A ROADMAP FOR CLIMATE ACTION AT THE UNIVERSITY OF CALGARY: HIGHER EDUCATION CAMPUSES AS CLIMATE LEADERS

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INTRODUCTION

As federal and provincial governments debate the viability of absolute emission reduction targets, universities and college across North America are steadfast on a voluntary movement to slash greenhouse gas emissions and model the way forward on climate action. These institutions are taking advantage of campus contexts that offer decentralized energy supply opportunities, district energy systems, large building portfolios, and research partnerships to leverage change. Higher education campuses are emerging as innovation hubs for the deployment of new technologies, policy development, best practices in portfolio scale building operating models, public-private partnership models and more.

Situated in the heart of the corporate oil and gas sector, the University of Calgary is one such innovation hub. To date, the University of Calgary has realized reductions equivalent to 35% of its 2008 main campus baseline emissions and approximately $7.4 million in annual cost avoidance. By 2016, the University of Calgary's 50th anniversary, the institution aims to attain a 45% reduction in emissions. Energy Innovation is one the research platforms supporting the University of Calgary's Eyes High strategy to become one of the top five research institutions in Canada by 2016. Operational innovation in the management of energy and greenhouse gas emissions (GHG) is a corresponding initiative. This article overviews the strategies behind the progress to date within institutional operations.

KEYWORDS

North American university and college climate action plans, "greening" college campuses, high performance campus buildings, energy management systems, building energy retrofits

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To learn more about the University of Calgary's sustainability initiatives or access the Climate Action Plan see www.ucalgary.ca/sustainability. You may reach the Office of Sustainability at sustain@ucalgary.ca.

FIGURE 1. The University of Calgary's Taylor Family Digital Library is one of a growing number of high-performance buildings on campus. Image courtesy University of Calgary.

NORTH AMERICAN INSTITUTIONS STEP UP

Across Canada and the Unites States, 700 universities and colleges have declared their commitment to leadership by becoming signatories to Canadian and American versions of climate leadership declarations. In the United States alone the collective impact to date is estimated at 10 million metric tonnes of GHG emission reductions.[1] The potential outcomes over the next decade are welcome news in the context of atmospheric emissions surpassing 395 parts per million of equivalent carbon dioxide (CO_2e) in February 2013.[2]

More than 660 presidents of American higher education institutions are signatories to the American College and University Presidents' Climate Commitment (ACUPCC). Following is an excerpt from the declaration:

> "We believe colleges and universities must exercise leadership in their communities and throughout society by modeling ways to minimize global warming emissions, and by providing the knowledge and the educated graduates to achieve climate neutrality. Campuses that address the climate challenge by reducing global warming emissions and by integrating sustainability into their curriculum will better serve their students and meet their social mandate to help create a thriving, ethical and civil society."[3]

The ACUPCC website hosts almost 500 Climate Action Plans and over 1,800 Greenhouse Gas Inventories that provide a wealth of best practice examples for other institutions. The ACUPCC Five Year Report[4] published in May 2012 confirms that the collective greenhouse gas emission reductions of signatories are estimated at 10.2 million metric tonnes of CO_2e. The report also confirms collective savings of more than $100 million from completed projects at 111 institutions. Large-scale projects are providing large-scale change. Arizona State University has installed 18 megawatts of photovoltaic arrays and is set to install an additional 5 megawatts in summer of 2013. Ball State University is creating the largest ground source, closed-loop district geothermal energy system in the country.[5] The heating and cooling system is forecast to provide $2 million in annual cost savings and a 50% reduction in institutional greenhouse gas emissions. The University of California Davis has achieved net zero energy in the first phase their new 130-acre West Village, a pubic-private partnership project providing student and staff housing and commercial space.

In Canada, 29 institutions have signed the University and College Presidents' Climate Change Statement of Action for Canada (UCPCCSAC). While a central registry for disclosure of progress does not yet exist in Canada, this is not a reflection on inaction. The University of British Columbia is aiming for a 33% GHG emission reduction by 2015, on a path to 100% by 2050. In addition to progress to date through their award-winning ECOtrek program, the institution is investing a further $117 million on innovative energy efficiency infrastructure projects. This includes a major steam-to-hot water retrofit, a Bioenergy Research and Demonstration Facility, and a "Building Tune-up" (retro-commissioning) project encompassing 72 buildings.[6] Nova Scotia's Dalhousie University has demonstrated a 25% reduction in total emissions since 2008 and will continue this trend through planned projects such as tri-generation, existing building retrofits, and the implementation of its Green Building policy.[7] The University of Northern British Columbia has reduced natural gas consumption by 89%, lowered energy costs and decreased greenhouse gas emissions by 3,500 tonnes through a new biomass gasification system.[8] Completed in 2011 the system enables the university to utilize locally sourced wood biomass to produce clean-burning syngas, displacing the natural gas used for heating the campus. The University of Calgary has also charted a course for major emissions reductions, with a 35% reduction on main campus to date from a 2008 baseline and plans to reach 45% by 2015.

DRIVERS OF CHANGE

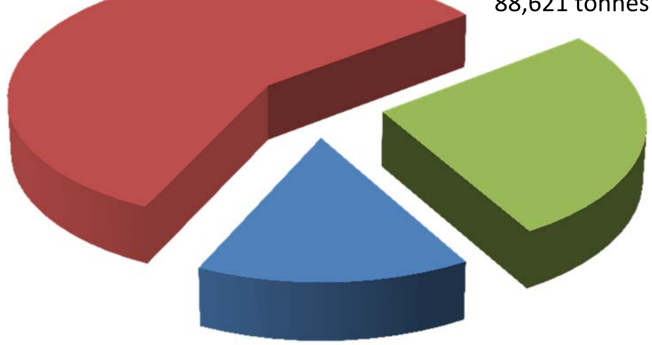
In 2008, the University of Calgary was the first institution outside of the creators of the UCPCCSAC to become a signatory to the Canadian climate action declaration. Located in the corporate heart of the oil and gas sector, the university is known for an appetite for innovation. With energy innovation an identified priority in the institutional Strategic Research Plan and sustainability an identified priority in the Academic Plan, demonstrating leadership in operational emissions management is a compelling complement to research and education endeavors. As a signatory to the UCPCCSAC declaration, the university committed to undertake a comprehensive greenhouse gas inventory within one year, to publish a Climate Action Plan within two years, and then publish progress against this plan going forward.

While the University of Calgary had tracked greenhouse gas emissions from the operation of buildings on main campus since 1990, undertaking a comprehensive GHG inventory provided the opportunity to see a more complete picture of the operational GHG footprint. To create the GHG inventory,[9] the University of Calgary followed The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (GHG Protocol) produced by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). This protocol classifies emissions into 'scopes' as follows:

> *Scope 1 emissions:* Direct GHG emissions from sources that are owned or controlled by the organization.
>
> *Scope 2 emissions:* Indirect GHG emissions resulting from offsite generation of utilities which are purchased by the organization.
>
> *Scope 3 emissions:* Indirect GHG emissions from sources not owned or directly controlled by the entity but related to the entity's activities.

When the University undertook the baseline GHG inventory, Scope 1 emissions were predominantly associated with natural gas combustion in the central heating plant boilers,

FIGURE 2. University of Calgary 2008/09 Greenhouse Gas Inventory Scope Breakdown.



with smaller contributions from distributed combustion equipment such as emergency generators and fuel burned in the vehicle fleet (right down to the propane fired Zambonis that work in the Olympic Oval).

At the time, Scope 2 emissions were predominately related to the use of electricity generated offsite. A relatively small amount of steam was also purchased from the Foothills Hospital power plant (operated by Alberta Health Services and outside the organizational boundary).

While this article focuses on emissions associated with the built environment, the University of Calgary elected to include Scope 3 emissions associated with electricity transmission and distribution losses, organic waste production, paper purchasing, institutionally financed travel, and commuting as part of the baseline GHG inventory and the subsequent Climate Action Plan.

The 2008–2009 baseline GHG inventory confirmed that the university was responsible for over 325,000 metric tonnes of greenhouse gases annually based on operational control. Figure 2 confirms the breakdown of 15% Scope 1, 58% Scope 2 and 27% Scope 3 in metric tonnes. Within this 49,468 tonnes of Scope 1 and 189,821 tonnes of Scope 2 emissions are associated with the operation of the built environment.

Another factor influencing institutional support for implementing a Climate Action Plan was increasing recognition of the need for an enterprise risk management strategy in the face of a changing and unpredictable GHG emissions regulatory environment. In 2004, the Federal Government amended the Environmental Protection Act, lowering the mandatory GHG emissions reporting threshold from 100,000 metric tonnes to 50,000 for Scope 1 emissions from a single site. With 49,468 tonnes CO_2e of the Scope 1 emissions originated from combustion of natural gas on main campus, it became apparent that the University would face mandatory reporting shortly. In 2007, the government of Alberta launched the Specified Gas Emitters Regulation and the Specified Gas Reporting Regulation. The regulation requires emitters over 100,000 metric tonnes of Scope 1 emissions from single sites to pay $15 per tonne of emissions if specified emissions reductions are not attained. Additionally, in 2008 the province of British Columbia introduced a mandatory carbon tax for public sector institutions resulting in Universities and Colleges paying $25 per tonnes of emissions. In the event that the Alberta government lowered the emissions threshold at which penalties apply, the University of Calgary could face financial penalties for emissions similar to post-secondary institutions in British Columbia.

DEVELOPING A CLIMATE ACTION PLAN

As a signatory to the University and College Presidents' Climate Change Statement of Action for Canada, participants must complete a comprehensive Climate Action Plan (CAP) within two years. A CAP is a detailed document that confirms an organization's GHG reduction goals, milestone dates for reaching the goals, and proposed actions for reaching the goals. The University of Calgary's CAP[10] also underscores institutional leadership in research and teaching within energy, environment, and climate change related fields; and highlights growing momentum in related student leadership. When the institution started developing the CAP there were no published precedents among Canadian Universities. In 2010, the University of Calgary became one of the first universities or colleges in Canada to publish a comprehensive CAP. In the United States, however, several post-secondary education institutions had published CAPs. The most common approach used by American institutions was a back-casting approach in which a desired emission reduction target was set followed by a backwards planning process to identify the policies and initiatives needed to realize the defined target. Recognizing that gaining institutional endorsement of the CAP targets would require a viable plan of action to reach the proposed targets an alternate approach was used to develop the University of Calgary CAP.

With the GHG inventory in hand, an emissions growth forecast was developed based on business as usual practices and forecast growth patterns. Armed with the institutional commitment to reduce greenhouse gas emissions, an understanding of the potential emissions growth pattern, and facing changing and unpredictable direction of provincial and federal greenhouse gas regulation, a CAP working committee was charged with identifying emissions reduction strategies. The working committee was comprised of cross-departmental task forces to focus on sectors such as transportation, built environment, waste, etc. Each group identified stretch goals within their operating jurisdiction and a time horizon in which the initiatives might be accomplished. The potential emissions reductions were then calculated for each initiative. The cumulative impact from each subgroup was aggregated and overlaid on the projected emissions growth to determine a realistic picture of what was attainable. For the University of Calgary, the outcomes were a 45% reduction by 2015 and a 60% reduction by 2020. Assuming continuing progress, an 80% reduction was set as a long-term goal for 2050.

Figure 3 is a wedge diagram showing total emission reductions stemming from the four sectors of the built environment, transportation, paper purchasing, and organic waste. The top of the wedge diagram indicates the hypothetical business-as-usual emissions considering the forecasted growth of the university. The bottom wedge shows the predicted total institutional emissions (and milestone targets) considering the net impact of all emissions reduction initiatives. Note that the current Climate Action Plan acknowledges that additional technologies, innovations, or opportunities not yet identified will be required to hit the 2050 target. The largest emissions wedge—and in the largest area of opportunity—relates to the built environment.

FIGURE 3. University of Calgary Climate Action Plan Total Emissions Portfolio Wedge Diagram.

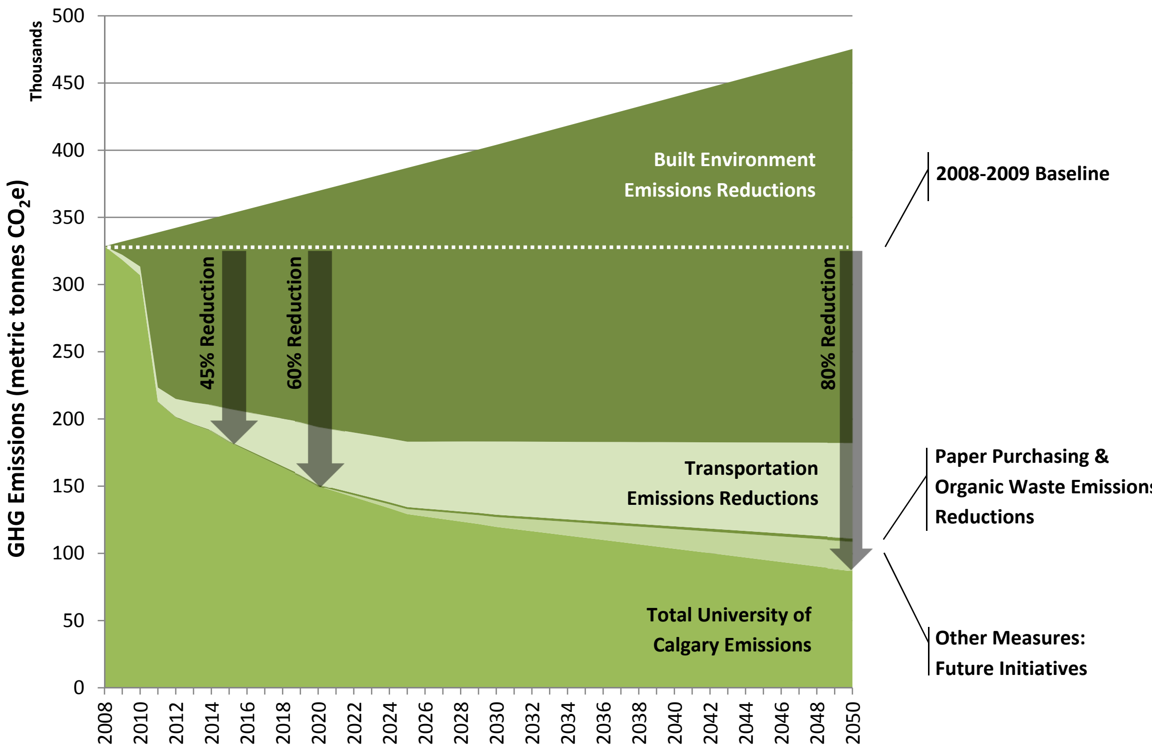


Figure 4 shows the breakdown of emissions within the built environment and confirms the specific targeted emissions reductions opportunities that remaining sections of this article will highlight. While emission reduction strategies continue to be implemented in all areas identified in the CAP, they are not covered in this article.

RETHINKING ENERGY SUPPLY

The University of Calgary main campus is served by a high temperature hot water district heating system. Until 2012, heating and hot water on campus was provided by natural gas fired boilers originally installed in the 1960s and 1970s. Facing the addition of almost one million square feet of new building area between 2007 and 2012, it was determined the aging boilers would be inadequate to serve the major capital expansion. This presented the opportunity to rethink energy supply. While the easiest option was to upgrade and expand the boiler capacity, further investigation revealed that the renewal of the system could also become a key part of the institutional greenhouse gas reduction strategy.

Historically, the University of Calgary sourced electricity from the provincial electrical grid. The Alberta grid has the highest emissions intensity factor of all provinces dues to its predominantly coal and gas-fired generation (roughly 0.840 kg/kWh).[11] As such, the University of Calgary's 2008–2009 Scope 2 greenhouse gas emission footprint was over 189,000 metric tonnes, representing 58% of total emissions. With no commitment to dramatic reductions in the Alberta electrical grid emissions intensity in the foreseeable future, an alternate approach to electrical supply was necessary to realize meaningful emissions reductions on campus. This

FIGURE 4. University of Calgary Climate Action Plan Built Environment Wedge Diagram.

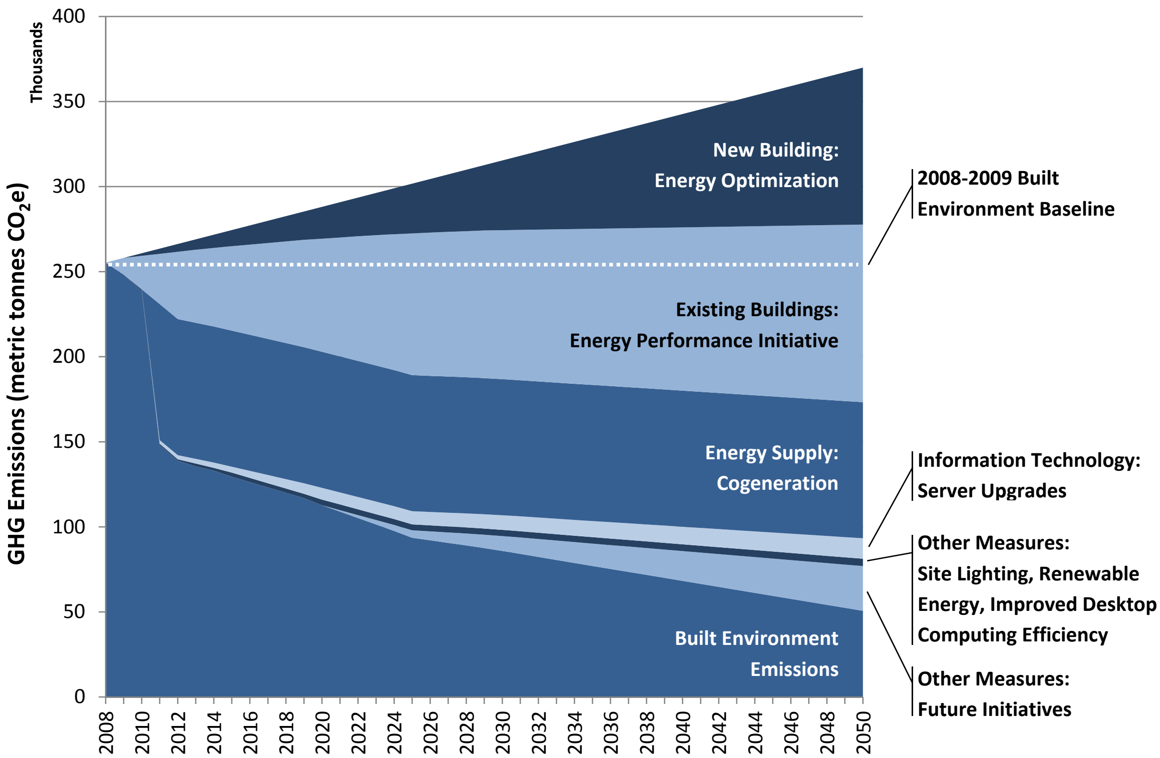
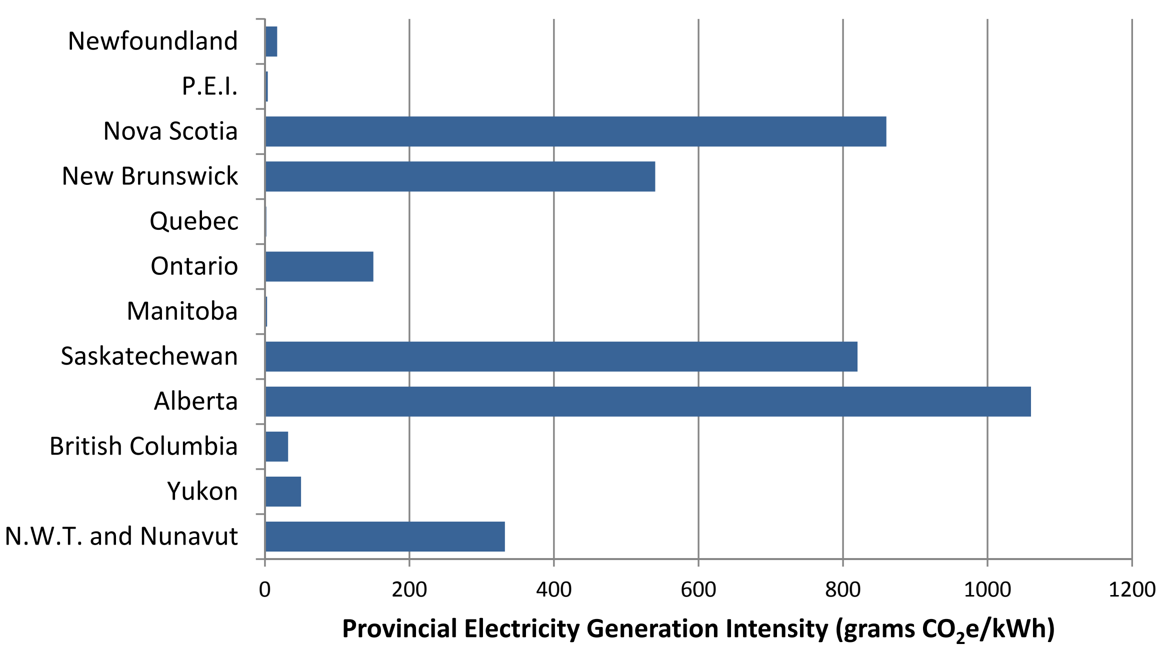
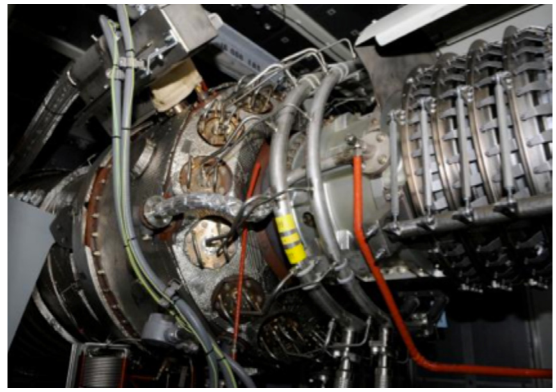


FIGURE 5. Relative Emissions Intensity of Electricity Generation in Canadian Provinces and Territories.



prompted the consideration of cogeneration as a means to simultaneously increase capacity of the district heating system while at the same time meeting a significant portion of the campus electricity demand through much lower-carbon electricity generation.

FIGURE 6. Gas turbine at the heart of the University of Calgary's cogeneration system.



Cogeneration, also known as combined heat and power, is the use of an engine or turbine to simultaneously generate both electricity and useful heat. Operation of the turbine produces electricity and waste heat is captured for building and hot water heating on campus. The University of Calgary's cogeneration system was sized to satisfy the campus' base load heating requirements of roughly 18 megawatts (60 million BTU/hr). The existing boilers were retained as back-up and to augment co-generation during peak heating periods. This sizing resulted in roughly 12 megawatts of electrical power generation which was coincidentally quite close to the base electrical load for the main campus. Some of the produced electricity is fed directly to campus buildings and the remainder is fed to the grid (offsetting electricity consumption elsewhere on campus). While at this point only approximately 15% of the electricity generated is consumed directly by campus buildings, additional electrical utility infrastructure will be added to increase the number of buildings that can be fed directly. Electricity consumption beyond the base load is met from the electrical grid.

Compared to upgrading to high-efficiency boilers, the incremental cost for co-generation was $18 million. With a projected annual reduction in operating costs of $3.5 million, the simple payback period for co-generation was just over five years. Project funding was provided by the Federal Government's Knowledge Infrastructure Program. The projected emissions reductions of 80,000 metric tonnes per year come from the dramatically lower emissions intensity of electricity produced through natural gas fired cogeneration. The University of Calgary's cogeneration system is able to generate electricity at only 240 gCO_2e/kWh; more than 75% lower than the Alberta electrical grid.

Following a 24-month construction and commissioning period, the University of Calgary's cogeneration system went live in January 2012. Based on measured data from the first year of startup and operation, the cogeneration system has provided over 55,000 tonnes of CO_2e reduction. Now operating at full capacity, the cogeneration system is forecast to provide over 80,000 tonnes of CO_2e reduction in 2013, a reduction equivalent to 30% of the baseline built environment emissions. Utility cost avoidance for 2013 is forecast at approximately $5 million, exceeding expectations. Low natural gas pricing and hedging strategies for natural gas have contributed to the extra cost avoidance to date.

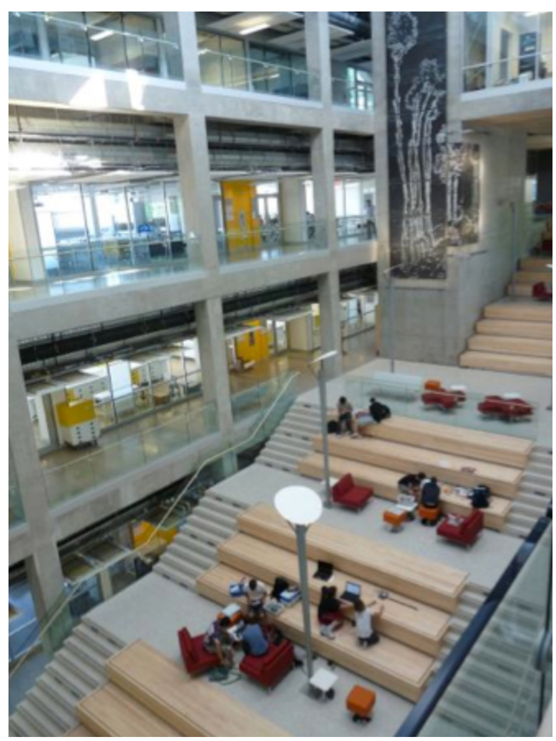
Based on the success of the main campus cogeneration installation, the University of Calgary will explore opportunities to employ cogeneration at its second largest building site, the Foothills Medical Campus. The campus, which includes both University of Calgary buildings as well as hospital and cancer care buildings operated by the provincial healthcare agency, is also operated on a district heating system. Employing a similar approach to cogeneration, the University of Calgary could realize more than 30,000 metric tonnes of addition greenhouse gas emission reductions. Beyond co-generation, the next area of exploration is finding regionally viable alternative to natural gas as a fuel source. A recent study assessed the viability of clean municipal wood waste to partially displace natural gas. In terms of renewable energy, to date the University has installed one 65,000 kilowatt hour photo-voltaic array on the Child Development Centre.

MANAGING GROWTH FROM NEW BUILDINGS

Within the spectrum of built environment emission reductions, new buildings in many ways represent the low hanging fruit. While new buildings are a relatively small portion of the University of Calgary's forecasted GHG growth in any given year, they contain some of the easiest opportunities in terms of investing in energy efficiency. As each new building adds to the organization's GHG footprint, managing emissions growth from new buildings is also critical to maximizing absolute emissions reductions. New buildings present greater opportunity to mitigate or even eliminate the incremental investment in energy efficiency through cost balancing strategies such as coupling a climate responsive building form and building envelope investments with reduced heating, ventilation, and cooling system costs. When approached with the intention of optimizing energy performance and designed using a true integrated design process, new buildings have the ability to be far lower in energy use than existing buildings with significantly less investment required.

While the University of Calgary's first approach to promoting green buildings relied heavily on mandating LEED certification, it was quickly understood that more specific guidance was essential to propel design and construction teams towards the step change envisioned for the University's buildings. To this end, the University of Calgary implemented a progressive energy performance standard for new buildings based on the targets of the Architecture 2030 challenge. The energy performance standard was integrated into the new institutional Design Standards and included in the design briefs for new projects.

FIGURE 7. The Energy Environment Experiential Learning Building, 2012 recipient of the Society for College and University Planning's Excellence in Architecture award.



In addition to the minimum energy performance requirements of the LEED certification, the design standard introduced a hard cap on the energy consumption of new buildings. The original version of the design standards required a 50% reduction in energy use when compared to the energy code (equivalent to 10 points under LEED credit EAc1). Additionally, it went beyond that to also specify a maximum Energy Use Intensity (EUI), a unit of measure that describes the energy consumed by a building relative to its size. The inclusion of a fixed target underscored the importance of an overall focus on energy reductions and decreased the incentive for energy modelers to spend time searching for ways to optimize performance through loopholes in the energy modeling standards. The additions to the design standard were accompanied by supporting changes in the University of Calgary's procurement and project management processes. As projects move through various stages of design, teams must demonstrate through predictive modeling that proposed designs are meeting the energy performance standards.

FIGURE 8. The Child Development Centre, note building integrated photovoltaic sunshades on south facade.

A number of University of Calgary buildings have already hit the ground running with innovative and efficient designs. The recently completed Energy Environment Experiential Leaning (EEEL) Building uses underground earth tubes and the thermal mass from its concrete structure to regulate the high occupant loads and incorporates the central atrium as part of a daylighting and natural ventilation strategy. This 24,000-square-meter laboratory building is on track for LEED Platinum Certification including 10 out of 10 energy credits.[12] The University of Calgary currently has four projects under design using the new standard and three additional completed buildings awaiting LEED certification.

While the existing Design Standards are pushing new building performance beyond status quo, further improvements are planned for the forthcoming version of the Design Standards. The Design Standards have been updated to align with the newest energy performance standards referenced in LEED. The standards now require buildings to demonstrate a 50% improvement over ASHRAE 90.1-2010 energy standards. The standards will also follow the direction taken in LEED 2009 and LEED v4 by including *non-regulated loads* (receptacle loads, process loads) in the energy modeling process. This will encourage building design teams to work with the university to develop integrated approaches to managing user loads.

Further, the University of Calgary has included clarification in the design standards around the district energy system on campus. Past projects have inconsistently addressed the impacts of the district energy system and in some cases buildings have been heavily buoyed by the high performance of the central system. The newest design standards will shift the burden of responsibility back to the design and construction team by setting targets which focus specifically on building-level performance.

Last, to ensure new building designs sensibly align with overall institutional Climate Action Plan goals, the energy targets are being translated to Greenhouse Gas Emissions Intensity targets, essentially giving each new building constructed on campus an emissions budget. Going forward, benchmarking tools such as the ENERGY STAR Target Finder will be used along with the Architecture 2030 targets to develop customized emissions targets for all new buildings on campus.

EXISTING BUILDINGS—THE WHITE ELEPHANT IN THE ROOM

While accolades mount for new LEED or Living Building Challenge projects, the white elephant in the room from a greenhouse gas management perspective is existing buildings. The

University of Calgary manages over 10 million square feet distributed across eight sites and 115 buildings. Ranging in date of construction from 1960 to 2012, the energy utility consumption of these buildings makes up 77% of the campus's GHG footprint. Existing buildings present more complex diagnostic challenges, persistent cultural occupancy and operating patterns, and can be costly to retrofit beyond the low hanging fruit opportunities such as relamping.

The University of Calgary's existing buildings have been the focus of a number of energy efficiency programs delivered through a phased Energy Performance Initiative (EPI) retrofit program. Lessons learned from each phase shape successive initiatives.

EPI Phase 1

The first coordinated program—EPI Phase 1—was run between 1997 to 2002. The program, undertaken with an Energy Service Company (ESCO), focused primarily on lighting retrofit and power factor correction. While this phase of the EPI identified significant energy savings, the partnership with the Energy Service Company meant these dollars were not available for reinvestment in the short term. Furthermore, this phase missed the opportunity to build momentum through engaging staff and developing in-house expertise. EPI Phase 1 resulted in approximately $1 million in avoided costs and 8,100 metrics tonnes of GHG emission reductions.

EPI Phase 2

EPI Phase 2 was kicked off in 2005. This phase expanded the Phase 1 program into an additional 24 buildings and looked at an increased breadth of energy efficiency measures. In addition to lighting retrofit opportunities, EPI Phase 2 considered variable frequency drive retrofits, heating element insulation programs, low flow aerators, and vending misers for vending machines. It also included additional building level metering. EPI Phase 2 resulted in approximately $3 million in avoided costs and 16,000 metric tonnes of GHG emission reductions. The project payback period was approximately five years with funding provided by the Federal Government's Knowledge Infrastructure Program.

With significant progress on the low hanging fruit from the first two phases of existing building retrofits in hand, planning for the next phases undertook a different approach. Building on lessons learned a new set of goals informed the next planning process. These included:

- Institutionalize a continuous improvement operating model for energy efficiency and occupant health and comfort;
- Engage an interdisciplinary cross-departmental planning and implementation team to bridge the common organizational barrier between facilities operations and engineering teams, and build the leadership capacity of this team;
- Leverage existing investments in metering into an enterprise energy management system to support a proactive approach to existing building energy management and occupant engagement;
- Develop a methodology to assess and prioritize the campus portfolio, delve deeper into existing buildings to identify key leverage points for investment, and establish a multi-year existing building energy optimization master plan; and
- Reduce annual utility costs and make a significant GHG emission reduction contribution to the Climate Action Plan.

Planning of this next phase started with participating in the Canada Green Building Council's GREEN UP pilot program. At that time, the Council's vision for GREEN UP was to develop and utilize a benchmarking database and information system to accelerate the energy and environmental performance of existing buildings across Canada. Through benchmarking building performance against weather normalized buildings of the same classification, building owners could determine if their buildings were leading or lagging performers and set appropriate performance targets. Rather than looking just at whole building performance, the University undertook a subsystem (fan power density, pump power density, etc.) energy performance audit of two buildings known to be poorer performers. Outcomes were entered into the GREEN UP database enabling benchmarking of subsystem performance against similar building types, immediately illuminating specific areas of opportunity. Additionally, the data supported the ability to analyze subsystem performance data highlighting anomalies such as concurrent heating and cooling.

The next step was to bring a cross-disciplinary internal team together to review the benchmarking data and performance trending. A team of building operators, building controls technicians, engineers, energy managers, sustainability professionals, and senior decision makers was convened for a one day workshop. Utilizing the collective knowledge on the buildings in question and the collective diversity of expertise, the analysis confirmed a potential of more than $750,000 in annual savings from the two buildings: over $640,000 from improvements in specific subsystem performance benchmarks, and a further $110,000 from a change of the HVAC system operating hours. By utilizing the principles of an integrated design process in this exercise, new information on barriers and opportunities was uncovered and the value of cross-disciplinary collaboration was confirmed. A permanent cross-disciplinary Energy Performance Working Group evolved from the original group to steward continued action in this area.

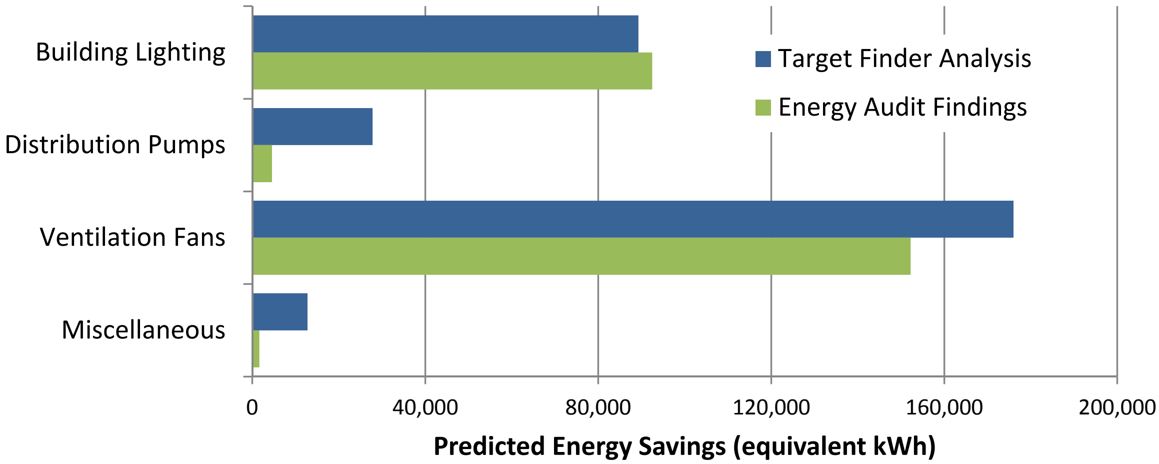
EPI Phase 3

In the short term, the university kicked off EPI Phase 3 to immediately capitalize on potential savings that could be accessed without detailed technical analysis. EPI Phase 3 differed from previous initiatives by focusing specifically on optimizing mechanical and electrical system scheduling to match with building occupancy. Due to the wide range of occupancies present on a university campus (from standard office and teaching space, to recreational facilities, to research laboratories, to residences) and diversity of effected departments, this was a significant undertaking. Unlike the first two EPI phases, these measures relied on building managers working with identified representatives in faculties and departments to establish viable HVAC system operating hours. Additionally, the location scheduling of evening classes was consolidated to reduce the number of buildings requiring night time HVAC system operations. Facilities operational staff closed the loop by modifying equipment scheduling based on the occupancy information. This phase was implemented in 26 buildings and the average schedule impact was roughly a 10% reduction in operation hours. EPI Phase 3 savings were estimated at $1 million. The utility cost avoidance delivered from EPI Phase 3 was then reinvested in developing EPI Phase 4.

EPI Phase 4

In EPI—Phase 4 the university commissioned a more detailed energy audit of one of the pilot buildings including a full building energy model (completed in IES Virtual Environment software). Overall, the energy audit consultant was able to identify over 6,200,000 ekWh of

FIGURE 9. Comparison between predicted energy savings between preliminary subsystem benchmarking and consultant detailed energy audit.



annual energy savings with an associated annual cost savings of more than $250,000. This represented over 82% of the predicted energy savings from the initial report—not including the savings from adjustments to operating hours. Based on this validation of the findings, the University elected to undertake subsystem performance audits of an additional 28 buildings.

From these audits the University of Calgary identified seven buildings as the best candidates for an EPI Phase 4 retrofit program. Within these seven buildings was the potential for 70% of the total savings identified in the performance audits. The benchmarking analysis indicated that while available cost savings were large, retrofit opportunities would likely require significant changes and capital investment in the buildings. The next step was to undertake detailed design to properly scope and price the retrofit measures. The first of the seven projects will be implemented over summer of 2013 and the remaining six are anticipated to follow in 2014.

Recommissioning

The remaining buildings were identified as prime candidates for recommissioning and minor efficiency measures. Estimated saving from recommissioning of the 21 buildings is just under $1 million. A protocol for an ongoing building recommissioning program has been developed and the first pilot project is underway in the Information Communications and Technology (ICT) building. In addition to bringing buildings into an enhanced state of operational performance, the recommissioning program has been developed as a training and engagement program for the building operations staff and controls technicians. The ICT building is also registered as a LEED for Existing Buildings: Operations & Maintenance (EB:O&M) project. Using the pilot model, the University is developing a portfolio approach to aligning with LEED EB:OM and assessing the viability of a volume approach to LEED EB:O&M certification. Managed internally, the LEED EB:O&M program includes extensive staff engagement, training, and a revamp of the documented standard operating procedures.

ENERGY MANAGEMENT SYSTEM

When it comes to effective management of energy consumption and GHG emissions, tools for measuring and verifying energy use in buildings can be a bridge to more significant impact or a roadblock if not in place. Universities and colleges as large building portfolio holders are prime candidates for advanced energy management systems, yet most do not yet have the necessary supporting infrastructure in place. Additionally, many institutions including the University of Calgary operate under central utilities budgets in which individual faculties and departments do not carry utility costs or other operating costs in their unit budgets. The result is inattention to factors that drive energy consumption and operating costs. Unit-level utility bills and performance data derived from energy management systems are important information feedback loops to help drive departmental and individual behavioral changes.

When the University of Calgary embarked on the creation of its Climate Action Plan, energy management tools on campus were not complete. While building level energy and water metering infrastructure was largely in place it was not complete across campus or consistent between buildings. Additionally, data from meters was gathered and assembled manually using excel spreadsheets limiting capacity to proactively use the data to assess buildings for problems and opportunities. Additionally, the time consuming analysis made it very difficult to share building performance with occupants, therefore missing the opportunity to drive behavioral change.

Recognizing the adage that what's measured gets managed, the University moved forward with both additional building level metering technology and an enterprise energy management system. The University has been working to complete its network of building level meters. With over a hundred buildings and a number of utilities (electricity, natural gas, district heating, and district cooling), this is not a small task. The university's Design Standards now require separate metering for spaces occupied by external tenants. However, the ongoing churn of faculties and departments expanding, contracting and moving, within existing buildings makes the task of sub-metering at faculty or departmental levels especially challenging.

The new PowerLogic ION EEM enterprise energy management software recently installed on campus has already dramatically increased the accessibility and dependability of building performance information. Leveraging the PowerLogic ION EEM system, the university has:

- Developed individual building EUI tracking to confirm new building performance;
- Created a validation methodology to determine the actual impacts of energy retrofits and recommissioning activities;
- Enabled the addition of greenhouse gas emissions targets into the design standards; and
- Supported the business case for long-term investment in energy performance through the quantification of the utility cost avoidance associated with previous EPI activities.

The university is supporting energy management efforts with the addition of a dedicated energy manager. On the close horizon, the university will build on-the-backbone energy management infrastructure using input from the recommissioning activities to create intelligent energy tracking that will provide up-to-the-minute feedback to building operators. As this is rolled out across campus, building operators will gain the ability to identify problems earlier and take action often before major failures occur.

Perhaps most interesting is the opportunity to use energy consumption information to change occupant behaviors. The energy management system has enabled the utility manager to develop a shadow billing program, linking building energy consumption to the faculties and departments within. Through a system of distributed energy dashboards, the university

FIGURE 10. Building will focus on presenting utility information in a timely and related manner to occupants.

is creating an opportunity for building users to understand and connect to energy consumption of their buildings. These dashboards, displayed on monitors in buildings and accessible from desktop computers (see Figure 10), will present near real time energy performance information in a relatable manner and will be used to run occupant engagement campaigns and energy reduction challenges. Because the presentation of energy data can be customized to the audience, this single system can inform a broad range of viewers including students, staff, and building operators.

USER DEMAND REDUCTION PROGRAMS

As technology evolves, buildings today are facing a shift in how energy is consumed within their walls. While technological advancement is driving down energy use in base building systems (lighting, heating, cooling, etc.), it is simultaneously catalyzing a dramatic increase in energy consumed by other equipment. Changing energy use patterns in buildings are forcing owners and operators to shift efforts to examine new systems including IT infrastructure, process equipment, and plug loads. As an example of the nature of the current changes; in 2006 the US EPA estimated that IT energy consumption made up 1.5% of US electricity consumption but was potentially poised to double that percentage by 2012.

While IT energy use is growing rapidly, the University of Calgary has made the first steps towards understanding and managing this growth. Under two key initiatives, the university has taken a closer look at energy consumption in computer labs and data centers. A pilot of power down software in a computer lab has estimated that more than 4,000,000 kWh annually could be saved through power management strategies. Each of the 6000 staff and lab computers across campus could save $30 per year with the power down strategies in place. While research labs present additional challenges with some machines operating 24 hours a day, the University is developing a strategy to implement power down software across campus starting with basic student labs, then non-lab administrative desktop computers and expanding to encompass specialized labs as the needs of users are mapped out.

Centralized IT energy use also represents a major source of energy consumption on campus. The majority of the data centers on campus were built before the establishment of data centre efficiency metrics and additionally lack robust systems for measuring and verifying energy use in these spaces. Without this metering infrastructure, it is more challenging to build a business case for energy efficiency projects. Based on a review of the current facilities, the university has developed a methodology for evaluating data centre efficiency (defining Power Usage Effectiveness (PUE) metrics for campus) and is drafting design standards for metering infrastructure in new IT facilities. Existing data centres offer their own low hanging fruit opportunities for energy efficiency. Strategies identified in the Climate Action Plan include energy management software for servers, data centre consolidation, and the use of free cooling. The later complemented by taking advantage of higher upper limit temperature ranges as identified in the ASHRAE TC 9.9 2011 Thermal Guidelines for Data Processing Environments.

The future may hold even more interesting opportunities with the growth of off-site data centers and cloud computing. It is important to note that the emissions impact of moving IT function off campus are not related to the shift itself, but rather to the potential efficiency improvements available in large scale, dedicated facilities. Including the emissions related to offsite IT systems within the Scope 3 GHG inventories will ensure that future decisions will fairly compare options.

Another significant opportunity for demand reduction comes from occupant engagement programs. Occupant plug load demands and occupancy decisions are estimated to be anywhere from 35% to 50% of electrical demand in commercial buildings. Recognizing the importance of occupant engagement in reducing energy use and addressing other institutional sustainability goals, the University of Calgary has developed an ongoing occupant engagement program. SustainabilityON—the *University of Calgary Stepping Up Together* is a call to action to leverage the collective impact of many small actions. The program is premised on the principles of Community Based Social Marketing and utilizes a train the trainer model to reach broadly into the campus community of more than 35,000 full time equivalent students, faculty and staff.

The program provides resources, tools and training to a team of SustainabilityON Coordinators. The Coordinators, who are dispersed in departments and residences across campus, in turn undertake peer-to-peer engagement within their areas of campus. Among the myriad of sustainability-related initiatives run by this group, an annual PowerOFF Challenge brings building energy use to center stage for occupants. Over the course of three weeks, buildings across campus compete against each other to see who can achieve the greatest percentage reduction in electricity consumption. In addition to spreading energy saving ideas to occupants, the 2012 PowerOFF Challenge (fourth annual challenge) produced energy savings reductions as high as 14% in the winning the building and an average 2.5% campus wide reduction; equivalent to more than 227,000 kWh in just three weeks. In 2011 occupants of the winning building had reduced energy use by 23%. Each year the competition becomes more challenging as energy savings behaviors slowly become the norm making building baselines increasingly difficult to beat.

FIGURE 11. As part of engagement effort during a PowerOFF challenge, occupants are encouraged to turn off their computers overnight and reminded of the impacts.

In addition to the annual PowerOFF Challenge, Coordinators are provided with a suite of communication tools. These include e-tools and printable materials to raise awareness as well as stickers that provide reminders at points of decision making such as shutting the sash on fume hoods or turning out lights. Last, the program includes recognition and rewards to share the success stories from individual and team actions. University and college campuses have the unique opportunity to reflect the collective impact of large numbers of small actions. While turning off a computer may not seem like it will make a difference, seeing the impact of a community taking action is highly motivating.

CONCLUSION

With GHG reductions equivalent to 35% of the main campus baseline emissions and more than 110,000 tonnes of annual emissions reduction, the University of Calgary has attained noteworthy progress in the reduction of greenhouse gas emissions. To realize the emissions reduction goals set out in the institutional Climate Action Plan will require a continual pursuit of alternative lower-carbon energy supply strategies—including renewable energy, a disciplined focus on minimizing emissions growth from new buildings, consistent progress in existing building energy retrofits, and ongoing engagement to drive necessary behavior change. The research community forecasts a one to two decade time horizon for large-scale low carbon energy supply to reach the market place. The critical factor to successfully transition to a low carbon community is to first reduce demand. This requires significant energy conservation for existing buildings and a disciplined approach to delivering net zero new buildings.

The University of Calgary is one of several Canadian institutions striving for leadership in managing operational greenhouse gas emissions. The collective potential across the country and across North America is powerful. University and college campuses offer a unique scale to explore district scale energy systems, waste to energy models, load sharing between buildings, development and deployment of energy efficiency technologies, workforce training, public private partnerships, regulatory and policy development, financing innovation, community engagement strategies, and more. The campus context enable a systems thinking approach to developing and deploying change—no other built community offers a whole system environment to test and bring solutions to market. The models developed on these campuses provide tangible application as contextually relevant district-scale models for emissions management. These district-scale models can inform the development of new communities and the transition of existing communities.

FIGURE 12. University of Calgary Solar Car team and the award winning Schulich Axiom.

So while the federal and provincial governments continue to debate the merits of absolute reduction targets for greenhouse gas emissions, the university and college sector continues a steady voluntary course on solutions-based leadership. More important than building models for the community at large, they are preparing the next generation of community, professional and political leaders who will turn the corner on the management of greenhouse gas emissions and adaptation to climate change.

NOTES

1. American College & University Presidents' Climate Commitment. (2012). *Celebrating Five Years of Climate Leadership.* Retrieved from http://www.presidentsclimatecommitment.org/reporting/annual-report/five-year-report
2. ftp://ftp.cmdl.noaa.gov/ccg/co2/trends/co2_mm_mlo.txt
3. *American College & University Presidents' Climate Commitment.* (n.d.) Retrieved from http://www.presidentsclimatecommitment.org/about/commitment
4. American College & University Presidents' Climate Commitment. (2012). *Celebrating Five Years of Climate Leadership.* Retrieved from http://www.presidentsclimatecommitment.org/reporting/annual-report/five-year-report
5. *Going Geothermal.* (n.d.) Retrieved from http://cms.bsu.edu/about/geothermal
6. *Climate Action Plan.* (n.d.) Retrieved from http://sustain.ubc.ca/campus-initiatives/climate-energy/climate-action-plan
7. Dalhousie University Office of Sustainability. (2012). *Greenhouse Gas (GHG) Inventory Report 2011–2012.* Retrieved from http://www.dal.ca/dept/sustainability/resources/Reports_and_Policies.html
8. *UNBC Celebrates Bioenergy Success.* (n.d.) Retrieved from http://www.nexterra.ca/files/university-northern-bc.php
9. University of Calgary. (2009). *Greenhouse Gas Inventory Report: Fiscal Year 2008–2009.* Retrieved from http://www.ucalgary.ca/sustainability/files/sustainability/GHGinventory.pdf
10. University of Calgary. (2010). *2010 Climate Action Plan.* Retrieved from http://www.ucalgary.ca/sustainability/files/sustainability/CAPfull.pdf
11. Environment Canada. (2012). *National Inventory Report 1990–2010: Greenhouse Gas Sources and Sinks in Canada.* Retrieved from http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/6598.php
12. The EEEL project was undergoing the final review by the Canada Green Building Council at the time of publication of this article.