Strategic Energy Management Plan
UBC Vancouver Campus
2020 to 2025

University of British Columbia

September 2021

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0	11/13/2020	Original Version
1	09/27/2021	2021 Update

Partnering with

BC Hydro Power smart

FORTIS BC Energy at work

Authored by: Julie West, Energy Conservation Manager

Blair Antcliffe, Energy Engineer

Approved by: Philip Brusse,

Position: Associate Director, Energy Conservation & Innovation

Signature: ______________________________

Approved by: David Woodson

Position: Managing Director, Energy and Water Services

Signature: ______________________________

Table of Contents

Table of Figures

1. Executive Summary

The University of British Columbia Department of Energy and Water Services (EWS) delivers utility services across the Vancouver campus, as well as demand side management services to reduce building GHG emissions, energy consumption and operational costs. UBC Vancouver has a proven track record for advancing operational sustainability. Since 2000, UBC's energy and water conservation efforts have avoided roughly $100 million in commodity costs.

In 2010, UBC's President announced ambitious climate targets for the University – to lower emissions by 33%, 67%, and 100% below 2007 levels by 2015, 2020, and 2050, respectively. UBC met the 33% reduction target in early 2016, through supply side energy savings from the conversion of our district energy system from steam to hot water and a Biomass Research and Demonstration Facility (BRDF), as well as demand side savings from our building re-commissioning program. To address the 67% target, EWS is currently constructing a 12 MW expansion of the biomass plant, and in the design phase of further expanding the facility's capacity through economizers. UBC is currently in the planning process for CAP (Climate Action Plan) 2030 to set intermediate targets on the path to 2050, and to identify the major initiatives to achieve these targets.

To manage load growth expected from intensification and new construction, internal demand side management (DSM) targets have been set at 20,000 GJ of gas savings and 4 GWh of electricity savings per year. The department plans to continue achieving these targets through:

1) Deep Efficiency Analysis & Retrofits
   The Energy Engineering Team analyzes energy use and equipment operation in UBC Vancouver's buildings. Through understanding the building's mechanical systems and operational goals, low-cost energy conservation measures and controls optimisations can be identified, as well as larger capital retrofit opportunities.

2) Continuous Retrocommissioning
   Over the past few years, EWS has been developing its capabilities using a Data Analytics platform called SkySpark. This data warehouse captures and categorizes BMS trending, in turn enhancing detection of energy conservation measures. Using the platform, EWS is now tracking implementation of measures identified in the most recent round of BC Hydro's Continuous Optimization (C.Op) program. In addition, in-house deep dives on building performance, echoing the techniques and findings of the traditional C.Op program.

3) Quality Assurance and Automated Fault Detection
   The Energy Conservation Group currently maintains $3.15 Million/yr in energy savings and cost avoidance for the University. Savings due to energy conservation measures typically degrade over time, decreasing by as much as 10% per year. To prevent this degradation, measurement and verification of past energy projects is completed at the end of fiscal. When savings decrease compared to baseline, an investigation is launched into why a project is no longer performing and corrective actions are taken. By continuously monitoring performance of energy projects, savings can be maintained or even enhanced over time. Because the amount of savings and projects that must be maintained continues to grow, more and more of the team's time is spent mitigating the $3.15 Million financial risk of losing these savings. UBC is currently in the beginning stages of implementing automated Fault Detection & Diagnostics (FD&D) on existing energy projects, so that automated alerts are generated when major energy savings projects need maintenance and repair.

The past fiscal year offered a unique challenge, with the emergence of COVID-19. UBC ceased offering in-person teaching, which allowed for significant energy savings by keeping buildings in their "unoccupied" modes for most of the year. These savings would not have taken place if not for the efforts of UBC's Energy Conservation & Innovation group, however they are *not* recurring savings. Further, the resumption of in-person classes for the 2021/22 academic year has led to an increase in energy use through aggressive outdoor air ventilation strategies, which may undermine traditional conservation efforts.

2. Context

2.1 Campus Profile

The University of British Columbia Vancouver campus is located on the Point Grey peninsula, to the west of the City of Vancouver, on the traditional, ancestral, unceded territory of the Musqueam people. It is bounded to the west by the Strait of Georgia and to the east by Pacific Spirit Park and Vancouver.

The campus includes over 350 institutional buildings, with 1.6 million square meters of institutional floor space. There are over 57 thousand students and 12 thousand staff and faculty, with over 60 thousand unique visitors to campus daily and approximately 10,000 students residing in student housing. In addition to institutional buildings, the Vancouver Campus has a hospital, a secondary school and five residential neighbourhoods.

2.2 Our Commitment

2.2.1 Sustainability Policy

The University of British Columbia has a long history of sustainability. In 1997, UBC was the first Canadian university to develop and implement a comprehensive sustainability policy, which is now integrated into UBC's comprehensive Land Use Policy (Policy UP12).

> ***UBC Policy UP12:***
> *UBC is committed to improving performance in sustainability in all areas of operations as part of working toward accomplishing its goal of making improvements in environmental and human well-being. UBC engages with UBC community members to increase capacity and awareness through behavioural change initiatives and provides support and resources to the UBC community to ensure these goals are achieved.*

Since that time, UBC has been the first Canadian university to open a Campus Sustainability Office (1998), and established a campus-wide sustainability strategy (2006) and climate action plan (2010).

2.2.2 Climate Action

In 2007, UBC met its target of reducing Academic building GHG emissions to 6% below 1990 levels, Canada's Kyoto Protocol target.

In 2010, UBC's Board of Governor's adopted bold greenhouse gas emission reduction targets for the Vancouver campus. UBC committed to reducing campus GHG emissions by:

- 33% below 2007 levels by 2015;
- 67% below 2007 levels by 2020; and
- 100% by 2050.

UBC achieved the 2015 target early in 2016, and is on track to achieve its 2020 target. Figure 1 shows the impressive progress that UBC has continued to make, particularly as the campus continues to grow. The Vancouver campus' GHG emissions have been reduced from roughly 61,000 tonnes of CO_2e in 2007 to about 38,000 in 2018. While this represents nearly a 38% reduction in absolute emissions reductions, it is closer to a 50% reduction when adjusted for growth in either capita for floor space.

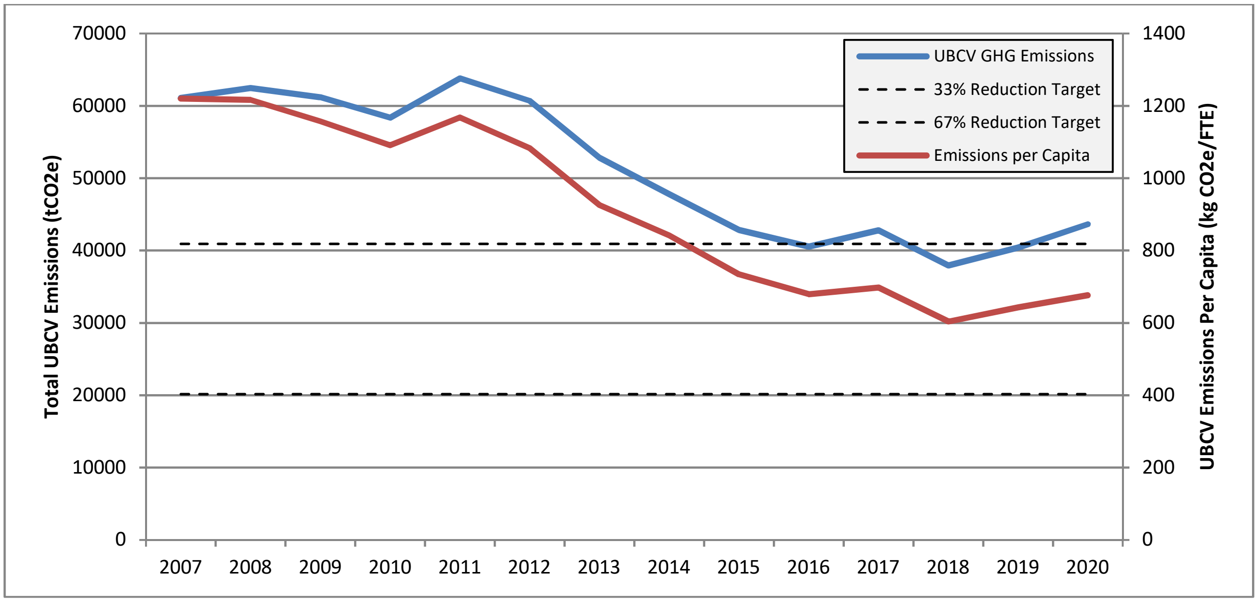

Figure 1: UBC's GHG Emissions 2007-2018

UBC is now looking to the future and investigating viable strategies for a 2030 target as a next step towards 100% reduction by 2050. Figure 2 shows UBC Vancouver's GHG emission trajectory in 2007, when the GHG targets were set, and the forecasted impact in 2010 of the first Climate Action Plan. Although good progress has been made to date, more action will be required in order to continue to reduce emissions.

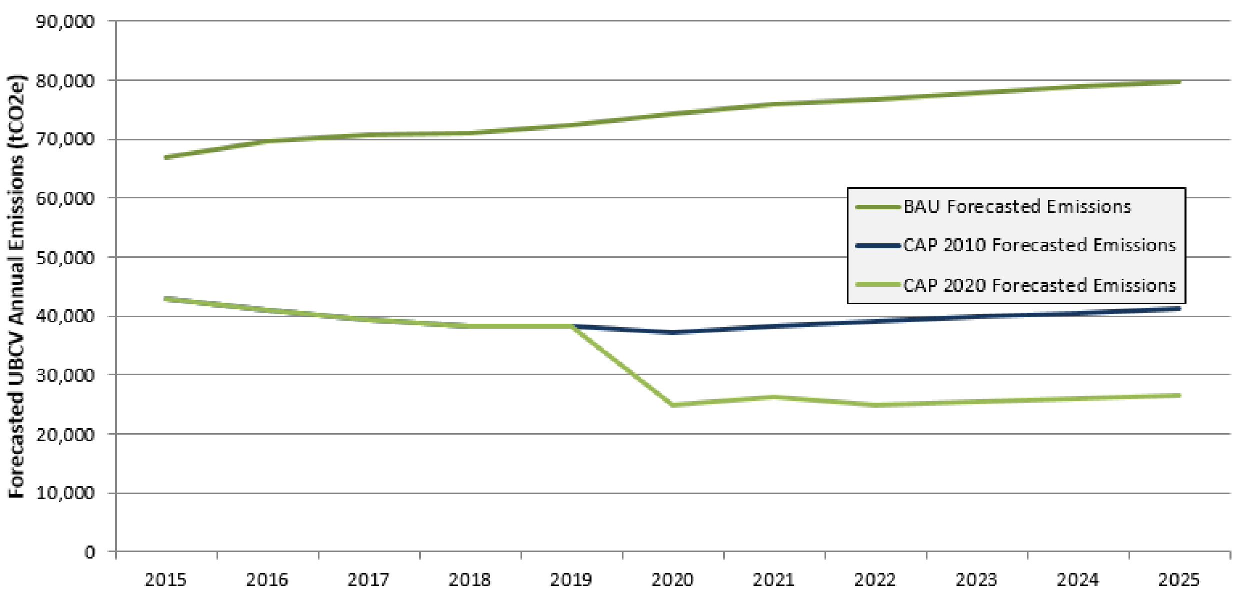

Figure 2: UBCV's 2007 BAU GHG Forecast to 2050

2.3 Organizational Profile

Broadly speaking, the University of British Columbia Vancouver campus can be broken down into various administrative units. Core administrative units include academic, operational and administrative departments. Ancillary units are self-funded operations of the university. The list of Ancillary units includes:

- Athletics and Recreation;
- Bookstore;
- Child Care Services;
- Food Services;
- Parking Services; and
- Student Housing and Hospitality Services.

Student Housing and Hospitality Services (SHHS) is particularly notable when it comes to campus energy use and campus growth. From 2015 to the start of the 2019 academic year, SHHS buildings have grown campus floor space by nearly 50,000 m^2 through three construction projects, adding almost 1400 student beds. Another two major residences are under construction, expected to add an additional 65,000 m^2 and 1500 beds. This growth in floor space is expected to be the largest contributing factor to increasing campus energy loads over the next five years.

Energy services are provided by UBC Energy and Water Services (EWS). The department serves two roles on campus. The first is through the Energy and Utilities unit, which manages UBC's energy and water generation and distribution infrastructure. The department's second role is undertaken by the Energy Conservation & Innovation (ECI) unit, tasked with providing energy services (heating, ventilation, air conditioning) to core buildings, and managing campus energy and water conservation and efficiency and GHG performance. This includes benchmarking energy and water use in buildings across campus, identifying opportunities for savings, developing and implementing energy and water projects and, monitoring savings.

EWS Vision:
Reduce UBC's consumption of energy and water, and eliminate our greenhouse gas emissions by 2050 through mindful stewardship of our campus energy and water resources.

EWS works closely with many other departments on campus. In particular, EWS collaborates with Building Operations, Infrastructure Development and Campus + Community Planning.

2.4 A History of Energy Efficiency and Conservation

UBC has gone through several phases of campus energy management since the University's sustainable development policy was introduced in 1997. Since 2000, UBC has avoided roughly $90 million in utility costs through its efforts in energy and water conservation and efficiency. Figure 3 gives annual energy costs savings from 2014 to present and Figure 4 illustrates the cumulative energy cost savings, including actual savings from energy and water budget as well as cost avoided from increasing energy prices.

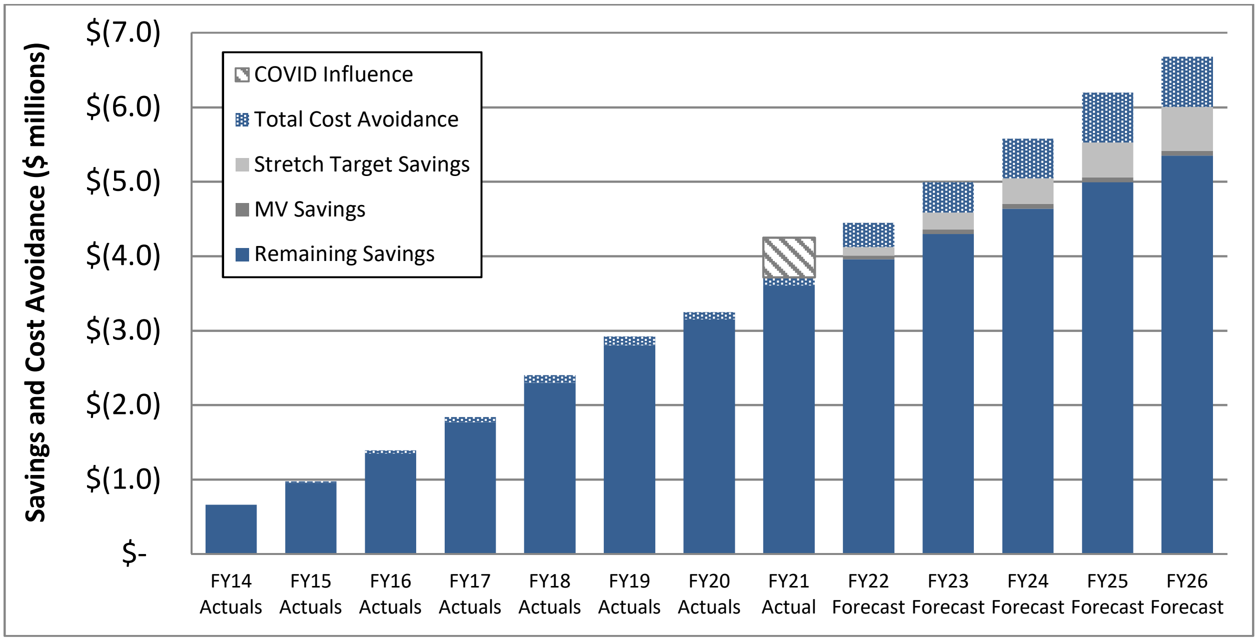

Figure 3: Annual Energy Cost Savings 2014 (inception of EWS) to Present

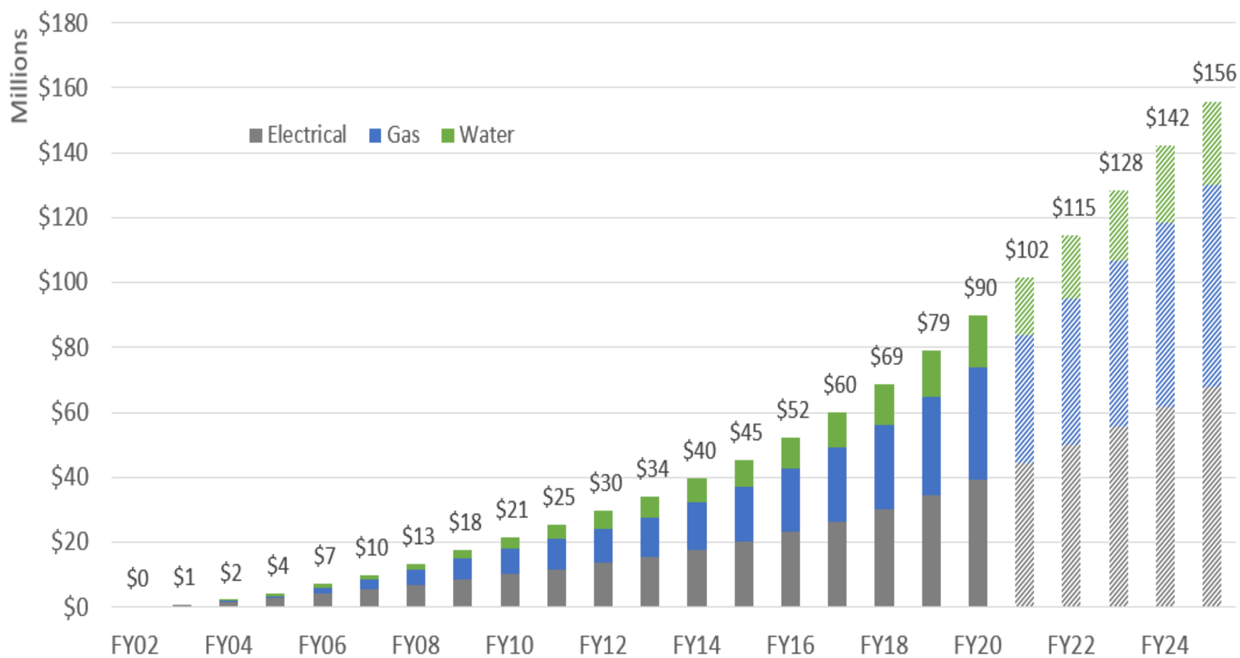

Figure 4: Cumulative Energy Cost Savings 2000-present

2.4.1 Improving the base case (1998-2008)

When UBC first committed itself to developing sustainably, the University took this as an opportunity to start managing campus energy consumption effectively. The first energy initiatives undertaken on campus were therefore designed to improve the baseline performance of buildings, trying to modernize them. Two major campus-wide programs were rolled out. The first, ELECTrek, focused on campus lighting. This program retrofitted many of the lighting systems on campus, reducing electrical consumption by 16 GWh/yr. Once this program was completed in 2003, the ECOTrek program was initiated. This was a much more comprehensive program, retrofitting and modernizing energy and water systems in all major buildings, and improving the performance of the steam district energy system. At that time, it was the largest energy and water retrofit project in Canadian history. ECOTrek reduced electricity consumption by 20 GWh/yr, natural gas consumption by 150,000 GJ/yr and water consumption by 1 million cubic meters per year. It also led to installation of energy, water, and steam meters in nearly all of UBC's buildings, which has in turn allowed for much more robust analysis of building energy use.

2.4.2 Supply and Demand Side Planning (2008-2010)

Between 2008 and 2010 UBC focused on energy planning. The Alternative Energy Sources Project evaluated the most cost effective opportunities for reducing campus energy and emissions. The Study identified building recommissioning as the most cost effective demand side management measure, and identified the conversion of the steam district energy system from steam to hot water as the most effective and efficient platform for distributing thermal energy across campus. The conversion would also introduce the opportunity to integrate renewable energy and biomass as cost-effective renewable energy sources.

2.4.3 Building Re-Commissioning (2011-ongoing)

Following ECOTrek, which aimed to bring all major buildings up to a minimum level of functionality, UBC started the Building Tune-Up program in partnership with BC Hydro. The Building Tune-Up program (or Continuous Optimization) seeks to accurately match the operation of building systems with the energy services they provide. Energy conservation measures primarily consisted of controls changes, and relatively low cost retrofit measures. Implementation was completed on two pilot buildings in 2010, and its success spurred UBC to implement the program on another 17 buildings in Phase 1 of the program, completed in 2013. Phases 2 through 4 were completed by the end of fiscal 2020. UBC is implementing Round 2 of the program, which reassess buildings that have gone through the program over 5 years ago as well as a new Round 3 re-launched by BC Hydro in collaboration with Fortis BC. Round 3 has aimed to incorporate Fault Detection and Diagnostic software to help automatically detect energy conservation measures and track their implementation.

Since 2010 UBC has significantly increased its energy management resources. Where the Building Tune Up program conducted a fairly surface-level analysis of buildings by third party consultants, EWS is now undertaking deeper analyses of building energy performance. In order to meet UBC's 67% GHG reduction target, more fundamental retrofits to building systems will be necessary. Over the next three to four years, many major projects will be taking place in UBC's buildings, which will dramatically reduce thermal and electrical energy demand. For a list of completed and proposed projects, see Appendix 2.

2.4.4 Supply-Side Efficiency (2011-2020)

While recommissioning is focused on demand-side energy efficiency measures in buildings, supply-side measures are also a fundamental component to UBC's Energy Management Plan; as most thermal energy is delivered to buildings through the campus' district energy system. First built in 1924, the system was still delivering inefficient but relatively simple steam in 2010, and was overdue for capital renewal. After extensive evaluation, the decision was ultimately made to replace the ageing steam system with a high-efficiency medium-temperature hot water system.

At the same time, UBC invested in a renewable energy center, the Bioenergy Research and Demonstration Facility (BRDF). This Campus as a Living Lab (CLL) initiative provides dual purpose as research and operational infrastructure, and was completed in 2012. The facility, the result of a partnership with a wide variety of stakeholders, was the first combined heat and power (CHP) facility in North America using biomass as a fuel. The cogeneration engine now runs on a blend of conventional and renewable natural gas. The facility generates 6 MW of renewable thermal energy from biomass, and 2 MW of renewable electricity and 2.5 MW of waste heat from cogeneration.

Following on the success of the BRDF, UBC has made the decision to invest further in biomass thermal energy generation. The University is now underway in expanding the BRDF, with construction underway to add another 12 MW of thermal capacity. This expansion alone is projected to bring UBC's greenhouse gas emissions to about 60% below 2007 levels when it becomes operational for the FY22 heating season, with further capacity to be added by relocating the condensing economizer originally located in the Campus Energy Centre to the expanded BRDF.

With the expansion nearly complete, further upgrades are being planned for the BRDF – this time targeting the existing systems. The proposed project would install an economizer on the exhaust airstreams of each the gasification boiler and the cogen engine. These economizers would recover heat directly into the DES as well as through a heat pump. This project is expected on its own to reduce GHG emissions by another 4% of the 2007 baseline.

3. UBC's BAU Energy Consumption

UBC Vancouver Campus has grown significantly over the past 20 years, and will continue to do so for the foreseeable future, as UBC increases academic space in order to achieve the academic mission, and student housing to achieve the 2010 Campus Plan target of housing 25% of students on campus.

As floor space is added to campus, it must be connected to UBC's utility systems; even the most efficient spaces represent additional loads. Understanding these new loads is important in modeling how the existing thermal, electrical, and water systems will need to change in order to meet future demand for utilities.

Figure 5 illustrates what UBC's energy consumption would be over the past 20 years had the University not invested in energy conservation on campus. Without investment in energy conservation, UBC's energy consumption would be roughly 50% higher than it is today.

Figure 6 gives an illustration of UBC's energy cost over the past 20 years and shows the University would be paying an additional cost of $12 Million/year had energy conservation projects not been pursued. Should energy growth continue on the same trajectory without conservation efforts, the University's energy costs would grow by an additional $13.5 Million to $50 Million by 2030. This continued growth highlights the importance of continued investment in energy conservation practices on campus.

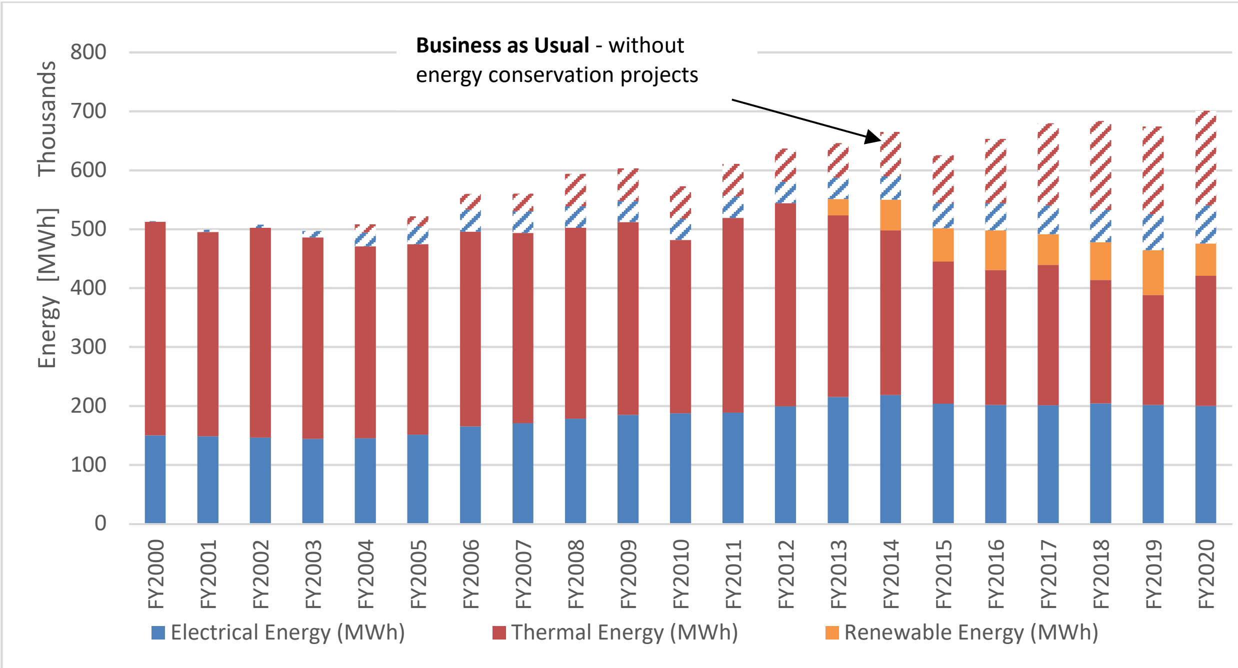

Figure 5: UBCV Business As Usual (BAU) Energy Use versus Actual

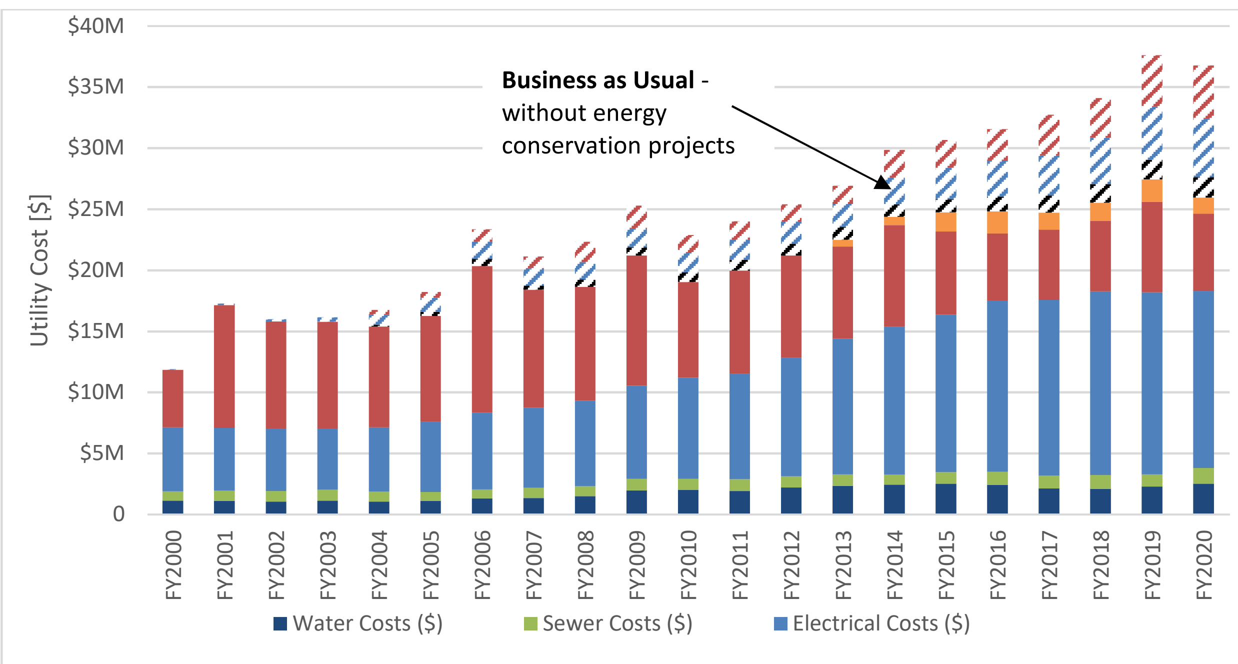

Figure 6: UBCV Business As Usual (BAU) Energy Cost versus Actual

4. Energy Management Goals and Targets

4.1 Maintain Indoor Environmental Quality

The primary goal of the Energy Conservation and Innovation unit is to maintain indoor environments for UBC Vancouver's core academic buildings, enable excellence in research, teaching and learning, and doing so in the most energy efficient manner.

Covid-19 poses an extra challenge this fiscal year. With the campus returning to full occupancy for the 2021-22 winter term, extra precautions have been put into place to ensure building occupant safety. These involve additional outdoor air ventilation of spaces before and/or after occupancy. With these measures in place, UBC expects some amount of additional energy use.

4.2 Reduce Campus GHG Emissions

As discussed in section 2.2.2, the Energy Conservation and Innovation unit is working to achieve the University's future greenhouse gas emission reduction target: 67% and 100% below 2007 levels by 2020 and 2050 respectively.

4.3 Manage Campus Energy Consumption

UBC Energy Conservation and Innovation has set annual energy savings targets of 20,000 GJ of thermal and 4 GWh of electricity per year. These targets are meant to offset energy increases due to campus floor area growth. A complete list of completed projects and targeted projects are provided in Appendix 2. Since the inception of the Energy and Water team at UBC, campus energy consumption at the Vancouver campus has continued to decrease despite significant increases in campus floor area and campus growth. This is illustrated in Figure 7 below. By improving campus energy performance, we will reduce the negative environmental impacts of energy consumption and reduce exposure to increasing energy costs.

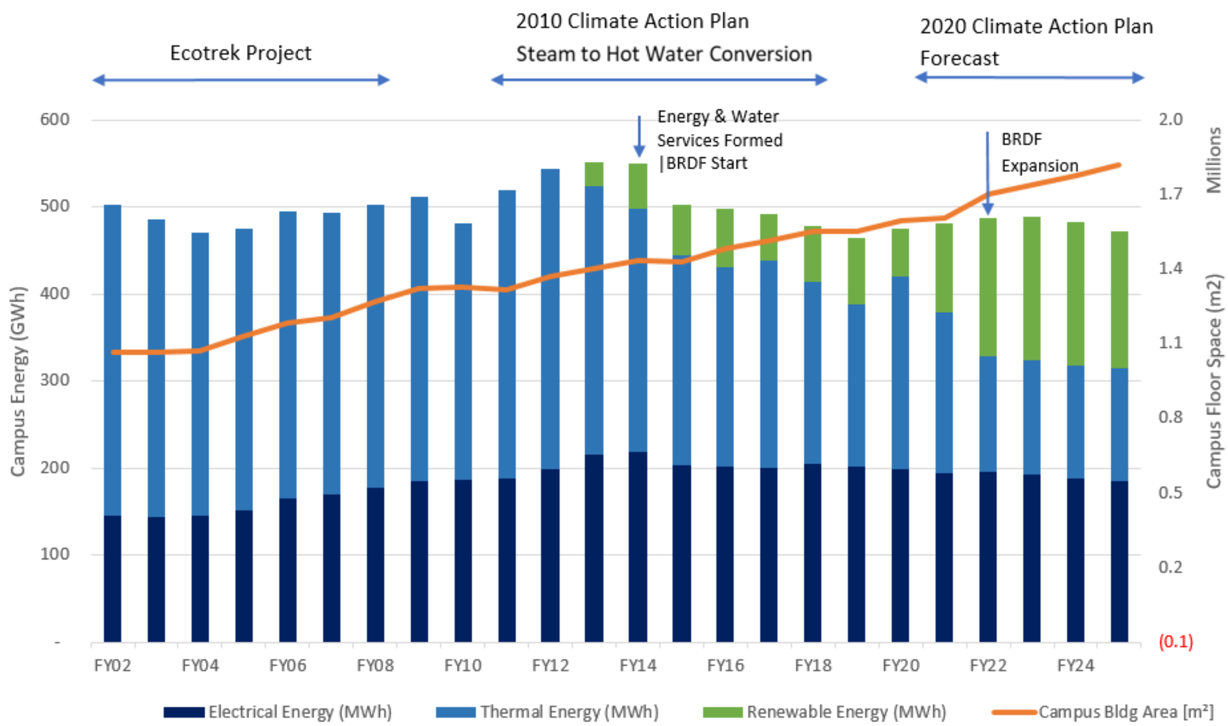

Figure 7: UBCV Energy Use Forecast

4.4 Manage Campus Peak Electrical Demand

BC Hydro transmission infrastructure is currently limited to 65 MVA through two transmission circuits. Climate change is leading to hotter summers creating more load on cooling systems as well as driving operations to install more cooling capacity. In addition, fuel switching from natural gas to energy efficient heat pumps is being investigated as part of UBC's CAP 2030 planning process. Efficient electrification of UBC's district energy system and individual buildings could contribute substantially to peak demand and needs to be balanced accordingly with capacity limitation through potential energy storage solutions and continued demand side management efforts. Fortunately UBC's focus on reducing 4 GWh of annual electricity consumption has the added benefit of contributing to peak demand reduction. Figure 8 below gives the campus peak demand since 2016 and the most recent forecast of peak growth.

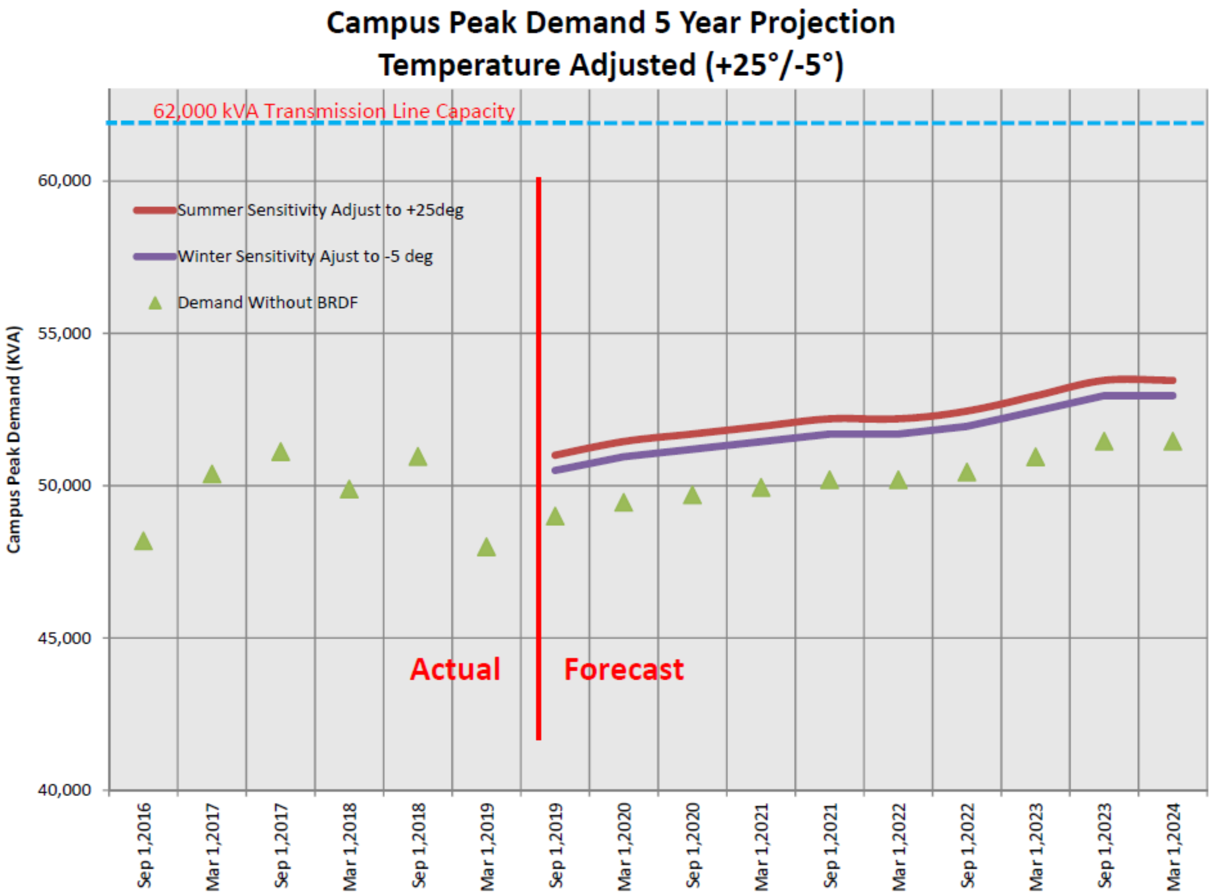

Figure 8: UBCV Peak Electrical Demand Forecast

5. Energy Management Actions

5.1 Energy Innovation, BMS & Engineering Collaboration

One of the key reasons why the Energy Conservation Group has been so effective in finding, implementing, and maintaining energy savings projects for the University, is due to the close collaboration between the Building Management System (BMS) Group and the Energy Engineers in EWS. In 2015 these groups were combined into Energy Conservation & Innovation; now working in close proximity and reporting to the same Director. Much of the energy savings found by the Energy Engineers is from relatively simple controls changes that need to be implemented by the BMS Group. For these changes to take place, a high level of trust and reliability had to be built between the two groups, as well as the incentive and directive to make the changes happen, which would not have been as seamless were the two groups divided. In addition, many energy conservation initiatives require proper control and feedback to the campus' BMS system. With the two groups in Energy Conservation and Innovation Department, consistent direction and prioritize of projects can take place that help synergize BMS upgrades that lead to energy savings projects down the road. Further, the integration of BMS trend data into the SkySpark platform, now a fundamental part of the Energy Engineering workflow, would not have been possible without close collaboration between the two groups.

5.2 Methodology to Identify Opportunities (Deep Efficiency Analysis)

Before energy savings projects can be developed by Energy and Water Services, they must first be identified and assessed. This begins with determining baseline energy use of the building being investigated. Energy use is examined, looking at the difference between daytime and nighttime use; summer and winter use; correlation with outdoor air temperature, and any number of other potential trends.

Major energy intensive systems are examined to find discrepancies between intended and actual operation. By generating a holistic understanding of the building's needs, its operation, and its capabilities, EWS is able to recommend energy conservation measures. These measures may be as minor as changing setpoints or the sequence of operations for a piece of equipment in the building management system. Such measures provide an instant payback, as they incur zero cost. However where equipment is particularly inefficient (especially when near its end-of-life), EWS may recommend larger retrofit projects.

If this is the case, EWS will then take steps to build a business case; analyzing costs and savings, and estimating the payback period of the proposed project. Partnerships with other departments on campus such as Campus and Community Planning, Infrastructure Development, or Building Operations, are important to synergize funding streams. Additional incentive and government funding sources are often necessary to make an attractive business case for the University. If a viable business case can be put together for the project, it will be pursued.

One mandate of the Energy Conservation and Innovation group, as denoted by the name, is to seek out innovative energy savings methods. Such measures might not become apparent through standard energy audits of buildings, and so ECI partners with researchers, or energy management groups at other advanced education facilities, to find unique or novel applications of technology in energy management. These projects may not have business cases as strong as projects which might otherwise be undertaken by EWS, but UBC's campus-wide commitment to advancing the overall institutional teaching, learning, and research goals of the institution lead the department to participate in these projects nonetheless. This is an example of the concept of the "campus as a living lab", ensuring that student or research groups on campus looking for real-world test cases for their ideas.

For a list of Energy Use Indexes for UBC's buildings, see Appendix 1.

5.3 Quality Assurance

The Energy Conservation Group currently saves $3.15 Million in energy savings and cost avoidance for the University each year. Because this number is so large, and all energy projects depreciate over time, there is a great financial risk in losing these recurring savings. Behaviours change, equipment degrades, maintenance is deferred, and program setpoints can get overridden. In order to counteract this depreciation of savings, the Energy Conservation Group must work to verify and provide corrective action on existing savings projects when necessary. This is done by completing a measurement and verification process at the end of each fiscal year as well as monitoring key performance indicators, BMS trends, metered energy data, and physical inspection.

UBC is presently developing a monitoring-based commissioning strategy using our Fault Detection & Diagnostics (FD&D) software, SkySpark. This will allow near-real-time monitoring of key performance indicators (KPIs), such as temperatures, valve and damper positions, system efficiencies, or equipment runtimes, as well as the development of very specific rules that automatically detect when energy conservation measures stop working. After project implementation, it will then be possible to monitor these KPIs, and if they are deviating from expected values, this will enable EWS and other UBC departments to take informed corrective action if and when necessary.

UBC has continued to move forward in using the SkySpark platform to implement the FD&D plan. A data analyst position was created to assist in streamlining the implementation. Thus far, all utility data has been integrated the platform and roughly 60% of BMS data. Energy analysis and building benchmarking is presently being performed in SkySpark. EWS is working to deploy select rules to detect easy-to-fix faults in BMS programming, and KPIs to supplement the Continuous Optimization Program.

The first major building renewal using this strategy is currently in progress, with expected occupancy next year.

5.4 New construction and major renovations

EWS actively participates in the design process for new construction and major renovations through the following activities:

- Input into the Owners Project Requirements/Design Brief (DSM guidance, helping to set energy intensity targets);
- Participation in mechanical and electrical design reviews;
- Review of Commissioning Plans;
- Participation in Commissioning Meetings;
- Review of Monitoring and Verification (M&V) Plans; and
- Review of Commissioning Reports and M&V Reports.

5.5 Minor Renovations

Tenant improvements and cyclical maintenance projects occur continuously, and some of these projects have a significant impact on building energy performance. EWS is invited to participate in the weekly *New Job Strategies* meeting and reviews all renovation projects with a significant energy implication. Where possible, EWS offers feedback to minimize growth in energy consumption.

5.6 Minimizing Load Growth

An ECI goal is to minimize the impact of new construction and major renovations on campus energy consumption. ECI has a role in the design phase of new construction projects, setting energy performance targets in the project Design Brief and Owners Project Requirements, and providing key inputs to energy models and reviewing results, and reviewing mechanical drawings and commissioning documentation.

Further, EWS has a role in planning and development of projects initiated by other departments. This is helpful, as it allows the department to leverage initiatives by other groups, such as Building Operations, when purchasing equipment or maintaining systems. This has already been the case for end of life replacement of chillers. Where the decision may otherwise have been made to perform a like-for-like replacement, EWS arranged for incentives to pay the cost difference to install a higher efficiency chiller instead. While it is difficult to plan more than a year ahead for such projects, continued EWS participation in the New Jobs Strategies meetings will allow the department to seize upon opportunities as they are presented.

Similarly, while behavior change programming is the responsibility of Campus + Community Planning, ECI is responsible for providing technical support when identifying the energy intensive behaviors which behavior change programs can target, and measuring impact of behavior change interventions.

5.7 Low-Carbon Electrification

With assistance from BC Hydro and the Provincial Government, UBC expects to reduce some of its GHG emissions through low-carbon electrification of some of its heating systems. This electrification will be high-efficiency, coming in the form of heat pumps in particular, while avoiding simple resistance heating. Some possible implementations include large industrial heat pump contribution to the district energy system, smaller CO2 heat pumps for domestic hot water generation in housing buildings, or air source heat pumps for make up air electrification. The Energy Conservation has been actively investigating these types of opportunities, most notably leveraging funding opportunities for the BRDF Economizer Retrofit project.

5.8 Notable Challenges

Energy and Water Services does face some hurdles in meeting its yearly energy savings goals, the first of which is availability and timing of funding. The department develops an annual plan of projects based on availability of funding from external sources, and simple payback opportunities that have a two year or less return on the commodity budget for the university. When funding is available, whether through grants or incentives, EWS acts quickly by having developed projects to the point of being “shovel ready”.

Infrastructure condition is a challenge for energy management as well. It is difficult to maintain energy savings in older buildings that have deferred maintenance challenges related to aging systems. Unreliable or inoperable valves, pumps, and motors may have a negative impact on energy improvement initiatives in older buildings.

One challenge that EWS faces in achieving its energy goals is illustrated in Figure 9. This graph shows the difference in anticipated growth in energy consumption between UBC’s core and ancillary groups. As student housing in particular adds floor space at a high rate, student residences are expected to account for a continuously increasing portion of campus energy demand. Energy and Water Services will work with SHHS and other Ancillary departments to identify and implement energy conservation measures.

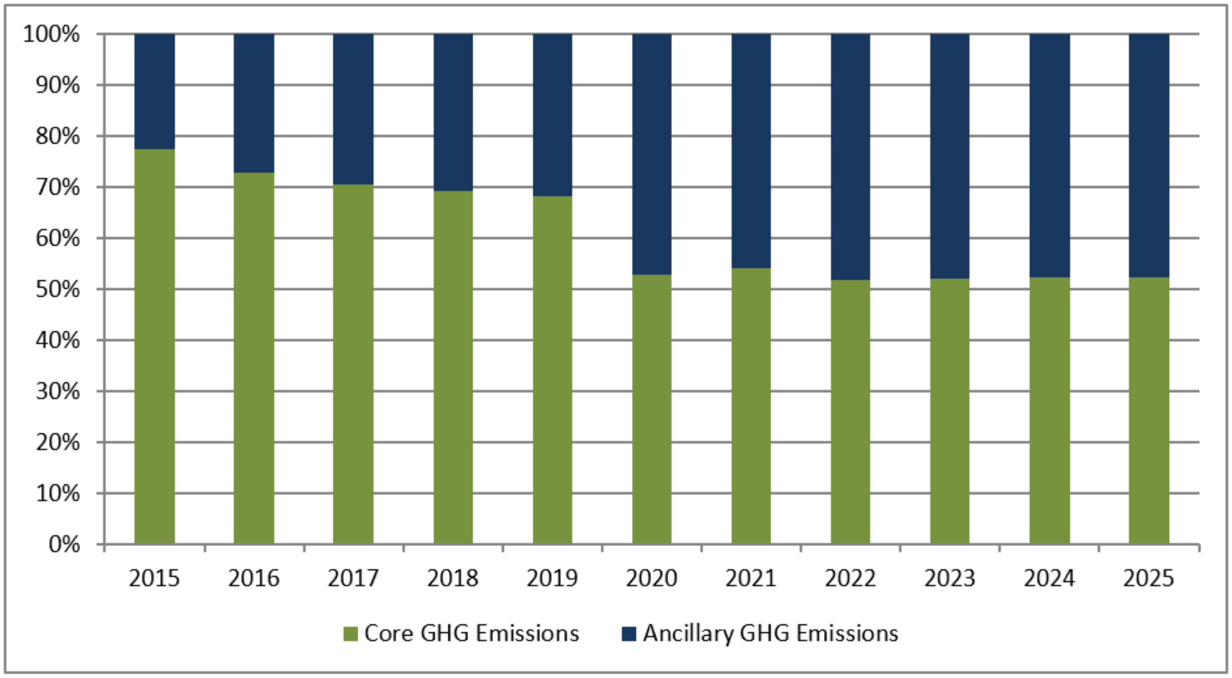

Figure 9: GHG Emissions Academic Core vs Ancillary

In an effort to mitigate this challenge, UBC now employs an Ancillary Energy Manager, funded partly by BC Hydro. As the title suggests, this position's role exists to manage the growing portion of UBC's energy which is consumed by Ancillaries. Annual energy savings targeted by this position are roughly 1 GWh/yr of electricity.

New buildings are designed for high energy performance due to UBC's green building requirements such as LEED Gold, mandatory LEED credits and energy intensity targets. However, a performance gap between expected and actual performance exists due to a number of issues including energy model accuracy and the ability of the project commissioning process to deliver optimized building energy performance. As a result, UBC has found that re-commissioning of new building systems represents an excellent opportunity for low cost energy savings. A first attempt to mitigate this risk is presently underway with the Hebb renewal project. Here, UBC is employing a Smart Commissioning strategy, where building controls will be commissioned *first*, and then used to commission all other building systems. This approach is designed to ensure that commissioning is data-driven, and that building systems work as per design intent. Pending the outcome of this project, UBC may move to integrate some or all of the lessons learned into its regular commissioning process.

Finally, savings of natural gas will become significantly more challenging as a result of the BRDF expansion and economizer retrofit projects. It is currently projected that after the expansion, the academic DES will run solely on biomass for roughly eight to nine months of the year. This means that natural gas savings for buildings connected to the district system will need to occur in just three or four months, which may prove to be an additional challenge for natural gas business cases.

5.8.1 COVID-19

The global COVID-19 pandemic had a significant effect on UBC's FY2021 energy figures, and will have an effect for years to come. When the pandemic arrived in Canada, UBC quickly moved teaching and learning to online-only. Buildings were put into unoccupied modes, with minimal ventilation and temperature control. It is important to note that Energy & Water services *is* claiming savings associated with COVID-19 setback modes. If the department didn't exist, buildings would continue to operate as normal. But as it happened, energy conservation measures put into place before COVID-19 were *enhanced* by the pandemic. For example, occupancy sensors installed as part of C.Op generated more savings than ever.

However, it is important to note that these savings are *not* recurring. Indeed, as campus has returned to full occupancy for the 2021/22 academic year, aggressive measures to ensure occupant health and safety have led to increased ventilation rates and higher-than-usual energy consumption in buildings.

5.9 Stakeholder Engagement

Stakeholder engagement takes many forms at UBC. Energy and Water Services engages with other departments for example, namely Building Operations, to address energy issues and concerns within the building stock. However, engagement with the university community and the wider public falls within the purview of the Sustainability group, which in turn is part of the department of Campus + Community Planning. They develop annual sustainability reports and GHG inventories, and run several engagement programs. Such programs include the Green Labs Program, designed to promote sustainable laboratory management practices; the Sustainability Coordinator Program, which maintains a network of sustainability "champions" within departments across the university, promoting engagement with other programs, initiatives, and events; Sustainability Ambassadors, which serves a similar purpose among the student body; and the SEEDS program, which aims to link practical sustainability research projects between community sponsors, UBC faculty, and students keen on taking on the projects. More information on these programs and more is available on the UBC Sustainability website.

5.10 Sources of Project Funding

ECI is constantly looking for internal and external sources of funding for energy and water conservation projects. A partial list of funding sources is as follows.

Operational Budget

For projects with less than a two year payback or pilot projects the department is typically able to pay for the project out of its operational budget.

Treasury Loan

For larger projects, EWS can access money from the central UBC treasury. This comes in the form of a loan to the department, on which interest must be paid. The loan is paid off through the value of energy saved through the project which is being financed. This means that EWS has to be confident in the savings, in order to minimize its liability.

Routine capital funding

Projects that mitigate or eliminate deferred maintenance, and by definition help to improve the building's Facilities Condition Index, are funded from Routine Capital Maintenance.

UBC Sustainable Revolving Fund

In 2015, UBC inaugurated its sustainability revolving fund. This is a $1 million dollar fund, managed by a committee of UBC staff. Sustainability-focused projects can apply for a loan from this fund, to be repaid through project savings.

BC Hydro Incentives

BC Hydro has been a major project sponsor in the past, incentivizing projects that reduce electricity consumption. The EcoTrek and Continuous Optimization programs in particular have been championed by BC Hydro. BC Hydro also administers provincial CleanBC funding for custom projects.

FortisBC Incentives

FortisBC provides an incentive to UBC for projects which reduce demand for natural gas. In order to be eligible for the incentive, however, projects must first undergo a feasibility study by a Fortis-approved consultant, and subsequent review by Fortis and their third-party consultant.

Climate Neutral Capital Fund

As part of the climate neutral government legislation in BC, UBC (and all public-sector organizations) must purchase offsets for all carbon emissions. The money from this goes into a provincially-managed fund, which is then paid back out to organizations with the intent to fund GHG-reduction projects.

6. Conclusion

Since 2010, when UBC's climate targets were originally announced, UBC has made consistent progress towards those goals. Since 2000, nearly $90 million in commodity costs have been avoided as a result of energy conservation, and greenhouse gas emissions have been reduced by 38% below 2007 levels.

And though this progress has been impressive, and helped to garner an international reputation as a leader on climate action, UBC Energy & Water Services plans to build on its successes. By continuing to transform our energy supply system and undertake projects both big and small, the department plans for UBC to meet its 2020 GHG emissions reduction target, and to mitigate physical and financial risks in doing so.

Appendix 1 – Building Energy Use Indexes

All following indexes are given for fiscal year 2020. Note that a null value can indicate either that a building does not use that utility, or that a meter is not present or not communicating. No differentiation is made.

Building Name	Floor Area (m^2)	Electric Use Index ($kWh/m^2/yr$)	Thermal Use Index ($kWh/m^2/yr$)	Water Use Index ($m^3/m^2/yr$)
Allard Hall	14,909	105	56.3	7.7
Anthropology and Sociology Building	6,220	57	75	< 0.1
Aquatic Ecosystems Research Laboratory	5,368	61	67	-
Asian Centre	4,926	45	82	1.5
Auditorium Annex Offices A	2,431	-	159	-
B.C. Binning Studios	1,501	-	300	-
Beaty Biodiversity Centre	12,466	220	104	< 0.1
Biological Sciences Building - South Wing	5,441	518	173	16.9
Biological Sciences Building - West Wing	8,021	449	206	-
Biomedical Research Centre	4,407	335	317	2.0
Brock Hall - West Wing	5,907	186	225	-
Buchanan A,B,C	10,936	53	46	0.4
Buchanan D,E	7,134	63	129	0.3
Buchanan Tower	10,728	45	146	-
C. K. Choi Building for The Institute of Asian Research	2,912	27	90	< 0.1
Centre for Comparative Medicine	10,367	249	385	0.3
Centre for Interactive Research on Sustainability (CIRS)	5,454	111	-	-
Chan Centre for The Performing Arts	11,440	62	43	0.5
Chan Gunn Centre	1,806	175	-	-
Chemical & Biological Engineering Building	14,030	177	168	10.6
Chemistry A Block, Chemistry Physics Building	7,805	558	543	3.3
Chemistry B Block, South Wing	5,373	170	345	2.1
Chemistry C Block, East Wing	3,573	96	268	0.7
Chemistry D Block, Centre Wing	7,274	527	194	1.3
Chemistry E Block, North Wing	2,739	358	269	0.4
Civil and Mechanical Engineering Building	9,361	86	282	0.5
Civil and Mechanical Engineering Laboratories (Rusty Hut)	5,636	206	77	< 0.1
Coal and Mineral Processing Laboratory	2,950	138	325	-
Continuing Studies Building	3,813	-	84	-
David Lam Management Research Centre	6,751	132	106	< 0.1

Building Name	Floor Area (m^2)	Electric Use Index ($kWh/m^2/yr$)	Thermal Use Index ($kWh/m^2/yr$)	Water Use Index ($m^3/m^2/yr$)
David Strangway Building	12,403	183	66	< 0.1
Douglas Kenny Building	9,613	66	54	0.1
Earth and Ocean Sciences - Main	10,799	261	89	-
Earth Sciences Building	17,755	196	38	-
Engineering Student Centre	953	-	80	-
First Nations Longhouse	2,352	80	185	0.1
Food, Nutrition and Health Building	5,962	179	153	1.3
Forest Sciences Centre	22,459	196	259	1.6
Frank Forward Building	7,880	75	246	0.9
Frederic Lasserre Building	4,710	67	143	0.7
Frederic Wood Theatre	2,885	50	155	-
Friedman	6,073	60	47	0.1
Geography Building	5,525	122	-	0.9
George Cunningham Building	4,901	47	72	0.1
H. R. Macmillan Building	14,193	71	162	0.6
Hebb Building	5,991	68	24	< 0.1
Hennings Building	11,428	63	79	< 0.1
Henry Angus Building	16,922	155	49	0.3
Horticulture Building	1,753	-	583	-
Institute for Computing, Information and Cognitive Systems / Computer Science	10,012	167	90	0.6
Institute for Computing, Information and Cognitive Systems / Computer Science Addition	9,668	159	93	0.2
Indian Residential School History and Dialogue Centre	399	194	-	-
International House	1,246	-	76	-
Irving K. Barber Learning Centre	27,316	73	52	0.1
J. B. Macdonald Building	7,328	114	203	0.5
Jack Bell Building for The School of Social Work	2,712	182	151	0.1
Leon and Thea Koerner University Centre	3,944	100	155	0.2
Life Sciences Centre	52,177	307	129	1.0
Liu Institute for Global Issues	1,729	65	87	< 0.1
Lower Mall Research Station	6,406	105	-	-
Macleod Building	7,345	-	-	-
Mary Bollert Hall	1,318	-	93	-
Mathematics Building	6,140	87	-	0.2
Medical Science Block C	4,014	74	227	< 0.1
Michael Smith Laboratories	8,477	527	176	0.8

Building Name	Floor Area (m^2)	Electric Use Index ($kWh/m^2/yr$)	Thermal Use Index ($kWh/m^2/yr$)	Water Use Index ($m^3/m^2/yr$)
Morris and Helen Belkin Art Gallery	1,504	-	429	-
Museum of Anthropology	10,652	229	89	-
Music Building	6,593	66	94	-
Neville Scarfe	19,382	47	78	0.2
Old Auditorium	2,634	-	109	-
P. A. Woodward Instructional Resources Centre	12,049	51	104	< 0.1
Parc Library	2,146	292	182	-
Pharmaceutical Sciences & Centre for Drug Research and Development	36,138	394	392	-
Pulp and Paper Centre	3,676	71	184	< 0.1
Robert F. Osborne Centre - Unit 2	2,740	117	-	0.1
Robert H Lee Alumni Centre	4,106	83	48	-
School of Population & Public Health	8,442	118	34	0.2
Sedgewick Library	7,303	176	159	0.7
Sing Tao Building	1,571	48	123	0.1
Thea Koerner House	4,061	109	145	1.1
The Brimacombe Building	13,781	443	198	0.4
The Fred Kaiser Building	11,798	100	38	< 0.1
The Leonard S. Klinck Building	10,720	130	66	0.3
UBC Life Building	19,026	102	21	0.1
Undergraduate Life Sciences Teaching Labs	9,069	314	144	-
University Services Building	11,598	155	-	0.3
Wayne and William White Engineering Design Centre	2,645	68	117	< 0.1
Wesbrook Building	10,272	52	180	4.4
West Mall Annex	1,962	-	182	-
West Mall Swing Space Building	5,399	54	82	0.1
Woodward Biomedical Library	7,777	137	71	0.6

Appendix 2 – Project Lists

Table 1: FY2022 Approved Projects

Project Name	Thermal Savings (GJ/yr)	Electrical Savings (MWh/yr)	Water Savings (1000 ft3/yr)	Total Capital Cost	Simple Payback (yrs)	EWS Cost	EWS Simple Payback (yrs)	Fiscal Year Completion
FY21 VFDs				$ -	-	$ -	-	FY22
CCM & EOS VAV EF CCP		415		$ 320,000	-	$ 244,885	-	FY22
Aircuity in Pharmacy	416	452		$ 230,000	-	$ 110,000	-	FY22
Pharmacy Night Setback Occ Sensors		383		$ 142,000	5.3	$ 72,677	2.7	FY22
Chem North HR Coils	1,462	-20		$ 120,000	12.5	$ 65,618	6.9	FY22
Chem Centre HRC	4,518			$ 560,000	16.5	$ 372,653	11.0	FY22
LSC HRC Module Expansion	5,844	-123		$ 305,000	8.7	$ 174,598	5.0	FY22
Nest Min OA Revisions	935			$ 5,000	0.7	$ 5,000	0.7	FY22
Lighting - Core		300		$ 130,000	6.2	$ 75,700	3.6	FY22
Chan Lighting (by Chan Centre)		100		$ -	-	$ -	-	FY22
C.Op Implementation - AMS Nest	1,790	230		$ 9,000	0.3	$ 9,000	0.3	FY22
C.Op Implementation - Life Bldg	595	566		$ 3,600	0.1	$ 3,600	0.1	FY22
C.Op Implementation - Wesbrook	750	39		$ 4,250	-	$ 4,250	-	FY22
CICSR demand based HWST reset				$ -	-	$ -	-	FY22
Chan Gunn Deep Dive				$ -	-	$ -	-	FY22
CHBE HWST reset				$ -	-	$ -	-	FY22
CHBE chiller optimization				$ -	-	$ -	-	FY22
SP reset		140		$ -	-	$ -	-	FY22
FY2022 Subtotal	**16,310**	**2,482**	**0**	**$ 1,828,850**	**6.2**	**$ 1,137,981**	**3.8**	**FY22**

Table 2: FY2023 Projects in Feasibility

Project Name	Thermal Savings (GJ/yr)	Electrical Savings (MWh/yr)	Water Savings (1000 ft3/yr)	Total Capital Cost/ Study Cost	Simple Payback (yrs)	EWS Cost	EWS Simple Payback (yrs)	Fiscal Year Completion
Belkin Art Gallery - HRC study								FY23
C.Op Phase 7 Completion Report Remainder								FY23
Aircuity at LSC								FY23
LSC ERC heat recovery								FY23
Electrification w Impact								FY23
BRDF Stage 2 Economizer	71,200	-4,525		$ 1,625,000	7.5	$ 1,050,000	5.0	FY23
Sports Med ASHP Operation vs Boiler Use								FY23
Steam leaks, Condensate Return in Pharmacy/LSC								FY23
Coil cleaning								FY23
Fan VFDs (CEME, Chem South, Chem East,	1,100	369		$ 170,000	5.0	$ 118,000	3.5	FY23
Strangway dedicated cooling	700	71		$ 60,000	5.9	$ 50,060	4.9	FY23
Strangway Deep Dive								FY23
CICSR demand based HWST reset								FY23
CHBE HWST reset								FY23
CHBE chiller optimization								FY23

Project Name	Thermal Savings (GJ/yr)	Electrical Savings (MWh/yr)	Water Savings (1000 ft3/yr)	Total Capital Cost/ Study Cost	Simple Payback (yrs)	EWS Cost	EWS Simple Payback (yrs)	Fiscal Year Completion
Non-lab Occupancy Sensors (ESB, BIOW, C	1,200	330		$ 150,000	4.7	$ 98,850	3.1	FY23
BIOS/W additional lab occ sensors for imp	300	50		$ 55,000	9.6	$ 47,250	8.2	FY23
MOA Lighting (by BO)	0	216			-	$ -	-	FY23
Pharmacy Basement Setback	190	145		$ 25,000	2.2	$ 25,000	2.2	FY23
Lab Exhaust DSP Reset	0	100		$ 50,000	7.1	$ 34,500	4.9	FY23
LSC Steam Leak, End Use Investigation, Co	2,500			$ 75,000	4.0	$ 50,000	2.7	FY23
AHU Coil & HRC Cleaning	500	320		$ 55,000	2.1	$ 55,000	2.1	FY23
ULTL to BIOW Integration	5,000	0		$ 350,000	9.3	$ 300,000	8.0	FY23
Lab Supply DSP Reset	0	160		$ -	-	$ -	-	FY23
BIO Workshop to South Integration	1,400	0		$ 150,000	14.3	$ 137,500	13.1	FY23
Fume Hood ACH Reset Opportunity								FY23

Table 3: Completed Projects

Project Name	Thermal Savings (GJ/yr)	Electrical Savings (MWh/yr)	Water Savings (1000 ft3/yr)	Total Capital Cost	Simple Payback (yrs)	EWS Cost	EWS Simple Payback (yrs)	Fiscal Year Completion
COP 4	5,949	1,821	-	-	-	-	-	FY21
Chem Bio 4th floor Occ Sensors	97	481	-	$ 11,715	0.34	$ 11,715	0.34	FY21
EDC Deep Dive	-	82	-	-	-	-	-	FY21
FY21 Lighting	-	124	-	$ 121,211	13.96	$ 66,855	7.70	FY21
Forest Sciences Airflow Reprogramming &	-	589	-	$ 11,715	0.28	$ 11,715	0.28	FY21
I.K. Barber Heat Recovery Optimization	322	-	-	-	-	-	-	FY21
LSC SP Reset and ACH	3,895	1,023	-	-	-	-	-	FY21
MOA ReCx Valves & Deep Dive	2,250	-	-	$ 2,146	0.13	$ 2,146	0.13	FY21
MSL Deep Dive	360	555	-	$ 5,411	0.13	$ 5,411	0.13	FY21
Pharmacy Deep Dive	-	99	-	$ 4,000	0.58	$ 4,000	0.58	FY21
Strangway Heat Pump Optimization	636	-126	-	$ 5,000	-1.23	$ 5,000	-1.23	FY21
Strangway Deep Dive	976	1,419	-	-	-	-	-	FY21
FY2021 Subtotal	**14,485**	**6,067**	**-**	**$ 161,198**	**0.3**	**$ 106,842**	**0.2**	FY21
CCM Aircuity	5,052	595	-	$ 345,950	4.3	$ 92,650	1.1	FY20
COP3 - Controls	13,310	923	-	-	-	-	-	FY20
COP3 - Sensors	3,170	67	-	$ 138,000	4.7	$ 138,000	-	FY20
COP4 - Controls	4,330	1,178	-	$ 214,000	1.8	$ 214,000	1.8	FY20
MSL Control Fixes	1,600	225	-	$ 23,305	0.8	$ 23,305	0.8	FY20
MSL Chiller Retrofit	-	120	-	-	-	-	-	FY20
FY20 Lighting	-	440	-	$ 151,000	4.9	$ 121,700	4	FY20
VSD Project (3W -> 2W)	-	146	-	$ 40,000	3.9	$ 21,000	2.1	FY20
FY2020 Subtotal	**27,462**	**3,694**	**-**	**$ 912,255**	**2.0**	**$ 610,655**	**1.3**	FY20
MSL Aircuity	1,500	237	-	$ 470,650	16	$ 10,650	0.4	FY19
FY19 LSC LED Lighting	-	482	-	$ 171,326	4.9	$ 38,771	0.9	FY19
FSC VSD Retrofit	0	152	-	$ 41,000	-	$ 26,700	1.76	FY19
Chem E Supply Air Optimization	500	78	-	$ 10,000	1	-	-	FY19
FSC Min Airflow	1,100	32	-	-	-	-	-	FY19
FSC DHW Tank	2,100	-	-	$ 20,000	1.2	$ 20,000	1.2	FY19
FY2019 Subtotal	**6,300**	**929**	**-**	**$ 712,976**	**6**	**$ 96,121**	**0.8**	**FY19**

Project Name	Thermal Savings (GJ/yr)	Electrical Savings (MWh/yr)	Water Savings (1000 ft3/yr)	Total Capital Cost	Simple Payback (yrs)	EWS Cost	EWS Simple Payback (yrs)	Fiscal Year Completion
Evaluate case for district cooling	-	-	-	-	-	-	-	FY18
Chem North Supply Air Optimization	-	-	-	-	-	-	-	FY18
FSC Min Airflow	1,100	32	-	-	-	-	-	FY18
Chem E FH	565	6	-	$ 9,075	-	$ 9,075	1.8	FY18
LED Lighting F18	-	480	-	$ 171,300	4	$ 4,000	0.1	FY18
COP2 - Controls	8,584	2,019	-	$ 170,000	0.8	-	-	FY18
COP2 - Sensors	4,354	329	-	$ 170,000	3	$ 170,000	3	FY18
COP3 - VFDs	1,214	434	-	$ 255,000	6.6	-	-	FY18
DES Piping	-	-	-	$ 1,200,000	-	-	-	FY18
Fumehood Face Velocity and ACH reductio	4,336	36	-	$ 350,000	9.6	-	-	FY18
Life Sci Air Changes	10,000	27	-	-	-	-	-	FY18
LSC Variable Exhaust	-	1,800	-	$ 890,000	7.4	-	-	FY18
MOA Heat Recovery Chiller	5,747	-60	-	$ 442,296	5.9	$ 47,704	0.6	FY18
Multi Building Variable Exhaust	-	2,128	-	$ 1,222,700	8.6	-$ 22,098	-0.2	FY18
Nest Recommissioning	50	215	-	-	-	-	-	FY18
FY2018 Subtotal	**35,585**	**7,518**	**-**	**$ 4,897,096**	**5.9**	**$ 209,406**	**0.25**	**FY18**
COP2 - ICICS & VFD	3,756	1,233	-	$ 697,815	6.2	$ 82,488	0.7	FY17
LED Lighting F17	-	937	-	$ 306,000	4.9	-	-	FY17
Angus Chiller Optimization	415	380	-	-	-	-	-	FY17
BRDF Condensate heat recovery	4,000	-	-	$ 20,000	0.6	$ 20,000	0.6	FY17
BRDF Fluid Cooler	-	175	-	$ 4,000	-	-	-	FY17
Brimacombe Heat Recovery project	6,850	-476	1,500	$ 1,075,228	18.2	$ 93,272	-1.6	FY17
ChemBIo heat recovery opt	2,500	41	-	-	-	-	-	FY17
Forestry Sciences Optimization	2,400	33	-	-	-	-	-	FY17
MSL Optimization	1,400	-	-	-	-	-	-	FY17
PSC Variable Exhaust	-	1,040	-	$ 200,000	2.9	-	-	FY17
BRC & WLIB Chiller	-1,100	974	-	$ 1,500,000	26.6	-	-	FY17
Chem South Once Through Cooling	-	-	440	$ 15,000	1.4	$ 15,000	1.4	FY17
Alumni to DES	-	-	-	$ 60,000	-	-	-	FY17
AMS NEST to DES	-	-	-	$ 20,000	-	-	-	FY17
LSC Chiller Optimization Phase 2	1,000	200	-	$ 5,000	0.2	$ 21,211	-	FY17
FY2017 Subtotal	**21,221**	**4,537**	**1,940**	**$ 3,903,043**	**7.8**	**$ 231,971**	**0.5**	**FY17**
BRDF Glycol optimization phase 1	3,024	168	-	$ 1,999	0.1	$ 1,999	0.1	FY16
Duct Static Opt 1	-	150	-	-	-	-	-	FY16
ESB Variable Exhaust	-	444	-	$ 200,000	6.7	$ 150,000	5.1	FY16
FSC Water Project	564	-	650	$ 35,000	1.7	$ 35,000	1.7	FY16
Life Sci Heat recovery chiller	15,000	-	-	$ 425,000	3.6	-		
Urinals Project	-	-	4,000	-	-	-		
Wifi Occupancy Pilot	73	69	-					
FY2016 Subtotal	**18,661**	**813**	**4,650**	**$ 661,999**	**3.1**	**$ 186,999**	**0.9**	**FY16**
Absorption Chiller Replacement	19,500	-540	-	$ 2,200,000	18.8	-	-	FY15
BIOLW & BIOLS Controls Opt	15,840	-	-	-	-	-	-	FY15
PSC HRC Optimization 1&2	-	2,269	-	$ 5,000	-	$ 5,000	-	FY15
FY2015 Subtotal	**35,340**	**1,729**	**-**	**$ 2,205,000**	**5.3**	**$ 5,000**	**0**	**FY15**
COP Phase 1	30,456	1,126	-	$ 612,000	1.9	$ 100,000	0.3	FY14
Filter Program	-	2,164	-	$ 40,000	0.3	-	-	FY14
Life Sci Chiller Opt	-	1,314	-	-	0.1	-	-	FY14
Life Sci OAT Lock out and chiller heat recov	14,360	-	-	-	0.1	-	-	FY14
FY2014 Subtotal	**44,816**	**1,604**	**-**	**$ 652,000**	**1.4**	**$ 100,000**	**0.2**	**FY14**
Coil Cleaning	-	1,320	-	$ 168,000	1.9	-	1.3	FY13
FY2013 Subtotal	**-**	**1,320**	**-**	**$ 168,000**	**1.8**	**-**	**0**	**FY13**