ENVS 3502

Studley House: Light Audit

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Final Report

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Abstract

Energy consumption in many buildings at Dalhousie University is an expenditure which, in several cases, is able to be reduced. An examination was done into one area of energy consumption, the lighting system within the Studley House residence, a section of Howe Hall at Dalhousie. Both qualitative and quantitative analyses were done in order to determine areas of unnecessary energy usage. Interviews with several staff affiliated with facilities, a meeting with the students of Studley House, an on-site lighting audit, a comprehensive document analysis and a cost-benefit analysis were all conducted to provide suitable information as to indicate how much of the equipped lighting system within Studley House would be improved with minor changes. It was found that the existing lighting system in the building could feasibly be improved in several sections, and by changing several of the installed fixtures to more efficient or suitable bulbs, costs would be returned through savings in as little as 3 years.

Introduction

Background

Energy use is very important to our present society as nearly everything humans do revolves around the consumption of energy. It is consumed and exploited in every sector of our economy; through residential, commercial, industrial, transportation and agricultural sectors, energy is created, and consumed (Natural Resources Canada, 2009b). In 2007, Canada consumed a total of 8,870.5 petajoule (PJ) of energy (Natural Resources Canada, 2009a). To put that into perspective, one PJ is equal to the energy consumed by 8900 average households within the span of a year (Natural Resources Canada, 2009b). Although Canada's population has not risen substantially since 1990, when the total amount of energy consumed was 6,936.3 PJ, the nation's total amount of energy consumed has significantly risen since that period (Natural Resources Canada, 2009a). Consequently, the increase in energy consumption has resulted in several harmful negative effects.

Resources have begun to diminish and many negative environmental effects have arisen from our exploits. Many of these negative impacts have stemmed from the production of greenhouse gases (GHGs). Negative effects can be seen through Canada's continued increase in greenhouse gas emissions growth. In 2007, Canada's total green house gas emissions exceeded 501 megatons (Natural Resources Canada, 2009c). Current GHG emissions were recently estimated at 747 megatons of carbon dioxide, roughly 25% more than previous decades, with individuals contributing 7.6 % more than previously recorded. As a result of the increase in energy consumption there has been a direct correlation to the amount of GHGs that Canada emits into the atmosphere. GHGs reduce biodiversity, promote habitat loss, destroy natural habitat and have created many other detrimental environmental affects which results in the alteration of natural landscape and every organism's health including our own (Human Resources and Skills Development Canada, 2010). Without the reduction of energy consumption such impacts will only be heightened by human activity and consumption.

Within Dalhousie, many environmentally sustainable projects have been implemented throughout the school. These may be attributed to the three declarations and treaties Dalhousie has signed to further the University's goal to become environmentally friendly and sustainable (Dalhousie University, 2010). With those documents in mind and the recent addition of sustainable faculties at Dalhousie, the future is beginning to look greener. Although this may be true, there is still a significant amount of room left to improve environmentally unfriendly practices, institutions and methods of consumption at Dalhousie.

Importance/ Rationale

In 1990 residential lighting in Canada accounted for 2.9 megatons of GHGs. In 2007 (most recent year that data could be found) it accounted for 3.6 megatons of GHGs. Emissions of GHGs due to residential lighting in Canada peaked in 2003 at 4.1 megatons (Natural Resources Canada, 2009d). Though, the amount attributed to residential lighting remains below 1% of total GHG emissions (~4-5% of residential GHG emissions), when combined with commercial lighting (information on industrial lighting was not available) it accounts for over 2 percent of total GHG emissions, and 7.3% of the GHGs emitted by the two sectors (residential and commercial) combined. However, improvements are easily made to reduce the levels of emissions. For example, if every Canadian household changed one traditional incandescent light bulb to a compact fluorescent light (CFL), the overall GHG savings would be 397,000 tonnes of CO_2 , the equivalent to taking 66,000 cars off of the road for one year (Natural Resources Canada, 2009e). If we take the average household to have 30 light bulbs (Environment Canada, Envirozine) and even 10% of these lights are currently incandescent which are changed to CFL, a reduction of almost 1.2 Mt of CO_2 would occur. CFLs last much longer than standard incandescent lights (up to 10 times longer) so converting to CFLs will also reduce the solid waste produced by discarded bulbs. Electricity use is an important part of our lives and that is unlikely to change anytime soon, so if we wish to reduce our day-to-day impacts we must find ways to reduce the impact of our daily action.

The reason why it is important to implement the project is to combat energy consumption and its negative environmental effects. The amount of energy used by inefficient light bulbs can be reduced by replacing them with more effective technologies. This project proposes to take action against the inconsistent system held within the residence. With the reduction of energy use, economic and environmental benefits will be created.

The Studley House residence houses environmentally minded students in an environmental cluster. The project is of utmost relevance to the cluster, since it will further enhance the student’s growth as environmentally conscious people and ideally help to continue their education. The implementation of the project will promote a sustainable future, something that will reflect the beliefs and interests of the students while giving them the experience of real world applications to accompany their academic studies within Dalhousie's institutions.

Research Question

In examining lighting systems within Studley House, Dalhousie, what are areas which need improvement, and what can be done to improve these areas?

Purpose

The project will address the issue of energy consumption in Dalhousie University's Studley House residence. The purpose of the project was to examine and identify an area of energy waste at Studley House. Specifically, the work done looked at electricity consumption and determined means of improvement. Through both qualitative and quantitative measures, data had been collected to assess the economic and environmental implications of electricity consumption within the residence building. Findings and recommendations are discussed and examined in greater detail below.

Stakeholders

There are several stakeholders that were affected directly and indirectly by the outcome of the project. Primary, secondary and should-be stakeholders will be discussed below.

Primary Stakeholders

These are the people that influenced or were directly affected by the immediate outcome of the project. These primary stakeholders include Mary-Anne Barkley, Everette MacDonald, and the current students who live in Studley House residence. Mary-Anne Barkley is Howe Halls Facilities Manager. She maintains and oversees the implementation of structural and system changes within the residence. Since Studley House residence is considered a part of Howe Hall's facility, Ms. Barkley will have the final decision as to the degree in which the proposed recommendations will be applied. Everette MacDonald works for Utilities Services at Dalhousie and he or his department would be directly involved in the implementation of the proposed changes or the contracting of the required workers who possess the skills to do so. Finally, the students who live within Studley House will be affected by the capacity in which the lighting will effectively enhance their stay in the residence.

Secondary Stakeholders

These are people who do not have a direct input into the implementation of the project but provide indirect help in the implementation. This includes Ken Burt, Vice President of Finance and Administration, as he would influence the decisions made by facilities management. As well, Peter Coolen, Studley Campus Facilities Coordinator, maintains electrical and water distribution, the building of structures on campus and their respective systems and heating. He determines the capacity in which the project would be implemented. His guidance and knowledge of the building's structure and systems would be beneficial to the projected outcomes of the project.

Should-Be Stakeholders

These are the people who do not necessarily have an input in the decision making process but are affected by the outcome of the project's implementation. With the completion of a more efficient electrical system, future students of the residence itself will be predominately affected by the changes. They will be the ones living in Studley House and in direct contact with the building's lighting. Also, if deemed successful the project can act as a guideline for other residences at Dalhousie, other facilities and institutions in and around the surrounding community to follow.

Methods

Our methods included both qualitative and quantitative sampling techniques in order to ensure a plurality of results, increasing the validity and accuracy of our results in a process known as triangulation (Palys and Atchison, 2008. p. 42). These sampling techniques included [1]meetings with the students of Studley House to inquire into problematic areas, [2]face-to-face meetings with members of Dalhousie staff who have experience working in our field of study, [3]performing a lighting audit in and around Studley House, [4]performing a document analysis, and [5]completing a cost-benefit analysis of existing lights in Studley House versus lights suggested to be implemented.

Student Meeting

Rather than performing a survey, we chose to meet with the students of Studley House in an informal, open-forum type of setting to inquire as to whether there existed any visible problems with the lighting system within their residence building. This type of meeting was chosen over surveys due to time constraints and student availability. It allowed for the asking of both closed- and open-ended questions in a setting whereby students were able to converse between themselves to decide upon the most significant problems related to lighting throughout Studley House, providing a broader spectrum of responses. Meeting with students was also done to complement the findings of a walk-about survey of the lighting system within Studley House, as the residents of the building would have much more insight into the visible workings than a short lighting audit would indicate. The students' answers were recorded for further analysis and reference.

Face-to-Face Meetings with Professionals

In an effort to learn more about the technical and logistical aspects of the lighting system throughout Studley House, professional staff affiliated with the maintenance, upkeep and monitoring of Dalhousie Campus systems were interviewed. Both closed- and open-ended questions were asked. Open-ended questioning allowed the interviewees to express their professional opinions in their own words through use of clear, singular, neutral questions, while closed-ended questions allowed for more succinct, specific responses which only required minimal answers (Patton, 1990. P. 295). Further, the use of face-to-face interviews allowed for the interviewer to further pursue any topics that may have been missed in the scripting of the questions. Staff interviewed included Rochelle Owen, Director of the Office of Sustainability; Everette MacDonald, Utility Service Person; and Maryanne Barkley, Facilities Building Manager. For a script of the questions asked, please see Appendix II.

Light Audit

A site survey around the interior and exterior of Studley House was completed to physically examine the lighting system. In doing so, all lights were counted, as well as all sensors. Interviews with staff produced data for the set time limits on all sensors, so in order to verify this information, the times for how long a light stayed on for after it was deactivated were measured and recorded. Photos were taken of notable problem spots, and any information gathered was recorded for future use.

Delimitations

Although several areas of significant energy use were identified around Studley House, the project was limited to examining solely the lighting system. Initially, an attempt was made to take into account the water, lighting and heat systems around the residence, yet this was determined to be too large an undertaking to successfully accomplish. Focusing on lighting systems allowed for a closer examination of a single system, rather than a broad overview of several systems.

Additionally, the research was limited to Studley House residence only. This was done because it is an isolated, enclosed environment, not attached to the bulk of Howe Hall, the residence facility it is associated with. Since Studley House also contains a cluster of Environmental Programs students, it also allowed more in-depth participation on behalf of the students in an environmental-themed project.

Limitations

In performing this project, a number of limitations were encountered. Most notably, lack of time was a large factor in performing many tasks. Although the researchers had sufficient time in many aspects, many of the interviewees simply did not. This resulted in a delay in the performing of two of the face-to-face interviews, as well as difficulties in finding suitable times to hold a student meeting with the residents of Studley House. As well, individual meetings were initially scheduled with several students in order to perform a more structured type of interview concerning the residence, yet lack of time on the potential interviewees' behalves prevented the carrying out of this task.

Due to the relatively constant traffic throughout the halls in Studley House, difficulties were encountered when attempting to test the time lengths on the hall motion sensors. Although times for the washroom sensors were attained, hallway motion sensor times were not measured.

As well, we were limited to performing calculations in order to determine any potential energy changes with alternate technologies, as opposed to actually carrying out the suggested changes in lighting systems and measuring the differences in energy consumption.

Further, due to the difference in lighting systems installed across campus, the technical data obtained from Rochelle Owen were average figures for around the university campus rather than figures specific to Studley House. Although this limiting factor still presents a relatively reliable source of data, results could have been more precise had the figures on specific lighting systems been available.

Document analysis

The analyzed documents came from a variety of sources including government websites, previous student reports, Nova Scotia Power, Energy Star Canada, prior Dalhousie lighting audits, and manufacturer websites. These documents provided useful and pertinent information for a range of issues such as light-fixture technologies, lighting-control technologies, methods to be undertaken, energy consumption, environmental issues, current energy rates, and alternatives. For example, Natural Resources Canada's websites provided key information on different types of fixtures, the type of environment in which they should be used (2009f) and other various energy saving tips (2009e). Previous student projects gave insight into what kind of steps were needed to complete such a project. Energy Star Canada was a reliable source of information regarding current types of light fixtures and how much energy they consume (Energy Star 2010). Local energy pricing rates were found via Nova Scotia Power's website (NS Power 2009). Rochelle Owen provided a previous lighting audit of Studley house from 2008 which ensured the reliability of the results of this audit. In part, the manufacturer websites were often used to find data relating to the costs associated with certain fixtures or controllers.

By analysing these documents, we were able narrow the scope of this report by highlighting the most applicable technologies and effective research methods. Most of the data collected during this process also enabled a cost-benefit analysis of recommended changes which is an integral part of any proposal.

Cost-benefit analysis

The document analysis and the interviews with facilities management, along with the lighting audit conducted for this proposal, provided the information needed for a cost-benefit analysis to change light fixtures in Studley House. The data used for the cost-benefit analysis was based on the present type of light fixtures installed in Studley (T-8 and T-12), the amount of watts needed to power them, the amount of lumens emitted by them, their life expectancy and their initial costs.

The same parameters were also found for one specific example of CFL and LED lights. Lumens were deemed to be an important factor to determine the suitability of a replacement technology. Costs of installing new fixtures were also accounted for when possible. Savings associated with light controller technologies were also added as a side to the analysis.

Finally, the last piece in the cost-benefit analysis is the cost per kilowatt-hour of energy used which was provided by Nova Scotia Power. As a side note, the amount of time the lights were actually on during the course of a day was considered to be somewhat irrelevant as new technologies would not aim to prolong this amount of time but rather shorten it. At the very least, it was decided that the amount of time would remain the same. The analysis was conducted as if all lights were functioning for an equal amount of time, allowing for results to be less subjective.

The equation used to calculate the costs linked to light usage was:

1). *{ [Watts x (kW/1000 W) x life expectancy (hrs) x $/kWh] + [(maximum life expectancy/life expectancy) x replacement cost ($)] } x the total amount of fixtures.*

Maximum life expectancy refers to the specific light fixture that has the highest life expectancy within the confines of this project. The second operation accounts for the extra costs associated with lights that must be replaced since they do not last as long.

The above equation calculates the cost of using a specific type of light over the lifetime of the longest-lived fixture. However, for the purpose of this proposal it was also useful to calculate the costs per year so as to be able to justify a payback period. To do this, usage was estimated at 12-hours per day, since many lights are on 24-hours a day. Others, such as those in dorm rooms, are only on a few hours a day and some are not turned on at all as indicated by Rochelle Owen's audit. This relates the cost (including the average replacement cost) over *X* amount of years if the lights were on 12-hours a day. Then, the cost per year can be calculated by dividing this number by the amount of years. Finally, payback period can be calculated by dividing the costs of installation by the amount of money saved per year (calculations found in appendix IV).

Results

General lighting

In referencing the lighting audit performed by the Sustainability Office and by combining our information gathered from facilities management and from our own investigations of Studley House, the following information regarding lights has been found.

Lighting type	Wattage	Expected lifetime	Lumens produced	Estimated avg yearly use	Estimated lifetime	Number of fixtures	Estimated yearly energy use
T-8 4' tubes	32	25000hr	2800	4000 *	~ 6 yrs	134**	17152 kWh
T-12 4' tubes	40	20000hr	3200	4000 *	~5 yrs	75**	12000 kWh
CFLs	15	9000hr	800	2000	~4.5 yr	8**	240 kWh
Total	N/A	N/A	N/A	N/A	N/A	217	29392 kWh

* These estimates are higher than the projected yearly light use given by Canadian Office of Energy and Efficiency due to the difference in function and use, many lights are believed to be on constantly and others may be used less.

**These exact numbers have been taken from the full energy audit performed by the Dalhousie Sustainability Office in 2009. Facilities has advised that some T-12s have been replaced by T-8s; exact numbers of the tubes replaced could not be found due to certain limitations.

Sensors

It was found that there were 7 sensors in the house and that they were on 5-10 minute timers. Timer length was not confirmed due to hallway traffic not allowing for an accurate timing.

Other timers

All bathroom lights are on timers that activate when light switches are turned into the “off” position. The timers, on average keep the lights on for 11 minutes.

Other problems

Lighting in the laundry room is currently on indefinitely, and is not attached to any mechanism or sensor to shut it off.

Student meetings

In attendance at the meeting held for students were roughly 15 of the 50 students that live in Studley house. Concerns discussed by the students about lighting include:

- Lights in the bathrooms staying on too long after use
- Not being able to turn off the laundry room light.
- Too much lighting during the day and non-peak hours
- Timers on sensors are too long
- Third floor skylight provides enough light for that area, but lights stay on during the day

From the student meetings we received the contact information of 10 of the 50 students living in the building.

After contacting the students for in room audits only one-student responded. In that room there are four, four-foot long ceiling mounted florescent tube lights and two desk lights (two-foot florescent tubes). The room investigated was a double room with two students living in it. Comments made by these students include that the lighting was too bright in the room causing them to cover the ceiling mounted lights with sheets to dim them.

Meetings

Maryanne Barkley

Questions asked in the meeting with Maryanne can be found in appendix II.A.

Maryanne was unable to give specific electricity usage information, as this information would be difficult to differentiate from all other areas of energy use in Studley House. When confronted with the problem of the washroom lights staying on too long Maryanne stated that it was a maintenance issue as the light and fan are connected to the same switch. To dissipate any water vapour after a shower has taken place, the fan must stay on for a certain amount of time after the shower ends. This is to reduce the possibility of mould in the washrooms. Several other concerns made by Studley House residents including the Laundry room light were among items that Facilities Management were unaware of. Maryanne stated that it would be looked into and advised that if students have concerns similar to this they should submit a Maintenance Request form (http://mrf.housing.dal.ca/). Maryanne stated that Facilities Management is open to any area in which they can reduce energy costs and they remained open to the ideas of reduced lighting periods and shortened timer times so long that they were safe. One problem with Studley house is that it may not be a priority due its size. Facilities Management are looking to reduce energy effectively and in volume. This can be accomplished in areas of Howe Hall where there are older technologies being used and thus a more significant change can be made to a larger area. Maryanne stated that they have newer energy efficient lights (fluorescent tube lights) that had been obtained at a discount through a government incentive program. For the new lights to work, new ballasts would need to be installed in the current lighting fixtures. The main cost to this is an electrician that would cost $64/ hr so work is being done piece by piece as the budget allows. Maryanne directed us toward another Facilities manager (Mateo Yorke) for more information.

In contacting Mateo Yorke through e-mail, it was learned that the new lights were 4' high-efficiency T-8 tubes and that the ballasts had also been purchased.

Everette MacDonald

Questions asked to Everette MacDonald can be found in appendix II.b.

Information is in regards to the general workings and maintenance of the Studley House lighting. The current lighting system in Studley was put in place 7 years ago and included new wiring and new lighting throughout the building. The lights were chosen as the most cost effective at the time. Information was unavailable with regards to the turnover rate at which lights are changed, but Everette told us that the only time a light is changed is when it is no longer functioning. The timers are set to around 5-10 minutes although there are some hallway lights that are on 24/7 (roughly 1-2 per floor). There are 2 light sensors per floor. Everette was able to tell us that it would take roughly 2 days worth of administrative work to put an order through to change the lighting. When asked for any other information Everette informed the researchers that Facilities Management may be changing the light switches for the bathroom timers in Studley. There are 12 bathrooms that would need to be changed and this would take an electrician about one full day work to perform.

Document analysis

As noted above, documents provided information regarding the environmental benefits associated with energy efficient lighting. The main benefits were reduced GHG emissions and reduced physical waste due to longer bulb life. There is however a downside coupled with switching to fluorescents. Fluorescents have mercury in them which is a heavy metal that may pollute the environment once these lights are disposed of (CCME 2001). Rochelle Owen's information confirmed that Studley House used 134 T-8s and 75 T-12 linear fluorescent bulbs. Since there is no standard type of lights used across campus, common bulbs for T-8s and T-10s were selected for the purpose of this paper. The chosen T-8s used 32W had a life expectancy of 25,0000 hours, a cost of 3.50$ per bulb and emitted 2,800 lumens, while the T-12's used 40W had a life expectancy of 20,000 hours, cost $3.95 per bulb and emitted 2,200 lumens (elightbulbs.com 2010). The cost for replacing T-12's with T-8's was found to be $64 an hour for installation costs since Dalhousie already has the required ballasts.

Two alternative forms of lighting were decided upon, the first being a CFL and the second being an LED. The particular choices that were made were based first on the fact that they were Energy Star Canada approved products. Second, they provided a sufficient amount of lumens to replace the currently installed bulbs and third for price. The chosen CFL was the Sylvania CF40EL/TWIST/RP 2700K, which is a spiral compact fluorescent that emitted 2,600 lumens, lasted 10,000 hours and used 40 watts (elightbulbs.com 2010). The LED chosen for the purpose of this proposal was LED Lights World SMD LED, which was used because it was more interchangeable with current T-8 systems. It emitted 1700 lumens (which is actually closer than it seems to the other values because of efficiency), cost $70.74 per bulb, had a life expectancy of 50,000 hours and used 16 Watts (LEDlights world.com 2010).

These are all specifications needed for a cost benefit analysis, demonstrated by other similar projects as being an effective tool for influencing implementation. Additionally, timers were found to be effective energy reducing control options that could potentially be applied in Studley House.

Cost-benefit analysis:

1.)
Maximum life expectancy = 50,000 hrs for LED
total fixtures in Studley = 75 T-12's + 134 T-8's = 209 fixtures

For T-12s:

Over the whole lifetime:
{ [40W x (kW/1000 W) x 20,000 hrs x $0.11796/kWh] + [(50,000hrs/20,000hrs) x $3.95] } x 209
= [$94.37 + $ 9.88] x 209 = $21,788.25

per year (12h/day):
20,000hrs/(12hrs/day) = 1666.66 days = 4.57 years
$21,788.25/4.57years = $4767.67/year

For T-8s:

Over the whole lifetime:
{ [32W x (kW/1000 W) x 25,000 hrs x $0.11796/kWh] + [(50,000hrs/25,000hrs) x $3.50] } x 209
= [$94.37 + $ 7.00] x 209 = $21,186.36

per year (12h/day):
25,000hrs/(12hrs/day) = 2083.33 days = 5.71 years
21,186.36/5.71 years = $3710.39/year

For CFLs

Over the whole lifetime:
{ [40W x (kW/1000 W) x 10,000 hrs x $0.11796/kWh] + [(50,000hrs/10,000hrs) x $16.99] } x 209 = [$47.18 + $ 84.95] x 209 = $27,615.17

per year (12h/day):
10,000hrs/(12hrs/day) = 833.33 days = 2.28 years
27,615.17/2.28 years = $12,111.92/year

For LEDs

Over the whole lifetime:
{ [16W x (kW/1000 W) x 50,000 hrs x $0.11796/kWh] + [(50,000hrs/50,000hrs) x $70.74] } x 209 = [$94.37 + $ 70.74] x 209 = $34,507.99

per year (12h/day):
50,000hrs/(12hrs/day) = 4166.66 days = 11.42years
34.507.99/11.42 years = $3021.72/year

2.)

LEDs are the least costly to run on a year to year basis, but payback period is always an issue.
Just the cost of buying the bulbs, not counting installation parts and labour amounts to:
$70.74/bulb x 209 bulb = $14784.66
Yearly savings amount to:
$3710.39-$3021.72 = $688.67 compared T-8s, which are the next best option.

The payback period would be: $14784.66/($688.67/year) = 21.5 years.

3.)

Since Facilities Management already has a large amount of T-8 bulbs waiting to be installed, it may be useful to do a cost benefit analysis of replacing the 75 remaining T-12s with T-8s in a new timeframe for bulb replacement costs that does not use the upper limit of the LED lifetime but rather the limit of the T-8s. Since there are specifically 75 T-12s in Studley House that could be changed over to T-8s, this number will be used here instead of the total 209 to calculate payback period.

For T-12s:

Over the whole lifetime:

{ [40W x (kW/1000 W) x 20,000 hrs x $0.11796/kWh] + [(25,000hrs/20,000hrs) x $3.95] } x 75 =
[$94.37 + $ 4.94] x 75 = $7448.25

per year (12h/day):

20,000hrs/(12hrs/day) = 1666.66 days = 4.57 years
$7448.25/4.57years = $1629.81/year

For T-8s:

Over the whole lifetime:

{ [32W x (kW/1000 W) x 25,000 hrs x $0.11796/kWh] + [(25,000hrs/25,000hrs) x $3.50] } x 75 =
[$94.37 + $ 3.50] x 75 = $7340.25

per year (12h/day):

25,000hrs/(12hrs/day) = 2083.33 days = 5.71 years
7340.25/5.71 years = $1285.50/year

Payback period: Since the ballasts are already paid for, the only costs associated with the switch of 75 T-12s to T-8s are electrician fees which were estimated at $64/h.

Money saved per year = $1629.81-1285.50 = $344.31

$344.31/($64/h) = 5.38h that each year's saving pay the electrician.

So if it theoretically took an electrician 15 hours to install 75 lights, then payback period would be in as little as three years.

4.)

Further notes:

a) Reducing the usage of all 209 T-8's by even an hour per day by perhaps changing the timer (which costs nothing) could reduce the costs by:

For T-8s:

Over the whole lifetime:
{ [32W x (kW/1000 W) x 25,000 hrs x $0.11796/kWh] + [(25,000hrs/25,000hrs) x $3.50] } x 209
= [$94.15 + $ 3.50] x 209 = $20,408.85

per year (11h/day):
25,000hrs/(11hrs/day) = 2272.72 days = 6.22 years
20,408.85/6.22years = $3281.17/year

Savings per year = cost of running at 12h/day – cost of running at 11h/day
= $3625.47/year - $3281.17/year = $344.30/year

b) Buying in bulk may even further reduce the costs associated with replacement bulbs.

Recommendations

Taking into account Studley House's role as home to environmentally-oriented students at Dalhousie University, the lighting audit recommends that several electrical fixtures throughout the residence be replaced. These changes would ensure that Studley House reduces the amount of energy being used, while also being cost-effective for Facilities Management and a symbolic gesture for future environmental students.

1. **Installation of new hallway sensors.** In order to be as completely efficient as possible in terms of total light usage in Studley House public areas, it is recommended that hallway sensors be installed. This would ensure that lights would be turned off to avoid wasting energy while nobody is present. Simultaneously, it would be of convenience for students living in the residence because they would not be responsible for turning lights on and off whenever they enter or exit a room.

2. **Reduce timer duration.** In our observations and through meeting with students living in Studley House, a major point of concern was the arbitrary length of light timers in the washrooms. The timers in use run for an excessive amount of time, but also, there are no clear instructions on how to turn the timers off once they are on. It is highly recommended that these washrooms timers be replaced with conventional light switches, or at the very least, have the timers adjusted to be more energy efficient.

3. **Installation of light dimmers.** Excessive amounts of energy is wasted throughout the day when lights are left on even when there are sufficient amounts of natural or external light in the building. We recommend that light dimmers be installed in public areas in Studley House and in each dormitory. This would ensure that students have the ability to save energy whenever it is feasible, while concurrently adding to each individual’s comfort level.

4. **Separate switches.** Instead of having all public lighting on one lighting circuit, it would be more cost effective and sustainable to have several circuits throughout Studley House that can accessed. This would allow lights to be turned off in certain areas of the floor that are not in use, permitting other areas to keep their lights on. Specifically, this would be applicable to the laundry rooms where students do not have access to light switches. Currently, lights in Studley House’s laundry rooms are on 24-hours a day, seven-days a week.

5. **Stagger lighting.** We recommend that students and residence assistants remain conscious of saving energy by staggering lights in public spaces. Our observations found that excessive amounts of light fixtures were in use throughout Studley House. A reduction of several lights in each hallway would permit the residence to save on the amounts of energy used.

6. **Reduce day time lighting.** Throughout Studley House, we found light fixtures in use during the day which need not be on. We recommend that Studley House dwellers make a conscious effort to reduce the amount of lights being used throughout the day, especially when natural light is sufficient in lighting certain parts of the building.

7. **Change all T-12s to T-8s.** The cost benefit analysis clearly showed that the most cost effective way to reduce energy consumption through lighting would be to change the remaining 75 T-12 fixtures to T-8s. Other technologies such as CFLs of LED were either not as energy efficient as T-8s were for this particular environment, or they were simply too costly.

Discussion and Conclusion

Lighting in Studley house may not at first glance seem important when compared to the overall energy use at Dalhousie or even if compared to the energy use of a larger residence. Though due to its small size, Studley House may be a good place to test out any new energy systems that could be implemented elsewhere in the future. As the home of Dalhousie's Environmental Academic Cluster it is important for Dalhousie to support these students by giving them an environment that reflects the community that they create. By giving these students a more positive atmosphere, Dalhousie can aid in their development as students in this discipline, as well as support those in other disciplines to take interest in energy efficiency. Facilities management has voiced their dedication to reducing energy; the only problem is that the funds for major changes may not always be there. The cost associated with many of the materials that could reduce energy use may not always be as significant as the cost to install new lights. Facilities currently has obtained a large amount of High-efficiency T-8 lights and ballasts, to install these new lights an electrician must be hired at $64/hr. This added cost can at times go unseen by many advocates of energy efficiency, but can be substantial depending on the project. Given these costs, other methods of reducing energy use through lighting may have a better chance at creating immediate results. For example, a reduction of average light use in Studley House by one hour per day can save over $344 per year. To put this in perspective, this is the same savings that would occur by exchanging all of the T-12 lights (75 in total) to T-8 lights. So reducing energy consumption is not only up to facilities, but is influenced by the behaviour of students as well.

Some methods that could save large amounts of energy did not always end up being appropriate for Studley House. Installing T-8 LED tubes in place of the current fluorescent tubes was found to save a significant amount $644 per year in energy costs. Though this reduction is significant, the LED tubes would take over 21 years to pay for themselves without accounting for the added costs of installation. In addition these were among the cheapest LED bulbs that could be found and they were not endorsed by Energy Star. Other more reputable LED replacements would require both more expensive lights and the installation of new fixtures.

From the results of this audit, the best course of action for the reduction of energy in Studley House caused by lighting is a combination of converting to high-efficiency T-8 lights and reducing the duration for which lights are used. Lighting use can be reduced by implementing recommendations such as staggered lighting in non-peak hours, reduced timer lengths on sensors, and reducing the amount of light in areas that have sufficient light levels during day time hours. These actions will both reduce the amount of energy used and be cost effective.

Appendix I: Excerpt from Master Audit

Performed by the Dalhousie Sustainability Office, provided by Rochelle Owens.

5. CFL Bulbs	Number	
7 W		
9 W		
11W		
13W		
15 W	8	
30 W		
26W (non compact)		
40W (non compact)		
6. T Series Lights		
T-12	75	
T-12 Short		
T-8	134	
T-8 Short		Many lights supposedly sensored, but many just seemed to be on all the time

Appendix II: Interview Questions

A). Maryanne Barkley

1) How much is spent on electricity per year?
2) What is the longest cost recuperation time you are willing to allow when implementing a new program?
3) What types of lights and sensors are in Studley?
4) What / when were the most recent lighting efficiency projects/
5) Were any implemented in Studley?
6) In your opinion, is it worth it to renovate / do an improvement project?
7) How much energy is used yearly for lights?
8) How often do lights have to be replaced, on average?
9) What is your opinion on switches, sensors, dimmers, non-working sensors and switches in Studley?

B). Everette MacDonald

1) How often are lights changed?
2) Are there any stats on Studley house lights we should be aware of?
3) How hard would it be / what would be necessary in changing anything light-related in Studley house?
4) How difficult is it to change the light sensor times?
5) What is the possibility of a change (i.e. reduced lights at night)?

Appendix III: Permission Form

Permission form given to students upon entry into their rooms for audits

Studley House Lighting Audit Permission Form

The student gives permission to the auditors (auditors include and are limited to Scott Aucoin, Chris Currie, Chris Dohnal, Jason MacGregor, and Ben Ojoleck) access to their room (room # _______) for the purposes of performing a lighting audit. During this time the student will retain the right to ask any or all of the auditors to leave for any reason. Any information gathered before being asked to leave may be used for the purposes of the final report. The auditors will require access to the lighting within the room. The student may be asked questions about lighting use. Any answers given by the students about their lighting may be used for the purposes of the auditor's final report. The students name and room number will not be used in the final report, rather only the type of lighting, number of lights, lighting use and function, and the type of area (in this case "student room lighting") will be used for the final report.

All students will be advised prior to the auditors entry that the auditor Chris Currie is also an employee of resident life services and is obligated to report any items within the students room that are against the regulations stated by residence life services. At the point of notice students hold the right to refuse the auditors entry.

By signing below the student agrees to the terms given above.

________________________   _________________________   ________________

Student Name   Student Signature   Date

Appendix IV: Calculations

Costs Over lifetime:

1). *{ [Watts x (kW/1000 W) x life expectancy (hrs) x $/kWh] + [(maximum life expectancy/life expectancy) x replacement cost ($)] } x the total amount of fixtures.*

Payback period:

Life expectancy/ 12h = days (since lights are estimated to be on 12h a day)

days x 1 year/ 365 days = years that the light will work

Therefore with equation (1) we now know how much it costs to run the fixture over X amount of years. Then:

Cost / X years = Cost / year

and finally:

Installation costs / money saved per year compared to current lighting = payback period.

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