*ENVS 3502*

*Final Report*

*Tarah Wright*

# *A Lighting Audit in the SUB: What a Bright Idea.*


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## *ABSTRACT*

A group of five students participated in a group project for the class of ENVS 3502, taught by Tarah Wright at Dalhousie University. We focused on the feasibility of reducing Dalhousie's energy consumption by evaluating current lighting practices and looking for areas of improvement. The research took place between January 10th and March 31st 2004. Due to time constraints we were only able to focus on one building; we chose the Student Union Building (SUB). Our research led us to the formation of several recommendations that, if implemented, will reduce the SUB's energy expenditures allocated to lighting and will therefore reduce the demand for power that is generated in a predominantly environmentally unsustainable way.

## *INTRODUCTION*

**Research Question:**

Could implementation of a new lighting strategy reduce energy consumption within the Student Union Building (SUB) at Dalhousie University?

Dalhousie University is dependent upon Nova Scotia Power for the majority of its energy needs. Fueled mostly by coal and oil, with a very small amount coming from renewable energy sources, the university relies on environmentally damaging resources that are unsustainable in the long term (Peter Howitt: personal interview; January 22, 2004). Dalhousie University is the largest university in the Atlantic region and therefore, has a central role to play in conserving energy. Although the university does not include an environmental policy within its mission statement, we believe that as one of the largest institutions in Halifax, Dalhousie has a responsibility in minimizing its total energy use.

In 1990, the university signed the *Talloires Declaration*, thereby authenticating its commitment to move towards more sustainable energy use. By putting their name under the growing list of other universities who have signed on, Dalhousie has declared to "increase awareness of environmentally sustainable development, create an institutional culture of sustainability, and practice institutional ecology" among other things (ulsf.org). Since signing the declaration, the university has followed up its commitment by implementing several green energy technologies which have contributed to a substantial decrease in the amount of energy which is used. However, there is still a huge amount of work to be done.

**mportance/Rationale**:

In today's society, energy use is one of the most important and costly expenses institutions face each year. Every dollar saved from energy use is a dollar that can be contributed elsewhere. Due to the current funding crunch being experienced by most universities nation wide, the importance of energy conservation has increased that much more. Energy audits are an essential aspect of proposed energy initiatives. However, they usually require extensive time and resources which many universities cannot afford. At Dalhousie, the facilities management team has already implemented several energy efficient lighting technologies but has not had the time or resources to do so on a large scale. Most new buildings which have been constructed over the past few years have incorporated more energy-efficient technologies, and several energy upgrades have been implemented throughout campus.

Our reliance on the combustion of fossil fuels has several negative consequences. Firstly, combustion produces several by-products that are deleterious to the environment. Carbon dioxide is a gas that collects in the upper atmosphere and is believed to be a major cause of global warming. Other by-products are also released during combustion causing a variety of health problems such as asthma and emphysema.

Secondly, fossil fuels are formed deep within the earth over millions of years. The extraction of these resources requires the destruction of complex ecosystems. A wide variety of species are dependent upon these places for survival, and without an approach which considers the wide scale implications of resource extraction, extirpations and sometimes extinctions are often the result.

Finally, once the resource has been extracted it must be sent for processing so it will can the requirements imposed by our infrastructure. The primary consequence of transportation is the possibility of an oil spill. Oil spills are of great concern because they are devastating from both a financial and an economic perspective. The processing of these resources results in a large amount of air-borne pollution (Shearwater refinery) as well as ground water pollution (Sydney tar ponds).

Campus audits have become increasingly popular in recent years as more and more students have been pushing for environmental change. With training and supervision, students can provide valuable assistance to energy retrofits, helping to decrease initial costs and improve a project's chances of success. By conducting a lighting audit we have provided facilities management with the data needed to question some of the current energy-related operating procedures within the SUB. Based on our findings we have generated six recommendations which can help Dalhousie in cutting down on the amount of energy required to light the SUB. Furthermore, a lighting audit could act as a catalyst to promote similar projects on campus and could compliment many energy conservation strategies currently in place.

Using our data we have put together a report which analyzes:

(1) **Existing conditions**: electricity demand (in kilowatts); electricity use (in kilowatt hours).
(2) **Lighting design**: proposed new lighting (lamps, ballasts); proposed lighting control (occupancy sensors).
(3) **Costs and savings**: resulting electricity demand, use and cost; summary of costs and savings from avoided electricity use (using assumptions about hours of use, hourly rates, and kilowatt hour costs).

Our hope is that the results of our research will be used to reduce Dalhousie's ecological footprint by encouraging the implementation of a lighting upgrade within the SUB. If successful, this could lead to further energy conservation projects around campus.

## *METHODS*

A wide variety of methods were used in conducting our research in order to improve the validity of our results. Data collection was triangulated by doing an extensive literature review, conducting interviews with relevant faculty and staff, and issuing a questionnaire to SUB employees/volunteers to determine lighting demands and promote environmental awareness about the importance of conserving energy. Associate director of facilities management, Peter Howitt, helped guide us through each stage of our research, helping us design our study so that we would be able to obtain the results we had set out for. We also set up a number of tours with Pat martin (the manager), and one of the lighting representatives from the university. They were able to identify all of the different bulb and fixture types within the building as well as the amount of energy being consumed by each one. We used the information they gave us to determine what additional information we would need, and designed a spreadsheet which would help us organize the results of our audit. We conducted the audit by doing a room-by-room analysis of lighting use, and used the results to produce six recommendations in which lighting use can be improved. We met with Phillip Hore, a lighting representative from ELM Marketing in order to help us make sense of our results, and further improve the validity of our recommendations.

**Instrumentation:**

Issues of reliability and validity were of great concern to us throughout our research. Palys describes reliability as being “generally synonymous with consistency, whether of the same phenomenon over time or of judgments about the same phenomenon across different observers” (Palys, Ted, 2003; p. 63). When designing our study we asked ourselves the question: if our research was performed by another group, would they come up with the same results? We attempted to select a measure which would allow us to obtain the information we set out for, while working within time-related constraints. Both Peter Howitt and Pat martin helped us in narrowing down the focus of our research, and Peter

Howitt used his knowledge of prior energy audits to help us design a spreadsheet which would help us organize our information accordingly. Because of the huge number of lighting fixtures in use at the SUB, we had to impose limits upon the extent of our research. For this reason, areas such as the McInnis Room were not given sufficient attention, and only generalized recommendations could be made. However, we believe that the methods employed in conducting the lighting audit give a reliable indication of lighting use in the SUB, and that the results of our research would be replicated if a lighting audit were done by an outside group.

In questioning whether or not our research findings are valid a few additional points must be made. Palys claims that “to demonstrate validity, you must show that your particular operationalization accomplishes the purpose for which you intended to use it. The researcher’s task is to pick a relevant criterion in which the construct is embodied and then show that the operationalization is indeed related to that criterion, but not related to other constructs you do not want to measure” (Palys, Ted, 2003; p. 64). In our case, we set out to select a set of research tools that would provide us with information related to lighting consumption at the SUB. We did not want information related to energy consumption as a whole, nor did we want to look into areas related to lighting that would be of no use. In that sense, we believe that the results of our research are both valid and reliable, and we hope that it will be put to good use.

**Procedures:**

Initially, our group was extremely unclear about where we wanted to focus our research. We all recognized the importance of clean energy use, and originally had intended to determine the feasibility of implementing renewable energy sources on campus. However, we quickly realized that renewable energy sources would not be considered a viable alternative to the consumption of fossil fuels until Dalhousie had done more in the way of conserving energy and implementing more energy efficient technologies around campus: “while renewable energy technologies can be incorporated throughout an institution’s energy infrastructure, the cost-effectiveness of some applications—such as photovoltaic-powered buildings—improves in proportion to energy efficiency" (Keniry, 2000; p. 60).

From there, we decided to conduct an interview with associate director of facilities management, Peter Howitt, in order to determine a useful area of research (see appendix for interview questions). We were well aware of the practical nature of this project and decided that by working with facilities management, the results of our research would more likely be used.

Peter Howitt informed us that facilities management is constantly looking for new projects to take on, but is limited by the amount of time and resources they have to determine which ones are most appropriate at any given time. Surprisingly, he listed time ahead of resources, as the biggest restriction they face each year in determining which projects get the go-ahead. The staff team at facilities management is simply not large enough to collect all the data that would be necessary to sufficiently compare every project proposal they face each year.

After our initial interview, Peter Howitt met with some of his associates and determined that a lighting audit of the Student Union Building would be the best way for us to spend our available time and resources. He further added that if we could show that a lighting retrofit of the SUB would save the university a significant amount of money over the coming years, and that any proposal would fit within a five-year plan, facilities management would consider taking action on our recommendations as early as this summer. He told us that as long as we were up for the task, he would provide us with a list of contacts that could further help us with our research. From there we conducted our research according to the following outline:

**(1) Literature Review:** we began by doing a brief literature review in order to better familiarize ourselves with some of the lighting technologies we would be encountering at the SUB (see appendix). This gave us a better idea of what to expect, and allowed us to approach the audit with the technical information we would need to narrow our focus.

**(2) Interviews:** from there we conducted a series of interviews with Pat Martin and Peter Howitt in order to identify what types of bulbs are being used within the SUB, and get a better idea of how we would calculate lighting consumption over the course of a day. Pat Martin referred us to a lamping representative from facilities management, who walked us through a room-by-room tour of the entire building, identifying bulb and fixture types, watts per bulb, and ballast types.

**(3) Lighting Audit:** in order to conduct the lighting audit, we assigned each group member a floor by drawing names out of a hat. Because there are both five group members and five floors, this was a useful method of dividing up our research. Based on the input we received from conducting interviews, we designed a spreadsheet so that our data collection would be organized similarly for each group member. This also helped us identify specifically what information we were aiming for, so that we would not collect any data that would not be of use. Each group member then did a room-by-room analysis, counting the number of bulbs and fixtures in each room, and identifying how many watts are used by each.

**(4) Questionnaires:** a questionnaire was designed in order to help us determine how many hours each room is in use at the SUB (see appendix). While conducting the audit, each group member administered a questionnaire to all relevant office managers, faculty, or other staff who would be able to answer this question. For areas such as hallways, storage rooms, and washrooms in which no one person is responsible for controlling lighting use, we relied on Pat Martin to give us a rough idea of lighting use. To obtain hourly use for each conference room, we scheduled a meeting with reservations coordinator, Shelly Brown, and had her give us the booking information of all of the conference rooms in the SUB over a two week span (see appendix). She pointed out that to accurately portray lighting use in conference rooms is extremely difficult due to the large difference in usage experienced during the summer months. She also mentioned that her figures only include the time the rooms are in use, and do not include the amount of time used in setting-up room space, which would likely increase the figures we used.

(5) **Analysis:** once we had collected all of our initial data, we met with Philip Hore, a marketing representative from ELP Marketing, who helped us identify six main areas in which lighting use can be improved within the SUB. We followed up by doing a more thorough literature review of alternative lighting technologies, and used our data to calculate the amount of money and energy that can be saved through the implementation of each of our recommendations.

**Method of Analysis:**

We conducted our data analysis by sifting through the information we had collected and selecting the most relevant areas to focus on. With the help of Philip Hore, a lighting representative from ELP Marketing, we narrowed our analysis down to six areas in which it was determined that lighting use can be improved. Within each area we multiplied the number of ballasts/bulbs by the amount of watts per bulb by the average number of hours per week each bulb was estimated to be in use. This gave us the total number of energy being consumed by each lighting fixture in an average year (although these figures were based on a number of assumptions which we will discuss later on).

Using a calculations matrix from the General Electric website, we were able to determine the amount of energy that would be consumed with the implementation of more energy-efficient lighting technologies. The GE calculations matrix included bulb types, watts, rated watts saved over bulbs replaced, rated life, and estimated energy savings over the course of the bulbs' life (because it was rated at $0.10/KwH we had to use 80% of the total). We used the GE calculations matrix in order to calculate the costs of replacing T-8 32W fluorescent bulbs with T-8 30W fluorescent bulbs, 75W incandescent bulbs with 20W compact fluorescents, and 60W incandescent bulbs with 15W fluorescents (gelighting.com).

In order to calculate the costs associated with replacing T-12 F40W fluorescent bulbs with T-8 30W fluorescent bulbs it proved to be more difficult. This is because a replacement of all F40s would require the installation of an entirely new set of lighting fixtures. Using a document which was recently issued by the Canadian Mortgage and Housing Corporation (CMHC) which estimates that to replace each F40 fixture with a T830 fixture costs roughly $57, we were able to come up with a general idea of how much this would cost (cmhc.gov.ca).

Finally, in order to calculate the costs associated with installing occupancy sensors in the washrooms of the SUB we used an estimated cost of installation of each new occupancy sensor of $250 which was provided to us by Philip Hore. In order to verify his estimation, we used a report issued by Green Seal which outlines the costs associated with the installation of occupancy sensors. Listed prices of occupancy sensors range from $60 - $140. We figure that with the costs of labor associated with the installation of new occupancy sensors, Philip Hore's estimate would be about right, although we are not certain (greenseal.org).

It is important to note that we relied on several assumptions in making our calculations which likely had an influence on the outcome of our results. The first of these assumptions was related to time. Because we did not have detailed information describing user conditions of the SUB throughout the entire year, we had to base our calculations upon the time period in which we conducted our audit. We realize that due to lower summer volumes during the summer months, some of our calculations are likely off.

The second assumption we made was that the washroom lights are on 24 hours per day. We made this assumption based on information we had gathered from both Pat Martin and "Buddy", a lighting representative from facilities management, who speculated that in all likelihood lights in the washroom are never turned off. It is important to note, however, that we used a conservative estimate of only 50 percent in calculating how much energy consumption would go down with the installation of occupancy sensors in all washrooms. In most cases, the actual figure would be much lower, reducing the payback period significantly.

Finally, we did not include the reduction in labor costs associated with installing longer lasting compact fluorescent and fluorescent light bulbs. In some cases, the installation of new bulbs would provide 15 times the bulb life. Considering that the university must pay someone to change each light that goes out, and keeping in mind the huge number of bulbs in use in a building such as the SUB, savings from labor costs can be significant. If we had included a calculation of these savings it would have likely improved the cost-effectiveness off some of our recommendations that much more.

**Limitations:**

The biggest limitations we faced were in relation to time. Initially, we had high expectations for the outcomes of our research, hoping that it would be used to carry out a full-scale lighting retrofit of the SUB. We felt that a comprehensive proposal was essential in achieving this goal, and realized that in order to put together a proposal within the time constraints we faced would be extremely difficult.

Although we feel as though we have achieved some of those goals, time availability limited the range and scope of our research. For example, the McInnis Room had originally been one of the main focuses of our research. However, by the time we had conducted the lighting audit and met with Philip Hore, we only had one week to put together our report. Hore told us that if we had come to him a month earlier he would have been able to help us put together a valid proposal outlining a complete upgrade of the McInnis Room. However, because we spent so much time collecting our data, we were not able to do a comprehensive analysis of the McInnis Room.

The second main limitation we faced had to do with a lack of prior knowledge related to our area of research. Had we known a thing or two about lighting audits or lighting in general, we may have been able to come up with a more valid method of analyzing our data. However, without this knowledge we were forced to depend upon figures obtained from the internet, some of which are questionable.

The third limitation we faced was in relation to the resources we had at our disposal. Quite simply, a lighting audit of the Student Union Building is quite a task for five university students who are all trying to juggle outside courses, and who have no prior experience in conducting energy audits. If we had more group members, the range and scope of our research could have been extended that much more.

**Delimitations:**

In order to narrow the scope of our project we chose to limit ourselves to only conducting a lighting audit of the Student Union Building. Although a lighting audit of the LSC may have been more useful, we decided that we did not have the time or resources to conduct a lighting audit of such a large building.

We also decided to limit the extent of our analysis so that it would only include the most important factors. Had we had the time and resources, we could have included an analysis of lighting levels, the viability of daylight sensors (which in many cases would likely be feasible), the implementation of energy conservation measures such as the installation of reflectors within all fluorescent fixtures as a means of increasing the output of light, and as was stated earlier, the inclusion of calculations related to labor costs.

## RESULTS

Facilities management uses a wide variety of lighting fixtures to meet lighting requirements within the SUB. Due to time constraints we limited our focus to four types of lighting fixtures: T8 32W fluorescent lights, F40 fluorescent lights, 75 watt incandescent lights, and 60 watt incandescent lights. To determine energy output for each type of fixture and/or bulb, we counted the number of lights within the building. It was this count that revealed the variety of lights to us. The results of the count are listed in table 1.

| Fixture type | Number of bulbs | Number of fixtures |
|---|---|---|
| T-8 32W fluorescent light | 929 | 461 |
| F-40 fluorescent light | 710 | 343 |
| 75 watt incandescent light | 151 | 151 |
| 60 watt incandescent light | 101 | 101 |

Table 1: The number of bulbs and fixtures that are the focus of our recommendations.

Knowledge of the number of lights in the SUB was a necessary factor in determining the energy consumption of each fixture type in the SUB. Another important factor necessary in analyzing our data was the amount of time each light was estimated to be in use. This number was determined through the administration of a questionnaire. The relevant data extracted from the questionnaire, in number of hours each light is on per year, is listed in table 2.

| Fixture type | Yearly hours of operation |
|---|---|
| T-8 32W fluorescent light | 2964 |
| T-12 F40 fluorescent light | 4168 |
| 75 watt incandescent light | 4732 |
| 60 watt incandescent light | 2652 |

Table 2: The number of hours each fixture type is on during the year.

By combining the data from table 1 with the data from table 2, it was possible to estimate the amount of energy consumed by each lighting fixture in the SUB. This figure was easily converted into dollars by using Dalhousie's current energy cost of $0.08 per kilowatt hour. The amount of energy consumed (kW/hr) and the costs associated with this energy consumption, are displayed in table 3.

Information we gathered during interviews with Peter Howitt, Pat Martin, and Peter Hore helped us in determining the best course of action for improving energy-efficiency within the limitations of a five-year plan. Table 4 provides a comparison of the current lighting technology (in wattage) compared with more energy-efficient lighting technologies. (In addition, it is important to note that by converting T-12 F40s to the more efficient T-8s will result in a reduction of 14 watts per ballast because each will be converted from magnetic to electric).

| **Old technology/wattage** | **New technology/wattage** | **Total energy savings per bulb (watts)** |
|---|---|---|
| T-8 32W | T-8 30W | 2 watts |
| T-12 F40 / 40W | T-8 30W | 17 watts (10 per bulb + 7 per ballast) |
| 75 watt incandescent | 20 watt compact fluorescent | 55 watts |
| 60 watt incandescent | 13 watt compact fluorescent | 47 watts |

Table 3: comparison of old technology with energy efficient new technology.

Using information obtained from the GE lighting calculations matrix and the CMHC document outlined above we were able to determine potential savings attributed to the conversion of more energy-efficient fluorescents and compact fluorescents. This information is displayed in Table 4.

| Fixture Type | Savings per year |
|---|---|
| T-8 fluorescent light | $474 * 929 bulbs = **$440.57**<br>no costs to switch |
| F-40 fluorescent light | $5.35 * 710 = **$3798.5**<br>costs associated with switching<br>($57 per fixture) |
| 75 watt incandescent light | **$3953.63**<br>no cost to switch |
| 60 watt incandescent light | **$1213.43**<br>no cost to switch |

Table 4: Savings associated with installation of more energy-efficient lighting fixtures.

## Discussion

Lighting costs are one of the largest expenses faced by Dalhousie University each year, accounting for roughly 35-40 percent of total energy use (Howitt, 2004). Lighting has become so common within our culture, that one rarely makes the connection between reckless lighting use and the burning of fossil fuels. Because Dalhousie relies upon coal and oil for the majority of their energy needs, inefficient energy consumption is a major problem. Every bit of energy saved can reduce Dalhousie's ecological footprint, lowering its dependence on fossil fuels. Some may say that due to the expansion of the university in recent years, our dependency upon fossil fuels is increasing so rapidly, that energy conservation has little effect. But the opposite is true. Every step made by Dalhousie at becoming more energy-efficient, brings us closer to a future in which renewable energy may provide the bulk of our energy needs. However, measures aimed at conserving energy must first be met, and lighting audits are an essential component in taking that next step. By conducting a lighting audit, we have collected data which can be used in justifying a lighting upgrade within the SUB. Our research could also lead to future energy audits and the implementation of lighting retrofits elsewhere on campus.

**Significant Findings:**

We have found six main areas in which lighting efficiency in the Student Union Building can be improved:

**(1) A gradual replacement of all T8 32W bulbs with more energy efficient T8 30W bulbs**. Because theses bulbs use the same fixture as the old ones, the only difference in cost would come from the price of the bulb itself. Despite an increased cost in price, the reduction in energy consumption has been proven to pay for itself (gelighting.com).

**(2) A replacement of all F40 fluorescent lighting fixtures with more energy efficient T830 fluorescent lighting fixtures**. Because this would involve replacing all existing F40 lighting fixtures with new ones, a high initial cost would be necessary. However, after a five year payback period, the savings in time and energy would be significant. It is important to note, however, that savings in labor costs due to extended bulb life would increase savings significantly. The health-related benefits of replacing magnetic ballasts (some of which contain harmful PCBs), with electrical ballasts should also be taken into consideration.

**(3) A gradual replacement of all 75W incandescent bulbs with more energy efficient 20W compact fluorescents**.

**(4) A gradual replacement of all 60W incandescent bulbs with more energy efficient 15W compact fluorescents**. Switching from incandescent to compact fluorescents is one of the most logical decisions an institution can make in reducing energy consumption. They last nearly 15times longer, give off more light, and pay for themselves immediately.

**(5) The installation of occupancy sensors in all washrooms**. Because the lights in most of the washrooms in the SUB are often left on 24 hours a day, an installation of occupancy sensors would reduce lighting consumption by at least 50 percent, if not more. Manufacturers claim that in some applications, savings can approach 75% (Green Seal Report).

**(6) A complete overhaul of the McInnis Room**. It has been estimated that a major renovation of the McInnis Room would require a high initial cost which may not pay for itself in the near future. However, it is important to consider that during one night of use, the McInnis Room consumes approximately the same amount of energy as the whole building does in one week (Martin, Pat, 2004).

**(7) Additional findings include**: the discovery of a storage room in the university bookstore which employees claim has no known light switch. As a result, 38 T32 light bulbs are left on 24 hours per day. We did not calculate the amount of savings which could be accrued by installing a light switch, but considering the fact that the area is only in use 8 hours per day they would likely be significant. We also found several hallways in the basement and sub-basement in which lights are unnecessarily left on 24 hours per day. We did not calculate how much energy this uses, but would recommend that facilities management investigates these matters further.

Julian Keniry of the National Wildlife Foundation has estimated that of the five major sectors in which energy can be conserved and provided more efficiently on campuses—insulation, ventilation, lighting, office equipment, and heating and cooling—lighting has most often been the easiest and least expensive to change (Keniry, 2000; p. 66). Low input lighting initiatives on university campuses usually fall into two categories: conservation and energy efficiency:

> “conservation encompasses those energy-saving measures which eliminate waste without over-hauling technology focusing instead on people and habits. Energy efficiency, on the other hand, employs relatively new technologies to provide comparable lighting, cooling, heating, etc. while expending less energy” (Keniry, 2000; p. 66).

Although they are more complex, we have chosen to focus on the implementation of lighting strategies related to energy-efficiency, rather than broadening our approach to encompass energy conservation measures (although occupancy sensors are considered a conservation measure).

The literature supporting the validity of implementing energy-efficient lighting technologies is extensive. Hundreds of cases have been documented in which universities have been able to reduce lighting costs by hundreds of thousands of dollars each year. Between 1992 and 1994 the Rochester Institute of Technology replaced 800 incandescent bulbs with compact fluorescent bulbs and ballasts and were able to save approximately $27 000 a year—with an average payback of only three months. Since that time they have saved an additional $23 461 annually by replacing F-40 fluorescent fixtures with T8-32 fluorescent fixtures (Keniry, 2000; p. 67).

Similarly, students conducting research at the New College in Sarasota, Florida, estimated that a lighting retrofit of some of the dorms would save $17 898 per year (or 411 oil barrels) and would only take 2.4 years to payback (Keniry, 2000; p. 64).

At Arizona State University annual energy savings resulting from a lighting retrofit reduced energy consumption by 2 705 600 kilowatt hours, leading to a concomitant reduction in fossil-fuel by-products such as nitrogen, carbon and sulfur of approximately 1512 tons (asu.edu).

Eastern Illinois University experienced much of the same benefits from a lighting retrofit. During the summer of 2002, the school replaced 10 000 F40 fluorescent fixtures and magnetic ballasts with 10 000 T8 fluorescent fixtures with electronic ballasts. They also outfitted nearly 1000 additional lighting fixtures, more than 300 occupancy sensors, and 200 LED exit signs. By the time the project was completed, the school's annual energy consumption had dropped by over 3.7 million kilowatt hours, reducing energy costs by about $250 000 for that year. The payback was a meager three years, and EIU experienced a return on investment of 30-35% from then on.

Obviously a rundown of all the successful lighting retrofits that have been implemented within the past few years on university campuses, would be much too long for this report. Rather, the point is to show the potential savings associated with lighting upgrades, and that savings can be translated into both economical and ecological results.

However, in approaching energy projects it is important to point out a common mistake, which many universities fail to observe. The most common approach to lighting retrofits is to implement the more inexpensive, quick payback measures first. Energy manager of the University of Buffalo, Walter Simpson warns that:

> "There is a danger in this approach, since it may make it difficult to impossible to ever financially justify the measures which take longer to pay for themselves. When quick payback projects are completed, the savings they generate rarely are made available to help finance longer payback measures; typically the savings are used for other, more immediate purposes. That leaves the longer payback projects 'standing alone', and on that basis they may never seem attractive enough to be addressed" (Keniry, 2000; p. 65).

The university of Buffalo solved that dilemma by developing a large, comprehensive energy project which uses short term paybacks to finance more long term ones. They also opened up the position of energy officer, and hired Walter Simpson, whose main job was to determine how the university could cut back on energy costs. Essential to the position was the creation of incentives. A part of every dollar saved goes towards Simpson's salary. In the ten years since he has been there, he has shaved off more than $3 million to the university's energy bill (and we would imagine now considers himself a wealthy man!).

Simpson credits the incentives-based approach to the university's success in cutting back costs: "energy conservation will never take hold if those who produce the savings can't benefit from them" (Keniry, 2000; p. 65).

Dalhousie does not currently have a position dedicated to energy conservation, although Peter Howitt and Mike Murphy do shoulder much of that load. As it was stated earlier on, one of the biggest limitations faced by facilities management each year has been a lack of available staff. To date, the university has been reluctant to implement incentives-based energy programs, and maintains that most projects must fall within a five-year plan (Howitt, 2004). Despite the importance of taking on longer-term projects such as an overhaul of the McInnis Room, due to higher initial inputs, and a slower rate of return, these projects are more likely to stay on the shelf.

Perhaps, the creation of a position dedicated to energy conservation would help the university become more energy efficient and further cut down on costs. Similarly, long term projects such as an upgrade of the McInnis Room could be considered in conjunction with short term projects such as a basic lighting retrofit of the SUB, as we have suggested above. If the savings were significant enough, they could help finance further projects, and set in motion a self-perpetuating energy savings plan.

There are also a large number of benefits to upgrading lighting which are usually overlooked. One benefit is a reduction in cooling load. Lighting generates heat as well as light. As a result, a lot of heat is commonly wasted from inefficient lighting fixtures. In warm weather waste heat increases the energy required to keep air temperature cool, so reducing the energy output of lighting can lead to reductions in the required output for AC.

A second benefit of upgrading lighting is that when energy in a building is reduced, the transformer that services that building gains more capacity and is able to use that energy somewhere else. Additional energy can go to meet the needs of new construction projects scheduled to take place over the next few years.

A third benefit is the increased environmental awareness that a student-led lighting audit/retrofit can produce. Our questionnaire had the additional purpose of being an educational tool, and we used it as a way of promoting the importance of cutting back on energy use (Creighton, 2001, p. 76).

**Recommendations for Further Research:**

Due to some of the limitations we faced in conducting our research, there were a lot of areas we did not have time to cover. Looking ahead, we would advise future "Greening the Campus" groups to work with facilities management in exploring the potential to further reduce energy consumption in some of these areas. They include:

(1) **A feasibility study to determine how much it would cost to do a complete overhaul of the McInnis Room**. Because of the sheer size of the room and the number of different lighting fixtures in use, we did not have the time or resources to determine how viable an upgrade of the McInnis Room would be. Philip Hore identified it as one of the most likely places in which the SUB could cut back on energy costs, and mentioned that he is interested in working with facilities management further to determine what the costs of an upgrade would be. The McInnis Room is a perfect example of wasted energy, as it can consume as much energy in one night of use as the entire building does in one week.

(2) **Research aimed at promoting smaller scale energy conservation measures**. Initiatives aimed at eliminating reckless energy use and focusing on people and habits instead of the implementation of new technologies. This would involve educating people about the importance of shutting off lights, or only using those lights which are necessary.

(3) **Further lighting audits throughout the university campus**. As it was mentioned earlier, lighting retrofits are the easiest and least

expensive means of cutting back on energy costs. Older buildings such as the LSC, the Chemistry Building, and the Dunn all still use wasteful T-12 F40 fluorescent lighting fixtures and lights are often left on 24 hours a day.

**Conclusion:**

As the largest university in Atlantic Canada, Dalhousie has a role to play in setting environmentally responsible practices. Although the facilities management team has already done a significant amount of work in conserving energy use around campus, there is still considerable room for improvement.

A lighting retrofit can reduce long-term operating costs associated with lighting, and reduce the amount of time required to change inefficient bulbs. It can also contribute to a significant reduction in the amount of fossil fuels being used to produce energy in the SUB, providing cleaner air for all. Every dollar saved on lighting costs is a dollar that can be used elsewhere, providing benefits for the university, as well as students and staff. The implementation of measures aimed at improving energy-efficiency also bring us closer to a future in which we could one day depend on renewable energy sources for the bulk of our energy needs. Because the SUB is owned and operated by the students, we see no better place to start conserving energy. In addition, we hope that our findings will be used to encourage further energy audits around campus, and promote awareness about the importance of consuming less.

## Appendix I

### Draft questionnaire:

1. What room do you occupy within the SUB?
2. Are you a student at Dalhousie or Kings?
3. Are you employed at Dalhousie?
4. Are you employed within the SUB?
5. Are you a volunteer within the SUB?
6. On average, how many hours a week do you spend in the SUB?
7. Of that, how much of that time is spent in your office or place of employment?
8. Do other people share that space with you?
9. Is the space used on the weekend?
10. Are the lights on during the day when it is sunny outside?
11. On average how many hours a day is your office occupied?
12. Do you shut the lights off when you leave for the day?
13. Is it customary to shut the lights off when you leave the room momentarily?
14. Is it possible to estimate the number of hours in a day that the lights are on?

## Appendix II

### Summary of Common Lighting terms:

**Lighting Fixtures***:* the entire assembly of the lamp, including, ballast, filter, reflector, lens, and other small parts. Incorporating reflectors and lens' can effectively direct light on work spaces and decrease the number of lamps needed to light a space.

**Incandescent lamps***:* work based on the principle of electrical resistance. Electric current flows through a wire filament, which gets hot and glows. Aside from producing light, incandescent lights tend to produce a lot of excess waste heat. The Student Union Building is estimated to be producing a significant amount of energy from incandescent lamps, most of which use between 75W – 150W.

**Compact Fluorescent lamps***:* usually a screw in version of a fluorescent lamp and can replace most standard incandescent bulbs. A 13W compact fluorescent bulb produces the same amount of light as a 60W incandescent lamp, while a 20W compact fluorescent bulb can replace a 75W incandescent bulb (www.gelighting.com/na/downloads/cfl_20563.pdf)

**Fluorescent Lamps***:* contain gas instead of wire filaments. Electrical current makes the gas atoms glow, creating light with very little heat. The most common fluorescent lamps are T-12 bulbs which are longer in diameter, and the more efficient T-8 bulbs. Most of the fluorescent bulbs currently installed at the SUB use 32W – 34W.

**Ballasts***:* devices that charge the electrical current in fluorescent lights. Magnetic ballasts are generally more inefficient than electrical ones. Most of the lamp fixtures at the SUB use magnetic ballasts which are fourteen times more inefficient than available electric ballasts.

**Sensors***:* detect changes in the room and trigger lighting changes accordingly. Occupancy sensors that detect the presence of movement or heat and turn on/off the lights accordingly; and daylight sensors which monitor the amount of natural light in a room and decide how much electrical light is needed are the two most common types of sensors. The Student Union Building is currently not using any sensors (Creighton, 2001, p. 74).

**Appendix III**

**Initial Interview with Peter Howitt**

(1) What is your official position?

(2) What is your educational background? Work background?

(3) There is a growing awareness among campus administrators that it pays to provide innovative, driven staff with the support necessary for them to concentrate on conservation – preferably by creating a full time position for a deserving candidate. After following this policy the University of Buffalo hired en energy conservation manager and over the next ten yrs. was able to save over $3,000,000. Is there a conservation manager at Dalhousie?

(4) If there is already an energy conservation manager at Dalhousie, how much money has been saved by implementing environmental initiatives since their inception?

(5) Does Dalhousie offer benefits to conservation managers? Or is their pay largely dependent on a salary? For example, at UBC, Freda Pagani was hired as conservation manager with the incentive that whatever amount of money she would save the university they would

give her and her team half that amount. Aside from that she was paid no additional salary, but managed to save the university over $2,000,000 in her first two years.

(6) Has Dalhousie ever considered the use of the following (if so please explain):

- Computerized Energy Management System (EMCS) – tracks temperature in respond to requests instead of maintaining standard temperatures. Allows for input of additional data as well. (RIT was able to save 21 million Kw in its first year using the system).
- Low flow shower heads which can have a payback period of as little as one month and which can lead to annual saving of $2500 - $7500 depending on size of school.
- Water efficient toilets which usually have a payback period 1-2 yrs. With annual savings of $1500 - $4500 depending on size of school.
- Low flow faucets which have a payback period of as low as 4 months and which can lead to annual savings of up to $15 000.
- Occupancy sensors which turn lights off when no one is in the room. 600 sensors at RIT saved them $24 461 in one year.
- De-lamping/disconnection of corridor lighting. Studies have shown that in many schools up to 50% of corridor lighting can be disconnected while maintaining adequate illumination levels.
- Replacement of 40 watt incandescent exit signs with 5 watt light emitting diodes. RIT saved $36 000 in its first year of installation.
- Replacement of incandescent bulbs with compact fluorescent bulbs. Has lowest payback, and saved RIT $27 000 in 1 yr.

- Organization of “volunteer building conservation contacts.” A building contacts program at the University of Buffalo relies on volunteer monitors to spread info about university environmental policies, monitor participation levels, and act as liaison’s to UB’s conservation programs and its environmental task force. Contacts receive an environmental checklist, which covers energy, waste, hazardous waste, water, purchasing and transportation. They are also asked to turn off unused lights/office equipment, and computers, and maintain adequate temperature control.
- Inter-dormitory energy conservation contests. Harvard was able to decrease energy consumption by 25% through the implementation of a Green Cup.
- Photovoltaic systems. Photovoltaic technology is about one tenth as expensive today as it was fifteen years ago.
- Solar hot water systems. In April of 1998, the government of Canada implemented the Renewable Energy Reduction Initiative, to provide eligible businesses and institutions with a 25% refund on the purchase of renewable energy systems up to a total cost of $80 000.
- Wind energy technology. Government incentives are in place which allows for full tax deductibility of all expenses related wind energy technologies from the costs of acquiring and installing a test wind turbine, to the costs of full installation of a wind energy system. Expenses may also be transferred to shareholders through the CRCE (Canadian Renewable and Conservation Expenses Initiative), in the form of ‘flow through shares.’ Adds to the Wind Power Production Incentive of 2001.

(7) Is the University a member of the Energy Innovators Initiative (EII)? The EII works with a network of partners and energy consultants

across Canada, providing funding for retrofit planning and projects related to the conservation and implementation of renewable energy systems; and an EII staff person to work with the organization to assess the feasibility of projects, perform an environmental audit, and provide information and consultation services. Energy Retrofit Planning (ERP) works with the EII to provide up to 50% of the costs for the development and planning of energy retrofits – up to a total cost of $25 000.

(8) To be considered for the EII, organizations must first be a part of Canada's Climate Change Voluntary Challenge and Registry Inc. Has Dalhousie committed to this registry?

(9) Are you aware of the Talloires Declaration of 1990 which Dalhousie signed? Two parts of the declaration specify that Dalhousie has declared to create an Institutional Culture of Sustainability (encouraging the engagement of education, research, policy formation and information exchange on population, environment and development to move towards global sustainability); and to practice Institutional Ecology (to set an example by establishing ecology principles of resource conservation, recycling, waste reduction and environmentally sound operations).

(10) In your opinion do you feel that Dalhousie has made significant efforts to follow up on their commitment to the declaration?

(11) Has Dalhousie put more emphasis on the implementation of short term energy projects at the expense of long term ones? If so, has a proposal ever been initiated to allow for the funding of long term projects by the success of short-term ones?

(12) Are you familiar with the green energy initiatives of other universities? Do you stay in contact with energy managers at other universities? If so, have you ever implemented a project based on its success on other campuses?

(13) What are the barriers to initiating renewable energy and energy conservation projects on campus?

(14) Do you think that students would agree to the creation of a fund which would draw on a $2 - $4 increase in tuition fees and which would go towards the funding and implementation of renewable energy and energy conservation projects on campus? At UNC they have successfully organized a committee on the basis of this fund, and to date have raised almost $200 000.

(15) What recommendations would you make to the university regarding energy policy? What direction do you see Dalhousie taking in the future in respect to renewable energy and energy conservation?

***Thank You!***

**Appendix IV**
**Thank You Letter**

Dear participant,

Thank you for your participation in our study. We hope to use the information gathered from this survey/questionnaire to contribute to a lighting audit we are conducting on the SUB. Our goal is to propose alternatives to inefficient lighting technologies that will reduce energy consumption within the building, thus curbing the university's dependence on fossil fuels. If you have any further questions regarding this study please do not hesitate to contact us. If you would like to make additional inquiries, please contact our supervisor Tarah Wright at tarah.wright@dal.ca

Thank you in advance,

Llewellen Saunders
Dave Crowell
Bob Jordan
Luc Cayer
Simon George

**Appendix V**

**Photos of the SUB**

This fixture is equipped with a 75W incandescent bulb

This is a T 12 F-40 fixture

A hallway on the fifth floor. An excessive amount of lighting

The lights in council chambers, very excessive lighting.

**Appendix VI**

**Calculation of savings**

Savings by switching from T-8 32W to T-8 30W: Assume 2964 hours usage/year

Savings of $.474 per bulb per year* x 929 bulbs = $440.57 per year

Savings by switching from 75W incandescent to 20W compact fluorescent:

Assume 4732 hours usage/year

Savings of $26.18 per bulb per year* x 151 bulbs = $3953.63 per year

Savings by switching from 60W incandescent to 15W compact fluorescent:

Assume 2652 hours usage/year

Savings of $12.01 per bulb per year* x 101 bulbs = $1213.43 per year

Savings by converting T12 F40's to T-8 30's: Assume 4168 hours usage per year

Savings of $5.35 per bulb per year x 710 bulbs = $3788.16 per year.

Costs associated with the conversion = $57 per fixture** x 343 fixtures = $19551

* from GE website (http://www.gelighting.com/na/downloads/cfl_20563.pdf)

** from CMHC website (http://www.cmhc-schl.gc.ca/en/imquaf/himu/wacon/waensatip/waensatip_018.cfm)

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