NRC·CNRC

NRC Publications Archive
Archives des publications du CNRC

Energy Management Plan: Section One Facilities Lighting Upgrade

Bartlett, Courtney

For the publisher's version, please access the DOI link below./ Pour consulter la version de l'éditeur, utilisez le lien DOI ci-dessous.

Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/18238671
Student Report; no. SR-2009-12, 2009-01-01

NRC Publications Archive Record / Notice des Archives des publications du CNRC :
https://nrc-publications.canada.ca/eng/view/object/?id=64664098-1460-4885-82c1-3fd9091ec91e
https://publications-cnrc.canada.ca/fra/voir/objet/?id=64664098-1460-4885-82c1-3fd9091ec91e

Access and use of this website and the material on it are subject to the Terms and Conditions set forth at
https://nrc-publications.canada.ca/eng/copyright
READ THESE TERMS AND CONDITIONS CAREFULLY BEFORE USING THIS WEBSITE.

L'accès à ce site Web et l'utilisation de son contenu sont assujettis aux conditions présentées dans le site
https://publications-cnrc.canada.ca/fra/droits
LISEZ CES CONDITIONS ATTENTIVEMENT AVANT D'UTILISER CE SITE WEB.

Questions? Contact the NRC Publications Archive team at
PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca. If you wish to email the authors directly, please see the first page of the publication for their contact information.

Vous avez des questions? Nous pouvons vous aider. Pour communiquer directement avec un auteur, consultez la première page de la revue dans laquelle son article a été publié afin de trouver ses coordonnées. Si vous n'arrivez pas à les repérer, communiquez avec nous à PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca.

National Research Council Canada
Conseil national de recherches Canada
Canada

National Research Council Canada
Institute for Ocean Technology

Conseil national de recherches Canada
Institut des technologies océaniques

SR-2009-12

Student Report

Energy Management Plan: Section One Facilities Lighting Upgrade.

Bartlett, C.

Bartlett, C., 2009. Energy Management Plan: Section One Facilities Lighting Upgrade. St. John's, NL : NRC Institute for Ocean Technology. Student Report, SR-2009-12.

Canada

DOCUMENTATION PAGE

REPORT NUMBER	NRC REPORT NUMBER	DATE
SR-2009-12		August 2009

REPORT SECURITY CLASSIFICATION	DISTRIBUTION
Unclassified	Unlimited

TITLE

AUTHOR(S)

Courtney Bartlett

CORPORATE AUTHOR(S)/PERFORMING AGENCY(S)

Institute for Ocean Technology, National Research Council, St. John's, NL

PUBLICATION

SPONSORING AGENCY(S)

IOT PROJECT NUMBER	NRC FILE NUMBER

KEY WORDS	PAGES	FIGS.	TABLES
Lighting, energy, inefficient, ergonomics, sensors	12, App. A-E		

SUMMARY

The current lighting system at the National Research Council - Institute for Ocean Technology (NRCIOT) is inefficient and causing an increase in energy costs, which raise the cost of energy bills, maintenance and labour. This rising cost is expected to continue to increase in the foreseeable future. NRC-IOT has searched for more efficient products and solutions that will help with the reduction in operating costs. Lighting is recognized as a major area for economic energy savings.

ADDRESS National Research Council
Institute for Ocean Technology
Arctic Avenue, P. O. Box 12093
St. John's, NL A1B 3T5
Tel.: (709) 772-5185, Fax: (709) 772-2462

National Research Council Canada
Conseil national de recherches Canada

Institute for Ocean Technology
Institut des technologies océaniques

Development & Implementation of a Lighting Efficiency Plan

SR-2009-12

Courtney Bartlett

August 20th 2009

Summary

The following report was based on work completed at the National Research Council – Institute for Ocean Technology (NRC-IOT). The current lighting system at NRC-IOT is inefficient and therefore causing an increase in energy costs. This in turn raises the cost of energy bills, maintenance and labour. The rising cost is expected to continue in the foreseeable future. NRC-IOT has searched for more efficient products and solutions that will help with the reduction in operating costs. Lighting is recognized as a major area for economic energy savings.

The following will be discussed in this report: ergonomics of lighting in offices, problems associated with the current system, savings in energy and cost associated with the new system, the environmental effects of the old and new system, and the reduction in maintenance and labour of the new system. The upgrade will consist of a modern more efficient lighting system that will be installed within a year. Occupancy sensors will be installed and integrated into the lighting circuits of the building. These sensors will turn the lights off when a space is unoccupied for a period of time and will turn these lights on again once the sensor has redetected a person in the area. Also, included in this report are recommendations for the plan to be completed in a timely manor and suggestions for proper implementation.

Methodology

Information for this report was obtained through the NRC-IOT network, which all employees have access to. Stored on this network is documentation pertaining to specific projects implemented at IOT, such as pdf and auto-cad drawings, facility project plans, forms and templates. Information was also obtained through Natural Resources Canada Energy Efficiency documentation. Depending on the topic of discussion, the appropriate personnel were contacted for guidance and assistance.

Acknowledgments

I would like to thank Mr. Rod Grittiths, Maintenance Supervisor, for answering questions and providing ongoing support and guidance for the past sixteen weeks. Rod was a major source of information and contributed his expertise to the Facilities Engineering Support & Maintenance department at IOT. His guidance and knowledge contributed to the development of the Lighting Efficiency Plan. He showed consistent determination in expanding my experience, and most importantly encouraging me to learn through involvement in changeling projects. This involvement fostered my independent development and expanded my responsibilities.

Table of Contents

List of Appendices

1.0 Introduction

The Institute for Ocean Technology (IOT), a branch of the National Research Council was established in 1985 to provide technical expertise in support of Canada's ocean technology industries. The Institute's capability is unique to the nation. No other organization offers the combination of knowledge, experience and world-class facilities. IOT conducts ocean engineering research through the modeling of ocean environments, predicting and improving the performance of marine systems, and developing innovative technologies that bring benefits to the Canadian marine industry [1].

The Facilities Engineering Support & Maintenance (FESM) department manages the provision of utilities for the Institute. It provides safe and efficient operations, maintenance management of buildings, grounds, process systems, and material handling equipment, maintenance servicing for lab and shop equipment, and project management services for design, construction and procurement projects.

Due to the large size of IOT's facility and its operations in the ice tank, tow tank and ocean engineering basin, energy costs soar in the tens of thousands every month. FESM is assigned the role of planning and implementing an Energy Management Plan to reduce these costs. Lighting is recognized as a major area for economic energy savings and is one of the simplest upgrades that can be made. It is for this reason that a lighting upgrade is chosen as section one of the energy management plan.

2.0 Lighting Efficiency Plan

IOT is composed of several thousand square feet of lighted area at its facility in St. John's (Refer to Appendix A for Site Map). Employment consists of over one hundred IOT staff and another fifty contractors. Since the facility was built in 1986, there has been no lighting retrofit. The current lighting system is inefficient, causing an increase in energy consumption; which therefore raises the cost of energy bills, maintenance and labour. This rising cost is expected to continue to increase in the foreseeable future. IOT has searched for more efficient products and solutions that will help with the reduction in operating costs. Objectives of this project are to reduce energy consumption and lower energy bills, reduce maintenance and labour, improve quality of lighting, consume less electricity and reduce harmful emissions associated with power generation.

The first step associated with the lighting upgrade is to divide the facility into separate construction phases, allowing each area's project management to be less complex. The second step is to develop a more comprehensive understanding of the current lighting system so it can be assessed. Once problems associated with the current system are determined, the third step it to establish a more efficient alternate method of lighting. The fourth step is to bring professionals, Blair Davis from B. Davis Agencies LTD. and Gus Gallant from McLoughlan Supplies Ltd., into the facility to complete tours of each phase area and decide exactly what supplies are needed for upgrade. The final step is the installation of supplies in each phase area.

3.0 Current and Proposed Lighting Systems

The current lighting system at IOT consists of T12 fluorescents, which are 40-watt four feet long lights with magnetic ballasts. The T in T12 means tubular and the lamp is twelve-eighths (1.5) of an inch in diameter. After a great deal of research, a more efficient method of lighting is determined. This method will not involve changing the current light fixtures, which would lead to a higher supplies cost. The proposed method is a T8 fluorescent, 32-watt four feet long light with electronic ballast (Refer to Appendix B for Bulb Diameter Comparison). The T8 has a 1-inch diameter and operates on 32 watts, 8 watts less than the T12. It functions with reduced mercury, a potentially harmful substance used in many lighting fixtures, [2] and after 10,000 hours still runs at 95% light output, whereas T12's operate at 85% light output [3]. Interior lighting represents approximately 29% of the energy consumed in commercial buildings each year. Lowering this percentage has the potential to reduce the emissions of carbon dioxide and other air pollutants generated during electricity production [3].

Ballasts regulate the amount of electricity that flows to the fluorescent lamp. Magnetic ballasts have been in use since the beginning of fluorescent lighting. They employ copper coils and transformers to run the lamp. While magnetic ballasts cost less, they weigh more and are less efficient than modern electronic ballasts. Electronic ballasts use high frequency and solid-state circuitry instead of heavy copper windings. As a result, electronic ballasts produce more light for each watt, run cooler and last longer. Compared to the magnetic ballast, they use 25% less energy and do not hum or flicker when starting [3].

Another component of the lighting upgrade is the installation of occupancy sensors. They will be integrated into the lighting circuit throughout the facility. The purpose of occupancy sensors is to control when lighting is on and off in designated areas, such as offices, bathrooms and shops. The sensors have timers that are push button programmable and reset when occupancy is redetected. It is important to set the timer no less than ten minutes. If the lights turn off and on again in less than ten minutes, more energy is actually consumed than saved. Advantages associated with the installation of occupancy sensors are extra security for the building and the ability to take control by ensuring that lights are not on when a room is not in use. Ensuring this leads to significant cost savings and less light pollution released into the environment.

4.0 Construction Phases

Due to the large amount of work and complexity associated with the upgrade, it is decided that the planning and construction will be divided into five phases. Reasoning for this being that if the project management for each phase acts separate to one another, the planning and implementation will run more smoothly. To plan all sections of the facility as one would add to the complication of the plan [4].

Phase one is recognized as the machine, model prep and carpenter shops. In 2008 the lighting in these shops was changed to T5 high output fluorescent bulbs. Due to the high Ceilings in these areas (approximately thirty-five feet), the T5 high output was the only option. Traditional fluorescent T8 & T12 bulbs are simply not powerful enough to light an area more than eight-ten feet below the bulb [5]. Due to the face that the lighting in this area was already retrofitted, just the type of occupancy sensor needed to be determined. The sensor that will be installed in the shops is a CMR-6 High Bay 360° occupancy sensor that is designed for mounting heights of forth-five feet. These sensors have already been ordered and are waiting in stores for installation; this should take place in early September.

Phase two is recognized as the first floor of the research offices section of the building. This area consists of approximately one hundred, four-light fixtures and will undergo new lighting installation, as well as occupancy sensors. The tour for phase two has been completed and the supplies that need to be ordered are in progress.

Phase three, is recognized as the second floor of the research offices section of the building, which is very similar to phase two. This area also consists of approximately one hundred, four-light fixtures and will undergo new lighting installation, as well as occupancy sensors.

Phase four is recognized as the three floors of the new building extension that was built in 2003. Because this area is relatively new, it was constructed with T8 lights and therefore only needs to be upgraded with occupancy sensors.

Phase five is recognized as the Offshore Engineering Basin (OEB), Ice Tank & Tow Tank. The upgrade for this area is yet to be determined. It is hoped that once phases one through four have been implemented, the planning for phase five can commence. Due to the large size and complexity of this area, it is placed last and will not follow the same steps as the previous phases.

As of August 2009, phase one is ready for installation and phase two supplies are in the process of being ordered and will then be ready for installation. Phases three and four tours need to be completed, supplies ordered and installed. Phase five is yet to be determined. The construction of this project will consist of the proposed more efficient lighting system to be installed within the year.

5.0 Cost Savings

It is estimated that you can save up to 35% of energy cost by replacing standard T12 lighting systems to T8 systems [6]. This savings is estimated to double with the replacement of electric ballasts and sensors (Refer to appendix C for Energy Efficient Lighting Savings Calculator).

The annual operating hours for the current method of T12 fluorescents, 40-watt four feet long lights with magnetic ballasts is estimated to be 2500. The annual operating hours for the proposed method of T8 fluorescents, 32-watt four feet long lights with electronic ballasts & sensors is calculated to be 1500 (See below for calculation).

<u>Calculations:</u>

52 weeks/year x 5 work days/week	=	260 work days/year
15 vacation days + 10 Christmas days	=	25 vacation days/year
260 work days/year – 25 vacation days/year	=	235 workdays/year
235 workdays/year x 7 hours/day	=	1645 operating hours/year

Note: 1645 hours/year rounded down to 1500 lights on hours/year

Once the total annual operating hours was determined, this information was entered into the energy efficient lighting savings calculator. Also entered into the calculator was the average electric cost per kilowatt-hour, the number of fixtures, fixture type and fixture specification. Once these numbers were entered, the total annual electric use and cost was computed. With reference to appendix B, the total annual energy savings is 28,400 kilowatt-hours per year. This calculation is based on the second floor office building only, where one hundred, four-light fixtures were counted. The reason for this is because counting all light fixtures throughout the whole facility would consume too much time. Counting the fixtures on the second floor office building was done in under an hour and is reasonably accurate due to the small area analyzed.

Through comparing the current lighting system with the proposed system the total savings of this area is $1,704 per year. This area only accounts for approximately 10 percent (Refer to appendix D for Reference Drawing) of the whole facility, it is estimated that the lighting upgrade will save approximately $17,040 per year.

6.0 Lighting in Offices

There are approximately one hundred and thirty office areas and some with more than one person to an office at IOT. Office work is visually demanding and has always required good lighting for maximum comfort and productivity. Good lighting means providing enough illumination so that people can see printed, handwritten or displayed documents clearly but are not affected by excessively high light levels. Poor lighting can cause eyestrain and headaches and may also contribute to stiff necks and aches in shoulder area.

A fluorescent lighting system consists of three parts: the luminaire, the lamps and the ballast. Luminaire is the technical term for any lighting fixture; it contains the lamps and the ballast, and might also include optical devices to direct the light. Fluorescent lamps emit light when their phosphor coating receives energy from gaseous mercury atoms excited by an electric arc. The ballast controls the electric arc across the lamps, preventing the voltage from increasing with destructive effect (Refer to Appendix E for Types of Light Sources).

Good office lighting is a key element in ensuring worker satisfaction, productivity and performance. People who work under lighting systems with electronic ballasts show less visual fatigue at the end of the day and perform better on reading and writing tasks. They also rate tasks as being less difficult compared to people who work under lighting systems lit with magnetic ballasts. Good-quality lighting that reduces glare and uses electronic ballasts is a smart investment because it saves energy and contributes to better task performance and greater employee satisfaction [7].

7.0 Conclusion

IOT is involved with arctic operations, marine safety and many other types of ocean engineering. It's ocean engineering basin and tanks consume thousands of gallons of water every year. Due to the type of operations IOT manages, it is very extraordinary and should not be penalized by high-energy costs. New ways to save energy and money are being discovered every day and this is why retrofits and upgrades need to take place. IOT can't afford to not take advantage of these new technologies.

The development and implementation of the lighting efficiency plan can save the Institute thousands of dollars. Not only will this plan bring dollars back into circulation at IOT, but it will also give employees the ability to work more productively and it will reduce the amount of pollution that is being released into the environment.

The pay back period for this project is estimated at 2 years. Considering the amount of money that this project will save, 2 years in a minor pay back period. To save on costs, IOT's own electrician will install all lights and sensors throughout the facility instead of hiring contractors to complete the job. A disadvantage associated with this is a delay in installation caused by the work being completed by one electrician only.

If this plan is not implemented within the next 3 years, IOT will face some difficulties due to the fact that T12 fluorescent lights are not being manufactured anymore.

8.0 Recommendations

The first recommendation is to ensure that the lighting efficiency plan does continue without the push of a co-op student to ensure continuity and to take control. A full-time employee should be hired, guaranteeing all phases are assessed and completed.

The next recommendation is to possibly turn phase five into it's own section of the Energy Management Plan. The OEB and tanks are so large and complex; they may need a longer period of time than the other phases for upgrade as well as a more in depth analysis.

The third recommendation is to hire on an apprentice to help IOT's electrician with the installation of lights and sensors. This is a large job and two people would complete it faster than just one.

A fourth and final recommendation is to ensure that the continuing sections of the Energy Management Plan get developed. The full time employee that I mentioned in the first recommendation should join FESM full time and continue on with this plan. There is a lot of work associated with FESM, including work orders, document control, preventative and scheduled maintenance, and not enough people to complete it.

9.0 References

The following are some of the publications that assisted with the research of this report.

[1] NRC Institute for Ocean Technology. (2009). Retrieved August 6th, 2009, from http://www.nrc-cnrc.gc.ca/eng/ibp/iot.html

[2] Fluorescent Lighting: The Benefits of T8 Over T12. (2009). Retrieved July 27th, 2009, from http://www.foodservicewarehouse.com/education/going-green/flourescent-lighting.aspx

[3] T8 Fluorescent Lamps and Electronic Ballasts. (2009). Retrieved May 29th 2009, from http://www.mge.com/business/saving/detail/t8.htm

[4] Project Context: Project Plan--Breaking the Project into Subprojects, or "Phases". (2000). Retrieved July 19th, 2009, from http://www.uprforum.com/Chap14.htm

[5] Fluorescent Lighting FAQs. (2009). Retrieved June 28th 2009, from http://www.specialty-lights.com/plant-grow-faq3.html

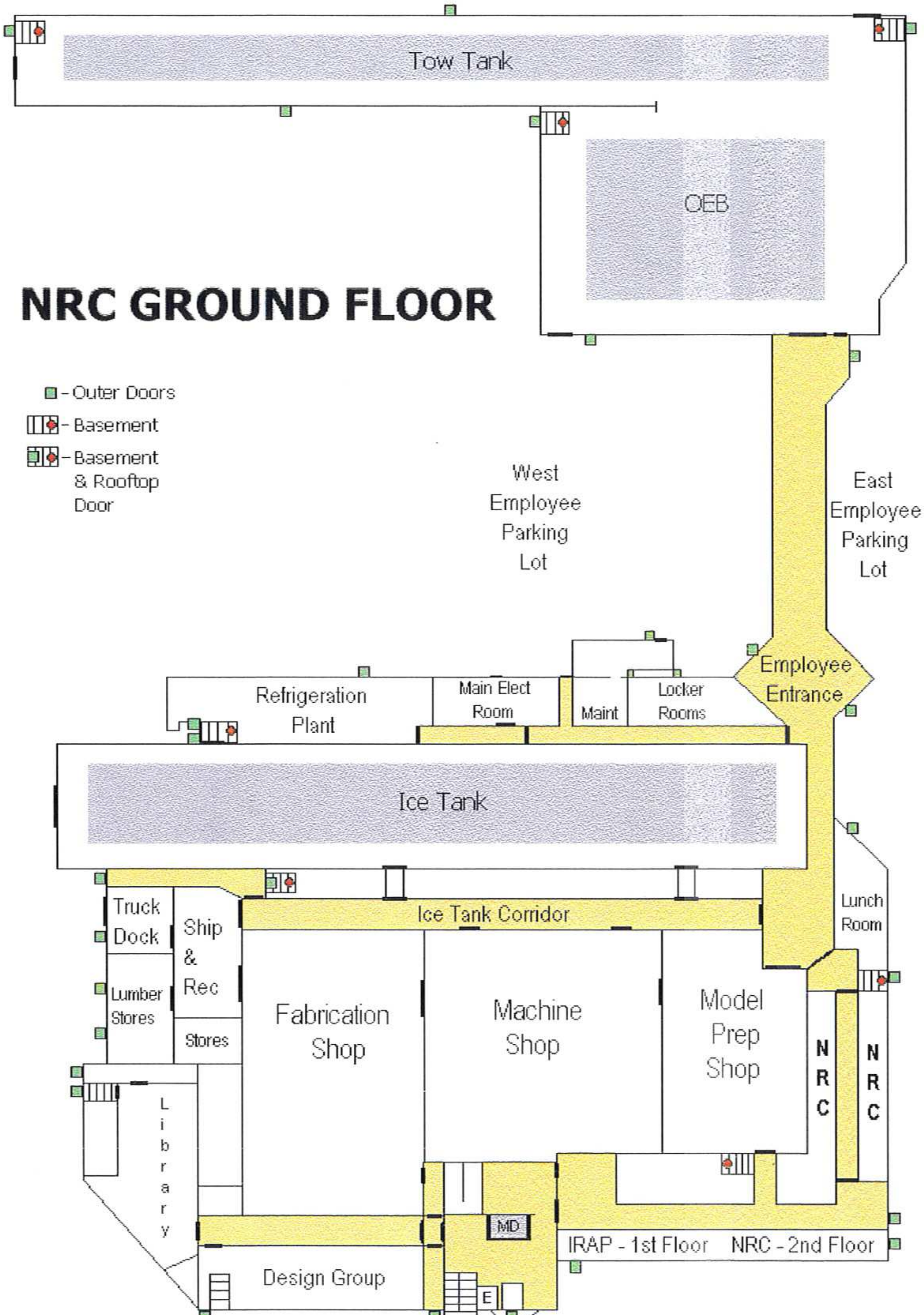
[6] T8 Lighting Retrofit in Toronto. (2009). Retrieved June 8th 2009, from http://groups.google.ca/group/Toronto-renovate/web/t8-fluorescent-lighting-retrofit-in-toronto

[7] Office Lighting Investments: Payoffs for People and the Environment. (1997). Retrieved August 7th 2009, from http://www.nrc-cnrc.gc.ca/eng/ibp/irc/ctus/ctus-n10.html

Appendix A

Site Map

NRC GROUND FLOOR

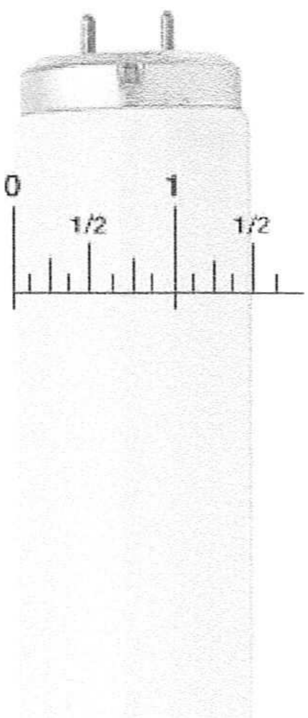


* Diagram is neither to scale or proportion

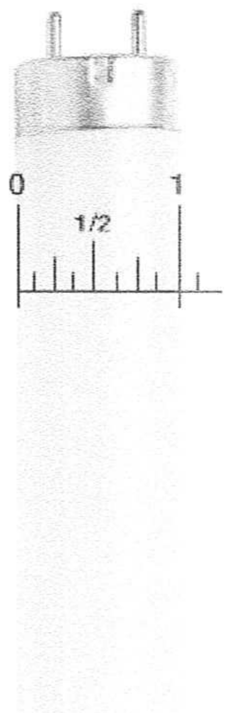
Appendix B

Bulb Diameter Comparison

T-12



T-8



Appendix C

Energy Efficient Lighting Savings Calculator

NRC-CNRC

Energy Efficient Lighting Savings Calculator

Room / Building Description: NRC/IOT Second Floor

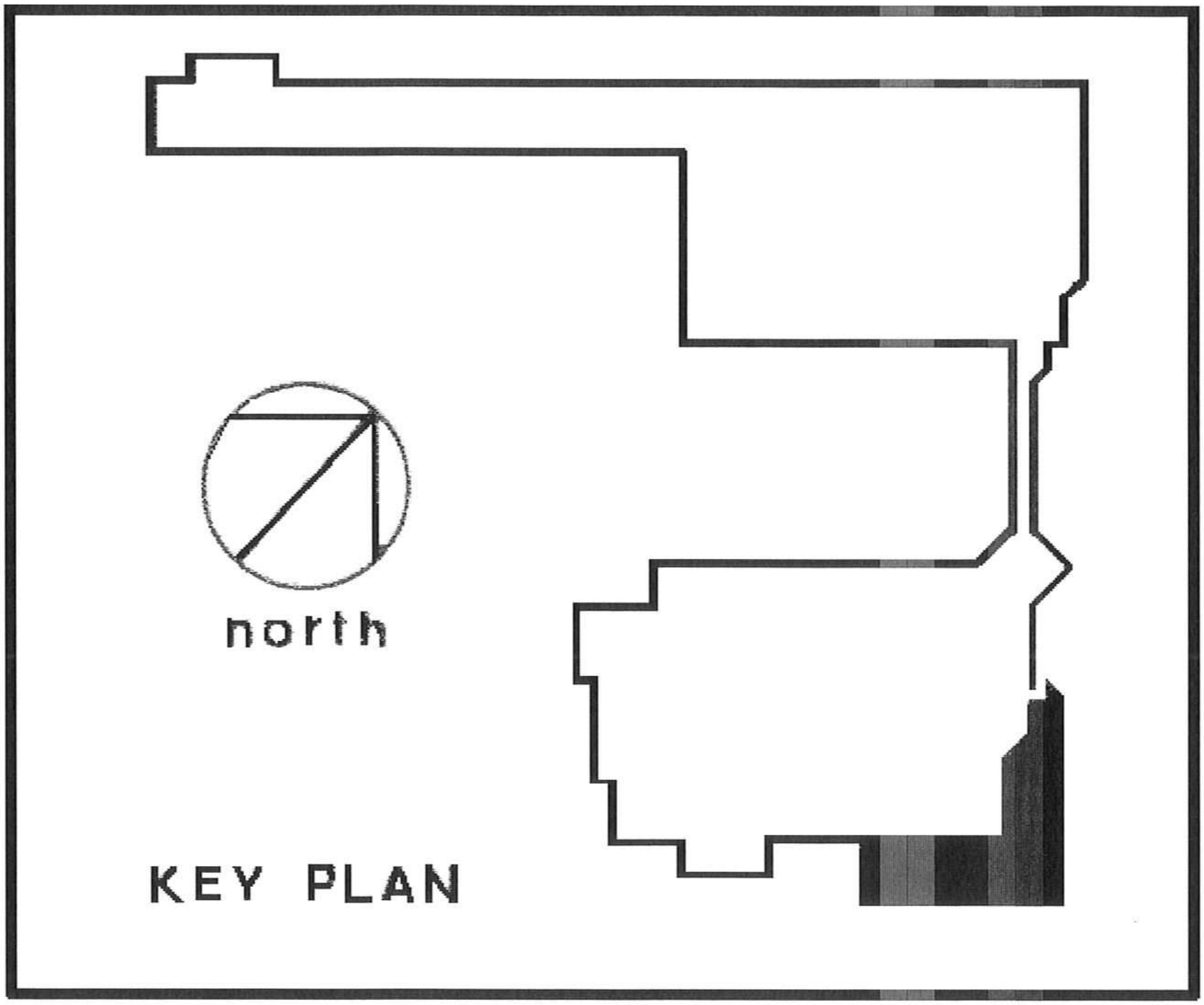
Enter Costs: (●) Per Fixture ( ) Total Project

Avg. Electric Cost per kWh: $0.0800
(Your actual rate can be written in)

	Existing / Baseline	Proposed
Annual Operating Hours:	2500 hrs per year	1500 hrs per year
No. of Fixtures:	100	100
Fixture Type:	T12 Fluorescent	T8 Fluorescent
Fixture Specification:	T12 4L-F40 w/ Mag - 4'	T8 4L-F32 w/ Elec - 4'
Fixture Watts:	182 watts	114 watts
Lamps per Fixture:	4 lamp	4 lamp
Total Annual Electric Use:	45500 kwh per year	17100 kwh per year
Total Annual Electric Cost:	$2,730.00 per year	$1,026.00 per year

Appendix D

Key Plan



*Shaded area is office area

Appendix E

Types of Light Sources

Light Bulbs			
Type	**Common Application**	**Efficiency**	**Colour Rendering**
Incandescent	Homes	Poor	Good
Fluorescent	Home&Office	Good	Fair to good
Mercury	Factories, offices	Fair	Fair to moderate
Low pressure sodium	Roadway	Good	Poor
High pressure sodium	Factories, commercial	Good	Fair to good
Metal Halide	Factories, commercial	Good	Good