Reducing the energy use in Dalhousie residences through infrastructural and behavioral changes

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Abstract

Dalhousie University is one of the leading institutions of higher learning in Canada. Over the years, it has taken a leadership role through signing both the Talloires and Halifax Declarations, committing itself to teach and practice principles of sustainable development. To truly be a leader, Dalhousie University must match its actions to its words. With respect to traditional residences, in which a potential 1,937 Dalhousie students could be housed, Dalhousie is not fulfilling its commitments. Residences are excessively energy consumptive. This research project aimed to identify ways in which five traditional Dalhousie residences (Eliza Ritchie, Gerard, Howe, Risley and Sherriff Halls) could be made both more cost effective and energy efficient. The objective was to contribute to the Greening the Campus movement, as it seeks to increase environmental awareness in both the operational facilities and the human community of the campus. The research process included holding interviews with members of the Dalhousie faculty and conducting a survey among students living in the five residences. The information gained was then analyzed so that informed recommendations could be made to improve the buildings' energy efficiency. A series of recommendations were made regarding the physical operations of the buildings. These included: the provision of drying racks to students, turning down the heat throughout the buildings, the installation of motion sensor lighting, and the installation of low flow shower heads. Additionally, a series of recommendations were made to alter the energy consumptive practices found in students' behaviour within residences. These included: reducing the use of machine dryers, turning down the room thermostat where possible, setting computers to sleep mode after ten idle minutes, and reducing the average shower length by two minutes. To promote a change in students' behaviour, the research team has also initiated an educational poster campaign in residences to raise awareness regarding the energy consumption involved in daily activities. If the recommendations made through this project were pursued, Dalhousie residences would become more substantial and energy efficient. However, we recommend that further research be conducted regarding both the physical structure of residence buildings and students' behavioural patterns. Many more improvements could and should be made if Dalhousie residences are to be a successful example of sustainable living.

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Introduction

In 1990, Dalhousie University, along with over 300 universities world wide, signed the Talloires Declaration. This Declaration officially committed universities to seek environmental sustainability in higher education, stating that:

> "Stabilization of human population, adaptation of environmentally sound industrial and agricultural technologies, reforestation, and ecological restoration are crucial elements in creating an equitable and sustainable future for all humankind in harmony with nature. Universities have a major role in the education, research, policy formation and information exchange necessary to make these goals possible" (ULSF, 1990).

Only a year later, representatives of 33 international universities met again, this time in Halifax, to discuss universities impact on the larger environment and to sign the Halifax Declaration. In signing this declaration, Dalhousie University again reaffirmed its commitment to:

> "Enhance the capacity of the university to teach and practice sustainable development principles, to increase environmental literacy, and to enhance the understanding of environmental ethics among faculty, students and the public at large" (LPI for ID, 1991).

Through signing these documents Dalhousie University has set the right example in taking the first steps towards creating a sustainable future. However, it is the initiation of action to support the commitments made in such Declarations that is the real challenge. In order to truly play a leading role in the promotion of environmentally sound practices, Dalhousie must do more than simply make the right promises. The policies, physical operations and the curriculum of the University must be a reflection of the stated ideals. It has been over a decade since Dalhousie made these commitments; by this time significant alterations should be visible within each of these three pillars of the University.

In light of this, within our research project we have chosen to examine energy consumption through both the physical operations and the human behaviour in a significant part of the Dalhousie campus – Residence buildings. Dalhousie residences currently provide a home for over 1, 752 students with the potential capacity to house 1,937 students. For eight months of the year, students will live within these buildings and utilize the provided facilities. For many students this is their first occasion living on their own and therefore it is within the residence setting that they are learning lifestyle habits which they will take with them into the real world. If Dalhousie University is to fulfill the requirements outlined in both the Talloires and the Halifax Declaration, residences should employ environmentally sound infrastructure and should be instilling within students ways in which to live sustainably. This is currently not occurring to a sufficient degree. To change this, our research team sought ways in which to make Dalhousie residences more energy efficient. It was our hypothesis that two different facets of residence life could be altered. Firstly, a variety of cost efficient changes could be made to the building's infrastructure and secondly, that the behaviour of residents could be influenced so as to make Dalhousie residences less energy consumptive.

When faced with the problem of energy consumption within residences, there are a variety of different contributing factors that need to be considered. Our research team divided these into two groups, infrastructural and behavioural factors. We focused our research on five of the six traditional residences established by Dalhousie University- Eliza Ritchie Hall, Gerard Hall, Howe Hall, Risley Hall and Sherriff Hall. The infrastructural energy consumptive components that we examined in each of these Halls included the use of machine dryers, heating, lighting, the use of conventional showerheads, and the possible installation of hand dryers. The energy consumptive behavioural factors which we examined in each of the five Halls included how often students left their windows open, how often students left their lights and computers on, how long student's showers lasted and how often students reported to staff any energy inefficiencies which they had noticed throughout the building. To find this information we conducted interviews with facilities management and Dalhousie administration, as well as conducted a survey with the student population living within the residences. When we had acquired all the necessary information, we used our findings to recommend ways that residences could become more energy and cost efficient. Recommendations were made to facilities management and housing staff regarding possible changes to the infrastructure of the five residence buildings. Recommendations were also made to students, highlighting ways in which they could alter their day-to-day behaviour so as to consume less energy. In addition to this, we created posters to be put up within residences that would educate students on how their lifestyle effects the environment. It is our hope that a poster campaign would positively influence students to alter their habits.

This research was compiled as part of the greater Greening the Campus movement. The objective of this movement is to "increase environmental awareness and/or action on campus in the operational facilities and processes of the campus, as well as in the human communities of the campus and surrounding area" (Wright, 2007). In analyzing the energy consumption found within the physical operations and behaviour of students living in residence, this research project works toward greening the Dalhousie campus.

The following report will give an outline of the findings we made through our research. First the research methods that we employed in order to obtain our information will be explained in full. Secondly, the results of our research will be displayed, along with the recommendations made based on these results. Lastly, the discussion section of the report will summarize our findings and explain how they apply to the greater practice of environmental sustainability within Dalhousie University.

Methods

In order to fully address the issue of energy consumption in residence buildings at Dalhousie University, this study included both exploratory and explanatory components (Palys, 2003). We gathered the relevant information through document analysis, data collection, and through interviews held with members of Residence Life Management and Facilities Management. We also conducted a survey of the residents in the form of a self-administered questionnaire, in order to assess the relationship between students' attitudes towards energy consumption and their actual energy consumption. Each of these methods will be described in full below.

When employing these methods, we encountered certain insurmountable limitations. We also realized a necessity to set certain delimitations for ourselves so as to make the research more feasible. These will be further explained in this section of the report as well.

Document Analysis

Nova Scotia Power

In order to determine the extent of the social and environmental externalities that are associated with energy consumption in Nova Scotia, information was acquired from Nova Scotia Power (NSP) pertaining to the emissions born of coal-generated power. The NSP website provided the quantitative data which allowed us to determine the carbon dioxide emissions which result from Dalhousie's energy consumption. Furthermore, the information acquired from the NSP website was incorporated into our educational campaign geared towards promoting energy conservation among students and faculty. It provided the data that was included on the 800 awareness-raising posters (Appendix B).

Related Projects

An exploration of previously published studies provided us with information and insight as to how the energy reduction efforts have been pursued in the past. The documents analyzed include; "Assessing the Use of Mini-Fridges in Residences on Studley Campus", "Artificial Lighting: Opportunities for Improvement in ES2", and "W.C.R.I. Energy Efficiency Project". These documents were obtained from the Greening the Campus websites of Dalhousie and Waterloo Universities. Examining these various projects increased our understanding of the broader focus of this study, while also providing information regarding relevant experiences geared towards the common goal of energy reduction. In addressing our specific problem, our team built on the research compiled by these previous studies and applied their experiences to our own project design.

Data Collection

Interviews

We obtained the majority of our information through face-to-face interviews with members of the Dalhousie faculty. An interview with Verity Astephen, the Associate Director of Marketing and Conference Services at Dalhousie, was first conducted. She provided us with the actual and potential number of residents within each building, as well as the number of single and double rooms in the residences to be assessed. She also had information regarding each building's drying facilities, specifically the quantity and models of all the dryers currently in use.

Interviews were also conducted with Residence Life managers Matteo York, Diana Curry and Jeremy Eastwood so as to establish an awareness of the residences' current facilities. They provided us with information regarding the presence of electric hand-dryers and motion-sensor lighting. Additionally, Matteo York provided us with blueprints of the areas that did not employ motion-sensor lighting. From this information, we were able to calculate the cost-effectiveness of the installation of motion-sensor lighting based on the dimensions of the areas in need of coverage.

An interview with Matt McKinnon, the Facilities Management energy director, provided us with the overall energy consumption of each residence. It also provided us with the monetary cost of energy at Dalhousie, which allowed us to calculate the savings that would accompany our proposed infrastructural alterations. This enabled us to establish the significance of our proposed behavioural and infrastructural alterations through placing the savings related to such changes within the broader context of current energy consumption in residences.

Survey

The survey was administered such that we obtained a proportionally representative sample of the potential capacity of Eliza Ritchie, Gerard, Howe, Sherriff, and Risley Halls. It was conducted in the form of a self-administered, voluntary questionnaire outside the residences' dining halls from 4-7 pm over the span of three consecutive days. A face-to-face questionnaire was appropriate, as it allowed us to be present to answer any questions that respondents may have had regarding the survey. This method also promoted a high level of participation, which is important in minimizing volunteer bias and ensuring that the appropriate persons completed the survey (Palys, 2003). Also, by providing residents with the option of completing the survey within the dining hall, our response rates were heightened. Respondents were assured of complete anonymity, but they were given the option to include their name and/or contact information to be notified of the outcome of the study.

Included in the survey were closed-ended questions of the single-response, categorical, and ranking-scale variety. Also included were open-ended questions, allowing residents to provide more descriptive and subjective responses to our questions. From such questions we obtained both qualitative and quantitative data. The qualitative information gathered was in regards to residents' perceptions of the facilities, their day-to-day behavioural patterns, and their openness to infrastructure changes. The quantitative data which was acquired was in regards to residents' average shower length, their use of electric clothes dryers, and any potential reduction in the use of electric clothes dryers should a drying rack be provided.

Analysis

The information gathered from the residents through surveying was entered into a spreadsheet for analysis, much of which was accomplished using descriptive statistics such as frequency distributions and indicators of central tendency (Palys, 2003). This included qualitative information, such as the residents' willingness to employ drying racks under certain circumstances, their perception of current average building temperature, their openness to the installation of motion sensors and hand dryers, their observations of heat and energy inefficiencies, and their awareness as to who should be contacted with concerns regarding facilities' inefficiencies. Other qualitative data that was analyzed through frequency distribution included the extent to which residents activated their computers, turned on their lights, and opened their windows.

A thorough analysis of the quantitative information obtained through the survey necessitated further calculations. After the appropriate distributional central tendency of the data was determined, it was possible to analyze the results in terms of associated financial and environmental costs. The formulas employed were as follows.

Dryer Usage

Residents' current monthly dryer usage was compared to their potential monthly dryer usage, which would occur if they were provided with drying racks. The average monthly energy consumption associated with the use of clothes dryers was calculated by multiplying the average number of monthly dryer cycles used per person by the amount of energy required for a dryer to run a full cycle, in kilowatts/hour. This indicated the amount of energy used for the average student to dry their clothes for one month. The same formula was used to determine the amount of energy that would be required for students to dry their clothes for one month if they were provided with a drying rack. We then compared the results by subtracting the potentially reduced monthly machine dryer usage from the actual monthly machine dryer usage, which gave us the energy savings to be accomplished if students were provided with a drying rack. In order to determine if it was economically viable to recommend that residents were provided with a drying rack, we calculated the cost of purchasing one rack per residence room. The cost of the drying racks was assumed to be at a bulk discount rate available from Canadian Tire. Next, we compared this cost of implementation to the savings associated with the reduced dryer usage each year. We projected the monthly savings until they were equivalent to the capital cost of supplying each room with a discount-priced drying rack, to determine whether the rate of return fell within the five-year budgetary period.

Shower Length

The quantitative responses to the question regarding shower length also necessitated certain calculations. After we determined the average shower length, we multiplied the number of minutes per shower by the number of litres of waters required for each minute of showering using a conventional showerhead. This allowed us to determine the quantity of water consumed by the average shower taken within the residences. We then employed the same formula to determine the amount of water that would be consumed by the average shower if low-flow showerheads were to be installed.

Validity and Reliability

In order to ensure the accuracy of the information that we obtained, we triangulated our data by accessing it from a variety of angles. The information regarding residences' facilities was accessed through both interviews and direct observation. The quantities and types of dryers in residences were obtained through interviews with Residence Life Managers, and confirmed through actual visits to the residences. Furthermore, the presence of low-flow showerheads and motion-sensing lighting was established through a combination of correspondence with Residence Life Managers and face-to-face interviews with custodial staff.

The application of the survey in the student population was preceded by a pilot test. The feedback that we received from the four pilot test respondents was used to minimize instances of confusion that would have potentially hindered the survey's reliability. When applying the survey full scale, we employed purposive sampling on a face-to-face basis. This enabled us to ensure that the survey respondents were in fact residents of the University. It also provided us with the opportunity to clarify any questions that respondents may have had, ensuring that responses were based on accurate and appropriate interpretations of the survey's content. When questions did arise, our answers to them were as neutral as could be allowed, so as not to indicate a preference for one type of response over another. Finally, information regarding the energy reduction campaign was provided only after the survey's completion, so as to further minimize any bias in the response.

The project's catalytic validity is born of the fact that it emphasized the importance of promoting ongoing efforts towards improving the University, the community, and society as a whole. The survey promoted residents' awareness of their own energy consumption. It was through the completion of the survey and access to its findings, that students were provided with the opportunity to relate their own behaviour to the broader trends exhibited by their peers. Furthermore, the survey provided students with the opportunity to partake in a petition at a later date, which contributed to their sense of involvement and contribution, especially if the changes that they supported were enacted in the future. The project's emphasis on an awareness campaign is based on the belief that sustained improvements are most likely to occur when they are inspired by a group of students whom seek to become involved in the broader social movement towards sound environmental practices.

Limitations

The study was affected by certain limiting factors. Some of these we were able to overcome, however certain flaws have influenced the study's results and therefore must be accounted for in our findings.

Although the actual administration of the survey seemed successful, we noticed some discrepancies in student's responses upon analyzing the results. Most significantly, a common misinterpretation of questions one and two forced us to discount a portion of responses for those specific questions. Students seem to have mistaken the term dryer to mean drying rack in question number two, leading many to indicate in their response that they would increase their use of the machine dryers when provided with a drying rack. As a result of this miscommunication and subsequent disqualification of responses, we did not obtain a statistically representative sample concerning the issue of the respondents' current and potential machine dryer usage. The information that we derived from those questions is instead based upon the number of respondents who did correctly interpret what was being asked. Secondly, a limitation was encountered regarding question number eight. This question asked students to provide their average shower length. We found that in many instances responses were rounded to the nearest multiple of five, such as five minutes, ten minutes or fifteen minutes. Therefore, responses were based upon simplicity rather than accuracy. We were able to utilize the data, yet it should be noted that student's responses might have been altered for the sake of simplicity. Lastly, in regards to the survey, we felt that certain biases were unavoidable and may have served to alter student's responses, possibly limiting the reliability of our data. Before student's filled out the questionnaire, it was first necessary to explain whom we were and the purpose of our study. It is possible that knowledge of our association with an environmental studies class, performing research meant to improve the campus environment, may have influenced respondents to make their answers seem as though their lifestyle practices were more sustainable than in reality.

Delimitations

Prior to commencing our research, we felt it necessary to place limits on various aspects of the study so as to narrow the scope of the project. Firstly, we restricted our research to focus on only five traditional residences. Though Dalhousie University offers more accommodations for student living, it would not have been possible to assess each of these buildings given the four-month timeframe in which we had to work. Secondly, we restricted the energy consumptive practices that would be the focus points of our research. Many factors in both the buildings' infrastructure and in the resident's behaviour lead to energy inefficiencies in residence. We had to limit ourselves to only a few of these, again given the timeframe of the project.

Results

The results from the survey will be given in order of the questions asked in the survey. See Appendix A for a copy of the survey.

Drying Racks

On average it was found that drying racks would reduce the machine dryer usage by 1.1 cycles per person per month (Figure 1).

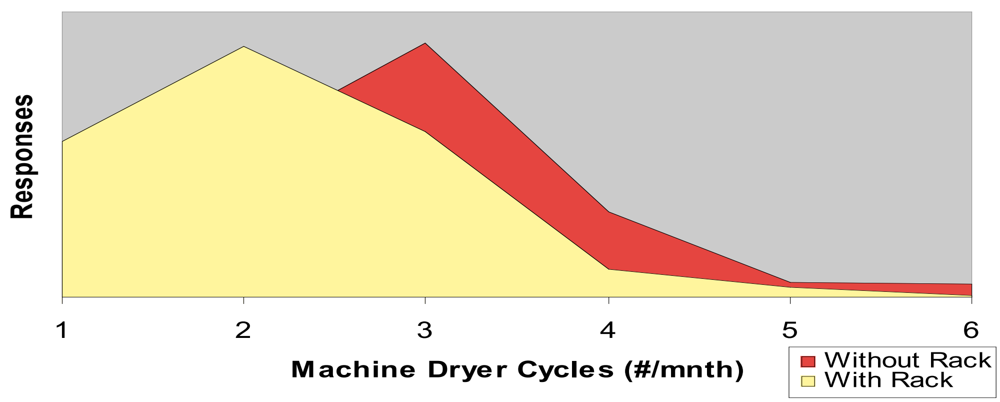


Figure 1. Machine dryer usage with/without drying racks

Factors that would encourage residents to use drying racks were determined. The results were divided as depicted in Figure 2. Additional responses were given to supplement the choices provided. These responses are listed in Table 1.

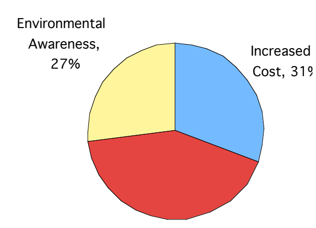


Figure 2. Motivators of drying rack usage

Table 1. Other responses to motivations to use drying racks

Provide Space Outside Room	10
Convenience	5
Already Has One	12
People Steal Stuff from Machine Dryers	1
Cash Incentive	3
Visually Pleasing	1
Works better on certain clothes	24
More Space in Room	7

Heat

The residents' opinion of the temperature in their residence was asked. Responses are shown in Figure 3. In addition, residents were asked if they saw heat wasted in residence buildings. The yes/no results are shown in Figure 4, while the responses given when asked "Where?" are shown in Table 2.

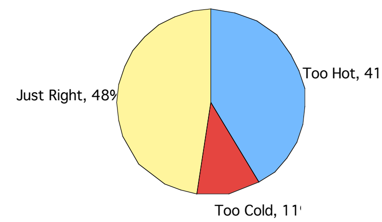


Figure 3. Opinion of room temperature

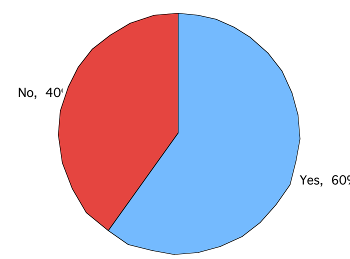


Figure 4. Witness heat energy wasted in residences

Table 2. Responses for where heat energy wasted

Too hot in specific areas - Total: 76	
Bedrooms	50
Hallways	15
Bathrooms	5
Common areas	5
Meal hall	1
Too hot at certain time - Total 47	
Always	35
At night	6
Usually	2
Sometimes	1
In the fall and spring	3
Windows left open – Total 30	
In general	18
In bedrooms	6
In shared areas	6
Everywhere – Total 22	
Poor insulations – Total 7	
Other - 6	
Dryer use	2
Lights produce heat	2
Excessive hot water use	2
Lack of thermostat in rooms – Total 5	
Don't Know – Total 2	
It's too cold – Total 2	

Heat by Residence Building

The results for building temperature are more appropriate when assessed per building so that accurate recommendations can be made for each building manager. The responses of the residents are given below for the question regarding the building temperature (Figure 5-1, 5-2, 5-3, 5-4, 5-5).

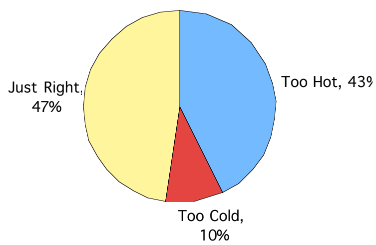


Figure 5-1. Howe Hall temperature

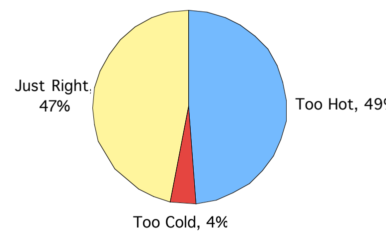


Figure 5-2. Risley Hall temperature

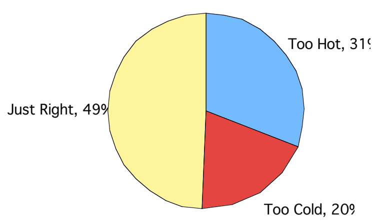


Figure 5-3. Sherriff Hall temperature

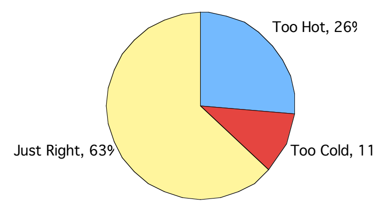


Figure 5-4. Eliza Ritchie Hall temperature

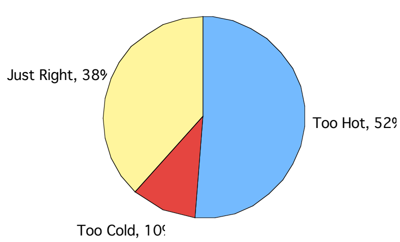


Figure 5-5. Gerard Hall temperature

Windows

To augment the prior discussion of heat, residents were asked when they opened their window (Figure 6). Responses to “Why?” are given in Table 3.

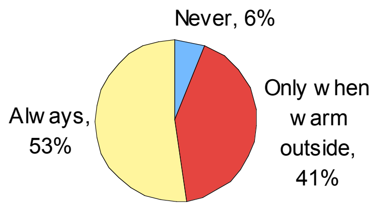


Figure 6. When windows are opened

Table 3. Why windows are opened

60% of time	1
Hot	36
Occasional	11
Regulate room temp	5
Need fresh air	7
Nice outside	1
Sickness	1
2X a day	1

Electricity

The next topic addressed was electricity consumption, primarily regarding lighting. Residents were asked if they witnessed electricity being wasted in the residence. The results for all of the residences are in Figure 7. The students who responded affirmatively where asked to elaborate on where. These responses are in Table 4.

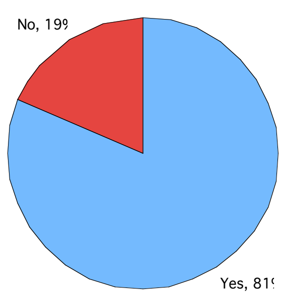


Figure 7. Witness electricity energy wasted in residences

Table 4. Responses for where electricity is wasted.

Lights – Total 249	
Bedrooms	45
Hallways	70
Bathrooms	44
Common areas	19
Meal hall	1
Laundry room	5
Garbage Rooms	1
Appliances – Total 25	
TV left on	8
Computers left on	6
In general	4
Mini fridges	3
Music left on	3
Dryers	3
Use of Facilities – Total 12	
Elevator overuse	4
Shower length	3
Water leakages	2
Water left running	1
Everywhere – Total 28	
Unsure – Total 1	

Individual habits were assessed to determine the percentage of residents who display energy consumptive behaviours. Of interest were computer and light usage. The results pertaining to computer usage are displayed in Figure 8 and Table 5, while those for lighting usage are displayed in Figure 9 and Table 6.

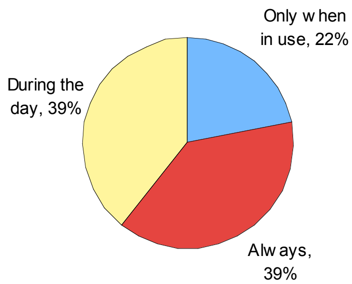


Figure 8. When computers are left on

Table #5: Additional responses to computer usage

Playing music	1
Until Sleep Mode	5
Until Sleep Mode: Reduces energy	1
Occasional	1

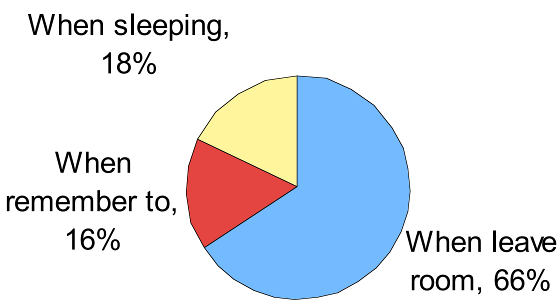


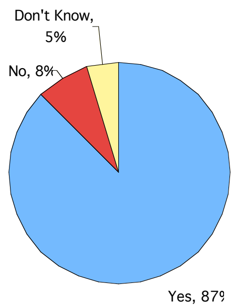
Figure 9. When lights are turned off

Table #6: Additional responses to lighting usage

During the day	1
If there is enough natural light to Work by	2
Watching movies	1
When unused	1
When dance disco	1

Motion Sensors

The overall acceptance of installation of motion sensors in the hallways and bathrooms was assessed. This technology is already installed in the hallways and bathrooms in Risley Hall, the bathrooms in Gerard and Howe Hall (Fountain House, Cameron House, and one bathroom in Bronson House). The responses are given in Figure 10.



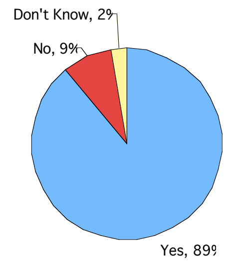


Figure 10. Acceptance of motion sensors in hallways

Acceptance of motion sensors in bathrooms

Residents who responded negatively to the installation of motion sensor lighting were asked to explain why. The responses are shown in Table 7.

Table 7. Reasons for negative acceptance of motion sensors in hallways

Already exist	9
Too dark	1
Scary	9
Prefer switches	1
Extraneous	2
Lights should always be on	1
Security Hazard	9

Reasons for negative acceptance of motion sensors in bathrooms

Already exist	17
Don't work	5
Scary	4
Lights should always be on	1
Unnecessary	5
Dangerous	2
Lights would go off when using toilet	3

Showers

The average shower length was found to be 11.2 minutes. The distribution of shower lengths is demonstrated in Figure 11. The average for males was found to be 10.1 minutes while the average female shower length was found to be 12.1 minutes.

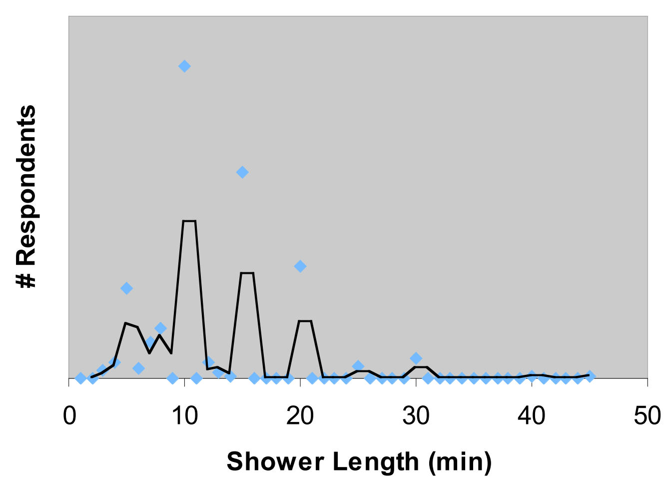


Figure 11. Shower length distribution

Hand Dryers

Past studies have shown that hand dryers are more sustainable, so the residents were asked if the installation of hand dryers in the bathrooms would be acceptable. The results are shown in Figure 12. Negative respondents were asked to elaborate as to why they would not accept hand dryers. These responses are listed in Table 8.

Table 8. Reasons for not accepting hand dryers

Prefer Paper	24
Slow	25
Unsanitary	10
Dislike	9
Have Dryers + paper	2
Ineffective	30
Wasteful to install new equipment	1
Noise	8
Status Quo fine	21
Annoyance	4
Personal Towel	3
Dysfunctional technology	3
Many uses of paper towels	1
Prefer RECYCLED paper	2
Wastes Energy	5

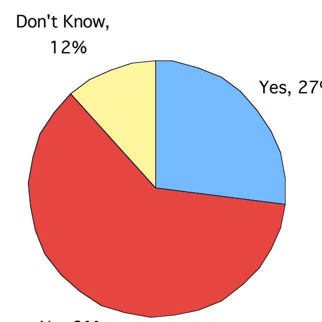


Figure 12. Acceptance of hand dryers

Reporting Inefficiencies

Finally, residents were asked if they had reported any of the energy inefficiencies they noticed. The responses were overwhelmingly negative (Figure 13). When asked whom inefficiencies were reported to, the responses received were as listed in Table 9.

Table 9. Who inefficiencies were reported to

Maintenance staff	5
RA	4
Front Desk	3
Facilities management	2
Building manager	2
Residence life manager	1
Doesn't know who to tell	1

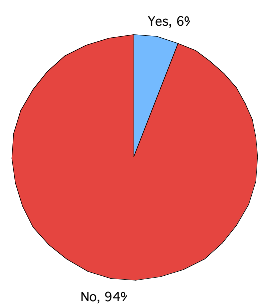


Figure 13. Inefficiencies reported

Discussion

Residence buildings on the Dalhousie campus have the capacity to produce an enormous environmental footprint if energy is used extensively to complete basic day-to-day activities. With 1752 students currently enrolled in residences at Dalhousie, and 1937 potential spots to fill, the impact of these small actions can be substantial. As a result, it is essential that we consider the impact our current lifestyle has upon the environment and work towards increasing the sustainability of the community in which we live. From a global perspective, Canada is among the highest consumers of energy per capita (Statistics Canada, 2005). As a result, we must all take responsibility for the impact we have upon our global community.

Drying Racks

Clothing dryers have been rated as the second or third largest energy-consuming appliance in an average residential setting and therefore offer great potential for energy savings. (U.S. Department of Energy, 2006). Currently, machine dryers are the only option for clothes drying provided to students in the residence buildings. On average, a residence student will use the dryer 3 times during a month, amounting to 5, 811 drying cycles/month across all residence buildings. This requires 22, 857 kWhr of energy and produces 22 tonnes of CO_2 each month. If one drying rack was provided in each residence room, it was found that the average dryer use could be reduced by 1.1 cycles/month for each student (Figure 14). This would reduce the total machine dryer use by 2,131 cycles/month. The total energy savings in all five residences would be 8,314 kWhr, reducing CO_2 emissions by 8 tonnes/month. Assuming an energy rate of $0.571/ kWhr, the savings on energy costs would amount to $3,798 over a span of 8 months. The payback period for this investment, should the drying racks be bought at a bulk discount price of $10/rack and supplied to each of the 1,877 rooms in Howe Hall, Sheriff Hall, Eliza Ritchie Hall, Risley Hall, and Gerard Hall, would amount to 4.9 years. This time frame is within Dalhousie's current budgetary period of 5 years. Should the drying racks be purchased at $15/rack, the payback period would be increased to 7.4 years. The mere provision of a drying rack in each of the residence rooms would encourage 42% of students to use it (Figure 15). Other motivating factors that would further encourage student use include increasing the cost of the machine drying cycles, knowledge that reducing machine drying cycles is environmentally sustainable, the belief that drying racks are more effective at drying certain clothing, and the provision of space outside of the rooms for drying rack use (Table 1).

Recommendations

For facilities management and housing staff:

- Provide each of the 1, 877 residence rooms with a drying rack purchased at the price of $10/rack.
- Promote the energy reduction poster campaign to encourage drying rack use (Appendix B).

For students:

- Reduce machine dryer cycles through the effective use of drying racks.

Heat Energy

Setting a temperature in the residence buildings that will accommodate 1, 937 students comfortably is a formidable task. Overall, it was found that the majority of students found the temperature in their residence building to be just right (Figure 3). However, if responses of too hot and too cold were combined to constitute a dissatisfied response, the majority of the total student population would be dissatisfied with the residence building temperature. Additionally, when isolating the responses of too hot or too cold, it can be noted that a significantly larger portion of students responded as being too hot (41%) as opposed to too cold (11%). It is also interesting to note that greater than half of Risley Hall residents found the temperature to be too hot (49%) or too cold (4%), even though students are provided with a thermostat in each room (Figure 5-2). Residents of Gerard Hall were found to be the only group that considered residence temperatures to be too hot (Figure 5-5).

When asked whether heat energy was being wasted around the residences, the majority (61%) of students perceived inefficiency (Figure 4). The bedrooms and hallways were recognized as the areas with the hottest temperatures at all times throughout the eight-month school year. It was also noted that throughout the residences windows were frequently left open, contributing to the heat energy loss. The majority of students always leave their windows open (53%), as a result of the hot temperatures (Figure 6). A 2˚C reduction in the temperature of residence buildings around campus would contribute to energy savings, as well as a decrease in the CO_2 emissions rate by 227kg/year. Additionally, this reduction in temperature may work to reduce the frequency that windows are left open around residences, further reducing energy inefficiency.

Recommendations

For facilities management and housing staff:

- Temperatures should be decreased by 2˚C in all 5 residences.
- Promote the educational poster campaign to reduce energy consumption (Appendix B).

For students:

- Where applicable, reduce heat in the residences rooms by 2˚C.

Electrical Energy

Providing electrical energy to the 6, 925 m^2 area comprising the five residence buildings requires vast amounts of energy. As Dalhousie students are not exposed to the direct impacts of excessive energy consumption, it is difficult to appreciate the impact our lifestyles have upon the environment. Currently, a majority of the students in residence perceive electrical energy being wasted around the residences (Figure 7). The majority of the energy inefficiency was attributed to the lights in the bedrooms, hallways, bathrooms, and common areas being left on unnecessarily (Table 4). Appliances including, televisions, computers, mini-fridges, overuse of the elevators and machine dryers were also considered areas of concern. In regards to computer use, the majority of students leave their computers on during the day or at all times (Figure 8). Setting a computer monitor to "sleep" mode after 10 idle minutes would eliminate the emission of 113kg of CO_2/year and reduce energy consumption and the corresponding costs.

Installation of motion sensor lighting in the bathrooms and hallways was found to be acceptable to the majority of residence students as a way to reduce energy consumption pertaining to the traditional lighting systems (Figure 10). Concerned students consider security, the lack of trust in the technology, and safety issues to be the highest barriers to successful implementation of the motion sensor lighting technology (Table 7). A study conducted by Tim Mcleod (2005) in Gerard Hall determined the payback period for motion sensor lighting to be 3-4 years. Assuming a similar payback period across all Dalhousie residence buildings and installation costs between $8.85-$12.82/m^2, costs are as follows:

Howe	$27, 545.82 - $39, 902.53
Sherriff	$21, 9997.02 - $31, 864.62
Eliza Ritchie	$2, 836.47 - $4, 108.87
Gerard	$8, 903.23 - $12, 897.10

The cost calculations are based upon the area of each of the residence building, determined from residence blueprints. Successful installation has already been displayed in the bathrooms and hallways of Risley Hall and the bathrooms of Howe Hall (Fountain House, Cameron House, and one bathroom in Bronson House).

Recommendations

For facilities management and housing staff:

- Promoting the energy reduction poster campaign to encourage setting computer monitors to "sleep mode" after 10 idle minutes (Appendix B).
- Installation of motion sensors where they currently do not exist, in the bathrooms and hallways of Sherriff Hall, Eliza Ritchie, Gerard Hall, and sections of Howe Hall.

For students:

- Setting computer monitors to "sleep mode" after 10 idle minutes.

Showers

Being among the highest per capita water consumers in the world (Environment Canada, 2003), Canadians must strive to use water resources conservatively. Although the supply is extensive, excessive water use results in increased energy consumption required in treatment and heating processes. The average shower length of a residence student was determined to be 11.2 minutes (Figure 11). Assuming a water consumption rate of 19L/min for a conventional showerhead, an 11.2-minute shower utilizes 212 L of water. If the conventional showerheads were replaced with low flow showerheads, water consumption would be reduced to 9L/minute or 100 L/shower. This would save 112/L of water for every shower taken and reduce water heating cost and the CO_2 emitted by 169kg/year. Additionally, if students decreased their average shower length by 2 minutes to 9.2 minutes/shower, water consumption could be decreased by 37L/shower (conventional) and 29L/shower (low flow).

Currently, low flow showerheads have been proven successful in Risley Hall and Howe Hall (Fountain House). It has been noted that low flow showerheads were previously installed in the other residences buildings and removed as a result of student dissatisfaction with the water pressure. Should installation commence in the summer months (May-August), it is likely that incoming student will accept low flow showerheads as the status quo. This conversion technique has been implemented successfully by Mount Allison University (Mount Allison University, 1998).

Recommendations

For facilities management and housing staff:

- Low flow showerheads should be installed in Howe Hall (Bronson House, Cameron House, Henderson House, and Smith House), Sherriff Hall, Eliza Ritchie Hall, and Gerard Hall during the summer.
- Promote the energy reduction campaign to encourage shorter showers (Appendix B).

For student:

- Reduce the average shower length by 2 minutes.

Hand Dryers

Hand dryers have been found to be an environmentally superior alternative to paper towel use. It was found that in residences, 61% of students would not accept the conversion from paper towels to hand dryers (Figure 12). Student perceptions' regarding hand dryers constitutes a large barrier to a successful conversion. Concerns include dryer inefficiency, the unsanitary conditions associated with hand dryers, increased noise levels, preference for paper, the energy consumption associated with hand dryers, and a general dislike of the technology (Table 8). With proper education regarding the environmental benefits of hand dyers, it is likely that a change in the current student perception will result.

Recommendations

For facilities management and housing staff:

- As there is low student acceptance, installation of motion sensors should not be initiated.

For students:

- Education regarding the environmental implications of hand dryers and paper towels.

Reporting Inefficiencies

Communication is key to successful conversion to a more environmentally sustainable campus. A link must exist between the decision-making bodies, the individuals responsible for implementing the change, and those being impacted most. Feedback must flow freely between each of these groups to ensure that all parties involved are working towards the goal of sustainability. As a result of this interconnected nature, positive change will be most effectively generated. When one link is severed, groups become isolated and creating change becomes a lengthy process. When asked whether students reported energy inefficiencies they observed, an overwhelming majority claimed they had not (Figure 13). This could be a result of many factors including lack of student knowledge regarding the proper way to report concerns, lack of communication between students and housing staff, lack student/staff awareness regarding the importance of sustainable energy consumption practices, and time constraints facing both students and staff. Students who had reported inefficiencies voiced their concerns to the facilities management/maintenance staff, residence assistants, the front desk, the building managers, and the residence life managers (Table 9). The most effective way to voice energy efficiency concerns is through the completion of a form available at the front desk of each residence building.

Recommendations

For facilities management and housing staff:

- Promote the educational energy reduction campaign to provide information regarding where energy inefficiencies can be reported (Appendix B).

For students:

- Report inefficiencies to the appropriate individuals.

Conclusion

Although efforts have been made to improve the energy efficiency of Dalhousie residences, energy consumption remains a major concern. As one of the leading institutes of higher learning in Canada, Dalhousie University has made a commitment to the promotion of environmental sustainability. It is necessary to fulfill this commitment, in part, by implementing environmentally friendly physical operations and encouraging sustainable human behaviour on campus. If the recommendations made in this report were pursued, the University would be working towards this goal through making residences on campus more energy efficient. Furthermore, students living in residence would gain an appreciation for the significance of practicing environmentally sustainable habits on a day-to-day basis. However, the recommendations we have made are only minor when considering the large-scale changes that would need to be pursued if Dalhousie residences were to be made into truly green spaces. We suggest further research be instigated to examine other factors beyond energy consumption. For example, the consumption of water in residences is a concern that needs to be addressed. The toilets currently present in residences across campus constitute a majority of the water loss in the washrooms. Investigating the feasibility of the installation of the ultra-low-volume (ULV) toilets would be a valuable direction. Additionally, the installation of low flow showerheads with a shut-off button for stopping the flow of water when using soap or shampoo could be examined for feasibility. These are only two examples, but there is an obvious need for much more research into the environmental sustainability of Dalhousie residences. This study should serve as a beginning point from which other research projects may branch from to pursue further knowledge and understanding.

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Appendix A – Residence Student Survey

Energy Use in Residences Survey – 2007

Age _______ Gender (F) (M) Residence Building _______________

1) How often do you use the clothes dryer per month? (circle one) Never 1-2 3-4 5-6 7-8 9+

2) If you were provided with a clothes-drying rack in your bedroom, how often would you use the dryer per month? (circle one)

Never 1-2 3-4 5-6 7-8 9+

3) What would influence you to use a clothes-drying rack (check all that apply)

( ) Increased cost for use of dryers

( ) Free drying rack supplied to each residence room

( ) Knowledge that drying racks save energy and help with environmental conservation

( ) Other (please explain): _________________________

4) Do you find the overnight temperature in your dorm room: (circle one) Too hot Too cold Just right

5) Would the installation of motion sensors, which ensure that most of the lights are off when no one is in the hallways, be acceptable to you? (circle one) Y N Don't Know If no, why? _________________________

6) Would the installment of motion sensors on the lights in the bathrooms be acceptable to you? (circle one)

Y N Don't know If no, why? _________________________

7(a) Do you see electricity being wasted in your residence building? Y N

If yes, where? ____________________

(b) Do you see heat energy being wasted in your residence building? Y N

If yes, where? ____________________

(c) Have you reported these inefficiencies to someone? Y N If yes, whom____________________

8) In regard to your own normal behaviour: (check all that apply)

I leave my computer on ( ) Only when I am using it

( ) During the day

( ) Always

( ) Other __________

I open my window ( ) Never

( ) Only when it is warm outside

( ) Always

( ) Other __________

I turn my lights off ( ) Every time I leave the room

( ) When I remember to

( ) When I go to sleep

( ) Other __________

My average shower length is: ____ minutes.

9) Would you like to see hand dryers install in the bathroom? (circle one) Y N Don't Know

If no, why? _________________________

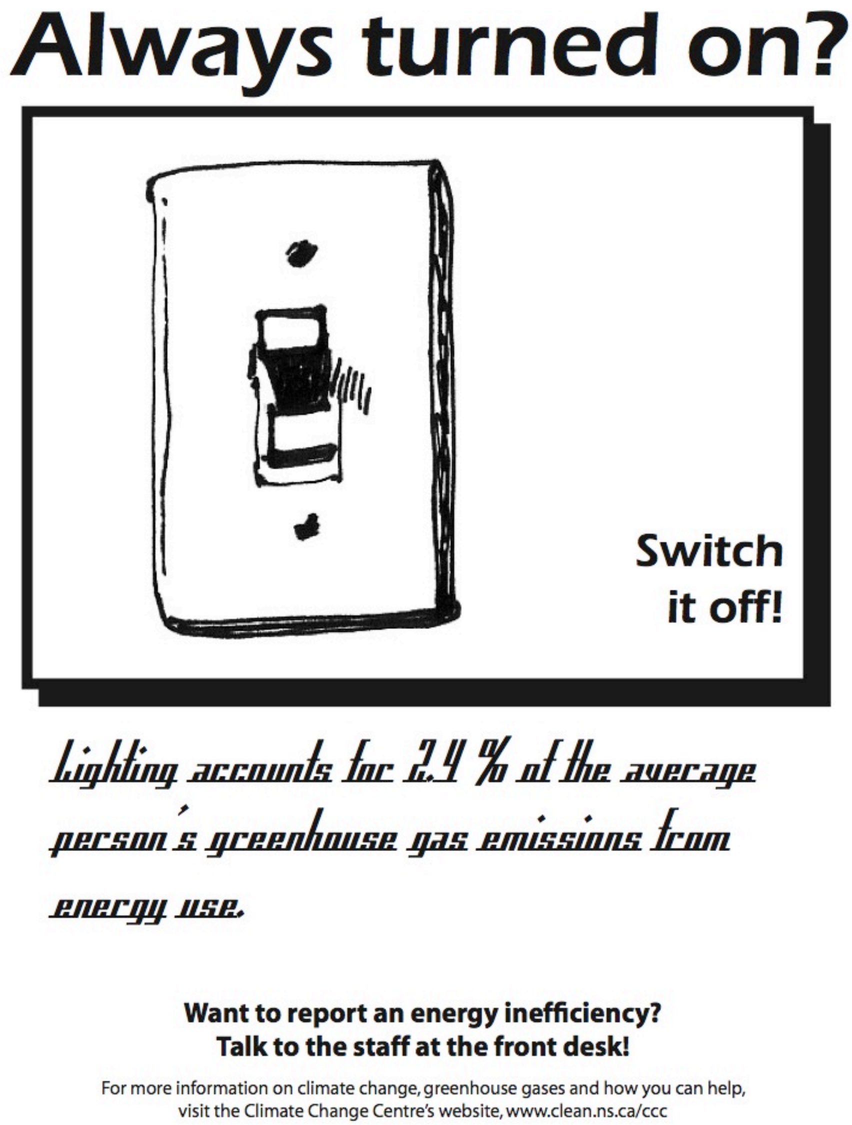
Thank you for filling out this survey! Your advice will be considered.

If you would like to support a petition regarding energy reduction efforts such as the ones mentioned above, please provide your name here: ________________________

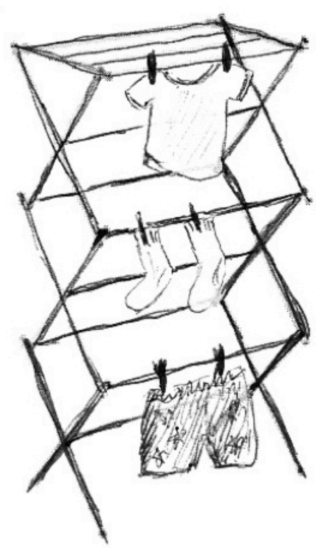
If you would like to receive the results from this survey, please provide your email here: _______________________

If you wish to contact us with questions, email **epss@dal.ca**

Appendix B – Energy Reduction Campaign Posters



Well hung?



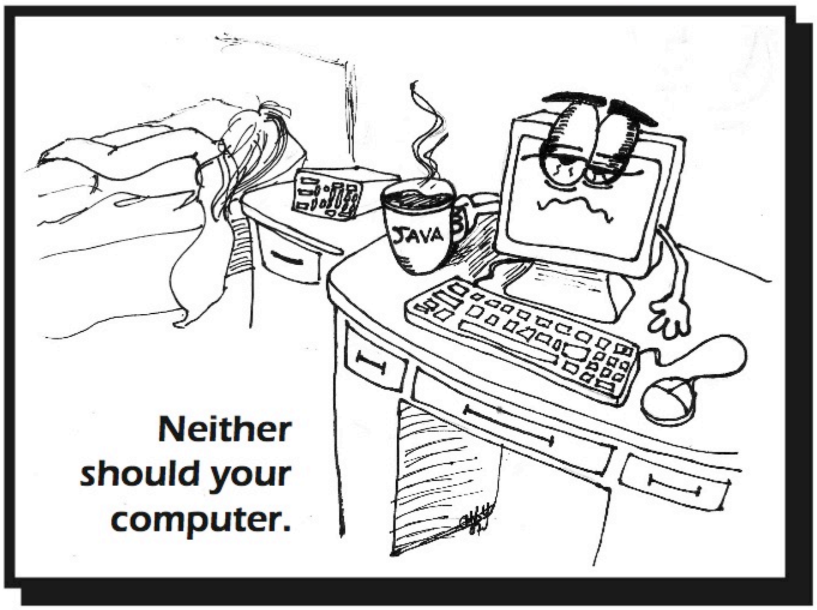
Use a clothes drying rack

Using clothes drying racks to dry laundry can reduce CO2 emissions by 8 tonnes/ 8 months in Dalhousie Residences.

Want to report an energy inefficiency?
Talk to the staff at the front desk!

For more information on climate change, greenhouse gases and how you can help, visit the Climate Change Centre's website, www.clean.ns.ca/ccc

Can't go all night?



Setting the computer to "sleep" mode after 10 idle minutes will reduce CO_2 emissions by 103 kg/yr. Turn it off when not in use.

Want to report an energy inefficiency?
Talk to the staff at the front desk!

For more information on climate change, greenhouse gases and how you can help, visit the Climate Change Centre's website, www.clean.ns.ca/ccc

Feeling Dirty?

Every extra minute you shower produces 0.2kg CO_2 emissions.

Want to report an energy inefficiency?
Talk to the staff at the front desk!

For more information on climate change, greenhouse gases and how you can help, visit the Climate Change Centre's website, www.clean.ns.ca/ccc

Appendix C – Letter of Appreciation

Dalhousie University
February 16, 2006

Dear ,

Thank you for you participation in our student survey. Your feedback is valuable to us and will be considered in our final report. As you have provided your e-mail address for follow-up, we have attached a copy of the results for your own interest.

Thank you for your support.

Sincerely,

The Energy Reduction Team