the full Team in March 2016.

Once the scenarios were agreed to, each was analyzed as a combination of Demand Efficiency (Step 8), Energy Distribution (Step 9) and Supply (Step 10) for each of the agreed risk profiles. The cost and effectiveness of the efficiency measures applied to the existing buildings were again estimated using the Energy Plus computer models. The efficiency of new construction was based on the College's requirement to have new buildings constructed at a LEED Silver[xxvii] rating. The Team also benchmarked findings against German A-Rated[xxviii] practice.

Workbooks were developed for each campus along with a combined College workbook. Multiple options and assumptions could be adjusted to evaluate their impact on meeting the Framing Goals. This structure allowed the optimum set of recommendation to be developed.

The results of each scenario were evaluated against the degree to which they meet all the Framing

Goals (Step11). This assessment allowed the Team to make short-, medium-, and long-term recommendations for the investments in energy management, building efficiency, energy distribution and supply on the College' campuses (Step 13). The Preliminary Recommendations were established at a full Team meeting in September 2016.

This was followed by a refinement and finalization process of the IEMP (Steps 14 to 16) with a further full Team review in October 2016. The IEMP gained conditional approval in October 2016 (Step 17). It will now set the foundation for Humber's ongoing Energy and Climate Strategy, laying out priorities, continuous improvement, carbon and energy reductions and risk avoidance approaches for the next 20 years.

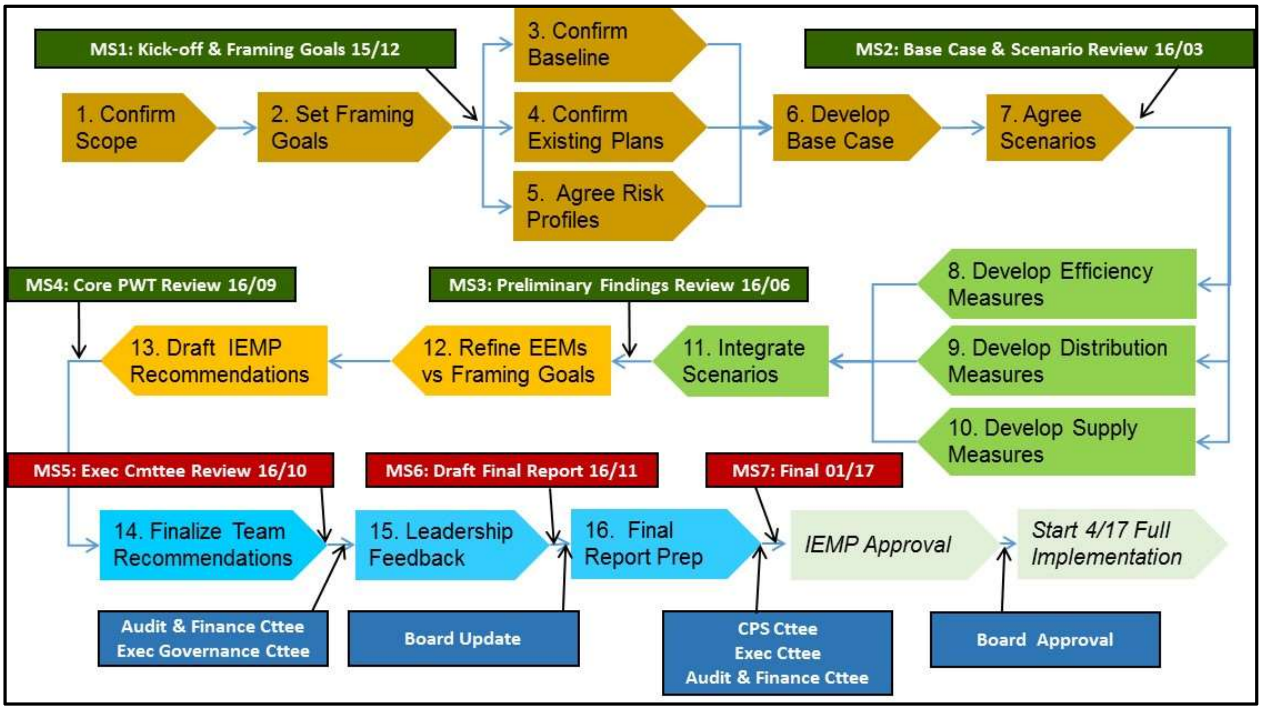


Figure 2A- 1 IEMP Structure

3 Appendix: College FTE Growth Assumptions

Based on current College plans supplied by Corrine Johnston – Director Strategic Planning & Institutional Analysis the following development is used:

- Lakeshore Campus:
  - 2015: 7,7%
  - 2016: 2.5%
  - 2017: 1.7%
  - 2018: 4.2%
  - 2019: 3.3%
  - 2020: 1.0%
  - 2021: 1.2%
  - 2022 to 2025: 0.64% each year
  - 2026 to 2030: 1.14% each year
  - 2031 to 2034: 1.3% each year

  - North Campus:
  - 2015: 2,3%
  - 2016: 1.0%
  - 2017: 2.2%
  - 2018: 1.5%
  - 2019: 1.0%
  - 2020: 0.9%
  - 2021: 0.9%
  - 2022 to 2025: 0.64% each year
  - 2026 to 2030: 1.14% each year
  - 2031 to 2034: 1.3% each year

The resulting FTE numbers are incorporated in the IEMP Integration Workbook.

			2034	2014	2015	2016	2017	2018	2019	2020
Full Time Equivalents	***Total***	**FTE**	42,957	**32,836**	**34,107**	**34,602**	**35,310**	**36,129**	**36,747**	**37,205**
North Campus		FTE	29,348	23,293	23,829	24,067	24,597	24,965	25,215	25,442
Lakeshore Campus		FTE	13,609	9,543	10,278	10,535	10,714	11,164	11,532	11,763

			2034	2021	2022	2023	2024	2025	2026	2027
Full Time Equivalents	***Total***	**FTE**	42,957	**37,575**	**37,816**	**38,058**	**38,301**	**38,546**	**38,986**	**39,430**
North Campus		FTE	29,348	25,671	25,835	26,001	26,167	26,335	26,635	26,938
Lakeshore Campus		FTE	13,609	11,904	11,980	12,057	12,134	12,212	12,351	12,492

			2034	2028	2029	2030	2031	2032	2033	2034
Full Time Equivalents	***Total***	**FTE**	42,957	**39,880**	**40,334**	**40,794**	**41,324**	**41,862**	**42,406**	**42,957**
North Campus		FTE	29,348	27,245	27,556	27,870	28,233	28,600	28,971	29,348
Lakeshore Campus		FTE	13,609	12,634	12,778	12,924	13,092	13,262	13,434	13,609

			2034	2014	2015	2016	2017	2018	2019	2020
Full Time Equivalents	***Total***	**FTE**	51.109	**32.836**	**34.849**	**35.574**	**36.228**	**37.477**	**38.479**	**38.853**
North Campus		FTE	38.749	23.293	25.087	25.714	26.151	27.249	28.148	28.430
Lakeshore Campus		FTE	12.361	9.543	9.762	9.860	10.077	10.228	10.330	10.423

			2034	2021	2022	2023	2024	2025	2026	2027
Full Time Equivalents	***Total***	**FTE**	51.109	**39.288**	**40.086**	**40.901**	**41.734**	**42.584**	**43.453**	**44.340**
North Campus		FTE	38.749	28.771	29.438	30.120	30.817	31.531	32.262	33.009
Lakeshore Campus		FTE	12.361	10.517	10.649	10.782	10.917	11.053	11.191	11.331

			2034		2028	2029	2030	2031	2032	2033	2034
Full Time Equivalents	***Total***	**FTE**	51.109		**45.247**	**46.172**	**47.118**	**48.084**	**49.071**	**50.079**	**51.109**
North Campus		FTE	38.749		33.774	34.556	35.357	36.176	37.014	37.871	38.749
Lakeshore Campus		FTE	12.361		11.473	11.616	11.761	11.908	12.057	12.208	12.361

Figure 3A- 1 FTE in Integration Workbook

4 Appendix: Demolitions & New Buildings Supporting Growth

These two tables give further background for the assumptions used for demolitions and new construction on both campuses after the 2014 Baseline. These tables are consistent with Humber's Campus Land Use Plan and Campus Development Plan developed in 2016, and with the enrollment numbers in Appendix 3.

Bldg. Name	Yr / Mo Incl/Excl	Size Sq ft	Base Case Model	Functionality
LRC	2015/04	262,667	As built	As built
F-Upper	2015/07	42,000	As built	As built
W	2017/01	(5,661)	As built	Demolished end 2016
DX	2017/05	(1,497)	As built	Demolished
Ctr of Inn Ph I	2018/04	80,000	LEED-Silver	5 storeys - 50% classroom/50% labs
GH Expansion	2019/09	40,000	LEED-Silver	Addition to GH – 100% classrooms
Ctr of Inn Ph 2	2020/04	120,000	LEED-Silver	5 storeys - 70% classroom/30% office
LX Demolition	2021/01	(32,102)	As built	Demolished
Res25	2023/01	327,000	LEED-Silver	6 storeys – 880 beds + common areas
G Demolition	2023/01	(15,780)	As built	Demolished
P Demolition	2026/01	(8,153)	As built	Demolished
M Demolition	2026/01	(30,692)	As built	Demolished
N Acad 26	2026/01	31,000	LEED-Silver	3 storeys - 70% classroom/30% office
N Acad 28	2028/01	37,000	LEED-Silver	4 storeys - 70% classroom/30% office
N Acad 30	2030/01	38,000	LEED-Silver	4 storeys - 70% classroom/30% office
N Acad 32	2032/01	42,000	LEED-Silver	4 storeys - 70% classroom/30% office
N Acad 34	2034/01	46,000	LEED-Silver	5 storeys - 70% classroom/30% office

Figure 4A- 1 North Campus - New Construction and Demolitions Assumptions

Bldg. Name	Yr / Mo Incl/Excl	Size Sq ft	Base Case Model	Functionality
LRC	2015/04	262,667	As built	As built
F-Upper	2015/07	42,000	As built	As built
W	2017/01	(5,661)	As built	Demolished end 2016
DX	2017/05	(1,497)	As built	Demolished
Ctr of Inn Ph I	2018/04	80,000	LEED-Silver	5 storeys - 50% classroom/50% labs
GH Expansion	2019/09	40,000	LEED-Silver	Addition to GH – 100% classrooms
Ctr of Inn Ph 2	2020/04	120,000	LEED-Silver	5 storeys - 70% classroom/30% office
LX Demolition	2021/01	(32,102)	As built	Demolished
Res25	2023/01	327,000	LEED-Silver	6 storeys – 880 beds + common areas
G Demolition	2023/01	(15,780)	As built	Demolished
P Demolition	2026/01	(8,153)	As built	Demolished
M Demolition	2026/01	(30,692)	As built	Demolished
N Acad 26	2026/01	31,000	LEED-Silver	3 storeys - 70% classroom/30% office
N Acad 28	2028/01	37,000	LEED-Silver	4 storeys - 70% classroom/30% office
N Acad 30	2030/01	38,000	LEED-Silver	4 storeys - 70% classroom/30% office
N Acad 32	2032/01	42,000	LEED-Silver	4 storeys - 70% classroom/30% office
N Acad 34	2034/01	46,000	LEED-Silver	5 storeys - 70% classroom/30% office

Figure 4A- 2 Lakeshore Campus - New Construction and Demolitions Assumptions

These two maps show the assumed location of new construction on the two campuses.

Blue indicates a building that came into service in 2015, red indicates demolitions and brown is new construction.

Figure 4A- 3 North Campus – Location of New Construction and Demolitions

Figure 4A- 4 Lakeshore Campus – Location of New Construction and Demolitions

5 Appendix: Assessment of Current Energy Management Approach

The key observed examples of the energy programme are:

- The energy team consists of facility personnel and managed by the facilities section but limited interaction with other sectors of the organization.
- The goals are established through the sustainability plan but limited initiatives or a developed action plan of how to meet the goals.
- Energy-related management tends to be reactive to pressing needs rather than built into all aspects of campus planning.
- There is limited staff / student / faculty engagement over energy- and climate-related topics, with no regularly structured energy efficiency-related events or process.
- Related to the utility contract area, there is invoice quality control, but opportunities exist on the specific utility contracts.
- There are tracking systems for data but limited analysis or overall reporting to others the information.
- The energy-related opportunities and impacts are limited in the planning of new construction and strategic infrastructure planning.
- There are minimal activities related to the development of an energy culture inside the College with emphasis on the curriculum.

ES Criterion	Humber Assessment	H	M	L
Commit to continuous energy performance improvement				
Energy Manager appointed	Spencer W is the energy director with minimal involvement by Senior management.			
Energy Team established	No coordinated cross functional activity through the organization, Facilities team is the lead.			
Energy Policy in place	Energy goals are incorporated and communicated through the sustainability plan.			
Assess of energy performance and opportunities				
Gather and track data	Utility bills are tracked monthly through out the year, information reported through facilities.			
Normalized energy data	No normalization activity in place for adjustment to weather or other factors.			
Establish Baseline	Baseline established for the year 2005 at a college/campus level.			
Benchmark performance	Benchmark energy internally year over year and compare to other regional colleges.			
Analysis	Monthly energy data reviewed by the energy manager but minimal analysis or actions .			
Technical audits	Energy audit completed in 2014, results of audit analyzed and some projects scheduled .			
Establish energy performance goals				
College-wide energy goals	Long term -5 year-goals established for energy through the sustainability plan.			
Identify efficiency potential	Some evaluation potential established based on benchmarking but focus was regional only.			
Campus-wide energy goals	Specific goals have been established and in place through the sustainability plan.			
Create energy action plan				
Energy action plan	Energy reduction projects were identified through the energy audit but results not confirmed.			
Assign energy plan resources	No specific roles or resources defined for project implementation.			
Implement energy action plan				
Communication plan	Minimal communication initiatives developed for implementation of plan or current status.			
Raise Awareness	Minimal activities identified and communicated. Information distributed under sustainability.			
Build capacity	Some technical training but only for facility personal. No structure or process plan.			
Track & monitor	Monthly and annual tracking, monitoring of the energy but only internally in facilities.			
Evaluate progress				
Measure plan results	Compare yearly energy usage per the target metric but only internally in facilities			
Review energy plan	Review annual information only, but no action taken based on the results.			
Recognize energy performance achievements				
Internal recognition	No internal recognition programs or activities.			
External recognition	No external recognition programs or activities.			
Education				
Create curriculum foundation	No targets or activities established.			
Define roles and resources	No internal or external activities established.			
Track and Monitor	No reviews or updates established.			

Figure 5A- 1 Energy Star Assessment of 2014 Energy Management Status

6 Appendix: Comparison of IEMP and Sustainability Plan Goals

Sustainability Plan Goals

Prior to developing the IEMP, the College had a Humber Sustainability Plan 2014-2019 that addresses multiple sustainability topics, including water, energy and greenhouse gas emissions. The Sustainability Plan goals were based on a 2005 reference year and a 2023 achievement year.

Item	Units	2005 Value	2014 Value	2023 % target	2023 Target
Energy Efficiency (Site)	kWhe/m²	331	296	50%	148
Energy Efficiency (Source)	*kWhe/m²*	*565*	*510*	*None*	*None*
Water Efficiency	M³/FTE	8.2	4.2	50%	4.1
GHG Emissions	mt	13,270	8,510	50%	6,635

Figure 6A- 1 Sustainability Plan Goals showing 2005 and 2014 Baselines

Energy Efficiency goal set based on the site (metered) energy used per square metre of floor area. For an indicative comparison, the source (fuel) energy used per square metre is shown in Figure 9-5 for 2005 using the same site/source ratios used in the IEMP for 2014.

Water efficiency was based on potable water consumption per FTE. Greenhouse gas emissions were based on energy related Scope 1 and Scope 2 absolute levels. There were no economic targets.

The Sustainability Plan had no intermediate year targets.

Integrated Energy Master Plan Framing Goals

The College leadership required that the Framing Goals for the IEMP should at least as challenging as the goals already in place from the Sustainability Plan. The IEMP Goals were based on a 2014 reference year and a 2034 achievement year. They are substantially more challenging than the Sustainability Plan.

Item	Units	2014 Value	2034 % target	2034 Target
Energy Efficiency (Site)	*kWhe/m²*	*296*	*None*	*None*
Energy Efficiency (Source)	kWhe/m²	510	50%	255
Water Efficiency	M³/FTE	4.2	50%	2.1
GHG Emissions	mt	8,510	30%	5,957
Internal Rate of Return	%	NA	NA	>7%

Figure 6A- 2 IEMP Goals showing 2014 Baseline

Energy Efficiency Goal was set based on the source (fuel) energy used per square metre. This definition is necessary since on-site generation of power is part of the energy solution.

Water efficiency and greenhouse gas emissions Goals use the same units as the Sustainability Plan. The IRR target was added based on the cash flows over 2014-2034 IEMP.

The IEMP has intermediate annual targets based on the Recommended Solution.

IEMP Framing Goals Background

Framing Goal for 2034 were set at the start of the IEMP process based on the following criteria:

- When achieved would constitute clear breakthrough success
- Address entire College are specific and easily measured
- Balanced set of goals covering:
    - Reliability / Redundancy
    - Energy efficiency
    - Environmental performance

- Return on Investment
- Academic Curricula

During the IEMP analysis, different scenarios were tested for best-fit to all goals based on a higher and lower energy and carbon cost, and interest outlooks. The IEMP recommended solution is scenario that best meets all Framing Goals considering the risks. Since the IEMP recommended solution meets all the initial Framing Goals, they are confirmed.

IEMP Energy Efficiency Framing Goal Background

The IEMP energy efficiency framing goal was based on source energy use per square metre. Source energy is an estimate of the total fuel used to serve the College, including the conversion energy needed to generate and transport electricity. The IEMP used a Site to Source ratio rounded to 2.5 based on the Ontario average generating mix for 2014 as published by the IESO combined with estimated 7% Transmission & Distribution losses.

Source	Share	Source /Site	Impact
Nuclear	62%	3.0	1.86
Hydro	24%	1.0	0.24
Coal	<1%	3.0	0
Gas/Oil	10%	2.5	0.25
Wind	4%	1.0	0.04
Biofuel	<1%	1.0	0
Solar	<1%	1.0	0
T&D	7%	1.0	0.07
Composite Site/Source			2.46

Figure 6A- 3 Site to Source Calculation for 2014 Electricity Supply

The site / source index for natural gas was 1.047 based on the index used by the US Army Corps of Engineers for energy planning purposes.

There is no IEMP Framing Goal for site energy efficiency

.

7 Appendix: Generalized Building Energy Demand Modelling

Modelling Categories use for IEMP

The models used to estimate the end use are listed below.

North - VAV reheat 2004 - Academic
North - CV no reheat 2004 - Academic
North - VAV reheat Post 1980s - Academic
North - VAV reheat Pre 1980s - Academic
North - DOAS wFanCoils 2004 - Residential
North - DOAS w/FanCoils Post 1980s - Residential
North - VAV electric Reheat Post 1980s - Office
North - VAV reheat Post 1980s - Office
North - VAV reheat Pre 1980s - Office
North - VAV reheat DX 1990s - N BUILDING North
Lakeshore VAV reheat 2004 - Academic
Lakeshore CV no reheat 2004 - Academic
Lakeshore VAV reheat Post 1980s - Academic
Lakeshore VAV reheat pre1980s - Academic
Lakeshore DOAS w/FanCoils Post 1980s - Residential
Lakeshore VAV reheat Post 1980s - Office
Lakeshore VAV reheat Pre 1980s - Office
Historic Renovation - I BUILDING
Lakeshore L-BUILDING
Ontario Code - Academic
Leed Silver - Residential
Welcome Center - eQuest Model
LRC - eQuest Model
Carrier Drive

Figure 7A- 1 List of Generalized and Individual Models used to Represent the Campuses

Lakeshore	Building B	Lakeshore VAV reheat Pre 1980s - Office
Lakeshore	Building C	Historic Renovation - I BUILDING
Lakeshore	Building D	Historic Renovation - I BUILDING
Lakeshore	Building E	Historic Renovation - I BUILDING
Lakeshore	Building F	Historic Renovation - I BUILDING
Lakeshore	Building H	Historic Renovation - I BUILDING
Lakeshore	Building I	Historic Renovation - I BUILDING
Lakeshore	Building J	Historic Renovation - I BUILDING
Lakeshore	Building K	Historic Renovation - I BUILDING
Lakeshore	Building L	Lakeshore L-BUILDING
Lakeshore	Building M	Historic Renovation - I BUILDING
Lakeshore	Building N	
Lakeshore	Building R	North - DOAS wFanCoils 2004 - Residential
Lakeshore	Centre for Justice L.	North - VAV reheat Pre 1980s - Academic
Lakeshore	Medical Building	Lakeshore VAV reheat Post 1980s - Office
Lakeshore	The Fashion Institute	Lakeshore VAV reheat Pre 1980s - Office
Lakeshore	Arts Commons	North - VAV reheat Pre 1980s - Academic
Lakeshore	Future Athletics facility	Ontario Code - Academic
Lakeshore	Building G	Historic Renovation - I BUILDING
Lakeshore	Welcome Centre	Welcome Center - eQuest Model
Lakeshore	A Ph I 18	Ontario Code - Academic
Lakeshore	A Ph I 20	Ontario Code - Academic
Lakeshore	A Ph I 23	Ontario Code - Academic
Lakeshore	Lakeshore Lodge	North - DOAS w/FanCoils Post 1980s - Residential
Lakeshore	L Acad 26	Ontario Code - Academic
Lakeshore	L Acad 28	Ontario Code - Academic
Lakeshore	L Acad 30	Ontario Code - Academic
Lakeshore	L Acad 32	Ontario Code - Academic
Lakeshore	L Acad 34	Ontario Code - Academic

Figure 7A- 2 Lakeshore – Allocation of Buildings to Models

North	Building B	North - VAV reheat 2004 - Academic
North	Building C	North - VAV reheat Post 1980s - Office
North	Building D	North - VAV reheat Pre 1980s - Academic
North	Building DX	North - VAV reheat Post 1980s - Office
North	Building E	North - VAV reheat Pre 1980s - Academic
North	Building EX	North - VAV reheat Pre 1980s - Office
North	Building F	North - VAV reheat Pre 1980s - Academic
North	Building FX	North - VAV reheat Pre 1980s - Office
North	Building G	North - VAV reheat Pre 1980s - Academic
North	Building GH	North - VAV reheat 2004 - Academic
North	Building H	North - VAV reheat Pre 1980s - Academic
North	Building I	North - VAV reheat Pre 1980s - Office
North	Building J	North - VAV reheat Pre 1980s - Academic
North	Building JF	North - VAV reheat Pre 1980s - Academic
North	Building K	North - VAV reheat Pre 1980s - Academic
North	Building KX	North - VAV reheat Post 1980s - Office
North	Building L	North - VAV reheat Pre 1980s - Academic
North	Building LX	North - VAV reheat Post 1980s - Academic
North	Building M	North - VAV electric Reheat Post 1980s - Office
North	Building N	North - VAV reheat DX 1990s - N BUILDING North
North	Building NX	North - VAV reheat Post 1980s - Academic
North	Building P	North - CV no reheat 2004 - Academic
North	Building R	North - DOAS w/FanCoils Post 1980s - Residential
North	Building S	North - DOAS w/FanCoils Post 1980s - Residential
North	Building T	North - DOAS wFanCoils 2004 - Residential
North	Building W	North - VAV reheat Post 1980s - Office
North	Humber Arboritum	North - Net Zero
North	Building F upper	North - VAV reheat 2004 - Academic
North	LRC	LRC - eQuest Model
North	Col Ph I	Ontario Code - Academic
North	GH expansion	Ontario Code - Academic
North	Col Ph II	Ontario Code - Academic
North	Res25	LEED Silver - Residential
North	Acad26	Ontario Code - Academic
North	Acad28	Ontario Code - Academic
North	Acad30	Ontario Code - Academic
North	Acad 32	Ontario Code - Academic
North	Acad 34	Ontario Code - Academic
North	Center for Trades	Carrier Drive

Figure 7A- 3 North – Allocation of Buildings to Generalized Models

Generalized Modelling Background

Building energy modelling is a complex mix of sophisticated software, large amounts of input data and an understanding of building physics. When modelling individual buildings to understand their energy use, the building must first be split into thermal zones. These are zones where the energy usage will be similar, loads, schedules, HVAC equipment and controls must then be added to each of these zones as well as the plant and AHU equipment applied to the large buidling. This level of detail is required for understanding a specific building's energy use in great detail in order to help reduce the levels of energy used and/or create a more thermally comfortable environment for the occupants of the building.

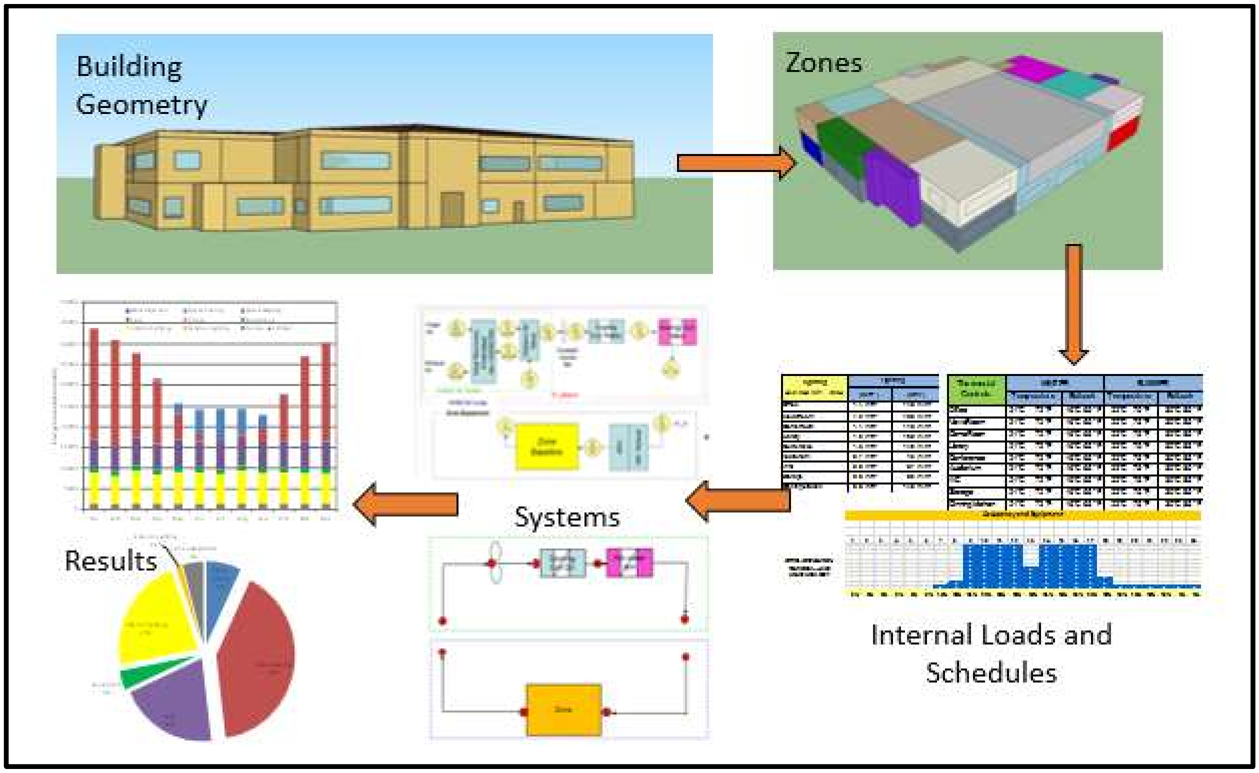


Figure 7A- 4 Details of Energy Modelling for a Single Building

This type of modelling is impractical for large scale modelling such as campuses, cities, or counties. Instead of modelling each building individually, the technique of generalized modelling is used. Generalized modelling plays an important part in creating a basis for analysing the campus energy needs as well as trialing efficiency measures to see if they can meet the goals set up in the kick off meeting. Generalized energy modelling in this context requires complex models but few of them. The community could consist of hundreds of thousands of buildings. It would be impossible and unnesary to model each individually, so these buildings are divided into similar functional categories, such as office, academic, residential and so on. It is also important to divide these categories further into age of building. In most campuses there will have been development waves where the campus has grown, therefore it can be quite clear what age category most buildings fall into. It is also important at this point to consider the building codes that were in place over the age of the town or campus. This helps to give more detail to the generalized models and create age categories.

Once the categories have been decided, generalized models are built. These are built with the same precision as an individual building model would be, but instead of exact data given by drawings or specifications, the inputs are calculated assuming the building was built to code at the time. Generalized schedules are made using studies for that type of building. Reference buildings produced by NREL and PNNL are also used. Each building is adjusted to fit with the climate of the city and the general assumptions made about the building. All models are then run under the weather file closest to the campus and the data is collated. The energy use calculated by the energy model is then output in the following categories: heating, cooling, lighting, pumps, fans, interior equipment, service hot water. This is useful for further matching to metrers and adding specific energy conservation measures to calculate potential energy savings.

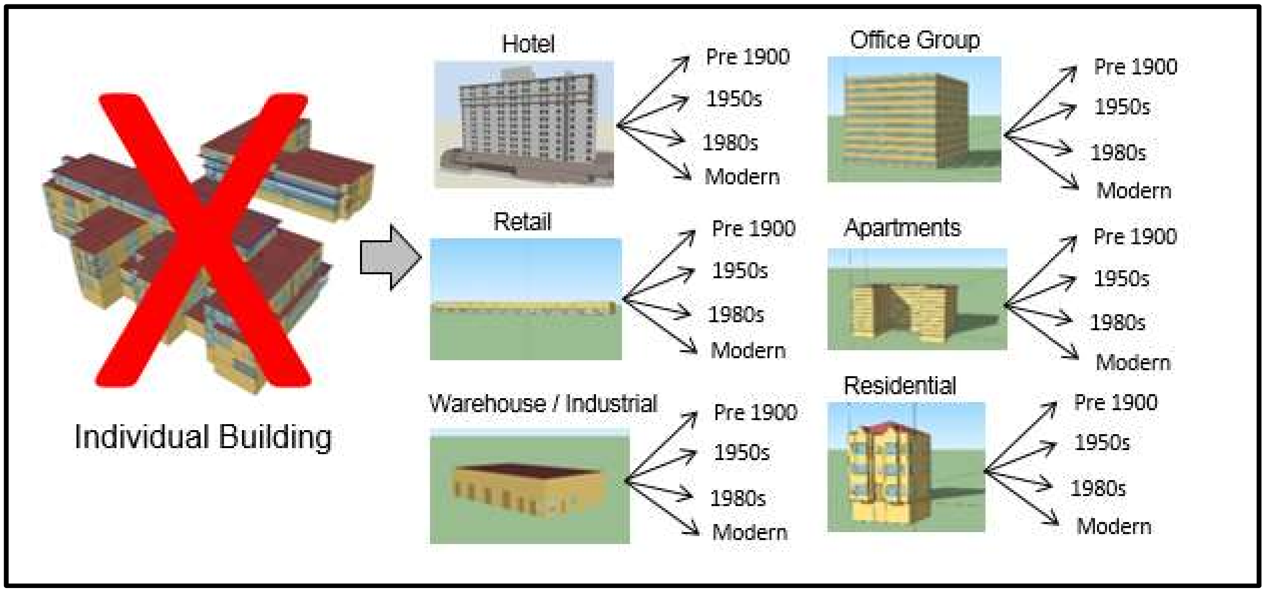


Figure 7A- 5 Theory of Generalized Modelling

Campuses on this scale can be large and so encompass many buildings. In this case generalized modelling works well because it can be assumed that the worst performing buildings in a category will be equalised by the better performing buildings. For a high level IEMP this analysis makes sense; as the plan progresses certain aspects may need more detailed modelling. If a community decides to incentivise single family home renovation, for example, generalized modelling could again be applied but the catergories widened to fit more variation into the model.

8 Appendix: Customized Building Energy Demand Modelling

Six models were customized for Humber College.Two of these were created by other modellers in eQuest - these are the LRC and the Welcome Centre. The results from these models were used in this study. Four of the customized models were created in EnergyPlus specifically for this study. These 4 buildings are: N-Building (North Campus), Carrier Drive (North Campus), I-Building (Lakeshore Campus) and L-Building (Lakeshore Campus). These were all built, using specific informtion such as floor plans, mechanical schedules, operation profiles and actual installed equipment. Where information was not available assumptions were made according to code standards at the time of building or renovation. The following figures show a summary of the inputs into these four customized energy models:

N-Building North Campus

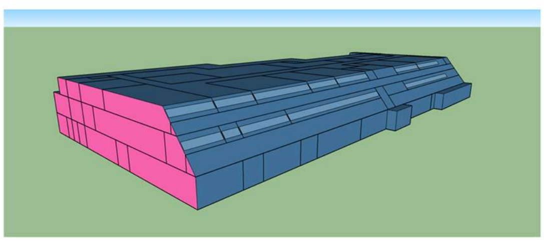
Location	Toronto	Built	1989
Climatezone	6a	ASHRAE 90.1 Version	2007
Description	Cold humid	Number of Floors	3
Heating Degree Days	4089	Building footprint	3,021 m²
Cooling Degree Days	232	New Construction Floor Area	9,062 m²
Weather File	CAN_ON_Toronto.716240_CWEC	Exisiting Building Floor area	9,062 m²
3D Building Model		**Site**	
			
Building Envelope		**Internal Gains**	
Construction Overview	Metal sloped envelope and curtain wall	Lighting	Design 6.6W/m² / Baseline 11.6W/m²
Window distribution	11%	People	3.3 m²/Per
Exterior Lighting	Baseline 0 kW / Design Case 25 kW	Equipment	11.7 W/m²
Infiltration	0.1 ACH	Service Hot Water	Electricity 0.93
Summary of HVAC			
Zone Conditioning	Spaces have VAV reheat with Perimeter heating		
Air Handling Units	3 RTUs with DX cooling and Gas furnace heating mostly used for cooling		
Other	There is a data center on the upper floor which has an individual cooling unit		

Figure 8A- 1 N-Building Customized Model

N Building was built in 1989 and has 3 stories with a total floor area of 9,060 m². The building currently operates with classrooms, offices and a corridor, which has an open area from the ground floor to the second floor. Part of the building has a data centre with roof top units specifically assigned to this room to cool the servers. The main HVAC is a VAV reheat system with hot- and cold-water coils fed by the central plant.

This building was chosen for an individual model because the façade of the building is due for an upgrade. The metered data for this individual building was not available and so it was extrapolated from the overall metres on the North Campus. The individual model showed an energy use of 2,985

MWh/year which is 11% higher than the College average, 2 times higher than LEED Gold and 3 times higher than a German A-rated building.

The Annual Utility Indexes for N-Building:

- Total 329 kWh/m^2
- Cooling electricity 71 kWh/m^2
- Gas 174 kWh/m^2
- Other electric 83 kWh/m^2

Carrier Drive North Campus

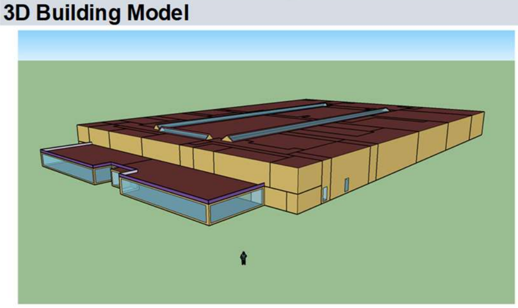
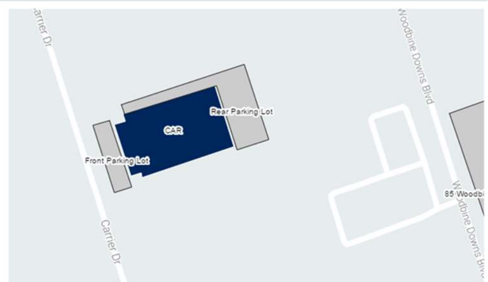
Location and Climate		Building Details	
Location	Toronto	Built	1893 renovated 2009
Climatezone	6a	ASHRAE 90.1 Version	2007
Description	Cold humid	Number of Floors	3
Heating Degree Days	3094	Building footprint	2,146 m^2
Cooling Degree Days	171	New Construction Floor Area	8,760 m^2
Weather File	CAN_ON_Toronto.716240_CWEC	Exisiting Building Floor area	
3D Building Model		**Site**	
			
Building Envelope		**Internal Gains**	
Construction Overview	Concrete with insulation	Lighting	Design 15.1W/m^2 / Baseline 14.6W/m^2
Window distribution	14%	People	17.3 m^2/Per
Exterior Lighting	Baseline 0 kW / Design Case 25 kW	Equipment	11.6 W/m^2
Infiltration	0.1 ACH	Service Hot Water	Electricity 0.93
Summary of HVAC			
Zone Conditioning	Spaces are cooled and heated using radiant ceiling panels		
Air Handling Units	Central AHUs deliver fresh air at ambient temperature to all occupied spaces		
Other	The IT rooms and server rooms have individual fan coil units to keep them cool		
Percentage of window to wall	14%		

Figure 8A- 2 Carrier Drive Customized Model

Carrier Drive was built in 1972 and has a floor area of 9,191 m^2. The building is essentially a converted warehouse, mostly one story and is used as a skills training centre for construction, plumbing, woodworking and so on. The corridors are two stories high and have skylights. The internal classrooms have low dropped ceilings to reduce the overall volume of the spaces. The building was renovated in 2009 and 80 kW of photovoltaic panels were installed. The building uses 3,063 MWh/year which is 13% higher than the College average, 2 times higher than LEED Gold and 3 times higher than a German A-Rated building.

The Annual Utility Indexes for Carrier Drive are:

- Total 333 kWh/m^2
- Cooling 10 kWh/m^2
- Gas 192 kWh/m^2
- Other electric 131 kWh/m^2

I-Building Lakeshore Campus

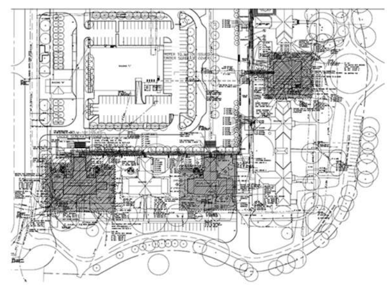
Location and Climate		**Building Details**	
Location	Toronto	Built	1893 renovated 2009
Climatezone	6a	ASHRAE 90.1 Version	2007
Description	Cold humid	Number of Floors	3
Heating Degree Days	3094	Building footprint	2,146 m^2
Cooling Degree Days	171	New Construction Floor Area	2,135 m^2
Weather File	CAN_ON_Toronto.716240_CWEC	Exisiting Building Floor area	
3D Building Model		**Site**	
			
Building Envelope		**Internal Gains**	
Construction Overview	Highly insulated envelope over original brick construction	Lighting	Design 7.8W/m^2 / Baseline 9.3W/m^2
Window distribution	14%	People	4.7 m^2/Per
Exterior Lighting	Baseline 0 kW / Design Case 25 kW	Equipment	5.8 W/m^2
Infiltration	0.1 ACH	Service Hot Water	Electricity 0.93
Summary of HVAC			
Zone Conditioning	Spaces are cooled and heated using radiant ceiling panels		
Air Handling Units	Central AHUs deliver fresh air at ambient temperature to all occupied spaces		
Other	The IT rooms and server rooms have individual fan coil units to keep them cool		

Figure 8A- 3 I-Building Customized Model

The I Building on Lakeshore Campus is one of the historic buildings that form most of the east side of the Lakeshore Campus. I Building was built in 1893 and has a floor area of 2,146 m^2. The building is mostly used for classrooms and offices and was renovated in 2009. This renovation concentrated on reducing the loads within the building as far as possible with the restrictions of maintaining the historic façade. This was done by installing interior insulation and double paned windows behind a more historically accurate single paned window which made a thermally efficient envelope. The total energy used by the I Building is 410 MWh/year, which is 35% lower than College average, falls into the upper end of LEED Gold and is 1.9 times greater than a German A-rated building of this type.

The Annual Utility Indexes for I Building are:

- Total 191 kWh/m^2

- Cooling electricity 15 kWh/m²
- Gas 124 kWh/m²
- Other electric 52 kWh/m²

L-Building Lakeshore Campus

Location and Climate		Building Details	
Location	Toronto, On	Project Type	Calibration
Climatezone	6a	ASHRAE 90.1 Version	2007
Description	Cold humid	Number of Floors	4
Heating Degree Days	3094	Building footprint	2,100 m²
Cooling Degree Days	171	New Construction Floor Area	8,398 m²
Weather File	CAN_ON_Toronto.716240_CWEC.epw	Exisiting Building Floor area	

3D Building Model

Site

Building Envelope		Internal Gains	
Construction Overview	concrete steel construction	Lighting	Design 9.4W/m² / Baseline 11.8W/m²
Window distribution	45%	People	4.1 m²/Per
Exterior Lighting	Baseline 0 kW / Design Case 25 kW	Equipment	5.9 W/m²
Infiltration	0.1 ACH	Service Hot Water	DistrictHeating 1

Summary of HVAC	
Zone Conditioning	Spaces are cooled and heated using radiant ceiling panels
Air Handling Units	Central AHUs deliver fresh air at ambient temperature to all occupied spaces
Other	The IT rooms and server rooms have individual fan coil units to keep them cool

Figure 8A- 4 L-Building Customized Model

The L-Building on Lakeshore Campus is relatively new, built in 2011, and consists of two storeys with a floor area of 9,500 m². The building mainly houses classrooms and offices. It has a make-up air unit with heat exchanger that feeds the building with outdoor air. Each floor contains an air handling unit with chilled water coils to provide cooling to the spaces, with a VAV reheat system to provide the heating required. The building utilizes the heating and cooling plant on the east side of the Lakeshore Campus. The individual model for L-Building showed high energy use in comparison with the other buildings on the site. The total energy usage of this building is 2,850 MWh/year, which is 25% higher than the College average, 2 times higher than LEED Gold and 3.5 times higher than a German A-rated building of this type.

The Annual Utility Indexes for L-Building are:

- Total 340 kWh/m^2
- Cooling electricity 55 kWh/m^2
- Gas 95 kWh/m^2
- Other electric 190 kWh/m^2

9 Appendix: Baseline Building Energy Demand Modelling Results

The following graphs summarize the building-by-building utility totals results of the Baseline and Base Case modelling, including both current and future buildings. This perspective is useful to establishing priorities by focusing in higher consuming buildings.

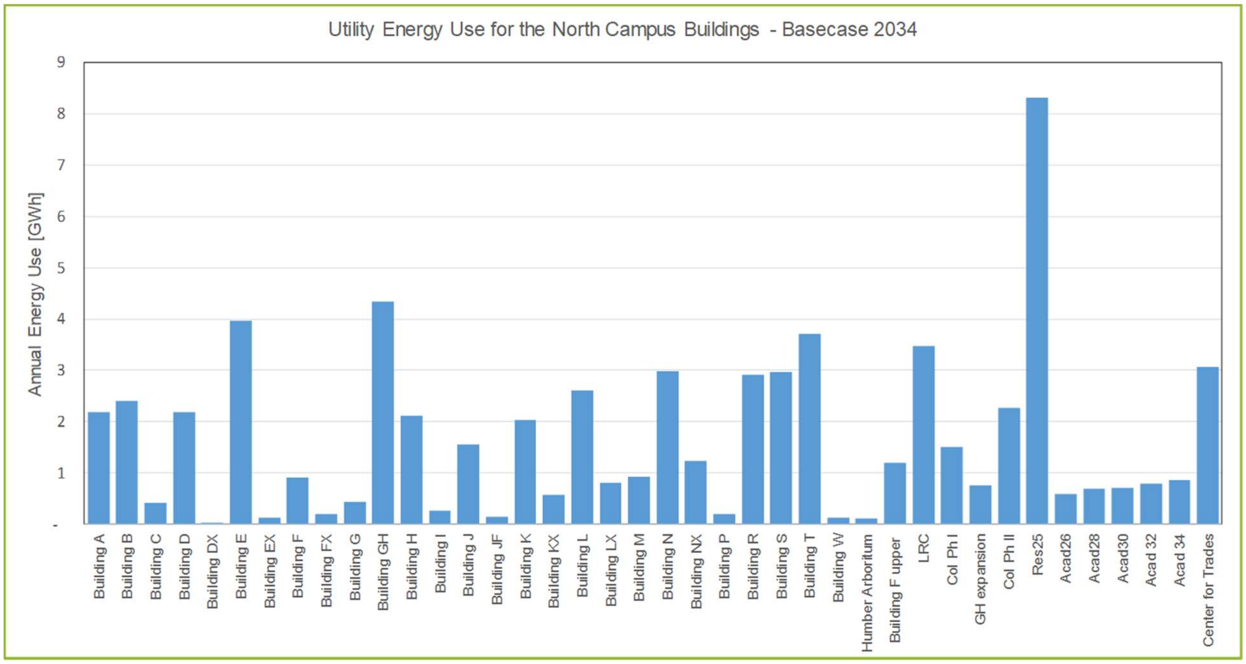


Figure 9A- 1 Utility Energy Use per Campus Building – North Campus

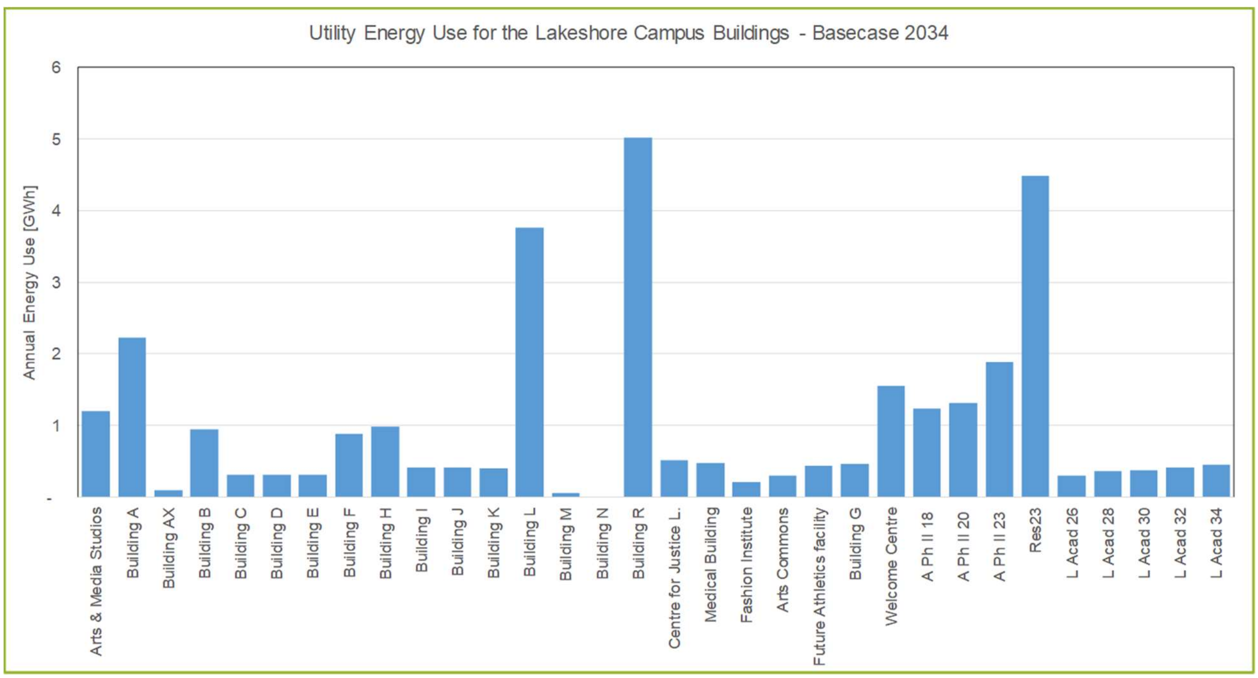


Figure 9A- 2 Utility Energy Use per Campus Building – Lakeshore Campus

The following graphs summarize the building-by-building End Use Indexes (EUI) results of the Baseline and Base Case modelling, including both current and future buildings. This perspective is useful to establishing priorities by focusing on least efficient buildings.

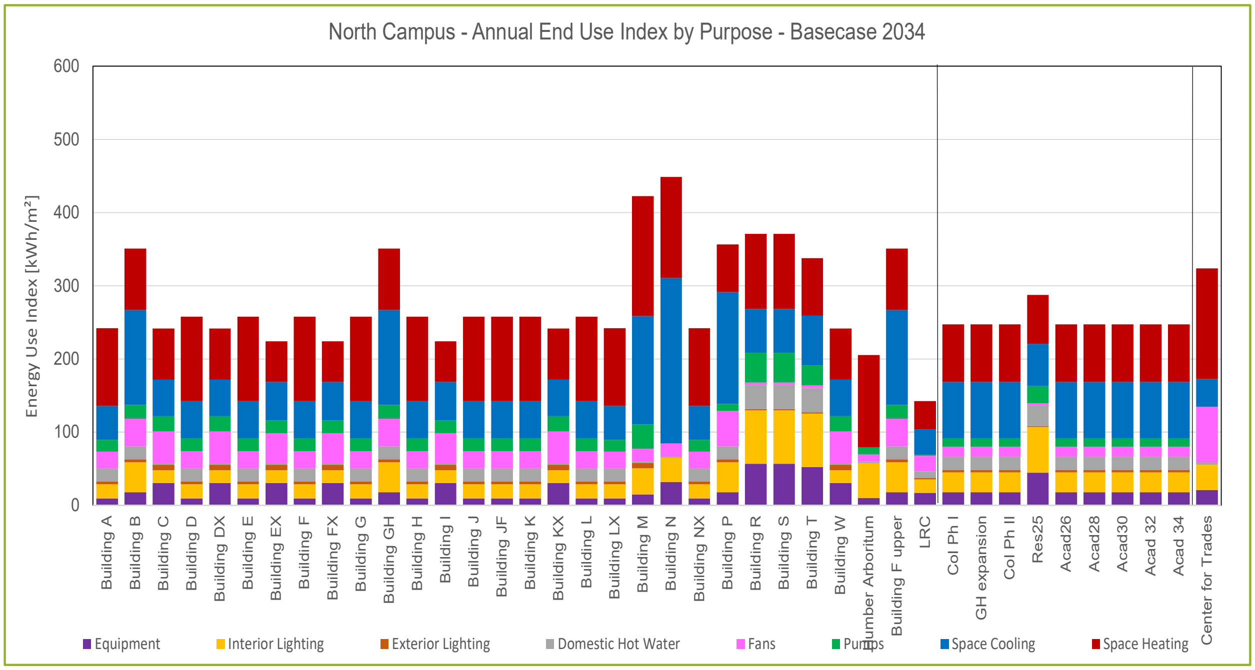


Figure 9A- 3 Energy Use Intensity for Each Building – North Campus

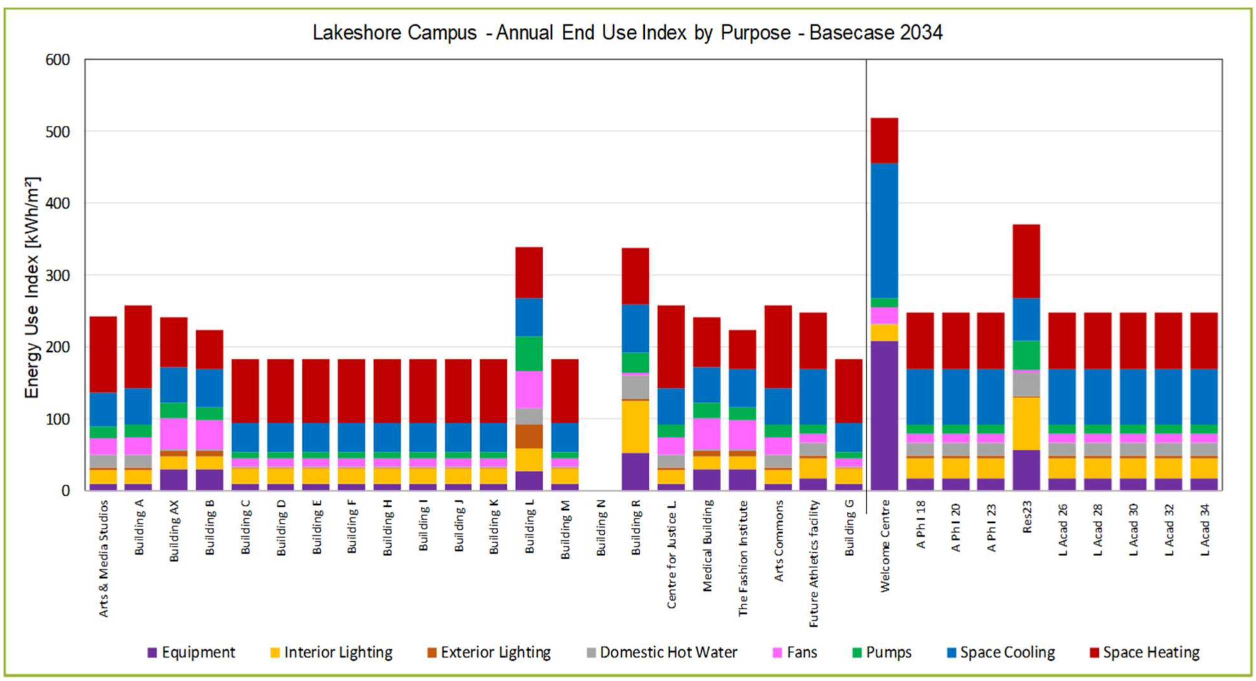


Figure 9A- 4 Energy Use Intensity for Each Building on Lakeshore Campus

Other than the few customized building models, the above results are based on generalized modelling. When consolidated at the total College or campus level, these are statistically significant results. At the building level, those are useful indictors but should be treated with caution to assess detailed building measures in the detailed implementation phase.

10 Appendix: Baseline Water Use Modelling

The College has a mix of water fittings, with some replaced with low flow fixtures. The Baseline service water usage was calculated using information from the prior energy audit done in 2014 which counted the number of water using objects in each building in the following categories:

- Shower – 2.5 gpm
- Faucet, Janitor – 4 gpm
- Faucet, Kitchen – 2.2 gpm
- Faucet, General – 1.5 gpm
- Faucet, W.C. – 0.5 gpm
- Urinal – 1 gal per flush
- Toilets – 1.6 gal per flush
- Coffee machine – 0.8 gal/cycle
- Ice Machine 22 gal/cycle
- Laundry - 13.4 gal/cycle

Where there was missing information for buildings, the water usage of the most similar type of building was applied. Lakeshore has four water meters and North there are six meters. North Campus has individual meters for the residential buildings, the arboretum and B-Building, with all the other buildings on a single meter. The water use was modelled and used to apportion the metered data to each building. The water use modelled and apportioned is detailed in the two tables below.

Campus	Building Name	Bldg. Size [m²]	Water Meter	Utility Meter Name	Baseline Water Usage Modelled	Baseline Water Usage Total proportioned by floor area
North	Building A	7,950	7000893	North Campus All other	1,021	669
North	Building B	7,822	67797710	Building B - Water	742	753
North	Building C	1,742	7000893	North Campus All other	179	147
North	Building D	7,429	70265485	North Campus All other	532	625
North	Building DX	139		North Campus All other	15	12
North	Building E	13,538	70265489	North Campus All other	578	1139
North	Building EX	607		North Campus All other	118	51
North	Building F	3,117	70265489	North Campus All other	198	262
North	Building FX	943	70265489	North Campus All other	220	79
North	Building G	1,466	60797040	North Campus All other	150	123
North	Building GH	14,085	8000393	North Campus All other	961	1185
North	Building H	7,212	70266301	North Campus All other	841	607
North	Building I	1,272	70274718	North Campus All other	46	107
North	Building J	5,296	70266301	North Campus All other	638	446
North	Building JF	534	70265489	North Campus All other	112	45
North	Building K	6,924	70266305	North Campus All other	1,388	582
North	Building KX	2,432	70266305	North Campus All other	80	205
North	Building L	8,923	70266305	North Campus All other	226	751
North	Building LX	2,982	70266305	North Campus All other	127	251
North	Building M	2,851	70266305	North Campus All other	127	240
North	Building N	9,062	60797117	North Campus All other	555	762
North	Building NX	4,484	60797117	North Campus All other	184	377
North	Building P	757	70266305	North Campus All other	118	64
North	Building R	7,829	60825762	North Residentail R	1,786	1715
North	Building S	8,002	70266304	North Residentail S	1,741	1808
North	Building T	11,575	70276250	North Residentail T - Water	2,952	2968
North	Building W	526	60797003	North Campus All other	355	44
North	Humber Arboritum	461	6000522	Centre for Ubran Ecology (Arbor	155	436

Figure 10A- 1 North Campus Buildings – Water Meters and Estimated Water Usage

Campus	Building Name	Bldg. Size [m²]	Water Meter	Utility Meter Name	Baseline Water Usage Modelled	Baseline Water Usage Total proportioned by floor area
Lakeshore	Arts & Media Studios	5,054	3253	300 Birmingham St	196	191
Lakeshore	Building A	8,923	70300124	3199 Lake Shore Blvd W	2,238	2065
Lakeshore	Building AX	424	70300124	3199 Lake Shore Blvd W	66	98
Lakeshore	Building B	4,464	70300124	3199 Lake Shore Blvd W	301	1033
Lakeshore	Building C	1,634	10002122	19 Col Samnuel Smith Park Dr	134	140
Lakeshore	Building D	1,674	10002122	19 Col Samnuel Smith Park Dr	120	144
Lakeshore	Building E	1,674	10002122	19 Col Samnuel Smith Park Dr	127	144
Lakeshore	Building F	4,606	10002122	19 Col Samnuel Smith Park Dr	394	396
Lakeshore	Building H	5,150	10002122	19 Col Samnuel Smith Park Dr	394	442
Lakeshore	Building I	2,146	10002122	19 Col Samnuel Smith Park Dr	127	184
Lakeshore	Building J	2,197	10002122	19 Col Samnuel Smith Park Dr	127	189
Lakeshore	Building K	2,098	10002122	19 Col Samnuel Smith Park Dr	127	180
Lakeshore	Building L	9,581	10002122	19 Col Samnuel Smith Park Dr	836	823
Lakeshore	Building M	319	10002122	19 Col Samnuel Smith Park Dr	305	27
Lakeshore	Building N	2,348	70300124	3199 Lake Shore Blvd W	196	543
Lakeshore	Building R	15,617	70300124	3199 Lake Shore Blvd W	4,557	3614
Lakeshore	Centre for Justice Leadership	1,754	60765775	3120 Lake Shore Blvd W	245	236
Lakeshore	Medical Building	1,999	60765755	3170 Medical Center	-	0
Lakeshore	The Fashion Institute	1,016	60765781	3166 Lake Shore Blvd W	66	65

Figure 10A- 2 Lakeshore Campus Buildings – Water Meters and Estimated Water Usage

11 Appendix: Baseline Energy Supply and Distribution

This Appendix has added background not included in Chapter 3. Parts of these descriptions are slightly edited versions from the recent (2014) energy audit conducted by the College before the IEMP study started.

North Campus Heating

The following figure shows the connections and uses of steam for the existing steam-based heating network on the North Campus.

Building Name	Connected to Steam Network	Steam Humidification	Steam for DHW	Steam for Radiators	Steam for AHU Heating	Steam for Process	Host Steam/Heat Exchanger	ERV with Steam preheat	Connected to Cooling Network
Building A	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Building B	Yes	Yes	No	No	No	No	Yes (4)	No	Yes
Building C	Yes	No	No	No	Fed from D	No	Yes	No	Yes
Building D	Yes	Yes	No	No	Yes	No	Yes (2)	No	Yes
Building DX	No	No	No	No	No	No	No	No	No
Building E (and IE)	Yes	Yes	No	No	No	No	Yes	No	Yes
Building EX	No	No	No	No	No	No	No	No	No
Building F	Yes	Yes	No	No	No	No	No	No	Yes
Building F upper	Yes	Yes	No	No	No	No	No	No	Yes
Building FX	Yes	Yes	No	No	No	No	No	No	Yes
Building G	No	No	No	No	No	No	No	No	No
Building GH	No	No	No	No	No	No	No	No	No
Building H	Yes	Yes	No	No	No	No	No	No	Yes
Building I	Yes	No	No	Yes	Yes MUA COIL	Yes DA only	No	No	Yes
Building J	Yes	No	No	No	No	No	Yes (2)	No	Yes
Building JF	Yes	No	No	No	No	No	No	No	Yes
Building K	Yes	Yes	Yes	No	Basement only	Yes	No	No	Yes
Building KX	Yes	No	Fed from K	No	Yes	No	No	No	Yes
Building L	Yes	Yes	Fed from K	No	No	No	No	No	Yes
Building LX	Yes	Yes	Fed from K	No	No	No	No	No	Yes
Building M	Yes	Yes	Fed from K	Yes	Yes	No	No	No	No
Building N	Yes	Yes	Fed from K	No	No	No	Yes	No	Basement only
Building NX	Yes	Yes	Fed from K	No	No	No	Yes	No	Perimeter AHU only
Building P	No	No	No	No	No	No	No	No	No
Building R	No	No	No	No	No	No	No	No	No
Building S	No	No	No	No	No	No	No	No	No
Building T	No	No	No	No	No	No	No	No	No
Building W	No	No	No	No	No	No	No	No	No
LRC	Yes	Yes	No	No	No	No	Yes	Yes	Yes
Centre for Trades and Technology	No	No	No	No	No	No	No	No	No
Humber Arboritum	No	No	No	No	No	No	No	No	No

Figure 11A- 1 North Campus Baseline – Steam Heating Connections and Uses

The buildings that are not connected to the network have a mix of islanded heating strategies. The condition of the network, given the dated technology, is generally good. The steam pipe has custom installed insulation in generally good condition. A significant number of valves, joints and other accessories have no insulation.

The make-up water requirement in 2014 was about 32,000 m^3 or 33% of the 98.000 m^3 used on North Campus. This is 23% of the 139,000 m^3 used by the College.

Lakeshore Heating and Cooling - East

The following figure shows the connections and uses of warm-water and chilled from the existing warm-water based heating network and chilling network on Lakeshore Campus-East.

Location	Building Name	Connected to Lake Shore East Hot Water Plant	Connected to Lake Shore East Cooling Network
Lake-Ancillary	Arts & Media Studios	No	No
Lake-West	Building A	No	No
Lake-West	Building AX	No	No
Lake-West	Building B	No	No
Lake-East	Building C	Yes	Yes
Lake-East	Building D	Yes	Yes
Lake-East	Building E	Yes	Yes
Lake-East	Building F	Yes	Yes
Lake-East	Building G	Yes	Yes
Lake-East	Building H	Yes	Yes
Lake-East	Building I	Yes	Yes
Lake-East	Building J	Yes	Yes
Lake-East	Building K	Yes	Yes
Lake-East	Building L	Yes	Yes
Lake-East	Building M	No	No
Lake-East	Building N	Yes	Yes
Lake-West	Building R	No	No
Lake-Ancillary	Centre for Justice Leadership	No	No
Lake-Ancillary	Humber Art Academy/Hairdressing School	No	No
Lake-Ancillary	Medical Building	No	No
Lake-Ancillary	The Fashion Institute	No	No
Lake-Ancillary	Athletics	No	No
Lake-Ancillary	Welcome Centre	No	No

Figure 11A- 2 North Campus Baseline – Steam Heating Connections and Uses

The networks are in good condition. The warm-water system is often referred to as a "hot-water system". The Lakeshore East heating is designed to run inside building with no heat exchanger (compact substation) between the network and the building. It is designed to operate well below 100 deg C. For the IEMP, this is referred to as a "warm water network". The term "hot water network" refers to a typical municipal district heating system using EN 253 et al compliant pipes and fittings capable of operating up to 120 deg C for short periods of time and 150 deg C for continuous operation. A hot water network is connected to buildings via a compact sub-station to drop internal temperatures to warm water level.

Primary and secondary heating water pumps are outfitted with VFDs. The warm water is distributed from the central plant to the campus buildings via pipes through tunnels. Some buildings have a set of hot water pumps downstream of the distribution throughout the building. The end uses for the water include heating coils in air handling units and Variable Air Volume VAV terminal boxes.

On the chilling side, there are three chillers. Primary chilled water pumps, three secondary chilled water pumps are outfitted with VFDs, two variable flow fluid coolers, and two condenser water pumps outfitted with VFDs. The condenser loop has glycol in it. This is a closed loop system with a heat exchanger. The chillers were installed at different times, as the East Campus expanded. The newest chiller, installed in 2011, is a 400 Ton variable speed chiller. The other two chillers, 300 Ton and 350 Tons, are constant speed. The variable speed fluid coolers are in an underground bunker next to Building H. End uses for the chilled water include cooling coils in the air handling units.

Lakeshore Heating and Cooling - West

The heating water system to supply Building A and B is in Boiler Room A171. Two natural gas boilers with circulation pumps feed this system. There are five hydronic pumps distributing the heating water. One pump serves the AHU heating coils, two pumps serve the perimeter heating for Building A, and two pumps serve the perimeter heating for Building B.

In addition, Building A is served by packaged roof top units and window A/C units. In Building B, chilled water is served to the cooling coils located in the air handling units. An air-cooled rooftop chiller and two chilled water pumps located in Mechanical Room B108B feed this system.

The heating water system for Residence Building R is in Mechanical Penthouse R627. Two natural gas boilers feed this system, as well as two primary hot water heating pumps and two secondary hot water heating pumps as constant volume systems. The chilled water system is also located in Mechanical Penthouse R627.

12 Appendix: Integration Workbook

The Integration Workbook (IW) is an Excel-Tool which is used for all balances. The IW is directly linked with the building modelling results both for baseline and efficiency cases. The investigation area can be chosen as College or by campus.

The IW handles various scenarios. These scenarios are:

- Efficiency scenarios
- Distribution and supply scenarios
- Energy Price scenario
- GHG price scenarios
- Interest scenarios

These can be combined with various alternative scenarios or options:

- Photovoltaic
- Co-generation (CHP)
- Absorption cooling

The IW provides outputs in table or graph format. These are:

- Energy and water balances
- Emission balances
- Price and cost graphs
- Investment overviews
- Financial balances
- Summary table for achievement of framing goals

The IW structure for Humber College is shown in the following graphic:

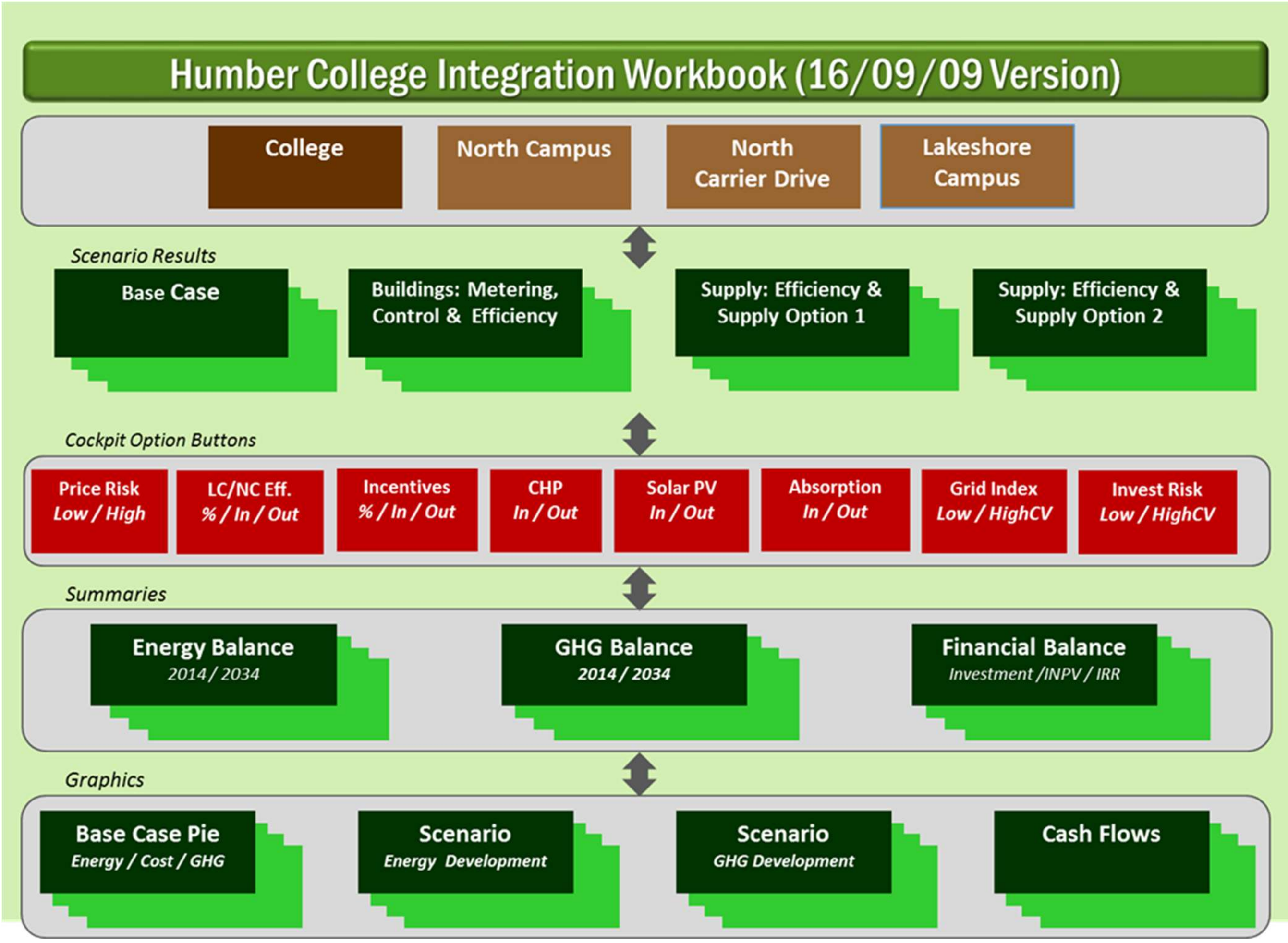


Figure 12A- 1 Structure of IEMP Integration Workbook

The following are some sample graphs for the recommended solution:

Figure 12A- 2 IW Sample – Source Efficiency showing Plan Targets

Figure 12A- 3 IW Sample – Water Efficiency showing Plan Targets

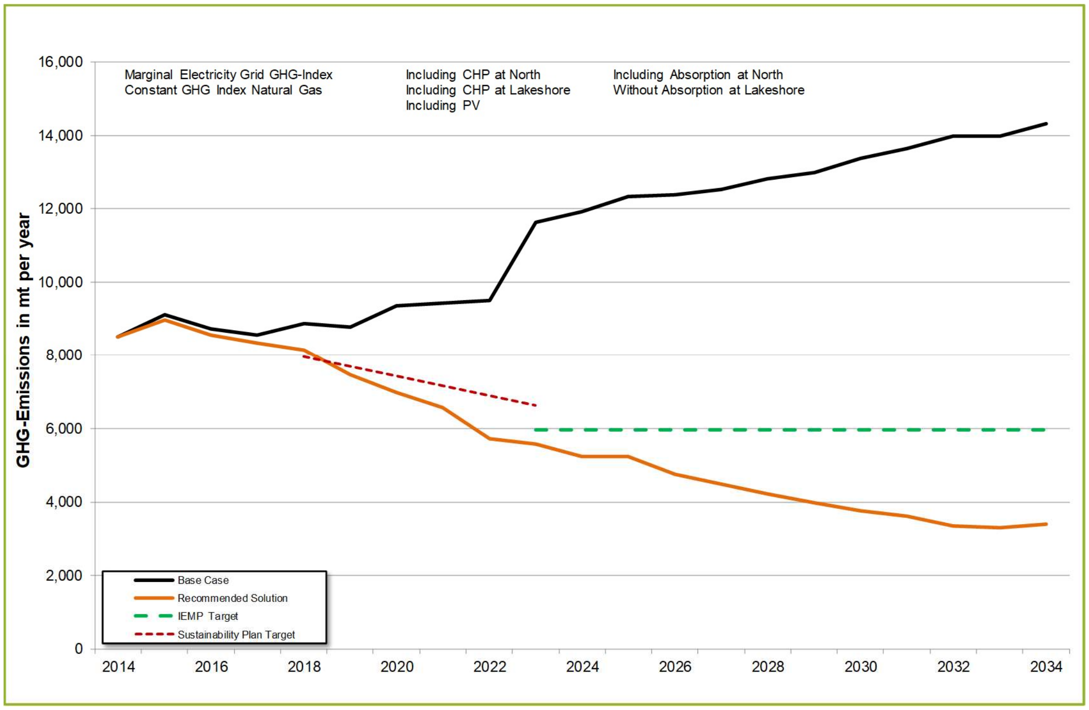


Figure 12A- 4 IW Sample – Carbon Emissions showing Plan Targets

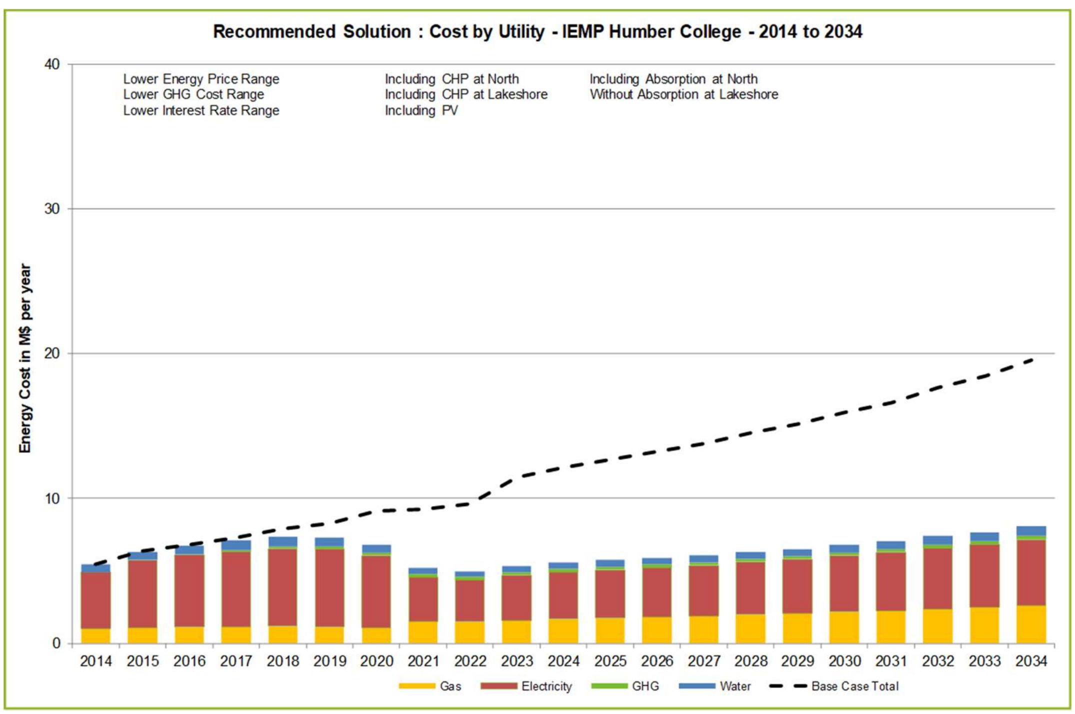


Figure 12A- 5 IW Sample–Recommended Solution against Base Case-Lower Cost Outlook

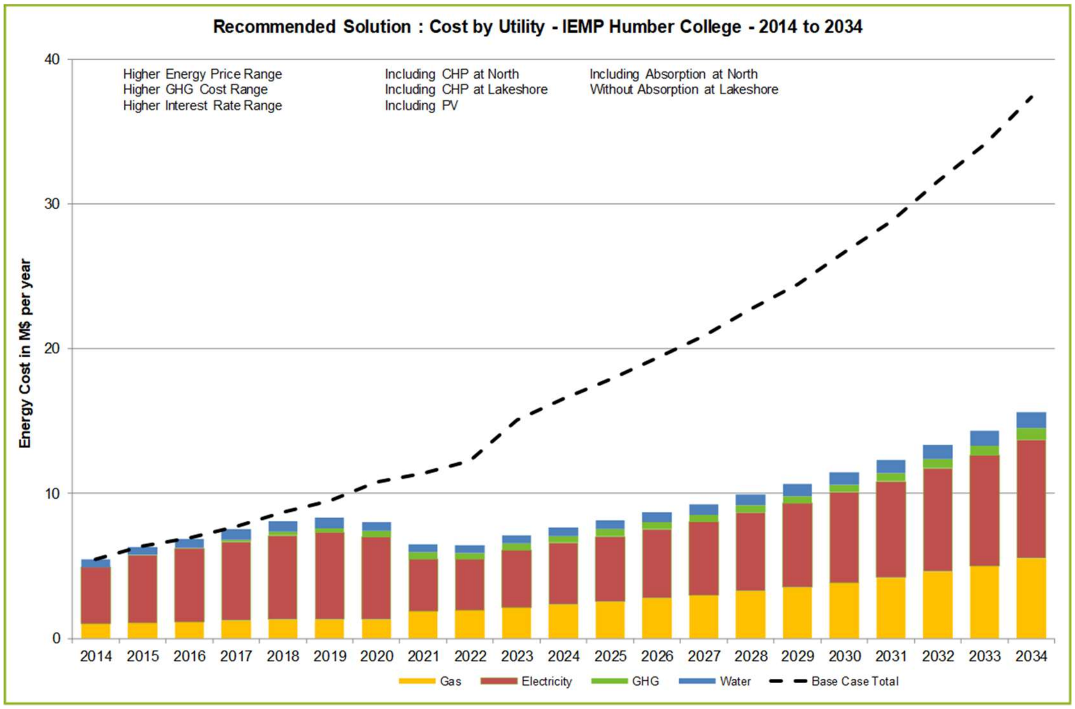


Figure 12A- 6 IW Sample–Recommended Solution against Base Case- Higher Cost Outlook

Humber College		**Reference Scenario**	**SIF funds to IEMP**	**Remaining IEMP**
Investment Measure Group				
Efficiency	**Metering and Control**	3,000,000	2,415,000	585,000
	Window Upgrade (Existing)	8,400,000	3,476,000	4,924,000
	Exterior wall insulation (Existing)	17,200,000	2,872,000	14,328,000
	Roof insulation (Existing)	5,700,000		5,700,000
	Lighting upgrade	400,000	400,000	
	HVAC Upgrade	3,000,000	523,000	2,477,000
	Commissioning	600,000	250,000	350,000
	Water Efficiency	1,000,000	500,000	500,000
	Heat Recovery Data Center	300,000	300,000	
Supply	**DH Network**	3,700,000		3,700,000
	Heating Substations	700,000		700,000
	CW Network	600,000		600,000
	CHP Engines	7,900,000		7,900,000
	Absorption Chiller	1,400,000		1,400,000
	Boilers	5,100,000		5,100,000
	Steam Conversion	3,900,000		3,900,000
Solar PV		3,100,000		3,100,000
Totals		**66,000,000**	**10,736,000**	**55,264,000**

Figure 12A- 7 IW Sample – Recommended Investments with Low Inflation

Humber College		Reference Scenario	SIF funds to IEMP	Remaining IEMP
Investment Group	Measure			
Efficiency	Metering and Control	3,100,000	2,415,000	685,000
	Window Upgrade (Existing)	8,700,000	3,476,000	5,224,000
	Exterior wall insulation (Existing)	17,800,000	2,872,000	14,928,000
	Roof insulation (Existing)	6,000,000		6,000,000
	Lighting upgrade	400,000	400,000	
	HVAC Upgrade	3,000,000	523,000	2,477,000
	Commissioning	700,000	250,000	450,000
	Water Efficiency	1,000,000	500,000	500,000
	Heat Recovery Data Center	300,000	300,000	
Supply	DH Network	3,800,000		3,800,000
	Heating Substations	700,000		700,000
	CW Network	600,000		600,000
	CHP Engines	8,400,000		8,400,000
	Absorption Chiller	1,500,000		1,500,000
	Boilers	5,300,000		5,300,000
	Steam Conversion	4,000,000		4,000,000
Solar PV		3,100,000		3,100,000
Totals		68,400,000	10,736,000	57,664,000

Figure 12A- 8 IW Sample – Recommended Investments with High Inflation

IEMP Humber College								
Including PV								
Lower Energy Price Range / Lower Energy Price Range	Marginal Electricity GHG Index		Including CHP at North		Including CHP at Lakeshore			
Lower Interest Rate Range	Constant GHG Index Natural Gas		Including Absorption at North		Without Absorption at Lakeshore			
Achieved targets 2034	Source Energy Reduction (kWh/m²*yr)	% of Target achieved	GHG Reduction (in mt/yr)	% of Target achieved	Water Intensity Reduction (m³/FTE*yr)	% of Target achieved	Internal Rate of Return (IRR)	% of Target achieved
Recommended Solution	50%	101%	60%	200%	54%	109%	10.0%	114%

Figure 12A- 9 IW Sample – Performance Summary with Lower Price Outlook

IEMP Humber College								
Including PV								
Higher Energy Price Range / Higher Energy Price Range	Marginal Electricity GHG Index		Including CHP at North		Including CHP at Lakeshore			
Higher Interest Rate Range	Constant GHG Index Natural Gas		Including Absorption at North		Without Absorption at Lakeshore			
Achieved targets 2034	Source Energy Reduction (kWh/m²*yr)	% of Target achieved	GHG Reduction (in mt/yr)	% of Target achieved	Water Intensity Reduction (m³/FTE*yr)	% of Target achieved	Internal Rate of Return (IRR)	% of Target achieved
Recommended Solution	50%	101%	60%	200%	54%	109%	16.5%	234%

Figure 12A- 10 IW Sample – Performance Summary with Higher Price Outlook

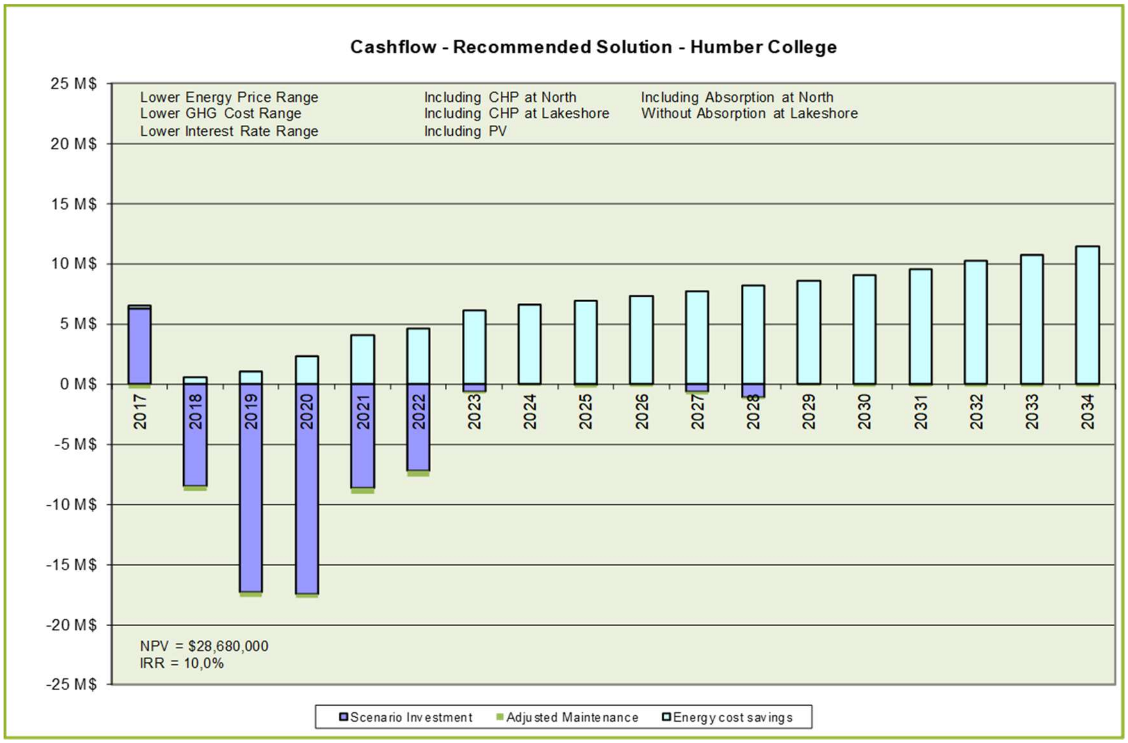


Figure 12A- 11 IW Sample – Cash Flow and NPV with Lower Price Outlook

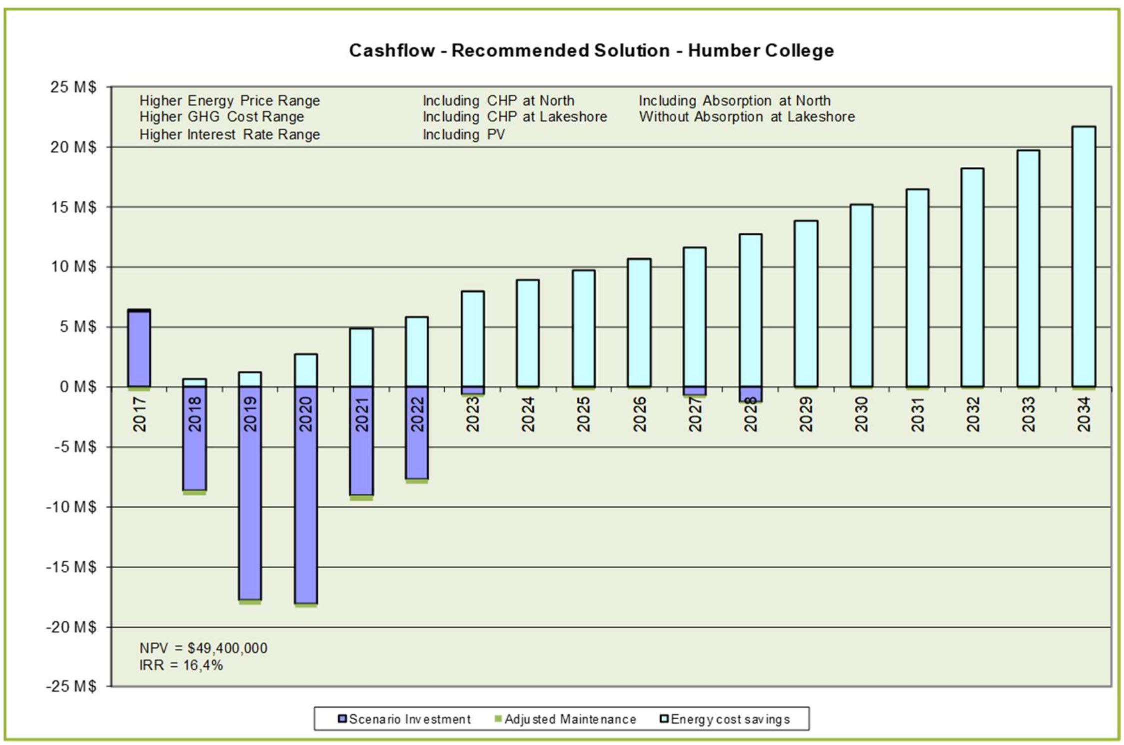


Figure 12A- 12 IW Sample – Cash Flows and NPV with Higher Price Outlook

13 Appendix: Federal & Ontario Energy and Climate Policy

2016 Federal Ratification of Paris Treaty

For many years, Canada has followed a range of energy related strategies aimed at improving the reliability and reducing the climate change impact of Canada's energy systems. Most recently, in 2016, Canada committed to implement the UN Paris Agreement[xxix].

The Paris Agreement is a bridge between today's policies and climate-neutrality before the end of the century. The key items addressed in that agreement are:

- Limit temperature rise 'well below' 2 C: The agreement includes a commitment to keep the rise in global temperatures "well below" 2 C compared to pre-industrial times, while striving to limit them even more, to 1.5 degrees.
- First universal climate agreement: It's the world's first comprehensive climate agreement, with all countries expected to pitch in. Under the previous emissions treaty, the 1997 Kyoto Protocol, developing countries were not mandated to reduce their emissions.
- Helping poorer nations: The deal also calls on developed nations to give $100 billion annually to developing countries by 2020. This would help these poorer countries combat climate change and foster greener economies.
- Publishing greenhouse gas reduction targets: Countries will be tasked with preparing, maintaining and publishing their own greenhouse gas reduction targets. The agreement says these targets should be greater than the current ones and "reflect [the] highest possible ambition".
- Carbon neutral by 2050: The deal sets the goal of a carbon-neutral world sometime after 2050 but before 2100. This means a commitment to limiting the amount of greenhouse gases emitted by human activity to the levels that trees, soil and oceans can absorb naturally.

Realizing commitments under the Paris Agreement will be no small feat for Canada. It will require action across several sectors, levels of government and society. It will also mean additional and increasing commitments to climate financing. Strong federal leadership will be needed to maintain momentum from Paris going forward. While the Paris Agreement's entry into force is a historic turning point, it is just the beginning. Accelerating and expanding global clean energy investment, at a pace and scale never undertaken in any context, is essential to realizing its goals.

Ontario Energy & Climate Background

Over the past decade, Ontario has put in place several significant policy measures aimed at reducing the climate change impact of energy use through increasing efficiency and diversifying energy mix. The policy is also recognizing the importance of more local decision as part of the energy decision making and planning mix. A partial list of the key policy initiatives is:

2009 Ontario Green Energy Act

This wide-ranging act aggressively encouraged the deployment of renewable power sources, notably wind and solar photovoltaic, through the provisions of Feed-In-Tariffs guaranteeing revenue streams for a guaranteed period. It also actively encouraged the deployment of high-efficiency combined heat and power through investment incentives.

2012 Ontario Building Code

This revision of the building code was announced about five years before it went into force. It has a major focus on improving the energy efficiency of new construction and with California, is now one of the most efficient codes in North America. Unlike much of Europe, the Ontario building code still has no systematic approach to improving the efficiency of existing buildings during deep renovation.

2013 Ontario Municipal Energy Plan Programme

This programme encourages municipalities to develop long-term Municipal Energy Plans by contributing to part of the cost on the understanding the MEP will be approved by the elected leadership as the basis for future policy in the community. Each MEP will establish efficiency and emissions targets for all the energy used in the community for home, buildings, industry and transportation. The plans at a high level establish community wide strategies to achieve the targets. While not explicitly stated, this is logical first step in localizing some level of the strategic management of energy.

2013 Ontario Long Term Energy Plan

This plan focusses heavily of the electricity side of Ontario's energy use. It focusses heavily on managing the phase out of coal-fired generation, including emphasis on local demand side management measures and the continuing diversification of generation with renewables.

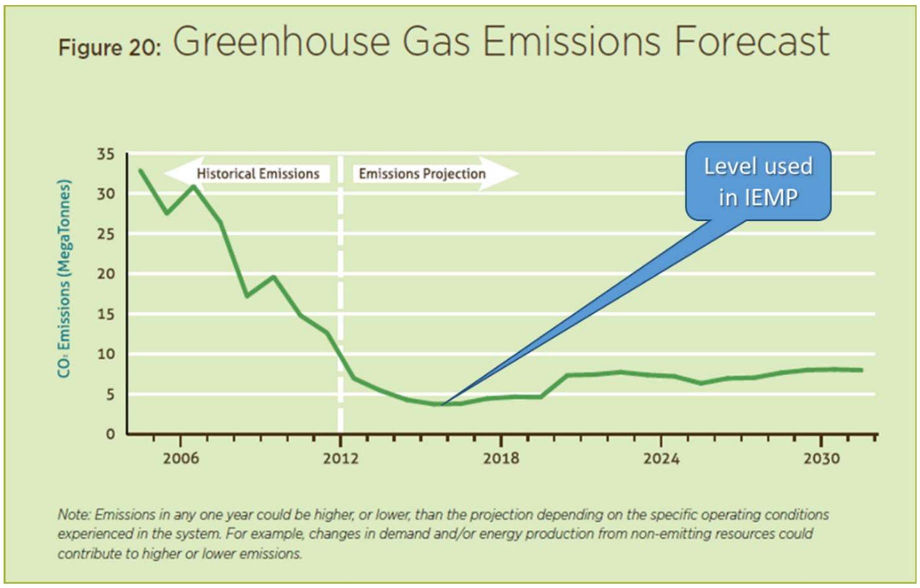


Figure 13A- 1 Ontario Power Grid GHG Emissions 2004 to 2031[xxx]

Under this and preceding plans, Ontario now has one of the lowest carbon grids in the world. The public input process is now underway for the next iteration of the plan.

2017 Grid Index Guidelines

The challenge Ontario faces is to maintain or even reduce the grid emissions in the face of population and economic growth in the Province. Growth will generally be served by power from natural gas fired peaker plants which have a marginal emission index much higher than the grid average. In the same way, efficiency or on-site clean and renewable generation will avoid the need for grid-based peaking. This is recognized in the recent guidelines issued by the City of Toronto in 2017 based on a study completed by The Atmospheric Fund. The IEMP uses these guidelines to estimate future emissions.

2015 Cap and Trade

This established a market-based approach to reduce the greenhouse gas emissions from large emitters. An emitter who beats the cap can trade their allowance to an emitter which is missing the cap. Every year the Province reduces the "cap" or the total number of allowances outstanding. Ontario is discussing possibly joining the California, Quebec and may be the EU cap & trade markets. The market opens at 5the start of 2017, with an estimated starting carbon price of about \$20 / metric ton of CO_2 equivalent.

2016 Ontario Climate Action Plan

This Plan lays out the Province's greenhouse reduction targets and broad strategy to meet the goals. The plan calls for the total emissions relative to 1990 levels to be 6% reduced by 2014; 15% down by 2020, 37% by 2030 and 80% by 2050.

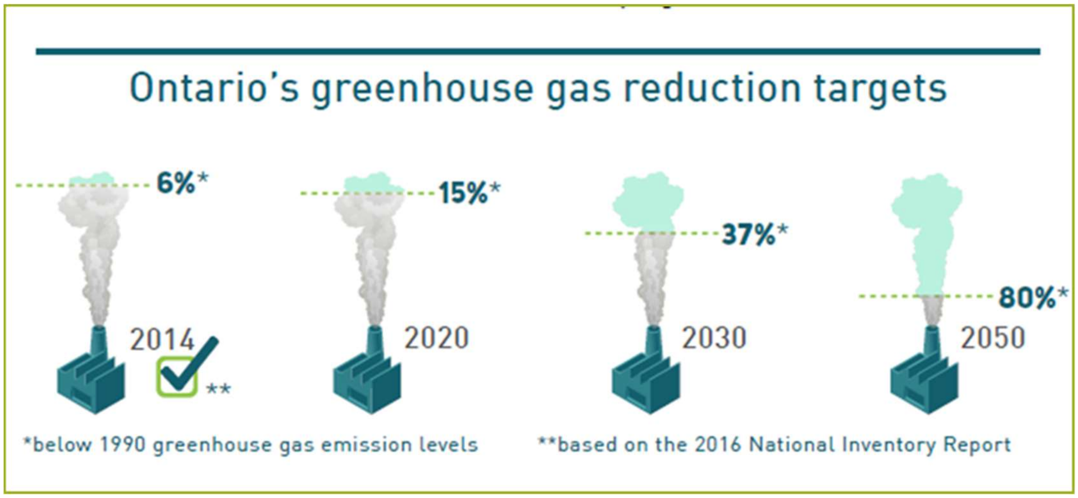


Figure 13A- 2 Ontario Climate Action Plan Emission Targets[xxxi]

The Plan highlights the challenge of reducing emissions from the use of natural gas for heating buildings and from transport fuels. The Ontario Climate Action mirrors the Federal commitments to the Paris Treaty.

Comment

Despite the inevitable bends in the road over the last decade, Ontario's policy framework is reasonably coherent and aims to aggressively reduce greenhouse gas emissions through efficient use and flexible, cost competitive, clean and efficient supply. The overall goals will be tough to meet and will require many transformations at municipal and regional level comparable to Humber's IEMP only on a much larger scale.

14 Appendix: Federal and Provincial Incentives

Background

Many of the elements (sub-projects) of the IEMP proposed solution (project) could be eligible for incentives from some combination of Federal, Provincial or Utility programmes. As a guiding principle, the IEMP has assumed no incentives, with one exception detailed below.

Notwithstanding the assumption of no incentive, the IEMP is recommending a member of the Implementation organization be assigned the task to aggressively pursue all available incentives on each sub-project. Any incentive would be an upside on the economic return calculation.

This Appendix summarizes some key incentives that would have a high probability of applying.

Post-Secondary Institutions Strategic Investment Fund

This Fund was established by the Federal Ministry of Industry during 2016 with the goal to invest in innovative infrastructure and repair for Colleges and Universities. It was capped at about $2Bn. A significant focus, among others, was making progress on sustainable infrastructure. It was a combination of an economic stimulus package and innovation driver.

Based on the early drafts of the IEMP, Humber College submitted a proposal that included items that are within the scope of the IEMP recommended solution. The proposal was accepted, and these items totaled $9,527,514. For some items, the HC team proposed to SIF to invest more than the IEMP estimate to gain further operating benefits, the most significant being to change the lighting recommendation from bulb replacement with LEDs to selective lighting system replacement, leaving a net of $6,927,514 that overlapped with the IEMP investment estimates. As this was a one-time incentive, with the specific policy goal to accelerate innovative infrastructure upgrades, and it occurred prior to the formal approval of the IEMP, the Project Working Team reduced the total investment estimate for the IEMP recommended solution by this amount.

IEMP Impact: This is the only public policy incentive included in the IEMP.

Solar PV Feed-in-Tariff Programme

The IEMP recommends installing 700kW Solar on the North Campus and 400kW on Lakeshore over four years from 2018 to 2021. Currently the IEMP assumes "net-metering" i.e. the PV power is subtracted from the electricity cost on a 1 to 1 cost per kWh basis

If these sub-projects were submitted today, they would probably qualify under the current Ontario Power Authority IESO FIT Programme (http://fit.powerauthority.on.ca/fit-program) – version 5.0.1. This pays a guaranteed price for the power generated. The final price on any particular contract is affected by multiple factors. Assuming Humber were treated as a Public-Sector Entity and covered 100% of the investments, the FIT would be around $220 / MWh.

IEMP Impact:

- Slightly more attractive to 2034 in the lower price outlook
- Slightly more attractive to 2024 in the higher price outlook after which net-metering is more attractive
- Recommendation:
    - Do a detailed work up of the PV sub-project and if reasonably attractive at the mid-range of price outlooks, consider accelerating implementation.
    - Do not jeopardize any roof insulation upgrade sub-project as these will have a higher energy and environmental value than PV – however, the combination of PV and roofing insulation sub-projects on the same building may reduce the overall set-up costs.

CHP Standard Offer Programme 2.0

The IEMP recommends installing gas-fired CHP on both campuses – 2x800kW on North and 2x400kW on Lakeshore. Currently the IEMP assumes net-metering for electricity and well over 70% average fuel efficiency bet6ween heat and power.

On emissions avoidance, the IEMP integration allows two CHP emission avoidance cases to be assessed. The first is where the CHP power avoids the grid average emissions of 50kg/MWh, which would be an overall increase for the College. The second is to avoid marginal emissions based on the 2017 TAF Guidelines (see Appendix 13). The TAF guidelines were used for the IEMP. This is a similar approach as the EU guideline describes for the certification of highly efficient co-generation equipment.

CHPSOP 2.0 was offered by the Ontario Power Authority to encourage the implementation of efficient gas-fired combined heat and power generation up to 20MW. Investment grants of up to 40% were available for accepted projects. The window on this closed in January 2015 for last applications. At the end of 2015, the Minister of Energy included the following statement in a year-end summary:

The CHPSOP 2.0 Report includes the following recommendations:

- *i. Not to implement a second CHPSOP 2.0 application window; and*
- *ii. Explore how small CHP can competitively participate in IESO'S anticipated capacity auction or other competitive procurements by recognizing local benefits of small CHP through new funding opportunities enabled by policy and regulatory changes or tax-based economic development grants. In addition, Ontario's next Long-Term Energy Plan (LTEP) in 2017or 2018 will provide an opportunity to reassess how CHP may contribute to meeting the needs of the electricity system.*

The same summary further invites CHP project developers to participate in the next round of the Ontario Long-term Energy Plan which is likely to include a redefined, but important, role for highly distributed CHP.

IEMP Impact:

- A similar future incentive would reduce investment by $3M increasing the IRR by 1%.
- There are a couple of years before the final CHP go/no go decision must be made.
- Recommendation:
  - Actively participate in the CHPSOP discussions to position the overall fuel efficiency benefits, the thermal efficiency, the pathway to bio-fueled options, site resilience, teaching, and the TAF guidelines as a matter of provincial policy
  - Proactively position all these benefits to the OPA and Minister of Energy to explore a case-exemption for Humber to extend CHPSOP 2.0 to the College.

Enbridge Gas

The IEMP calls for extensive improvement of envelopes to reduce heating and cooling energy. Once completed the internal heating and cooling systems will be updated or redesigned, consistent with the redefined loads and connection to the campus thermal networks. In the current modelling, only modest energy saving has been assumed from the internal mechanical upgrades effectively understating the economic return. Efficient procurement of energy consuming end-use equipment such as catering items is recommended but no savings assumed.

Enbridge Gas offers several incentives for upgrading the efficiency of commercial buildings. There are basically four incentive categories, all of which could align with IEMP sub-projects in some way: The incentive programmes are mostly grants on equipment or engineering costs and are:

- Space Heating
- Water Heating

- Cooking
- Engineering projects

IEMP Impact

- Any applicable incentive would be a discount on the overall IEMP investments or operating costs and improve the IRR
- Gas for heating and hot water has been strategically identified by the province as a major challenge to meet the OCAP goals; the IEMP greatly reduces the use of gas through both efficient end use and efficient supply and distribution.
- Recommendation:
    - Immediately make a pro-forma assessment of all the potential IEMP sub-projects that could qualify in some way for these programmes.
    - Proactively brief the Enbridge Gas efficiency team on the IEMP outcomes and time.
    - Mutually prioritize the incentive eligible sub-projects that best meet the goals of the IEMP
    - Do not allow this prioritization to deflect from the overriding need to upgrade the building envelopes.

Toronto Hydro

The IEMP calls for extensive conversion of existing lighting to LED and improved control and habits to avoid unnecessary use. It also calls for reducing cooling demand through improved envelopes and plant. As for gas, the IEMP also call for the procurement of energy efficient end-use equipment. The IEMP has assumed a relatively aggressive Low Cost / No Cost continuous improvement much of will come from continuing attention to curtailing electricity use in a myriad of small ways.

Toronto Hydro offers many incentives for efficient equipment urges and some engineering and assessments both the new and existing buildings.

IEMP Impact

- Any applicable incentive would be a discount on the overall IEMP investments or operating costs and improve the IRR.
- Recommendation
    - Immediately make a pro-forma assessment of all the potential IEMP sub-projects that could qualify in some way for these programmes.
    - Proactively brief the Toronto Hydro efficiency team on the IEMP outcomes and time.
    - Mutually prioritize the incentive eligible sub-projects that best meet the goals of the IEMP
    - Do not allow this prioritization to deflect from the overriding need to upgrade the building envelopes.

Government and Foundations

The IEMP has many of the characteristics of a strategy that would have to be implemented by a community on a much larger scale to meet future energy and climate challenges. This combined with the educational aspect make it attractive to Government agencies and Foundations as a microcosm of a bigger picture. The recommendation is for senior leadership to proactively brief the relevant agencies and foundations of Humber's intent and to keep them apprised of progress. The obvious message is with added resources, the IEMP can move forward either faster or more completely.

15 Appendix: Utility Pricing Outlook Assumptions

The IEMP has two price outlooks from the 2014 Baseline to 2034 for natural gas, electricity and greenhouse gas emissions. The lower outlook is in line with the relevant government outlooks which historically tend to be on the low side. For electricity, these were largely based on the current OLTEP, for natural gas a combination of the US EIA and the Government of Canada National Energy Board outlooks. The higher outlook assumes some reasonable, but not extreme combinations of upside risks are present. The lower outlook was used to evaluate the recommended solution. Gas and electricity prices were expressed $/MWh, greenhouse emissions were costed in $/metric ton of CO_2 equivalent.

For electricity, the key risk factors are the uncertainty of the cost of maintaining a low carbon grid when some of the nuclear facilities are possibly decommissioned along with the uncertain capital cost of modernizing the grid. For natural gas, the uncertainty is the degree to which gas is used as a power generating and transportation fuel along with the uncertain impact of increased LNG exports to Asia and Europe. For Greenhouse gas pricing, the impact of the new legislation is uncertain as the final market rules are detailed out, along with the degree to which the Federal Government will intervene if the provincial market is deemed to be too cheap.

Current indicators (2016) are showing that the tendency is to the higher outlook. The 2014 average prices for gas and electricity are slightly different between the North and Lakeshore Campuses. The IEMP applies the same nominal escalators to the different starting points. The pricing outlooks shown below are in nominal $. A lower inflation of 1% and higher of 2% is applied as part of the overall integration.

Gas, Electricity and Carbon Pricing Outlook – North Campus

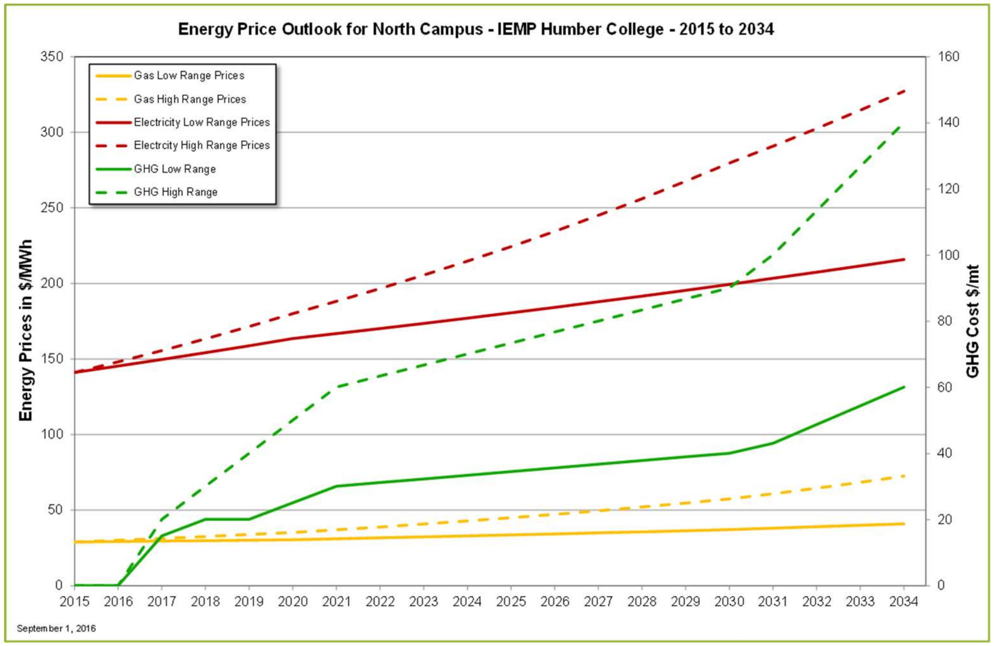


Figure 15A- 1 Utility and Carbon Pricing Outlooks – North Campus

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Gas Low Range Prices	29.00	29.00	29.29	29.58	29.88	30.18	30.48	31.09	31.71	32.34	32.99
Gas High Range Prices	29.00	29.00	30.16	31.37	32.62	33.93	35.28	37.05	38.90	40.84	42.89
Electricity Low Range Pric	126.00	141.12	145.35	149.71	154.21	158.83	163.60	166.87	170.21	173.61	177.08
Electrcity High Range Pric	126.00	141.12	148.18	155.58	163.36	171.53	180.11	188.21	196.68	205.53	214.78
GHG Low Range	0.00	0.00	0.00	15.00	20.00	20.00	25.00	30.00	31.11	32.22	33.33
GHG High Range	0.00	0.00	0.00	20.00	30.00	40.00	50.00	60.00	63.33	66.67	70.00

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Gas Low Range Prices	33.65	34.32	35.01	35.71	36.43	37.15	38.08	39.04	40.01	41.01
Gas High Range Prices	45.03	47.28	49.65	52.13	54.74	57.47	60.92	64.58	68.45	72.56
Electricity Low Range Pric	180.62	184.24	187.92	191.68	195.51	199.42	203.41	207.48	211.63	215.86
Electrcity High Range Pric	224.45	234.55	245.10	256.13	267.66	279.70	290.89	302.53	314.63	327.21
GHG Low Range	34.44	35.56	36.67	37.78	38.89	40.00	43.00	48.67	54.33	60.00
GHG High Range	73.33	76.67	80.00	83.33	86.67	90.00	100.00	113.33	126.67	140.00

Figure 15A- 2   Utility and Carbon Pricing Outlooks Table – North Campus

Gas, Electricity and Carbon Pricing Outlook – Lakeshore Campus

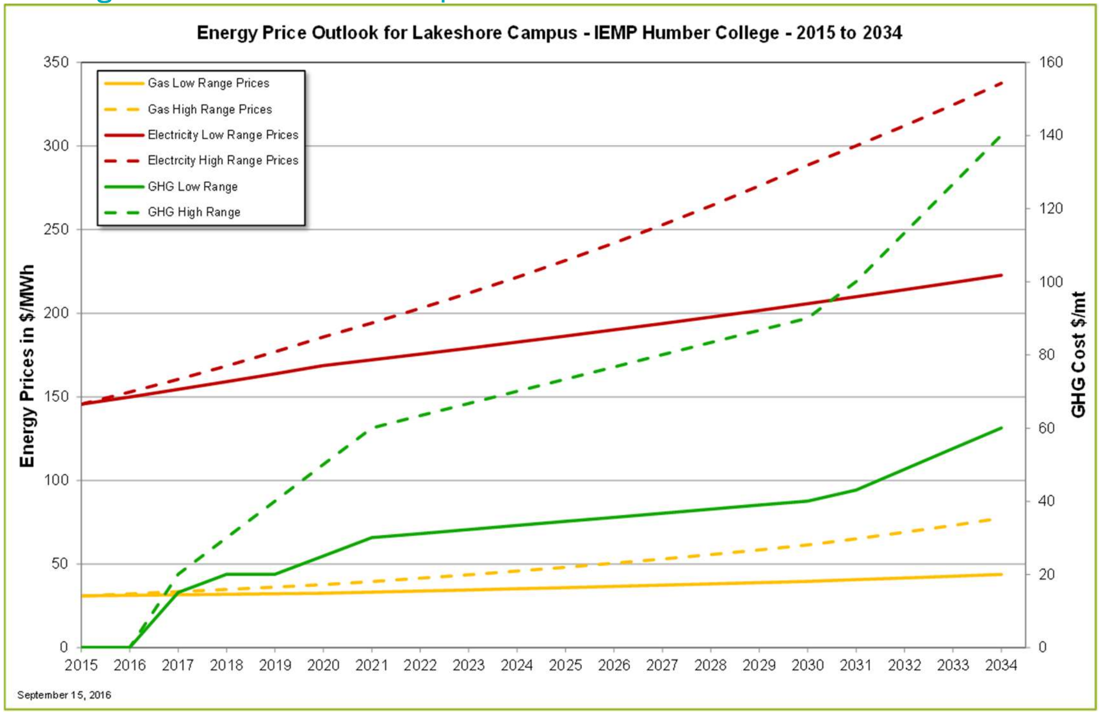


Figure 15A- 3 Utility and Carbon Pricing Outlooks – Lakeshore Campus

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Gas Low Range Prices	31.00	31.00	31.31	31.62	31.94	32.26	32.58	33.23	33.90	34.58	35.27
Gas High Range Prices	31.00	31.00	32.24	33.53	34.87	36.27	37.72	39.60	41.58	43.66	45.84
Electricity Low Range Pric	130.00	145.60	149.97	154.47	159.10	163.87	168.79	172.17	175.61	179.12	182.70
Electrcity High Range Pric	130.00	145.60	152.88	160.52	168.55	176.98	185.83	194.19	202.93	212.06	221.60
GHG Low Range	0.00	0.00	0.00	15.00	20.00	20.00	25.00	30.00	31.11	32.22	33.33
GHG High Range	0.00	0.00	0.00	20.00	30.00	40.00	50.00	60.00	63.33	66.67	70.00

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Gas Low Range Prices	35.97	36.69	37.43	38.17	38.94	39.72	40.71	41.73	42.77	43.84
Gas High Range Prices	48.14	50.54	53.07	55.72	58.51	61.44	65.12	69.03	73.17	77.56
Electricity Low Range Prices	186.36	190.09	193.89	197.76	201.72	205.75	209.87	214.07	218.35	222.72
Electricity High Range Prices	231.57	241.99	252.88	264.26	276.16	288.58	300.13	312.13	324.62	337.60
GHG Low Range	34.44	35.56	36.67	37.78	38.89	40.00	43.00	48.67	54.33	60.00
GHG High Range	73.33	76.67	80.00	83.33	86.67	90.00	100.00	113.33	126.67	140.00

Figure 15A- 4 Utility and Carbon Pricing Outlooks Table – Lakeshore Campus

Water Pricing Outlook

Both campuses are supplied by Toronto Water. A City of Toronto Report ("2016 Water and Wastewater Consumption Rates and Service Fees" dated November 6th, 2015) was used to establish the Lower outlook. The overall demand is dropping significantly causing the utility to seek higher prices. In addition, concerns over storm water infrastructure and the uncertain impacts of changing weather could push significant capital investments. Water is priced in $/cubic metre.

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Water Low Range Prices	3.84	4.15	4.48	4.70	4.94	5.09	5.24	5.40	5.56	5.72	5.90
Water High Range Prices	3.84	4.15	4.56	5.02	5.52	5.85	6.20	6.57	6.97	7.39	7.83

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Water Low Range Prices	6.07	6.26	6.44	6.64	6.84	7.04	7.25	7.47	7.69	7.92
Water High Range Prices	8.30	8.80	9.33	9.89	10.48	11.11	11.77	12.48	13.23	14.02

Figure 15A- 5 Table of Water Pricing Outlooks – Both Campuses

16 Appendix: North Campus - IEMP Solution Details

The energy solutions for each campus are described in section 3.

The core is a new Energy Centre as an adjacent to the new Centre for Technology Innovation Phase 1. All buildings will be connected and supplied through new a hot water distribution network. The buildings on the west side of the campus will be converted from steam. The distribution will be implemented as a combination of in building pipes and ground buried pipes. Final routing is subject to detailed engineering.

Existing steam supply point will be converted through replacement of heat exchangers. Where steam is needed, equipment will be replaced by hot water or electric equipment.

The following picture is showing the North Campus overview with the recommended conceptual solution:

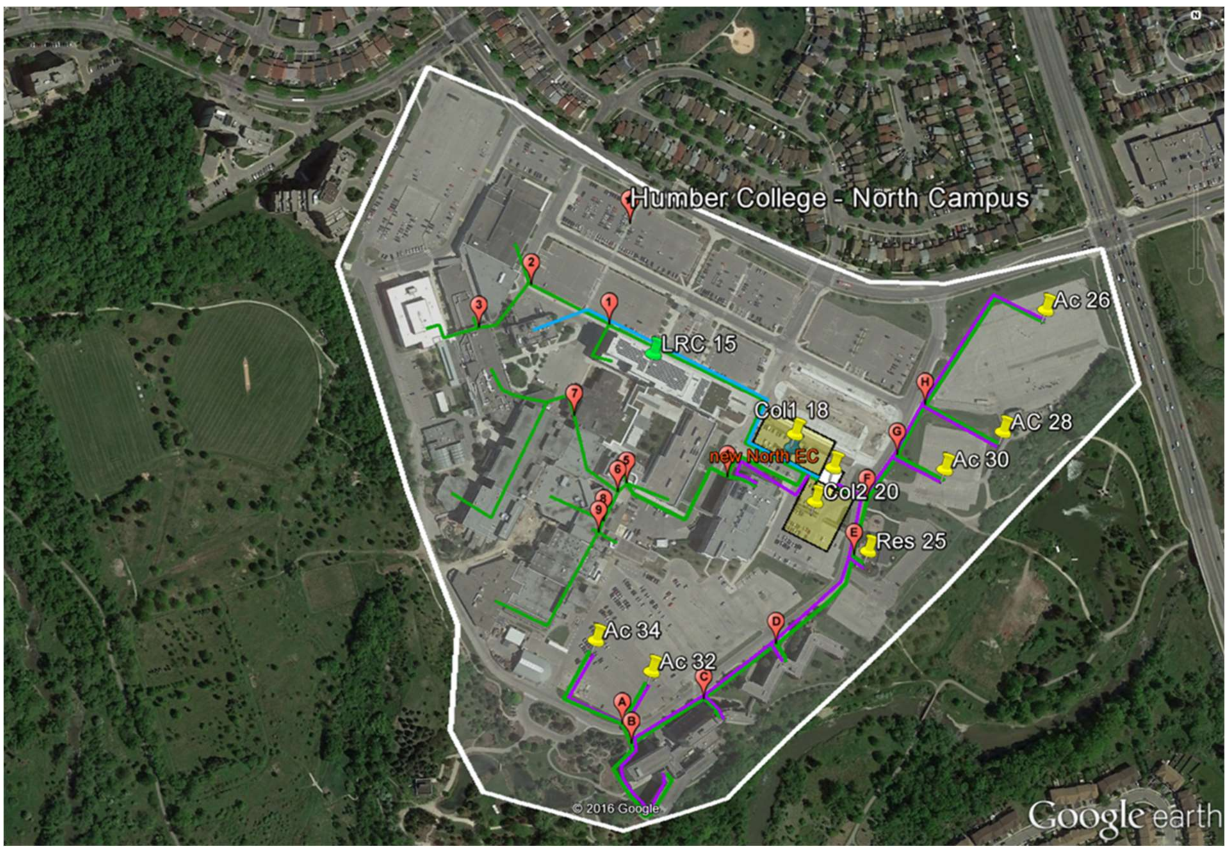


Figure 16A- 1 North Campus Overview

Green lines are indicating hot water pipes. The chilled water generated in the absorption chillers will be fed into the existing distribution on the west side. The blue line indicates the cooling connection from the new Energy Centre with the current Energy Centre in Building I. The purple lines are the extension of the cooling network to complete the east side.

17 Appendix: North Campus Energy Centre

The Energy Centre will be sized to give enough space for all equipment which is required for the final extension. The following equipment is included:

- 3 Hot water boilers (each about 3 MW th)
- 2 CHP engines (each about 800 kW el)
- 2 Absorption Chiller (each about 750 kW th)
- 2 Electric Chillers (each about 650 kW th)
- Supply distributor and return collector
- Auxiliary equipment (pumps, tanks, etc.)

All sizes are subject to final design.

The following drawing is showing the conceptual design of the Energy Centre:

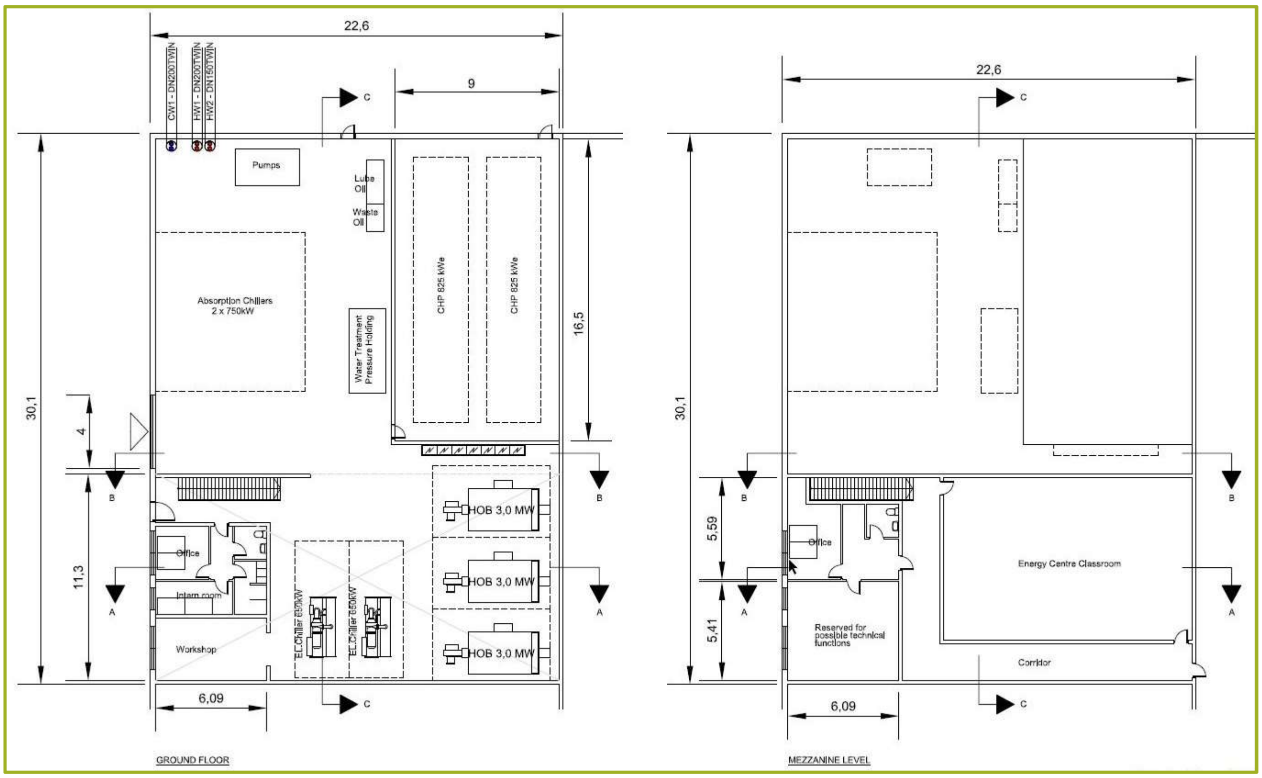


Figure 17A- 1 Conceptual Design for Energy Centre on North Campus

18 Appendix: Lakeshore Campus - IEMP Solution Details

The energy solutions for each campus are described in section 3.

The core is a new Energy Centre which is co-located in the new Building A, Phase 1. All buildings on the West Campus will be connected and supplied through a new hot-water distribution network. The existing distribution on the East Campus will be integrated in the West Campus supply. Buildings on the other side of Lakeshore Boulevard will remain as stand-alone. The hot water distribution will be implemented as a combination of in building pipes and ground buried pipes. Final routing is subject to detailed engineering.

The following picture is showing the campus overview with the recommended conceptual solution:

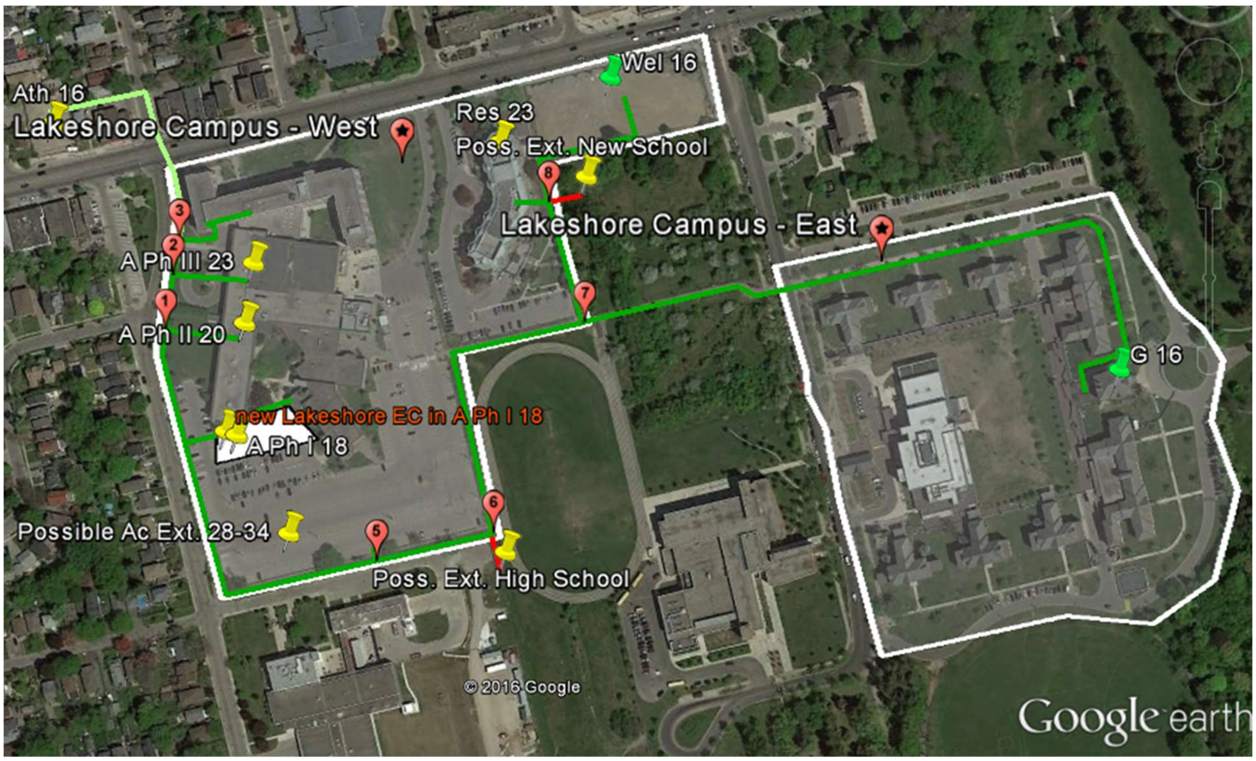


Figure 18A- 1 Lakeshore Campus Overview

Green lines are indicating new hot water pipes. The network at marker 6 will be sized and structured to allow for the possible integration of the Father J Redmond Catholic High School. This is a provision to share the benefits of the campus integrated energy solution with an immediate neighbour sometime in the future. The immediate incremental cost is negligible. The network at marker 3 will be structured and sized for a possible extension to the Athletics Centre. This will involve crossing a public right-of-way and a final decision on this is deferred.

19 Appendix: Lakeshore Campus Energy Centre

The Energy Centre will be sized to give enough space for all equipment which is required for the final extension. The following equipment is included:

- 3 Hot water boilers (each about 1.5 MW th)
- 2 CHP engines (each about 400 kW el)
- 2 Electric Chillers (each about 1,500 kW th) with expansion for a further 2 units
- Supply distributor and return collector
- Auxiliary equipment (pumps, tanks, etc.)

All sizes are subject to final design.

The following drawing is showing the conceptual design of the Energy Centre:

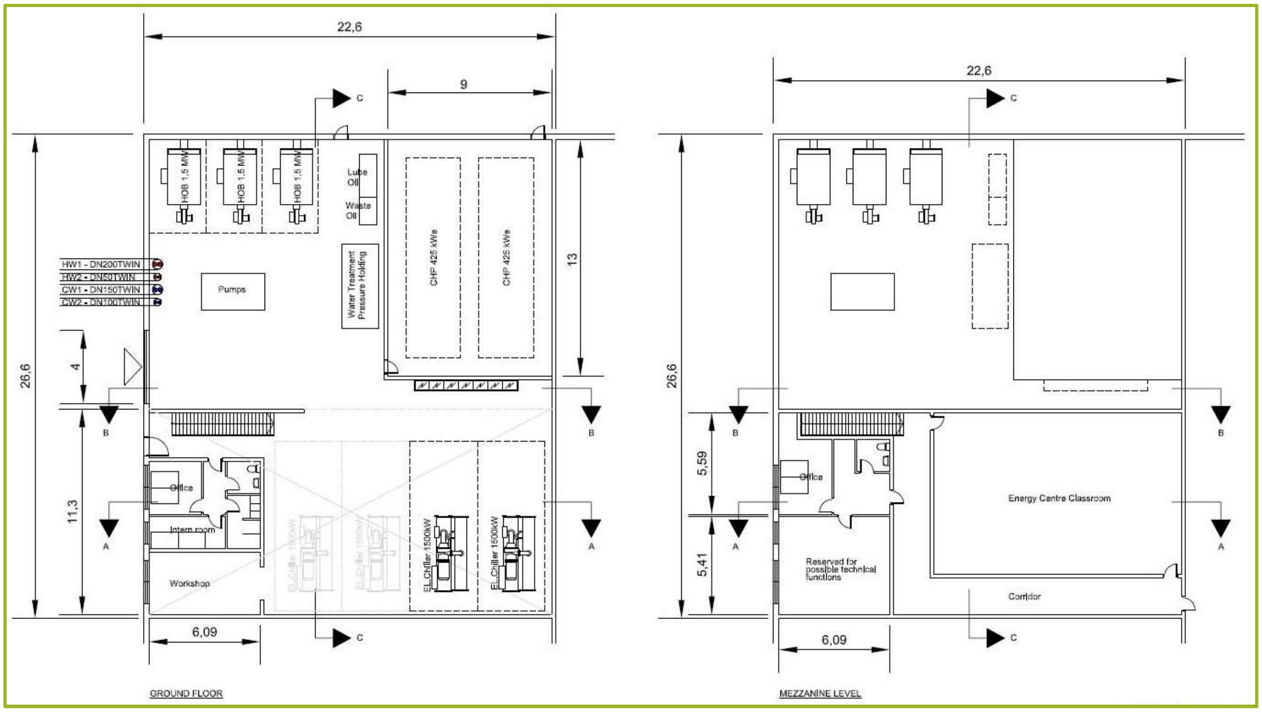


Figure 19A- 1 Conceptual Design for Energy Centre on Lakeshore Campus

20 Appendix: IEMP Water Efficiency Case

The following adjustments were made in the generalized modelling to the water flow rate for each fixture, flush and piece of equipment:

- Shower – 1.25 gpm (previously 2.5 gpm)
- Faucet, Janitor – 1.5 gpm (previously 4 gpm)
- Faucet, Kitchen – 1.5 gpm (previously 2.2 gpm)
- Faucet, General – 1.5 gpm (unchanged)
- Faucet, W.C. – 0.5 gpm (unchanged)
- Urinal – 1.0 gal per flush (unchanged)
- Toilets – 1.6 gal per flush (unchanged)
- Coffee machine – 0.8 gal/cycle (unchanged)
- Ice Machine - 22.0 gal/cycle (unchanged)
- Laundry - 13.4 gal/cycle (unchanged)

These adjustments were added to all relevant fixtures across the campus. The results of the newly modelled efficiencies and the proportioned energy usage by floor area are seen in the figures below:

Campus	Building Name	Water Meter	Baseline Water Usage		Efficient Water Usage	
			Modelled	Metered proportioned by floor area	Modelled	% reduction
North	Building A	7000893	1,021	669	346	34%
North	Building B	67797710	742	753	426	57%
North	Building C	7000893	179	147	124	69%
North	Building D	70265485	532	625	326	61%
North	Building DX		15	12	11	69%
North	Building E	70265489	578	1,139	300	52%
North	Building EX		118	51	63	53%
North	Building F	70265489	198	262	126	63%
North	Building FX	70265489	220	79	140	64%
North	Building G	60797040	150	123	49	32%
North	Building GH	8000393	961	1,185	562	58%
North	Building H	70266301	841	607	440	52%
North	Building I	70274718	46	107	23	51%
North	Building J	70266301	638	446	204	32%
North	Building JF	70265489	112	45	43	39%
North	Building K	70266305	1,388	582	1,045	75%
North	Building KX	70266305	80	205	27	34%
North	Building L	70266305	226	751	127	56%
North	Building LX	70266305	127	251	88	70%
North	Building M	70266305	127	240	88	70%
North	Building N	60797117	555	762	330	59%
North	Building NX	60797117	184	377	122	66%
North	Building P	70266305	118	64	63	53%
North	Building R	60825762	1,786	1,715	1,141	64%
North	Building S	70266304	1,741	1,808	1,010	58%
North	Building T	70276250	2,952	2,968	1,780	60%
North	Building W	60797003	355	44	175	49%
North	Humber Arboritum	6000522	155	436	87	56%
North	Center for Trades		466	468	230	49%

Figure 20A- 1 Water Usage after EEMs Applied - North Campus

Campus	Building Name	Water Meter	Baseline Water Usage		Efficient Water Usage	
			Modelled	Metered proportioned by floor area	Modelled	% reduction
Lakeshore	Arts & Media Studios	3253	196	191	116	59%
Lakeshore	Building A	70300124	2,238	2,065	1,234	55%
Lakeshore	Building AX	70300124	66	98	40	61%
Lakeshore	Building B	70300124	301	1,033	162	54%
Lakeshore	Building C	10002122	134	140	65	48%
Lakeshore	Building D	10002122	120	144	54	45%
Lakeshore	Building E	10002122	127	144	59	47%
Lakeshore	Building F	10002122	394	396	235	60%
Lakeshore	Building H	10002122	394	442	235	60%
Lakeshore	Building I	10002122	127	184	59	47%
Lakeshore	Building J	10002122	127	189	59	47%
Lakeshore	Building K	10002122	127	180	59	47%
Lakeshore	Building L	10002122	836	823	765	91%
Lakeshore	Building M	10002122	305	27	293	96%
Lakeshore	Building N	70300124	196	543	124	63%
Lakeshore	Building R	70300124	4,557	3,614	2,101	46%
Lakeshore	Centre for Justice Leadership	60765775	245	236	137	56%
Lakeshore	Medical Building	60765755	-	-	-	0%
Lakeshore	The Fashion Institute	60765781	66	65	48	73%

Figure 20A- 2 Water Usage after EEMs Applied - Lakeshore Campus

21 Appendix: IEMP Solution Investment Assumptions

Background

As the IEMP was developed, each major category of investment was assessed for the entire College. Depending on the category, the method to arrive at the estimate for the College varied. In some cases, a notional measure-by-measure approach was applied to the generalized building models in other cases investment indexes are used and so on.

Whichever assessment approach is being used, the goal is to arrive at a reasonable estimate for that category for the entire College, not to predict the actual cost range for an individual item or sub-project. The estimation approach can sometimes give the impression that the estimation process is more granular than it really is, and caution should be exercised in interpretation.

Investment Overview

The Reference Scenario is the basis for the IEMP Recommended Solution and has the following investment pictures for low and high inflation assumptions.

Humber College		Reference Scenario	SIF funds to IEMP	Remaining IEMP
Investment Group	Measure			
Efficiency	Metering and Control	3,000,000	2,415,000	585,000
	Window Upgrade (Existing)	8,400,000	3,476,000	4,924,000
	Exterior wall insulation (Existing)	17,200,000	2,872,000	14,328,000
	Roof insulation (Existing)	5,700,000		5,700,000
	Lighting upgrade	400,000	400,000	
	HVAC Upgrade	3,000,000	523,000	2,477,000
	Commissioning	600,000	250,000	350,000
	Water Efficiency	1,000,000	500,000	500,000
	Heat Recovery Data Center	300,000	300,000	
Supply	DH Network	3,700,000		3,700,000
	Heating Substations	700,000		700,000
	CW Network	600,000		600,000
	CHP Engines	7,900,000		7,900,000
	Absorption Chiller	1,400,000		1,400,000
	Boilers	5,100,000		5,100,000
	Steam Conversion	3,900,000		3,900,000
Solar PV		3,100,000		3,100,000
Totals		66,000,000	10,736,000	55,264,000

Figure 21A- 1 IEMP Reference Scenario Investment Overview – Low Inflation

Humber College		Reference Scenario	SIF funds to IEMP	Remaining IEMP
Investment Measure Group				
Efficiency	Metering and Control	3,000,000	2,415,000	585,000
	Window Upgrade (Existing)	8,400,000	3,476,000	4,924,000
	Exterior wall insulation (Existing)	17,200,000	2,872,000	14,328,000
	Roof insulation (Existing)	5,700,000		5,700,000
	Lighting upgrade	400,000	400,000	
	HVAC Upgrade	3,000,000	523,000	2,477,000
	Commissioning	600,000	250,000	350,000
	Water Efficiency	1,000,000	500,000	500,000
	Heat Recovery Data Center	300,000	300,000	
Supply	DH Network	3,700,000		3,700,000
	Heating Substations	700,000		700,000
	CW Network	600,000		600,000
	CHP Engines	7,900,000		7,900,000
	Absorption Chiller	1,400,000		1,400,000
	Boilers	5,100,000		5,100,000
	Steam Conversion	3,900,000		3,900,000
Solar PV		3,100,000		3,100,000
Totals		66,000,000	10,736,000	55,264,000

Figure 21A- 2 IEMP Reference Scenario Investment Overview – High Inflation

The background approach to estimate each is summarized in the following paragraphs. Unless otherwise noted the Risk Assessment Index for the category is set at 1.0.

Metering and Control

- Reference Market: Canada/Toronto
- Estimation method: Team experience
- Energy Savings: None

An investment index of $3,000/ metre for 258 additional metres and $1,500 for an additional 860 control points plus O&M costs for six years' results in $3M which was allocated to the building models on a square metre allocation basis.

Window Upgrade (Existing)

- Reference Market: Canada/Toronto
- Estimation Method: Generalized EnergyPlus model with RS Means Indexes
- Energy savings: EnergyPlus Generalized model results

It was assumed 40% of the generalized model of the wall areas was comprised of windows. The number of windows is estimated using an average of 4m^2 per window. The reference window is wood framed, triple glazed. Using an overhead and profit factor of 1.1, a 10% design costs and the Toronto adjustment factors, the total investment per window is $1,026. Recognizing there is a wide range of window qualities, frames and styles, a Risk Assessment Factor of 2.5 is used in the financial integration. The very conservative risk factor also reflects the current state of the Canadian and US retrofit markets which are both low volume and high-priced compared to other major world markets. The Project Work Team recognizes that this is an area for sustained pressure on the selected Strategic Implementation Network (SIN) partner to bring replacement window pricing more in line with global norms.

Exterior wall insulation (Existing)

- Reference Market: Germany adapted with Canada /Toronto adjustments
- Estimation Method: RS Means Canada/Toronto & BKI Germany
- Energy savings: EnergyPlus Generalized model results

Comprehensive exterior cladding is not a Canadian market norm, a fact confirmed by contractors in recent discussions with Humber College. As Ontario pushes to reduce the carbon impact of heating in buildings, the market will transform. This underlines the importance of a rigorous implementation of the SIN Partner approach.

Where the generalized model recommends exterior wall insulation, the building is assumed to have four faces, the length being the square root of the footprint of the generalized model. The height of each storey is assumed to be 4m.

Insulation has been applied to 100% of the area of the generalized walls. The actual structure of many of the buildings is contiguous and these do not always have 4 faces. No allowance is made for windows. The combination of these two factors means the estimated wall area is substantially greater than the reality; a conservative factor.

Two sources were used to estimate the investment index ($/m^2) for the installation of 180mm insulation with a 13mm cement board facing, BKI[xxxii] and RS Means Canada. Germany was selected as a benchmark from a high-labour and material cost country where there is a substantial market for high-efficiency envelope retrofits.

BKI gave a proposal guide price of €69. Recognizing both the custom nature of many of the Humber sub-projects and the market learning curve, a further 30% was added for an installed total of €90. The contractor's overhead and profit, design provision, and Toronto adjustments which combined with an exchange rate of 1.48 combines to $211.10 / m^2. This level was used.

RS Means gave material and labour estimate of $175 for 100mm insulation. If we assume the additional material cost to get to 180mm is $20, along with the Toronto Factors, design cost and overhead and profit, the result is $292 or about 38% higher than the assumptions based on BKI and generously adjusted for Canada. This is probably a realistic reflection of the differences between the developments of the two markets.

A Risk Assessment Factor of 2.5 is used in the financial integration. As for windows, the very conservative risk factor reflects the current state of the Canadian and US retrofit markets which are both low volume and high-priced compared to other major world markets. The Project Work Team recognizes that this is an area for sustained pressure on the selected Strategic Implementation Network (SIN) partner to bring retrofit insulation pricing more in line with global norms.

Roof insulation (Existing)

- Reference Market: Germany adapted with Canada /Toronto adjustments
- Estimation Method: Generalized EnergyPlus model plus RS Means Canada/Toronto and specific projects in Germany
- Energy savings: EnergyPlus Generalized model results

The generalized roof insulation estimation was applied to the assumed roof areas of the generalized building models, except Carrier Drive where actual estimate area was used. Given the contiguous nature of many of the actual buildings and roof obstructions this is almost certainly an overestimate of area.

The assumption is that the enhanced insulation of 200mm/R25 would be an upgrade during other deferred or ongoing maintenance actions and not the primary purpose. However, the IEMP is recommending as much of this be completed in the first 6 to 7 years.

Two sources were used for investment estimates, RS Means and current German projects. RS Means had material cost data for 89mm / 3.5 inch polyiso (R20 to R25) at $30/m² material cost. Applying the same factors as above yielded an investment index of $53.

The German projects had material cost of €32/m² and incremental installation cost of €2.5. This combined with the O&P factor, design factor and Toronto adjustments yielded an investment index of $81. This higher number has been used for the revised IW.

Recognizing there is a wide range of installation uncertainties a Risk Assessment Factor of 1.5 has been applied to the roof insulation making the investment index effectively $122/m².

The investment estimates are based on upgrading and renovating the external roof. From an energy standpoint, interior insulation can be as, or even more, effective and maybe lower cost. Adopting a ceiling insulation approach should be assessed as an alternative approach in any building undergoing significant envelope retrofit.

Lighting upgrade

- Reference Market: Canada /Toronto adjustments
- Estimation Method: Investment index applied to all finished floor area
- Energy savings: EnergyPlus Generalized model results

The IEMP is based on a systematic replacement of existing bulbs with compatible LED replacements during normal course of business. The estimated generalized number of bulbs was based on a lighting level of 7.6W/m², which translated to 76 bulbs per 1000m². Replacement will be complete in six years. This could be accelerated to enhance savings value, and if resources are available[xxxiii], extended to include selective full replacement of fittings and enhanced controls which would also increase the energy savings.

An investment index of $50 / bulb was used based on local bulb costs of $23, installation of $10 and the same O&P, Design and Toronto Factors. This is $3.8/m². This measure is applied to about 127,000 m² of the total.

The current $200K per year third party lighting maintenance contract is assumed to be reduced to $150K per year to reflect the lower maintenance needs of LEDs.

HVAC Control and Update Strategy

- Reference Market: Canada /Toronto
- Estimation Method: Investment provision derived from RS Means
- Energy savings: Team experience plus ENREL studies reduced by 50%

The HVAC control strategy will be applied once the envelope measures are completed, to the following generalized building categories:

- North - VAV reheat Pre-1980s – Academic
- North - VAV reheat Post-1980s – Academic
- Lakeshore VAV reheat Pre-1980s – Office
- Lakeshore VAV reheat Post-1980s – Office

The enhanced control system enables changing control strategy on the heating and cooling coils to supply air at between 16 – 20C and reducing the air flow to ventilation rates. This has a personnel cost impact which is included in the IEMP as part of the IEMP organization costs. There is no investment impact, and none is included in the IEMP for this part.

Assuming the existing plant allows for the control changes, significant further saving beyond the envelope measures would be achieved. Further savings would be achieved with the addition of ventilation heat recovery.

The energy savings from the HVAC control strategy plus ventilation heat recovery are likely to be a further 30% based on recent ENREL studies. 20% was assumed for the IEMP, reduced by as safety factor of 50% in case not all the target buildings would accept this HVAC control strategy. To put this in the College context the overall source energy savings from this strategy is about 3% of the baseline energy use.

The HVAC Control and update strategy is predominantly enabled by substantial investments and improvements in the building envelopes and the completion of the control systems. However, there may be a selective need to invest in upgrading, adding or replacing HVAC components such as AHUs, heat exchangers and other elements. An HVAC investment provision of $3.0M has been included to cover these contingencies.

Water Efficiency

- Reference Market: Canada /Toronto
- Estimation Method: RS Means applied
- Water savings: EnergyPlus Generalized model results

Humber College has already achieved over 50% water efficiency gain since 2005. Supplementary end-use saving is achieved with the completion of the installation of low-flow toilets, showers and taps, based investment indexes per measure from RS Means.

The investment costs for these fixtures were calculated with a 2.5 factor on material cost to account for design and installation costs. Shower heads were considered at $11 each, faucet flow fixtures were estimated at $10 per fixture and low flow urinals at $100 per urinal.

An Investment Risk Factor of 3 was assigned to the water efficiency investments to reflect the level of current proposals.

By far the biggest water efficiency measure in the IEMP comes from the conversion of the North Campus steam heating network to a modern pressurized hot-water system, eliminating the need for make-up water. The investment for this measure is not in this category.

DH and DC Networks

- Reference Market: European municipal DH Markets / recent Canadian projects
- Estimation Method: Team experience based on sizing from generalized modelling
- Energy savings: Indexes based generalized network models

The USA and Canada are very small, immature markets for District Energy. Total installed costs in the IEMP are estimated based on high-priced more mature global markets. In some cases, these are comparable to current or emerging Canadian practice, in others, the need to close the gap through strategic procurement has been recognized by the Core PWT. The IEMP recommends that Humber team with other community and college entities implementing similar solutions to gain market leverage in the selection of SIN partners and globally competitive terms.

Network sizing is estimated using the generalized heat and cooling peak demand based on the generalized building modelling, in turn creating generalized networks in length and pipe size. The investments are estimated using a representative index per metre for the installed costs of the relevant EN253 compliant pipe size, including provisions for accessories.

Investments are assessed on the assumption that the selected SIN Partners for design, installation, and material would be experienced and have the appropriate expertise.

Material cost is based on levels negotiated by other Ontario clients as part of their SIN strategies and are comparable to the levels paid by municipal utilities in high-cost Scandinavian and German markets with an added provision recognizing the immaturity of the Canadian market.

Design and construction costs are similarly based on levels experience in more mature markets with some provision for the Canadian market immaturity

Heating Substations

- Reference Market: European municipal DH Markets
- Estimation Method: Team experience based on sizing from generalized modelling
- Energy efficiency: Indexes based on published specifications

Material cost is based on levels typical to the levels paid by municipal utilities in high-priced Scandinavian and German markets with an added provision recognizing the immaturity of the Canadian market[xxxiv]. Sizing is based on the generalized model heating demand. Design and construction costs are similarly based on levels experience in more mature markets with some provision for the Canadian market. Investments are estimated using an investment index in $/kW thermal.

In larger DH markets, substations are available in standardized forms that can be easily configured from standard modules. This is not the case in US or Canada where this functionality is generally a customized, and much costlier, one-off design. Since all new buildings will be DH connected; it will be easy to design in standardize sub-stations, in turn creating an incentive for the SIN partner to collaborate on the retrofits.

CHP Engines

- Reference Market: Germany
- Estimation Method: Team experience based on sizing from generalized modelling
- Energy efficiency: Indexes based on published specifications

CHP engines are sized for optimum heat efficiency based on providing about 65% to 70% of the heating load.

Installed costs is based on 2015 German Reference Project costs – ASUE BHKW Kenndaten[xxxv] which include allocation for simple building, engineering and transport costs, plus a provision for the Canadian market. An exchange rate from EUR to CAD of 1.5 was used.

Germany is a higher volume market than Canada for small and medium CHP engines. However, the pricing gap is closing, and recent Canadian projects are comparable, including one at a nearby college[xxxvi]. Humber College will identify a SIN partner for this category.

Absorption Chiller and Boilers

- Reference Market: Canada
- Estimation Method: Team experience based on sizing from generalized modelling
- Energy efficiency: Indexes based on published specifications

Boiler and absorption chiller investments are based on local Canadian norms including some provision. Boilers are added as needed based on heating demand growth

Steam Conversion

- Reference Market: None
- Estimation Method: Provision based on team experience
- Energy savings: None

This category only covers the investment needed to convert the internal steam uses of buildings that are served by the current steam system. The provision based on $40 per square metre floor area. This is an assumption for any necessary investment related to the steam to HW conversion. It includes the conversion to electric humidification and provisions for any necessary equipment which is currently on steam and needs replacement, like kitchen equipment, small radiators, etc., which was not explicitly captured in the IEMP. The provision does not include the costs of new substations or network side investments. These are included in their relevant categories.

The existing steam network is assumed to be abandoned in place or selectively removed within the estimated DH and DC installation costs.

22 Appendix: New Construction Procurement Guidelines

The IEMP recommends that the College formalize these guidelines for the procurement of all new buildings, obviously with some adaptation as necessary for any given new building [PROJECT]. In no situation, should the case-by-case adaptation jeopardize the requirement that the design must meet systematic global best practice.

These guidelines are written in today's (2016) context, relative to the expected level of efficiency. It is expected that systematic global practice will become more efficient and the targets will be adapted accordingly.

Background

Sustainability is one of Humber's core values including maximising energy efficiency and minimising energy-related climate change impacts.

Humber has developed a long-term, decision-grade integrated energy and water master plan (IEMP) to create an efficient, long-term integrated approach to energy use, distribution, and supply in support of world-class energy performance. The IEMP takes a 20-year view of the overall opportunity and implementation. The purpose of the IEMP is to prioritize projects to achieve the most transformational effect on energy consumption at the minimum cost, while also reducing greenhouse gas emissions. The IEMP was completed in November 2016 and is available at http://www.humber.ca/IEMP/ .

Under this plan, by 2034, the College's primary energy efficiency will be 50% better than in 2014, and the total greenhouse emissions 30% less.

As part of the IEMP, all new buildings are expected to perform at or near global best practice for energy efficiency. To meet this goal, this [PROJECT] includes a Design Energy Target (DET) of 100 kWh/m^2*year for all new construction. Compliance will be demonstrated through design-stage whole building energy modelling.

General Direction

It is recommended that designers adopt a "passive design" (also known as "near Zero Energy Building" or nZEB) approach. This approach uses the building architecture to maximize occupant comfort and minimize energy use. Key passive design recommendations are summarized below:

- Design each façade specific to its orientation
- Limit glazing ratios, consistent aesthetic and user comfort criteria
- Locate glazing to maximize daylight harvesting and minimize solar gains.
- Consider shading and landscaping to minimize unwanted solar gains.
- Use thermal mass that is exposed to the conditioned space and combine it with other passive elements to achieve its full potential.

The design team is encouraged to focus on reducing loads through passive design practices and a high-performance building envelope. The College will generally favor solutions that utilize low-maintenance, unsophisticated HVAC solutions, including radiant heating and cooling.

The building envelope design should minimize thermal bridging in the assembly as well as interface details. The design should utilize best-practices as exemplified in BC Hydro's *Building Envelope Thermal Bridging Guide*.

Design Energy Target Background

The DET of 100 kWh/m^2*year is based on the specific energy end-use (site) for heating, domestic hot water, cooling, lighting and other plug and process loads in normal use.

The DET assumes all new construction, including this [PROJECT] is connected to a campus district heating and cooling network.

The DET assumes all new construction, including this [PROJECT] meets the energy performance of systematic global best practices as currently seen in jurisdictions such as Germany[xxxvii] and Scandinavia. In these markets, a significant portion of new construction operates at higher levels of efficiency (so-called A or A+ rated buildings).

In establishing the DET, an average functional mix of new academic construction is approximately 70% teaching facilities and 30% office with normal allocations for common areas. The DET assumes a full building operating schedule for 5 days a week from 0800 to 18:00.

Design Energy Target Modelling Requirements

The [PROJECT] must meet the DET requirement of 100 kWh/m²*year or less in end-use (site) energy, of which no more than 45 kWh/m²*year should be for heating.

The energy performance of the [PROJECT] design must be supported by a rigorous model that demonstrates the facility complies with the DET. The model must meet the following requirements:

1. Permitted energy modelling software:

    - eQUEST
    - EnergyPlus
    - IES Virtual Environment

    EE4 will not be permitted. Any alternative modelling software may be accepted but requires consent from Humber.

2. Plug load & Electrical Process Loads – The final DET value submitted must include all plug/receptacle loads and all process/non-regulated loads. The methodology including sources used to estimate plug load must be clearly documented.
3. Natural Gas Process loads – The final DET value submitted must include all natural-gas use for non-heating, non-domestic hot water process use. A mutually agreed allowance on the DET will be made in the event natural gas is used for process applications.
4. Schedules – Allowances will be made for design schedules that exceed the assumed schedule, provided the modelling demonstrates the DET has been clearly met on the 08:00 to 18:00 5-day schedule.
5. Lighting Controls – No reduction in lighting power from occupancy sensor control will be permitted. Reductions in lighting power from daylighting are to be realized through direct modelling in the energy modelling software – manual calculations will not be permitted.
6. The DHW load should be modelled according the actual functions of the building.
7. Heating, domestic hot water and cooling should be assumed to be supplied from the secondary side of a heat exchanger and assume a COP of 1. Building-level pumps must be captured separately in the energy modelling software.
8. Ventilation rates to be modelled as per ASHRAE 62.1 or any future standard.
9. Energy generated by on-site renewable energy systems including solar thermal and solar PV is not to be subtracted from building energy end-use in the final DET value.
10. The DET will be calculated using the gross conditioned area of the building including common areas

RFP Deliverable:

A [PROJECT] Modelling Report from an individual on the CaGBC's Experienced Modelers List, following the CaGBC's *Guidance for Energy Modelling Compliance Documentation in LEED Canada* document.

The [PROJECT] Modelling Report should include the following key items & metrics:

- Total Floor Area
- Total Site Energy assuming metered district energy (heating and cooling), other electricity (and natural gas if needed for process specific uses)

- Total Energy Costs using lower and cost outlooks provided by the College
- Energy Use Intensity (EUI) in kWh/m2*year
- Graphical and Tabular End-Use Breakdown by Cost and Energy
- Sizing methodology
- Calculations to support effective R values used in modelling. A narrative describing how assembly and interface thermal bridging has been captured in effective R values.
- Window to Wall Ratio (WWR) by façade
- Occupancy and Schedule Assumptions
- Peak Lighting Power Density (LPD)
- Peak Heating Load
- Peak Cooling Load
- Peak Receptacle Loads
- Additional Calculations and Workarounds
- Electronic energy modelling simulation files and computer simulation output files
- A detailed narrative describing the energy efficient features and overall design strategy. Describe how best practices for passive design were analyzed during early stage design and have been incorporated. Describe the approaches used by the design team to reduce building heating and cooling loads. Please include a discussion on predicted simultaneous heating and cooling loads and how the design strategy mitigates its energy impacts.
- Background benchmarking used by the design team to ensure the [PROJECT] reasonably meets current systematic global best practice. The benchmarking should clearly demonstrate that benchmarks beyond Canada and the USA were used.

23 Appendix: IEMP Existing and New Buildings Efficiency Background

The energy use intensity from the general and individual modelling including all EEMs for 2034 for each campus is shown in the following figures.

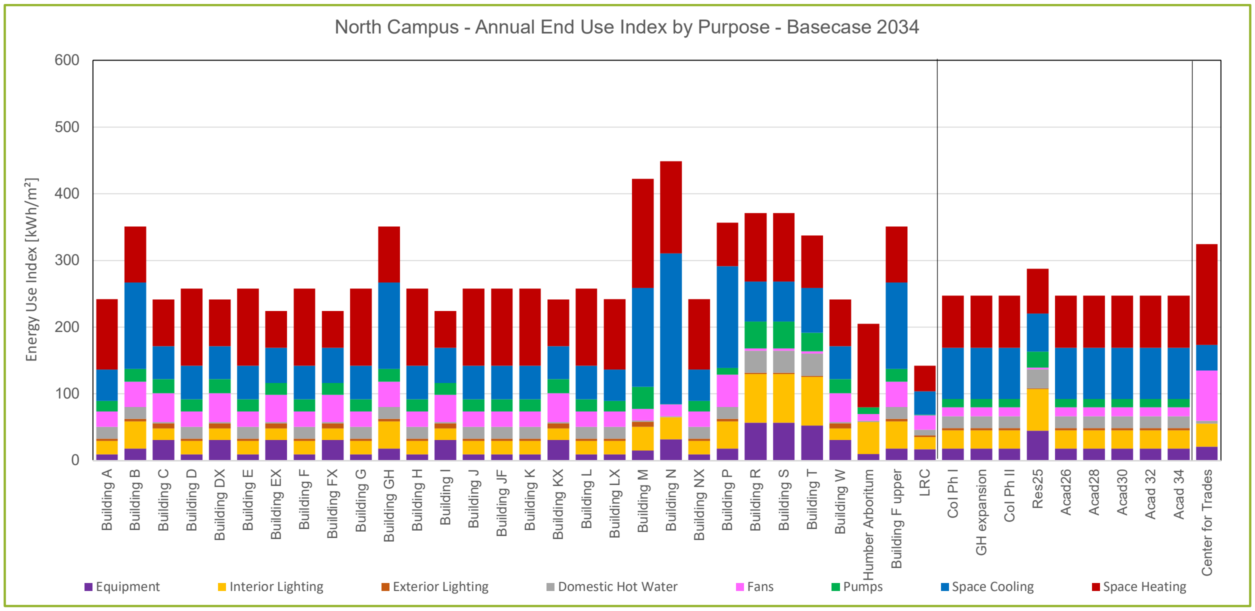


Figure 23A- 23-1 EUI for North Campus Efficiency Case

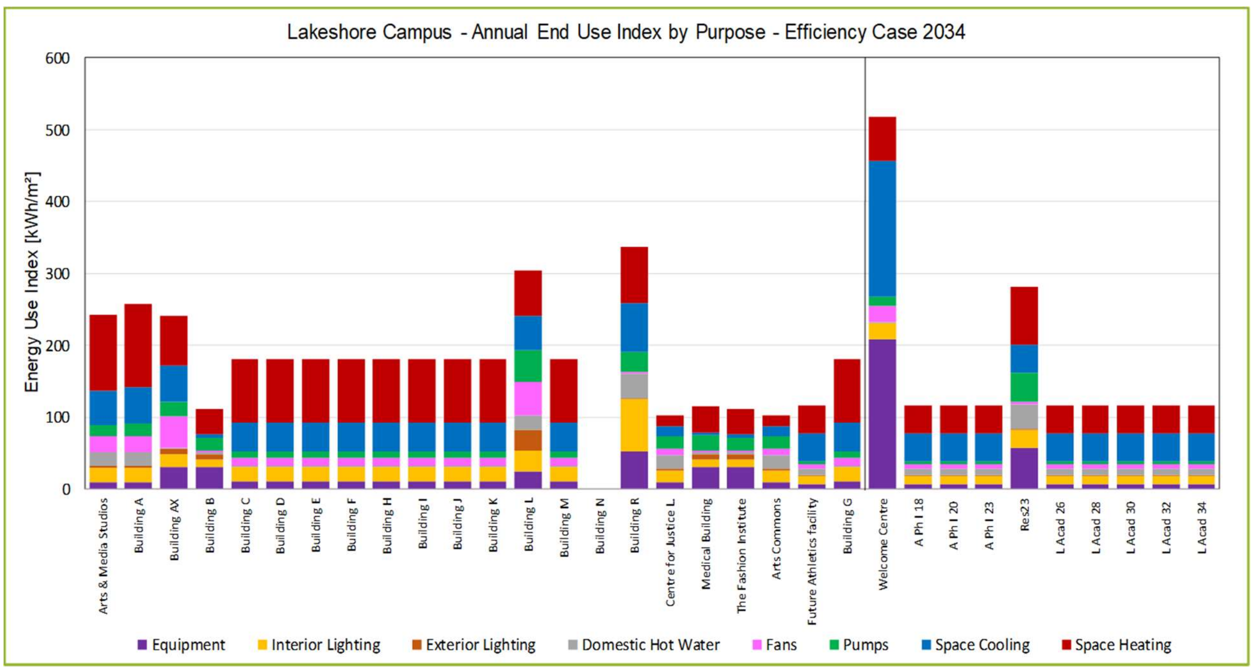


Figure 23A- 23-2 EUI for Lakeshore Campus Efficiency Case

These indexes are used to aggregate the energy needs for each end-use purpose for integration to the College level.

1 END NOTES AND REFERENCES

[i] Unless specifically mentioned, Carrier Drive was treated as part of North Campus in all analytical summaries.

[ii] The Integration Workbook can be easily adapted and extended to include energy use and emissions from Scope 3 sources

[iii] Investment return defined as the Internal Rate of Return using the standard Excel cashflow calculations.

[iv] Available at the Ontario Ministry of Energy website: http://www.energy.gov.on.ca/en/ltep/

[v] Throughout this report, "Carbon Footprint" refers to the total of Scope 1 emissions from natural gas used on campus, and Scope 2 emissions from electricity. The emission indexes use in the report are 198 kg/MWh for natural gas and 50 kg/MWh for grid electricity. For the report these are held constant to 2034. In the supporting Integration Workbook, both the baseline index and the year by year profile can be changed to test various outlooks.

[vi] Throughout this report, the terms "student"; "full-time equivalent"; FTE have been used interchangeably.

[vii] See http://www.energystar.gov/index.cfm?c=guidelines.assess_energy_management

[viii] Under the EU Energy Performance in Buildings Directive (EPBD), all new and existing buildings are required to have a current Energy Performance Label (EPL) when sold or rented. Each EU country has a slightly different rating scale, but most range from A to F. For new construction, C would typically represent full code compliance. In the case of Germany, an A-rated building would be about 30% more efficient that the applicable code. A-rating represents at least 20% of the new construction market (source: Baumann Consuting GmbH).

[ix] Through the report "warm-water" heating is used for a system designed to operate well below 100 deg C. "Hot water" network refers to a system capable of operating up to 120 deg C continuously or 150 deg C for shorter periods of time and is compliant with the EN253 and related norms.

[x] Full name – Lakeland Community College in Kirtland, Ohio (http://www.lakelandcc.edu/). See http://www.lakelandcc.edu/web/about/sustainability for more background on the energy plan and performance.

[xi] Energy efficiency is measured in source energy use per square metre of conditioned building floor area

[xii] Water efficiency is measured in potable water consumption per Full Time Equivalent student (FTE)
These recommendations are aimed at limiting global average temperature increase to less than 1.5 deg C above pre-industrial levels, and broadly aim for an 80% reduction in anthropomorphic greenhouse gas emissions by 2050 relative to 1990 levels.

[xiv] Current rules limit unattended operation to below 100 deg C. In most part of the world, EN 253 systems can operate up to 150 deg C and it is likely the Canadian rules will adapt as DE becomes more common. This will mean there is considerable reserve capacity in the proposed solution for expansion or smaller sizing.

[xv] The IEMP assumes electricity is priced at annual average rates, which are treated as fully variable based on consumption. In reality, electricity is priced with a fixed and variable component. In the future, the expectation is that the fixed portion will increase. It also expected that Ontario will introduce significant price variation based on the time of day and/or season when the power is used. The detailed operating cycle of the CHP engines will be tactically adjusted to optimize technical and economic performance.

[xvi] The plan assumes there will a 1.5% per year efficiency gain between 2017 and 2021 from so called low cost/no cost measures. Most of this will come continuous improvement and adjusted operating frameworks summarized in this section. The low cost/no cost efficiency rate is planned to drop to 1% per year from 2022 to 2026 and to 0.5% thereafter. The early higher changes are a direct result of resetting and optimizing the operating frameworks.

[xvii] See https://www.energystar.gov/buildings/tools-and-resources/energy-star-treasure-hunt-guide-simple-steps-finding-energy-savings for further background.

[xviii] There are two ways used to estimate GHG emissions relative to power. The "Grid Average" average approach assume power additions or subtractions cause or avoid GHG emissions based on the grid average index. The "Marginal" approach assumes any increase in power will statistically cause the grid to add marginal (peaker) generation, and any efficiency or local generation will avoid the need for marginal generation. In Ontario, marginal generation is natural-gas fired power plants for the foreseeable future. Following the completion of the IEMP at Humber, the City of Toronto contracted The Atmospheric Fund to create practice guidelines for marginal emissions factors for Ontario. These were published July 2017 and have been used for the IEMP emissions estimates. (www.taf.ca)

[xix] The Ontario Municipal Energy Plan Programme (http://www.energy.gov.on.ca/en/municipal-energy/) was introduced in 2013.

[xx] As an example, the City of Windsor uses about 190 GJ site energy per capita compared to 90 GJ for its sister city of Mannheim in Baden-Württemberg, Germany.

[xxi] The role of public agencies and intuitions in influencing sustainable procurement, often also called green procurement, was formally recognized by the Canadian Government in 2006 (http://www.tpsgc-pwgsc.gc.ca/ecologisation-greening/achats-procurement/politique-policy-eng.html).
The European Union actively encourages all member states to implement public procurement policies where they use their "*their purchasing power to choose environmentally friendly goods, services and works, they can make an important contribution to sustainable consumption and production - what we call Green Public Procurement (GPP) or green purchasing.*" The EEA website has useful background resources (http://ec.europa.eu/environment/gpp/index_en.htm).
The Association for the Advancement of Sustainability in Higher Education (AASHE) has some excellent background to Sustainable Procurement including best practice examples. (http://www.aashe.org/files/publications/aashe_sustainable_procurement_toolkit.pdf).

[xxii] See Wikipedia entry for general background https://en.wikipedia.org/wiki/One_Watt_Initiative

[xxiii] Examples are the EU supported Innocat initiative: http://www.sustainable-catering.eu/about-innocat/; US EPA Energy Star commercial catering guidelines;
https://www.energystar.gov/products/commercial_food_service_equipment
NRCan Energy Star Guidelines: https://www.nrcan.gc.ca/energy/products/categories/food-service/13749

[xxiv] A data manipulation and reporting tool developed for Corning Incorporated's worldwide energy and climate performance in all its operations was used to organize Humber's historical data and is a good starting point to develop the ongoing data reporting. See https://www.corning.com/worldwide/en/about-us/corporate-citizenship/energy-management.html

[xxv] The approach used by Toyota is a well-recognized benchmark Kaizen approach. See https://us.kaizen.com/knowledge-center/toyota-production-system.html

[xxvi] See http://www.ghgprotocol.org/

[xxvii] See http://www.cagbc.org/

[xxviii] See http://www.enev-online.de/index.htm (in German). Humber performance was confirmed against EnEV 2009 A-Ratings for educational institutes in comparable climate zones.

[xxix] See http://unfccc.int/paris_agreement/items/9485.php

[xxx] Source: Government of Ontario: http://www.energy.gov.on.ca/en/ltep/

[xxxi] Source: Government of Ontario: https://www.ontario.ca/page/climate-change-action-plan

[xxxii] Building Cost Institute from Germany - http://www.bki.de/

[xxxiii] As of November 2016, Humber College is applying a total of $3M from the SIF Grant to extended lighting measures.

[xxxiv] Recent client study comparing EU and Canadian markets is available from GIL under confidentiality agreement

[xxxv] http://www.bhkw2016.de/bhkw2016-bhkw-kenndaten/

[xxxvi] Details available from GIL under confidentiality agreement

[xxxvii] The current Danish and German applicable mandated energy performance standards for new construction in their commercial and educational market would meet the requirements of the College. In Germany, this is EnEv 2014, which will have a new revision in 2017 to meet the EU "Lowest Energy New Construction" guidelines by 2019. In Denmark, it is BR10, which has 2015 (Low-Energy) and 2020 (nZEB) expectations already published.