UBC Social Ecological Economic Development Studies (SEEDS) Student Report

Demand Side Strategies for Energy Efficiency in University of British Columbia Residences

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DEMAND-SIDE STRATEGIES FOR ENERGY EFFICIENCY IN UNIVERSITY OF BRITISH COLUMBIA RESIDENCES

Phase 5: Synthesis Report

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Executive Summary

The University of British Columbia (UBC) is currently retrofitting its district heating system to reduce its greenhouse gas emissions and energy needs. Despite improving its energy efficiency, UBC still faces constraints in peak load energy consumption, due in part to its ambitious plan to increase the number of students living on campus by nearly 65% in just 15 years. UBC's Student Housing and Hospitality Services and Campus Sustainability Office have therefore asked for an investigation into demand-side energy consumption reduction strategies, specifically for the new student residences to be built at the Ponderosa Commons.

Five such strategies are assessed in this study: (1) the use of normative messaging to influence residents' energy consumption behaviour, (2) an energy quota and rebate program, (3) an energy saving contest, (4) a voluntary agreement program, and (5) provision of clothes drying racks in each unit. The options are evaluated using an assessment framework that weighs energy efficiency criteria above all else, followed by economic feasibility, educational contribution, and social contribution and equity. Potential reductions in electricity and hot water consumption are used as indicators for evaluating energy efficiency. Estimated costs are compared to cost savings in a return on investment analysis as an indicator of economic feasibility. In order to assess the educational contributions of an option, the research potential and level of engagement associated with each option are also considered. Finally, potential participation rates, contribution to social capital, and social equity are taken into account.

The energy quota and rebate program is considered the least effective option, yielding relatively minor reductions in electricity consumption, low participation rates, and lacking any significant educational component. Although the option could potentially pay for itself with its projected cost savings, there is much uncertainty associated with its financial projections. The contest option would likely become a net expense for UBC, even after taking into account energy cost savings. Furthermore, its potential energy savings are calculated to be low relative to the other options. However, due to a high projected participation rate and a powerful interactive and educational component, the option is still considered to have good potential.

The voluntary agreement program and normative messaging options are predicted to produce substantial reductions in energy consumption and potentially high financial returns due to low initial capital cost. Moreover, they both feature an educational component and foster social equity. The key difference between the two options is the greater research potential offered by the voluntary agreement program.

While not overtly educational, the drying rack option offers the greatest financial certainty, with a moderate (relative to the other options) predicted return on investment. Reductions in energy consumption are predicted to be on the high end of the spectrum, as are participation rates.

As a result of this analysis, we strongly recommend the provision of clothes drying racks to residents of the Ponderosa Commons. We also recommend the further exploration of a voluntary agreement program and energy saving contest to encourage energy conservation and engage student residents in an educational process. We believe that normative messaging would complement the implementation of our other options.

1. Introduction

While UBC originated in 1914 as a small, rural campus far removed from the city of Vancouver, it has since grown together with the city, with 8,500 of its roughly 48,000 students living on the campus as of 2010. On-campus student housing is expected to increase to 14,000 beds by 2025 (UBC 2010a). To accommodate these increases, UBC expects to add 374,000 square metres of new living space (Robinson 2012). In an effort to ensure that the Ponderosa Commons, a future project which will be built in three phases beginning in 2011, adheres to UBC's sustainability goals, the students of APSC 364 (Applied Sustainability – UBC as a Living Lab) worked with UBC operations staff to identify barriers to the adoption of sustainable behaviour in the new residences and discover potential solutions that could be adopted in the new buildings.

UBC has made sustainability the foundation of its vision for the future and recognizes that increased energy efficiency and decreased consumption will be vital to achieving its goal of reducing its GHG emissions to 33% below 1997 levels by 2015 (UBC 2010a). UBC's main energy sources—natural gas and electricity—respectively provide roughly 52 and 48% of the energy used by UBC's residential buildings (Storey 2012). The steam system, used to heat campus buildings and water, is the single biggest consumer of natural gas at UBC (Stantec Consulting 2010). UBC is currently in the process of converting the existing steam system to a hot water heating system that will reduce greenhouse gas (GHG) emissions by 22%, reduce energy costs by up to four million dollars annually, and allow UBC to leverage emerging energy technologies. Construction of UBC's new Bioenergy Research and Demonstration Project is also underway; this facility is expected to reduce UBC's GHG emissions by a further 9% by decreasing natural gas consumption (Robinson 2012).

The university itself is the primary body regulating residential buildings on campus, mandating that any new campus residential building must meet the standards of UBC's own Residential Environmental Assessment Program (REAP) which has more stringent sustainability standards than any other applicable provincial or federal code (UBC 2012a). REAP also regulates energy use (UBC 2009a).

The student residents of Ponderosa Commons will greatly influence the building's energy consumption. They will have control over their energy consumption via use of light switches, thermostats, and power outlets; access to operable windows; and the length of their showers. UBC has programs in place that aim to encourage sustainable behavior in students and staff through its Campus Sustainability Office, Sustainability Coordinators, and Residence Sustainability Coordinators (students living in residences hired as coordinators to set positive examples and coordinate student activities that promote energy conserving behaviours). This last initiative has not only saved the campus an estimated $75,000 annually by reducing energy use, but has also provided valuable networking, learning, and leadership opportunities for students (UBC Campus Sustainability Office 2009).

Students, faculty, staff, and visitors will be most affected by new energy efficiency measures. For example, in student residences, changes such as light conservation through motion sensor fixtures may compromise students' sense of security while moving around campus at night (Henderson 2012; Kiloh 2012). The needs of all stakeholders must be considered in the selection of energy conservation initiatives.

Many benefits may also result from energy system changes. As Roseland (2005) notes, *Sustainable campus communities are likely to be cleaner, healthier and less expensive; to have greater accessibility and cohesion; and to be more self-reliant in energy, food, and economic security than they are now. Sustainable communities are not merely about 'sustaining' the quality of our lives – they are about improving [them].*

On-campus sustainability initiatives may not only facilitate education and formation of sustainable habits, but may also create a stronger sense of unity and teamwork within the university community. Vancouver and the region as a whole may also benefit from a reduction of GHG emissions and more efficient use of natural resources. Finally, if changes in UBC's energy systems prove to be economically viable, other universities, city planners, and developers outside the immediate area may be persuaded to engage in similar actions, to the benefit of their own local environments and populations.

2. Option Assessment Methodology

2.1 Overview

Five options were initially proposed as possible demand-side energy solutions for Ponderosa Commons. These were: (1) the use of normative messaging, (2) an energy quota and rebate program, (3) an energy saving contest, (4) a voluntary agreement program, and (5) provision of clothes drying racks in each unit. In order to assess these options, a set of criteria and indicators was developed to evaluate each option in four major areas:

- energy efficiency;
- economic feasibility;
- educational contribution; and
- social contribution and equity.

Indicators were selected to measure the potential performance of the options in each of these four areas. Sections 2.2 to 2.5 present an overview of this assessment framework, and the full criteria and indicator matrix is presented in Appendix H. The proposed options themselves are described in Chapter 3. Analysis of the five options, utilizing this framework, is presented in Chapter 4, and a summary and ranking of options is provided in Chapter 5.

2.2 Energy Efficiency

In line with the principal goal of the entire project and with UBC's ambitious commitment to become energy positive in less than four decades (UBC 2010b), it was deemed appropriate that successful options must demonstrate quantifiable potential for increasing the energy efficiency of Ponderosa Commons. Two steps were taken in order to calculate the energy consumption reduction potential of each option:

1) Through a literature review, a set of relevant case studies was collected that quantified actual or predicted energy savings resulting from initiatives similar to the five proposed options.
2) The energy savings obtained through each of these initiatives was considered (giving precedence to those initiatives with direct relevance to UBC and the options under evaluation) and a conservative estimate of the potential annual energy savings afforded by each of the five proposed options was made and compared against baseline energy

model data provided by UBC Properties Trust, and Campus Sustainability (Ehret and Hepting 2011).

2.3 Economic Feasibility

Recognizing that cost would be a key consideration to UBC decision-makers, the economic feasibility of the proposed options was assessed using a return on investment analysis, which took into account the potential for savings through the energy efficiency predicted by the calculations described in Section 2.2. Options were judged to be more successful if they were associated with reasonable costs relative to their potential for cost savings (stemming from energy conservation).

2.4 Educational Contribution

As UBC has asserted its vision "to provide integrated learning opportunities that result in the development and implementation of climate change solutions" (UBC 2010b), the potential for each option to provide such an opportunity was evaluated using three different criteria.

First, the options were rated on a three-point scale, from offering no opportunity for new avenues of study to offering high academic research potential. Second, another dimension of the options' educational contribution was examined by considering the educational value of the option to residents of the Ponderosa Commons. Options were considered successful if they presented the potential to educate and influence the energy usage habits of residents. Third, as initiatives with an interactive component have shown to be more effective in motivating energy-saving behavior than comparable passive measures (Becker 1978), such options were considered to have greater educational contributions.

2.5 Social Contribution and Equity

The proposed options' potential for social contribution and social equity was evaluated using three different criteria.

First, further to UBC's pledge to "support the campus community in energy management activities," to "encourage energy-conserving behaviours" in students (UBC 2010b), and to support UBC's performance in external benchmarking programs such as STARS (AAESHE 2012) by engaging students in sustainability-related outreach, the potential for student participation in each proposed option was considered. Estimated participation rates were calculated using a similar method to that employed to calculate energy efficiency. Through a literature review, a set of relevant case studies was collected that reported on actual or predicted participation rates for initiatives similar to the five proposed options. Participation rates for each initiative were then considered (giving precedence to those initiatives with direct parallels to UBC and the options under evaluation) and a conservative estimate of the potential annual student participation rate for each of the five proposed options was made.

Second, social equity was determined to be an important consideration, as real or perceived inequity might provoke a public backlash that would undermine the intention of the options. For this reason, successful options were considered to be those that did not privilege wealthy residents.

Third, while the main goal of the project is to influence energy consumption behaviours, the promotion of social well-being was deemed a desirable side effect. Thus, options were considered preferable if they could be demonstrated to promote social interaction by engaging the residents with one another and with the larger community.

3. Proposed Options

This chapter describes five potential demand-side strategy options to promote energy efficiency at Ponderosa Commons. Evaluation of the options, together with recommendations to UBC, can be found in Chapter 4.

3.1 Normative Messaging

Many people say they value sustainability, but frequently act in direct opposition to these beliefs. This "value-action gap" may result when people encounter perceived behavioral barriers, which can be overcome using normative messaging (Black, Davidson, and Retra 2010). Messaging norms may be injunctive or descriptive. Descriptive norms refer to the most common behaviours exhibited by a society; injunctive norms refer to behaviours of which a society either approves or disapproves. Normative messaging involves aligning both descriptive and injunctive norms to work together instead of against one another (Cialdini 2003). A message with norms in opposition may say, for instance, that "because Canada's CO_2 emissions per year far exceed sustainable levels, we should reduce the amount of energy we use" (this reinforces that the normal behaviour is highly consumptive and inadvertently motivates people to conform to it at the same time as telling them to conserve energy). Positive normative messaging may instead point out that a growing tide of people conserve energy and save money as a result, encourage the reader to do the same, and provide information on how to achieve a similar result.

<u>High-level Cost Implications</u>

Minimal capital costs would be incurred from implementing this option. However, there would be an initial time investment on the part of UBC staff and residence monitors to research and craft effective normative messages plus costs associated with whatever type of educational campaign was undertaken.

<u>Potential Environmental Impacts and Co-benefits</u>

The use of normative messaging to create behavioural change has great potential. While there has been some initial research on how it can be used to increase household recycling (Goldstein, Cialdini, and Griskevicius 2008) or reuse of hotel towels (Goldstein, Cialdini, and Griskevicius 2008), using normative messaging to change young adult energy consumption behaviour has not been well-explored. This opens up possibilities for future research by sociology or sustainability students on the UBC campus; in fact, the authors of one study stress the need for further research (Goldstein, Cialdini, and Griskevicius 2008) into all aspects of how the use of norms can change human behaviour.

Because little research has gone into using messaging to change behaviours specifically around energy consumption, it is difficult to predict how much of an impact using normative messaging will have on student residents in Ponderosa Commons. Precedents show that using normative messaging by itself can be expected to improve adoption of other sustainable behaviours by 2 to as much as 28% (Goldstein, Cialdini, and Griskevicius 2008; Schultz et al. 2007; Nolan et al. 2008; Cialdini 2003).

While messaging can change behaviour on its own, we suggest layering this approach over other initiatives to be implemented at Ponderosa Commons (for example, the drying rack option described in Section 3.5). Messages must be carefully crafted to ensure that they do not reinforce negative behaviours, and that they adhere to the principles of normative messaging. Some examples of normative messaging used to promote three of our other options are presented in Appendix I.

<u>Research and Academic Potential</u>

The effects of normative messaging on rates of household recycling have been researched, as have some of the impacts of normative messaging in student residences. However, there are still case study opportunities to conduct research on how normative messaging could be combined with other more concrete options and in determining levels of reductions in energy consumption that may be achieved.

<u>Affected Stakeholders and Potential Controversy</u>

UBC staff charged with creating educational materials, residence monitors, and student residents are the mostly likely to be affected. It is unlikely that this option will create substantial controversy as long as issues regarding sustainability are dealt with in an inclusive fashion. For example, acknowledgment of the downside to each positive example such as colder rooms or shorter showers should be made and weighed against the benefits.

3.2 Energy Quota and Rebate Program

In this option, quotas for energy consumption would be set at the beginning of each year for student residents of the Commons. Students would then be offered financial incentives to reduce energy usage to levels below the predetermined quota and would potentially receive penalties for exceeding it. A similar system was suggested by researchers at Rhodes University, modelled on its existing cafeteria rebate program, as a response to the South African energy crisis (Rickerts et al. 2007). Such a policy would involve a sum to be paid by each tenant at the beginning of the year, which would later be returned as a rebate. This sum would be communicated to students as an "environmental damage deposit."

This option would require the separate metering of each unit (known as submetering) in the Commons. Prior studies, both in and out of the university setting, have shown that receiving feedback about personal energy use encourages residents to reduce energy consumption (Petersen et al. 2007; Grønhøj and Thøgersen 2011; Darby 2008). While UBC operations staff have confirmed that submetering capabilities are planned for the Ponderosa Commons, it is still unclear exactly what the scale of implementation will be.

<u>High-level Cost Implications</u>

Incorporating submetering capabilities into the construction of the Commons would be costly. One model of in-suite meter, the PowerCost Monitor, retails for about $120 per unit (Energy Center of Wisconsin 2010); even without the infrastructure required to support the system and aggregate data, the cost for the entire Commons would be nearly $100,000. However, if submetering were incorporated into the development (as planned), the costs directly associated with this incentive program would be relatively minor. Most work associated with implementation—such as educating residents on how the program works and how to maximize their energy conservation—could be handled by student volunteers passionate about sustainability. Nonetheless, human resource services needed to attract and recruit the appropriate volunteers as well as bookkeeping and administrative services associated with the calculation and disbursement of rebates would have to be considered (for estimates of these costs, see assumptions in Appendix G).

Potential Environmental Impacts and Co-benefits

The environmental impacts of student conservation would be reduced electricity and natural gas usage, with associated reduction in greenhouse gas emissions, depending upon whether or not the majority of students stayed under their quotas.

A demand-side reduction in energy consumption would move UBC further towards its goal of energy self-reliance. Furthermore, linking financial incentives to actual electricity consumption would promote a fair distribution of energy fees, accountability, and conservation to tenants (Mane 2005).

Research and Academic Potential

UBC students would have an opportunity to participate in research to calculate the optimal levels of energy consumption to be set as quotas for the following year. Research could also be carried out to determine the optimal structure of these quotas to best suit the needs and goals of both students and the university.

Stakeholders and Potential Controversies

The key stakeholders for this option would be the student residents of the Ponderosa Commons and UBC, as the owner. A penalty system for students exceeding the quota would likely cause many students to resent the initiative and could pose a serious burden to those on a tight budget. If the program strictly offered rebates to those whose consumption fell below the quota, no controversy would be expected.

3.3 Energy Conservation Contest

Educating on the various practical means of energy conservation is critical to altering the behaviour of Commons residents; providing incentives to capture their interest is equally important. An energy conservation contest would serve both these goals, and could be accomplished in one of two ways: (1) real-time data on energy consumption collected through submetering could be used to determine the lowest energy use (by Commons unit, by floor, or by tower, for example), or (2) Commons students could submit their ideas on innovative energy saving measures, as was carried out at Rhodes University for a grand prize of $1,000 (Rickerts et al. 2007).

High-level Cost Implications

As noted in the discussion of the previous option, submetering would be costly; however, it would provide the best means for engaging students in an energy saving contest. As submetering is already planned for the development, these costs would have no bearing on implementing an energy saving contest. The contest itself might require sponsors to provide monetary incentives to the contest winners as well as pay for some basic administrative costs. Alternatively, these expenses would have to come out of UBC's budget. Costs to attract and recruit student volunteers with an interest in sustainability would have to be considered as well (for estimates of these costs, see assumptions in Appendix G).

Potential Environmental Impacts and Co-benefits

The environmental impacts of student conservation efforts during the contest would be reduced electricity and natural gas usage, with associated reduction in greenhouse gas emissions. These impacts would be positive, with significance depending on the number of students involved, and may even persist for a time after the contest has concluded.

A co-benefit of this option would be widespread education on energy conservation throughout campus during the competition. If successful, the scope of the contest could expand to other UBC residences.

Research and Academic Potential

It has been demonstrated that campus residence buildings are prime locations to influence student behavior, as their occupancy remains constant throughout the year, as opposed to the ever-changing flow of students in and out of academic buildings (Petersen et al. 2007; University of Maryland 2009). Such a setting provides a good opportunity for researchers to experiment with different incentives and types of conservation competitions. Students could also be put in charge of designing a website to display energy consumption data and analyzing the results of the competition.

Stakeholders and Potential Controversies

Students would be the main stakeholders involved in this option, as they would be the researchers designing the competition, the contest participants, and the evaluators of results. UBC would also be a key stakeholder as it is planning to install submetering infrastructure at Ponderosa. As there is a cash prize involved, controversies could potentially arise from perceived injustices in the methodology used to determine the eventual winner or winners.

3.4 Voluntary Agreements

A program would be developed for the Commons that would facilitate voluntary commitments from residents to reduce or control their energy usage. The program could be ongoing and be run and supported by the residence staff, who would provide information and monitoring. Commitment would be made via signed agreements. An important feature would be giving residents the opportunity to be directly involved in creating their own unique plans for controlling their energy usage.

Voluntary agreements have documented successes within a long industrial history (Price 2005; Howarth, Haddad, and Paton 2000). Different challenges are expected in the implementation of such a program in a residential situation, but it is hoped that the behavior change achieved in an industrial setting will translate. Related programs, such as voluntary recycling in households, have been successful (Werner et al. 1995), suggesting the basic idea is transferable.

High-level Cost Implications

No significant material costs are associated with the proposed program, other than the human resources to plan and manage it. Residence staff would establish the agreements and provide monitoring and feedback to the residents. With a network of residential advisors already in place in UBC dormitories, most of the human infrastructure needed to coordinate these commitments already exists. Baseline costs for maintenance of the program is estimated at approximately $2,000 a year (see assumptions in Appendix G).

Potential Environmental Impacts and Co-benefits

The goal of the voluntary agreement program is primarily to reduce electricity usage in the residence units. Residents achieve this through usage targets and savings techniques, developed themselves with the aid of residence staff, to hit goals for energy consumption within their units. A leading voluntary agreement program in the United States industry sector, Green Lights, saw participants reduce their lighting usage by as much as 40% (Howarth, Haddad, and Paton 2000). Considering their strong potential for energy conservation and the low cost of implementation, voluntary agreements provide a unique long-term option for positive environmental change.

Voluntary agreement programs are unique among inducements to behavior change because they promote long-term change. With more directly external inducements such as competitions or rewards, behavior tends to revert back to previous levels after the motivations are removed; voluntary agreements offer an alternative method that fosters sustained change (Werner et al. 1995). Thus secondary benefits include fostering long-term environmentally sustainable behavior and thus providing an educational benefit. It is suggested that there may be a synergistic benefit to initiating a voluntary agreement program at the conclusion of an energy savings contest: the university may capitalize on the momentum started by the contest and extend newly learned sustainable behaviours among those who participate in the voluntary agreements.

Research and Academic Potential

The proposed program does not have a direct precedent in a university setting, and therefore represents an opportunity to trial a new type of energy saving program and add to the body of research on voluntary agreements.

Stakeholders

Stakeholders would include student residents, residential monitors, and UBC staff tasked with facilitating and monitoring agreements.

3.5 Clothes Drying Racks

Of all major household appliances, clothes dryers are among the largest energy consumers. Even newer models consume an average of 921 kilowatt hours per year (kWh/yr) compared to the next largest consumer, self-cleaning stoves, at 521 kWh/yr (NRCan, 2011; see Appendix B). In the current design of the Ponderosa Commons buildings, mechanical dryers are the only built-in option for drying laundry. To provide students with an alternative to mechanical dryers, UBC could provide each Commons unit with wall- or ceiling-mounted drying racks. Use of the drying racks could be promoted within the Commons via a poster campaign incorporating normative messaging (see Section 3.1).

Positioning drying racks in every unit will make air-drying clothes more convenient than making additional trips to the laundry room (especially for residents of some of the higher floors), and will save students money on each load of laundry. Other advantages for residents include (1) not having to wait for an available and functioning machine, (2) not having to worry about privacy or the security of clothing left in a communal space, and (3) greater longevity for garments, particularly delicate fabrics.

High-level Cost Implications

The Commons will comprise 796 residential units (Kuwabara et al., 2011a, 2011b; UBC Board of Governors, 2011). Appendix C contains some examples of potential drying racks, which retail individually for between $25 and $100. Assuming a 25% discount could be obtained via bulk purchasing, the capital cost for these racks would be between $14,925 and $59,700. The potential energy savings of 68,942 kWh/yr (discussed more fully in the following section), at current electricity prices of about $0.058/kWh (Stantec Consulting 2010) would equate to cost savings of just over $4,100 annually. The capital cost of the drying racks could therefore be recovered via energy savings alone in between 4 and 14 years. Additional savings may result from reduced wear-and-tear on the Commons' machine dryers, or (if the drying rack program is extremely successful) reducing the number of dryers leased for the building.

While UBC collects revenues from the company that leases the appliances, laundry amenities are for the comfort and convenience of student residents, and the money collected is intended to offset the cost of keeping the machines in place and not as a revenue stream (B. Heathcote pers. comm; Coinamatic 2011). It is suggested (though, for simplicity's sake, not incorporated into the cost analysis in this study) that a potential means to both further encourage drying rack use and recover some of the resultant revenue losses would be to increase the cost of each dryer cycle, perhaps from $0.65 to $1.00. Dis-incentivizing an undesirable behaviour while simultaneously providing a sustainable alternative has a proven track record at UBC, as illustrated by the successful implementation of the U-Pass program (which was introduced in conjunction with more limited and costly parking).

Potential Environmental Impacts and Co-benefits

At 100% occupancy, the Commons will house 1,116 students (Kuwabara et al., 2011a, 2011b; UBC Board of Governors, 2011). At UBC's average of about four loads of laundry per month (Coinamatic 2011), students will generate an estimated 53,568 loads of wet clothing each year. According to BC Hydro (2012) data, drying that laundry mechanically in the Commons' laundry rooms could consume 208,915 kWh/yr. If use of drying racks could replace one-third of these dryer loads, this measure may reduce energy consumption by 68,942 kWh/yr (full calculation is provided in Appendix C). Additional energy would be saved by reducing student elevator trips to and from the Commons laundry rooms.

The drying rack models presented in Appendix C are all available for purchase locally, but many of the cheaper models are made overseas from non-renewable resources. The most expensive model has the advantage of being manufactured in North Vancouver from locally milled Forest Stewardship Council certified Douglas fir (Hogan 2012). The indirect environmental impacts resulting from the manufacture and transport of drying racks would vary depending on the model of rack selected, but would likely be far smaller than that of machine dryers.

A potential environmental co-benefit would be to encourage the practice of air-drying clothes in the greater community as students leave UBC. According to Statistics Canada (2011), 57% of BC households currently air-dry at least some of their clothing. While many residents will come from outside BC, this statistic can perhaps be taken as indication that many Commons residents will arrive with established habits of air-drying some clothes. Although it is acknowledged that cultural norms (for example, associating hanging laundry with poverty) may be a barrier for some students, a subset of these residents may become motivated to use drying racks out of a desire for convenience, privacy, or economy; out of the greater environmental awareness gained while at UBC (potentially prompted by the normative messages contained in the poster campaign); and/or because of the new conforming influence of the neighbours or roommates they see using the racks. Provision of drying racks will thus serve to reinforce desirable established behaviours in some students and encourage more students to adopt those behaviours.

Stakeholders and Potential Controversies

The primary stakeholders for this option would be the student residents themselves. As the drying racks would not have a large physical footprint within the Commons' units, they would be useful to those students who chose to use them without inconveniencing other students.

A common concern with indoor clothes drying is the concomitant humidity and risk of mould and mildew. However, the Commons' design features a well-distributed air circulation system with a central make-up air unit serving fresh air directly into suites and corridors (Ehret and Hepting 2011). In a meeting with UBC operations staff on March 1, 2012, it was suggested that this system should mitigate any in-suite moisture from drying clothes.

4. Analysis and Recommendations

This chapter evaluates the proposed options presented in Chapter 3 using the assessment framework described in Chapter 2. The full option evaluation matrix is provided in Appendix H.

4.1 Normative Messaging

When pricing out the normative messaging option, it was assumed that no educational messages were currently planned. We estimated printing 500 posters: one small, full-colour poster per residence unit, plus larger ones for common areas (for both Phase 1 East and West) and enough to replace those lost or damaged. If there are existing plans for educational media in place already, then the poster costs can be omitted and the messages incorporated into other educational materials. Accepting these assumptions, there is a high cost benefit to normative messaging in addition to its valuable educational component. However, normative messaging compares less favorably to other options as it is a passive system and does not feature an interactive component, making it very difficult to estimate how many students will participate in and be affected by the measure.

4.2 Energy Quota and Rebate Program

While possessing limited research potential, this option presents an opportunity to experiment with an energy quota/rebate program to take full advantage of UBC as "Living Lab." However, as UBC has made a commitment to lower housing fees (UBC 2010b), increases in fees or in energy consumption quotas could spur serious backlash from students and put those on tight budgets in an unfair position. The educational component for participating students would be minor, especially to those who do not pay any of their own school fees. Moreover, the option seems inequitable as a whole; for example, students with higher disposable incomes may eat out more often and therefore use less energy in their rooms.

Overall, a relatively small proportion of Ponderosa Commons residents would be likely to participate in a rebate program, based on the past performance of similar programs. Furthermore, social interactivity does not play any role in this option. Compared with the other options, a rebate program would likely yield a smaller reduction in electricity consumption than voluntary agreements, drying racks, and normative messaging, but a greater reduction than a three-week energy saving competition. This option is expected to provide savings that are virtually equal to the costs of implementing it (assumptions presented in Appendix G).

4.3 Energy Conservation Contest

An energy conservation contest provides a practical approach to energy reduction as it engages students and fosters a common social experience based around learning. Another intangible benefit of such a contest is its research potential when integrated with normative messaging (as a means of promoting the contest) and on incentives for students. The participation rate for a three-week contest is expected to be high, engaging half of the students in residence. Moreover, this rate is likely to increase as the scope of sustainability teaching expands throughout the university. Despite having the lowest impact on electricity consumption of the five options, a contest could have the added benefit of reducing hot water consumption; the length of the contest could also be extended to increase its impact. Unfortunately, similar to a rebate program, those with higher incomes are best positioned to do well in a contest through measures such as eating out. Furthermore, student volunteers or administrators in charge of the competition would be required to seek outside sponsors for prizes for contest winners in order to avoid a financial loss, and due to the amount of effort required for planning and executing a contest each year, maintaining enthusiasm and momentum for the program year over year presents a significant challenge.

4.4 Voluntary Agreements

A voluntary agreement plan is attractive in terms of both cost and energy savings. However, estimated participation rates are low (see Appendix E for detailed analysis) and there is no prior data from which to draw any concrete estimates of performance. The option presents perhaps the most potential for new research, being the only option presented with no direct university precedent found. It also features an interactive educational component, making it valuable beyond its bottom-line energy impact. Because of its low cost and relatively simple implementation, it could be valuable as a program that runs in addition to a more impactful initiative. Due to its low participation and uncertain nature, however, it is not recommended that this be pursued as a primary feature of the energy savings/education component of the residential space.

4.5 Drying Racks

While presenting only modest research potential to academics, provision of drying racks in Ponderosa Commons will provide student residents with a low-tech, constantly visible, and easily accessible alternative to machine drying. Exposure to drying racks may be educational to those residents with no established habits of air-drying clothes, which is less prevalent in BC than in the rest of Canada (Statistics Canada 2011). Based on the enthusiastic response to a similar measure proposed at several other universities (Ashworth et al. 2007; Kupatt, Scandella, and Waters 2012; Hodge 2009; Deamer et al. 2010), and on the fact that this option will place a drying rack in each student's living space, participation—in the form of drying rack use—is anticipated to be high (65%). By eliminating approximately a third of Ponderosa Commons dryer cycles, this option is expected to provide energy savings of 68,942 kWh annually, or about 3.3% of the Commons' annual electricity consumption. Economic return on investment for this option will depend on the model of drying rack selected (see Appendix G for calculations based on the cheapest and most expensive drying rack models).

5. Summary and Options Ranking

The goal of this study was to research and analyse a selection of demand-side strategies to reduce energy usage among residents in a university dormitory. In doing so, five methods were selected for analysis. These were: (1) a normative messaging program, (2) an energy quota and rebate system, (3) an energy conservation contest, (4) a voluntary agreements program, and (5) a program providing clothes drying racks. A set of indicators was created to measure the five methods on their performance and benefits in order to reasonably report their value. The options were assessed according to four areas: energy efficiency, economic feasibility, educational contribution, and social contribution and equity. Each of these areas was deemed to contribute to the overall desirability and effectiveness of each option.

Based on the results of the analysis, providing drying racks stands out as the most viable and impactful option among the five. It alone can be reliably measured in terms of cost and return on investment because the costs and benefits are the most straightforward and clearly defined (all other projections are subjective estimates with more assumptions taken). It has a concrete set of precedents to evaluate. Finally, it scores the highest in terms of potential energy savings and participation (see Figures 5.1 and 5.2). For these reasons, providing drying racks ranks as the most desirable option.

As secondary options, normative messaging, energy conservation contests, and voluntary agreements all contain value in their educational components, interactivity, and potential energy savings. Each option has significant limits, however, and may perform better in conjunction with a more substantive program, such as the drying racks option. Normative messaging, in particular, would be very valuable used alongside the drying racks option, both to promote it and to provide an educational component.

An energy quota and rebate program ranks as the least desirable of the five options. It presents substantial problems, most notably its low participation rate and social inequality concerns.

Figure 5.1. Estimated Student Participation Rates

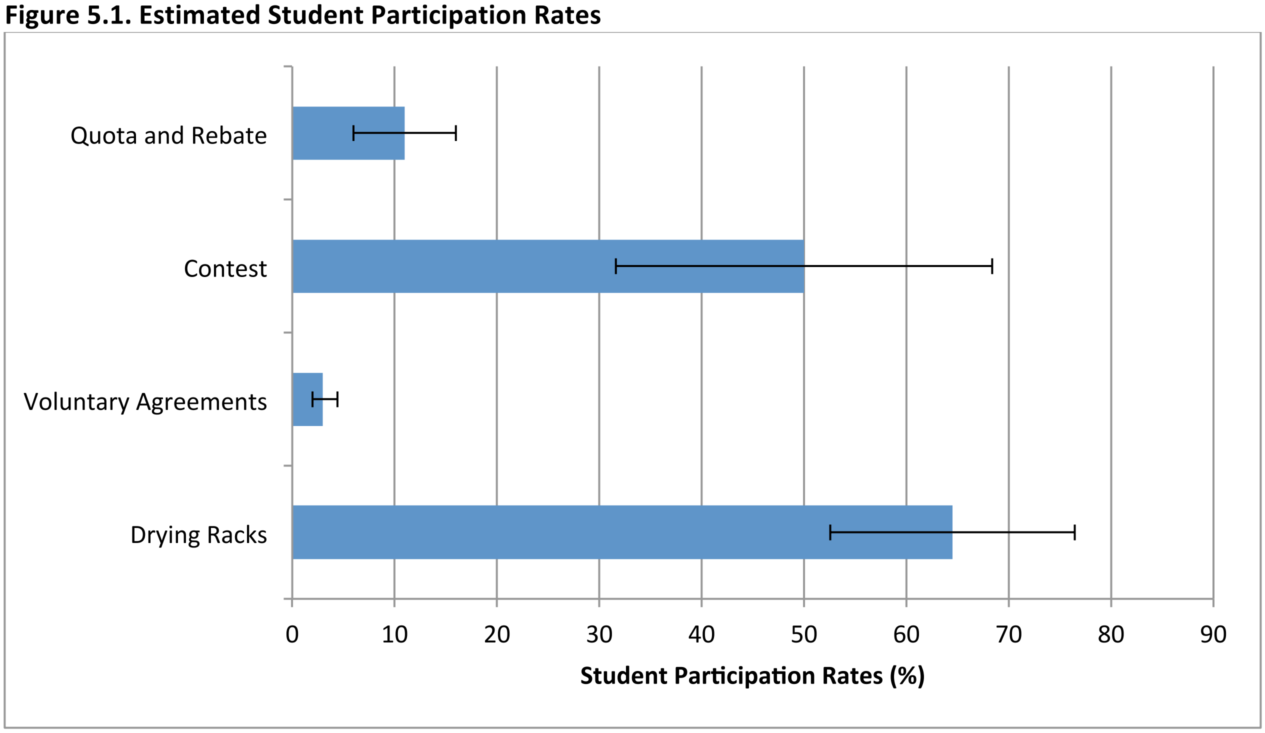
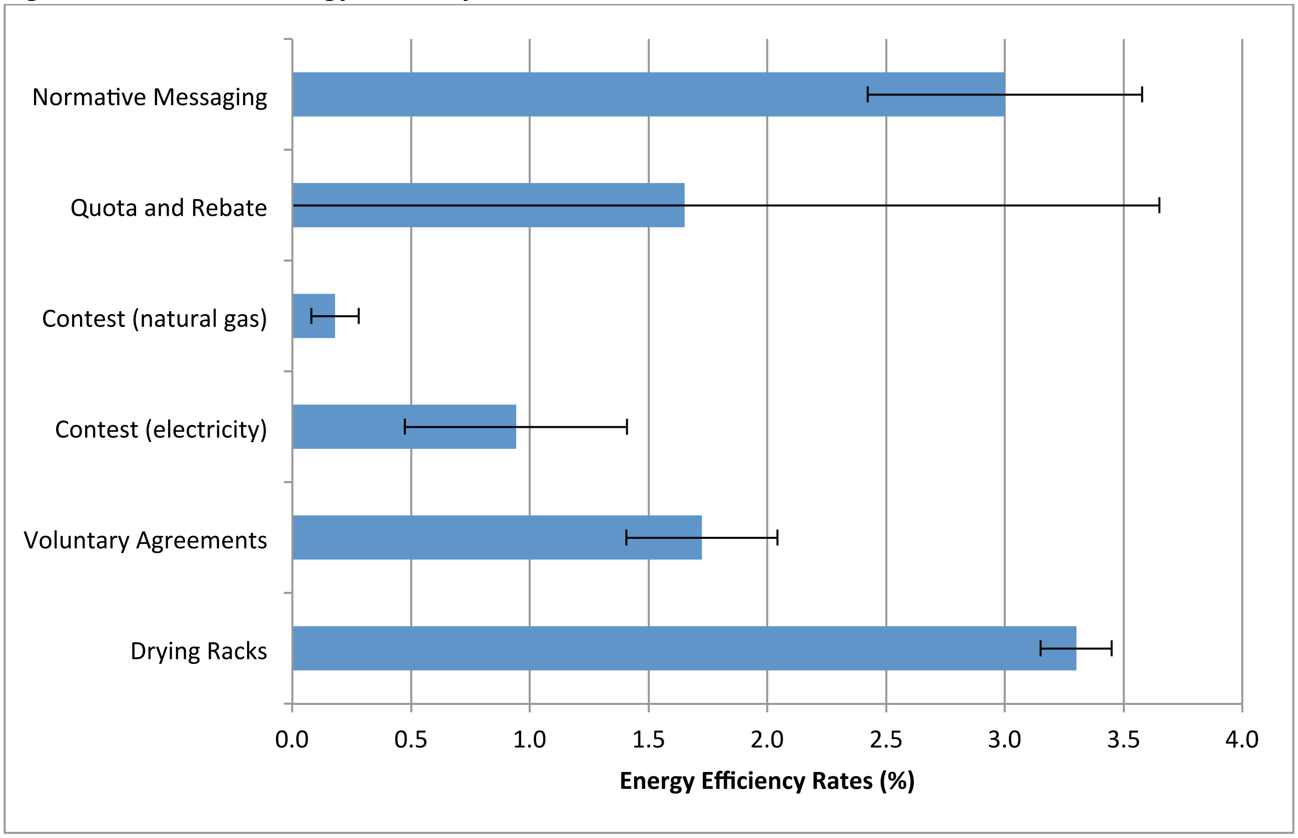


Figure 5.2. Estimated Energy Efficiency Rates



Appendix A
Summarized Baseline Energy Consumption Data for Ponderosa Commons

Annual Energy Consumption by End Use[1]	kWh
ELECTRICITY	
Cooling	40,000
Heating	384,000
Lights	683,000
Equipment (including clothes dryers)	584,000
Fans	322,000
Exterior lights	42,000
Elevator	58,000
Subtotal	**2,113,000**
NATURAL GAS	
Heating	424,000
Domestic hot water	361,000
Subtotal	**785,000**
Total annual energy consumption	**2,898,000**
Annual GHG Emissions[2]	**tCO_2e**
Annual GHG emissions from electricity	53
Annual GHG emissions from natural gas	142
Total annual GHG emissions from energy consumption	**195**
Annual Carbon Tax Cost[3]	**$**
Annual GHG emission tax cost	6,237
Annual GHG carbon offset cost	5,204
Total annual carbon tax cost	**11,441**
Annual Utility Cost[4]	**$**
Annual electricity cost	126,579
Annual natural gas cost	26,415
Total annual utility cost	**152,994**

Notes:
[1]*The energy model consulted* (Ehret and Hepting 2011) *presented four different design combinations, but did not clearly indicate which would be implemented at Ponderosa Commons. Since the design combinations were roughly equivalent in terms of estimated energy consumption, the data relating to "Combo A" is used in this estimate.*
[2]*Using rate of 0.000025 tCO2e/kWh of electricity and 0.000181 tCO2e/kWh of natural gas* (Stantec Consulting 2010).
[3]*Using rates of \$32/tCO_2e and \$26.70/tCO_2e for emission tax cost and carbon offset cost, respectively* (Storey 2012)
[4]*Using rates of \$0.05990485/kWh for electricity and \$0.033649682/kWh for natural gas* (Stantec Consulting 2010).

Appendix B
Average Annual Energy Consumption by Major Appliances

Appliance	Energy Consumed (kWh/yr)
Refrigerators	
Top-mounted standard	514
ENERGY STAR	440
Dishwashers	
Standard	592
ENERGY STAR	492
Clothes Washers	
Standard	779
ENERGY STAR	299
Clothes Dryers	
Standard	916
Compact	896
Freezers	
Standard chest	368
Ranges	
Standard	784
Self-cleaning	735

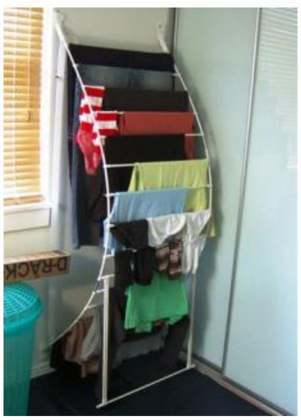
Source: 2004 National Energy Use Database (NRCan 2011).

Appendix C
Examples of Potential Drying Rack Designs and Approximate Retail Costs

IKEA Grundtal wall rack, stainless steel ($25)

Greenway coated wire "Laundry Lift" ($35)

Urban Clotheslines coated wire "D-rack" ($89)



Ballard Designs pine rack ($89)

Hogan Wood FSC-certified Douglas fir rack, local manufacturer ($100)

Appendix D
Calculation of Energy Consumed in Ponderosa Commons Mechanical Dryers and Potential Energy Savings from Use of Drying Racks

Unit Type	Unit Occupancy	# of Units[1]	Annual Laundry Cycles[2]	Annual Energy Consumed by 100% Mechanical Drying (kWh)[3]	Potential Annual Energy Savings (kWh)[4]
Studios	1	594	28,512	111,197	36,695
2-Bedrooms	2	143	13,728	53,539	17,668
4-Bedrooms	4	59	11,328	44,179	14,579
Total		**796**	**53,568**	**208,915**	**68,942**

Sources and assumptions:
[1] *Source: Kuwabara et al., 2011a, 2011b; UBC Board of Governors, 2011.*
[2] *Based on four laundry cycles/occupant/month, as per UBC student resident average usage* (Coinamatic 2011).
[3] *Assuming full-size commercial clothes dryer model consuming 3.9 kWh/cycle* (BC Hydro 2012)
[4] *Assuming air-drying is used in place of one-third of annual dryer cycles (see Appendix E for details).*

Appendix E
Student Participation and Energy Efficiency Precedents and Assumptions

Table E.1. Criteria: Contribution to sustainability-related student outreach

Option	Participation Rate Selected[1]	Certainty	Rationale and Notes	Precedent(s)
Normative Messaging	n/a	n/a	As this is a passive measure, participation is not applicable as a criterion.	n/a
Quota and Rebate	11%	±5%	Precedent was part of a larger campaign with many other components besides incentive system. No other relevant precedents could be found. The low degree of certainty reflects this knowledge gap.	• 11% - Western Washington University Go for Green Challenge (Mauny 2008)
Contest	50%	±18%	Precedents are both relevant, and one is a recent UBC example. Note that this participation rate is for the 3-week duration of a contest; it is unclear what, if any, behaviours persist after contests conclude.	• 63% - UBC's Do It In the Dark International Energy Competition (UBC 2011; UBC 2012) • 37% - University of Hawaii at Manoa's 2011 Kukai Cup Competition (Brewer 2011)
Voluntary Agreements	3%	±1%	Both precedents listed are specific to the UBC context.	• 2% - UBC's Do It In the Dark International Energy Competition - public commitments to conservation component (UBC 2011; UBC 2012) • 4% - UBC Sustainability Pledge (UBC 2007)
Drying Racks	65%	±12%	It should be noted that all precedents cited report the results of four student surveys regarding occasional to exclusive use of drying racks, and do not document actual behaviour.	• 68% - Dalhousie University Student Survey (Ashworth et al. 2007) • 75% - University of North Carolina Student Survey (Kupatt, Scandella, and Waters 2012) • 61% - Pomona College Student Survey (Hodge 2009) • 47% - Ithaca College Student Survey (Deamer et al. 2010)

[1]Based on median of precedents found, where possible.

Table E.2. Criteria: Contribution to energy efficiency of Ponderosa Commons[1]

Option	Energy Efficiency Rate Selected[2]	Certainty	Rationale and Notes	Precedent(s)
Normative Messaging	3.0%	±0.6%	The fourth and fifth precedents cited at right applied to recycling and towel re-use, respectively, instead of energy conservation; the sixth precedent was part of a larger campaign combining several different measures; thus, the estimated energy efficiency rate was calculated using only the first three precedents.	• 2% - California study involving use of normative messaging in electricity (Schultz et al. 2007) • 3% - Average energy efficiency rate obtained through normative messaging by a commercial customer engagement platform (OPOWER 2012) • 3% - Results of a New Zealand study of the effects of normative messaging on self-reported energy efficiency in residential households (Tilyard 2011) • 25% – Arizona residential recycling PSA program with normative messaging (Cialdini 2003) • 44% - hotel towel re-use study of normative messaging (Goldstein, Cialdini, and Griskevicius 2008) • 28% - Australian study combining feedback mechanisms with a social marketing campaign (Black, Davidson, and Retra 2010)
Quota and Rebate	1.7%	±2.0%	The precedent cited was part of a larger campaign with several other components besides an incentive system. In the absence of more detailed data, it was assumed that the incentive was responsible for approximately 15% of the reported energy savings. No other relevant precedents could be found. The low degree of certainty reflects this knowledge gap.	• 12% - Western Washington University Go for Green Challenge - with reward system (Mauny 2008)

(continued)

Table E.2. Criteria: Contribution to energy efficiency of Ponderosa Commons (completed)[1]

Option	Energy Efficiency Rate Selected[2]	Certainty	Rationale and Notes	Precedent(s)
Contest	0.9% (electricity) 0.2% (natural gas) *See Rationale and Notes*	±0.5% (electricity) ±0.1% (natural gas)	Energy efficiency rate selected represents respective 17% and 3% electricity and natural gas consumption reductions, limited to the 3-week contest period.	• 17% - UBC's reduction in the Do It In the Dark International Energy Competition (UBC 2011) • 9% - Average energy reduction in the Do It In the Dark International Energy Competition (Hodge 2010) • 10% - Pomona College's Power Down dorm energy challenge (Pomona College) • 32% electricity and 3% natural gas- Oberlin College's Dorm Resource Reduction Competition (Petersen et al. 2007) • 16% - Harvey Mudd College's Dorm Energy Competition (Engineers for a Sustainable World 2012) • 21% - California Polytechnic State University's residence hall energy competition (Alliance to Save Energy 2011) • 12% - UC Berkeley's Blackout Battles Competition (Alliance to Save Energy 2011)
Voluntary Agreements	1.7%	±0.3%	No precedent of voluntary agreements being used in this specific way in a campus setting could be found. The precedents cited were part of larger campaigns with other components besides a voluntary pledge. In the absence of more detailed data, it was assumed that the pledges were responsible for approximately 15% of the reported energy savings.	• 13% - Western Washington University Go for Green Challenge (Mauny 2008) • 10% - Personal Sustainability Pledge as part of the REWIRE Project, University of Toronto
Drying Racks	3.3% *See Rationale and Notes*	±0.2%	Energy efficiency rate selected represents a 33% reduction, limited to estimated baseline dryer energy consumption (208,915 kWh annually), and takes into account participation rate.	• 37% - Dalhousie University Student Survey (Ashworth et al. 2007) • 38% - St. Lawrence University NY Student Survey (Meade and Garlock 2008) • 35% - Ithaca College Student Survey (Deamer et al. 2010) • 35% - Danish study of energy-saving domestic measures (Norgard 2003)

[1] Most literature reviewed did not distinguish between reductions in electricity and natural gas consumption; where information specific to natural gas was not found, savings were assumed to be electricity only.

[2] Based on median of precedents found, where possible.

Appendix F
Indicator Calculations

Baseline[1] Annual Energy Consumption (kWh)		Normative Messaging	Rebate and Quota	Contest	Voluntary Agreements	Drying Racks
		Estimated Annual Energy Consumption Reductions (kWh)				
Electricity	2,113,000	63,390	34,865	19,887	36,449	68,942
Natural Gas	785,000	0	0	1,413	0	0
Total annual energy consumption	**2,898,000**	**63,390**	**34,865**	**21,300**	**36,449**	**68,942**
Annual GHG Emissions (tCO_2e)		**Estimated Annual GHG Emissions Reductions (tCO_2e)**				
Annual GHG emissions from electricity	52.8	1.6	0.9	0.5	0.9	1.7
Annual GHG emissions from natural gas	142.1	0.0	0.0	0.3	0.0	0.0
Total annual GHG emissions from energy consumption	**194.9**	**1.6**	**0.9**	**0.8**	**0.9**	**1.7**
Annual Carbon Tax Cost ($)		**Estimated Annual Carbon Tax Cost Savings ($)**				
Annual GHG emission tax cost	6,237	51	28	24	29	55
Annual GHG carbon offset cost	5,204	42	23	20	24	46
Total annual carbon tax cost	**11,441**	**93**	**51**	**44**	**53**	**101**
Annual Utility Cost ($)		**Estimated Annual Utility Cost Savings ($)**				
Annual electricity cost	126,579	3,797	2,089	1,191	2,183	4,130
Annual natural gas cost	26,415	0	0	48	0	0
Total annual utility cost	**152,994**	**3,797**	**2,089**	**1,239**	**2,183**	**4,130**

[1]See Appendix A for sources.
Note: Calculations are based on energy efficiency rates identified in Table E.2 (Appendix E), and should be considered to have the same degree of uncertainty.

Appendix G
Return on Investment for Options

Normative Messaging (over an 8 year period for consistency)

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
	$ 3,890	$ 3,890	$ 3,890	$ 3,890	$ 3,890	$ 3,890	$ 3,890	$ 3,890
-$ 7,463	-$ 1,866	-$ 1,866	-$ 1,866	-$ 1,866	-$ 1,866	-$ 1,866	-$ 1,866	-$ 1,866
-$ 7,463	$ 2,025	$ 2,025	$ 2,025	$ 2,025	$ 2,025	$ 2,025	$ 2,025	$ 2,025

ROI (IRR) 21.37%

Energy Quota/Rebate Program (over an 8 year period for consistency)

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
	$ 2,140	$ 2,594	$ 2,594	$ 2,594	$ 2,594	$ 2,594	$ 2,594	$ 2,594
-$ 2,590	-$ 2,590	-$ 2,590	-$ 2,590	-$ 2,590	-$ 2,590	-$ 2,590	-$ 2,590	
-$ 2,590	-$ 451	$ 4	$ 4	$ 4	$ 4	$ 4	$ 4	$ 2,594

ROI (IRR) -1.91%

Energy Saving Contest (over an 8 year period for consistency)

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
	$ 1,283	$ 1,283	$ 1,283	$ 1,283	$ 1,283	$ 1,283	$ 1,283	$ 1,283
-$ 1,196	-$ 1,196	-$ 1,196	-$ 1,196	-$ 1,196	-$ 1,196	-$ 1,196	-$ 1,196	
-$ 1,196	$ 87	$ 87	$ 87	$ 87	$ 87	$ 87	$ 87	$ 1,283

ROI (IRR) 7.28% (would become negative if $1000+ in contest prizes are funded by UBC)

Voluntary Agreements (over an 8 year period for consistency)

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
	$ 2,237	$ 2,237	$ 2,237	$ 2,237	$ 2,237	$ 2,237	$ 2,237	$ 2,237
-$ 2,096	-$ 2,096	-$ 2,096	-$ 2,096	-$ 2,096	-$ 2,096	-$ 2,096	-$ 2,096	
-$ 2,096	$ 141	$ 141	$ 141	$ 141	$ 141	$ 141	$ 141	$ 2,237

ROI (IRR) 6.73%

Clothes Drying Racks

Cheapest Drying Rack Available (estimated lifetime of 8 years)

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
-$ 14,925	$ 4,231	$ 4,231	$ 4,231	$ 4,231	$ 4,231	$ 4,231	$ 4,231	$ 4,231

ROI (IRR) 22.90%

High End Drying Rack (estimated lifetime of 20 years)

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
-$ 53,133	$ 4,231	$ 4,231	$ 4,231	$ 4,231	$ 4,231	$ 4,231	$ 4,231	$ 4,231
Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18
$ 4,231	$ 4,231	$ 4,231	$ 4,231	$ 4,231	$ 4,231	$ 4,231	$ 4,231	$ 4,231
Year 19	Year 20	Year 21						
$ 4,231	$ 4,231	$ 4,231						

ROI (IRR)	4.91%

Assumption: All labour detailed below is to be provided internally as UBC already has related infrastructure in place.

Normative Messaging Costs	
Assume 300 posters at 18"x24": avg price $15.50 each[1]	$ 4,650
Assume 200 posters at 24"x36": avg price $26.50 each[1]	$ 5,300
Assume 25% volume discount (long-term agreement)	$ 9,950
Assume 25% replacement of posters/year.	
Total	**$ 7,463**
Rebate Program Costs	
Assume 40 hours for HR professionals to advertise for, hire, and train volunteers (to educate residents) at $29.90 per hour[2.]	$ 1,196
Assume 80 hours of accounting and bookkeeping work related to the collection of extra fees and end-of-year disbursement of rebates at $17.43 per hour[3]	$ 1,394
Total	**$ 2,590**
Energy Saving Contest Costs (before incentive expenses)	
Assume same HR expenses.	**$ 1,196**
Voluntary Agreement Program Costs	
Assume same HR expenses.	$ 1,196
Assume 60 hours of work by student at $15 per hour to adminster the signing of voluntary agreements by Ponderosa residents.	$ 900
Total	**$ 2,096**
Clothes Drying Racks Cost	
Cheapest: Assume cheapest model used with 25% volume discount.	**$ 14,925**
High End: Assume most expensive model with a 25% volume discount.	**$ 53,133**

[1]Pricing. 2012. Vanprint.
[2]Average hourly wages for human resources in Canada (BC). 2011. Living in Canada.
[3]Average hourly wages for accounting related clerks in Canada (BC). 2011. Living in Canada.
See Appendix E for additional sources.

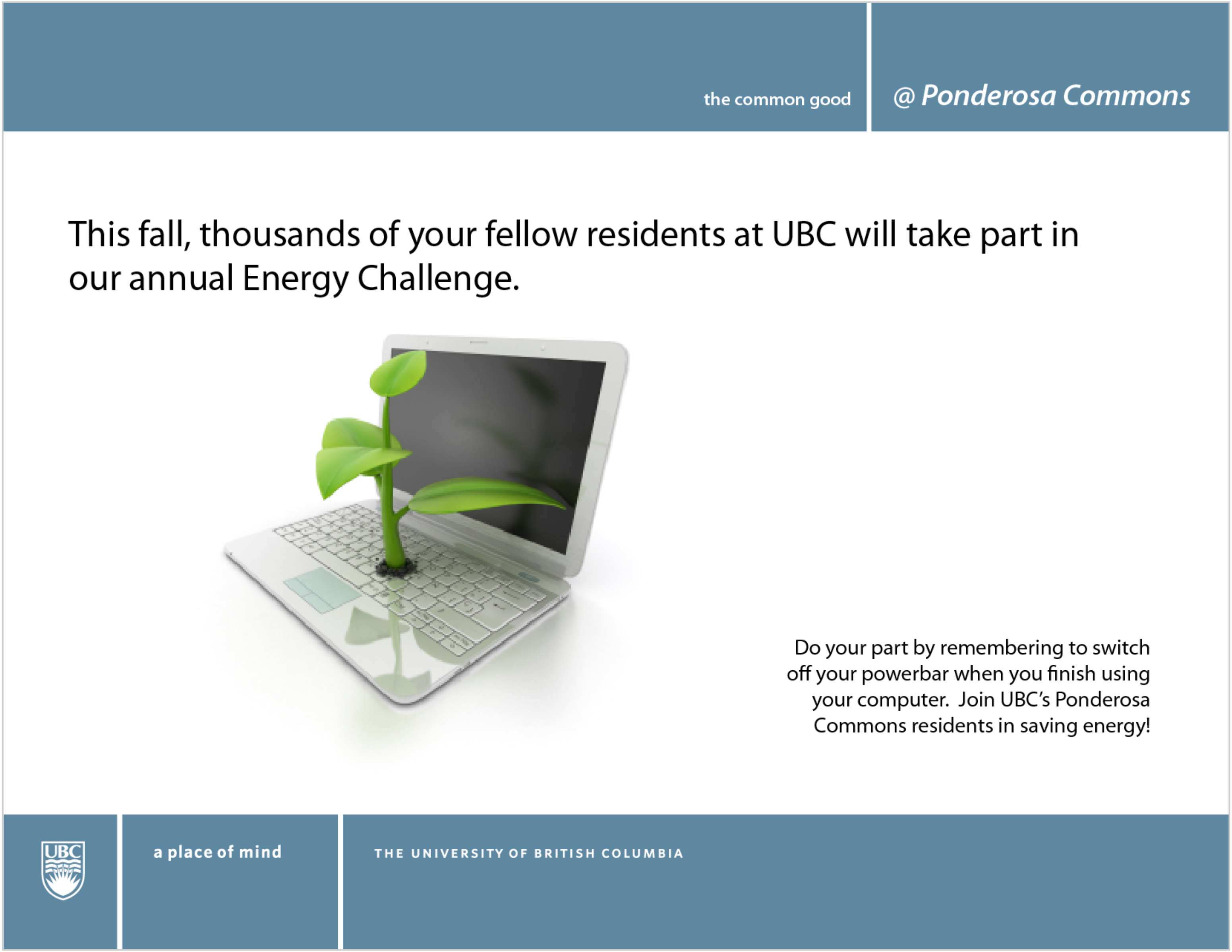
Appendix H
Option Evaluation Matrix

Indicators (by theme)		Normative Messaging	Quota and Rebate	Contest	Voluntary Agreements	Drying Racks
Energy Efficiency	Reduction of annual electricity consumption - based upon estimated percent reduction from estimated level.[1]	3.0%	1.7%	0.9%[2]	1.7%	3.6%
	Reduction of annual hot water consumption - based upon estimated percent reduction from baseline level.[1]	0%	0%	0.2%	0%	0%
Economic Feasibility	Return on investment from implementing the option (IRR). Reflects the feasibility of implementing option and identifies those that are the most profitable. See Appendix G for full calculation.	21.37%	-1.91%	7.28%[3]	6.73%	22.90%[4]
Educational Contributions	Rate the research potential of this option according to the following scale: 2 - No previous research on this could be found – thus, this is an option with high research potential 1 - Some research has been done, but some new ground could be covered 0 - Exhaustive research has already occurred on this measure	1	1	1	2	1
	Does the option feature an educational component? (Yes/No)	Yes	No	Yes	Yes	No
	Is the option a passive change to energy infrastructure (i.e., does it have no interactive component?) (Yes/No)	Yes	No	No	No	No
Social Contribution and Equity	Does the option build social capital by fostering social interaction among student residents? (Yes/No)	No	No	Yes	No	No
	Does this option impact those of varying amounts of wealth equally? (Yes/No)	Yes	No	No	Yes	Yes
	Estimated annual percent of student residents participating in energy efficiency initiatives.[5]	n/a	11%	50%[6]	3%	65%

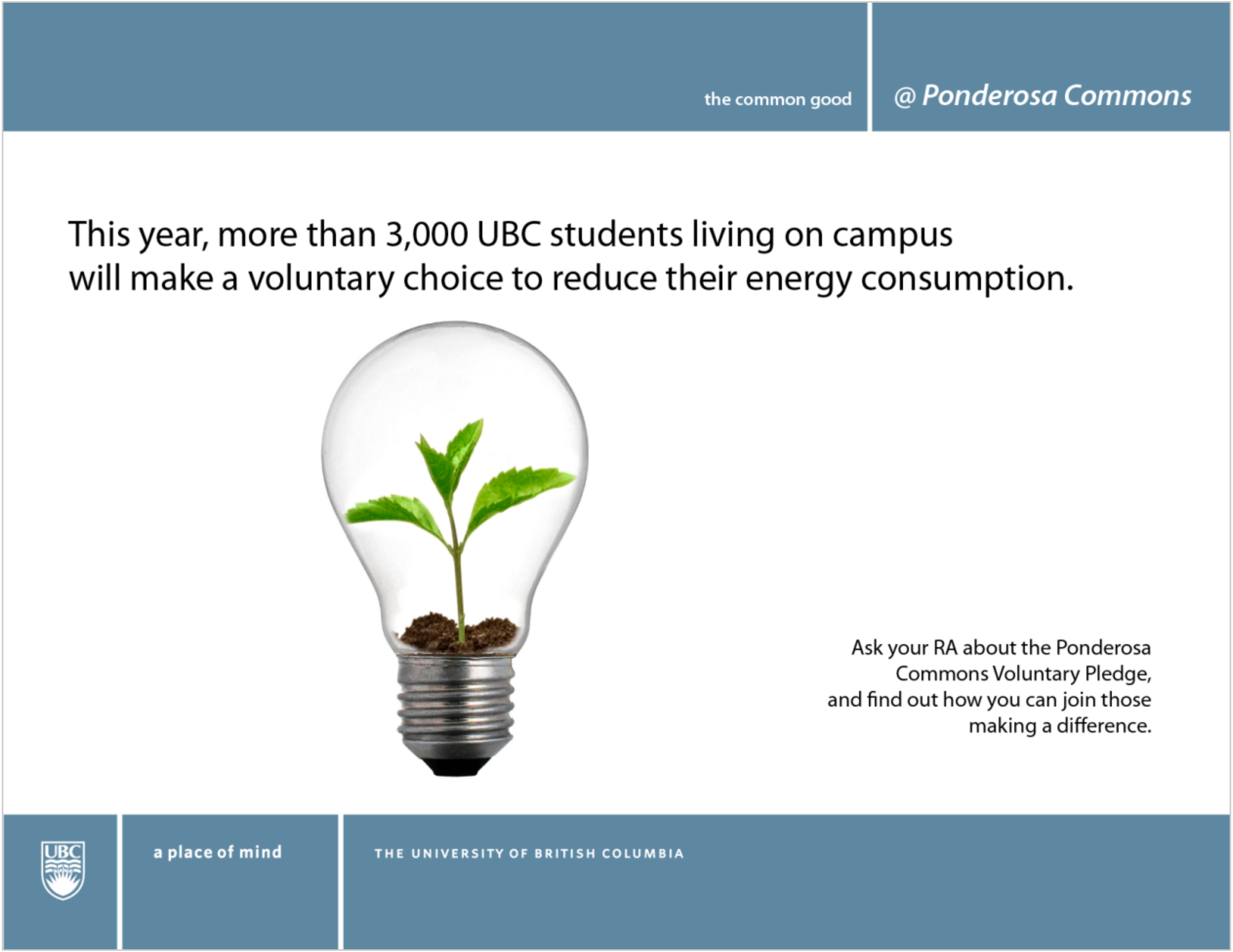
[1] *See Appendices E and F for precedents and calculations.*
[2] *Based on savings from a 3-week contest averaged over one year.*
[3] *Before cost of competition prizes. The return would become negative if funding for these prizes came from UBC's budget.*
[4] *Based on cheapest drying rack model. See Appendix G for details.*
[5] *See Appendix E for precedents.*
[65] *For 3-week contest duration.*

Appendix I
Mock-ups of Posters Promoting Recommended Options with Normative Messaging

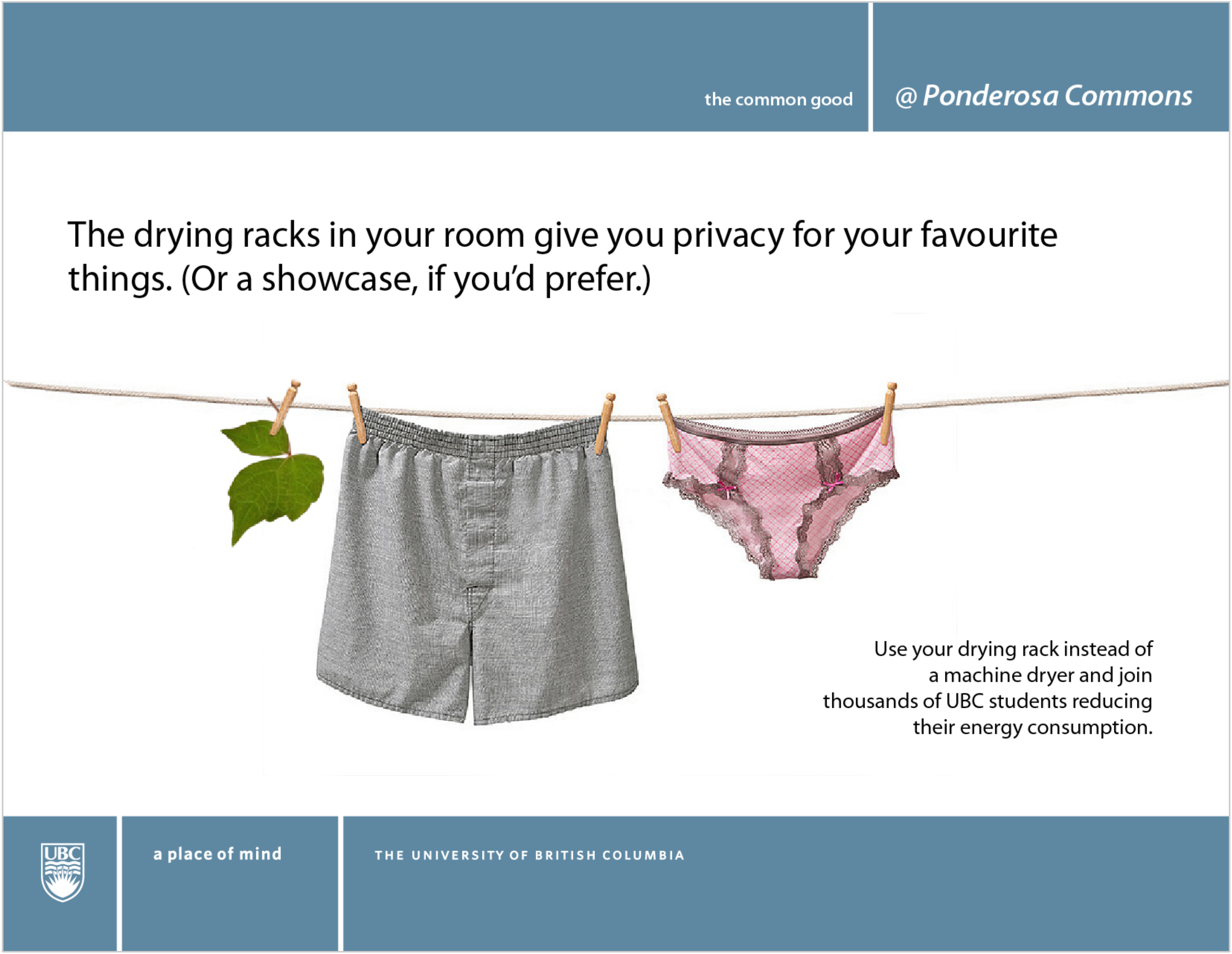
Energy Contest Poster



Voluntary Agreements Poster



Drying Racks Poster



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