Green Building Policies at Three University Campuses: Lessons for UBC

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APSC 598G

April 19, 2015

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Abstract

The University of British Columbia UBC is preparing a new Green Building Plan to define strategies so future buildings will fulfill its commitment to sustainable development. Knowing what other sustainable leaders are doing to make their campuses sustainable is very beneficial to help UBC to achieve as best of a Green Building Plan as possible. To compare green building policies, this report summarizes developments strategies used in universities of Calgary, Harvard and Plymouth, analyze the strength and weakness of some of the strategies and discuss pros and cons of strategies for UBC use. We included recommended policies and practices worthy of further investigation by UBC.

Acknowledgements

The project team would like to acknowledge and thank the following for their insights and collaboration:

- Penny Martyn - Manager, Green Buildings, UBC Campus + Community Planning Sustainability and Engineering
- Dr. Steve Rogak - Professor, UBC Mechanical Engineering
- Charlene Ponto - Coordinator, Sustainability Engagement and Reporting, Sustainability and Engineering, UBC Campus + Community Planning
- Joanne Perdu e- Director of Sustainability, University of Calgary Office of Campus Sustainability
- Jessica Woolliams - Sustainability and Outreach Lead, BC Provincial Government; past Green Campus Manager, Harvard University

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Introduction

The University of British Columbia (UBC) is a leading university in sustainability in North America, and has committed to the "integration of [its] operational and academic efforts in sustainability" (UBC, 2015a). With ambitious and aggressive greenhouse gas emission reduction targets to reduce emissions on campus by 33 percent by 2015, 67 percent by 2020 and by 100 percent by 2050 compared to a 2007 baseline (UBC, 2015b), UBC is addressing sustainability in all aspects of the institution, including its land, assets and operations (UBC, 2015b).

Recognizing building operations as the largest contributor to UBC's environmental footprint (UBC, 2015c), UBC is preparing a Green Building Plan to define strategies so future buildings will fulfill its commitment to sustainable development. The purpose of the Green Building Plan is to provide a clear standard and strategy for buildings on UBC campus to move towards regenerative designs that will have a positive environmental and social impact; a plan focusing on green buildings that will support and be integrated into UBC's aggressive Climate Action Plan and 20 year Sustainability Plan.

Background

Established in 2010, UBC's Climate Action Plan (CAP) defines targets and actions necessary to address our climate issue as a university. The CAP's vision is to 1) become a net positive energy producer by 2050; 2) become a partner for change by establishing partnerships with the community and industries to learn and share solutions with others; 3) using the campus as a living laboratory; and 4) account for the full costs of UBC's decisions (UBC 2010).

In realizing its CAP vision, UBC has committed to the following GHG emission reduction targets (UBC 2010):

- 33% below 2007 levels by 2015
- 66% below 2007 levels by 2020
- 100% below 2007 levels by 2050

To achieve its aggressive GHG emission reduction targets, the CAP has identified six action areas:

1) Campus Development and Infrastructure
2) Energy Supply and Management
3) Fleets and Fuel Use
4) Travel and Procurement
5) Food
6) Transportation

Campus development and infrastructure, which includes buildings, has been identified as having high degree of influence to affect change in other key action areas (UBC, 2010). Influencing change in building development is crucial to UBC's efforts to combat climate change because buildings operations are a major component to UBC's environmental footprint. In 2008, UBC Vancouver Campus totals 1,550,142 m^2 of floor space, which is anticipated to increase by 450,000m^2 by 2020 (UBC, 2010). Based on a 50 year life cycle, it is estimated that the embodied emissions of buildings on campus is 10,200 T CO_2 e/year and operating emissions of 60,390 T CO_2e/year (UBC, 2010).

For that reason, under the Campus Development and Infrastructure action area, the CAP has compiled key actions associated with this area of focus (UBC, 2010). Some of the actions directly related to new construction and major retrofits include:

- "Adopt the 2011 Model National Energy Code for Buildings (MNECB)"
- "Commit all UBC ReNew buildings to achieve energy performance targets"
- "Adopt higher energy efficiency standards for Residential Environmental Assessment Program"
- "Develop a LEED Guide to identity optional LEED points that are priority for UBC"
- "Develop design guidelines around site orientation to include passive solar heating and light access, tree shading, and co-locating buildings to support shared infrastructure"
- "Ensure that UBC's Technical Guidelines explicitly require the highest standards of energy efficiency"
- "Develop 'Energy Density Targets' for new student housing and core academic development"

Furthermore, the CAP set out an implementation strategy to dedicate an estimated $3.25 million to continuous commissioning of core academic buildings, and $40 million to convert the existing district energy system from steam to hot water to meet its 2015 target (UBC, 2010).

Currently, two green building rating systems are used to guide new building development at UBC:

1) LEED @ UBC
2) Residential Environmental Assessment Program (REAP)

LEED@UBC aims to facilitate and accelerate the development of high-performing green buildings on campus (UBC, 2015c). As part of this initiative, all new construction and major renovations on UBC campus must achieve LEED Canada-NC Gold certification. To support this initiative, UBC has developed a LEED Implementation Guide to facilitate the building design process and to ensure design teams implement LEED standards.

Furthermore, additional mandatory green building requirements have been added to UBC's Technical Guidelines (UBC, 2015c).

While LEED@UBC applies to all new construction and major renovations on campus, the REAP standard is used for UBCs residential development. UBC has made it mandatory for all new residential buildings on campus to achieve a minimum of REAP Gold Certification (UBC, 2015c).

To encourage and support green building developments on campus, it is required that all academic projects must follow the UBC Sustainability Process (UBC, 2015c). The UBC Sustainability Process – Major Capital Projects provides a green building development process outline with five phases and specific steps in each (UBC, 2015c):

- Pre-design:
    - Step 1: Design Brief Development
- Schematic design:
    - Step 2: Design Brief Handoff
    - Step 3: Preliminary Energy and Water Workshop
    - Step 3B: General Sustainability Workshop (technical)
- Design development:
    - Step 3C: Interactive Energy Workshop
- Construction documents:
    - Step 4: Sustainability Reporting
- Construction/occupancy:
    - Step 5: Report Performance

UBC Sustainability Process ensures that stakeholders are engaged and that sustainable goals are thoroughly explored in an integrated design process (IDP) (UBC, 2015c).

Project Goals and Objectives

This report aims to investigate and compare green building policies from other universities to inform the development of future green building policy and tools for UBC. The goals and objectives of this study are to:

1) Identify and summarize development strategies for new green buildings used by other leading campuses
2) Analyze reasons why some strategies are more or less successful than others
3) Discuss the pros and cons of campuses' strategies for potential use by UBC
4) Suggest new ideas and provide recommendations that could improve UBC's policies and practices to develop new green buildings and major retrofits of existing buildings

Methodology

This study is based on a literature review of university sustainability policies and tools, particularly focused on those that guide new building and major retrofits. High performance as measured by campus sustainability rating systems and other criteria were used to select three universities for detailed review as in-depth case studies, based on their self-reported, publicly-accessible information.

While the initial intent was to follow up with review of more detailed information on the performance of new buildings and major retrofits, and to interview responsible parties on each campus on implementation of their building sustainability policies to assess why some strategies and tools are more successful than others (Objective 2), this was not possible due to confidentiality and time constraints.

Campus Case Study Selection

Three campuses were selected to inform UBCs green building policy development based on their reputation for innovative sustainability performance, and on availability of documents on their sustainability efforts with regards to new building and major retrofit development.

Harvard University was selected because it has the highest number of LEED-certified buildings of any North American university, and the broad range of its publicly-accessible sustainability policy documents. However, recent performance sustainability information and building metrics was not available for use in preparing this study, as Harvard is currently preparing its STARS report for 2014.

The University of Calgary was selected because its 2013 STARS Gold rating is the highest in Canada (AASHE, 2014). The Sustainability Tracking, Assessment & Rating System™ was created by the Association for the Advancement of Sustainability in Higher Education (AASHE) as a self-reporting framework, and is widely used by North American colleges and universities. Calgary too had a broad array of sustainability policy documents available to the public via the world wide web. Calgary is currently preparing its 2014 Sustainability and STARS reports, and plans to update its Institutional Sustainability Plan in 2015; as a result, performance information on the last two years of sustainability indicators and building metrics were unavailable.

Research into European university sustainability rating system revealed the "People & Planet University League", the largest student network in Britain with a goal of protecting the environment. People & Planet University League offers the only comprehensive, independent and publicly accessible annual ranking of UK universities for environmental and ethical performance (People & Planet University League, 2015). Plymouth University

was ranked first among UK universities with a total score of 83% in 2015. Key sustainability policy documents are publicly available on Plymouth University's website, but performance data on individual buildings was not available for this study.

A general literature review, and review of available information on each campus were guided by specific research questions. Findings are summarized in Table 1 in the Synthesis section below.

Literature Review

A review of recent literature revealed several common themes in current university green building and sustainability policies.

Systemic Integration of Sustainability Policy and Administration

The 1990 Talloires Declaration sparked widespread efforts to improve education on sustainability and environmental literacy by many universities and colleges, providing a ten step program that includes teaching, research, outreach, service and operations (Clugston & Calder, 1999; University of Calgary (2011a). Subsequent follow-up research revealed that institutions most successful in following through on their Talloires statement of principle typically took several mutually-reinforcing actions to overcome institutional barriers:

- Forming a responsible body to implement and monitor action,
- Incorporating sustainability systemically into policy, strategies and procedures,
- Developing an Environmental Management System (EMS) to define metrics, assign responsibilities and performance reporting,
- Establishing a performance baseline for EMS metrics to measure progress, and
- regularly evaluating of and reporting on sustainability progress (Clugston & Calder, 1999).

The Sustainable Endowments Institute's 2011 survey of more than 300 Canadian and U.S. universities and campuses indicated that three have created staff positions dedicated to sustainability, more than half (57%) have established a sustainability office, and almost all have a campus advisory committee with multiple stakeholders (Sustainable Endowments Institute, 2011a). Evidence for this move to dedicated sustainability staffing was reinforced by Brinkhurst et al (2011), who noted that combining top-down and bottom-up efforts is useful, but that a university's middle management plays a key role in successfully implementing sustainability poicy, particularly in operations and new developments.

The Talloires Declaration call to incorporate sustainability systemically throughout policy, programs and operations was reinforced by Finlay and Massey, (2012), who argued that higher education institutions have particular advantages when adopting an "ecocity" approach to sustainability (Register, 2006) as compared with other communities. They also note that most North American universities have now defined

strategic campus-wide goals for "energy conservation, building environmental performance, natural habitat protection and waste reduction", and regularly review progress.

Dunkel and Torres-Antonini (2009) noted that most universities and colleges developing new sustainable student residences require various levels of LEED certification.

Green Revolving Funds
The Sustainable Endowments Institute (2011b) also examined the rapid growth of "Green Revolving Funds" (GRFs) as a way to finance sustainable building development and other campus sustainability efforts. It found 52 institutions of all sizes across North America that have GRFs, mostly instituted since 2008; most largely fund energy conservation efforts and provide a very attractive median annual return on investment of 32 percent.

Harvard University

Context and Background

Established in 1636, Harvard is one of the most prestigious universities in the world with over 20,000 students and 2400 faculty members (Harvard, 2015a).

Harvard University has established a campus wide Sustainability Plan since 2008 and has held a strong reputation in its sustainable initiatives over the years. Specifically in terms of green buildings, Harvard is a world leader in green buildings, recognized by the USGBC for having the most LEED-certified projects of all academic institutions in 2011 (Harvard, 2010).

Harvard University Sustainability Plan Overview

The Harvard University Sustainability Plan was first developed in 2008, and set very ambitious greenhouse gas reduction goal and green building targets (Harvard, 2015). Over the 6 year period from 2008 to 2014, the Sustainability Plan has been reviewed and revised. The most updated version of the 5 year Sustainability Plan is for fiscal year 2015 to 2020.

In the Harvard University Sustainability Plan, there are specific actions identified to achieve campus sustainability. These actions are categorized as *Goal*, *Standard*, *Commitment* (Harvard, 2015*).*

The overarching goals of the Harvard University Sustainability Plan are (Harvard, 2015):

1) Reduce university-wide greenhouse gas emissions by 30% by 2016 including growth (from 2006 baseline)
2) Reduce waste per capita 50% by 2020 (from 2006 baseline), with the aspirational goal of becoming a zero-waste campus

3) Reduce university wide water use 30% by 2020 (from 2006 baseline), including process, irrigation, and potable water usage
4) Maintain at least 75% of the university's landscaped areas with an organic landscaping program by 2020

These actions are associated with 5 core topics around which The Harvard University Sustainability Plan is organized (Harvard, 2015):

1) Emissions and Energy
2) Campus Operations
3) Nature and Ecosystems
4) Health and Well-being
5) Culture and Learning

Green buildings are associated with 2 core topics of the Sustainability Plan: Campus Operations, and Nature and Ecosystems (Harvard, 2015).

Under Campus Operations, Harvard aims to have a restorative impact on the surrounding environment by developing and operating Harvard's campuses to conserve resources, reduce pollution and enhance personal well-being (Harvard, 2015). One initiative that greatly reduced Harvard's GHG emissions was the upgrade of its steam-based district energy system to provide both heat and power to campus buildings

Under *New Construction*, Harvard requires university-wide compliance with the Harvard University Green Building Standards (discussed below).

Under *Campus Design* in the Nature and Ecosystem category, Harvard is committed to continue to incorporate sustainability goals into facility, district and campus planning.

Harvard University Green Building Standards

The Green Building Standards is Harvard's main Green Building Strategy. The Standard is a set of comprehensive requirements that apply to all new construction and renovation projects. As crucial component of the University's commitment to sustainability, the Standards provide a framework for new and existing building projects to align with the University's five-year Sustainability Plan to reduce greenhouse gas emissions by 30% below 2006 baseline levels by 2016 (Harvard, 2014).

The Standards were created in 2007 as the Green Building Guidelines and are reviewed annually and was to be revised every 4 years (Harvard, 2014). The current 2014 Green Building Standards was built on the 2009 revision. They identify a minimum level of design and process requirements for all capital projects, as well as providing recommendations for project teams to strive for.

The Standards, with its requirements and recommendations, are organized into four tiers (Harvard, 2014):

- Tier 1: new buildings and full building renovations
- Tier 2: partial renovations or fit-outs of existing facilities in which systems within the renovated spaces are largely replaced
- Tier 3: system upgrades
- Tier 4: no or limited energy and GHG impact projects

This study will focus on Harvard's Tier 1: new buildings and full building renovations.

A project analysis in terms of pursuit of specific rating system certification must be completed before the end of the Schematic Design phase of the project. The project must be analyzed for the feasibility of pursuing Living Building Challenge certification, net zero energy, renewable energy generation, or other enhanced strategies above and beyond LEED gold certification (Harvard, 2014).

The Tier 1 requirements are as followed (Harvard, 2014):

1) *Integrated Design*
    a. Require at least three integrated design charrettes
2) *Life Cycle Costing (LCC)*
    a. LCC for 20 year impacts on GHG, energy costs, maintenance costs..etc. **Harvard Life Cycle Calculator (available Harvard Green Building Resource) can be used available for this analysis.
3) *Energy Modeling*
    a. Use of eQuest, Energy Plus or other software to model proposed building designs
4) *Prescriptive Requirements and Certification*
    a. Specific design and performance requirements for energy, commissioning, indoor potable water use, outdoor potable water use, materials, education, labs, data centers
    b. Requirements are based on a combination of LEED NCv4 requirements, ASHRAE 90.1-2010, Labs21 Environmental Performance Criteria version 3.0, and EU Code of Conduct on Data Center-2014 Best Practices v5.1.1
5) *Metering and Ongoing Verification of Performance*
    a. Meter all utilities going into the building
    b. Must meet LEED NCv4 requirements for Advanced Energy Metering or Enhanced Commissioning, Option 1, Path 2, Enhanced and Monitoring-Based Commissioning
    c. Require a metering and verification (M&V) strategy
    d. Must evaluate the feasibility of LEED-EBOM certification one year post-occupancy

6) *Close-out Documentation/O&M readiness*
    a. Keep and turn over all documents as reference for future University projects

Green Building Tools and Resources

Green Loan Fund

One of Harvard's successful tools to support their Green Building Plan is the Green Loan Fund (GLF). Since 2001, the GLF has been an active source of capital for high performance campus design, operations and maintenance projects, particularly for energy efficiency and waste reduction projects on campus. Since its creation in 2001, the GLF has financed over $16 million dollars in over 200 projects. Today, the size of the fund is $12,000,000 and is an important self-replenishing tool to encourage and support investments in projects that reduce environmental impacts and generate cost savings.

There are two types of green loans provided by the Fund:

1) Full cost loans with simple payback period of five or less years
2) Incremental loans with an internal rate of return of 9% or higher

Projects must go through an approval process, starting with a project proposal submission. Once the project is submitted, the project applicant is then required to present the project to a committee made up of multi-stakeholder. The project can then be modified according to the committee's feedback, with particular considerations to project cost savings and how the results of the project is quantified and verified. A report on the project's performance and savings six months after the completion of the project is required. The department in charge of the project starts repaying the loan at the start of the fiscal year following the completion of the project.

The GLF is available on a first-come first served basis for either new or existing building projects and can commit up to $1,000,000 for any single approved project.
There are three main criteria for the GLF:

3) Project must result in a direct reduction of costs and environmental impact for the university
4) Project must have a simple payback period of 11 year based on cost savings
5) Project requires an engineering study or other form of documentation demonstrating the basis behind the projected cost and resource savings

As of 2013, the GLF has funded approximately 200 net present value positive projects projected to save $5.4 million in annual utility and reduce 14,000 metric tons of CO_2 annually (Harvard, 2013).

Life Cycle Cost Policy and Calculator

In addition to being a requirement under the Standards for new projects to perform a life cycle cost analysis, the life cycle cost analysis is also a criteria for the GFL approval. Another tool that Harvard Sustainability provides is the Life Cycle Cost Policy and Calculator.

Based on a 20-year project lifetime, the Life Cycle Costing Policy and Calculator facilitates the decision making process, taking into account all present and future costs associated with capital projects.

Green Building Resource

To extend further support for projects complying with the Standard, Harvard's Office for Sustainability offers additional resources and services.

Some of the resources available include detailed information on integrated design process, energy modeling, building resiliency, post-construction optimization and energy benchmarking and auditing.

There is also a Harvard Green Building Tip document that provides information and tips on different technical aspects of a building (ie: mechanical, electrical and water systems, site and landscape, finishes and furniture, renewable energy, and envelope and façade).

These resources, in combination of a "Deliverables Checklist" document "that contains templates for documentation, deliverables and guidance on review requirements" (Harvard, 2014), streamline the approval process of the new project. The readily available resources encourage the compliancy and facilitate the implementation of the Green Building Standard.

Green Building Services

In additional to the green building resources available online, the Harvard Green Building Services, made up of a group of experienced green building professionals, also provide additional support for green building design, construction and operation (Harvard, 2015b). The Green Building Services offer services in: sustainability consulting, commissioning, energy auditing, LEED project management, energy conservation measure implementation, incentive application, weatherization project management, measurement and verification, green building advocacy, education and training in (Harvard, 2015b).

Pros & Cons of Strategies for UBC Use

Harvard has severa; green building strategies that UBC could adopt to streamline the transition to high-performance buildings on campus.

The most valuable lessons learned from Harvard's green building plan are 1) having a systemic approach to green building development; 2) establishing clear, comprehensive Green Building Standards; 3) providing tools and resources to ensure the proper implementation of the Green Building Standards and 4) establishing an in-house staff capability to grow institutional capacity and memory.

By integrating Green Building Standards into a larger long-term sustainability plan and following it through to building construction and operation, Harvard's systemic approach identifies a clear target and basis for having a Green Building Standard, as well as bridging the the overarching Sustainability Plan and implementation of operational improvements.

Having a clear and comprehensive Green Building Standards document establishes a minimum standard for new projects. This ensures that all new projects are clear on their expectations in design and performance.

Above all initiatives, having tools such as the LCC calculator and deliverables check list, and having resources such as Green Loan Fund and the Green Building Services, team of experienced professionals, dedicated to provide technical support through every step of the design and project approval process can prevent delays in the project and encourage the development of more high-performing buildings. In addition, having the continual support of the Green Building Services team from building design to energy conservation measures implementation can ensure the projects can achieve its design potentials and fulfills all of Harvard's Green Building Standards requirements. The Team also provides a way to capture and enhance institutional memory of new green building features for use in future projects.

On the flip side, while having a systematic approach to project approval is a valuable and crucial aspect of the green building plan, the extensive documentations, the submission and approval process of projects are administratively burdensome. Moreover, it is important to take into consideration the financial feasibility of added resources.

Plymouth University

Plymouth University started working as school of navigation in 1862; it received university status in 1992. Plymouth has a very similar climate to UBCs, with its close proximity to the coast resulting in moderate seasonal weather, and significant winter rain. Plymouth recorded 26,955 students (21,399 FTE) and around 3,000 staff during its 2013/14 calendar year.

Figure 1 – The House
Opened in 2014 – BREEAM Excellent standard

Much of Plymouth's sustainability success is likely to be due to the creation of the Center for Sustainable Futures (CSF) with funding from the Higher Education Funding Council for England (HEFCE) in 2005. The Center's aim was to transform the university to an institution modeling university-wide excellence and subsequently make major contributions to already strong areas of excellence in Plymouth's Education for Sustainable Developments (ESD) program regionally, nationally and internationally (Sustainability Report, 2014). Other notable successes of Plymouth University (Sustainability Report, 2014) include:

- Achieved ISO 14001 accreditation for Environmental Management Systems in 2009
- Established its Institute for Sustainability Solutions Research (ISSR) in 2012
- ranked seventh in 2013 (against 301 international entrants from 61 countries) for overall sustainability performance by International Green Metric World University Ranking
- Special Commendation from People & Planet Green League in 2014 for retaining 'highest performer' place since its inception in 2007
    - Ranked 1st in People & Planet University League 2015

Plymouth Sustainability Plan Overview

Plymouth's Sustainability Plan sets strategic goal of achieving the best sustainable university possible in it's own rights, and to achieve carbon-neutrality (Scope 1 & 2) by 2030. Plymouth's sustainability plan consists of three-point plan that includes

- Campus operations – managed by the departments of Finance and Sustainability and Estates
- Teaching and learning – managed by CSF

- Research – managed by ISSR

Plymouth's goals in becoming a sustainable campus include:

- Be carbon neutral by 2030 - 43% reduction in CO2e by 2020 (2005 baseline)
- Reduce water consumption to below 3.3 m3 per student by 2015 (2005 baseline)
- Recycle 70% of waste by 2015 and reduce waste to 20kg or less per student (2010 baseline)
- Require all construction and refurbishment projects rated BREEAM Excellent (on-going; since 2012)
- Sustainable procurement from socially, ethically and environmentally responsible businesses (baseline TBA)

Plymouth Green Building Standards

Plymouth has a continuous process of construction and refurbishment to improve the efficiency of its campus, reduce operating costs, carbon emissions and other environmental impacts (Sustainable Construction & Refurbishment Strategy, 2012). In 2012, Plymouth introduced their Sustainable Construction and Refurbishment Strategy outlining minimum requirements for all construction and refurbishments. The Strategy breaks the Sustainable Construction Process into:

- Strategic business need
- Feasibility of project
- Planning and design
- Construction
- Operation and maintenance

Noteworthy successes of Plymouth to date with regards to green buildings (Sustainable Construction & Refurbishment Strategy, 2012):

- 95% of building are now equipped with Building Managements System (BMS) to optimize their operations
- New buildings:
    - Roland Levinsky building achieved BREEAM Very Good – opened 2008
    - Marine Building Project achieved BREEAM Excellent and EPC (Building Energy Performance Certificate) rating of 26 – opened in 2012
    - Performing Arts Centre achieved BREEAM Excellent – opened in 2014
    - Wellbeing Centre designed to BREEAM Excellent – opened in 2015

Moreover, a combined heat and power plant (CHP) completed September of 2012 provides 50% of the campus heat. Although introduction of the CHP has increased gas consumption, it has resulted in net reduction in GHG emissions.

Minimum requirements for all construction and refurbishment projects (Sustainable Construction & Refurbishment Strategy, 2012) include:

- BREEAM Excellent certification for all new construction.
- BREEAM Excellent certification where appropriate, or significant energy performance enhancement on all refurbishment projects.
- Target for energy efficiency on new buildings to be Part L plus 10%. A-rated EPC (Energy Performance Certificate), required by EU legislation, target on new build or 10% improvement on refurbishment where possible and practical.
    - Part L is section of building regulations used in UK dealing with conservation of fuel and power.
    - EPC is used in England and Wales to assess energy efficiency of buildings.
- Maximise value to students and local economy.
- Ensure early stakeholder involvement.
- In selection of design team and contractor, sustainability experience to be a key factor.
- Define and communicate project sustainability objectives to design team and contractor from beginning.
- Ensure local biodiversity is at worst protected, and at best enhanced, by the project.
- Use sustainable and ethical procurement policies and strategies to deliver better quality building.
    - Include sustainability commitments into tendering and specification documents.
    - Encourage contractors and suppliers to identify products/construction methods which are parallel to sustainability ambitions.
- Involve contractors early during design.
- Assign a construction and design management coordinator on all projects.
- Use renewable energy technologies where possible and practical, including connections to energy centres rather than individual heating plant.
- Incorporate renewable technologies in new designs (e.g. natural ventilation, solar shading, solar hot water and heating and photovoltaics) where possible and practical.
- Incorporate water conservation technologies in new designs (e.g. rainwater harvesting, grey water, low volume water fittings and sustainable drainage systems) where possible and practical.
- Install low-loss transformers or voltage optimisers on all new buildings where possible and practical.
- Install smart meters on all new buildings.
- Select materials and equipment on the basis of whole life-cycle cost with goal of delivering buildings that last. Locally source materials and equipment where available and practical.

- Specify use of timber from FSC (Forest Stewardship Council) certified sources.
- Specify use of alternatives to materials containing PVC.
- Maximise the potential for recycling.
- Seek to use steel/concrete/brick/block and aggregates with the lowest embodied energy commercially available.
- Seek to use environmentally benign coating where practical.
- Utilise equipment with the highest energy ratings.
- Use low embodied-energy, recycled and reused materials where possible and practical.
- Use contractors with ISO 14001 accreditation where possible and practical.
- Design out waste where possible and practical.
- Target zero waste to landfill.
- Track sustainability targets and integrate them into project manager reports, discussed at monthly project board meetings.
- Provide Lessons Learned workshops after practical completion.
- Monitor building performance on an ongoing basis by using energy dashboards, energy bureau services and BMS system to constantly monitor and audit.
- Conduct post occupancy workshop after the first 12 months of operation and then again after 3 years.

These minimum requirements are intended to be modified with best practices annually.
There are other practices that are used at Plymouth but are not required. These practices include:

- Mechanical heat recovery systems used in large buildings.
- Inverter controls used in large buildings.
- Low energy LED lighting installation program teamed with presence/absence detection controls.

A number of incentives are available to encourage sustainability performance:

- Contractor's incentives to use materials from a renewable source.
- Fiscal incentives to achieve higher sustainability performance– targets for energy, water, waste minimization or recycling.

Air Conditioning & Electric Heating Policy

Plymouth has several interesting policies regarding air conditioning and electric resistance heating, which may be particular to UK circumstances and long-lived buildings. PThe University prohibited the use of portable electric supplementary heating except in an emergency, particularly focusing on personal heating appliances; if it can be shown that supplementary heating is required, they must be issued by Estates Services. Plymouth discourages comfort cooling and explictly instructs new building designs to avoid

mechanical cooling for comfort, allowing exceptions only for special circumstances such as research laboratories that need close temperature control.

Campus Information Control System (CICS)

HEFCE awarded nearly £1m funding for the CICS project, an innovative integrated building management system (BMS) and information control technology system (ICT) capable of remotely monitoring and controlling equipment. The CICS project's aim is to reduce energy and carbon emissions through better energy information and monitoring systems at a campus-wide scale. The integration of BMS and ICT allows it to accurately match the energy supply to demand, which is essential in efficient management of occupant demand for energy and maximizing economic benefits. Moreover, it provides a system ready for future "smart grid" implementation. "This initiative was responsible for providing over 60% of the university's 2015 carbon reduction targets (2,800 TCO_2e), and has set a foundation for Plymouth becoming a 'smart campus' and achieving its goal of carbon neutrality by 2030." (Sustainability Report, 2014) The CICS was completed mid-2013 with an anticipated return on investment (ROI) of less than three years.

Funding

Energy and water conservation and carbon initiatives for all new building and refurbishment projects are largely funded from project budgets. However, Plymouth has also adopted HEFCE's Salix ISP scheme for carbon reduction projects to provide additional funds for worthwhile conservation features. Salix Finance Ltd. is an independent, publicly funded company that provides 100% interest-free loans to the public sector for energy efficiency and carbon emission reduction projects. Salix ISP has strict approval parameters for energy savings and carbon reductions from the energy and water conservation schemes it funds.

Plymouth has successfully won three HEFCE Revolving Green Fund contributions; its total awards amount to nearly £2 million. Its third bid secured £565,000 in 2013 to improve the supply of heating and hot water in the Library and Students Union Buildings (Sustainability Report, 2014).

Pros & Cons of Strategies for UBC Use

Plymouth and UBC are both located in similar weather conditions. Discouraging mechanical cooling at UBC could result in reduction in energy use; but could lead to uncomfortable spaces in hot summer days on campus if not carefully implemented. Adoption of the Campus Information and Control System by Plymouth was responsible for over 60% of university's carbon reduction in 2015, and it is expected to be a major contributor in achieving their goal of carbon neutrality by 2030. Currently, over 100 UBC buildings have a BMS; continuous monitoring of BMS systems connected to a similar system could help UBC achieve its ambitious goals.

University of Calgary

Context and Background

The University of Calgary (U of C) has grown rapidly since its birth in 1966; it is now one of Canada's large universities with over 31,000 students, 1800 faculty and 3000 staff (slightly smaller than UBC) (U of C, 2015a). Its Main Campus includes 61 buildings ranging in age from 1950 to 2014; currently four new buildings are under development (U of C, 2015b).

U of C is a Canadian leader in sustainable campus development, as evidenced by its 2013 STARS Gold rating, the highest in Canada (AASHE, 2014). Calgary was an early signatory to the University and College President' Climate Change Statement of Action for Canada, the Talloires Declaration, and the imagine CALGARY Plan for Long Range Urban Sustainability (U of C, 2011a. p.5). Its 2011 "Eyes High Vision & Strategy" confirmed sustainability as a core value, and called for incorporating sustainability into teaching and research, and for campus administration and operations that uphold "...balanced budgets, positive social relationships and the health of the planet that we all call home" (U of C, 2011a. p.31).

Office of Sustainability

The University of Calgary established its Office of Sustainability to coordinate its sustainability efforts in teaching, research, operations and campus development. Currently with seven staff and three interns, its Director of Sustainability, Joanne Perdue, previously worked with UBCs Planning and Community Development on its initial sustainability efforts. The Office

- works with the University's senior leadership to integrate sustainability into its teaching, research, student activities and campus operations
- oversees Residence SustainabilityON Coordinators program and Sustainability Street Team volunteers
- advises campus business units on development and delivery of operational sustainability and energy efficiency practices
- coordinates sustainability performance reporting
- updates the University's Institutional Sustainability Plan and Climate Action Plan, and works with responsible parties to improve its Campus Master Plan and Design Standards.

Institutional Sustainability Plan

Calgary's Institutional Sustainability Plan performance categories were adapted from those of the AASHE STARS, which has eased U of Cs subsequent STARS reporting. The Plan instituted a systemic, holistic approach with a comprehensive set of "stretch" sustainability goals, each with key performance indicators and 2012, 2015 and 2030 performance

targets. These include achieving LEED Canada-NC 2009 Gold or better certification by 2015, and meeting specific targets for

- GHG emissions reductions
- building energy efficiency intensity
- potable water use reduction
- construction waste reduction

The Sustainability Plan identified specific parties responsible for actions, and initiated annual sustainability performance reports that provide accountability and public transparency.

Campus Master Plan & Climate Action Plan

The Sustainability Plan was coordinated with an update of its Campus Master Plan and creation of a new Climate Action Plan (U of C, 2010a, b). The Campus Master Plan calls for new developments and major retrofits that address

- Building Design Guidelines for building siting and form for passive cooling, ventilation and solar heating
- habitat landscaping with native / adapted plants, conserving potable water and managing stormwater
- a Design Review Committee responsible for ensuring quality design that addresses sustainability particularly in energy, greenhouse gas emissions, water and materials

U of Cs Climate Action Plan set ambitious GHG reduction Goals of

- 45% by 2015
- 60% by 2020 and
- 80% by 2050

as compared to its 2008/2009 baseline footprint of 328,574 tonne CO2e /yr (U of C 2010b, T.7, p. vii). The 2012/2013 Sustainability report indicates that this "stretch" Goal has been challenging to meet, with the growth of the student body and campus floor space.

U of Cs Climate Action Plan established a key resource for building energy conservation: retrofits through an Energy Performance Initiative, financed by a revolving Energy Efficiency Fund (EEF) in which energy cost savings are reinvested into energy efficiency projects. The Fund prioritizes "...funding to actions directly related to energy supply and building energy demand". The Energy Performance Initiative is implemented by contractors overseen by U of Cs Office of Sustainability. The Plan calls for purchase of Renewable Energy Certificates to meet energy targets "...only after all other efforts to use clean energy and reduce energy use have been exhausted."(U of C 2010b, p.iii)

Calgary's 2012-2013 Sustainability Report (the latest publicly available) reported 22% GHG savings for all campuses from the 2008-2009 baseline; it is currently compiling its report on 2014 performance, so it is not yet clear that it will meet its 2015 GHG

performance target (U of C, 2013). The reported 45,000 MT CO2e/yr net reduction on 2012/2013 largely resulted from a new natural gas combined heat and power co-generation plant commissioned in 2012 to provide central campus heating & electricity (Perdue and Stoker, 2013), and from Energy Performance Initiative energy savings.

New Buildings

The Climate Action Plan identifies GHG emission reductions for new buildings and major retrofits of 9500 tonne CO_2e/yr by 2015, 18,700 tonnes in 2020, and 92,250 tonnes in 2050 (U of C 2010b, T.4, p. iv).

New building energy savings are aimed at mitigating GHG emission growth associated with new added building space. The Plan also calls for aligning energy Performance Standards and targets for new construction projects with the Energy Utilization Index (EUI) targets of the Architecture 2030 Challenge.

The University established and continually updates its Design Standards for new buildings and major retrofits. The Standards include detailed performance requirements and criteria for the design process, envelope, mechanical, electrical, interiors and commissioning (among others).

They currently call for at least certification of LEED Canada-NC 2009 Silver for new construction and major retrofits; and LEED Canada-CI (Commercial Interiors) Certification of interior retrofits larger than 4000m^2. (The University's new buildings have consistently bettered the minimum LEED certification requirements.)

Each project is guided by a Project Sustainability Brief that lists project-specific sustainability requirements that identify required LEED credits and minimum performance requirements (U of C 2014). Mandatory Design Standards requirements that extend beyond LEED requirements include

- optimizing life-cycle costs
- energy cost reduction targets of at least 38% compared to ASHRAE Standard 90.1-2010 for new buildings, and 36% for major retrofits
- use of energy modelling early in the design process to inform decisions and demonstrate energy performance target compliance
- design for long-term flexibility and adaptability
- review of schematic & near-final design documents by the Design Review Committee and Office of Sustainability
- limiting mechanical air conditioning to high-occupancy assembly & animal containment rooms,
- minimizing heating, cooling and lighting loads with climate-responsive massing, orientation and envelope design

- HVAC and lighting systems that operate efficiently and both full and part-load conditions
- use of energy simulation to inform design decisions early in schematic design
- energy & water meters that communicate with building and campus-scale Energy Management Systems
- "striving for" LEED daylighting & views credits
- indoor air quality management plan, testing and flushout
- performance measurement and verification and commissioning plans
- use of low-emitting materials
- achieving the LEED Durable Building credit (with a 100 year structure service life),
- diverting at least 75% of construction waste from landfills, and
- pursuit of the LEED Innovation credit for educational outreach and staff training.

Campus-wide Building Monitoring System and Dedicated Energy Management Staff

Calgary recently installed a new "PowerLogic ION EEM" enterprise energy management software to provide centralized accessibility to building performance information (Perdue and Stoker, 2013). The system provides "intelligent energy tracking" in real time to help Operations and Sustainability staff to

- Track individual building Energy Use Intensities (EUIs) to confirm new building performance
- Identify problems and take corrective action on a timely basis
- Provides measured energy consumption data for a validation methodology that helps assess actual performance of energy retrofits and recommissioning efforts;
- Enabled tracking of greenhouse gas emissions performance versus design targets and standards; and
- Supported creation of business cases for long-term investment in energy performance by quantifying utility cost savings by new and existing buildings

The University has also created a dedicated Energy Manager staff position to provide input to new building designs based on growing experience with operation and performance of green features of existing buildings. This ensures that the university creates of an "institutional memory" that provides continuity and builds a body of knowledge to improve future energy conservation and GHG mitigation efforts (Perdue and Stoker, 2013).

Pros & Cons of Strategies for UBC Use

A number of Calgary's policies suggest ways that UBC could improve its green building development process and performance.

Strengthening passive heating, cooling and daylighting elements in the next UBC Campus Plan update would help ensure new developments have the potential to maximize free low-energy design opportunities at little cost.

Adopting the Architecture 2030 energy performance criteria as minimum or aspirational requirements for new facilities and major retrofits would challenge design teams. For some projects it might be impractical, depending on the functions served by the facility; but such a stretch goal offers the potential to inform performance improvements by others.

Integrated design processes informed by early energy modeling were pioneered by UBC, but it would likely be valuable to explicitly require design reviews and anticipated performance at the end of schematic design, design development and near the completion of construction documents by campus Sustainability and Operations staff.

The University of Calgary is currently updating its Carbon Action and Sustainability Plans. A 2013 paper by Perdue and Stoker underscores the dual focus on both new and existing buildings, and suggests that net zero carbon targets for future buildings may be in the wings:

> "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."

Synthesis

Table 1 – Research Questions and Findings Summary

Research Question	Harvard	University of Calgary	Plymouth University	UBC
Holistic Approach to Sustainable Development				
Overall Sustainability Plan?	Yes	Yes	Yes	Yes
Dedicated Green Building Plan?	Yes- Green Building Standards integrated in Sustainability Plan	Yes- Green building requirements integrated in Campus Master Plan, Climate Action Plan + building Design Standards	No – but Plymouth has a Sustainable Construction & Refurbishment Strategy	Yes - Green building requirements integrated in Climate Action Plan, LEED Guide + building Technical Guidelines

Green Building Plan and Standards				
Does the University refer to a green building rating system? Which?	Yes (LEED-NC & Living Building Challenge as alternative)	Yes (LEED Canada–NC 2009, LEED Canada-CI, LEED Canada-EB:O&M)	Yes (BREEAM)	Yes (LEED & REAP)
Is there a minimum required green building rating?	LEED-NC Gold or pursue Living Building Challenge (LBC certification not required, but must prove that it was evaluated)	LEED Silver; 2015 & beyond: LEED Gold	BREEAM Excellent	LEED-NC Gold Certification; REAP Gold Certification for all new residential buildings
Are there any specific required green building rating system credits?	Gold in each LEED credit category	Commissioning; Innovation	New Build: Target energy efficiency of part L plus 10% or A-rated EPC Refurbishment: Target energy efficiency of 10% improvement (neither is BREEAM)	27 Mandatory credits across all credit categories
Does the Green Building Plan have specific new building performance requirements (e.g. energy, GHGs, water, IEQ, etc.?	Yes- for energy, commissioning, indoor and outdoor potable water use, materials, education, labs, and data centers	Yes- LEED-NC +	Yes- Energy	Yes – at least - 2 Water Use Reduction (WEc3) points - 11 Optimize Energy Performance (EAc1) points and others

Are there any requirements for green building design process (e.g. integrated design process)?	Yes (3+ IDP charrettes)	Yes (IDP, schematic & construction document reviews)	Yes (IDP, Sustainable Design Brief)	Yes (Design Brief, IDP with 3 workshops, Sustainability Report, Performance Report)
Are there contractual rewards for designers & builders for sustainability performance metrics?	No	No	1) Fiscal incentives to achieve higher sustainability performance – targets for energy, water, waste minimisation or recycling. 2) Contractor's incentive to use renewable material	No
Are there any additional performance requirements over and above those of the green building rating system?	Living Building Challenge	Energy savings > LEED; Durable building; IAQ testing and flushout; 75% construction waste diversion	Daylighting & lighting occupancy controls; Target zero waste to landfill	Technical Guidelines Design brief requirements for major projects (including EUI target, water reduction targets etc)

Specific innovative Green Building features				
Are there any requirements for green building design features / strategies?	No specific design features required	Yes – passive cooling designs; no mechanical cooling for comfort	Yes – passive cooling designs; smart meters; voltage optimisers; solar shading; solar hot water and heating; photovoltaics; operable windows; no mechanical cooling for comfort; 10% of electricity demand from building renewables	Yes - mechanical cooling for comfort discouraged
Green Building Implementation and Operations Support				
How does the university support the implementation of green building design and construction standards and process?	Green Building revolving fund; life cycle cost calculator, GB Resource & GB Services team	Lowest life-cycle cost of ownership criterion	Lowest life-cycle cost of ownership criterion; HEFCE Revolving Green Fund	Green Lab Research Fund
Is there any green building measurement and verification regime to track performance over time?	Require building utility meters	Requires building utility meters; building automation systems tied to campus information & control system	Inverter controls, energy dashboards, building management system and campus information & control system	Yes, LEED M&V credit mandatory

How well have new green buildings created under the performance requirements been performing?	From 2002-2013, the Green Revolving Fund has funded over 200 projects that is projected to reduce 14,00 metric tonnes of CO_2 annually	Information not available	Information not available	Information not available

Lessons Learned

Upon comparing the Green Building Plan for Harvard, University of Calgary and Plymouth, several common themes emerged.

Approach to Green Building Plan development

- Have holistic, systemic approach to sustainability: research, teaching, operations and development; energy, GHGs, water, indoor environmental quality, materials
- Sustainability or climate plans define goals, key performance indicators, regular public reporting
- The number of new buildings and major retrofits are small relative to the number of existing buildings, but as they define future performance and reduce energy growth as the campus attendance and floor space expand, they are important to slow energy and GHG emissions growth

Green Building Guidelines/ Standards/ Criteria

- All three campuses are also focused on LEED or BREEAM-certified high green performance retrofits of existing buildings
- All require ambitious certification targets for their new buildings (LEED-NC Gold or BREEAM Excellent), which include minimum requirements for energy performance

Support for Implementation and Operations of Green Buildings

- Harvard and Calgary both have revolving funds dedicated to energy efficiency retrofits & initiatives; Plymouth draws on the United Kingdom's national HEFCE and Salix Finance Ltd. revolving funds
    - cost savings are re-invested in further improvements
- Calgary & Harvard emphasize minimizing life-cycle costs, not just capital costs
    - Harvard created an LCC tool for use in new projects & major retrofits
- Harvard's Office for Sustainability has now consulted on green, energy-efficient design for all of its new construction and major retrofits, establishing in-house

expertise (Green Building Services), building a university-specific body of knowledge and experience and a valuable knowledge resource for designers of new buildings
- Calgary's detailed Design Standards are regularly updated to specify detailed performance requirements and criteria for the design process, envelope, mechanical, electrical, interiors and commissioning (among others) - an approach worth emulating

Specific Innovative Features for Green Buildings

- All three universities have upgraded their district energy systems to combined heat & power that contributed greatly to CO2e reductions
- Calgary and Plymouth ban mechanical cooling solely for comfort (with few exceptions)
- Plymouth has banned personal electric-resistance heating appliances
- All three require BMS for large buildings to reduce energy usage; Calgary and Plymouth have BMS energy records reported to a campus-wide energy monitoring system.

Recommendations

Specific recommendations for UBCs future Green Building Plan can be considered in terms of building procurement process, features, and strengthening its capacity to learn from building operations and apply knowledge gained to new developments.

New Building Procurement Process

Both Harvard's and Calgary's successes are in part founded on performance targets for individual buildings that follow through on sustainability metrics called for by their vision and strategy documents and contributory plans. Systemic performance targets are also a keynote of UBCs leadership, but with the low carbon content of BCs electricity and rising electricity prices, there is a growing disconnect between energy consumption and cost savings (as measured by LEED credits) and GHG emissions by UBC buildings. With the increasing urgency of climate change mitigation, this disconnect between fiscal and environmental targets could be addressed by explicitly defining a minimum GHG performance target for each new project, in addition to minimum LEED energy and energy cost savings targets. Defining ambitious GHG, energy consumption and cost performance targets for each new building will depend on its unique mix of uses, constraints and opportunities, but should be crafted to contribute significantly to UBCs organization-wide GHG reduction and energy savings targets.

While ambitious and explicit energy and GHG performance targets are important elements to inform design and construction efforts, the design process itself provides significant opportunities to reduce impacts and life-cycle costs. Calgary and Harvard both call for use

of an integrated design process (IDP) for each new building project; and Sustainability Process – Major Capital Projects document makes it a standard practice at UBC (UBC, 2015c). UBCs process might be enhanced by explicitly calling for:

- Calling for minimizing life-cycle costs, including energy and maintenance costs in the Design Brief, and documenting calculated estimates used to inform design decisions
- Noting that Building Operations - Technical Services staff as UBC stakeholders, and contractors with successful experience in construction of green building features early in and throughout the IDP
- Formal design reviews by UBC Sustainability Office and Operations staff before completion of schematic design, design development, and construction drawings and specifications
- Post-occupancy evaluations after the first 12 months of operation, and again after 2-3 years of occupancy
- A "lessons learned" workshop for UBC Campus Planning, Sustaianability and Building Operations - Technical Services staff and building design professionals, coordinated with the Commissioning Agents' 10 month Occupancy and Operations review after project completion, with updates following post-occupancy evaluations.

Green Building Design Features

Both Plymouth and Calgary clearly and formally ban use of mechanical cooling systems for comfort cooling, reserving it for spaces with special needs such as animal laboratories, etc. UBC has a similar clause in its Design Guideline Section 15001 2.1.2 Mechanical – General Requirements, but it would be worthwhile to strengthen this to unambiguously call for natural ventilation and cooling design, and to bar mechanical cooling solely for comfort except for special needs.

However, passive cooling design and operations, particularly with natural ventilation strategies, are as yet new to most North American designers, builders and controls professionals. If a ban on mechanical cooling is adopted, it is recommended that IDP requirements emphasize the need for extensive passive cooling design analysis to maximize benefits throughout the building, thorough commissioning and documentation of passive cooling control sequences across the expected range of outdoor temperatures and wind conditions, and operator and occupant education to ensure systems function as designed.

Calgary and Plymouth are also instituting campus-wide building operations monitoring systems to trend-log energy consumption and other real-time operating parameters collected by individual BMS systems. Instituting similar systems at UBC would allow closer management of building operations, and real-time analytics that notify operators of

excursions of operating parameters beyond normal ranges, and assist with prompt corrective action.

Strengthening Institutional Green Building Knowledge and Capacity

Harvard's permanent in-house Green Building Services team, Plymouth's new Energy Manager staff position, and Calgary has created several staff positions with a similar role. These provide a significant and growing asset by increasing the in-house body of knowledge of the performance of green features that improves their capacity to procure new buildings.

UBC has a unique opportunity to create and consolidate an institutional memory with growing experience in the operational performance of green features of new and existing buildings, and to apply this empirical knowledge to new building design, construction and commissioning. UBCs Centre for Interactive Research in Sustainability (CIRS) and growing sustainability teaching and research efforts such as the SEEDS (Social Ecological Economic Development Studies) Program engage graduate students, post-doctoral fellows and faculty provide a significant research resource. However, students are inherently transitory, and faculty are rewarded primarily for research, which presents a risk of losing valuable knowledge over time.

To maintain continuity and maintain an institutional memory of green building feature performance it would be worthwhile to establish a formal mandate and permanent staff role(s) in Campus Sustainability or Building Operations - Technical Services to collaborate with academic research efforts, and to maintain and share in-house knowledge of and experience with the operational performance of green building features over time. This knowledge would become an increasingly valuable resource for updates of UBCs Technical Guidelines and new buildings and major retrofit designs.

Conclusion

UBC has become a North American leader in creating new green buildings; the literature reviewed frequently cited it as an inspiration and source of ideas for other universities' policies and programs. The recommendations made in this paper are more enhancements than major changes, but are believed are likely to be helpful in maintaining UBCs leadership role.

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