University of British Columbia

UBC Sustainability Scholars Program

Campus Energy Infrastructure Study

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Executive Summary

The following study compiles the University of British Columbia's (UBC) accomplishments and challenges in terms of energy infrastructure, and shows UBC's ability to use the campus as a test bed to demonstrate innovative sustainability solutions. This study covers a period of twenty years, from 1997 when the first Sustainability Office was created to the present day, when the Vancouver campus has become an example of sustainability, aggressive Green House Gas (GHG) reduction targets and innovative energy production systems.

The study describes the evolution of the sustainability culture in UBC, the influence this had on the Vancouver campus energy infrastructure, and the policies, plans and projects to achieve its GHG emission reduction targets. It does so from the perspective of energy demand and supply systems. It also shows the efforts of staff, faculty, and students towards sustainable energy.

The study provides a brief overview of the Federal and Provincial policy context that facilitated the path towards sustainability and how University leaders have aligned with government-driven sustainability efforts. It also compiles the different decisions, actions and champions that led the campus towards establishing GHG reduction targets, and facilitate the path of projects that involved students, faculty and industry to achieve these goals.

The projects that carved this path are analyzed, such as Eco-TREK, the Bioenergy Research Demonstration Facility and the Academic District Energy System. Finally with the plans and actions that the University of British Columbia have shaped to reach its goals such as the Green Building Action Plan, the Climate Action Plan and the LEED Implementation Guide.

The campus Energy Infrastructure of UBC is a story of forward thinking individuals and groups that combined key elements which guided to be what it is today (Metras, 2018).

1. Introduction

1.1. Research goal and objectives

The goal for this study is to provide a high-level understanding of the evolution of the University of British Columbia (UBC) Vancouver campus energy systems and infrastructure. The study will be used as a case study to learn from UBC's accomplishments and its unique ability to use the campus as a test bed to demonstrate innovative sustainability solutions.

This study covers from 1997 when the first Sustainability Office was created, to the present day when the Vancouver campus is an example of sustainability, aggressive Green House Gas (GHG) reduction targets and innovative energy production systems.

This report shows how the sustainability culture evolved, the efforts of staff, faculty, and students, how decisions from the Universities' leadership align with the government, provincial and federal sustainability efforts, and how the university has created policies, plans and projects to achieve its GHG emission reduction targets.

The campus Energy Infrastructure of UBC is a story of forward thinking individuals and groups that combined key elements which guided to be what it is today (Metras, 2018).

1.2. Research Methodology

This research was accomplished by analyzing the existing documents and interviewing key stakeholders (Interview Transcripts are available in Appendix 2) to identify the following:

- The goals and milestones set for the campus, such as GHG emissions and energy use reduction (planned versus actual).
- Vision, plans and policies which enabled innovation.
- Projects and programs which contributed to achieving the goals.
- Challenges encountered and lessons learned throughout this process.
- The role of the champions who encouraged and implemented innovation.
- Future projects and programs to achieve planned milestones and goals.

This study can inform the development of future educational and outreach projects, to communicate UBC activities to academic, professional and public sector audiences. It may also help inform future policies, development, and research at UBC.

2. Campus Energy and Sustainability evolution

The University of British Columbia has been a pioneer regarding sustainability efforts by creating the first Campus Sustainability Office in Canada (UBC Sustainability, 2018). Federal and provincial context has helped bolster UBC stand with federal and provincial policies such as carbon tax. In 2008, the province implemented North America's first broad-based carbon tax (Government of British Columbia, 2018).

2.1. Federal and Provincial Context

In the 2015 United Nations Climate Change Conference COP 21[1] member states took stock of their climate-change strategies and set new targets to curb their greenhouse-gas emissions. Prime Minister Justin Trudeau set the same emission reduction goal by his predecessor, Stephen Harper: a 30-per-cent reduction in emissions from 2005 levels by 2030. (Cipriani & Associated Press, 2017). Also, at the COP 21 open speeches, Mr. Trudeau promised "Canada will take on a new leadership role internationally" (Cipriani & Associated Press, 2017).

The province of British Columbia (BC) has been recognized as leaders in the fight against climate change. BC has develop the Climate Leadership Plan (British Columbia Government, 2016) which sets actions to meet BC reduction goals passed on Act for Greenhouse Gas Reduction Targets (GGRTA) in November 2007 (Government of British Columbia, 2018).

This act states a reduction of:

1. 33% reduction in GHG emissions below 2007 levels by 2020
2. 80% reduction in GHG emissions below 2007 levels by 2050

Also, under the Carbon Neutral Government Regulation, the BC government implemented a Carbon Tax Act in 2008. This tax puts a price on greenhouse gas emissions, providing an incentive for sustainable choices that produce less emissions (Government of British Columbia, 2018).

In order to obtain the country's goals on GHG emissions reduction, the province of BC is regulating the energy demand through the BC Building Code that contains the requirements for the minimum energy efficiency of buildings and their equipment. But the BC Building Code only sets the minimum requirements. Therefore, the government recently implemented the BC Energy Step Code that takes incremental steps to increase energy-efficiency requirements in the BC Building Code to make buildings net-zero energy ready by 2032. (Government of British Columbia, 2018).

Canada's federal government and the province of British Columbia are both creating frameworks to work towards GHG emissions reduction with clear targets and timelines. In this context, UBC is aligning their efforts and leading the charge. UBC electric power source comes from BC Hydro, and more than 90% of BC Hydro's generation is produced by hydroelectric generation. (Hydro, 2018)

2.2. UBC Decisions & Policies

UBC made the decision, by being a teaching and research institution, to promote and lead change by example, which was triggered by Policy #5. This Sustainable Development policy was launched by the

[1] COP 21: The 2015 United Nations Climate Change Conference: http://www.cop21paris.org

board of governors in 1997 to develop an environmentally responsible campus, making UBC the first university in Canada to adopt a sustainable development policy. To implement it, the first sustainability office in the country was created under the leadership of Geoff Atkins (Associate Vice-president) at UBC (Woodson, 2018).

One mandate of the Sustainability Office was to integrate academic and operational efforts. An example of such initiatives is the establishment of the Social Ecological Economic Development Studies (SEEDS) program in 2000 under Freda Pagani's leadership. The SEEDS Program has been a systematic launch pad to create a sustainability culture amongst the people that shape UBC. (UBC Sustainability, 2018). The SEEDS projects involve staff, faculty, and students and gives a platform to students to identify, implement, and assess various sustainability related solutions on campus through their coursework (UBC Sustainability, 2018). The program also facilitates faculty members' partnership with the internal operations staff and the industry to apply cutting edge technologies to solve sustainability challenges.

Energy management has been a focal point on SEEDS projects (see the project list in Appendix 4). An example of these projects is one conducted in 2013, by students from the Clean Energy Research Centre that recommended alternatives for the steam to hot water conversion challenges encountered in the Academic District Energy Systems (ADES) project (Appendix 4). This recommendation was further investigated and finally implemented by the operational staff (further details in Section 3.1.3).

UBC worked on a balance between operating a university campus and reshape it towards sustainability. To achieve that goal, in a cost effective way without compromising operations, various UBC Departments launched retrofit programs and projects, such as UBC Renew and Eco-Trek which are further discussed in Chapter 3. These projects fulfilled not only operational needs and energy reduction savings, but also support sustainable goals. Therefore, sustainability had an opportunity to prove not only to be an attractive tool to help the environment but also reduce the operational costs (UBC Campus Sustainability Office, 2008).

The former President of the United States of America, Bill Clinton, held up Eco-Trek and UBC Renew as North American examples of excellence at a United Nations Colloquium of University Presidents held in November 2007 (Henderson, 2008). With the increasing national and international recognitions, sustainability in energy and projects such as Eco-TREK gained more traction among UBC leadership, including the UBC president at the time, Steven Toope. During his mandate, he made sustainability one of his strategic pillars.

The full engagement of the university leadership and a set of provincial policies such as the British Columbia carbon tax marked the starting point of a new sustainability era on campus (Government of British Columbia, 2018). Steven Toope supported the efforts to set sustainability targets for UBC (Woodson, 2018). Those targets defined a roadmap to follow. This unchained a series of projects and programs in different departments of UBC that are further explained in chapter 3.

In 2008 President Toope, signed the "University and college presidents' climate statement of action for Canada" that encourages UBC to share knowledge, research, and best practices about climate change with students and the community (Toope, et al., 2008).

In 2010 the UBC Climate Action Plan 2020was released setting GHG emissions reduction targets and a roadmap comprised of a set of achievable and realistic actions to develop in the future. These targets are:

1. 33% reduction in GHG emissions below 2007 levels by 2015
2. 67% reduction in GHG emissions below 2007 levels by 2020
3. 100% reduction in GHG emissions below 2007 levels by 2050

After the release of this action plan, efforts started to achieve these targets. The Climate Action Plan was a turning point in UBC where policies, leadership, vision and culture aligned towards aspirational sustainability goals.

As part of the efforts of achieving the 2015 goal, the Bioenergy Research and Demonstration Facility was created. This facility uses biomass in the form of wood waste, instead of natural gas, to produce thermal energy to heat the campus buildings. This biomass is a renewable low carbon fuel, as opposed to natural gas, which is a non-renewable high carbon fossil fuel.

These policies and projects, such as Eco-Trek and the BRDF, helped UBC achieve a 34 per cent greenhouse gas (GHG) emission reduction from 2007 levels in 2016, despite a 16 per cent increase in building floor space and a 23 per cent increase in student enrolment (UBC Energy & Water Services, 2018).

With all the advancement, UBC needed a dedicated and specialized department to manage the utility demand and supply efficiency and management. Therefore, the Energy and Water Services (EWS) Unit was created in the spring of 2014. This office become responsible for managing the utility related projects contributing to GHG reduction, under one unit led by David Woodson.

After achieving the first milestone, the focus went on to the next goal: 67% reduction by 2020, both from energy supply and demand.

From past experiences, UBC leaders realized that improving energy efficiency of existing buildings is one of the most affordable ways to cut emissions. Therefore, the following are identified as the pathway to improve performance of the existing buildings. (UBC Renew & Eco-TREK)

1. Recommission of 80% of buildings that have not undertaken any retrofits towards high performance standards
2. Undertake deep retrofits in 60% of buildings to high performance standards (e.g. LEED)
3. Incorporate solar or other renewable energy onsite systems in 40% of buildings
4. Switch fuel sources in 20% of buildings

The LEED 2009 UBC requirements were expected to result in an energy reduction. However, LEED certification does not ensure low energy consumption in buildings. In this sense, UBC established specific LEED requirements, such as an energy performance of 42% below Canadas's Model National Energy Code for Buildings (MNECB). Even though the gold or platinum certifications were accomplished, the actual energy demand of the buildings were considerably higher than the estimates (Woodson, 2018). Therefore, further energy performance efforts have been implemented trying to enhance building energy performance.

By noticing the performance gap on the energy demand side, UBC decided to create a more powerful methods tool than the LEED implementation guide that envelops new features as biodiversity and

wellbeing of inhabitants of buildings. In 2018, they created the Green Building Action Plan (GBAP). This plan incorporates the lessons learned from the past and the efforts to reach a sustainable net zero campus with the 2050 target on mind.

THE GBAP provides a coherent plan to guide the development of buildings. Building on the lessons learned, different Energy Use Intensity (EUI) targets were implemented for different types of buildings such as High/Low Intensity Science Buildings and Office Classroom Buildings (University of British Columbia, 2018).

The UBC Climate Action Plan shows the road map, with the Green Building Action Plan controlling the demand of energy for the years to come. Additional measures are also being taken to improve the GHG emission from energy supply. (Metras, 2018). Future projects like the BRDF Expansion from 6 MW to 18 MW are just the beginning of an exciting future. With the leadership of the University compromised to sustainability, with the Building Operations, Energy & Water Services and Infrastructure Development working in a cohesive way following a common goal, being guided by the Climate Action Plan and the Green Building Action Plan and the innovative and academic mindset, there is no doubt that UBC will reach its goals and be an example to the world of sustainability (Woodson, 2018).

The University of British Columbia has a unique position to use the campus as a living laboratory to combine industry, innovation and academia focused on achieve clear targets. Initiatives like Campus as a Living Lab, promotes research and new alternatives to reach those goals by stimulating innovation and research opportunities to obtain new energy sources (Metras, 2018).

3. Campus Energy Projects & Programs

Energy use in buildings accounts for over 95 per cent of UBC's greenhouse gas (GHG) emissions (UBC Sustainability, 2018). Therefore, a major part of UBC's plan to hit the carbon reduction targets were regarding reducing GHG emissions from energy systems and infrastructure by two fronts: demand and supply.

3.1. Energy demand reduction and management

3.1.1. UBC Renew

This program was launched in the early 2000s, after a partnership between UBC and the provincial government. This program was initiated with the goal to renovate buildings rather than demolish them. Through its renovation process, this program focused on making buildings more sustainable, reduce GHG emissions and reduce energy and water consumptions (UBC Campus Sustainability Office, 2008).

3.1.2. Eco-TREK

This project was the biggest energy retrofit ever attempted in Canada. It was launched by UBC Sustainability Office in 2001 and completed in 2008 as a partnership between UBC and MCW Company. It established a real time and easy access energy management platform with a sub-metering infrastructure to reduce campus energy and water consumption. The program resulted in 15,000 tons of CO_2 emission reduction and generated savings of up to $3 million CAD per year (UBC Sustainability, 2008).

3.1.3. Building Tune-up Program

The building tune-up program, also known as "Continuous Optimization", is built on the success and lessons learned from UBC Renew and Eco-TREK programs. Launched in 2010 by UBC Building Operations and UBC Energy and Water Services, the program is a continuous recommissioning of the existing buildings across campus to identify opportunities for increasing the energy efficiency and reducing emissions. This program has reduced the electrical and heating energy demand and was a key part of the actions that helped UBC Climate Action Plan 2015 target – to reduce GHG emissions by 33% below 2007 levels. Along with behaviour change programs, the tune-up will lead to a 5,000 tonnes additional GHG emissions reduction by 2020 (UBC Sustainability, 2018).

3.1.4. New Buildings Energy Demand Reduction

As sustainability gained more traction in a local, provincial, and national scale, more regulations were set by the government and authorities. As of 2008, all publicly-owned new construction and major renovation projects over 600 m^2 in British Columbia were required to achieve LEED Gold certification (UBC Sustainability, 2013).

In 2009, UBC started requiring new buildings and major retrofits to follow the UBC LEED Implementation Guide (UBC Sustainability, 2013). The Guideline requires all new buildings to comply with a mandatory LEED gold certification as well to achieve an energy performance rating of 42 percent below Canada's Model National Energy Code for Buildings (UBC Sustainability, 2013).

UBC Campus and Community Planning department is encouraging high performance and high quality built infrastructure that aligns with established regulatory green building requirements and encourages accountability through exemplary LEED ratings. LEED v4 guide provides specific direction for the UBC Vancouver Campus to implement the LEED Building Design + Construction v4 Rating Systems. It has been developed to support all UBC policy and in particular, is aligned with the UBC Vancouver Campus Plan, the Technical Guidelines and the Climate Action Plan (UBC Sustainability, 2013).

UBC LEED Implementation Guide LEED v4, kept the mandates for all new buildings to achieve LEED Gold certification, with mandatory credits specifically to UBC campus. These credits include those that require energy demand reduction compared to the baseline design (University of British Columbia, 2016).

3.1.5. Green Building Action Plan

The Green Building Action Plan, currently under development, will create a pathway for achieving net positive buildings and GHG emissions reduction goals at UBC by reducing energy demand and focusing on site specific passive design approaches.

3.2. Energy Supply Efficiency and Management

In 2009 most of the UBC campus GHG emissions were generated by the supply side of the energy systems (Metras, 2018). At that time, thermal energy came from a steam system heated by fossil fuels that generated enormous amounts of GHG emissions.

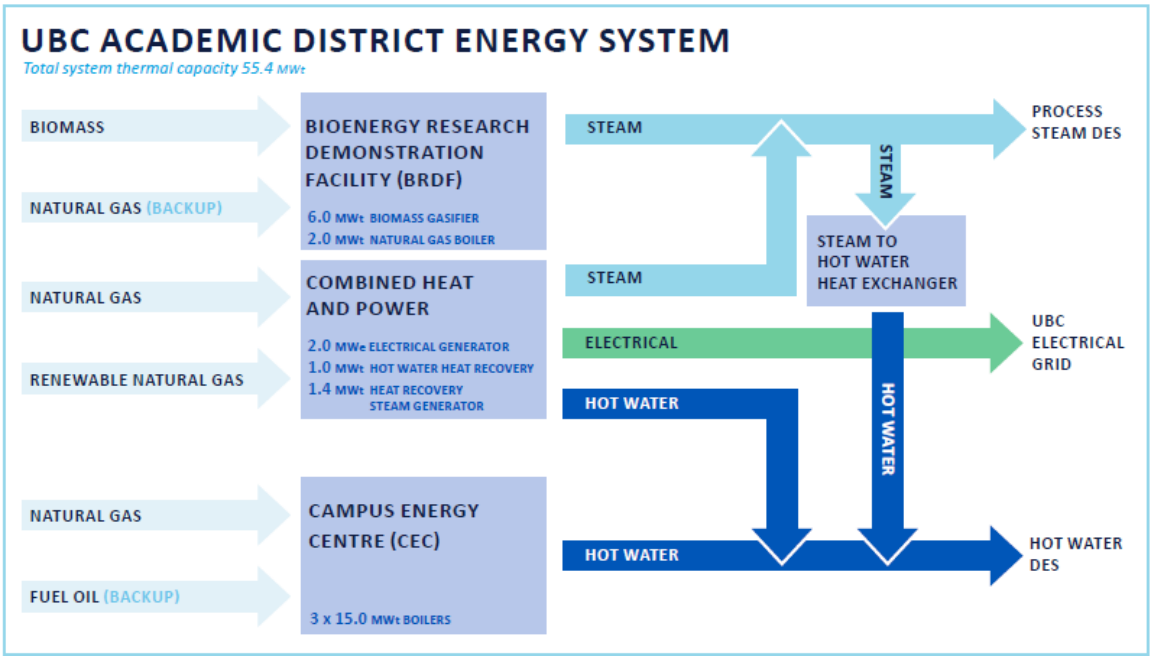
3.2.1. Academic District Energy System (ADES)

After analyzing the efficiency of the aging gas-fired steam district energy system and in an effort to reduce GHG emissions, UBC decided to replace the old system with a state-of-the-art, medium-temperature hot water system to heat up the buildings on campus.

The Academic District Energy System (ADES) Steam to Hot Water Conversion Project was conducted from 2011-2017. It replaced 14 kilometres of 90-year-old steam piping and converted more than 160 buildings off steam to a highly efficient hot water district energy system (UBC Energy & Water Services, 2018).

This project that was a result of the operational staff's drive to replace an inefficient system, which saved millions of dollars in deferred maintenance, with a sustainable alternative that supports the sustainability goals (Woodson, 2018). This transfer played a significant role in the campus GHG reduction (22% vs. 2007 levels) and laid the foundation for further key projects on the energy supply side, such as using renewable sources for heating (Woodson, 2018).

The hot water district energy system provides a versatile foundation that can be heated from different sources of energy. This allows continuous GHG emissions reduction by increasing the share of the renewable energy sources to heat the water.



Source: (UBC Energy & Water Services, 2018)

3.2.2. Bioenergy Research Demonstration Facility (BRDF)

The Bioenergy Research Demonstration Facility (BRDF) is an energy generation facility that processes renewable biomass sourced from wood waste and transforms it into synthesis gas (syngas) to generate thermal energy for heating campus buildings. In addition to the thermal system, the facility houses a biomass combined heat and power demonstration system that originally employed the syngas, after conditioning and filtering it from impurities, to fuel a cogeneration engine. (UBC Sustainability, 2018)

Biomass gave the campus a solid business case and the opportunity to partner up with the industry to explore innovative sources of energy, such as Nexterra and GE Power. Completed in 2012, the BRDF is an IDEA Innovation Award winner and the first-of-its-kind bioenergy facility in North America. This energy supply system produces renewable thermal energy with a 6 MW thermal energy boiler with a cogeneration unit of 2.4 MW, reducing the GHG emissions by 14 per cent. Today, 25 per cent of the campus' heating and hot water needs are met by using clean wood waste. This projects was another major contributor to reaching the 2015 goal for GHG emissions reduction.

The idea of using biomass to produce energy on campus first came from the Alternative Energy Supply Study. This study, which was conducted as a partnership between UBC Utilities and STANTEC, investigated different sources of renewable energy and concluded that there were three possible alternative sources: biomass, deep water cooling and heating, and heat recovered from the treatment plants near YVR airport. Given the intergovernmental dependencies, resource efficiency, and return of investment, the study concluded that biomass was the preferred clean and renewable energy source alternative for UBC space heating and hot water needs. (UBC Sustainability, 2018)

3.2.3. Campus Energy Centre

The Campus Energy Centre is a high efficiency water heating plant and distribution loop for the UBC Vancouver campus that replaced the 90 year-old steam powerhouse. The 45 MW natural-gas powered plant consists of three 15 MW hot boilers alongside a 1 MW condensing economizer. The centre is an integral part of UBC's greenhouse gas reduction program as it reduces campus emissions by 22%.The facility is the primary energy source for the new campus hot water district energy system, and it includes additional space to expand and increase capacity as future heating demands increase.

3.2.4. Energy and Water Services (EWS) Unit

As one of the 10 largest consumers of electrical energy in BC, UBC has a significant impact on energy consumption in the province—and a unique opportunity to encourage other organizations to learn from our energy management practices. (UBC Sustainability, 2015)

As UBC expanded and improved its efforts into energy demand and supply efficiency and sustainability programs, a dedicated unit was created to manage these program and projects over the past decade. These projects are mostly self-funded through the return of investment in operational cost savings. As a growing organization, EWS aims to continue improving UBC's energy consumption efficiently and to decouple energy consumption from GHG emissions resulting in the reduction of the campus impact on climate change. (UBC Energy & Water Services, 2018)

To manage the costs of these services, UBC's Energy and Water Services (EWS) Unit manages and operates UBC's utility assets, delivers utility master plans, load forecasts, and associated capital upgrades. Established in 2014, the unit mission is to generate, distribute, and conserve the Vancouver campus' energy and water resources. (UBC VP Finance & Operations, 2018)

4. Conclusion

Improving the campus energy systems and achieving GHG emission reductions through new and clean technologies has been the result of constant effort and conscious decisions from UBC leaders and champions supported by staff, faculty and students. This is also supported by government initiatives which have provided useful policy tools such as carbon taxes to redirect the economy and support the transition to clean energies. Other examples of useful policy are Policy #5, which provides guidance on how to develop campus green initiatives, and the creation of the Sustainability Office at UBC.

UBC has found a way to push forward projects like Eco TREK and BRDF by demonstrating their environmental benefits, but also through appealing business cases. For instance, the Eco TREK project generated savings up to $3M CAD per year by reducing energy use on campus by 30 per cent, and the BRDF has reduce the campus GHG emissions by 14 per cent per year.

In terms of policy, UBC has been able to condense previous experiences, lessons learned and best practices into their Action Plans (such as the Green Building Action Plan & the Climate Action Plan) to present a clear path of what actions to take to accomplish GHG reduction targets.

The University campus provides a great test bed to promote new ways to explore technologies and then implement them through innovative projects. Initiatives such as the Campus as a Living Laboratory and the SEEDS Sustainability program promote ideas and a positive feedback loop between industry, academics and students that together set the pathway for a sustainable future.

In addition, these are further areas of research that could complement the study of energy infrastructure at the UBC Vancouver campus and help explain the enablers for innovation and campus sustainability. First, a more in depth review of the interactions between departments and how they work together to achieve sustainability goals. Second, an analysis of how UBC leaders plan to continue pushing and improving campus sustainability. And third, enable and encourage research on new technologies that can be implemented such as smart grids, and future renewable sources for the ADES, including the BRDF expansion.

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Appendix 1: Interviews Transcripts

Not to be disclosed

Appendix 2: Timeline

Not to be disclosed

Appendix 3: SEEDS Projects related to Energy Infrastructure on campus

1. Building Water Consumption & Benchmarking Analysis

Author(s): Michael McBurnie

Course: PLAN 527A

Themes: Buildings, Finance, Water

Date: February 26, 2018

2. Exploring the Potential of Wi-Fi Occupancy Data

Author(s): Kevin Chen, Zeshan Nurani

Course: PLAN 528A

Themes: Buildings, Climate

Date: March 15, 2018

3. Options for EV Charging Infrastructure Requirements for New MURB Construction on the UBC Campus

Author(s): Borui Yang

Course: APPP 506

Themes: Energy, Buildings, Transportation

Date: December 13, 2017

4. AMS/SEEDS Energy Producing Mobile

Author(s): Andrew Clayton, Nerine Law, Diana Nino, Christopher Yik Bing Hii

Course: MECH 457

Themes: Energy, Community

Date: April 11, 2018

5. An Investigation into: Energy Monitoring

Author(s): Brad Burt, David Slade, Kevin Lowe

Course: APSC261

Themes: Energy

Date: November 30, 2010

6. Thermal Energy Demand Indices Targets for UBC non-DES Classroom/Office Archetype

Author(s): Xicheng Gong

Course: Capstone Project & APPP 506

Themes: Buildings, Climate, Energy

Date: December 19, 2016

7. Building Energy Benchmarking for UBC Neighbourhood MURBs

Author(s): Joshua Power

Course: VOL 500

Themes: Buildings, Energy

Date: January 29, 2016

8. Energy Savings & GHG Reductions through behavior change programs

Author(s): Monish Pawar

Course: VOL 500

Themes: Community, Energy

Date: July 31, 2016

9. Energy Conservation Measures for Existing UBC Buildings

Author(s): Manojkiran Casilingam

Course: APSC 410

Themes: Climate, Energy

Date: September 10, 2015

10. UBC transition from steam to hot water district energy: alternatives for addressing MacMillan's steam orphanage and UBC's absorption chillers

Author(s): Brenda Scott Castro

Course: CEEN 596

Themes: Climate, Energy

Date: April 17, 2013