An-Najah National University
Faculty of Graduate Studies

Study and Design of An Automatic Control System for Electric Energy Management - Case Study An-Najah National University

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DEDICATION

To the owners of the glowing hearts and burning vigor……………………..

To those who sacrificed their money, souls and blood for their faith...........

To those who faced the devil of evil and the devil of craving……………..

To Al-Aqsa Intifada martyrs and all martyrs of Palestine…………………

To those who loved Palestine as a home land and Islam as a way of life…...

To my tender mother, honored father and dear sisters.

To all of them,

I dedicate this work

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Abbreviations

ANSI	American National Standards Institute
ASHREA	American Society of Heating, Refrigerating and Air-conditioning Engineers
BACnet	Building Automation Communications Network
BAS	Building Automation System
CFL	Compact Fluorescent Lamp
Cu	Coefficient of Utilization
EC	Energy Conservation
ECO	Energy Conservation Opportunity
EMS	Energy Management System
EPA	Environmental Protection Agency
EUI	Energy Utilization Index
FLA	Full Load Ampere
GHG	Greenhouse Gases
HVAC	Heating Ventilating and Air Conditioning
IEC	Israeli Electric Corporation
IP	Internet Protocol
Km	Maintenance Factor
kVAR	Kilovolt Ampere Reactive Power
kWh	Kilowatt hour
LAN	Local Area Network
LLD	Lamp Lumen Deprecation
LMS	Lighting Management System
MAC	Media Access Control
MRS	Monitoring Remote System
NIS	New Israeli Shekel
O&M	Operation and Maintenance
PEA	Palestinian Energy Authority
PHP	Hypertext Preprocessor
PIC	Programmable Interrupt Controller
PIR	Passive Infrared Sensor
RLA	Rated Load Ampere
SNMP	Simple Network Management Protocol
SPBP	Simple Pay Back Period
TCP/IP	Transmission Control Protocol/Internet Protocol
TQM	Total Quality Management
UDP	User Datagram Protocol
US	Ultrasonic Sensor
VBA	Visual Basic for Application
XML	Extensible Markup Language

إقـــرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

Study and Design of an Automatic control System for Electric Energy Management - Case Study An-Najah National University

دراسة وتصميم نظام تحكم آلي لإدارة الطاقة الكهربائية - دراسة حالة جامعة النجاح الوطنية

اقر بأن ما اشتملت عليه هذه الرسالة إنما هي نتاج جهدي الخاص، باستثناء مـــا تمـــت الإشارة إليه حيثما ورد، وان هذه الرسالة ككل، أو أي جزء منها لم يقدم من قبل لنيل أية درجة علمية أو بحث علمي أو بحثي لدى أية مؤسسة تعليمية أو بحثية أخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's name: **اسم الطالب:**

Signature: **التوقيع:**

Date: **التاريخ:**

Values used

Cost of one kWh = 0.73 NIS

Cost of one liter of diesel #2 = 5.5 NIS

NIS = $ 0.285

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Study and Design of an Automatic Control System for Electric Energy Management – Case Study An_Najah National University

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Abstract

The energy situation in Palestine, the efficient use of energy, and the energy conservation in universities, is not in a better condition than most developing countries. In this thesis, we have established a start or a beginning step toward the efficient use of energy and energy conservation in universities through conducting several energy audits in some faculties of An-Najah National University which are considered as high energy consumers and allocate the potential for energy savings opportunities.

In this thesis we have successfully proven that there is a huge potential for energy savings in the Palestinian universities sector (15-25%) by implementing some energy conservation measures (with no or low cost investment) on the most energy consumption equipment such as boilers, air conditioning, and lighting system. Where we have achieved a percentage of saving 24% in the lighting system (low cost), 7% in the cooling system (no cost), and 5% in the heating system (no cost).

In addition, we succeeded in developing a new energy management software, which is used to estimate the total energy savings from each opportunity in our study, this program has several advantages through tabulating large quantities of energy use data, minimizing calculation errors, and providing reliable and neatly organized data for use in analysis and post-retrofit troubleshooting.

In this thesis also we have designed and implemented a new web-based automatic light management and control system , in order to reduce the lighting consumption, by taking into account the classrooms schedule table, the occupancy sensors, and the daylight distribution, this system resulted in extra saving of 45%.

CHAPTER ONE

INTRODUCTION

Chapter One
Introduction

1.1 Scope

Electrical energy bill in the West Bank is very high, Palestine imports all its need of energy (electric, petroleum, and gas) from Israel electrical company (IEC), which make the price uncontrollable. The economic situation of the Palestinian people is very bad, the political and social situation is uncertain because of Israeli occupation. Due to the bad situation of all the factors given above, we must take all the possible efforts to reduce electrical energy consumption in our country, because decreasing the consumption affects the economy and contributes to keeping our environment clean.

Higher education sees much attention at various levels in all countries of the world, in addition to being a contributor to steady development to better meeting the needs of the individual and society.

Undoubtedly, higher education has witnessed a remarkable development in Palestine during the last decade despite the difficulties faced by our Palestinian society, of which the Israeli occupation is the main cause.

The higher education sector in Palestine consists of 46 institutions in the academic year 2006/2007, which provide educational services for more than one hundred and thirty two thousand students [1], these institutions are distributed as follows:

- 13 universities which award Bachelors', Masters', and PhD degrees.
- 12 university colleges, offering Bachelor's degree and 2 years Diploma.
- 21 community colleges, offering Diploma level.

The annual electrical energy consumption of the universities in the West Bank, is illustrated in table 1.1.

Table (1.1): Electrical energy consumption in 2007, for the West Bank universities

Universities	Area (m2)	Std #	Consumption (kWh/Year)	EUI (kWh/m^2)
An-Najah National University	106,825	16,000	3,215,432	30.1
Palestine Polytechnic University	22,004	4,311	1,144,208	52.0
Palestine Technical University	13,100	1,500	218,627	16.7
Arab American University	31,263	3,051	1,258,222	40.2
Al-Quds Open University	28,786	35,425	949,940	33.0
Bethlehem University	14,850	5,500	653,400	44.0
Al-Quds University	36,886	7,600	1,426,746	38.7
Hebron University	17,000	2599	637,520	37.5
Birzeit University	66,000	7,172	2,350,000	35.6
Total	**336,714**	**83,158**	**11,854,095**	

In our ongoing attempts to reduce the Palestinian electrical bill, we decided to study the energy consumption in a very important sector which is universities; in particular we took An-Najah National University, as a case study in this thesis to manage and reduce the energy consumption. Since it has four campuses, big buildings, huge and different loads, this will make the energy management more sensible and feasible. In fact, there was no any previous or current experience in the field of energy management, which urged us to built our research.

After reviewing the energy bills of An-Najah National University, it became obvious to us that it, like many commercial buildings and establishments suffers from high consumption with respect to its connected loads, as shown in figure 1.1.

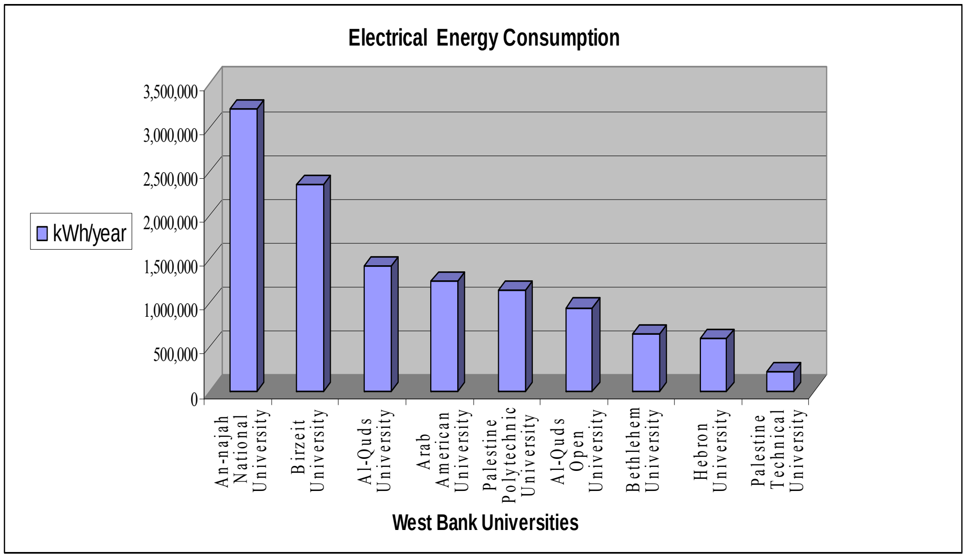


Figure (1.1) : Electrical energy consumption in 2007, for the West Bank universities

Also figure 1.2 shows the percentage of the total electrical energy consumption in 2007, distributed on the four campuses. The total electrical energy consumption was approximately 3,215,432 kWh.

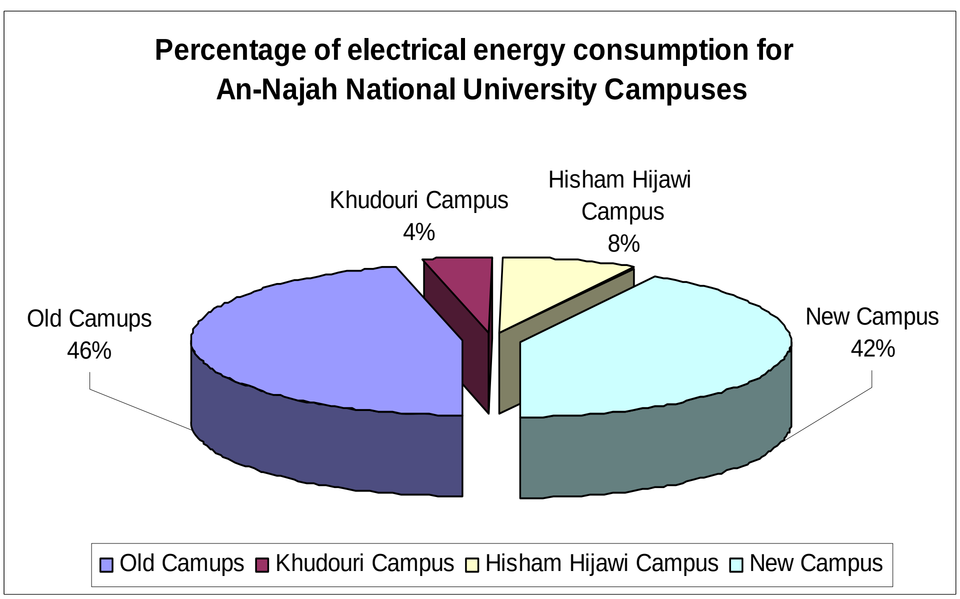


Figure (1.2): Percentage of electrical energy consumption for An-Najah National University campuses

So, we suggest that the university must adopt new energy improvement projects, as developments in technology open up new opportunities. Such investment allows the university to maintain control of increases in utility costs.

Our research focused specifically on lighting efficiency in campus classrooms. We identified electrical energy waste as one of the current and most pressing obstacles to the fulfillment of our committed goal - sustainability. In an attempt to solve this problem, we design an automatic light and management control system in a more efficient way to light classrooms by installing occupancy (motion) sensors in these rooms. This will not only reduce the total energy consumption of the university, but it is projected to significantly reduce energy costs to the university over time.

However, in all occupancy lighting control situations, the operation of the lighting by the occupants emerges as the dominant factor in determining potential lighting energy savings. Generally, lighting energy reductions from occupancy sensors will roughly follow room vacancy rates. Savings will be, of course, modified by occupant responsiveness in turning off lights in unoccupied areas. Such behavior is also impossible to evaluate within a laboratory environment. Thus, we intended to conduct a series of tests of the technology using a "before and after" measurement to determine actual potentials.

Moreover, the utilization of this new developed light and management control system will keep An-Najah National University on the forefront of environmental technologies, a goal that is extremely important to primary educational institutions.

1.2 Objectives of the Study

In this study we will concentrate on the following activities:

Main objective:

"Study and Design of an Automatic control System for Electric Energy Management - Case Study: An-Najah National University".

Specific objectives:

- Reduce the energy consumption of An-Najah National University and consequently energy bills by designing light and management control system.
- Designing a well-structured software to supervise and monitor the lighting system remotely through the internet.
- Make strategies to increase energy performance in universities sector.
- Contribution in keeping our environment clean.

1.3 Methodology

The methodology is divided into three categories:

- First category: Collecting data and energy audit.

1. Establishing energy audit for the new campus of An-Najah National University.
    - Identifying the types and costs of energy use, to understand how that energy is being used and possibly wasted.

  - Identifying and analyzing the alternatives, such as operation techniques and/or new equipments that could substantially reduce energy cost.
  - Performing an economic analysis on those alternatives and determine which ones are cost effective for our target.

2. Utilizing the energy audits recommendations to determine the energy conservation opportunities.
3. Making some suggestions on the best lighting fixtures which have been tested world wide and approved in energy conservation.

- Second category: Designing a well-structured energy management software, to realize the energy conservation opportunities.
- Third category: Designing a lighting panel for controlling lights remotely from any computer connected to intranet of the university, through a user graphical interface software that we have designed.

1.4 Thesis Outline

This thesis is divided into (9) chapters including this introductory chapter.

In chapter one of this thesis, a brief description of the energy situation in Palestine was presented, together with the objectives of the study and the methodology.

In chapter two, literature review in the field of energy efficiency and conservation in universities was presented. The most energy consumption systems were lighting system, boilers, and air conditioning. Also the control strategies for lighting system were discussed.

Chapter three presents, a brief description for the audited university in this thesis , the annual electric and fuel energy consumption in addition to the energy bill analysis for each faculty were also discussed.

Chapter four presents, the energy conservation measures implemented on each system from the technical and economical sides, the amount of energy savings in each energy conservation opportunity of each system with the required investment and the simple payback period were found and analyzed.

The amount of energy saving that could be achieved through the no/low cost investment in university is 15 - 25%, as a result of decreasing the demand on energy, which enhances the national economy and leads to a huge reduction in the harmful environmental emissions such as CO_2.

Chapter five presents, the developed energy conservation software, illustrating the methods employed in energy conservation, and transforming them into mathematical models and flow charts, to find the total energy saving from each opportunity in our study.

In chapter six the system development and analysis of the occupancy sensors were presented, descriptive statistics were calculated and cost analysis were performed for weekdays, weekends, and for the total monitoring period. the percentage of saving in each area were measured for the occupancy sensor. Description of the system main components and operation, and the installation of the sensors were also presented in this chapter.

Chapter seven presented, the light management and control web-based software development, illustrating the main components, its language, flow charts, the designing procedures, and the principle work.

Chapter eight presents, the system testing and results of the new developed automatic light and management system, the PIC and serial interface, the XPort Direct+ configuration and its kit, the placement and adjustment of the occupancy sensors, the daylight distribution, the impact of time delay on energy saving, and the economical evaluation of the designed system.

In chapter nine the conclusion and recommendations for our thesis are presented.

CHAPTER TWO

LITERATURE REVIEW

Chapter Two
Literature Review

2.1 Introduction

The energy management program is a systematic on-going strategy for controlling a building's energy consumption pattern. It is meant to reduce waste of energy and money to the minimum permitted by the climate where the building is located, its functions, occupancy schedules, and other factors. It establishes and maintains an efficient balance between a building's annual functional energy requirements and its annual actual energy consumption [2].

A whole systems viewpoint to energy management is required to ensure that many important activities will be examined and optimized. Presently, many businesses and industries are adopting a Total Quality Management (TQM) strategy for improving their operations. Any TQM approach should include an energy management component to reduce energy costs [2].

The primary objective of energy management is to maximize profits or minimize costs. Some desirable sub-objectives of energy management programs include:

1. Improving energy efficiency and reducing energy use, thereby reducing costs.
2. Cultivating good communications on energy matters.
3. Developing and maintaining effective monitoring, reporting, and management strategies for wise energy usage.

4. Finding new and better ways to increase returns from energy investments through research and development.

5. Developing interest in and dedication to the energy management program from all employees.

6. Reducing the impacts of curtailments, brownouts, or any interruption in energy supplies.

2.2 The Need for Energy Management

Business, industry and government organizations have all been under tremendous economic and environmental pressure in the last few years. Being economically competitive in the global marketplace and meeting increasing environmental standards to reduce air and water pollution have been the major driving factor in the most of the recent operational cost and capital cost investment decisions for all organizations. Energy management has been an important tool to help organizations meet these critical objectives for their short term survival and long term success [2].

Energy management is necessary to Palestine because:

1. Electric energy management is good for the Palestinian economy, as the balance of the payments becomes more favorable.

2. Electric energy management make us less vulnerable to energy cutoffs or curtailments due to political unrest.

3. Energy management is friendly to our environment as it eases some of the strain on our natural resources and may leave a better world for future generation.

2.3 Control Systems and Computers

Energy use can be controlled in order to reduce costs and maximize profits. The controls can be as simple as manually turning off a switch, but often automated controls ranging from simple clocks to sophisticated computers are required. Our view is that the control should be as simple and reliable as possible.

As one moves through this hierarchy of controls, each level of automation and complexity requires additional expenditure of capital. That is, the automated controls are more expensive, but they do more. Because choosing the proper type of control is often a difficult task, we will explore this decision process.

Computers can also help the energy manager in the analysis of proposed and present energy systems. Some excellent large-scale computer simulation programs have been written that enable the energy analyst to try alternative scenarios of energy equipment and controls, such as BLAST 3.0 and DOE-2.1D [3].

Every piece of energy-consuming equipment has some form of control system associated with it. Lights have on-off wall switches or panel switches, and some have timers and dimmer controls. Motors have on-off switches, and some have variable speed controls. Air conditioners have thermostats and fan switches. Large air conditioning systems have extensive controls consisting of several thermostats, valve and pump controls, motor speed controls, and possibly scheduling controls to optimize the operation of all of the components. Large heating systems have modulating controls on the boilers and adjustable speed drives on pumps and variable air volume fans [3].

These controls are necessary for the basic safety of the equipment and the operators, as well as for the proper operation of the equipment and systems. Our interest is in the energy consumption and energy efficiency of this equipment and these systems, and the controls have a significant impact on both of these areas. Controls allow unneeded equipment to be turned off, and allow equipment and systems to be operated in a manner that reduces energy costs. This may include reductions in the electric power and energy requirements of equipment, as well as the power and energy requirements associated with other forms of energy such as oil, gas and purchased steam.

2.3.1 Lighting controls

Controls are an excellent way to reduce lighting energy while enhancing lighting quality. Occupancy sensors can eliminate wasted lighting in unoccupied spaces. Daylighting controls or advanced load management can reduce lighting demand when energy is most expensive. And manual dimmers, which allow occupants to adjust light levels to their preference, are becoming more affordable. Lighting controls have been shown to reduce lighting energy consumption by 50% in existing buildings and by at least 35% in new construction [4].

Lighting control systems are becoming digital. Digital lighting control systems have been developed as stand-alone systems or as part of building- wide automation systems. In a digital system, each segment of the lighting system has its own device-specific address. That allows commands to be issued to specific portions of the building's lighting system.

Digital systems can perform the same lighting automation functions that independent, stand-alone systems perform, only better. They can schedule the operation of lights in any area within the facility. They can override the set schedule to match changes in operating schedules. They can monitor occupancy patterns in an area and adjust the operation of the lighting systems as required [5].

Digital systems also give facility executives the ability to control building lighting energy use from any location. In addition to providing a central control station for the building's lighting systems, most digital systems are Internet compatible, allowing managers to monitor and control building lighting systems from any location that has Internet access.

The ability to remotely control building lighting systems is particularly important for facilities facing high or uncertain electricity costs. One method of reducing those costs is to limit the facility's demand for electricity during peak-use periods when rates are the highest. During these times, the lighting control system can turn off as many lighting system components as possible, or dim those systems that are equipped with dimming ballasts. With building lighting systems accounting for such a large portion of the electrical load, any reduction in lighting load during peak-rate periods will translate into savings, in both energy use and energy demand charges [5].

Another benefit of digital lighting control systems is their ability to monitor the operation of the lighting systems. At the minimum, the digital system can receive feedback from each lighting system, confirming that it is on or off as commanded. The digital system can also monitor the number of hours that the lights are operated in a given area, as well as the number of times the lights are turned on, which are the most important factors in determining lamp life. Using this information, managers can schedule the group relamping of particular areas in the building before the number of lamp burnouts becomes excessive while ensuring that the lamps have been used for as long as possible [5].

Most facility executives can expect to achieve a 25 to 45 percent reduction in lighting energy use by implementing an automated lighting control program [6]. Most facilities will recover their investment in lighting automation in two years or less. The actual savings and payback that will be achieved depend on a number of factors, including how the facility uses lighting, the type of lighting systems installed, the hours that lighting is required, the lighting level needed, when the lights are required and the ability of the facility to make use of daylighting.

2.3.1.1 Occupant needs

Lighting controls are intended to fulfill two, potentially conflicting, objectives: (1) reduce lighting energy costs and (2) maintain or improve occupant satisfaction and comfort. Except for the most humble of lighting controls -the manual wall switch- lighting controls have historically had little to offer the building occupants. In the past, the occupants' lighting control needs were thought to be adequately served if they could turn their lighting on or off when arriving or leaving work. In the modern work environment, this attitude is no longer sufficient. Changing visual needs is now the norm rather than the exception and controls can help to meet this variety of needs [7].

2.3.1.2 Building operation

Cognizant building managers use the building lighting control system as a tool to control building operation costs. Since lighting energy is a substantial fraction of electric energy in many buildings, improved lighting controls can have a major positive impact on building energy consumption and peak demand.

Savings from lighting controls may come from:

- Reduced electric lighting use.
- Reduced peak demand charges.
- Downsizing HVAC equipment (reduced first cost).
- Reduced HVAC operating costs.
- Lower maintenance costs.
- Productivity improvements.

Lighting also affects other building loads, especially HVAC. The usual “rule of thumb” is that every watt saved in lighting saves an additional 1/4 watt in avoided HVAC energy [8].

Most controls require commissioning to ensure that they operate according to design intent and are properly adapted to local conditions. With occupancy sensors, the time delay and sensitivity should be adjusted for each workspace. With automatic daylighting controls, the sensitivity to changes in daylight must be set for local room conditions. Initial commissioning may be done by a professional or by the facility management staff, but for best performance, occupants should be involved in fine-tuning control system operation according to their preference [9].

2.3.2 Control selection guidelines

This section provides an overview of general control strategies and devices, as well as several useful tables to evaluate which strategies and devices are appropriate for various space types.

There are several general strategies for using lighting controls to reduce operating costs and improve lighting system functionality:

1. Occupancy Sensing: Turning lights on and off according to occupancy as detected with occupancy sensors. Appropriate for unpredictable occupancy patterns.

2. Scheduling: Turning lights off according to program using programmable relays, timers and other time clock devices. Appropriate for predictable occupancy patterns.

3. Tuning: Reducing power to electric lights in accordance with the user needs at the time. Tuning may be accomplished with dimming devices, but bi-level switching of overhead lighting should also be considered, especially when daylight is available.

4. Daylighting: Reducing power to electric lights or turning lights off in the presence of daylight from side lighting or top lighting. Daylighting controls typically employ a photo sensor, linked to a switching or dimming unit that varies electric light output in response to available daylight. Bi-level switching should be considered if dimming is not economically justified.

5. Demand Limiting: Reducing electric lighting power during or in anticipation of power curtailment emergencies. During Emergency Alerts periods lighting loads can be shed either through voluntary curtailment or automatically by the facilities manager or utility service provider.

6. Lumen Maintenance: Compensating for lamp lumen depreciation using a photocell. This strategy is generally deprecated today, as the lamp lumen depreciation from modern building lighting systems is too small to make lumen maintenance economically viable.

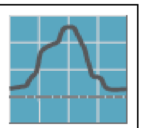
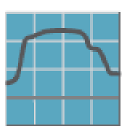
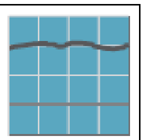
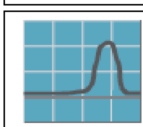
7. Integrated system: Integrated lighting controls provide all necessary control adjustments and inputs at one location, where several control strategies can be applied at once. Although integrated controls are somewhat more expensive, the convenience of having one accessible location for performing all system commissioning can reduce setup and maintenance costs.

2.3.2.1 Control devices

The above control strategies define what the lighting controls do. The control devices are the physical equipment that is installed to implement the desired control strategies in a particular application. The needs of both the lighting users and the facility manager must be considered when developing the lighting control program.

Control selection should consider the building's expected electric load profile as shown in table 2.1. For example, daylighting control may be very attractive for a building with peak loads during daylight hours, to reduce demand charges, but not interesting for a building with most of its electric use at night. For this application, adaptive compensation may be a more cost-effective strategy [10].

Table (2.1): Selecting control devices based on expected lighting load profile [10]

Lighting use profile		Selection	Devices
	Typical work hours 8 to 5 with limited weekend use	Select controls that reduce peak demand	Occupancy sensors and photo sensors for tenant spaces Time clock devices for public areas
	Extended hours	Select controls that reduce unpredictable use	Occupancy sensors Manual dimming/multilevel switching for adaptive compensation
	24-hour	Select controls that reduce lighting day and night	Photo sensors Manual dimming/multilevel switching for adaptive compensation
	Event-oriented operation	Manual controls work best	Manual dimming Multilevel switching

2.3.2.2 Occupancy sensors

Occupancy sensors are switching devices that respond to the presence and absence of people in the sensor's field of view. The occupancy sensor system is usually made up of one or more components, which include a motion detector and a control unit consisting of a transformer for power supply and a relay for load switching, sometimes called a power pack. The sensor sends a signal to the control unit that switches lights on and off. Most sensors include manual and/or automatic controls to adjust sensitivity to motion and to provide a time delay for shut-off of lights upon vacancy.

The relationship between the power supply, relay, controller and motion detector is shown in figure 2.1.

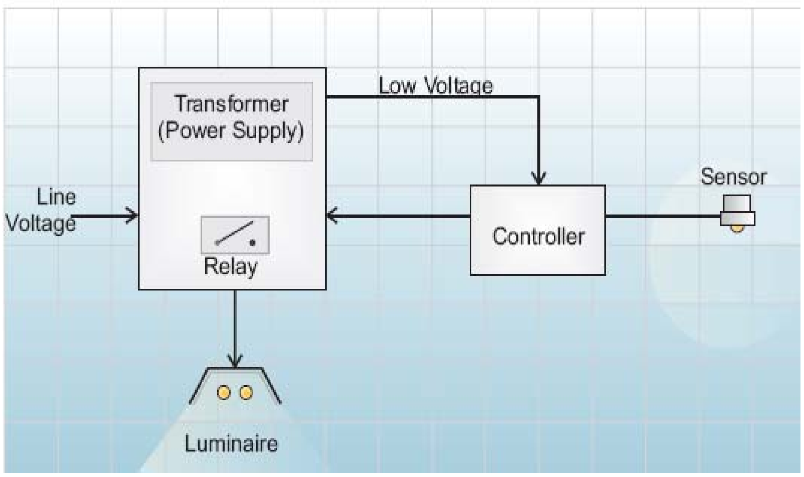


Figure (2.1): Occupancy sensor control system [7]

Figure 2.2 provides a flow diagram to help decide whether Ultrasonic, PIR, or Dual-technology occupancy sensors are more appropriate for a particular application.

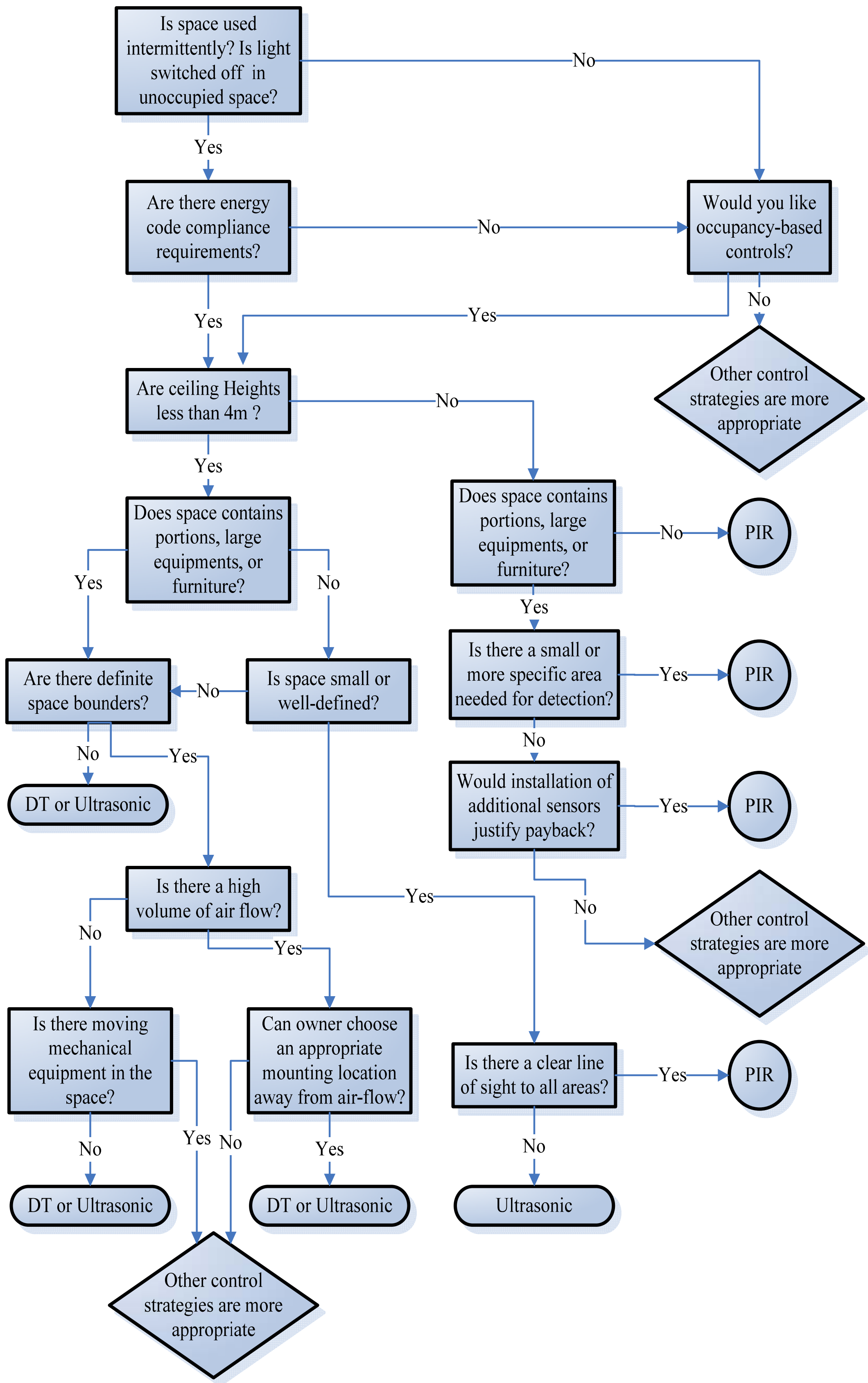


Figure (2.2): Selecting occupancy sensor types [7]

2.3.3 Daylighting controls

Daylighting controls are devices that regulate the level of illumination provided by electric lights in response to the presence of daylight. They usually consist of a sensing device (photocell or photo sensor) that monitors either the total light level in the space or the available daylight level at the daylight aperture, and a control module that then switches or dims the electric lighting to maintain the needed illumination with minimal energy use.

Since daylight may be present in large areas of commercial buildings for many hours of the day, automatic photo electrically controlled lighting systems can easily save 10–50% of the annual lighting energy [11], reducing both building operating costs and consumption of natural resources. Equally important, since daylight availability usually coincides with the utility's peak demand profile, daylight controls can also reduce peak demand charges.

2.3.4 Building controls integration

There are many benefits to integrating the operation of the building lighting with other electrical loads in a building, especially if the overhead lighting is dimmable. Even in facilities without dimmable lighting systems, there are economies from combining switching control of lighting circuits with other building electric loads. Scheduling controls require commissioning the operation of many lighting zones in a complex, and this is best accomplished from one facility. As lighting averages 37% of a typical commercial building's total electrical demand, reducing power to a building's dimmable lighting system by 25% (hardly noticeable in terms of light output) would reduce a building's electric demand by 10% [7]. With dimmable lighting, it is even possible to adjust lighting power according to the hourly price of energy or other utility pricing signal.

2.3.4.1 Protocols

Integrating lighting control with other building equipment requires consideration of the protocols used to allow communications between control products from different equipment vendors. The development and acceptance of open-protocol communications standards for building equipment controls and the pervasiveness of the Internet are creating new opportunities for building owners and operators. BACnet (Building Automation Communications network) is an open-protocol standard (ASHRAE/ANSI standard) for intermediating BAS transactions, as is LonMark, which is based on LonWorks from the Echelon Corp [7]. Both protocols integrate control networks from different vendors with the Internet. Both protocols use the Internet (or TCP/IP) as the communications medium between control networks. Most modern buildings already have wiring to support their computer networks; this "road" serves as well for building equipment communications as it does for enterprise computing. Comparisons between LonMark and BACnet are beyond the scope of these guidelines, but any modern building using BAS controls will probably elect to use a hybrid system with some equipment running LonMark and other control networks running BACnet as shown in figure2.3. Gateways between LonMark and BACnet are straightforward.

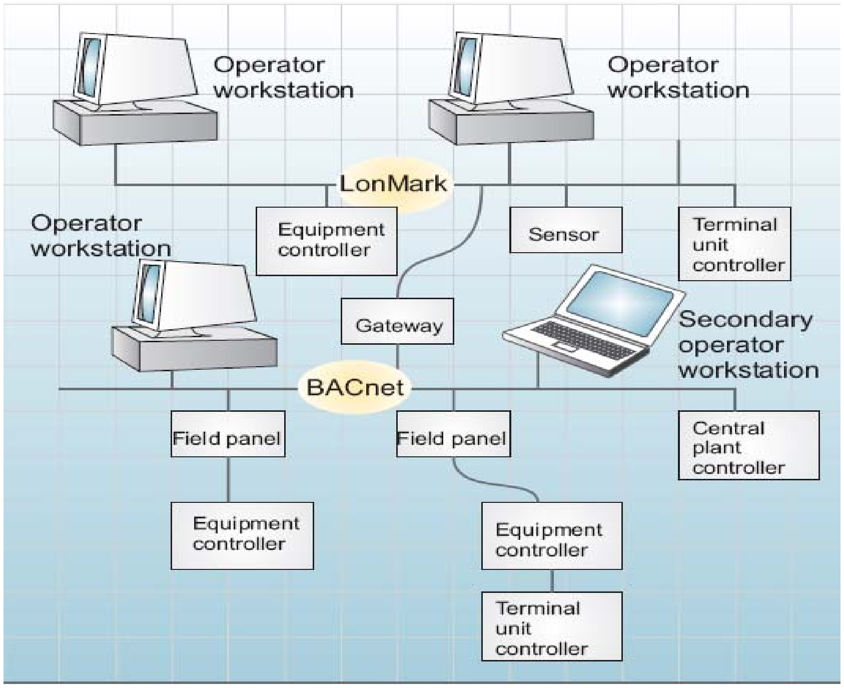


Figure (2.3): Control network running LonMark and BACnet [7]

2.3.4.2 Integrated controls

With integrated controls, more than one lighting control strategy is implemented at a time with the same lighting hardware. For example, integrated controls for a classroom application might exploit daylighting, tuning, and scheduling all with the same hardware.

By combining more than one strategy, more energy can potentially be saved and the greatest economic benefit extracted from the investment in controls. Combining several strategies increases the economic benefits if the marginal cost of adding additional strategies onto one base strategy is small. While integrated controls offer the potential of greater energy savings and more highly responsive lighting systems, they also run the risks inherent in any complex system: more complexity in design and more difficulty in diagnosing failure. These trade-offs should be carefully considered in the design of a system [7].

2.3.5 Energy savings

Lighting controls reduce building operation costs. Properly operated lighting controls reduce lighting energy when lighting is unnecessary and reduce lighting demand when and where possible.

Occupancy sensors reduce the time of lighting operation. Time switches and programmable relay systems also reduce hours. Dimming controls, such as daylighting, reduce or eliminate lighting power throughout the day even in occupied areas. Reducing energy use during peak periods may also reduce lighting demand and related peak demand charges.

Since every building is different, it is difficult to know how much energy lighting controls are likely to save in any given application. In large part, the energy savings from controls depend on how the building lighting was operated before the controls were installed. If building occupants are conscientious with lighting, then energy savings would be modest. However, many buildings enclose spaces where automatic controls can significantly reduce wasted lighting energy by eliminating lighting during unoccupied times or reducing electric light levels where adequate daylight is available [7].

Table 2.2 presents estimates of the maximum yearly energy savings that would be expected per controlled circuit according to control type, space type and typical hours of operation. The energy savings values listed are the maximum expected values, not the average, and assume that the control devices are properly specified, installed, and commissioned.

Table (2.2): Lighting control energy savings examples by application and control type. [7]

Space type	Controls type	Maximum expected yearly energy savings
Private Office	Occupancy sensor	45%
	Side lighting w/photo sensor	35%
	Manual dimming or multilevel switching	30%
Laboratory	Side lighting w/photo sensor	40%
	Occupancy sensor	35%
Classroom	Multilevel switching	15%
	Side lighting w/photo sensor	40%
	Occupancy sensor	25%

2.4 Previous Studies

Energy management is becoming a major concern on university campuses. The university's facilities are an eclectic mix of building styles and construction, including research facilities, libraries, offices, auditoriums, dormitories, classrooms, dining halls, a central steam-heating plant, individual building chillers for air conditioning, thousands of lighting fixtures and exit lights.

The Duke University Board of trustees had been approved of $ 3.5 million loan , in September 1996. After 8 years, definitely in June 2004, the energy management program has saved over $4.7 billion in directly metered utilities [12].

Initially the university focused on projects that were relatively easy to implement and that produced immediate savings. The initial projects fell into the general categories of steam trap maintenance, lighting improvements, and HVAC repair and replacement. The sample of saving in the period of FY 96/97 are illustrated in the next table:

Table (2.3): FY 96/97 savings & cost avoidance [12]

Efficiency measure	Detail	First Cost ($)	Estimated annual saving	Simple payback (years)
Steam Traps	Trap maintenance pilot program.	12,472	$10,393	1.2
Compact Fluorescent Lamps	Energy efficient replacement for incandescent lamps. Consume less energy and have longer life.	83,622	$25,340	3.3
LED Exit Signs	Consume much less energy than incandescent signs and last many times longer.	58,464	$12,180	4.8
Motion Sensors	Save energy by automatically turning off lights during unoccupied periods.	2,565	$1,166	2.2
HVAC Controls	Replacement of pneumatic controls by DDC enabled more efficient operation of buildings.	59,400	$11,000	5.4

University of New Brunswick has two campuses, one in Fredericton and the other in Saint John. The university has been investing in energy conservation measures for three decades. These investments have enabled the university to control the rate at which its utility costs have increased, and students have profited by an improved learning environment.

During the energy crisis of the 1970s, the university installed an automated energy management system that utilized Honeywell Delta 1000 panels and was monitored by a central computer located in the Services Building. The system introduced, for the first time, occupancy scheduling and monitoring of heating, ventilation and air-conditioning systems.

In 1991 the front end of the Automated Energy Management System was upgraded to a Honeywell Graphic Central System. The Graphic Central System was accessible from one work station utilizing a Dell 425E computer. The upgraded system was user friendly and it dramatically increased the capacity of the automation system. Occupancy scheduling and monitoring of 50 heating, ventilation and air-conditioning systems in 11 facilities was provided by the system [13].

In 1996, the university's Board of Governors approved an energy management program for the Fredericton campus. The program calls for an investment in energy conservation projects of up to $1,900,000. Projected annual cost avoidance of all projects was $436,000, resulting in a simple payback of 4.36 years [14].

Elizabethtown College in Pennsylvania, has recently started a 'Green Lights Program' in which all regular light switches in common areas (i.e. social rooms, laundry facilities, and bathrooms) will be replaced with occupancy sensors. Green Mountain College in Poultney, Virginia has begun to use the EPA's Energy Star™ program to replace inefficient light fixtures and switches in order to cut energy costs while improving building conditions and helping the environment [15].

Large universities, on the other hand, have engaged in much more extensive audits and programs for obvious reasons. Princeton University, for example, has the most thorough online environmental audit regarding energy use. Princeton has installed motion and daylight sensors in classrooms, auditoriums, and hallways. According to their research, these sensors result in an approximate 50% reduction in classroom lighting and a 20-25% reduction in hallway lighting demands [16]. Princeton's Environmental Audit Team has made further recommendations that motion and daylight sensors be installed in dormitory bathrooms to reduce electrical waste because lights in dormitory bathrooms are rarely, if ever, switched off.

Brown University is also worth mentioning here because a project team recently researched lighting efficiency at Brown University as part of an environmental geology course. The goal of the lighting efficiency project at Brown was to determine whether or not timers and/or motion sensors should be installed in dormitory and office hallways to reduce energy consumption and expenditures. Their findings, however, showed that sensors may not be the most energy efficient method of reducing lightening in hallways at night. Dimming hallway lights seems to be a much better option, according to the students who conducted this audit [16]. In addition, they recommend that installing motion sensors in on-campus bathrooms would not be a feasible option for Brown University.

CHAPTER THREE

DESCRIPTION OF THE AUDITED UNIVERSITY

Chapter Three
Description of the Audited University

3.1 Introduction

An-Najah National University is recognized as Palestine's leader in higher education. In almost 90 years of teaching, the university has been playing a leading part in the development of modern higher education in Palestine. The university is one of the pioneering and well-established universities in Palestine. Students from different parts of the country attend the university in pursuit of learning, knowledge and personal development.

The university has four campuses distributed between the cities of Nablus and Tulkarm. There are three campuses in Nablus: the Old Campus, the New Juneid Campus, and Hisham Hijawi College of Technology Campus. The fourth Campus is Khudouri which is located in the city of Tulkarm.

An energy conservation study was performed for An-Najah National University in Nablus. The study objective was to obtain an overview of existing building energy consuming systems related to the lighting, Heating Ventilating and Air Conditioning (HVAC), and building control. In order to determine the energy consumed by this buildings, daytime walk-through were performed, building occupants were questioned as to equipment and building usage schedules. Most building characteristics and systems were also discussed.

3.2 New Campus Description

The new campus of An-Najah National University is constituted by four different poles (buildings) located at 121,000m^2 land in the west region of Nablus city, named building of Fine Arts which consists of: School of Arts, Faculty of Graduate Studies, College of Law and Theater building, building of Science and IT which consists of: Faculty of Science, Faculty of Optometry and Faculty of IT, Pharmacy & Medicine building and building of Engineering College. The description of the main faculties and its operating schedules could be seen in table 3.1.

Table (3.1): The main faculties and its operating schedules in the university

Faculty	Area (m^2)	Working hours / day	
		From	To
Engineering	12.795	8 AM	5 PM
Pharmacy & Medicine	7.700	8 AM	5 PM
Science, IT and Optometry	19,250	8 AM	5 PM
Fine Arts, Graduate Studies and Law	12.185	8 AM	5 PM

3.3 University Layout

The general layout of the university and the location of the main faculties is shown in figure 3.1.

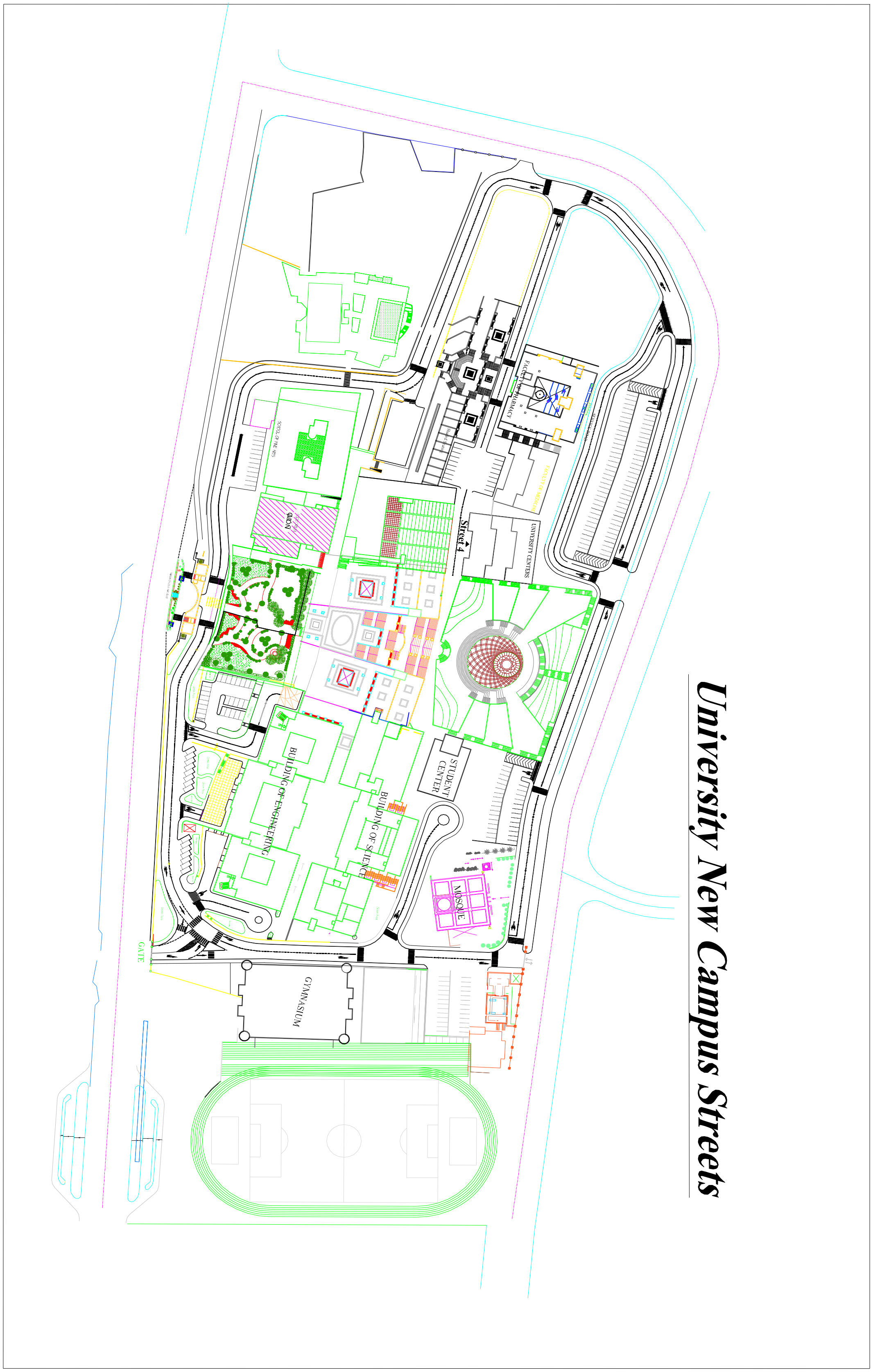


Figure (3.1): New campus layout

3.4 University Faculties

3.4.1 Building description

Table 3.2 shows the general description of the buildings, which may give some of the no cost opportunities to reduce energy consumption.

Table (3.2): Buildings description

Faculty of Engineering					
Gross area (m^2)	**X**	**Ceiling height (m)**		**=**	**Volume (m^3)**
12,795	X	3		=	38385
Conditioned floor area (if different than gross floor area) (m^2)					1270 m^2
Total southern exterior glass area (m^2)					134 m^2
Single panes (m^2)		134 m^2	**Double panes (m^2)**		0.0
Other general building descriptions					
Faculties of Science, IT and Optometry					
Gross area (m^2)	**X**	**Ceiling height (m)**		**=**	**Volume (m^3)**
19,250	X	3		=	57750
Conditioned floor area (if different than gross floor area) (m^2)					763 m^2
Total southern exterior glass area (m^2)					222 m^2
Single panes (m^2)		222 m^2	**Double panes (m^2)**		0.0
Other general building descriptions					
Faculties of Fine Arts, Graduate Studies and Law					
Gross area (m^2)	**X**	**Ceiling height (m)**		**=**	**Volume (m^3)**
12,185	X	3		=	36555
Conditioned floor area (if different than gross floor area) (m^2)					2,185 m^2
Total southern exterior glass area (m^2)					84 m^2
Single panes (m^2)		84 m^2	**Double panes (m^2)**		0.0
Other general building descriptions					
Faculties of Pharmacy and Medicine					
Gross area (m^2)	**X**	**Ceiling height (m)**		**=**	**Volume (m^3)**
7,700	X	3		=	23,100
Conditioned floor area (if different than gross floor area) (m^2)					298 m^2
Total southern exterior glass area (m^2)					50 m^2
Single panes (m^2)		50 m^2	**Double panes (m^2)**		0.0
Other general building descriptions					
• **Not all the faculties southern windows have curtains (shutters).**					

3.4.2 Major energy consuming equipment

Table 3.3 lists the major energy consuming systems and equipments in the university faculties.

Table (3.3): Major energy consuming equipments

Equipment / System	Faculty of Engineering		Faculties of Science, IT and Optometry		Faculties of Fine Arts, Graduate Studies and Law		Faculties of Pharmacy and Medicine	
	Number of units	Nameplate rating per unit	Number of units	Nameplate rating per unit	Number of units	Nameplate rating per unit	Number of units	Nameplate rating per unit
A. Hot water								
Space Heating Diesel Boilers	3	415-1364 kW	3	420 kW	2	990 kW	2	590 kW
Electrical Boilers	15	3 kW	18	3 kW	6	3 kW	-	-
B. Lighting								
Fluorescent Lamps	1,711	18-36 W	1,943	18-36 W	1,141	18-36 W	746	18-36 W
Emergency Lamps	88	16 W	72	8 W	44	8 W	40	8 W
C. Air Conditioning								
Chillers	1	11 kW	2	7.5 kW	3	187 kW	2	11,27 kW
Split Units	36	2 kW	35	3.5 kW	3	3.5 kW	8	3.5 kW
D. Hot water Pumps								
	14	1.1-3 kW	9	4-7.5 kW	24	0.75-11 kW	10	0.2-0.6 kW
E. Compressors								
	1	4 kW	1	4 kW	-	-	1	4 kW
F. Refrigerators								
	13	300 W	18	300 W	8	300 W	12	300 kW
G. Elevators								
	2	11 kW	4	8 kW	2	11 kW	3	75 kW

3.4.3 Electricity bills

The university receives its electric utility service from Nablus Municipality. Table 3.4 shows how the electrical energy consumption is varied with months, and the energy utilization index (EUI); dividing the kWh by the faculties areas.

Table (3.4): Electrical energy use and cost for the university faculties

Month	Faculty of Engineering			Faculties of Science, and IT			Faculty of Fine Arts			Faculty of Pharmacy		
	Consump. (kWh)	Cost (NIS)	EUI (kWh/m^2)	Consump. (kWh)	Cost (NIS)	EUI (kWh/m^2)	Consump. (kWh)	Cost (NIS)	EUI (kWh/m^2)	Consump. (kWh)	Cost (NIS)	EUI (kWh/m^2)
January	14500	9669	1.13	42500	28345	2.2	24000	16006	1.96	6720	4480	0.87
February	20500	13671	1.60	46000	30680	2.38	29000	19341	2.38	9120	6081	1.18
March	29000	20298	2.26	57000	39898	2.96	39500	27648	3.24	12480	8734	1.62
April	26000	18198	2.03	55500	38848	2.88	30500	21348	2.5	11520	8062	1.49
May	22000	16055	1.72	45000	32845	2.33	25500	18610	2.09	8400	6127	1.09
June	20500	14960	1.60	45000	32845	2.33	40500	29560	3.32	8880	6477	1.15
July	25000	18245	1.95	59000	43065	3.06	32000	23355	2.62	9120	6652	1.18
August	21000	15325	1.64	47500	34670	2.46	26500	19340	2.17	9840	7178	1.27
September	26000	18975	2.03	46500	33940	2.41	29500	21530	2.42	8640	6302	1.12
October	21000	15325	1.64	58500	42700	3.03	27000	19705	2.21	11760	8580	1.52
November	24500	17880	1.91	58500	42700	3.03	29000	21165	2.38	10800	7879	1.4
December	21500	15690	1.68	41000	29925	2.13	27500	20070	2.25	9840	7183	1.3
Total	**271,500**	**194,291**		**602,000**	**430,461**		**360,500**	**257,678**		**117,120**	**83,735**	

Figure 3.2 shows the electrical energy consumption in kWh variations with respect to time in months, for the university faculties.

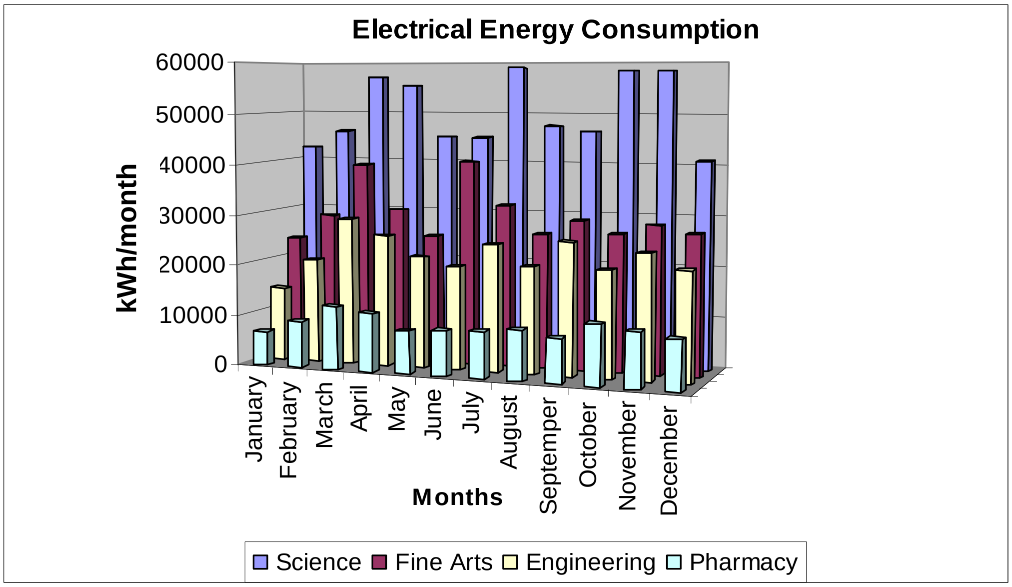


Figure (3.2): Electrical energy consumption for the university faculties

Then another type of energy which is consumed by the faculties, is the diesel burned in boilers to produce hot water for space heating in winter, table 3.5 shows the diesel consumption around the months.

Table (3.5): Diesel consumption and cost for the university faculties

	Faculty of Engineering	Faculty of Science	Faculty of Fine Arts	Faculty of Pharmacy
Fuel type	Diesel	Diesel	Diesel	Diesel
Total cost (winter season)	198,000 NIS	247,500 NIS	222,750 NIS	198,000 NIS
Number of consumed liters	36,000 liters	45,000 liters	40,500 liters	36,000 liters

Figure 3.3 Illustrates the percentage of energy cost distribution for electricity and fuel as a source of energy, for the university faculties.

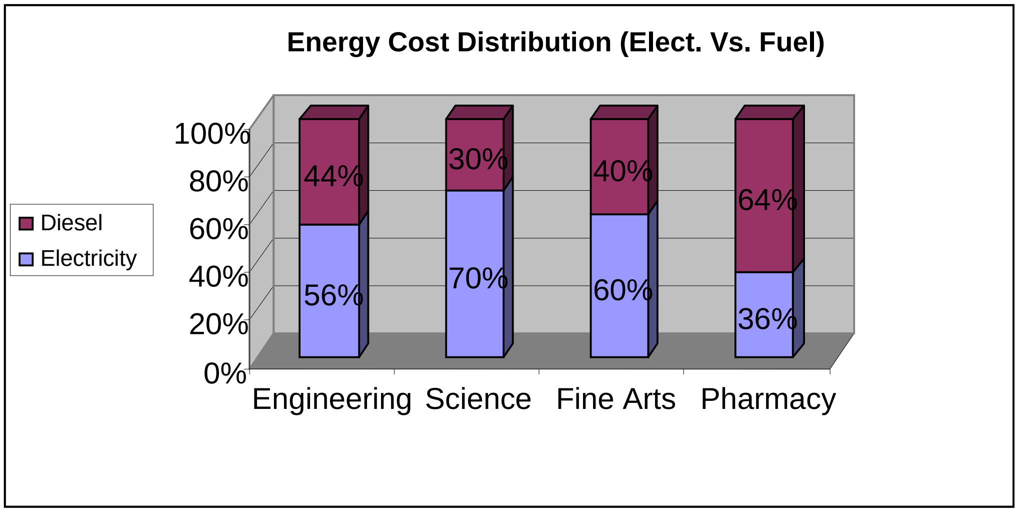


Figure (3.3): Energy cost distribution (elect. vs. fuel)

3.4.4 Weekly load curve

The relationship of power supplied to the time of occurrence, illustrates the varying magnitude of the load during one week called weekly load curve. The weekly load curve is good tool for load management to achieve many benefits:

1. Demonstrates load distribution in a facility during one week.
2. Facility management can redistribute load to suit transformers and cables capacities.
3. Facility management can redistribute load to avoid maximum demand penalty, which is charged for monthly maximum load occurs during system peak load period.

The weekly load curves for the university faculties were measured by using the Energy Analyzer apparatus, as shown in the next figures 3.4, 3.5, 3.6, and 3.7, referred to appendix 3.

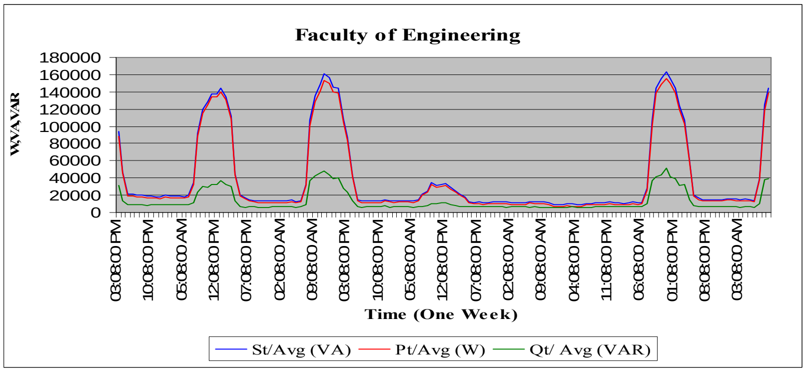


Figure (3.4): Weekly load curve for the faculty of Engineering

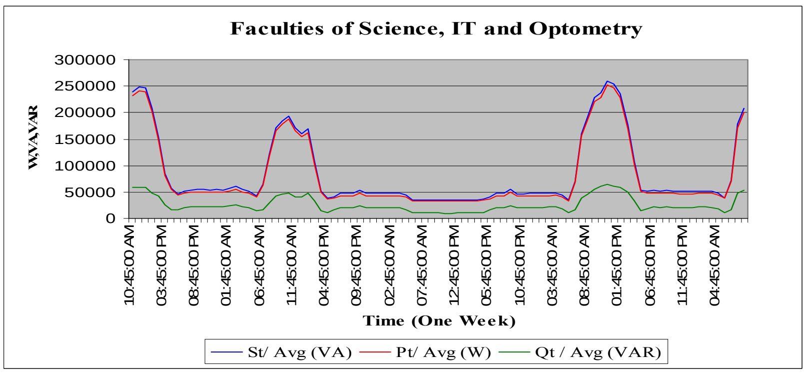


Figure (3.5): Weekly load curve for the faculty of Science

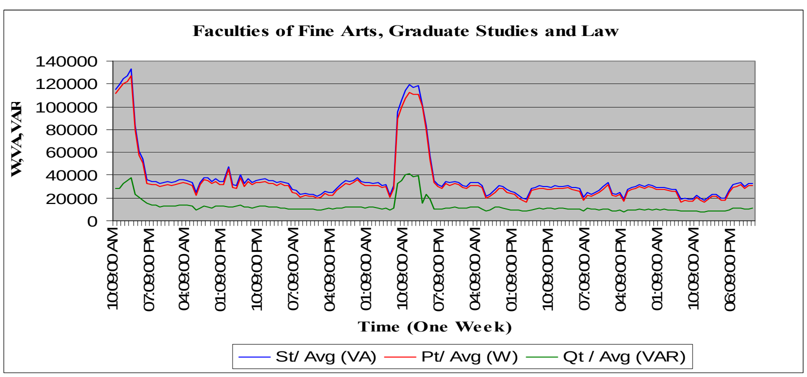


Figure (3.6): Weekly load curve for the faculty of Fine Arts

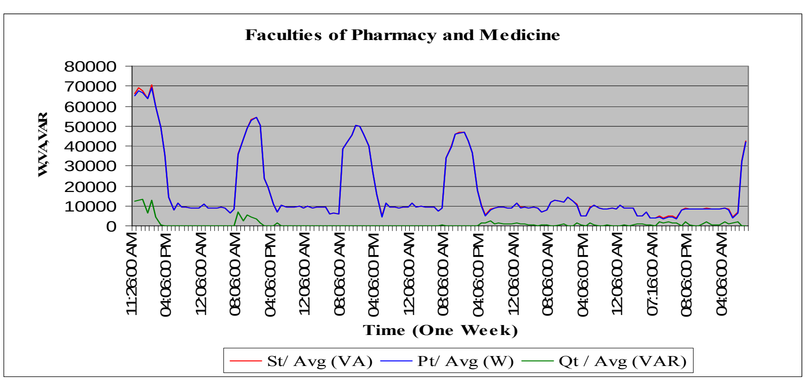


Figure (3.7): Weekly load curve for the faculty of Pharmacy

3.4.5 Data collection

3.4.5.1 Boilers

There are ten boilers in the university, with different capacities, used for space heating in winter season, three of them is out of service. In order to determine the efficiency of these boilers we used the apparatus called Combustion Analyzer, and the measured data from the exhausted flue gas in the stack is illustrated in table 3.6.

Table (3.6): Boilers flue gas data measured at university faculties

	Faculty of Engineering		Faculties of Science, IT and Optometry			Faculty of Fine Arts	Faculty of Pharmacy
	Boiler 1	Boiler 2	Boiler 1	Boiler 2	Boiler 3	Boiler	Boiler
Temperature (^oF)	413	304	260	252	224	386	264
O_2%	6.9	4.4	4	9.1	7.4	10.9	6.2
CO_2%	10	12.3	8.2	7.7	9.8	6.5	11
CO%	9	2	6	2	52	8	4
Excess air %	45	24	21	72	49	98	39
Losses%	15.8	4.6	10.6	12.2	10.5	18.8	11.5
NO_x (ppm)	60	85	99	60	68	40	65
SO_x (ppm)	0	0	0	0	0	0	0
Efficiency %	84.2	88.4	89.4	87.8	89.5	81.2	88.5

3.4.5.2 HVAC distribution system

The university faculties uses an electrical chillers for space cooling in some areas, these chillers consists of an indoor unit and an outdoor unit, the outdoor unit contains a compressor, condenser, fans, and motors; the indoor unit consists of an evaporator and a flow control device, the chillers specifications are illustrated in tables 3.7, and 3.8.

Table (3.7) Chillers nameplate

Faculty of Engineering						
Compressor Motor	**Qty**	**Volt**	**Hz**	**Ph**	**LRA.EA**	**Amp.EA**
	4	380	50	3	130	29
Condition Fan Motor	**Qty**	**Volt**	**Hz**	**Ph**	**kW.Ea**	**FLA.EA**
	2	380	50	3	11	3
Coil Test Pressure	450 Psig					
Refrigerant	R-22					
Faculties of Science, IT and Optometry						
Compressor Motor	**Qty**	**Volt**	**Hz**	**Ph**	**LRA.EA**	**Amp.EA**
	1	380	50	3	145	32
Condition Fan Motor	**Qty**	**Volt**	**Hz**	**Ph**	**kW.Ea**	**FLA.EA**
	1	380	50	3	75	2 3
Coil Test Pressure	450 Psig					
Refrigerant	R-22					
Faculties of Pharmacy and Medicine						
Compressor Motor	**Qty**	**Volt**	**Hz**	**Ph**	**LRA.EA**	**Amp.EA**
	3	380	50	3	145	32
Condition Fan Motor	**Qty**	**Volt**	**Hz**	**Ph**	**kW.Ea**	**FLA.EA**
	2	380	50	3	11	3
Coil Test Pressure	450 Psig					
Refrigerant	R-22					

Table (3.8) Chillers nameplate (other types)

Chiller specifications	Faculties of Pharmacy and Medicine	Faculties of Fine Arts, Graduate Studies and Law
Model	HAE 251	PH 100
V / Ph / Hz	400 / 3 / 50	400 / 3 / 50
Max Absorption	44	322
Power	27 kW	187 kW
Refrigerant	R-22	R-22
Refrigerant Pressure	26 BAR	28 BAR
Water Pressure	6 Bar	10 Bar
Water Temperature	65 ºC	90 ºC

3.4.5.3 Power factor improvement

The average power factor measured by Energy Analyzer for one week was 0.96, for all faculties of the university. Thus, there is no required action for power factor improvement. Figure 3.8, 3.9, 3.10, and 3.11 illustrates the existed average power factor for each faculty, referred to appendix 3

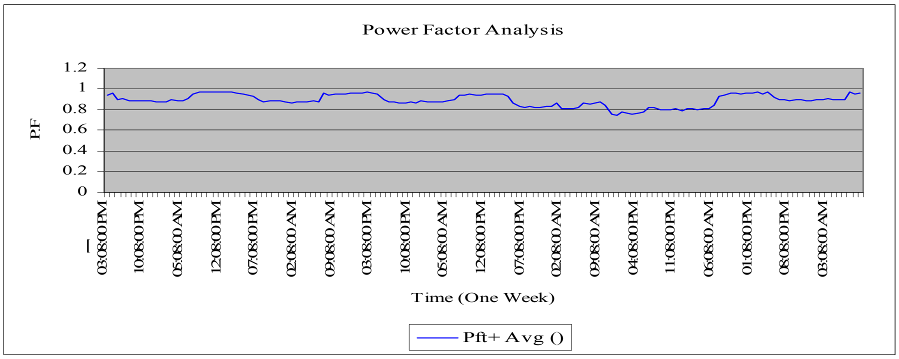


Figure (3.8): Average power factor measured at the Engineering faculty

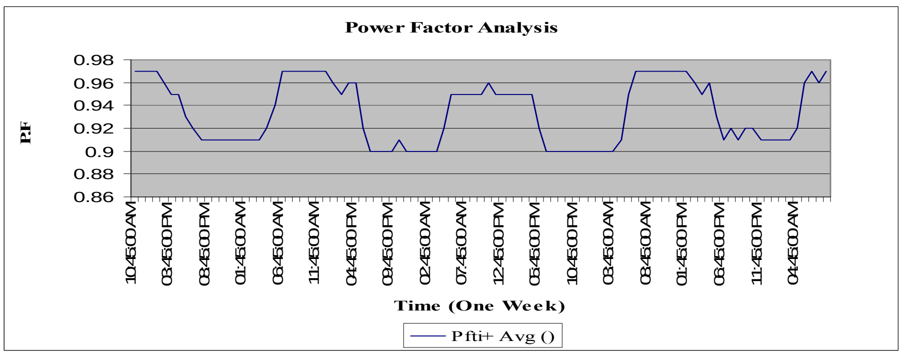


Figure (3.9): Average power factor measured at the Science faculty

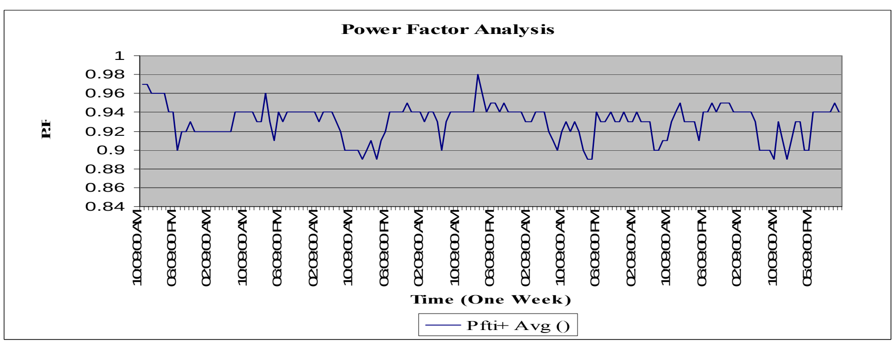


Figure (3.10): Average power factor measured at the Fine Arts faculty

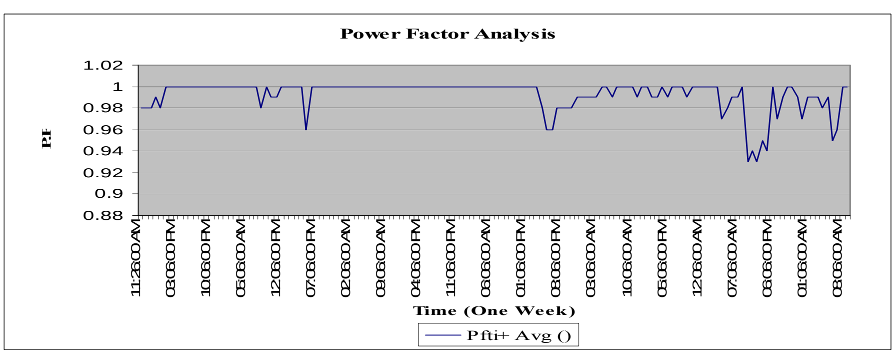


Figure (3.11): Average power factor measured at the Pharmacy faculty

3.4.5.4 Lighting system

A lighting system is an integral part of a building's architectural design, and interacts with the shape of each room, its furnishings, and the level of natural light. There is great potential for saving electricity, reducing the emission of greenhouse gases associated with electricity production, and reducing consumer energy costs through the use of more efficient lighting technologies as well as advanced lighting design practices.

Lighting averages 45% of the university building's total electrical demand. Lighting at the university according to the measurements taken by the Extech Data logging light meter, and comparing them with the standards (appendix 1) are very excessive in many areas. Appendix 2 illustrates the existing lighting system, the luminance in each area in the university, and the recommended conditions for each area are also presented.

CHAPTER FOUR

ENERGY AUDIT IN DIFFERENT FACULTIES OF THE UNIVERSITY

Chapter Four

Energy Audit in Different Faculties of the University

4.1 Introduction

As mentioned in the previous chapter, four faculties were audited and analyzed in this study. The data were collected using measurement instrumentation and through effective estimation based on sound engineering judgment.

The measurements instruments used for measuring and collecting data were:

- The energy analyzer equipment: It was installed on each electrical board of the facility for power measurements and energy consumed and for determination of the power factor.
- Combustion analyzer equipment: It was used on the boiler's chimney for determination of the combustion efficiency, excess air percentage, flue gas temperature, O_2 and CO_2.
- Thermometer: For temperatures measurement.
- Lux meter: For lighting illumination measurements.

Evaluation of alternative energy conservation measures based on the evaluation of energy use pattern of the buildings, several energy conservation measures (ECMs) were analyzed. Energy conservation measures were studied in different energy systems; lighting system, cooling system, and heating system. Also they were classified into the three categories of:

- No cost measures (low return): These are measures that can be implemented through operational and behavioral means without the need for system or building alterations and, therefore, do not require extra cost for their implementation.

- Low cost measures (medium return): These are measures that can be implemented for building alterations or modifications and thus, extra but low cost is required for their implementation.

- Major investment measures (high return): These measures require major financial investment for their implementation. They can be implemented through system renovation or retrofitting to the building or for new similar projects.

4.2 Heating System Saving Opportunities

A large fraction of a facility's total energy usage begins in the boiler plant. The cost of boiler fuel is typically the largest energy cost of a facility, or the second largest. For this reason, a relatively small efficiency improvement in the boiler plant may produce greater overall savings than much larger efficiency improvements in individual end users of energy. Also, most boiler plants offer significant opportunities for improving efficiency [17].

The main efficiency measures is to reduce boiler excess air. Excess air is the extra air supplied to the burner beyond the air required for complete combustion. Excess air is supplied to the burner because a boiler firing without sufficient air or "fuel rich" is operating in a potentially dangerous condition. Therefore, excess air is supplied to the burner to provide a safety factor above the actual air required for combustion.

The more air is used to burn the fuel, the more heat is wasted in heating this air rather than in producing steam. Air slightly in excess of the ideal stochiometric fuel/air ratio is required for safety, and to reduce NOx emissions, but approximately 15% is adequate [17]. Poorly maintained boilers can have up to 140% excess air, but this is rare. Reducing this boiler back down to 15% even without continuous automatic monitoring would save 8% of total fuel use. A rule of thumb often used is that boiler efficiency can be increased by 1% for each 15% reduction in excess air or 40°F (22°C) reduction in stack gas temperature [17].

The apparatus used to measure the boilers combustion efficiency was "Combustion Analyzer" as mentioned before, in tables 3.6. The boiler efficiency and excess air before and after controlling the excess air are illustrated in tables 4.1, 4.2, 4.3, and 4.4:

Table (4.1): Excess air and efficiency for the faculty of Engineering boilers

Engineering faculty	Before controlling	After controlling
Boiler (1)		
Excess Air (%)	45	11
Efficiency (%)	84.2	87.2
Boiler (2)		
Excess Air (%)	24	10
Efficiency (%)	88.4	89.2

Table (4.2): Excess air and efficiency for the faculty of Science boilers

Science faculty	Before controlling	After controlling
Boiler (1)		
Excess Air (%)	21	10
Efficiency (%)	89.4	90.4
Boiler (2)		
Excess Air (%)	72	12
Efficiency (%)	87.8	90.1
Boiler (3)		
Excess Air (%)	49	11
Efficiency (%)	89.5	91

Table (4.3): Excess air and efficiency for the faculty of Fine Arts boilers

Fine Arts faculty	Before controlling	After controlling
Boiler		
Excess Air (%)	98	13
Efficiency (%)	81.2	87.5

Table (4.4): Excess air and efficiency for the faculty of Pharmacy boilers

Pharmacy faculty	Before controlling	After controlling
Boiler		
Excess Air (%)	39	10
Efficiency (%)	88.5	89.9

Figure 4.4 support the previous tests, and shows the relation between the percent of the flue gas oxygen, the percent of excess air and the combustion efficiency.

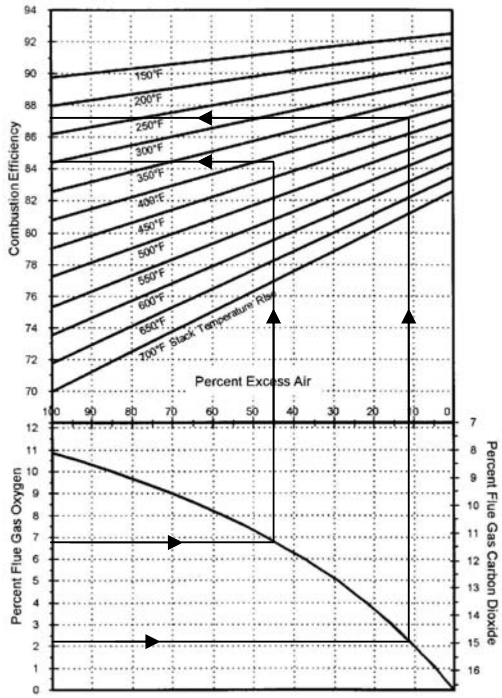


Figure (4.1): Combustion efficiency chart for #6 fuel oil

To compute the saving achieved by this efficiency improvement, the fuel consumption should be known, based on the faculties diesel bills the yearly consumption cost is known, then the next equation could be used to estimate the saving:

$$\textbf{Saving} = \textbf{k} \times [1- (\eta_{\text{before}} / \eta_{\text{after}})] \quad \text{......................4.1}$$

Where:

k = annual fuel usage by boiler, liters/yr.

η_1 = combustion efficiency before improvement.

η_2 = combustion efficiency after improvement.

So by using equation 4.1, and taking the engineering faculty as an example to compute the saving we obtain that:

Saving = $k \times [1- (\eta_{\text{before}} / \eta_{\text{after}})]$

$= 36,000 \times [1- (84.2 /87.2)]$

$= 36,000 \times (0.0344)$

= 1,238.4 (liters/year).

Knowing that each liter of diesel costs 5.5 NIS of energy, and approximately 10.5 kWh, we can compute the saving in (NIS/year), (kWh/year) respectively.

Saving in NIS/year = 1,238.4 Liter × 5.5 (NIS/Liter)

= 6,811.2 (NIS/year)

By applying the previous equation on the other boiler in the engineering faculty we can achieve additional saving equal to 1,775.78 NIS, so the total saving are:

8,586.98 (NIS/year)

Applying the previous scenario, and by using equation 4.1, we can calculate the saving in the other faculties.

Table (4.5) Boilers saving for the university faculties

Faculty	Saving (kWh/year)	Saving (NIS/year)
Engineering	16,393.3	8,586.98
Pharmacy	5,886.6	3,083.45
Fine Arts	30,618	16,038
Science	25,076.8	13,135.46
Total	**77,974.7**	**40,843.89**

4.3 Cooling System Saving Opportunities

The space cooling system in the university works by electrical energy; it covers about half of the total volume.

The energy consumption by this system could be estimated by taking the total load for each faculty multiply by the total hours operating in the summer season.

Total load = 36 unit × 1.8 kW + 1 chiller × 10.5 kW = 75 kW

In diagnostic phase it was noticed that the temperature of the chiller were set on 9^{o}C and it's too low, in the other hand the temperature of the cooled space were about 21^{o}C, this means that there is a large amount of air leakage in the building because of opened windows or doors.

Saving could be achieved by increasing the temperature that the chiller is set on, percentage of saving is calculated as follows:

$$\text{Percentage saving} = [(T_{out} - T_{existing}) - (T_{out} - T_{suggested})]/(T_{out} - T_{existing}) \quad \ldots 4.2$$

Where:

T_{out}: before cooling the space (30 ^{o}C)

$T_{existing}$: the temperature in the room (21 ^{o}C)

$T_{suggested}$: suggested room temperature (24 ^{o}C)

Percentage saving = [(30 – 21) – (30 – 24)] / (30 – 21)

= 33%

Energy consumption saving = 0.33 × 75 kW × 600 h/year

= 14,850 (kWh/year)

Cost reduction = 0.73 × 14,850 = 10,840.5 (NIS/year)

Table (4.6): HVAC saving for the university faculties

Faculty	Saving (kWh/year)	Saving (NIS/year)
Engineering	14,850	10,840.5
Pharmacy	19,764	14,427.7
Fine Arts	23,490	17,147.7
Science	31,135	22,728.5
Total	**89,239**	**65,144.4**

This energy saving opportunity is very attractive because it could be done without any initial investment cost, and the SPBP is immediately.

4.4 Lighting System Saving Opportunities

By having an understanding of the lamps, ballasts, fixtures and control option available today as well as the techniques used to develop efficient lighting. Lighting can be produced that is energy efficient cost effective and yields a higher quality of light. Improvements in lighting efficiency can be obtained in the following areas:

ECM # 1: Extra-lamps removal (no cost measure)

According to illumination measurements shown in Appendix 2, it was found that values, which were measured at some areas, exceeds the standard illumination required for the certain areas or places as shown in Appendix 1. So removing extra lamps is recommended for the areas specified in Appendix 2.

In order to calculate the optimum number of fixtures and reducing the number of excessive lamps equation 4.3 was used:

$$N = \frac{E \times A}{n \times \Phi \times K_u \times K_m} \quad \ldots\ldots\ldots\ldots\ldots\ldots 4.3$$

Where:

N: number of units, E: illumination lm/m² (lux), A: area in m², n: number of lamps in the unit, Φ: luminous flux in lumen, K_u: reflectance factor , and K_m: maintenance factor.

Table 4.7 illustrates the annual energy saving achieved upon the removal of the lamps specified in Appendix 2.

Table (4.7): Annual energy saving achieved upon lamps removal specified in appendix 2

Lamp type	# of lamps	Saved demand kW	Saved energy (kWh)
Fluorescent	4677	110.939	157,418

With reference to Appendix 2, it is expected to achieve an annual energy saving of approximately 157,418 KWh upon removal of the specified lamps. The corresponding savings in electricity bills are calculated as shown in table 4.8, knowing that lamp removal doesn't incur any costs from the university:

Table (4.8): Annual cost saving achieved upon lamps removal specified in appendix 2

Energy saving	Electric tariff	Total saving in electricity bill	Investment	S.P.B.P
157,418 kWh/year	0.73 NIS/kWh	114,915 NIS/year	0	Immediate

ECM # 2: Installing reflectors in lamp fixture (medium cost measure)

Reflectors are mirror-like devices that can be mounted inside existing fluorescent fixture to direct light out of the fixture more efficiently. These reflectors approximately double the light output of the lamp fixture. By installing reflectors in the fixtures, one lamp in every two lamp fixture can be disconnected [19].

Reducing the number of lamps will not appreciably decrease the light levels in the university. Ballast consumes energy whether the lamps are working or not, reducing the number of lamps by installing reflectors this will reduce the number of ballast used.

Table 4.9 showing the energy savings results when installing reflectors. The following formula is used to calculate the energy used (kWh/year):

Energy used = [wattage from lamps] × [wattage from ballasts]

Energy used = (# of lamps × w/lamp × oper. hours/year)/1000 + 0.2 × (# of lamps × w/lamp × oper. hours/year)/1000....4.4 [18]

Table (4.9): Annual energy savings results when installing reflectors

Existing system						Recommended system			
Lamp type	watt	# of lamps	# of ballast	Oper time	Energy used kWh/y	# of lamps	# of ballast	Energy used kWh/y	Energy savings kWh/y
FL	36	2*1766	3532	1500	288,87	1*1766	1766	114437	114437

From table 4.9, it is expected to achieve an annual energy saving of approximately 114,437 kWh upon installing reflectors in lamp fixtures in specified lamps. The corresponding savings are calculated as shown in table 4.10.

Table (4.10): Annual cost saving achieved upon the installing reflectors in lamp fixtures in specified lamps

Energy saving	Electric tariff	Total saving in electricity bill	# of fixtures	Reflector cost	Investment	S.P.B.P
114,437 kWh/year	0.73 NIS/kWh	83,539 NIS/year	1766	100 NIS	176,600 NIS	2.1 Years

ECM # 3: Installing high-efficiency lamps and ballasts (medium cost measure)

The efficiency and output of fluorescent lamps varies depending on both the lamps itself and ballast installed. New ballast has been developed that has superior qualities over conventional wound choke ballast's (magnetic ballast).

Electronic ballast offer some advantages such as, 20-30% energy reduction compared with conventional ballast, 50% longer service life of lamps, net power factor of 95%-99%, reduction in weight, cool operation, eliminates the annoying problems of light flicker and noise and this lead to an improvement in the quality of lighting [18].

The high efficient lamps (HOT5), 24W offer some advantages such as, longer life time 20,000 hours, 10-40% more light output than standard T8 lamps, and 2,700 out put lumen [18].

This opportunity recommends that if the university starts to phase out inefficient lighting lamps and ballast by replacing the lamps that bum out with high efficiency lamps, also replacing the magnetic ballasts that burn out with electronic ballasts.

The power consumption by ballasts at the building can be reduced by 8 watt per 2-lamp fixture. Each ballast serves one lamp (36w). And saves

12 watt by one lamp. Tables 4.11, 4.12 shows the annual energy savings results due to replacing the ballasts and lamps.

Table (4.11): Annual energy savings by installing high-efficiency electronic ballasts

Fixture type	# of fixtures	# of ballasts	Wattage reduction/ballast	Oper. hours/yr	Energy saved (kWh/yr)
Faculty of Engineering					
FL/36/2	906	453	4	1800	3,261.6
Faculties of Science, IT and Optometry					
FL/36/2	1,436	718	4	1800	5,169.6
Faculties of Fine Arts, Graduate Studies and Law					
FL/36/2	786	393	4	1800	2,829.6
Faculties of Pharmacy and Medicine					
FL/36/2	404	202	4	1800	1,454.4
Total Energy Saved					**12,715.2**

Table (4.12): Annual energy saving achieved upon the replacement of the specified lamps

Replaced lamp type	Replace with	# of Lamps	Saved demand kW	Annual operation hours	Saved energy (kWh/year)
FL 36 W	HOT5 24 W	1,766	21.192	1800	38,145.6

With reference to tables 4.11 and 4.112, it is expected to achieve an annual energy saving of 50,860.8 kWh upon installing high-efficiency electronic ballasts, and high efficiency lamps. The corresponding savings are calculated as shown in table 4.13.

Table (4.13): Annual cost saving achieved upon installing electronic ballasts, and high efficiency lamps

Energy saving	Total saving in electricity bill	Price difference (elec. Pallast - mag. Ballast)	Price difference (24W lamp -36W lamp)	Investment	S.P.B.P
50,860.8 kWh/y	37,128.4 NIS/year	(80-10) = 70 NIS	(15-5) = 10 NIS	141,280 NIS	3.8 years

ECM # 4: Domino Effect savings (no cost measure)

In addition to the direct savings that results from the previous ECO's; an additional saving occurs through reduced air-conditioning demand; lower wattage means less heat, so the air conditioning units do less work to cool the conditioned areas. The air conditioning savings have been called the Domino Effect; it can be calculated using the Rundquist Method [18].

According to our local climate and the operating time in the building the air conditioning is used only in summer season about 14 weeks per year.

$$\frac{14\text{ weeks}}{52\text{ weeks / year}} \times 100\% = 27\% \text{ of the year}$$

In this opportunity the air conditioned areas is computer labs, conference rooms, and head of department rooms, the Domino Effect Energy Savings (DE_{ES}) can be calculated in each of the previous ECO's as follows:

(DE_{ES}) = (Fraction of year in cooling season × 0.33× total energy saving from the previous ECO's in the conditioned areas)…...4.5 [18]

Table 4.14 shows the Domino Effect Energy Savings (DEES), for the conditioned areas that mentioned before.

Table (4.14): Domino Effect energy savings (DE_{ES})

Area #	ECO's	Energy saved kWh/yr	Fraction of cooling season	DE_{ES} kWh/yr
Faculty of Engineering				
G0030	ECO#1	9,690	0.27	863.379
Faculties of Science, IT and Optometry				
G360	ECO#1	7580.2	0.27	699.453
Faculties of Fine Arts, Graduate Studies and Law				
20	ECO#1	870.4	0.27	77.552
Faculties of Pharmacy and Medicine				
G0030	ECO#1	3,450	0.27	207.395
Total Energy Saved				**1,847.78**

From table 4.14, it is expected to achieve an annual energy saving of approximately 1,847.78 kWh upon Domino Effect Energy Savings (DE_{ES}). The corresponding savings are calculated as shown in table 4.15.

Table (4.15): Domino Effect cost savings (DE_{CS})

Energy saving	Electricity tariff	Total saving in electricity bill	Investment	S.P.B.P
1,847.78 kWh/year	0.73 NIS/kWh	1,348.88 NIS/year	0	Immediate

4.5 Summary of the Saving Opportunities

Table 4.16 illustrates the saving opportunities summary for An_Najah National University, that includes the annual saving in kWh, the annual cost saving, the annual Co_2 reduction, and the simple payback period for each energy conservation measure.

Table (4.16): Summary of the saving opportunities

Opportunity	Description	Energy saved (kWh/year)	Cost reduction (NIS/year)	Opportunity implementation cost (NIS)	Equivalent kg of CO_2 reduction	S.P.B.P
Boiler combustion efficiency	Increasing boiler combustion efficiency by controlling the amount of excess air.	77,974.7	40,843.89	No cost	84,212.67	Immediately
Space cooling system	Saving could be achieved by changing the temperature that the system is set on.	89,239	65,144.4	No cost	96,378.12	Immediately
Lamps removal	Saving could be achieved by removing unnecessary lamps.	157,418	114,915	No cost	170,011.44	Immediately
Lamp reflectors	Saving could be achieved by installing reflectors for fixtures.	114,437	83,539	176,600	123,591.96	2.1 years
High-Efficiency lamps and ballasts	Saving could be achieved by replacing old lamps with high efficient lamps, and magnetic ballasts with electronic ballasts.	50,860.8	37,128.4	141,280	54,929.66	3.8 years
Domino Effect	Saving could be achieved by reducing the air-conditioning demand.	1,847.78	1,348.88	No cost	1,995.60	Immediately
Total		**491,777.28**	**342,919.57**	**317,880**	**531,119.45**	

The energy cost before and after improvements which obtained from table 4.16 are illustrated in figure 4.2, also the percentage of energy saving for each energy conservation measures shown in figure 4.3.

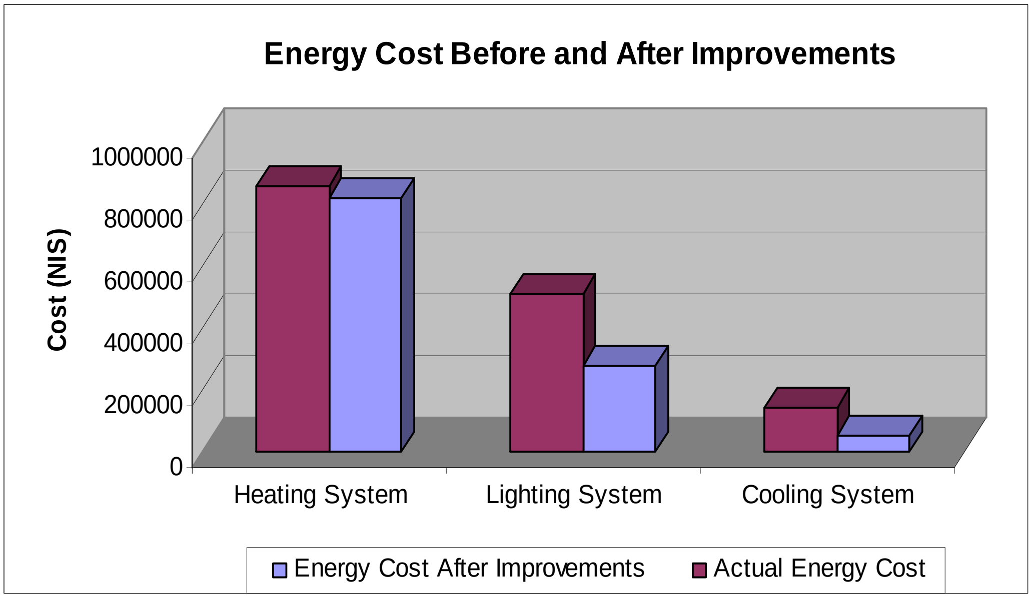


Figure (4.2): Energy cost before and after improvements

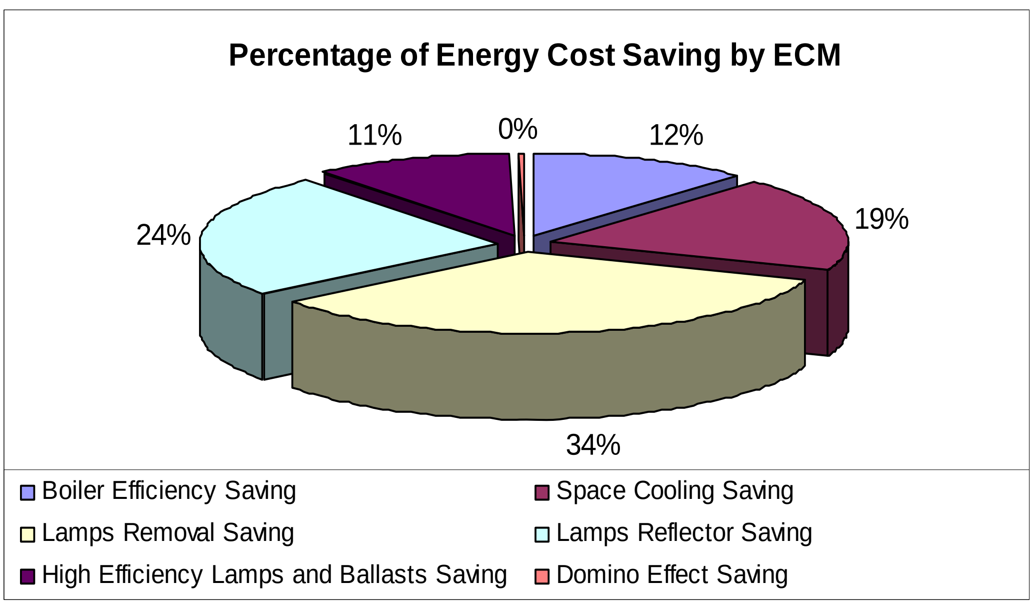


Figure (4.3): Percentage of energy cost saving by ECM

CHAPTER FIVE

ENERGY CONSERVATION SOFTWARE DEVELOPMENT

Chapter Five
Energy Conservation Software Development

5.1 Introduction

In the previous chapter, we had illustrated the methods employed in energy conservation, transforming them into mathematical models, which used to find the total energy saving from each opportunity in our study, and crowning that in this chapter, by designing a software in which all energy conservation calculations are accomplished on universities or any other facilities, printing the outcome in specific tables, with each study per se, in addition to a list of final consequences that indicates all forms of energy saving in our study.

Utilizing the computer softwares instead of manual calculations has numerous beneficial effects, including:

- Tabulating large quantities of energy use data.
- Minimizes calculation errors.
- Provides reliable and neatly organized data for use in analysis and post-retrofit troubleshooting.
- Pro-rating the data so as to provide calendar-month consumption figures (as opposed to varying-length billing periods).
- Showing recent trends in energy use accounting for savings achieved by an energy retrofit program, including documenting and adjusting for the effects of weather and other independent variables.

5.2 Software Components

The energy conservation software in universities, includes a set of partial programs to certain study cases illustrated in chapter four. It includes lighting, air-conditioning, improving the power factor, raise the boilers efficiency and recover the expense of capital. The main data screen is shown in figure 5.1.

Figure (5.1): Energy management program main data screen display

The list design block diagram of the main data screen display is shown in figure 5.2. Since they are available in the user interface for choosing any process to be implemented. It is needless to say that it is not crucial to process all the cases in each study. On the contrary we could choose any case study independently according to subject matter.

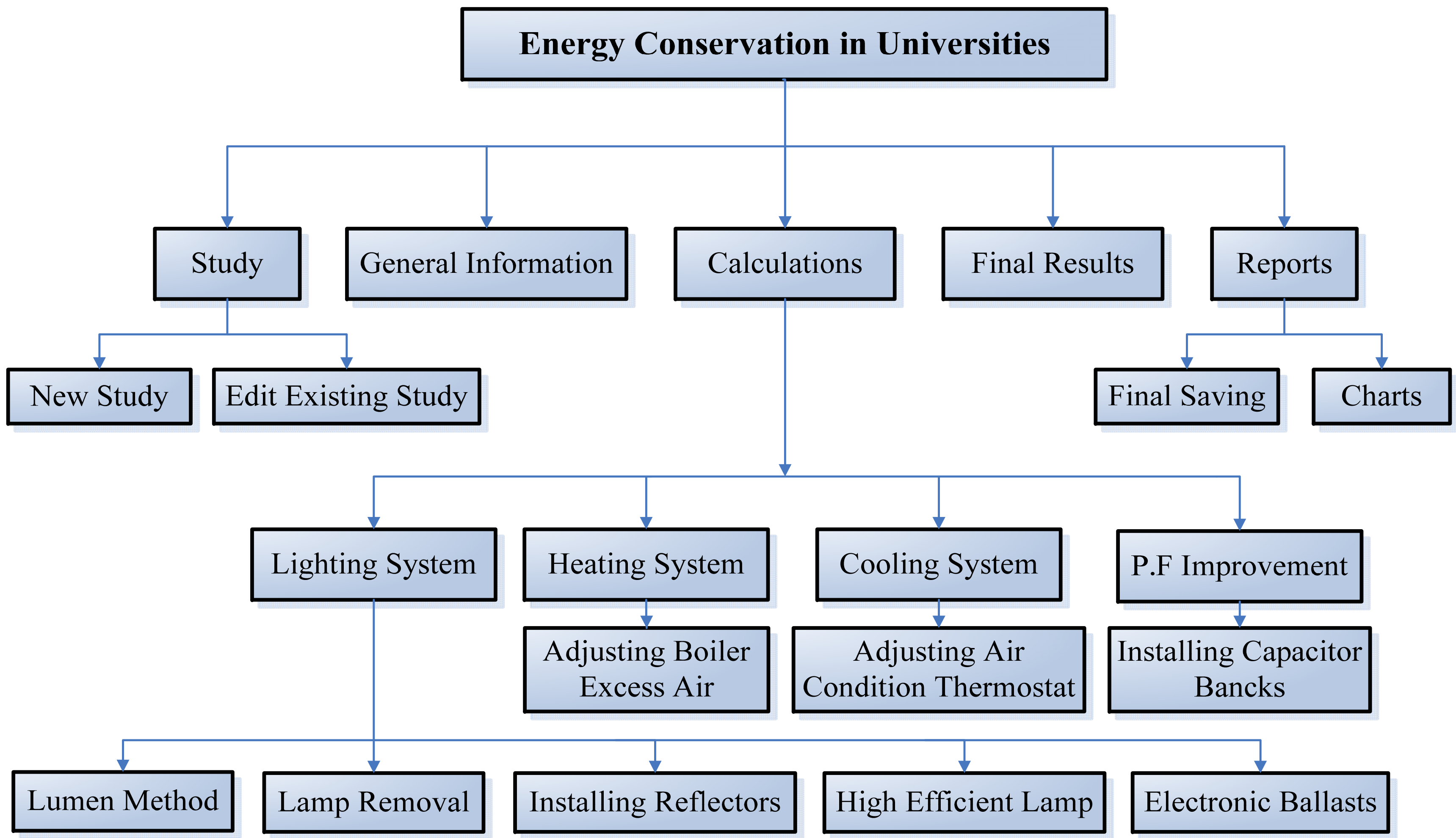


Figure (5.2): Block diagram of the main data screen display

5.3 Software Language

In designing and programming this software we use Microsoft Office Excel 2007, which is one of the strongest softwares, used to create and format spreadsheets, analyze and share information to make more informed decisions. With the Microsoft Office Fluent user interface, rich data visualization, and Pivot table views, professional-looking charts are easier to create and use.

Microsoft Office Excel 2007, combined with Excel Services, a new technology provides significant improvements for sharing data with greater security. We can share sensitive information more broadly with enhanced security with other partners. By sharing a spreadsheet using Office Excel 2007 and Excel Services, we can navigate, sort, filter, input parameters, and interact with Pivot table views directly on the web browser [20].

A valuable aspect of Excel is the ability to write code using the programming language Visual Basic for Applications (VBA). With this code any function or subroutine that can be set up in a Basic or like language can be run using input taken from the spreadsheet proper, and the results of the code are instantaneously written to the spreadsheet or displayed on charts [20].

5.4 Energy Conservation Measures Flow Charts

We are going to transform the most important methods of energy conservation in universities which we illustrated in chapter four, into mathematical models to put its flow charts. so we can implement the case study on our facility and others in general.

We recall that the process of modeling on all issues that can be formulated in the form of mathematical calculations. There remains some issues that are on the suggestions and advice can be implemented purely administrative procedures. We note here that the method of modeling is to turn every issue into two parts, one containing various kinds of information available (nominal, measured, extracted from the tables, and virtual), and the second contains the accounts according to the model mathematical formulas for each issue.

5.4.1 Lighting system (Lumen Method)

This method is based upon utilization factor, which is used to determine and calculate the number of fixtures necessary to achieve an average luminance. It is also a quick method to get an overview of the necessary number of fixtures in the room to have a good opportunity to reduce number of fixtures.

Lumen Method calculation input requirements:

- Physical characteristics of the room, including length, width, and height.
- Ceiling, wall, and floor reflectance's (% of light reflected by the room surface).
- Work plane height (i.e. desk height or height above the floor at which the visual work is to be performed).
- Distance from the work plane to the fixtures.

- Coefficient of utilization (Cu) of the fixtures: This value depends on the design of the fixtures and the characteristics of the space where the fixtures is located.

- Maintenance factor (Km): May be either recoverable due to maintenance of lighting system and room surfaces, lamp depreciation, ballasts factors, and thermal application effect. The overall of maintenance factor range from 0.65-0.85 for ballasted lighting systems and from 0.75-0.95 for most incandescent systems.

The flow chart of the lumen Method main function is shown in figure 5.3.

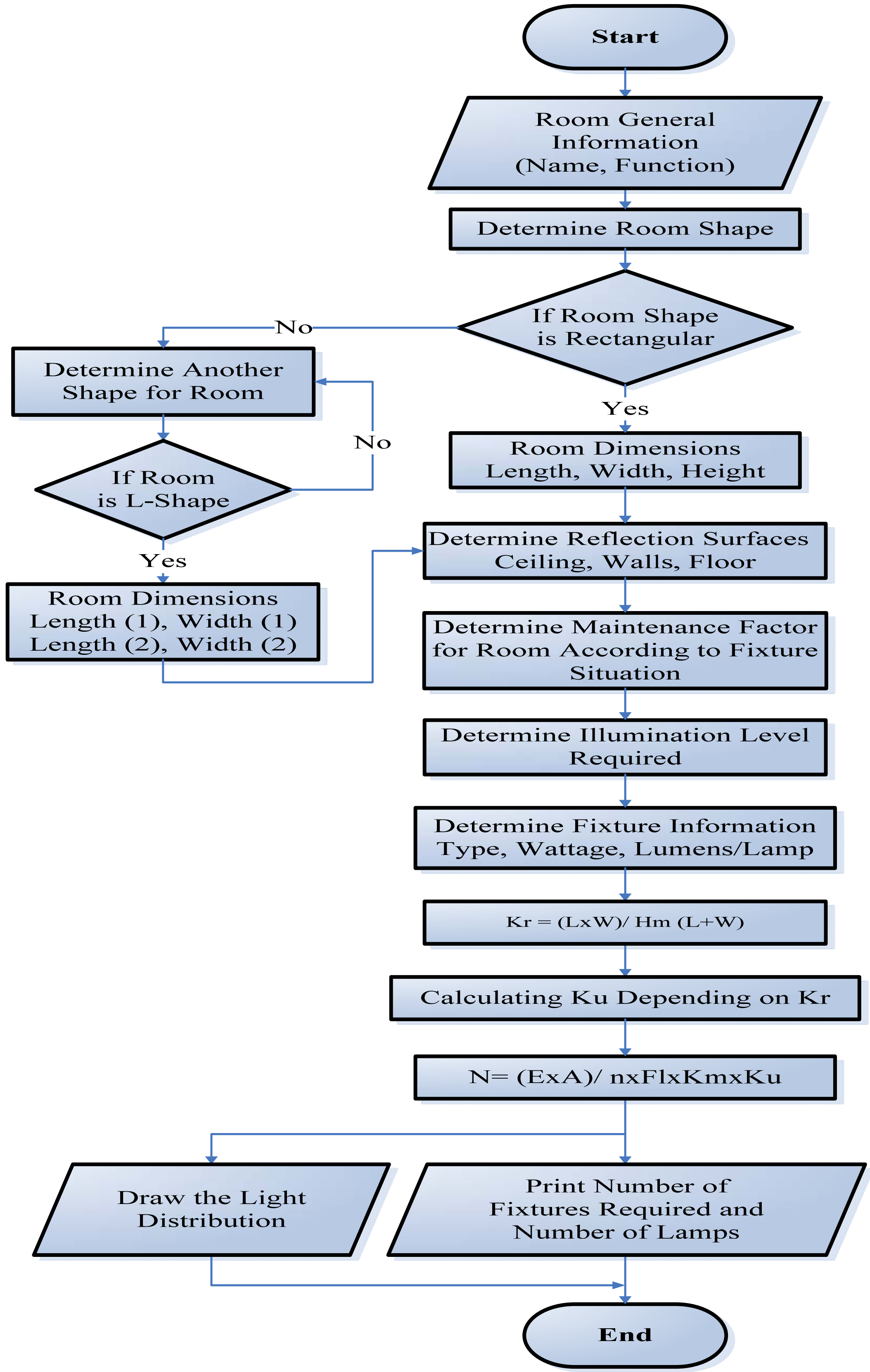


Figure (5.3): Flow chart of Lumen Method function

Also the Lighting Distribution is shown in figure 5.4.

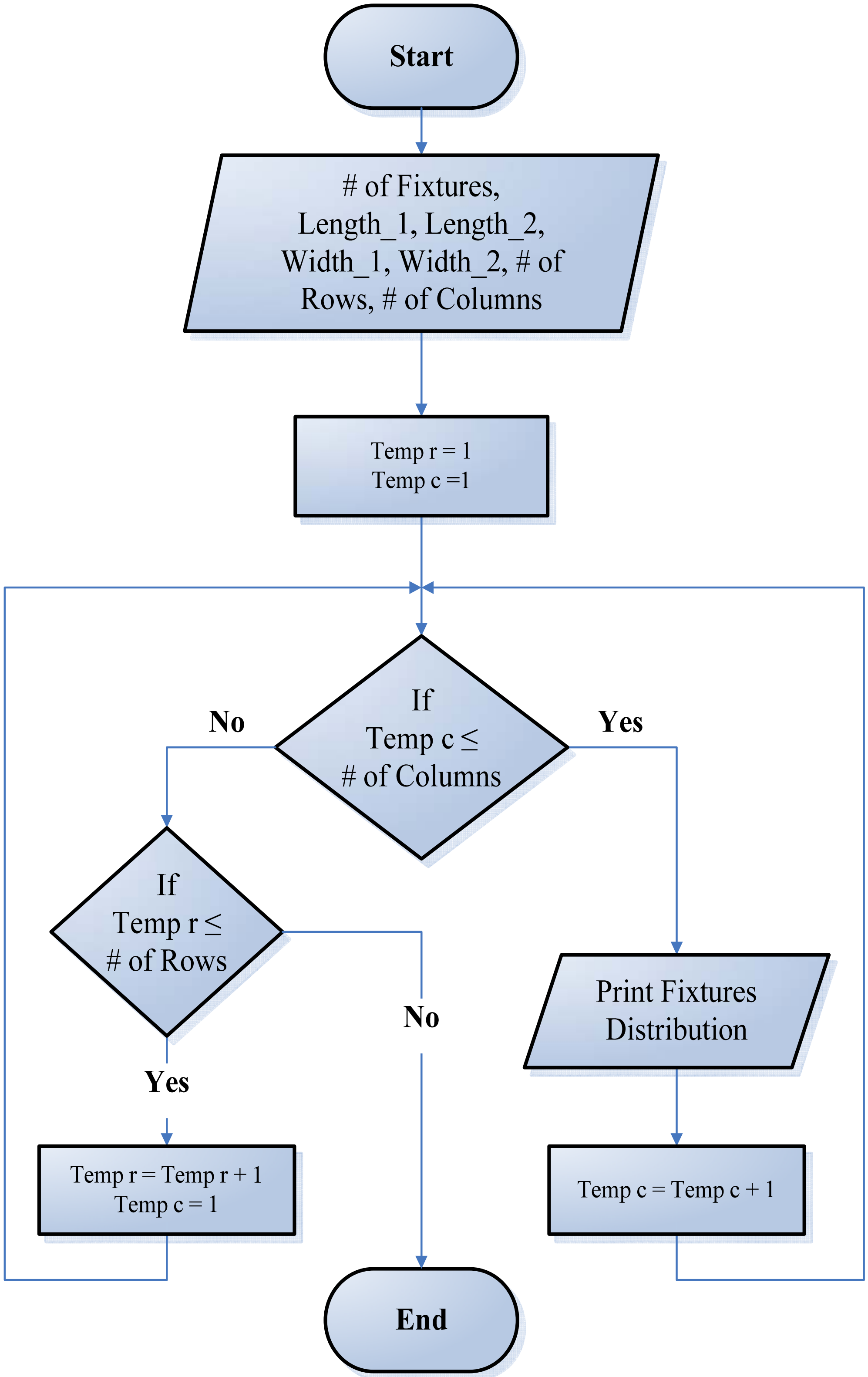


Figure (5.4): Flow chart of Lumen Method lighting distribution

5.4.2 Heating system

This method is based mainly upon the boiler efficiency and its fuel consumption. The measures used is controlling the excess air which is the most important tool for managing the energy efficiency and atmospheric emissions of a boiler system.

Heating system calculation input requirements:

- Physical characteristics of the building, including area, number of floors, floors area and height, and building envelop.
- Exterior doors and windows, types and orientation.
- Boilers annual fuel consumption, fuel type and price.
- Boiler stack gases characteristics, temperature, percent of oxygen and excess air, combustion efficiency and losses.
- Combustion efficiency after improvements (controlling excess air).

The flow chart of the heating system main function in figure 5.5, illustrates all steps required for calculating the saving and the simple payback period.

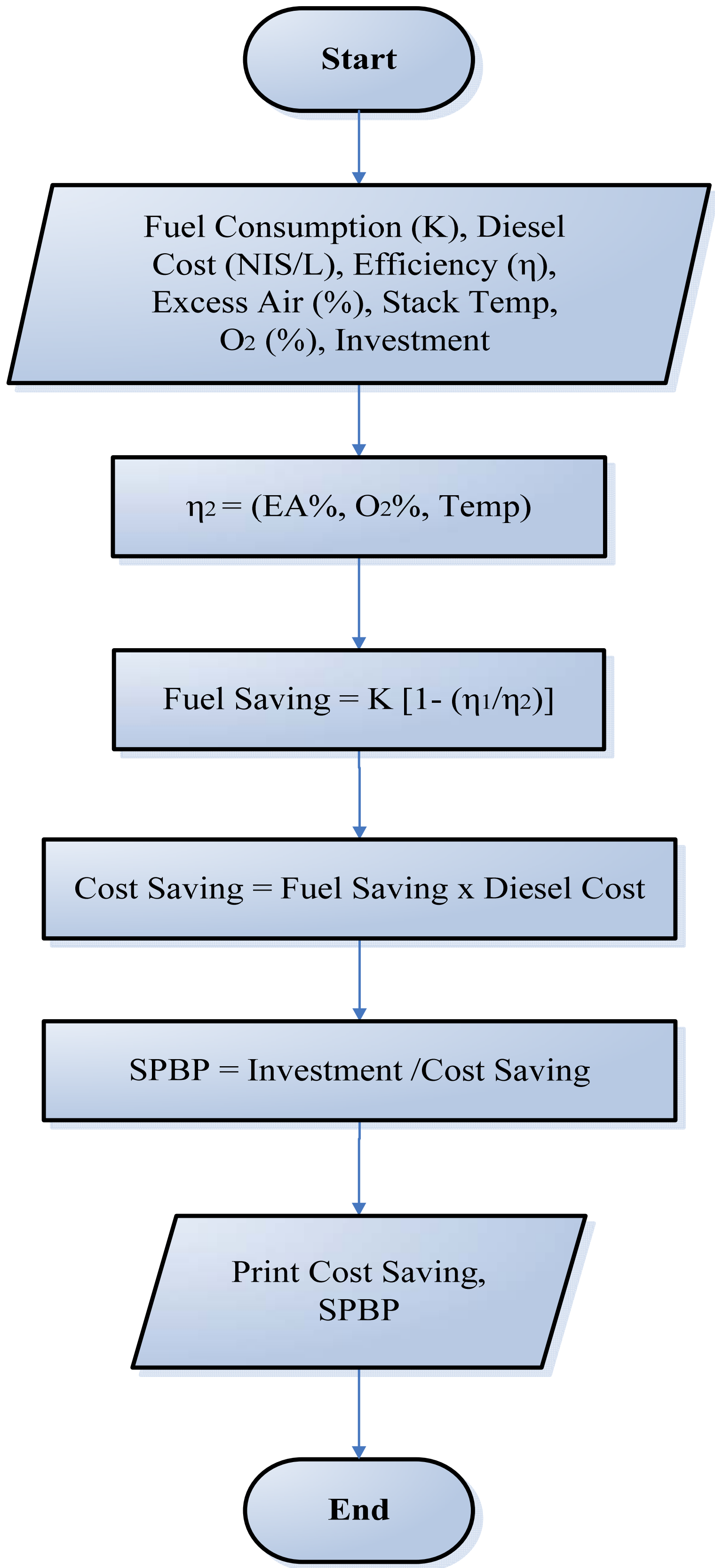


Figure (5.5): Flow chart of heating system function

5.4.3 Cooling system

This method is based upon the number of air conditions, chillers and their set point temperatures. The measures used is to controlling the set point temperature of the air condition and the chiller systems to suit the indoor climate, depending upon the ambient temperature, and the seasonal operation hours.

Cooling system calculation input requirements:

- Physical characteristics of the building, including area, number of floors, floors area and height, and building envelop.
- Exterior doors and windows, types and orientation.
- Number of Air conditions, chillers, and their rated power.
- Indoor, ambient, and set point temperatures .
- Seasonal operation hours .
- Electric tariff rate.

The flow chart of the cooling system main function in figure 5.6, illustrates all steps required for calculating the saving and the simple payback period.

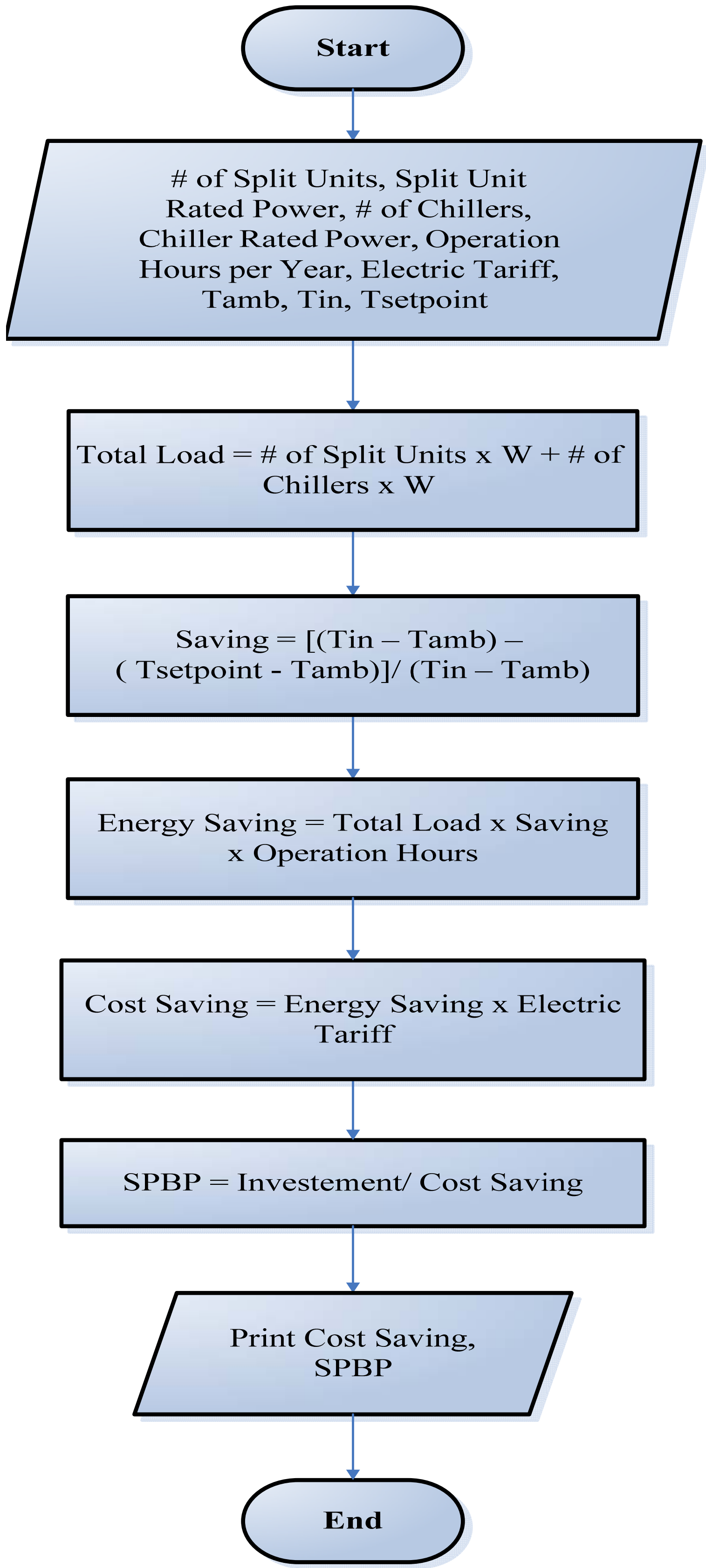


Figure (5.6): Flow chart of cooling system function

5.4.4 Power factor improvement

This method is based upon measuring power factor in the facility to make sure that is equal or more than 92%. Because low power factor is expensive and inefficient, and also reduces the electrical system's distribution capacity by increasing current flow and causing voltage drops.

Power factor improvement calculation input requirements:

- Total annual electrical energy consumption for the facility, and the maximum demand.
- The existing power factor of the facility.
- The price of 1 kVAR, and the electric tariff rate.
- The percentage of penalties depending on the existing power factor.
- The total investment of the required capacitor bank.

The flow chart of the power factor improvement main function in figure 5.7 illustrates how we can calculate the penalties due to low power factor. Saving and simple payback period will be display in the end of the process.

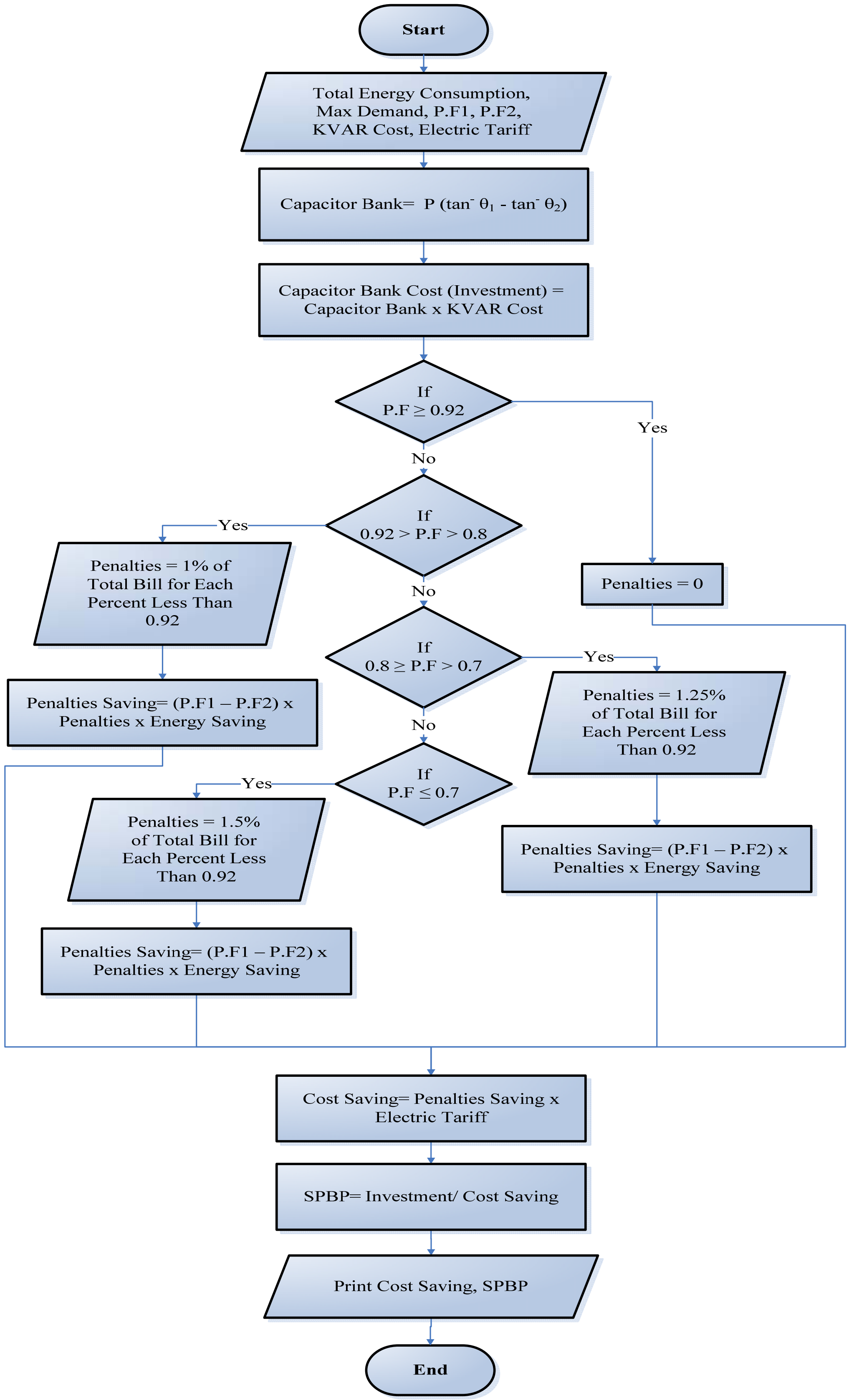


Figure (5.7): Flow chart of power factor function

5.5 Software Verification

Software verification is the process of ensuring that software being developed will satisfy functional and other requirements, and each step in the process of building the software yields the right results, this making sure that the software will function as required.

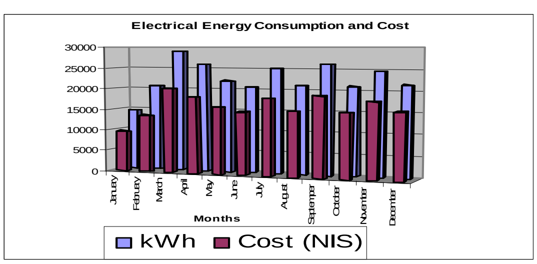
The information in our software is entered either directly into the spreadsheet cells or by selecting from pull-down menus. Once we fill in these basic inputs, we can generate a savings estimate and analysis for our building in a few seconds.

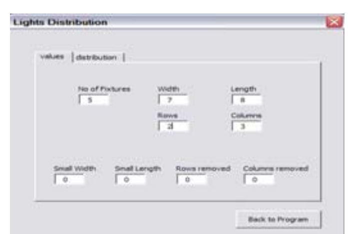
All the worksheets can be printed out as reports on the design and expected performance of our case study. Table 5.1 summarizes the energy characteristics and savings results from the Engineering faculty which is taken as an example of our study.

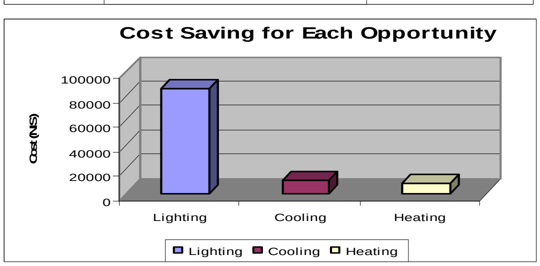
Table (5.1): Energy saving report

Name of Institution	An-Najah National University	Address	Nablus
Name of the Building	Faculty of Engineering	Building Area	12,795 m2
Electric Bill (kWh/year)	271,500	Electric Cost	194,291 (NIS)
Building Operation	0:08 Am to 0:16 Pm Sun-Wed		

Heating System					
Diesel Consump.(L/year)	36000	Combustion Efficiency Before		84.20%	88.40%
		Combustion Efficiency After		87.10%	89.20%
Total Saving (L/Year)	1,561.2	Cost Saving	8586.93 (NIS)	S.P.B.P	Immediate
Cooling System					
# of air-conditions	36	Rated Power	2 kW		
# of Chillers	1	Rated Power	11 kW		
Ambient Temperature	30	Operating Hours	600	S.P.B.P	Immediate
Indoor Temperature	21	Energy Saving	33%	Cost Saving	10,883.86
Setpoint Temperature	24	Energy Consumption Saving (kWh/year)			14,909.40
Lighting System					
Total No. of Lamps	3,914	Total Wattage	108.165 W	Consumption	17927 kWh
		LAMP REMOVAL			
# of Removed Lamps	1,381	Total Wattage	33.506 W	Consumption	51843 kWh
		Cost Saving	37,845 (NIS)	S.P.B.P	Immediate
		INSTALLING REFLECTORS			
# of Fixtures	110	Consumption	14256 kWh/y	Energy Saving	7128 kWh/y
		Investment	11000 (NIS)	S.P.B.P	2.1 Years
		HIGH EFFIECIENCY LAMPS & BALLASTS			
# of Ballasts	2072	Watt Reduction	8,288 W	Energy Saving	14,918 kWh
# of Lamps	2072	Watt Reduction	12 W/Lamp	Energy Saving	44,755 kWh
		Cost Reduction	43,561 (NIS)	Investment	176,120
		S.P.B.P	4 Years		
		LUMEN METHOD			
Room Function	Class	Room Area	56 m2	Illumination	300 Lux
Maintenance Factor	0.65	Lamp Lumen	3100 Lumen	Fixture height	2.3 m
No. of Lamps /Fixture	2	Utilization factor	0.72	No. of Fixtures	6







CHAPTER SIX

SYSTEM DEVELOPMENT AND ANALYSIS

Chapter Six
System Development and Analysis

6.1 Introduction

As demonstrated in chapter four, and affirmed by the software in chapter five, there is a huge potential of energy saving in An-Najah National University, specially in the lighting system, this led us to design an automatic light and management control system, to achieve the greatest possible saving that we could. This system consists of lighting panels and sensors that are distributed throughout a facility and tied together via a local-area network (LAN), and considered as apart of the energy management system (EMS).

An energy management system (EMS) is a multiprocessor control system that controls most or all of a facility's building equipment loads. Most building EMS's are able to control many (typically hundreds) of electric loads in a building, such as motors and HVAC equipment. These systems are very good for controlling many switching loads throughout a facility and for coordinating their day-to-day operation. Each switch is considered “one control point”. Systems are usually priced by the number of control points [21].

Since lighting systems are also loads in a building, many manufacturers have developed systems that manage energy functions for lighting systems. These lighting management systems (LMS) typically have similar capabilities to energy management systems, although their specific function is optimized for the operation of a large number of smaller lighting loads.

Nowadays, a building EMS will be attached to the facility's existing information technology (IT) network.

6.2 Methodology

Educational institutions and universities face some unique challenges in IT and network equipment management. Universities often have multiple data centers, labs, and equipment located across a campus in multiple buildings. In addition, there are often heating, cooling, security, and phone equipment which also needs to be managed. These diverse pieces of equipment can be in different locations around the faculty as well as at satellite campuses, but they are often managed by a central support organization. Figure 6.1 shows the faculties distribution of the campus and there relationship with each through the local area network (LAN).

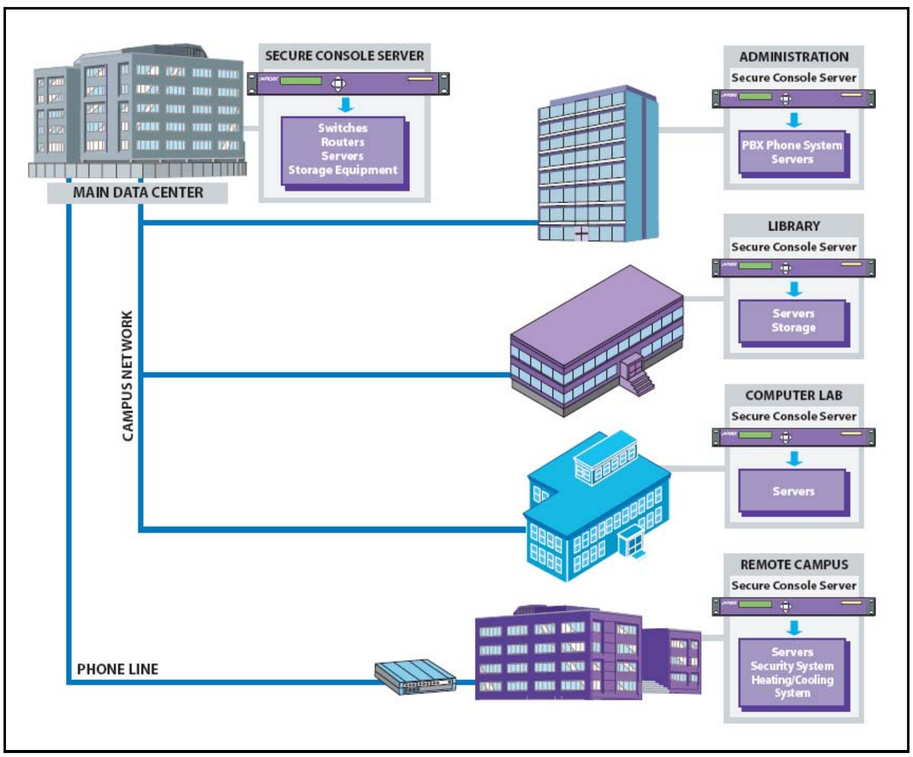


Figure (6.1): Faculties distribution of the campus through the network [26]

The buildings under consideration are located in the New Campus of An-Najah National University, In this study, we intend to design and implement an automatic light and management control system for the Engineering faculty building. The building was built in 2005. The total floor area of the building is $12{,}795m^2$. The building includes: teaching rooms, drawing rooms, labs, workshops and teacher's offices. It serves the different engineering departments; civil, architecture, mechanical, industrial, chemical, computer and electrical departments. The diversity of age, size, efficiency, and occupancy types for this building was intended to represent a typical cross section of the country’s educational building stock.

Rooms for study were contained manual controls for the lighting systems, with a minimum connected lighting load of at least 504 watts. A three-weeks monitoring period between September and October 2007 was chosen to represent a typical lighting and occupancy schedule. Data for 40 rooms were originally collected; after eliminating records with inconsistent or incomplete data, the study database contained 32 rooms categorized by primary occupancy type into 8 classrooms, 10 private offices, 6 drawing halls, 4 laboratories, and 4 W.C's. Rooms were surveyed for occupancy type, dimensions and lighting system specification. Occupancy and lighting operation data was collected using Extech Data logging light meter. The logger device recorded the time and state of the light and/or occupancy condition. Each time occupancy or the lighting condition changed, the logger documented the time of day and the change in condition. The data were downloaded to a computer and organized into consistent for data aggregation and analysis.

Descriptive statistics were calculated and cost analyses were performed for weekdays, weekends, and for the total 21-days monitoring period. weekdays were analyzed from 08:00am to 18:00pm. Data presented for weekdays were averaged over the 15 weekdays, and for weekends were averaged over the 6y weekends in the monitoring period. Data presented for the total period were averaged over the 21-days monitoring period. Baseline occupant switching and occupancy patterns were established using the collected data on occupancy and light usage. The baseline occupancy and light usage data were then used for modeling the effects of installing occupancy sensors with 5, 10, 15, and 20 minute time delay periods, as illustrated later in chapter 8.

Statistical analyses also were conducted to generalize the results of the measured data to the whole buildings in the university, as will seen later in chapter 8.

For the energy calculations, the total load for each room was used to determine lighting energy usage and waste. Lighting energy use was calculated by multiplying the total lighting load by the time that the lights were on and the room was occupied. Lighting energy waste was calculated by multiplying the total load by the time that the lights were on and the room was unoccupied. Total energy savings was determined by applying a flat rate (0.73 NIS/kWh) to the energy savings under each control scenario.

6.2.1 Total energy savings potential (baseline data)

Determining the basic energy savings potential across applications requires establishing a baseline of observed occupancy and lighting conditions. Lighting and occupancy use in any space will always fall into one of the following four conditions:

1. Occupied with the lights on

2. Occupied with the lights off

3. Unoccupied with the lights on

4. Unoccupied with the lights off

Of the four conditions, the first three are of particular interest. Condition one is of interest for gathering information about how frequently occupants use these types of spaces with the lights on. Conditions two and three are of interest when considering lighting controls. If occupants frequently occupy a space with the lights off (condition two), then a manual lighting control device that allows occupants to turn lights off when needed should be provided. Condition three represents wasted lighting energy by having lights on when spaces are unoccupied. This condition is of primary importance when considering using automatic occupancy sensor control. Table 6.1 lists the average percentage of time each application was in each of the four occupancy and lighting conditions.

Table (6.1): Average percentage of time each area was occupied with lights on and off, and unoccupied with lights on and off

	Occupied lights on	Occupied lights off	Unoccupied lights on	Unoccupied lights off
Classroom	52%	4%	32%	12%
Drawing Hall	46%	1%	26%	27%
Private Office	35%	8%	17%	40%
Laboratory	40%	3%	22%	35%
W.C	62%	0%	28%	10%

Table 6.1 illustrates that spaces were infrequently occupied, with the daily percentage of total occupied time with lights on and off never

exceeding 62%. Also, occupants did not diligently turn lights off when they vacated spaces. with the lighting system in drawing halls, private offices, and W.C's operating more often when the occupants were out of the room than in the room. This is intuitively understandable in such areas where occupants do not feel that the lighting is “theirs” to control. The data shown for condition 2 indicates that occupants rarely occupied spaces with the lights off, indicating that for these spaces there may be a small potential benefit of installing manual controls.

6.2.2 Time of day/week impacts on energy savings

Determining the applicability of occupancy sensors as a control strategy suitable to obtain these savings requires an examination of when those savings present themselves. As an automatic control strategy, occupancy sensors work best in areas where occupancy is intermittent and unpredictable.

Table (6.2): Average percentage of energy used and waste for weekdays and weekends

	Energy use (%)		Energy waste (%)	
	Weekdays	Weekends	Weekdays	Weekends
Classroom	80%	4%	30%	2%
Drawing Hall	70%	2%	23%	3%
Private Office	48%	6%	16%	1%
Laboratory	59%	3%	20%	2%
W.C	89%	1%	27%	1%

As expected, table 6.2 demonstrates that the majority of energy use (48-89%) occurs for all space types during the weekdays. Likewise, the majority of energy waste (16-30%) occurs during the weekdays, not on the weekends. This indicates that occupants controlled their lighting poorly during the workday, such as classrooms, where a high percentages of waste occurred over after hours. This indicates that occupancy-based controls would be more effective given they save not only after hours but also at capturing savings during working hours.

6.3 Scheduling Using EMS

With scheduling, a lighting control strategy best implemented by using building-level controls, lighting loads throughout a facility are turned on and off at appropriate times. The primary function of scheduling controls is to turn off lighting loads when the space is expected to be unoccupied (also called "sweep-off" control since lighting circuits are swept off at scheduled times).

Scheduling works well for large spaces where occupancy is predictable. For smaller zones and zones where occupancy patterns cannot be predicted ahead of time, occupancy sensors are a better solution. In large buildings (over 4,500 m^2) [22], scheduling is typically implemented using EMS type systems that are designed for large multizone building control. For small commercial buildings, there are compact programmable relay panel controls. In both large and small buildings, scheduling is typically implemented using latchable relays that are installed at the lighting circuit breaker panels.

The controllable relays are usually connected in series with the existing branch circuit wiring, which results in on/off control of entire lighting circuits. Since most lighting circuits in buildings are typically 30 amp breakers, each circuit breaker may control lighting power for between 200–450 m^2 of lighting [22]. Thus scheduling implemented with relays and lighting circuit breaker panels usually results in on/off control over large banks of lights. For new construction, it may be economical to apply the relays at a smaller level, that is, at the switch leg level. This provides a finer degree of control over the building lighting, but has greater installation costs because of the increased number of control points.

Figures 6.2 and 6.3, show how scheduling might be applied in large commercial buildings as required by ASHRAE Standard 90.1–1999.

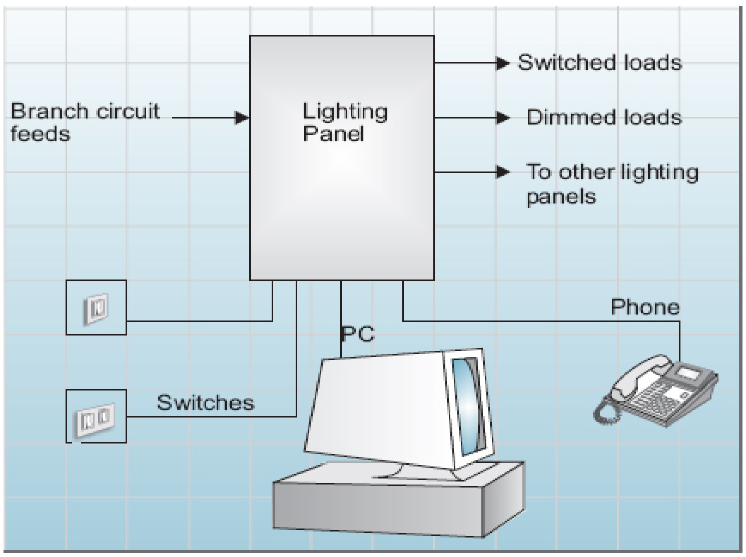


Figure (6.2): Circuit diagram for EMS-based scheduling, large building [22]

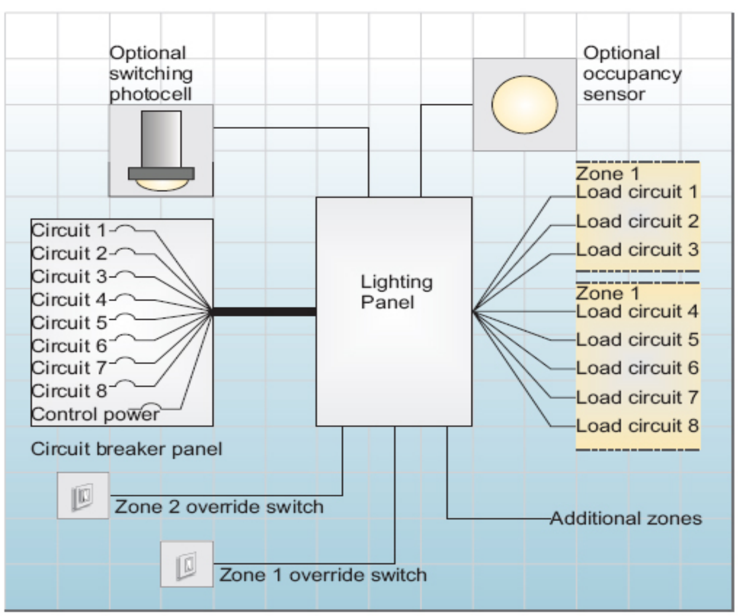


Figure (6.3): Circuit diagram for EMS-based scheduling, small building [22]

6.4 Implementation

There are two ways to implement integrated controls. The first method relies on assembling discrete components to form systems capable of executing more than one strategy. The second method uses multifunction controllers that may take inputs from several different sensors, including light sensors, occupancy sensors, and signals from energy management systems. Multifunction controllers represent state of the art in lighting controls.

A knowledgeable specifier can design a lighting control system that exploits more than one strategy. A simple example of this is the combination of occupant-sensing controls and daylight controls. Figure 6.4 shows how the different lighting control components would be wired together into the building's electrical system to provide both occupancy-based and light-sensing-based control. In this application, the photocell is connected to the low-voltage control that ties together the different ballasts serving the control zone, while the occupancy sensor merely interrupts the high-voltage power going to the lighting system [22].

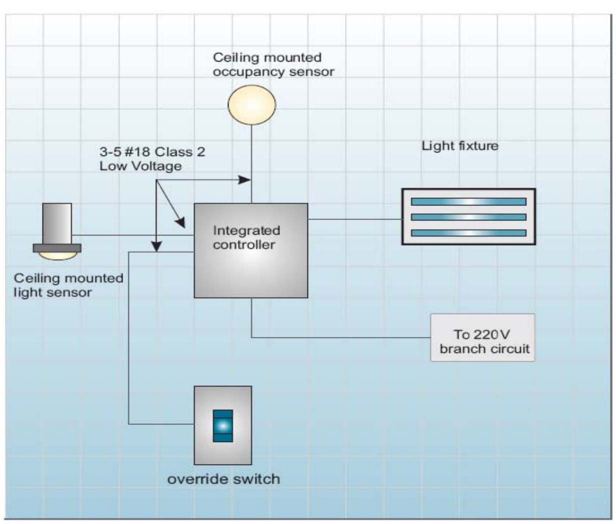


Figure (6.4): Wiring for combination occupancy and light sensors [22]

6.5 System schematic Diagram and Its Main Components

The schematic diagram shows, by means of graphic symbols, the electrical connections and functions of a specific circuit arrangement. It also used to trace the circuit and its functions without regard to the actual physical size, shape, or location of the component devices or parts.

Figure 6.5 shows the block diagram of the main components of our light management and control system (PIC16F877, RS232, XPort Direct+, ULN2003, power pack, and occupancy sensor). These components will discussed in details later in this chapter.

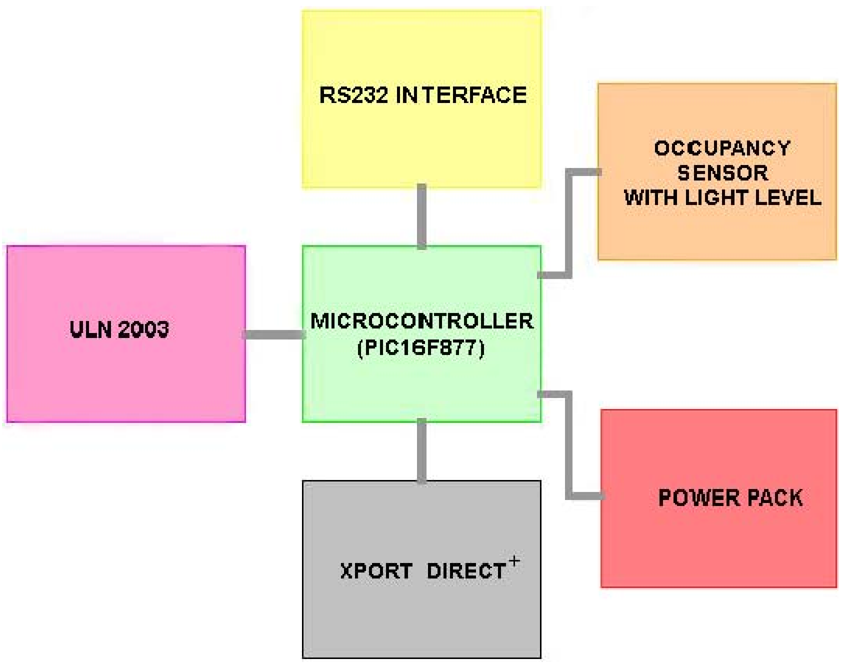


Figure (6.5): System block diagram

Figure 6.6 shows the schematic diagram of the lighting control board, which illustrates the main components of the lighting kit that we developed to replace with the Lantronix kit, which is needed to interface and configure the XPort. By designing this kit we avoided an extra cost that could be paid.

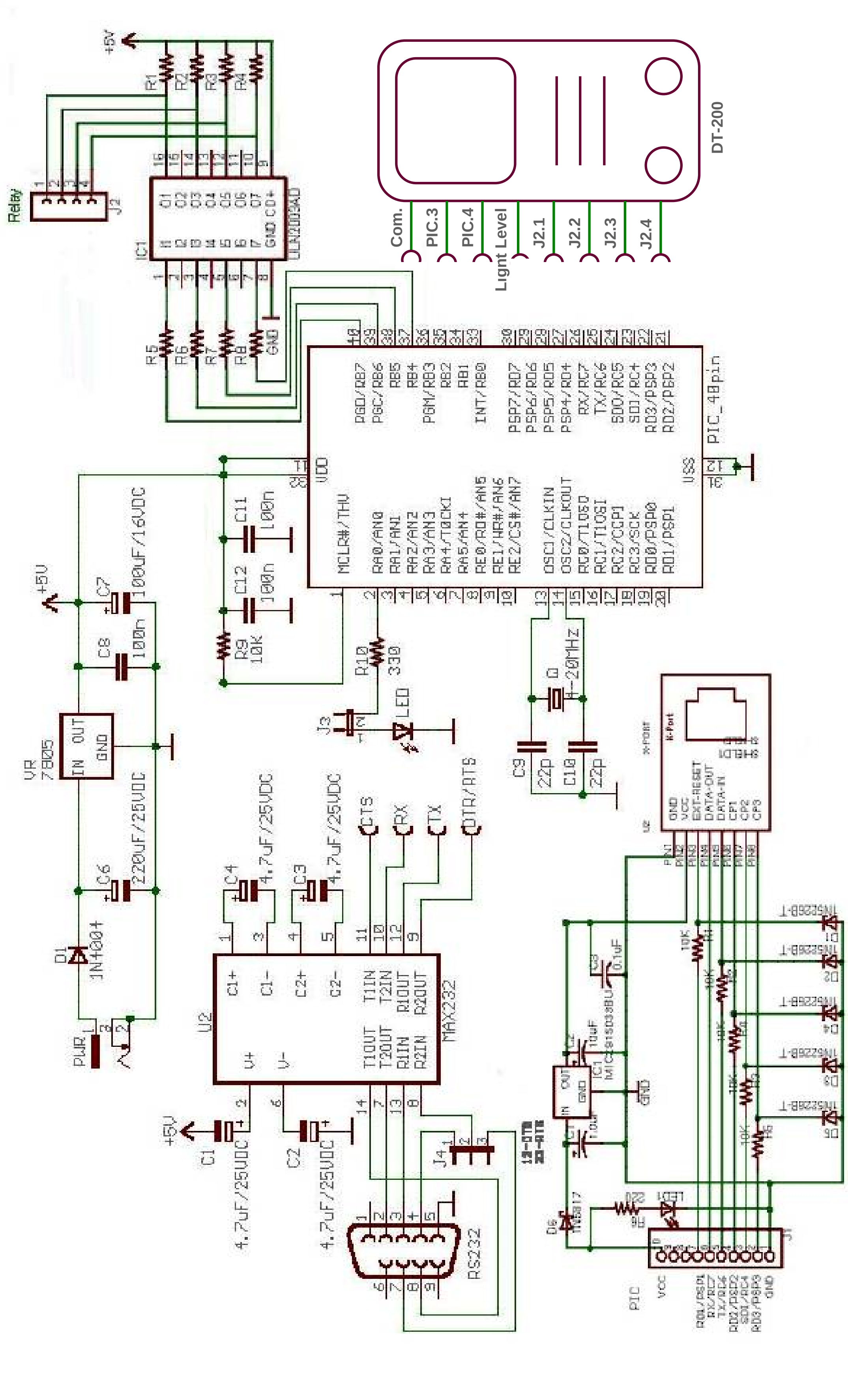


Figure (6.6): Lighting control board schematic diagram

The lighting control panel can be seen in figure 6.7 after the parts added.

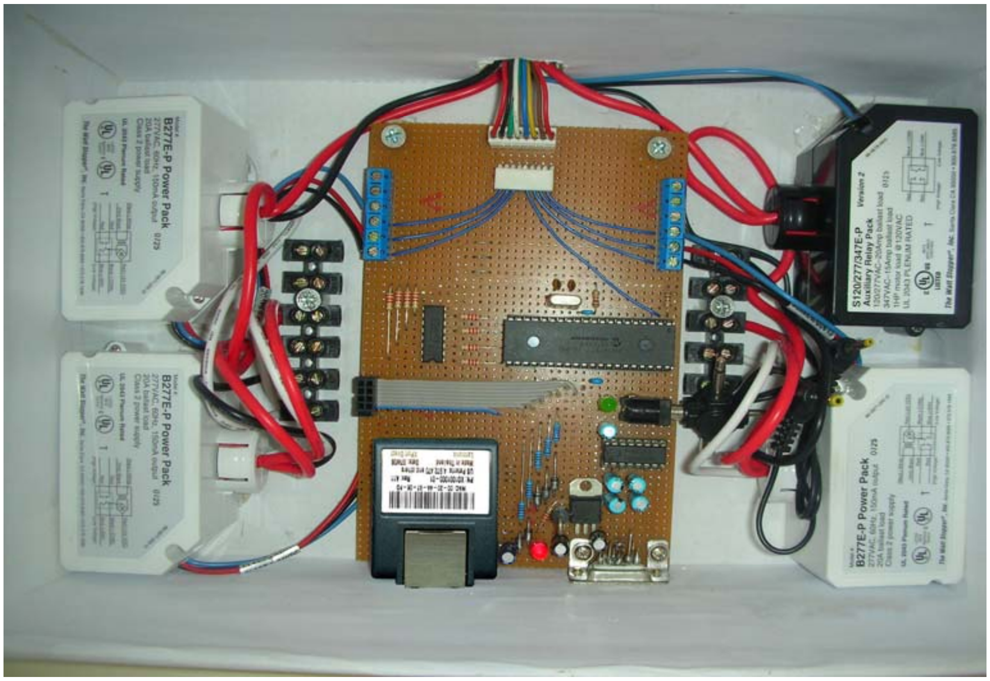


Figure (6.7): Lighting control panel

From the previous schematic diagram in figure 6.6, and the lighting control panel in figure 6.7, the main components of our system are:

- **Microcontroller PIC16F877:** Are general purpose microprocessors which have additional parts that allow them to control external devices. Basically, a microcontroller executes a user program which is loaded in its program memory. Under the control of this program, data is received from external devices (inputs), manipulated and then data is sent to external output devices [23].

Programmable interrupt Controlling chip is used in my system to be the interface between the computer and the hardware. The main reason for choosing 16F877 microcontroller is the need for larger number of input/output ports. In figure 6.8 the pin diagram of the PIC16F877.

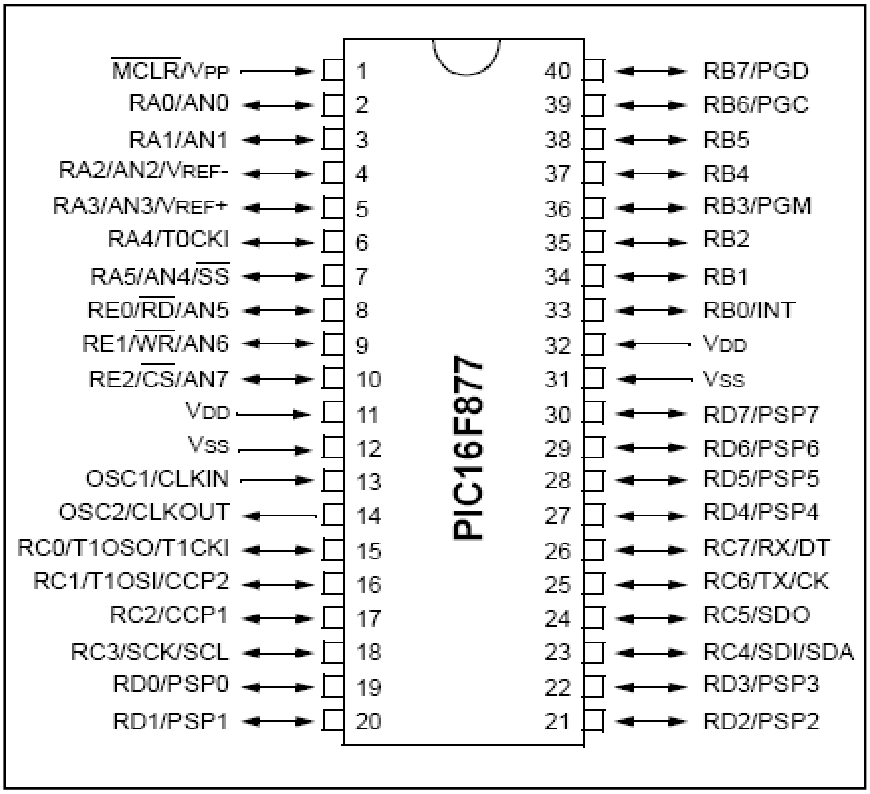


Figure (6.8): Pin diagram of PIC16F877 [23]

- **MAX232:** Since we can send and receive data at the same time due to the separate lines of sending and receiving data, the full-duplex mode block which enables this way of communication is called serial communication block, data moves here bit by bit, or in a series of bits what defines the term serial communication comes from. Figure 6.9 shows the connection of MAX232 chip and the DB9 port.

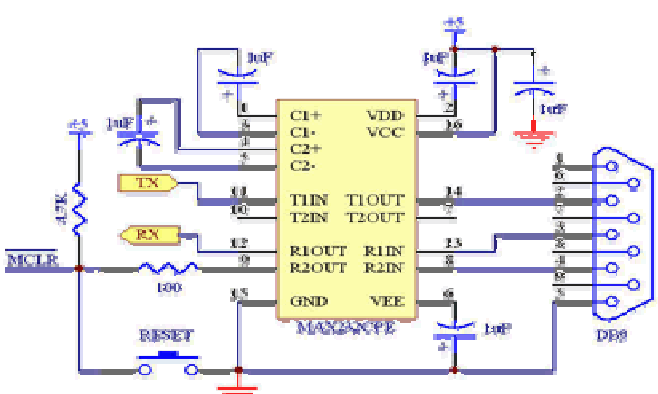


Figure (6.9): RS232 serial port

- **ULN2003:** We use ULN2003 because that the PIC can only supply up to 25mA. This is fine for logic levels, and even small devices like LED's, but we can't drive a relay, motor, etc with a PIC.

The ULN2003 is a very cost effective chip that acts like a switch. It simply switches an earth to/from an external circuit, and can withstand a continual 500mA current drain and a maximum 50V, as shown in figure 6.10.

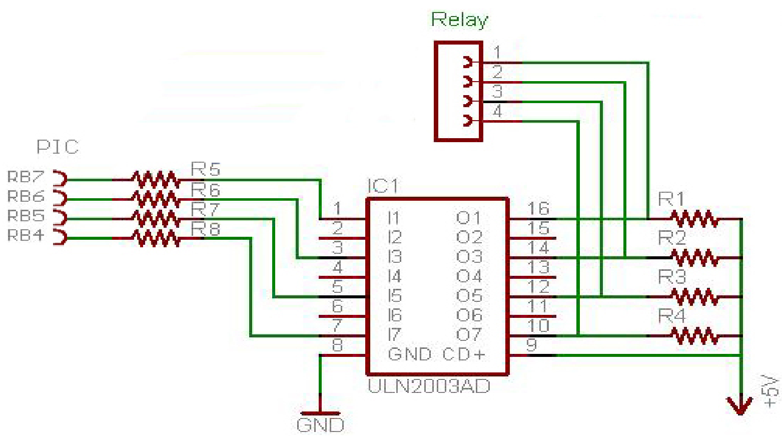


Figure (6.10): Pin diagram of ULN2003

- **XPort Direct+ embedded device server:** It is an embedded device server module delivering high-performance Ethernet connectivity and web server capabilities. The part shown in figure 6.11 can now rapidly and even more affordably web-enable virtually any device with a serial interface on its microcontroller [24].

Figure (6.11): XPort Direct+ embedded device server [24]

XPort Direct+ acts as a dedicated co-processor module to optimize network activities, permitting the device's host microcontroller to function at maximum efficiency. Serial data from the device microcontroller's CMOS logic-level serial port is packetized and delivered over an Ethernet network via TCP or UDP data packets. Similarly, incoming TCP or UDP packets are unbundled and presented to the attached device over its microcontroller's serial interface. XPort Direct+ features a built-in web server for communications with a device via a standard Internet browser. Web capability can be used for remote configuration, real-time monitoring, upgrades and troubleshooting.

XPort has 512 KB of on module Flash for web pages and firmware upgrades. This fully-integrated and ready-to-deploy module also includes a 10/100 MAC/PHY, 256 KB of SRAM and an RJ45 jack [24]. The data sheet and the configuration of the XPort are shown in appendix 6.

The XPort has one serial port and three configurable I/O pins. It operates on 3.3 volts, DC, and not 5V-compliant. To use it with a PIC or similar microprocessors that have TTL serial capability, I built a circuit to convert from 5V to 3.3V.

Figure 6.12 shows the schematic for XPort carrier board. +5V input goes to pin 10 of Connector J1, and ground goes to pin 1 of J1.

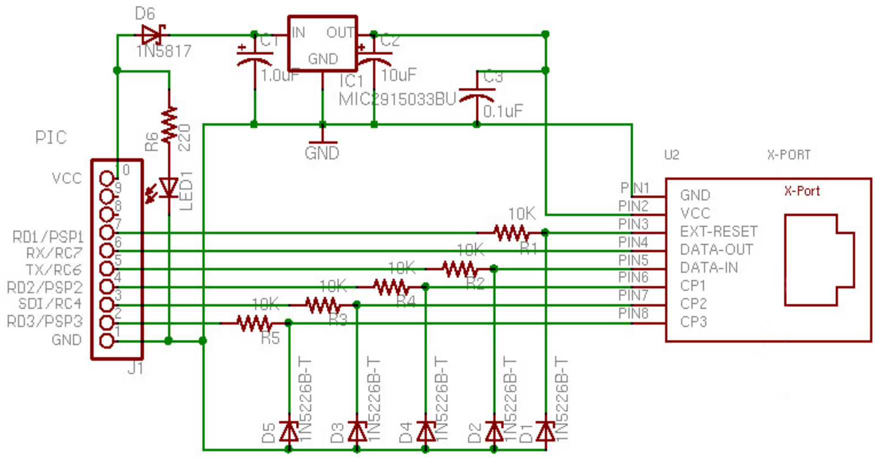


Figure (6.12): XPort schematic carrier board

- **Dual Technology occupancy sensor (DT-200)**: The Watt Stopper DT-200 Dual Technology occupancy sensors combine advanced passive infrared (PIR) and ultrasonic technologies into one unit. The combination of these technologies helps to eliminate false triggering problems even in difficult applications [25], as shown in figure 6.13.

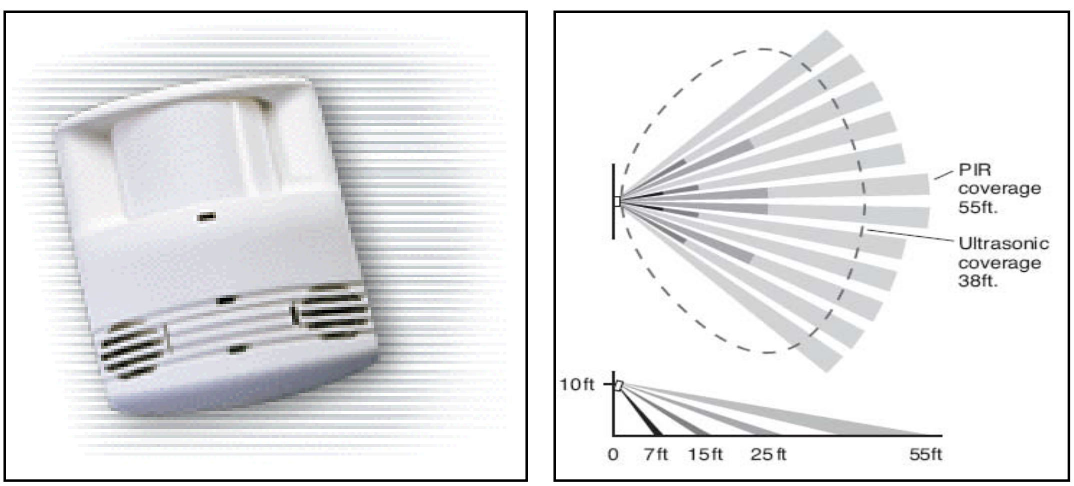


Figure (6.13): a) DT-200 Dual Technology sensor. b) Coverage area [25]

The DT-200 offers numerous operating modes that can be combined to create the ideal custom control. The sensors can be configured to turn lighting on, and hold it on as long as either or both technologies detect occupancy. After no movement is detected for the user specified time or

SmartSet time (5 to 30 minutes) the lights are switched off. DT-200 sensors also have an isolated relay with Normally Open and Normally Closed for integration with HVAC and BAS. Sensor data sheet shown in appendix 7.

- **Power Pack**: In most occupancy and light sensor systems, the power supply and relay comprise in one unit, sometimes called a power pack or switch pack, I've drawing the wiring diagram of the power pack and the sensor, as shown in figure 6.14.

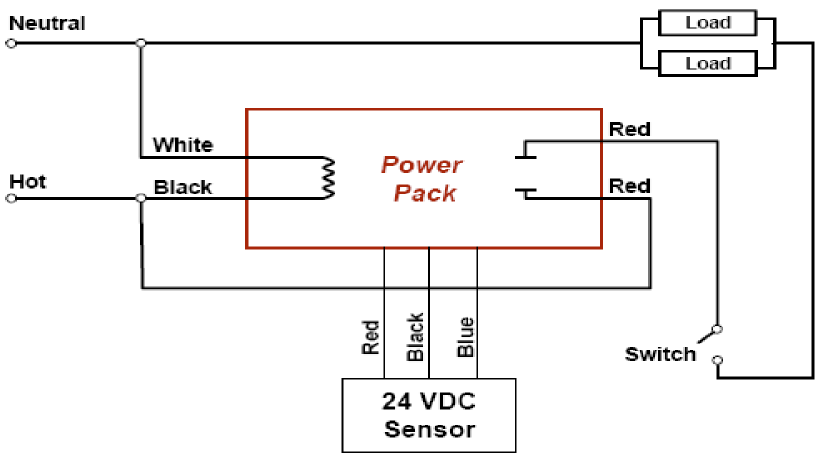


Figure (6.14): Power pack wiring diagram

6.6 The Benefits of Networked Management

Device Server technology allows an isolated device to be networked into the campus or corporate network. There are several reasons for networking these devices:

1. Easy installation and maintenance

Network connections tend to populate every location of a campus or corporate site. Wherever one goes, a network access port is usually nearby.

This means a device in any location can be put onto the network and accessed from anywhere else on the local network or even over the Internet [26]. As networks are extended to great lengths using switches, hubs and converters, connectivity becomes available to areas that previously required long dedicated serial cable run.

2. Management from anywhere

Network managers now have a great many tools at their disposal for ensuring that the network performs efficiently. SNMP (including MIBs) is a standardized management protocol providing pro-active management information arising from continuous process monitoring. Many vendors, such as HP (HPOpenview) and SUN (SunNetmanager), have well-developed software packages for network management, while most vendors support simple telnet or menu-based management interfaces. These protocols are supported over the Internet, allowing a network manager to roam at will, literally around the world, and still have access to a device [26].

3. Reliable management access

Corporate and campus networks have become very highly scrutinized. In most larger networks, 24-hour-a-day maintenance and monitoring takes place to ensure the network is running properly. Networking protocols designed for data delivery ensure that information arrives from node to node. Routed networks provide multiple pathways for data deliver [26]. New software capable of measuring quality of service helps the network manager to tune the network topology to allow data to flow freely between devices virtually all the time. All of these reasons combine to make management over the network one of the most reliable ways to manage a remote device.

4. Lower management costs

With a reliable remote management tool available, network managers can streamline their staffing and troubleshooting requirements to a centralized or even automated system. Standards-based management features such as SNMP maximize the investment in software and analysis devices based upon that protocol [26]. Even a simple management technique such as a ping or a telnet login to validate that a node is alive can be run from a script. With a management scheme based upon established standards, network managers can train internal staff better and more easily hire new staff with known levels of skill regarding the management suite. Better management technology and better staff results in lower costs for the network manager.

CHAPTER SEVEN

LIGHT MANAGEMENT AND CONTROL WEB-BASED SOFTWARE DEVELOPMENT

Chapter Seven

Light Management and Control Web-Based Software Development

7.1 Introduction

In chapter six, we had illustrated the system development and analysis, including the baseline data survey, implementation, and results. In this chapter we connect all parts of the system together via a web-based software, called monitoring remote system (M.R.S) software, which mentoring and controlling the lighting system in the university buildings, from anywhere else on the local network or even over the Internet.

7.2 Software Components

The light management and control software in universities, includes a set of tasks that coverage the whole issues in monitoring and controlling the lighting system. The list design block diagram of the main data screen display is shown in figure 7.1, they are available in the user interface for choosing any process to be controlled.

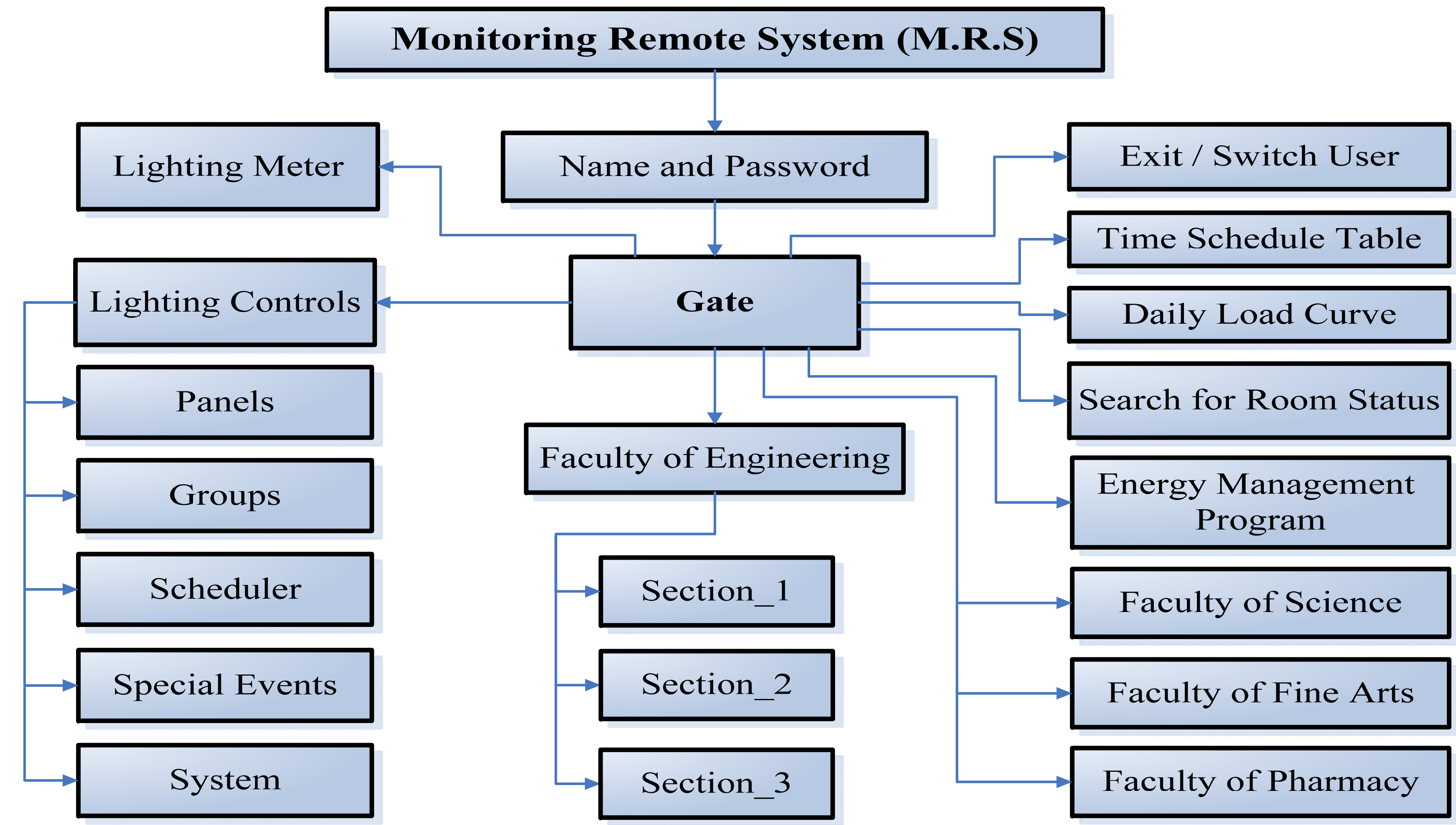


Figure (7.1): Block diagram of the main data screen display

7.3 Software Language

In designing and programming this software we use PHP language, PHP is one of the most popular server side scripting languages running today, that can be embedded into HTML. It is used for creating dynamic web pages that interact with the user, it offers many advantages; it is fast, stable, secure, easy to use and open source [27].

Another key advantage of PHP is its connective abilities. PHP uses a modular system of extensions to interface with a variety of libraries such as graphics, XML, encryption, etc. In addition, programmers can extend PHP by writing their own extensions and compiling them into the executable or they can create their own executable and load it using PHP [28].

It can also be used with a large number of relational database management systems, runs on all of the most popular web servers and is available for many different operating systems.

7.4 Flow Charts

The flow chart of the main procedures of our software are illustrated in figure 7.2.

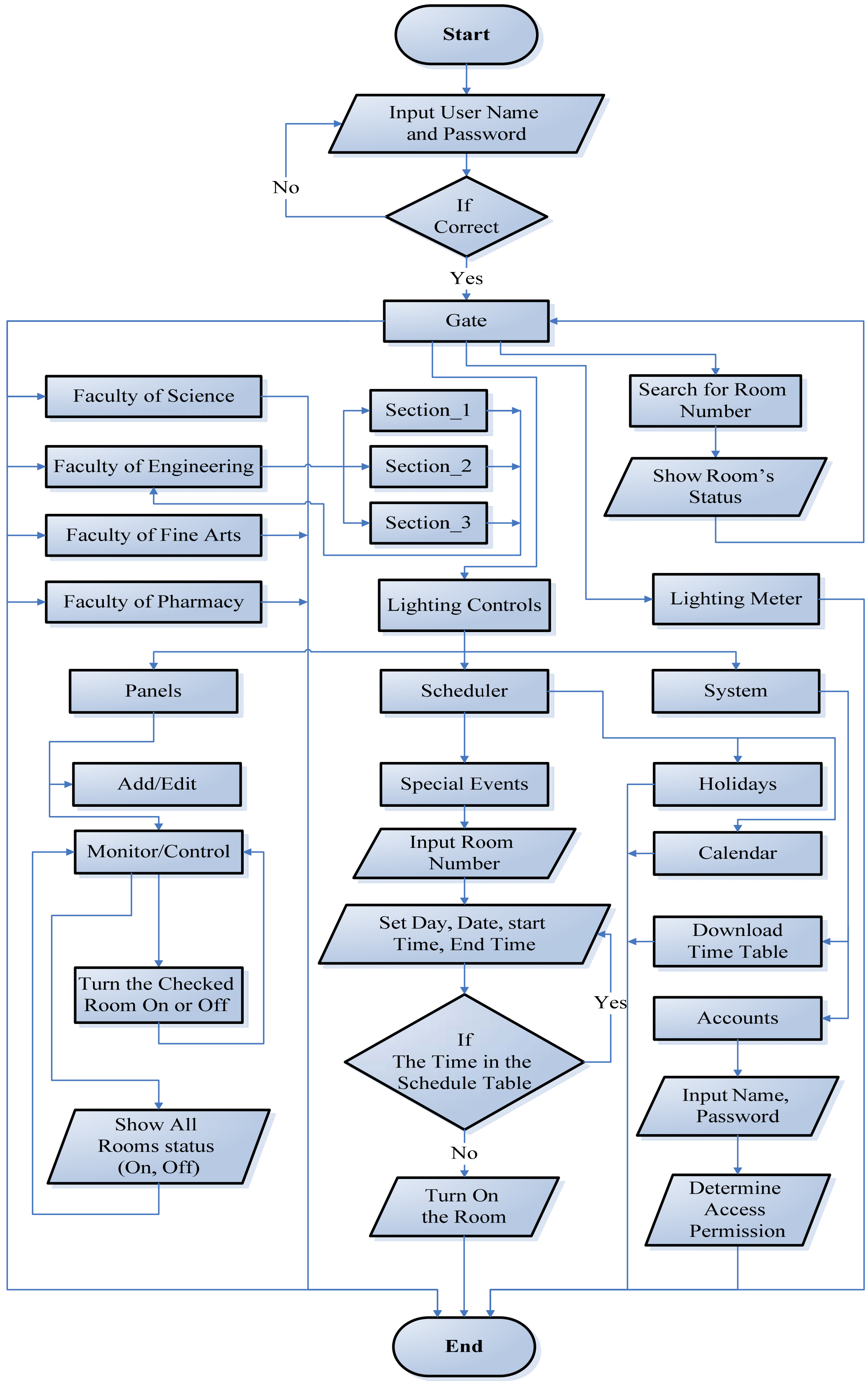


Figure (7.2): Flow chart of the software main functions

The lighting control procedures are illustrated in figure 7.3.

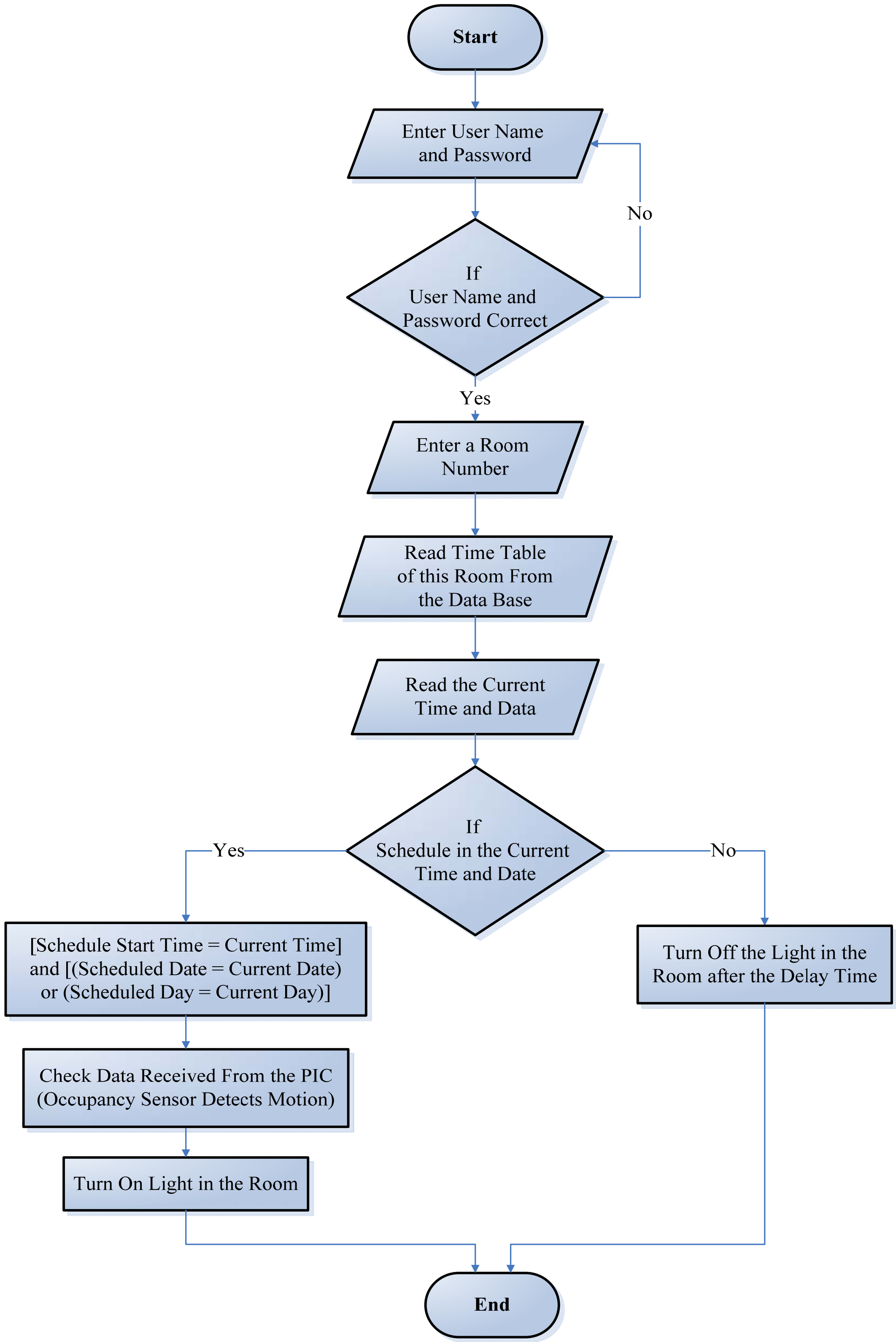


Figure (7.3): Flow chart of the lighting control procedures

7.5 Software Design

There are many aspects to consider in the designing of web-based software. The importance of each should reflect the goals the software is trying to achieve. Some of these aspects are:

- Extensibility: New capabilities can be added to the software without major changes to the underlying architecture.
- Robustness: The software is able to operate under stress or tolerate unpredictable or invalid input.
- Reliability: The software is able to perform a required function under stated conditions for a specified period of time.
- Fault-tolerance: The software is resistant to and able to recover from component failure.
- Security: The software is able to withstand hostile acts and influences.
- Maintainability: The software can be restored to a specified condition within a specified period of time.
- Compatibility: The software is able to operate with other products that are designed for interoperability with another product.
- Modularity: The resulting software comprises well defined, independent components. That leads to better maintainability. The components could be then implemented and tested in isolation before being integrated to form a desired software system. This allows division of work in a software development project.

The main screens in the software are illustrated in figures 7.4and 7.5,

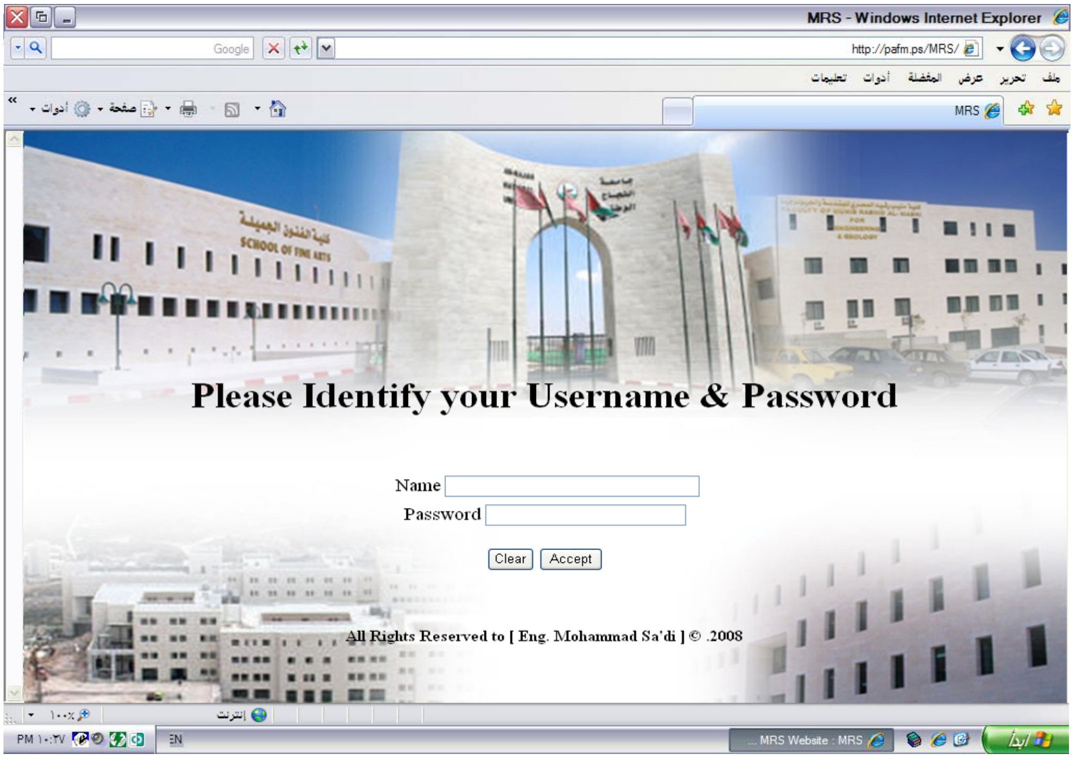


Figure (7.4): Software home page

Figure (7.5): Software main display screen

figures 7.6, and 7.7 shows the lighting control procedures which depends on the room schedule table and the occupancy pattern.

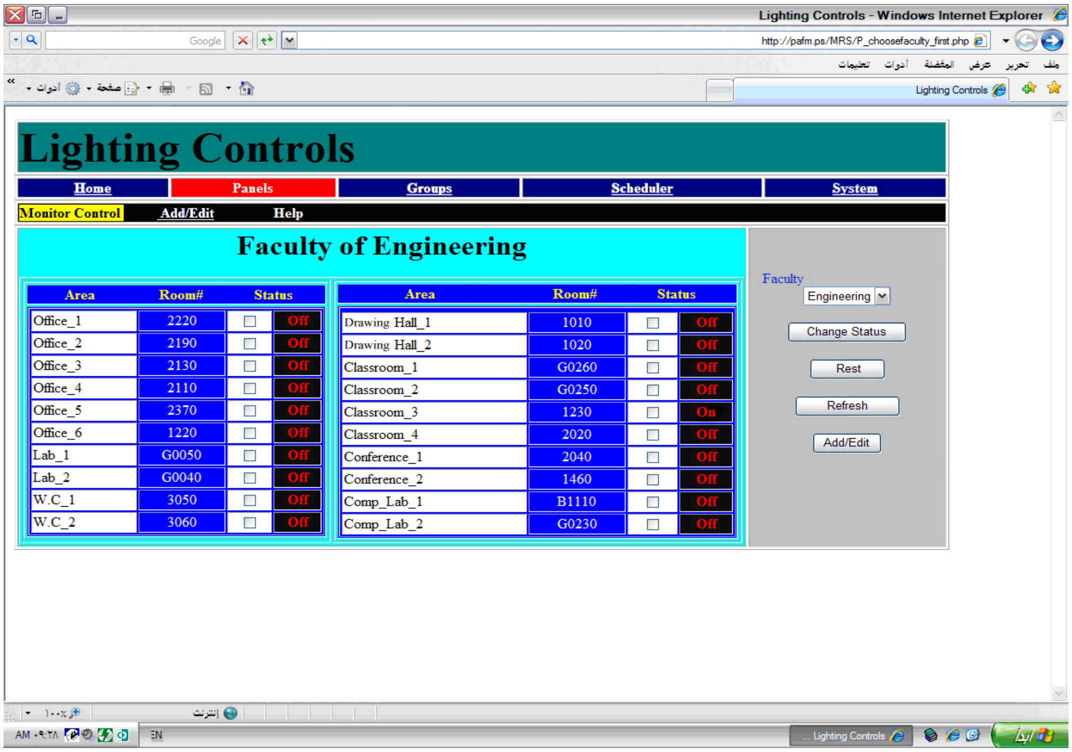


Figure (7.6): Software lighting control

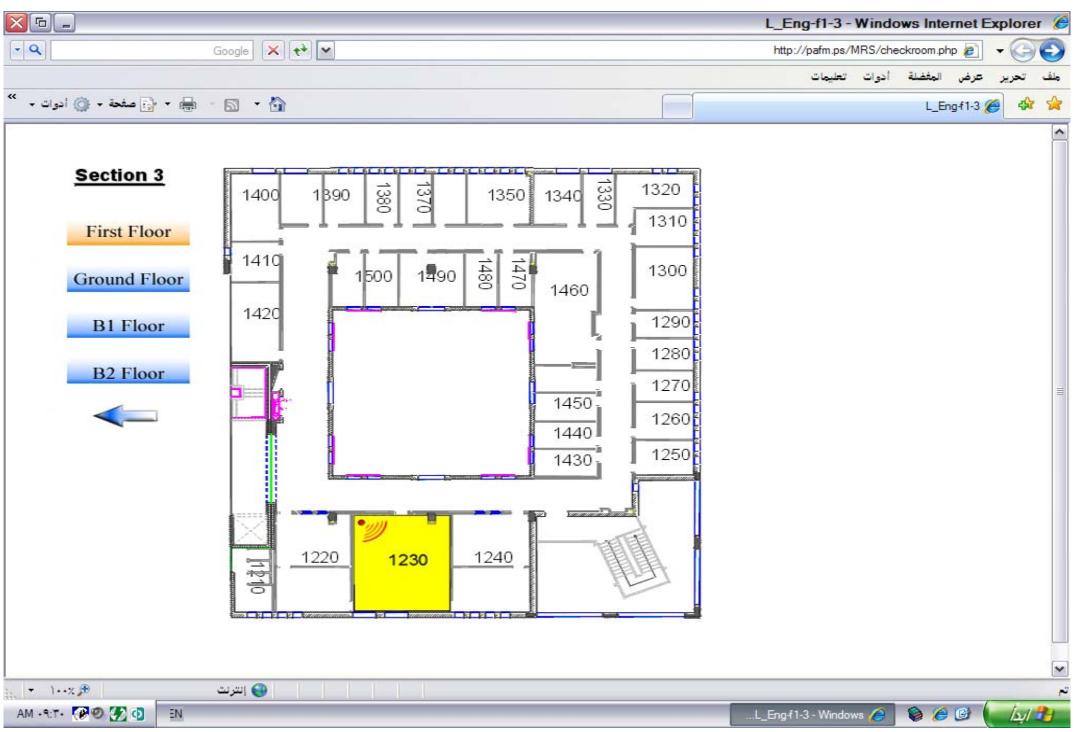


Figure (7.7): Room lighting monitor

7.6 Principle of the Software

The web-based software, has several functions which achieved the desired objectives of it. The main function is to turn the lights on and off, depending on the schedule table of the area, and the occupancy pattern, the schedule table is downloaded from the university server at the beginning of each semester, for example, the lights turn on in a classroom when two conditions are achieved together: (1) there is a lecture at this time, (2) the occupancy sensor detects a motion (the students enter the room), otherwise the lights remain off even one of the previous conditions are verified. Through this scenario, we can achieve a maximum possible saving in the classrooms.

Another wonderful feature that the software provided is the special events, this option allow the instructors to override the previous scenario, if they want to make a lecture out of the schedule table, they can firstly determine the room number, then enter the start time, end time, and the date of the desired lecture, and submit this information, the software verify this information, to make sure they don't conflict with the schedule table.

The monitoring control allows the user to monitor the university faculties by displaying all rooms in the selecting faculty and its status as shown in figure 7.6, or searching for a specific room number to show whether it is on or off as shown in the previous figure 7.7.

Through the system accounts we can make a permissions for the software users, there are three permissions: administrator, instructor, and security. The administrator has the full privacy for editing, deleting, and modification of the software, the instructors have also privacies for monitoring and assigning new lectures, a limited permissions given to the security.

The software also supports other features, such as:

- Light meter: Monitoring the illumination in any room remotely by using Extech Data logging light meter, which is connected to the lighting panel through the serial port.
- Daily load curve: Displaying the load curve for any chosen room, and calculating the total energy consumption for a specific day.
- Energy management: All energy conservation calculations are accomplished on universities or any other facilities, printing the outcome in specific tables, with each study per se, in addition to a list of final consequences that indicates all forms of energy saving in the study.
- Groups: By using groups we can arrange all the areas which have the same functions in on group to apply a command on it.
- Holidays: We can assign a general holidays such as (Friday, Saturday, Great Bairam, Lesser Bairam, etc), or any new holiday from the calendar, to apply a certain function on it.

CHAPTER EIGHT
SYSTEM TESTING AND RESULTS

Chapter Eight
System Testing and Results

8.1 Introduction

This chapter is dedicated to the different experiments we have executed during the development of our system. It explains basically how we managed to make every component work as expected. We will be focusing in this chapter on how we dealt with the PIC and serial interface, the XPort Direct+ embedded device server configuration and its interfacing board, and the occupancy sensor adjustment. The end part of this chapter illustrates the economical evaluation of the system, including the total investment cost, and the simple payback period (S.P.B.P).

8.2 PIC and Serial Interface Testing

Firstly we built the circuit of the PIC and the serial interface on the testing board to insure that it is working well, as shown in figure 8.1, then we connect it with the PC through the serial port to install the program to the PIC, that is needed to interface with the sensors. Finally we connect the PIC and the serial interface to the XPort direct embedded device server, this kit shown in figure 8.2.

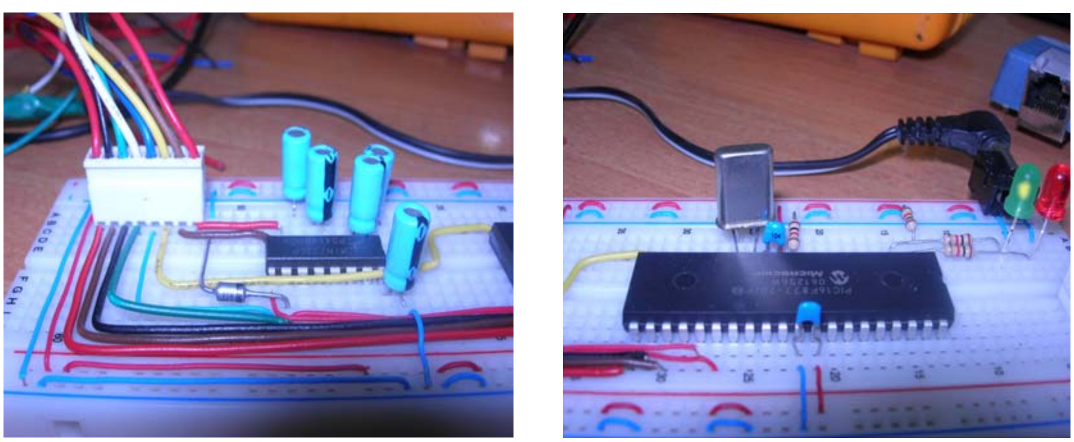


Figure (8.1): PIC16F877 and MAX232 testing board

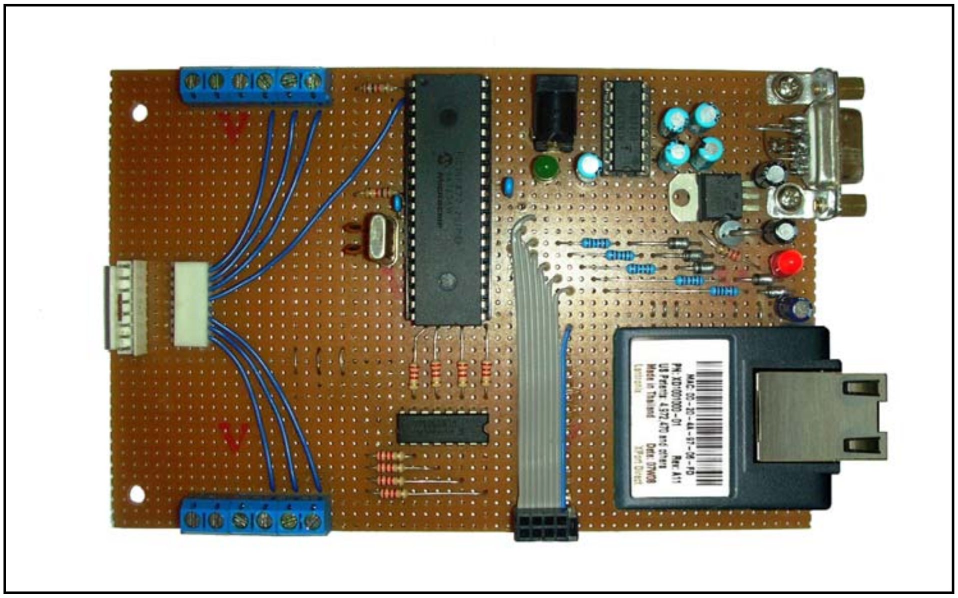


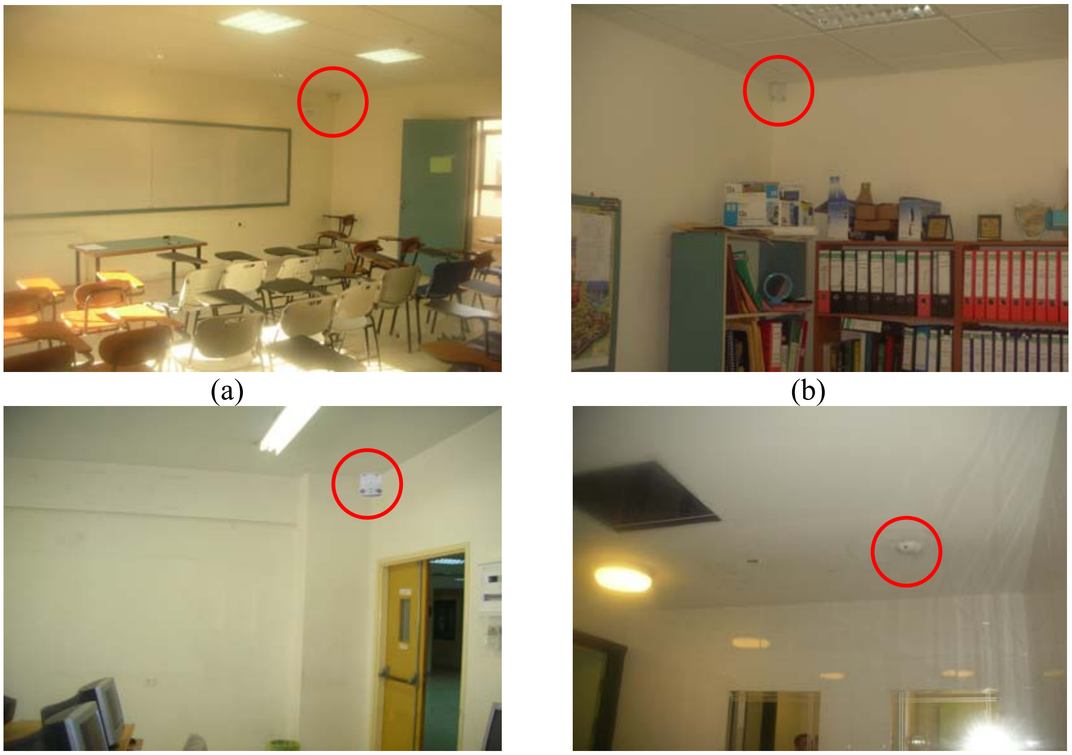
Figure (8.2): Lighting control kit

The previous kit I developed to replace with the kit that supported by Lantronix which is needed to configure the XPort, so by developing this kit we save approximately $100.

8.3 Occupancy Sensor Testing

8.3.1 Commissioning adjustments

Most occupancy sensors require commissioning upon installation to adapt the sensor to the specific space. Commissioning reduces the number of false ONs and false OFFs. A false OFF occurs when an occupancy sensor switches off lights while the space is still occupied. A false ON occurs when the sensor switches on lighting when the space is not occupied. Virtually all sensors allow adjustment of sensitivity and the time delay period. The adjustment device should be located so that it is accessible to the contractor performing the commissioning but not so accessible that unauthorized personnel can interfere with it, as shown in figure 8.3. The sensors drawing also shown in appendix 5.



(a) (b) (c) (d)

Figure (8.3) : Sensor placement: a) Classroom, b) Office , c) Laboratory, d) W.C

8.3.2 Sensitivity to motion

With the sensitivity adjustment, the sensor can be fine-tuned to accommodate the activities being performed in the space, the presence of air currents or drafts, and the distance of the sensor from the person being detected. If the sensitivity is correctly set for the application, false OFFs and ONs will be minimized.

Sensors commonly encounter changing ambient conditions that can affect their ability to detect moving heat. Some sensors incorporate an adjustable sensitivity feature that helps the sensor perform more consistently year round. The range of this sensitivity adjustment is typically 80–120%. If there is a false detection, the sensor will automatically increase the detection sensitivity.

8.3.3 Timeout adjustment

The time delay adjustment allows changing the time period between when the sensor last detects occupancy and when it turns the lights out (often called the timeout period). Many systems come factory preset with a 10-minute timeout, which is reasonable for many applications. If the lights cycle often because an occupant frequently moves in and out of the space, the time delay can be set longer to mitigate any potential shortening of lamp life.

DT-200 Dual Technology occupancy sensor can adapt the timeout delay according to the usage patterns in the room (SmartSet). If a room is used infrequently, the sensor will set a short time delay. If the room is used more often, the time delay will lengthen.

8.3.4 Daylight distribution

The daylighting controls operate on the ambient electric light system; accent lighting is usually placed on a time schedule and task lighting may be manually controlled or occupancy sensed with one of the newer personal lighting controls.

Sometimes, daylight distribution appears uniform across the space. But more often, daylight levels vary across the space depending on distance from the daylight apertures. The daylight intensity and distribution also change through time, depending on hour of day, season, sky condition (clear versus cloudy) and condition of blinds and shading devices. Figure 8.4 shows a sample of the lighting distribution which is measured by the Extech Data logger light meter for a classroom # 1230, this figure shows the high potential for the daylighting in classrooms and also for different areas of the university. Referred to appendix 4. It seems clear from the figure that there is excess daylight approximately 1600 Lux when the lights on, this higher than the illumination standard for the classroom which is 300-500 as seen in appendix 1, even with the lights off the illumination is higher than the standards, this supports the 4% (occupied and off) that obtained in table 6.1.

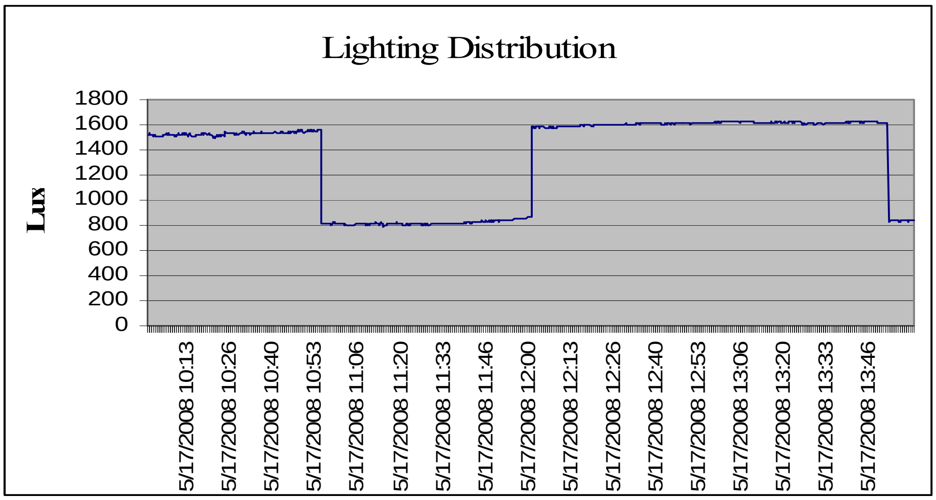


Figure (8.4): Classroom lighting distribution

As a result, the DT-200 Dual Technology occupancy sensor with light level, turns off the lighting raw which is parallel to the window during the availability of daylighting, the resulted saving will be shown in table 8.2.

8.4 XPort Configuration

There are a variety of ways to set the Lantronix devices up. For the initial setup, it's easiest to do it serially. We connect the device's serial port1 (pins 4 and 5 on the XPort) to a PC's serial port through a MAX232 chip. We open the Hyper terminal to connect to the serial port on the PC at 9600-8-N-1. And we open the serial port on the computer, then, while holding down the "x" key, we power up the device, a menu will come up allowing to modify the various settings of the XPort, as shown in figure 8.5.

```
Change Setup:
  0 Server
  1 Channel 1
  3 E-mail
  5 Expert
  6 Security
  7 Defaults
  8 Exit without save
  9 Save and exit            Your choice ? _
```

Figure (8.5): Setup menu options

The full configuration of the XPort direct plus embedded device server will seen in appendix 7.

8.5 Energy and Cost Savings Results From Our System

Most occupancy sensors are equipped with a variable time delay feature to adjust the time interval between the last detected motion and the switching off of the lamps. This allows the sensor to be customized to the application to reduce the chance of lamps switching off when a room is occupied but minor motions are not detected. Adjusting the time delay creates a tradeoff between saving energy and avoiding occupant complaints. Longer time delays reduce the incidence of occupant complaints. Shorter time delays increase energy savings (particularly in rooms that are infrequently and briefly occupied). Manufacturers report time delay setting ranging from several seconds to more than 30 minutes.

To examine the impact of time delay on energy savings, control scenarios for 5, 10, 15, and 20 minute time delays were modeled for each application.

Table 8.1 lists the descriptive statistics for room area, connected lighting load, and power density for each application.

Table (8.1): Descriptive statistics for room area, connected lighting load, and power density for each application

Application	Sample size		Area (m^2)	Connected lighting load (W)	Power density (Lux)
Classroom	8	Minimum Maximum Average σ	39 85 65 18.7	504 972 787 161.4	340 780 520 137
Drawing Hall	6	Minimum Maximum Average σ	109 125 114 5.1	792 1296 1,008 182	1,000 1,300 1,166 121.5
Private Office	10	Minimum Maximum Average σ	7 43 20 13.3	144 648 309 201.8	300 830 478 163
Laboratory	4	Minimum Maximum Average σ	86 164 121 32.4	846 1440 1100 203.6	580 500 545 34.2
W.C	4	Minimum Maximum Average σ	10 20 15 4.5	108 336 208 95.3	250 380 307 56.7

As demonstrated in table 8.2, and from the load curves that obtained by the software, the savings estimates were considerable across all space types (ranging from 17-45%), which illustrates that both application and time delay selection significantly impacts the quantity of available savings. For this data set, classrooms showed the highest overall savings, followed by drawing halls, laboratories, private offices, and W.C's. The range of savings between the shortest and longest time out setting varied with application as well because of the occupancy pattern differences among the applications.

Table (8.2): The effects of time delay on energy and cost savings for the total monitoring period

Application	Total daily energy use (kWh)	Energy saved compared to baseline (%)	Annual energy cost (NIS)	Annual energy cost reduction (NIS)
Classroom				
Baseline	6.77	---	8,895.78	---
5-minute	3.74	45%	4,914.36	3,981.42
10-minute	4.08	39%	5,361.12	3,534.66
15-minute	4.43	34%	5,821.02	3,074.76
20-minute	4.77	29%	6,267.78	2,628.00
Drawing Hall				
Baseline	6.75	---	8,869.50	---
5-minute	3.89	42%	5,111.46	3,758.04
10-minute	4.25	37%	5,584.50	3,285.00
15-minute	4.60	31%	6,044.40	2,825.10
20-minute	4.94	27%	6,491.16	2,378.34
Private Office				
Baseline	1.49	---	652.62	---
5-minute	0.52	35%	227.76	424.86
10-minute	1.04	30%	455.52	197.1
15-minute	1.13	24%	494.94	157.68
20-minute	1.20	19%	525.60	127.02
Laboratory				
Baseline	6.86	---	9,014.04	---
5-minute	4.10	40%	5,387.40	3,626.64
10-minute	4.47	35%	5,873.58	3,140.46
15-minute	4.84	29%	6,359.76	2,654.28
20-minute	5.21	24%	6,845.94	2,168.10
W.C				
Baseline	1.93	---	2,536.02	---
5-minute	1.27	34%	1,668.78	867.24
10-minute	1.39	28%	1,826.46	709.56
15-minute	1.48	23%	1,944.72	591.30
20-minute	1.60	17%	2,102.40	433.62

8.6 Economical Evaluation of the System

One of the most commonly used cost analysis methodologies is the Simple Pay Back Period (SPPB), which is a broad indicator of how long it will take to recover the capital investment cost as a result of the improvement in annual saving cost. It is expressed as:

$$S.P.B.P = \frac{\text{Capital Investment Cost}}{\text{Annual Saving Cost}} \quad \text{............8.1 [1]}$$

SPBP must always be shorter than the expected life of the project and in comparison to other projects, a shorter SPB period generally indicates a more attractive investment.

We calculate the capital investment cost for installing our system in 70 classrooms, as shown in table 8.3.

Table (8.3): Capital investment cost of the system

Item	Qty	Price (NIS)
Panels (30x20x10 cm)	70	2,000*
XPort Direct+ Embedded Device Server	70	10,400
DT-200 Dual Technology Sensor, With Light Level	70	21,000
B220E-P Power Pack220 VAC, 20 A ballast Load	70	4,900
PIC16F877 Microcontroller	70	2,300*
MAX232 Serial Interface	70	280*
ULN2003	70	210*
7805 Voltage Regulator	70	100*
1N5226B-T	490	490*
Installation Cost	70	3,500
DB9 Serial Adapter	70	260*
Capacitors, Resistors, LED's	2,100	260*
Cable 3 x 1.5	1,400 m	2,800*
Software Development	-	3,500
Shipping Charges	-	1000
Total		**53,000**

* Market Price (Jardaneh Electronic and Electrical Supplier)

We have two scenarios to calculate the energy saving , first scenario is to install the system on the current situation (without implementing any energy conservation measures), so the total annual energy consumption for the lighting system in the seventy classrooms (with referred to appendix 2) is 100,145.6 kWh, and from table 8.2 by taking five minutes as time delay we have achieved 45% electric energy saving compared to the base line, so the total saving in electric energy is:

Electric energy saving = 100,145.6 × 0.45

= 45,065.52 kWh

and the corresponding cost saving is:

Energy Cost Saving = 45,065.52 × 0.73

= 32,897.83 NIS

from the previous we can calculate the simple payback period which is:

S.P.B.P = 53,000 / 32,897.83

= 1.6 years

Second scenario is to install the system after implementing the energy conservation measures, so the total annual energy consumption for the lighting system in the seventy classrooms (with referred to appendix 2) is 64,510.3 kWh, we have also achieve 45% electric energy saving compared to the base line, so the total saving in electric energy is:

Electric energy saving = 64,510.3 × 0.45

= 29,029.635 kWh

and the corresponding cost saving is:

Energy Cost Saving = 29,029.635 × 0.73

= 21,191.633 NIS

from the previous we can calculate the simple payback period which is:

S.P.B.P = 53,000 / 21,191.633

= 2.5 years

From the previous we have shown that the two scenarios have the same percentage of saving 45%, because our system depends on the behavior of the occupancy and not the consumption, the second scenario has less energy consumption because of the energy conservation measures, this led to provide less energy saving, which affect the simple payback period and raise it from 1.6 to 2.5 years.

CHAPTER NINE

CONCLUSIONS AND RECOMMENDATIONS

Chapter Nine
Conclusions and Recommendations

9.1 Introduction

Regarding audits and energy conservation measures and despite the fact that the measures were discussed at small-scale levels it is evident that they could actually make substantial energy savings. These savings could reduce the financial burden of the current energy bills at the universities. There would also be environmental benefits derived from implementing energy conservation measures. There would be tremendous reduction of localized gaseous emissions to the environment.

9.2 Conclusions

The key conclusions of this research, in light of the furnished analyses and the corresponding discussions, are the following:

1. It was presented and approved in this thesis that there is a great potential for energy savings in the Palestinian universities by implementing energy conservation measures of no and low cost investment.

2. After reviewing the energy bills of An-Najah National University, it became obvious to us that it is like many commercial buildings and establishments suffers from high consumption with respect to its connected loads.

3. We have achieved a percentage of energy saving 24% in the lighting system (low cost), 7% in the cooling system (no cost), and 5% in the heating system (no cost).

4. Although some of the recommendations in this thesis are specific to the universities, many could be translated to any facility. In our experience, most universities can reduce their energy cost by (15-25%) with investments that have immediately payback periods in most cases, excepts in the case of installing reflectors then we have payback period of 2.1 years (low return), and in case of installing high efficient lamps and ballast we have payback period of 3.8 years (medium return).

5. The automatic light and management control system achieve extra 45% saving, with low capital investment cost, whether installed before or after the energy conservation measures, because our system depends on the behavior of the occupancy and not the lighting consumption, but the simple payback period raises form 1.6 years (before making measures), to 2.5 years (after making measures).

6. By designing a web-based software application through the using of XPort direct+ embedded device server, we reduce the cost of remote connecting devices, due to its low cost. Also many advantages were achieved by using it like, remote access and control any device with a serial interface on its microcontroller over the web, this web capability can be used for remote configuration, real-time monitoring, upgrades and troubleshooting

7. There is great abundance in daylight in the university buildings, but unfortunately it is not exploited properly, this led to remove a large quantity of lighting units from different areas.

8. A large quantity of heat losses through the building's windows, this explained by the higher consumption in the amount of fuel used in

boilers, and this shows the lack of awareness among students towards energy management and conservation.

9.3 Recommendations

The research encompasses a multitude of parameters at different spatial levels. Several recommendations can be drawn out of this research. The recommendations listed here below are mainly directed to the decision makers and for researchers :

1. We advice that similar energy management researches must be conducted in other universities.

2. The web-based application software that has been designed and tested in this thesis, should be installed and adopted by An-Najah National University and other universities.

3. Support the existing and new energy research and information centers to acquire the potentials in energy sector and to encourage investment and use of new technology and concepts of energy conservation and efficiency in universities and other facilities.

4. Establishment of a campaign program to raise awareness of the benefits of energy conservation could happen change the attitudes or ignorance of the students or the employee in the universities for a better prospect of responsibility.

5. Strengthen the role of Energy Research Centers, and encourage other universities by encouraging investments in energy conservation programs within the sector.

6. Introduce technical training for energy conservation practices to schools, vocational colleges and universities.

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Appendix

Appendix 1	**Illumination Standards**
Appendix 2	**Existing Lighting System**
Appendix 3	**Measured Weekly Load Curve**
Appendix 4	**Sample of Measured Illumination**
Appendix 5	**Sensors Drawing**
Appendix 6	**XPort Direct+ Data Sheet**
Appendix 7	**DT-200 Occupancy Sensor Data Sheet**
Appendix 8	**Software Sample Codes**

Appendix 1

Illumination Standards

Illumination Standards [29]

Place	Standard illumination (lm/m^2) or lux
Classrooms	300-500
Offices	250-500
Laboratories	500-700
Conference Room	700
Dissect Hall	700
Drawing Halls	500
Studio	300
Lobbies	150
Corridors	150
Cafeteria	150
Electrical Room	150
Boiler Room	150
Store	200
Mosque	100
W.C	100

Appendix 2

Existing Lighting System

Faculty of Engineering

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
3rd Floor																
3000	MOSQUE	110	FL	30	4	18	940	100	1800	2.16	3,888	60	1.08	1,944	1.08	1,944
3030	MOSQUE	196	FL	50	4	18	980	100	1800	3.6	6,480	100	1.80	3,240	1.8	3,240
			PL	16	2	26				0.832	1,498	32	0	0	0.832	1,498
3040	Comp-Lab	115	FL	15	2	36	400	500	1800	1.08	1,944	0	1.08	1,944	0	0
3070	Multimedia Lab	56	FL	7	2	36	350	500	1800	0.504	907.2	0	0.504	907.2	0	0
3080	Comp-Lab	92	FL	17	2	36	380	500	1800	1.224	2,203	0	1.224	2,203	0	0
3010	W.C	12	2D	6	1	26	470	100	1800	0.156	280.8	3	0.078	140.4	0.078	140.4
3020	W.C	12	2D	6	1	26	490	100	1800	0.156	280.8	3	0.078	140.4	0.078	140.4
3050	W.C	5	2D	2	1	26	320	100	1800	0.052	93.6	0	0.052	93.6	0	0
3060	W.C	5	2D	2	1	26	300	100	1800	0.052	93.6	0	0.052	93.6	0	0
	Corridor	130	FL	14	2	18	600	150	1800	0.504	907.2	12	0.288	518.4	0.216	388.8
	Lobbies	54	PL	9	2	18	460	150	1800	0.324	583.2	8	0.18	324	0.144	259.2
2nd Floor																
2010	OFFICE	50	FL	8	4	18	700	250	600	0.576	345.6	14	0.324	194.4	0.252	151.2
2020	CLASS	55	FL	8	4	18	630	300	1600	0.576	921.6	12	0.36	576	0.216	345.6
			PL	10	2	36				0.720	1,152	10	0.36	576	0.36	576
2030	OFFICE	61	FL	12	4	18	600	250	600	0.864	518.4	16	0.576	345.6	0.288	172.8
2040	OFFICE	61	FL	12	4	18	600	250	600	0.864	518.4	16	0.576	345.6	0.288	172.8
2050	OFFICE	52	FL	8	4	18	630	250	600	0.576	345.6	12	0.36	216	0.216	129.6
			PL	10	2	36				0.720	432	10	0.36	216	0.36	216
2060	OFFICE	50	FL	8	4	18	660	250	600	0.576	345.6	12	0.36	216	0.216	129.6
2070	OFFICE	23	FL	2	2	36	290	250	600	0.144	86.4	0	0.144	86.4	0	0

Area #	Area Type	Area m²	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
2080	OFFICE	10	FL	1	2	36	160	250	600	0.72	432	0	0.72	432	0	0
2090	OFFICE	18	FL	3	2	36	490	250	600	0.216	129.6	2	0.144	86.4	0.072	43.2
2100	OFFICE	13	FL	2	2	36	330	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2110	OFFICE	14	FL	2	2	36	320	250	600	0.144	86.4	0	0.144	86.4	0	0
2120	OFFICE	14	FL	2	2	36	320	250	600	0.144	86.4	0	0.144	86.4	0	0
2130	OFFICE	14	FL	2	2	36	320	250	600	0.144	86.4	0	0.144	86.4	0	0
2140	OFFICE	13	FL	2	2	36	330	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2150	OFFICE	13	FL	2	2	36	330	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2160	OFFICE	9	FL	2	2	36	370	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2170	OFFICE	20	FL	2	2	36	290	250	600	0.144	86.4	0	0.144	86.4	0	0
2180	OFFICE	16	FL	2	2	36	350	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2190	OFFICE	16	FL	2	2	36	350	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2200	OFFICE	16	FL	2	2	36	350	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2210	OFFICE	16	FL	2	2	36	350	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2220	OFFICE	14	FL	2	2	36	330	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2230	OFFICE	42	FL	9	4	18	600	250	600	0.648	388.8	12	0.432	259.2	0.216	129.6
2240	OFFICE	54	FL	8	4	18	620	250	600	0.576	345.6	12	0.36	216	0.216	129.6
			PL	10	2	36				0.720	432	10	0.36	216	0.36	216
2250	OFFICE	42	FL	9	4	18	600	250	600	0.648	388.8	12	0.432	259.2	0.216	129.6
2280	OFFICE	4	FL	1	2	36	600	250	600	0.72	432	0	0.72	432	0	0
2290	OFFICE	22	FL	3	2	36	260	250	600	0.216	129.6	0	0.216	129.6	0	0
2300	OFFICE	13	FL	2	2	36	290	250	600	0.144	86.4	0	0.144	86.4	0	0
2310	OFFICE	8	FL	1	2	36	180	250	600	0.72	432	0	0.72	432	0	0
2320	OFFICE	8	FL	1	2	36	180	250	600	0.72	432	0	0.72	432	0	0
2340	OFFICE	15	FL	2	2	36	320	250	600	0.144	86.4	0	0.144	86.4	0	0
2350	OFFICE	12	FL	2	2	36	330	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2360	OFFICE	12	FL	2	2	36	330	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
2370	OFFICE	15	FL	2	2	36	320	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2380	OFFICE	13	FL	2	2	36	300	250	600	0.144	86.4	0	0.144	86.4	0	0
2390	OFFICE	8	FL	2	2	36	200	250	600	0.144	86.4	0	0.144	86.4	0	0
2400	OFFICE	8	FL	2	2	36	200	250	600	0.144	86.4	0	0.144	86.4	0	0
2410	OFFICE	13	FL	2	2	36	300	250	600	0.144	86.4	0	0.144	86.4	0	0
2420	OFFICE	22	FL	3	2	36	260	250	600	0.216	129.6	0	0.144	86.4	0	0
2430	Maintenan.	4	FL	1	2	36	600	300	1800	0.720	1,296	1	0.684	1,231	0.036	64.8
2460	OFFICE	14	FL	2	2	36	320	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2480	OFFICE	16	FL	2	2	36	300	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2490	OFFICE	18	FL	1	2	36	140	250	600	0.72	432	0	0.72	432	0	0
2500	OFFICE	16	FL	2	2	36	360	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2520	OFFICE	16	FL	2	2	36	360	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2530	OFFICE	20	FL	2	2	36	300	250	600	0.144	86.4	0	0.144	86.4	0	0
2540	OFFICE	22	FL	2	2	36	290	250	600	0.144	86.4	0	0.144	86.4	0	0
2550	OFFICE	10	FL	2	2	36	340	250	600	0.144	86.4	0	0.144	86.4	0	0
2560	OFFICE	10	FL	2	2	36	330	250	600	0.144	86.4	0	0.144	86.4	0	0
2570	OFFICE	22	FL	2	2	36	290	250	600	0.144	86.4	0	0.144	86.4	0	0
2580	OFFICE	20	FL	2	2	36	310	250	600	0.144	86.4	0	0.144	86.4	0	0
2260	W.C	20	2D	12	1	28	450	100	1800	0.336	604.8	8	0.112	201.6	0.224	403.2
2270	W.C	15	2D	8	1	28	450	100	1800	0.224	403.2	6	0.056	100.8	0.168	302.4
2440	W.C	8	2D	5	1	28	470	100	1800	0.140	252	3	0.056	100.8	0.084	151.2
2450	W.C	10	2D	6	1	28	490	100	1800	0.168	302.4	3	0.084	151.2	0.084	151.2
	Corridor	305	FL	33	1	28	520	100	1800	0.924	1,663	14	0.532	957.6	0.392	705.6
	Corridor	254	FL	40	4	18	550	150	1800	2.880	5,184	72	1.584	2,851.2	1.296	2,333
	Lobbies	106	PL	18	2	18	500	150	1800	0.648	1,166	16	0.36	648	0.288	518.4
1st Floor																
1010	Drawing	109	FL	13	2	36	1100	500	1800	0.936	1,685	10	0.576	1,036.8	0.36	648

Area #	Area Type	Area m²	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
1020	Drawing	124	FL	13	2	36	1000	500	1800	0.936	1,685	10	0.576	1,036.8	0.36	648
1030	Drawing	109	FL	13	2	36	1100	500	1800	0.936	1,685	10	0.576	1,036.8	0.36	648
1060	CLASS	55	FL	7	2	36	450	300	1600	0.504	806.4	4	0.36	576	0.144	230.4
1070	CLASS	52	FL	7	2	36	460	300	1600	0.504	806.4	4	0.36	576	0.144	230.4
1080	CLASS	54	FL	7	2	36	450	300	1600	0.504	806.4	4	0.36	576	0.144	230.4
1090	COMP. DESIGN	154	FL	18	2	36	300	500	1800	1.296	2,333	0	1.296	2,333	0	0
1100	CLASS	67	FL	10	2	36	340	300	1600	0.720	1,152	0	0.720	1,152	0	0
1130	METRO. LAB	85	FL	12	2	36	370	500	1800	0.864	1,555	0	0.846	1,555.2	0	0
1140	MATERIA LAB	52	FL	9	2	36	330	500	1800	0.648	1,166	0	0.648	1,166	0	0
1170	Drawing	109	FL	13	2	36	1300	500	1800	0.936	1,685	10	0.576	1,036.8	0.36	648
1180	Drawing	121	FL	13	2	36	1200	500	1800	0.936	1,685	10	0.576	1,036.8	0.36	648
1190	Drawing	112	FL	13	2	36	1300	500	1800	0.936	1,685	10	0.576	1,036.8	0.36	648
1220	OFFICE	18	FL	6	4	18	830	250	600	0.432	259.2	12	0.216	129.6	0.216	129.6
1230	CLASS	54	FL	8	4	18	650	300	1600	0.576	921.6	12	0.36	576	0.216	345.6
			PL	8	2	28				0.448	716.8	8	0.224	358.4	0.224	358.4
1240	OFFICE	18	FL	6	4	18	830	250	600	0.432	259.2	12	0.216	129.6	0.216	129.6
1250	OFFICE	11	FL	2	2	36	100	250	600	0.144	86.4	0	0.144	86.4	0	0
1260	OFFICE	12	FL	2	2	36	300	250	600	0.144	86.4	0	0.144	86.4	0	0
1270	OFFICE	10	FL	2	2	36	250	250	600	0.144	86.4	0	0.144	86.4	0	0
1280	OFFICE	10	FL	2	2	36	250	250	600	0.144	86.4	0	0.144	86.4	0	0
1290	OFFICE	9	FL	2	2	36	260	250	600	0.144	86.4	0	0.144	86.4	0	0
1300	OFFICE	20	FL	2	2	36	390	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
1310	OFFICE	12	FL	2	2	36	300	250	600	0.144	86.4	0	0.144	86.4	0	0
1320	OFFICE	16	FL	2	2	36	390	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
1330	OFFICE	9	FL	2	2	36	330	250	600	0.144	86.4	0	0.144	86.4	0	0

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
1340	OFFICE	13	FL	2	2	36	280	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
1350	OFFICE	18	FL	4	2	36	320	250	600	0.288	172.8	2	0.216	129.6	0.072	43.2
1360	OFFICE	9	FL	2	2	36	270	250	600	0.144	86.4	0	0.144	86.4	0	0
1370	OFFICE	8	FL	2	2	36	200	250	600	0.144	86.4	0	0.144	86.4	0	0
1380	OFFICE	9	FL	2	2	36	250	250	600	0.144	86.4	0	0.144	86.4	0	0
1390	OFFICE	11	FL	2	2	36	300	250	600	0.144	86.4	0	0.144	86.4	0	0
1400	OFFICE	13	FL	2	2	36	290	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
1410	OFFICE	11	FL	2	2	36	230	250	600	0.144	86.4	0	0.144	86.4	0	0
1420	OFFICE	21	FL	2	2	36	200	250	600	0.144	86.4	0	0.144	86.4	0	0
1430	OFFICE	9	FL	2	2	36	300	250	600	0.144	86.4	0	0.144	86.4	0	0
1440	OFFICE	9	FL	2	2	36	300	250	600	0.144	86.4	0	0.144	86.4	0	0
1450	OFFICE	9	FL	2	2	36	300	250	600	0.144	86.4	0	0.144	86.4	0	0
1460	OFFICE	39	FL	4	2	36	350	250	600	0.288	172.8	2	0.216	129.6	0.072	43.2
1470	OFFICE	9	FL	2	2	36	350	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
1480	OFFICE	10	FL	2	2	36	340	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
1490	OFFICE	19	FL	4	2	36	350	250	600	0.288	172.8	2	0.216	129.6	0.072	43.2
1500	Maintenan.	18	FL	4	2	36	330	300	1800	0.288	518.4	6	0.072	129.6	0.216	388.8
1110	W.C	5	2D	2	1	28	300	100	1800	0.056	100.8	0	0.056	100.8	0	0
1120	W.C	5	2D	2	1	28	310	100	1800	0.056	100.8	0	0.056	100.8	0	0
1150	W.C	20	2D	12	1	28	450	100	1800	0.336	604.8	8	0.112	201.6	0.224	403.2
1160	W.C	16	2D	8	1	28	450	100	1800	0.224	403.2	6	0.056	100.8	0.168	302.4
1200	W.C	16	2D	12	1	28	450	100	1800	0.336	604.8	8	0.112	201.6	0.224	403.2
1210	W.C	20	2D	8	1	28	450	100	1800	0.224	403.2	6	0.056	100.8	0.168	302.4
	Corridor	200	PL	28	1	28	600	150	1800	0.784	1,411	14	0.392	705.6	0.392	705.6
	Corridor	458	FL	34	4	18	800	150	1800	2.448	4,406	60	1.368	2,462.4	1.08	1,944
	Lobbies	106	FL	18	2	18	600	150	1800	0.648	1,166	16	0.36	648	0.288	518.4

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
Ground Floor																
G0010	Cafeteria	108	FL	12	2	36	700	150	1800	0.864	1,555	16	0.27	486	0.576	1,037
G0020	Service	15	FL	2	2	36	150	200	1800	0.144	259.2	0	0.144	259.2	0	0
G0030	Safety-Lab	74	FL	10	2	36	500	500	1800	0.720	1,296	4	0.576	1,036.8	0.144	259.2
G0040	Mechanic Vibration	74	FL	12	2	36	540	500	1800	0.864	1,555	4	0.720	1,296	0.144	259.2
G0050	Fluid Mechanic	74	FL	12	2	36	550	500	1800	0.864	1,555	4	0.720	1,296	0.144	259.2
G0060	Lecture Hall	270	FL	45	4	18	800	300	1800	3.240	5,832	68	2.016	3,628.8	1.224	2,203
G0070	Machine Design	50	FL	9	2	36	580	500	1800	0.648	1,166	4	0.504	907.2	0.144	259.2
G0080	Aero-dynamics	85	FL	12	2	36	600	500	1800	0.864	1,555	6	0.648	1,166.4	0.216	388.8
G0110	CLASS	47	FL	7	2	36	580	300	1600	0.504	806.4	4	0.288	460.8	0.144	230.4
G0120	CLASS	54	FL	7	2	36	600	300	1600	0.504	806.4	6	0.288	460.8	0.216	345.6
G0130	Comp-Lab	121	FL	18	2	36	500	500	1800	1.296	2,333	8	1.008	1,814.4	0.288	518.4
G0140	CLASS	54	FL	7	2	36	590	300	1600	0.504	806.4	6	0.288	460.8	0.216	345.6
G0150	CLASS	53	FL	7	2	36	600	300	1600	0.504	806.4	6	0.288	460.8	0.216	345.6
G0180	Thermo-Dynamics	86	FL	12	2	36	400	500	1800	0.864	1,555	0	0.864	1,555.2	0	0
G0190	CLASS	52	FL	7	2	36	600	300	1600	0.504	806.4	6	0.288	460.8	0.216	345.6
G0220	Unit Operation	114	FL	20	2	36	550	500	1800	1.44	2,592	10	1.08	1,944	0.36	648
G0230	Comp-Lab	104	FL	18	2	36	450	500	1800	1.296	2,333	4	1.152	2,073.6	0.144	259.2
G0240	Comp-Lab	54	FL	10	2	36	410	500	1800	0.720	1,296	0	0.720	1,296	0	0
G0250	CLASS	54	FL	7	2	36	500	300	1600	0.504	806.4	4	0.36	576	0.144	230.4
G0260	CLASS	54	FL	7	2	36	500	300	1600	0.504	806.4	4	0.36	576	0.144	230.4

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
G0090	W.C	20	2D	12	1	28	450	100	1800	0.336	604.8	8	0.112	201.6	0.224	403.2
G0100	W.C	16	2D	8	1	28	450	100	1800	0.224	403.2	6	0.056	100.8	0.168	302.4
G0160	W.C	15	2D	8	1	28	450	100	1800	0.224	403.2	6	0.056	100.8	0.168	302.4
G0170	W.C	20	2D	12	1	28	450	100	1800	0.336	604.8	8	0.112	201.6	0.224	403.2
G0200	W.C	5	2D	2	1	28	300	100	1800	0.056	100.8	0	0.056	100.8	0	0
G0210	W.C	5	2D	2	1	28	300	100	1800	0.056	100.8	0	0.056	100.8	0	0
	Corridor	535	FL	50	4	18	800	150	1800	3.600	6,480	100	1.8	3,240	1.8	3,240
	Lobbies	106	PL	18	2	18	600	150	1800	0.648	1,166	16	0.36	648	0.288	518.4
	Entrance	146	PL	20	2	18	900	200	1800	0.720	1,296	7	0.594	1,069.2	0.126	226.8
			FL	14	1	36				0.504	907.2	10	0.144	259.2	0.36	648
B1 Floor																
B1030	Traffic-Lab	60	FL	10	2	36	410	500	1800	0.720	1,296	0	0.720	1,296	0	0
B1040	Soil Mechanics	72	FL	12	2	36	500	500	1800	0.864	1,555	4	0.720	129.6	0.144	259.2
B1050	Electrical Circuits	164	FL	20	2	36	560	500	1800	1.44	2,592	8	1.152	2,0773.6	0.288	518.4
B1060	CLASS	72	FL	12	2	36	510	300	1600	0.864	1,382	6	0.648	1,036.8	0.216	345.6
B1070	Survey Lab	60	FL	10	2	36	420	500	1800	0.720	1,296	0	0.720	1,296	0	0
B1100	Communic. Lab	85	FL	16	2	36	600	500	1800	1.152	2,074	12	0.720	1,296	0.432	777.6
B1110	Digital-Lab	51	FL	12	2	36	520	500	1800	0.864	1,555	0	0.864	1,555.2	0	0
B1140	Electronic Circuits	109	FL	20	2	36	400	500	1800	1.44	2,592	0	1.44	2,592	0	0
B1150	Network Lab	104	FL	15	2	36	350	500	1800	1.080	1,944	0	1.080	1,944	0	0
B1160	Microproc. Lab	51	FL	8	2	36	360	500	1800	0.576	1,037	0	0.576	1,037	0	0

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
B1170	Control Systems	112	FL	12	2	36	430	500	1800	0.864	1,555	0	0.864	1,555.2	0	0
B1180	Reactor Lab	52	FL	8	2	36	350	500	1800	0.576	1,037	0	0.576	1,037	0	0
B1190	Control Lab	78	FL	11	2	36	470	500	1800	0.792	1,426	0	0.792	1,426	0	0
B1200	Hydraulic	86	FL	12	2	36	540	500	1800	0.864	1,555	4	0.720	129.6	0.144	259.2
B1210	Machines Lab	86	FL	12	2	36	540	500	1800	0.864	1,555	4	0.720	129.6	0.144	259.2
B1010	W.C	11	2D	8	1	28	450	100	1800	0.224	403.2	6	0.056	100.8	0.168	302.4
B1020	W.C	11	2D	8	1	28	450	100	1800	0.224	403.2	6	0.056	100.8	0.168	302.4
B1080	W.C	16	2D	8	1	28	460	100	1800	0.224	403.2	6	0.056	100.8	0.168	302.4
B1090	W.C	21	2D	12	1	28	490	100	1800	0.336	604.8	8	0.112	201.6	0.224	403.2
B1120	W.C	5	2D	5	1	28	320	100	1800	0.140	252	3	0.056	100.8	0.084	151.2
B1130	W.C	5	2D	5	1	28	300	100	1800	0.140	252	3	0.056	100.8	0.084	151.2
	Corridor	300	FL	40	4	18	600	150	1800	2.880	5,184	80	1.44	2,592	1.44	2,592
	Lobbies	118	PL	18	2	18	460	150	1800	0.648	1,166	12	0.432	777.6	0.216	388.8
B2 Floor																
B2010	Electrical Room	70	FL	10	2	36	300	150	100	0.720	72	10	0.36	36	0.36	36
B2040	Concrete Lab	80	FL	16	2	36	600	500	1800	1.152	2,074	8	0.864	1,555.2	0.288	518.4
B2050	Carving & Modeling	50	FL	8	2	36	500	500	1800	0.576	1,037	4	0.432	777.6	0.144	259.2
B2080	Transporta. Lab	86	FL	16	2	36	700	500	1800	1.152	2,074	12	0.72	1,296	0.432	777.6
B2090	Maintenan. Lab	80	FL	15	2	36	900	500	1800	1.080	1,944	12	0.648	1,166.4	0.432	777.6

Area #	Area Type	Area m²	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
B2100	Workshop	293	FL	46	2	36	650	300	1800	3.312	5,962	20	2.592	4,665.6	0.72	1,296
B2110	Boiler Room	115	FL	12	2	36	450	200	100	0.864	86.4	14	0.36	36	0.504	50.4
B2120	Generator Room	38	FL	6	2	36	280	150	100	0.432	43.2	4	0.288	28.8	0.144	14.4
B2130	Transform. Room	72	FL	6	2	36	250	150	100	0.432	43.2	4	0.288	28.8	0.144	14.4
B2020	W.C	11	2D	8	1	28	500	100	1800	0.224	403.2	6	0.056	100.8	0.168	302.4
B2030	W.C	15	2D	8	1	28	450	100	1800	0.224	403.2	6	0.056	100.8	0.168	302.4
B2060	W.C	5	2D	2	1	28	250	100	1800	0.056	100.8	0	0.056	100.8	0	0
B2070	W.C	5	2D	2	1	28	250	100	1800	0.056	100.8	0	0.056	100.8	0	0
	Corridor	104	2D	14	1	28	600	150	1800	0.392	705.6	7	0.196	352.8	0.196	352.8
	Lobbies	56	PL	9	2	18	460	150	1800	0.324	583.2	6	0.216	388.8	0.108	194.4
Total				**1,711**	**3,914**					**108.156**	**179,269**	**1,381**	**74.65**	**127,426**	**33.506**	**51,843**

Faculties of Science, IT, and Optometry

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
2nd Floor																
2010	Visual Room	50	FL	6	3	36	408	600	1000	0.648	648	0	0.648	648	0	0
2020	Meeting Room	71	FL	8	3	36	550	600	800	0.864	691.2	0	0.864	691.2	0	0
2030	OFFICE	13	FL	2	4	18	620	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2040	OFFICE	12	FL	2	4	18	490	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2050	OFFICE	13	FL	2	4	18	550	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2060	OFFICE	13	FL	2	4	18	540	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2070	OFFICE	41	FL	6	4	18	810	250	600	0.432	259.2	8	0.288	172.8	0.144	86.4
2861	OFFICE	19	FL	4	4	18	990	250	600	0.288	172.8	6	0.18	108	0.108	64.8
2860	OFFICE	19	FL	4	4	18	1100	250	600	0.288	172.8	6	0.18	108	0.108	64.8
2850	OFFICE	19	FL	4	4	18	1200	250	600	0.288	172.8	6	0.18	108	0.108	64.8
2840	Guest Room	37	FL	6	3	36	650	700	600	0.648	388.8	0	0.648	388.8	0	0
2750	OFFICE	7	FL	2	4	18	630	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2760	OFFICE	6	FL	2	4	18	860	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2770	OFFICE	7	FL	2	4	18	590	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2780	OFFICE	11	FL	3	4	18	845	250	600	0.216	129.6	4	0.072	43.2	0.072	43.2
2800	OFFICE	8	FL	2	4	18	840	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2810	OFFICE	8	FL	2	4	18	870	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2090	OFFICE	7	FL	1	4	18	570	250	600	0.072	43.2	0	0.072	43.2	0	0
2100	OFFICE	7	FL	1	4	18	577	250	600	0.072	43.2	0	0.072	43.2	0	0
2110	OFFICE	7	FL	1	4	18	565	250	600	0.072	43.2	0	0.072	43.2	0	0
2120	OFFICE	7	FL	1	4	18	550	250	600	0.072	43.2	0	0.072	43.2	0	0

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
2130	OFFICE	7	FL	1	4	18	560	250	600	0.072	43.2	0	0.072	43.2	0	0
2140	OFFICE	7	FL	1	4	18	533	250	600	0.072	43.2	0	0.072	43.2	0	0
2150	OFFICE	7	FL	1	4	18	540	250	600	0.072	43.2	0	0.072	43.2	0	0
2160	OFFICE	7	FL	1	4	18	531	250	600	0.072	43.2	0	0.072	43.2	0	0
2170	OFFICE	7	FL	1	4	18	524	250	600	0.072	43.2	0	0.072	43.2	0	0
2180	OFFICE	7	FL	1	4	18	544	250	600	0.072	43.2	0	0.072	43.2	0	0
2190	OFFICE	7	FL	1	4	18	552	250	600	0.072	43.2	0	0.072	43.2	0	0
2200	OFFICE	6	FL	1	4	18	578	250	600	0.072	43.2	0	0.072	43.2	0	0
2460	OFFICE	8	FL	2	4	18	480	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2470	OFFICE	8	FL	2	4	18	422	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2490	OFFICE	10	FL	2	4	18	493	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2500	OFFICE	7	FL	2	4	18	433	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2510	OFFICE	7	FL	2	4	18	487	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2520	OFFICE	7	FL	2	4	18	445	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2530	OFFICE	7	FL	2	4	18	487	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2540	OFFICE	6	FL	2	4	18	470	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2550	OFFICE	7	FL	2	4	18	448	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2560	OFFICE	7	FL	2	4	18	460	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2570	OFFICE	7	FL	2	4	18	490	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2580	OFFICE	7	FL	2	4	18	540	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2610	OFFICE	7	FL	2	4	18	840	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2620	OFFICE	8	FL	2	4	18	853	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2630	OFFICE	8	FL	2	4	18	842	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2640	OFFICE	8	FL	2	4	18	844	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2650	OFFICE	8	FL	2	4	18	817	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2660	OFFICE	8	FL	2	4	18	825	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
2690	OFFICE	7	FL	2	4	18	840	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2700	OFFICE	7	FL	2	4	18	850	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2710	OFFICE	7	FL	2	4	18	700	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2720	OFFICE	7	FL	2	4	18	780	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2730	OFFICE	6	FL	2	4	18	660	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2740	OFFICE	7	FL	2	4	18	670	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2210	OFFICE	7	FL	2	4	18	650	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2220	OFFICE	7	FL	2	4	18	644	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2230	OFFICE	7	FL	2	4	18	643	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2240	OFFICE	7	FL	2	4	18	665	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2250	OFFICE	7	FL	2	4	18	670	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2260	OFFICE	7	FL	2	4	18	683	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2270	OFFICE	7	FL	2	4	18	673	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2280	OFFICE	8	FL	2	4	18	653	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2290	OFFICE	16	FL	6	4	18	1020	250	600	0.432	259.2	10	0.252	151.2	0.18	108
2300	OFFICE	7	FL	2	4	18	644	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2310	OFFICE	15	FL	6	4	18	1029	250	600	0.432	259.2	10	0.252	151.2	0.18	108
2320	OFFICE	9	FL	2	4	18	580	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2330	OFFICE	10	FL	2	4	18	400	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2340	OFFICE	9	FL	2	4	18	410	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2350	OFFICE	14	FL	4	4	18	867	250	600	0.288	172.8	6	0.18	108	0.108	64.8
2360	OFFICE	8	FL	2	4	18	620	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2370	OFFICE	7	FL	2	4	18	660	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2380	OFFICE	7	FL	2	4	18	680	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2390	OFFICE	7	FL	2	4	18	650	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2400	OFFICE	7	FL	2	4	18	690	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
2410	OFFICE	7	FL	2	4	18	630	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
2420	OFFICE	8	FL	2	4	18	600	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2430	OFFICE	8	FL	2	4	18	520	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
2670	W.C	14	PL	4	2	9	300	100	1800	0.072	129.6	4	0.036	64.8	0.036	64.8
			FL	2	1	18				0.036	64.8	0	0.036	64.8	0	0
2680	W.C	10	PL	3	2	9	250	100	1800	0.054	97.2	2	0.036	64.8	0.018	32.4
			FL	2	1	18				0.036	64.8	0	0.036	64.8	0	0
2590	W.C	10	PL	3	2	9	260	100	1800	0.054	97.2	2	0.036	64.8	0.018	32.4
			FL	2	1	18				0.036	64.8	0	0.036	64.8	0	0
2090	W.C	15	PL	4	2	9	290	100	1800	0.072	129.6	4	0.036	64.8	0.036	64.8
			FL	2	1	18				0.036	64.8	0	0.036	64.8	0	0
	Corridor	434	FL	56	4	18	400	150	1800	4.032	7,258	68	2.808	5,054.4	1.224	2,203
1st Floor																
1720	OFFICE	24	FL	6	4	18	700	250	600	0.432	259.2	8	0.288	172.8	0.144	86.4
1710	OFFICE	20	FL	4	4	18	560	250	600	0.288	172.8	4	0.216	129.6	0.072	43.2
1730	OFFICE	27	FL	6	4	18	703	250	600	0.432	259.2	8	0.288	172.8	0.144	86.4
1700	OFFICE	40	FL	6	4	18	550	250	600	0.432	259.2	6	0.324	194.4	0.108	64.8
1690	OFFICE	18	FL	4	4	18	744	250	600	0.288	172.8	6	0.18	108	0.108	64.8
1680	OFFICE	19	FL	4	4	18	700	250	600	0.288	172.8	6	0.18	108	0.108	64.8
1670	OFFICE	18	FL	4	4	18	540	250	600	0.288	172.8	4	0.216	129.6	0.072	43.2
1660	OFFICE	16	FL	4	4	18	640	250	600	0.288	172.8	4	0.216	129.6	0.072	43.2
1010	OFFICE	21	FL	4	4	18	560	250	600	0.288	172.8	4	0.216	129.6	0.072	43.2
1020	OFFICE	20	FL	4	4	18	460	250	600	0.288	172.8	4	0.216	129.6	0.072	43.2
1030	OFFICE	19	FL	4	4	18	750	250	600	0.288	172.8	6	0.18	108	0.108	64.8
1040	OFFICE	20	FL	4	4	18	760	250	600	0.288	172.8	6	0.18	108	0.108	64.8
1050	CLASS	40	FL	6	3	36	580	300	1600	0.648	1,037	3	0.54	864	0.108	172.8

Area #	Area Type	Area m²	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
1060	CLASS	40	FL	6	3	36	400	300	1600	0.648	1,037	3	0.54	864	0.108	172.8
1570	OFFICE	7	FL	2	4	18	740	250	600	0.144	86.4	4	0.216	129.6	0.072	43.2
1580	OFFICE	7	FL	2	4	18	670	250	600	0.144	86.4	4	0.216	129.6	0.072	43.2
1590	OFFICE	7	FL	2	4	18	820	250	600	0.144	86.4	4	0.216	129.6	0.072	43.2
1600	OFFICE	10	FL	3	4	18	620	250	600	0.216	129.6	4	0.144	86.4	0.072	43.2
1620	OFFICE	7	FL	2	4	18	820	250	600	0.144	86.4	4	0.216	129.6	0.072	43.2
1630	OFFICE	7	FL	2	4	18	600	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
1080	OFFICE	7	FL	2	4	18	760	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
1090	OFFICE	7	FL	2	4	18	750	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
1100	OFFICE	7	FL	2	4	18	749	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
1110	OFFICE	7	FL	2	4	18	735	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
1120	OFFICE	7	FL	2	4	18	740	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
1130	OFFICE	8	FL	2	4	18	720	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
1140	OFFICE	8	FL	2	4	18	715	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
1150	OFFICE	7	FL	2	4	18	755	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
1160	OFFICE	7	FL	2	4	18	730	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
1170	OFFICE	7	FL	2	4	18	710	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
1180	OFFICE	7	FL	2	4	18	750	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
1190	OFFICE	7	FL	2	4	18	753	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
1280	OFFICE	7	FL	2	4	18	590	250	600	0.144	86.4	2	0.108	64.8	0.0.36	21.6
1290	OFFICE	7	FL	2	4	18	750	250	600	0.144	86.4	4	0.216	129.6	0.072	43.2
1310	OFFICE	10	FL	3	4	18	550	250	600	0.216	129.6	4	0.072	43.2	0.072	43.2
1320	OFFICE	9	FL	3	4	18	600	250	600	0.216	129.6	4	0.072	43.2	0.072	43.2
1510	OFFICE	7	FL	2	4	18	830	250	600	0.144	86.4	4	0.216	129.6	0.072	43.2
1520	OFFICE	7	FL	2	4	18	955	250	600	0.144	86.4	4	0.216	129.6	0.072	43.2
1530	OFFICE	7	FL	2	4	18	897	250	600	0.144	86.4	4	0.216	129.6	0.072	43.2

Area #	Area Type	Area m²	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
1540	OFFICE	7	FL	2	4	18	1110	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
1550	OFFICE	7	FL	2	4	18	1100	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
1560	OFFICE	7	FL	2	4	18	1050	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
1200	CLASS	64	FL	9	3	36	620	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
1210	CLASS	66	FL	9	3	36	600	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
1220	CLASS	66	FL	9	3	36	950	300	1600	0.972	1,555	8	0.684	1,094.4	0.288	460.8
1230	CLASS	65	FL	9	3	36	690	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
1240	Comp-Lab	101	FL	18	2	36	630	500	1800	1.296	2,333	8	1.008	1,814.4	0.288	518.4
1250	Comp-Lab	98	FL	18	2	36	600	500	1800	1.296	2,333	6	1.08	1,944	0.216	388.8
1640	W.C	14	PL	4	2	9	290	100	1800	0.072	129.6	4	0.036	64.8	0.036	64.8
			FL	2	1	18				0.036	64.8	0	0.036	64.8	0	0
1650	W.C	10	PL	3	2	9	260	100	1800	0.054	97.2	2	0.036	64.8	0.018	32.4
			FL	2	1	18				0.036	64.8	0	0.036	64.8	0	0
1060	W.C	10	PL	3	2	9	260	100	1800	0.054	97.2	2	0.036	64.8	0.018	32.4
			FL	2	1	18				0.036	64.8	0	0.036	64.8	0	0
1070	W.C	15	PL	4	2	9	310	100	1800	0.072	129.6	4	0.036	64.8	0.036	64.8
			FL	2	1	18				0.036	64.8	0	0.036	64.8	0	0
	Corridor	476	FL	51	4	18	300	150	1800	3.672	6,610	60	2.592	4,665.6	1.08	1,944
Ground Floor																
G360	OFFICE	24	FL	6	4	18	710	250	600	0.432	259.2	8	0.288	172.8	0.144	86.4
G350	OFFICE	20	FL	4	4	18	740	250	600	0.288	172.8	6	0.18	108	0.108	64.8
G370	OFFICE	27	FL	6	4	18	540	250	600	0.432	259.2	6	0.324	194.4	0.108	64.8
G340	CLASS	40	FL	6	3	36	590	300	1600	0.648	1,037	4	0.504	80.6.4	0.144	230.4
G330	OFFICE	18	FL	4	4	18	860	250	600	0.288	172.8	6	0.18	108	0.108	64.8
G320	OFFICE	19	FL	4	4	18	600	250	600	0.288	172.8	4	0.216	129.6	0.072	43.2
G310	OFFICE	19	FL	4	4	18	450	250	600	0.288	172.8	4	0.216	129.6	0.072	43.2

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
G300	OFFICE	17	FL	4	4	18	430	250	600	0.288	172.8	4	0.216	129.6	0.072	43.2
G010	CLASS	41	FL	6	3	36	930	300	1600	0.648	1,037	8	0.36	576	0.288	460.8
G020	CLASS	10	FL	6	3	36	560	300	1600	0.648	1,037	6	0.432	691.2	0.216	129.6
G030	CLASS	41	FL	6	3	36	460	300	1600	0.648	1,037	3	0.54	864	0.108	172.8
G040	CLASS	40	FL	6	3	36	400	300	1600	0.648	1,037	3	0.54	864	0.108	172.8
G240	CLASS	61	FL	9	3	36	880	300	1600	0.972	1,555	9	0.648	1,036.8	0.324	518.4
G230	CLASS	65	FL	9	3	36	670	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	129.6
G220	CLASS	65	FL	9	3	36	660	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	129.6
G210	CLASS	61	FL	9	3	36	520	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	129.6
G060	CLASS	12	FL	1	4	18	235	300	1600	0.072	115.2	0	0.072	115.2	0	0
G070	CLASS	68	FL	6	3	36	735	300	1600	0.648	1,037	6	0.432	691.2	0.216	345.6
G080	CLASS	68	FL	6	3	36	750	300	1600	0.648	1,037	6	0.432	691.2	0.216	345.6
G090	CLASS	68	FL	6	3	36	740	300	1600	0.648	1,037	6	0.432	691.2	0.216	345.6
G110	CLASS	67	FL	9	3	36	930	300	1600	0.972	1,555	9	0.648	1,036.8	0.324	518.4
G160	COM-LAB	98	FL	18	2	36	450	500	1800	1.296	2,333	0	1.296	2,333	0	0
G150	COM-LAB	101	FL	18	2	36	500	500	1800	1.296	2,333	0	1.296	2,333	0	0
G120	CLASS	68	FL	9	3	36	800	300	1600	0.972	1,555	9	0.648	1,036.8	0.324	518.4
G130	CLASS	70	FL	9	3	36	500	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
G140	CLASS	67	FL	12	2	36	420	300	1600	0.846	1,354	3	0.738	1,180.8	0.108	172.8
	Corridor	417	FL	46	4	18	450	150	1800	3.312	5,962	60	2.232	4,017.6	1.08	1,944
G170	W.C	15	PL	4	2	9	330	100	1800	0.072	129.6	4	0.036	64.8	0.036	64.8
			FL	2	1	18				0.036	64.8	0	0.036	64.8	0	0
G180	W.C	31	PL	6	2	9	250	100	1800	0.108	194.4	6	0.054	97.2	0.054	97.2
			FL	2	1	18				0.036	64.8	0	0.036	64.8	0	0
G250	W.C	31	PL	6	2	9	270	100	1800	0.108	194.4	6	0.054	97.2	0.054	97.2
			FL	2	1	18				0.036	64.8	0	0.036	64.8	0	0

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
G050	W.C	15	PL	4	2	9	310	100	1800	0.072	129.6	4	0.036	64.8	0.036	64.8
			PL	2	1	18				0.036	64.8	0	0.036	64.8	0	0
B1 Floor																
B1220	CLASS	35	FL	9	3	36	700	300	1600	0.972	1,555	9	0.648	1,036.8	0.324	518.4
B1210	CLASS	35	FL	9	3	36	600	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
B1200	CLASS	35	FL	9	3	36	490	300	1600	0.972	1,555	3	0.864	1,382.4	0.108	172.8
B1190	CLASS	35	FL	9	3	36	460	300	1600	0.972	1,555	3	0.864	1,382.4	0.108	172.8
B1010	SERVER ROOM	7	FL	1	4	18	300	200	200	0.072	14.4	0	0.072	14.4	0	0
B1020	OFFICE	17	FL	3	3	36	280	250	600	0.324	194.4	0	0.324	194.4	0	0
B1030	EMPTY	17	FL	3	3	36	360	200	100	0.324	32.4	3	0.216	21.6	0.108	10.8
B1040	PH-LAB	38	FL	9	3	36	750	500	1800	0.972	1,750	6	0.756	1,360.8	0.216	388.8
B1050	PH-LAB	39	FL	9	3	36	800	500	1800	0.972	1,750	6	0.756	1,360.8	0.216	388.8
B1140	CLASS	60	FL	9	3	36	800	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
B1130	COM-LAB	60	FL	12	4	18	550	500	1800	0.864	1,555	0	0.864	1,555	0	0
B1120	COM-LAB	60	FL	12	4	18	550	500	1800	0.864	1,555	0	0.864	1,555	0	0
B1070	RES-LAB	32	FL	3	3	36	340	500	1800	0.324	583.2	0	0.324	583.2	0	0
B1090	CLASS	65	FL	9	3	36	800	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
B1100	CLASS	65	FL	9	3	36	840	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
B1110	CLASS	65	FL	9	3	36	900	300	1600	0.972	1,555	9	0.648	1,036.8	0.324	518.4
B1060	W.C	15	PL	4	2	9	320	100	1800	0.072	129.6	4	0.036	64.8	0.036	64.8
			FL	2	1	18				0.036	64.8	0	0.036	64.8	0	0
B1070	W.C	31	PL	6	2	9	220	100	1800	0.108	194.4	6	0.054	97.2	0.054	97.2
			FL	2	1	18				0.036	64.8	0	0.036	64.8	0	0
B1120	W.C	31	PL	6	2	9	240	100	1800	0.108	194.4	6	0.054	97.2	0.054	97.2
			FL	2	1	18				0.036	64.8	0	0.036	64.8	0	0
	Corridor	334	FL	38	4	18	350	150	1800	2.736	4,925	52	1.8	3,240	0.936	1,685

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
B2 Floor																
B2260	BIO-LAB	62	FL	9	3	36	620	500	1800	0.972	1,750	3	0.864	1,555.2	0.108	194.4
B2250	BIO-LAB	57	FL	9	3	36	825	500	1800	0.972	1,750	9	0.648	1,166.4	0.324	583.2
B2240	BIO-LAB	57	FL	9	3	36	820	500	1800	0.972	1,750	9	0.648	1,166.4	0.324	583.2
B2230	BIO-LAB	62	FL	9	3	36	480	500	1800	0.972	1,750	0	0.972	1,750	0	0
B2251	OFFICE	12	FL	2	4	18	500	250	600	0.144	86.4	2	0.108	64.8	0.036	21.6
B2241	OFFICE	12	FL	2	4	18	450	250	600	0.144	86.4	2	0.108	64.8	0.036	21.6
B2010	STORE	34	FL	3	3	36	380	200	100	0.324	32.4	3	0.216	21.6	0.108	10.8
B2020	STRILIZE.	34	FL	3	3	36	820	500	1000	0.324	324	3	0.216	216	0.108	108
B0300	BIO-LAB	85	FL	12	3	36	800	500	1800	1.296	2,333	9	0.972	1,749.6	0.324	583.2
B2032	OFFICE	11	FL	2	4	18	500	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
B2031	OFFICE	11	FL	2	4	18	840	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
B2040	BIO-LAB	85	FL	12	3	36	720	500	1800	1.296	2,333	9	0.972	1,749.6	0.324	583.2
B2160	CLASS	39	FL	9	3	36	600	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
B2150	CLASS	39	FL	9	3	36	810	300	1600	0.972	1,555	9	0.648	1,036.8	0.324	518.4
B2170	INCBATO	8	FL	2	4	18	290	200	1000	0.144	144	2	0.108	108	0.036	36
B2180	INCBATO	8	FL	2	4	18	250	200	1000	0.144	144	0	0.144	144	0	0
B2130	Cold-Room	11	FL	2	4	18	415	250	1000	0.144	144	4	0.072	72	0.072	72
B2120	PREPAR.	11	FL	2	4	18	500	500	1600	0.144	230.4	0	0.144	230.4	0	0
B2140	OFFICE	11	FL	2	4	18	420	250	600	0.144	86.4	2	0.108	64.8	0.036	21.6
B2111	INSTRU.	11	FL	2	4	18	320	150	1600	0.144	230.4	4	0.072	115.2	0.072	115.2
B2050	RES-LAB	17	FL	6	4	18	380	500	1800	0.432	777.6	0	0.432	777.6	0	0
B2060	RES-LAB	17	FL	6	4	18	580	500	1800	0.432	777.6	4	0.36	648	0.072	129.6
B2070	RES-LAB	17	FL	6	4	18	360	500	1800	0.432	777.6	0	0.432	777.6	0	0
B2080	RES-LAB	17	FL	6	4	18	520	500	1800	0.432	777.6	0	0.432	777.6	0	0
B2090	CLASS	39	FL	9	3	36	750	300	1600	0.972	1,555	9	0.648	1,036.8	0.324	518.4

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
B2100	CLASS	39	FL	9	3	36	880	300	1600	0.972	1,555	9	0.648	1,036.8	0.324	518.4
B2110	W.C	15	PL	4	2	9	300	100	1800	0.072	129.6	4	0.036	64.8	0.036	64.8
			FL	2	1	18				0.036	64.8	0	0.036	64.8	0	0
B2200	W.C	31	PL	6	2	9	240	100	1800	0.108	194.4	6	0.054	97.2	0.054	97.2
			FL	2	1	18				0.036	64.8	0	0.036	64.8	0	0
B2210	W.C	31	PL	6	2	9	250	100	1800	0.108	194.4	6	0.054	97.2	0.054	97.2
			FL	2	1	18				0.036	64.8	0	0.036	64.8	0	0
B2270	W.C	7	PL	2	2	9	350	100	1800	0.036	64.8	2	0.018	32.4	0.018	32.4
			FL	2	1	18				0.036	64.8	0	0.036	64.8	0	0
B2280	W.C	7	PL	2	2	9	340	100	1800	0.036	64.8	2	0.018	32.4	0.018	32.4
			FL	2	1	18				0.036	64.8	0	0.036	64.8	0	0
	Corridor	274	FL	30	4	18	380	150	1800	2.160	3,888	40	1.44	2,592	0.72	1,296
B3 Floor																
B3290	RES-LAB	17	FL	3	3	36	400	500	1800	0.324	583.2	0	0.324	583.2	0	0
B3280	RES-LAB	17	FL	3	3	36	490	500	1800	0.324	583.2	0	0.324	583.2	0	0
B3270	CLASS	61	FL	12	3	36	700	300	1600	1.296	2,233	9	0.972	1,555.2	0.324	518.4
B3274	PREPAR.	7	FL	2	4	18	660	300	1600	0.144	230.4	4	0.072	115.2	0.072	115.2
B3271	TECHNIC.	7	FL	2	4	18	1000	200	100	0.144	14.4	4	0.072	7.2	0.072	7.2
B3273	STERILIZ.	7	FL	2	4	18	650	300	1000	0.144	144	4	0.072	72	0.072	72
B3272	INCUBAT.	7	FL	2	4	18	640	300	1000	0.144	144	4	0.072	72	0.072	72
B3260	BIO-LAB	61	FL	12	3	36	460	500	1800	1.296	2,233	0	1.296	2,233	0	0
B3300	BIO-LAB	31	FL	9	3	36	300	500	1800	0.972	1,750	0	0.972	1,750	0	0
B3250	BIO-LAB	39	FL	9	3	36	775	500	1800	0.972	1,750	6	0.756	1,360.8	0.216	388.8
B3240	BIO-LAB	39	FL	9	3	36	755	500	1800	0.972	1,750	6	0.756	1,360.8	0.216	388.8
B3230	BIO-LAB	39	FL	9	3	36	750	500	1800	0.972	1,750	6	0.756	1,360.8	0.216	388.8
B3220	BIO-LAB	39	FL	9	3	36	740	500	1800	0.972	1,750	6	0.756	1,360.8	0.216	388.8

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ Year
B3040	Cold Room	10	FL	2	4	18	220	250	600	0.144	86.4	0	0.144	86.4	0	0
B3050	Dark Room	8	FL	1	4	18	120	250	600	0.072	43.2	0	0.072	43.2	0	0
B3060	COM-LAB	18	FL	3	3	36	400	500	1800	0.324	583.2	0	0.324	583.2	0	0
B3070	PREPAR.	8	FL	1	4	18	180	300	1600	0.072	115.2	0	0.072	115.2	0	0
B3080	STORE	39	FL	4	4	18	230	200	100	0.288	28.8	0	0.288	28.8	0	0
B3170	CH-LAB	42	FL	12	3	36	450	500	1800	1.296	2,333	0	1.296	2,333	0	0
B3172	TECHNIC.	5	FL	2	4	18	900	200	200	0.144	259.2	6	0.036	7.2	0.108	21.6
B3171	PREPAR.	5	FL	2	4	18	650	300	1600	0.144	230.4	4	0.072	115.2	0.072	115.2
B3160	CH-LAB	42	FL	12	3	36	950	500	1800	1.296	2,333	9	0.972	1,749.6	0.324	583.2
B3180	OFFICE	8	FL	4	4	18	650	250	600	0.288	172.8	6	0.18	108	0.108	64.8
B3190	OFFICE	8	FL	4	4	18	330	250	600	0.288	172.8	4	0.216	129.6	0.072	43.2
B3152	OFFICE	8	FL	2	4	18	650	250	600	0.144	86.4	4	0.072	43.2.6	0.072	43.2
B3151	PREPAR.	8	FL	2	4	18	270	300	1600	0.144	230.4	0	0.144	230.4	0	0
B3150	INGR-LAB	53	FL	12	3	36	500	500	1800	1.296	2,333	0	1.296	2,333	0	0
B3110	LAB	20	FL	6	3	36	810	500	1800	0.648	1,166	6	0.432	777.6	0.216	388.8
B3120	RES-LAB	16	FL	3	3	36	280	500	1800	0.324	583.2	0	0.324	583.2	0	0
B3130	CLASS	34	FL	9	3	36	830	300	1600	0.972	1,555	9	0.648	1,036.8	0.324	518.4
B3140	CLASS	34	FL	9	3	36	680	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
B3090	W.C	15	PL	4	2	9	350	100	1800	0.072	129.6	4	0.036	64.8	0.036	64.8
			FL	2	1	18				0.036	64.8	0	0.036	64.8	0	0
B3010	W.C	10	PL	3	2	9	220	100	1800	0.054	97.2	3	0.027	48.6	0.027	48.6
			FL	1	1	18				0.018	32.4	0	0.018	32.4	0	0
B3020	W.C	10	PL	3	2	9	210	100	1800	0.054	97.2	3	0.027	48.6	0.027	48.6
			FL	1	1	18				0.018	32.4	0	0.018	32.4	0	0
	Corridor	604	FL	58	4	18	400	150	1800	4.176	7,517	88	2.592	4,665.6	1.584	2,851

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
B4 Floor																
B4250	CLASS	39	FL	9	3	36	640	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
B4240	CLASS	39	FL	9	3	36	820	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
B4230	CLASS	39	FL	9	3	36	860	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
B4220	CLASS	39	FL	9	3	36	780	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
B4210	CLASS	39	FL	9	3	36	800	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
B4260	STORE	31	FL	4	3	36	280	200	100	0.432	43.2	3	0.324	32.4	0.108	10.8
B4200	CH-LAB	42	FL	9	3	36	590	500	1800	0.972	1,750	3	0.864	1,555.2	0.108	194.4
B4190	CH-LAB	42	FL	9	3	36	580	500	1800	0.972	1,750	0	0.972	1,750	0.0	0
B4180	CH-LAB	42	FL	9	3	36	520	500	1800	0.972	1,750	0	0.972	1,750	0.0	0
B4170	CH-LAB	42	FL	9	3	36	500	500	1800	0.972	1,750	0	0.972	1,750	0	0
B4280	HALL	71	FL	8	3	36	450	500	1600	0.864	1,382	0	0.864	1,382	0	0
B4290	HALL	71	FL	8	3	36	400	500	1600	0.864	1,382	0	0.864	1,382	0	0
B4040	ROOM	25	FL	6	3	36	270	200	1600	0.648	1,037	3	0.54	864	0.108	172.8
B4050	COM-LAB	25	FL	6	3	36	380	500	1800	0.648	1,166	0	0.648	1,166	0	0
B4070	INSTRU.	25	FL	6	3	36	580	450	1600	0.648	1,037	6	0.432	691.2	0.216	345.6
B4160	CH-LAB	61	FL	15	3	36	880	500	1800	1.620	2,916	9	1.296	2,332.8	0.324	583.2
B4161	PREPAR.	7	FL	2	4	18	460	300	1600	0.144	230.4	4	0.072	115.2	0.072	115.2
B4162	TECHNIC.	7	FL	2	4	18	500	200	200	0.144	28.8	4	0.072	14.4	0.072	14.4
B4150	CH-LAB	61	FL	15	3	36	900	500	1800	1.620	2,916	9	1.296	2,332.8	0.324	583.2
B4110	OFFICE	8	FL	3	4	18	740	250	600	0.216	129.6	6	0.108	64.8	0.108	64.8
B4120	OFFICE	8	FL	2	2	36	270	250	600	0.144	86.4	0	0.144	86.4	0	0
B4141	TECHNIC.	8	FL	2	4	18	350	200	200	0.144	28.8	2	0.108	21.6	0.036	7.2
B4142	PREPAR.	8	FL	2	4	18	320	300	1600	0.144	230.4	0	0.144	230.4	0	0
B4140	CH-LAB	61	FL	12	3	36	380	500	1800	1.296	2,333	0	1.296	2,333	0	0
	Corridor	531	FL	52	4	18	400	150	1800	3.744	6,739	88	2.592	4,665.6	1.584	2,851

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
B4010	W.C	10	PL	3	2	9	220	100	1800	0.054	97.2	3	0.027	48.6	0.027	48.6
			FL	1	1	18				0.018	32.4	0	0.018	32.4	0	0
B4020	W.C	10	PL	3	2	9	210	100	1800	0.054	97.2	3	0.027	48.6	0.027	48.6
			FL	1	1	18				0.018	32.4	0	0.018	32.4	0	0
B4270	W.C	10	PL	3	2	9	250	100	1800	0.054	97.2	3	0.027	48.6	0.027	48.6
			FL	1	1	18				0.018	32.4	0	0.018	32.4	0	0
B4080	W.C	10	PL	3	2	9	230	100	1800	0.054	97.2	3	0.027	48.6	0.027	48.6
			FL	1	1	18				0.018	32.4	0	0.018	32.4	0	0
B5 Floor																
B5190	ELEC-SH	43	FL	9	3	36	500	450	1600	0.972	1,555	0	0.972	1,555	0	0
B5192	OFFICE	4	FL	2	4	18	750	250	600	0.144	86.4	4	0.072	43.2	0.072	43.2
B5191	STORE	6	FL	1	2	36	160	200	100	0.072	7.2	0	0.072	7.2	0	0
B5180	RESE.LAB	13	FL	6	4	18	420	500	1800	0.432	777.6	0	0.432	777.6	0	0
B5170	RESE.LAB	13	FL	6	4	18	445	500	1800	0.432	777.6	0	0.432	777.6	0	0
B5160	RESE.LAB	13	FL	6	4	18	450	500	1800	0.432	777.6	0	0.432	777.6	0	0
B5150	RESE.LAB	13	FL	6	4	18	430	500	1800	0.432	777.6	0	0.432	777.6	0	0
B5200	Glass-Ws	42	FL	9	3	36	420	450	1600	0.972	1,555	0	0.972	1,555	0	0
B5040	STORE	16	FL	6	2	36	180	200	100	0.432	43.2	0	0.432	43.2	0	0
B5050	STORE	11	FL	4	2	36	130	200	100	0.288	28.8	0	0.288	28.8	0	0
B5080	Dark Room	7	FL	3	4	18	450	250	600	0.216	129.6	4	0.144	86.4	0.072	43.2
B5070	Dark Room	7	FL	3	4	18	450	250	600	0.216	129.6	4	0.144	86.4	0.072	43.2
B5080	ROOM	10	FL	4	4	18	275	200	1600	0.288	460.8	4	0.216	345.6	0.072	115.2
B5090	ROOM	17	FL	6	4	18	280	200	1600	0. 432	691.2	4	0.216	345.6	0.072	115.2
B5140	CH-LAB	91	FL	15	3	36	650	500	1800	1.620	2,916	3	1.584	2,.721.6	0.108	194.4
B5142	TECHNIC.	9	FL	2	4	18	440	200	200	0.144	28.8	4	0.072	14.4	0.072	14.4
B5141	PREPAR.	9	FL	2	4	18	600	300	1600	0.144	230.4	4	0.072	115.2	0.072	115.2

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
B5130	CH-LAB	91	FL	15	3	36	850	500	1800	1.620	2,916	12	1.188	2,138.4	0.432	777.6
B5110	W.C	10	PL	3	2	9	260	100	1800	0.054	97.2	3	0.027	48.6	0.027	48.6
			FL	1	1	18				0.018	23.4	0	0.018	32.4	0	0
B5120	W.C	10	PL	3	2	9	250	100	1800	0.054	97.2	3	0.027	48.6	0.027	48.6
			FL	1	1	18				0.018	23.4	0	0.018	32.4	0	0
B5030	W.C	10	PL	3	2	9	250	100	1800	0.054	97.2	3	0.027	48.6	0.027	48.6
			FL	1	1	18				0.018	23.4	0	0.018	32.4	0	0
B5020	W.C	10	PL	3	2	9	240	100	1800	0.054	97.2	3	0.027	48.6	0.027	48.6
			FL	1	1	18				0.018	32.4	0	0.018	32.4	0	0
	Corridor	84	FL	8	4	18	400	150	1800	0.576	1,037	16	0.288	518.4	0.288	518.4
	Corridor	304	FL	41	2	36	420	150	1800	2.952	5,314	30	1.872	3,369.6	1.08	1,944
B6 Floor																
B6080	CH-LAB	100	FL	15	3	36	600	500	1800	1.620	2,916	0	1.620	2,916	0	0
B6082	TECHNIC.	11	FL	2	4	18	480	200	200	0.144	28.8	4	0.072	14.4	0.072	14.4
B6081	PREPAR.	11	FL	2	4	18	390		1600	0.144	259.2	4	0.072	115.2	0.072	115.2
B6070	CH-LAB	100	FL	15	3	36	560	500	1800	1.620	2,916	0	1.620	2,916	0	0
B6060	W.C	10	PL	3	2	9	240	100	1800	0.054	97.2	3	0.027	48.6	0.027	48.6
			FL	1	1	18				0.018	32.4	0	0.018	32.4	0	0
B6050	W.C	10	PL	3	2	9	240	100	1800	0.054	97.2	3	0.027	48.6	0.027	48.6
			FL	1	1	18				0.018	23.4	0	0.018	32.4	0	0
B6090	W.C	10	PL	3	2	9	270	100	1800	0.054	97.2	3	0.027	48.6	0.027	48.6
			FL	1	1	18				0.018	32.4	0	0.018	32.4	0	0
B6010	W.C	10	PL	3	2	9	260	100	1800	0.054	97.2	3	0.027	48.6	0.027	48.6
			FL	1	1	18				0.018	23.4	0	0.018	32.4	0	0
	Corridor	304	FL	40	2	36	420	150	1800	2.880	5,184	32	1.728	3,110.4	1.152	2,074
Total				**1,926**	**6,160**					**156.006**	**230,481**	**1,642**	**119.664**	**178,504**	**36.342**	**51,977**

Faculties of Fine Arts, Graduate Studies, and Law

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
3rd Floor																
3010	OFFICE	14	FL	4	4	18	620	250	600	0.288	172.8	6	0.180	108	0.108	64.8
3020	OFFICE	14	FL	4	4	18	760	250	600	0.288	172.8	8	0.144	86.4	0.144	86.4
3030	OFFICE	14	FL	4	4	18	900	250	600	0.288	172.8	8	0.144	86.4	0.144	86.4
3420	OFFICE	34	FL	8	4	18	260	250	600	0.576	345.6	0	0.576	345.6	0	0
3040	OFFICE	14	FL	4	4	18	670	250	600	0.288	172.8	6	0.180	108	0.108	64.8
3050	OFFICE	9	FL	3	4	18	665	250	600	0.216	129.6	4	0.144	86.4	0.072	43.2
3060	OFFICE	9	FL	3	4	18	650	250	600	0.216	129.6	4	0.144	86.4	0.072	43.2
3430	STORAGE	42	FL	4	2	36	500	200	100	0.288	28.8	4	0.144	14.4	0.144	14.4
3070	OFFICE	9	FL	3	4	18	670	250	600	0.216	129.6	4	0.144	86.4	0.072	43.2
3080	OFFICE	9	FL	3	4	18	665	250	600	0.216	129.6	4	0.144	86.4	0.072	43.2
3090	OFFICE	9	FL	3	4	18	740	250	600	0.216	129.6	6	0.108	64.8	0.108	64.8
3100	OFFICE	8	FL	3	4	18	700	250	600	0.216	129.6	4	0.144	86.4	0.072	43.2
3110	OFFICE	24	FL	6	4	18	630	250	600	0.432	259.2	8	0.324	194.4	0.144	86.4
3120	OFFICE	50	FL	8	4	18	450	250	600	0.576	345.6	6	0.468	280.8	0.108	64.8
			HL	4	1	50				0.200	120	2	0.100	60	0.100	60
3130	OFFICE	9	FL	3	4	18	570	250	600	0.216	129.6	4	0.144	86.4	0.072	43.2
3140	OFFICE	8	FL	3	4	18	920	250	600	0.216	129.6	6	0.108	64.8	0.108	64.8
3150	OFFICE	9	FL	3	4	18	800	250	600	0.216	129.6	6	0.108	64.8	0.108	64.8
3480	OFFICE	10	FL	2	2	36	550	250	600	0.144	86.4	0	0.144	86.4	0	0
3490	OFFICE	9	FL	3	4	18	650	250	600	0.216	129.6	4	0.144	86.4	0.072	43.2
3500	OFFICE	9	FL	3	4	18	540	250	600	0.216	129.6	4	0.144	86.4	0.072	43.2
3510	OFFICE	9	FL	3	4	18	600	250	600	0.216	129.6	6	0.108	64.8	0.108	64.8
3180	OFFICE	9	FL	3	4	18	650	250	600	0.216	129.6	6	0.108	64.8	0.108	64.8

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
3170	OFFICE	9	FL	3	4	18	670	250	600	0.216	129.6	4	0.144	86.4	0.072	43.2
3160	OFFICE	8	FL	3	4	18	700	250	600	0.216	129.6	6	0.108	64.8	0.108	64.8
3190	CLASS	50	FL	8	4	18	500	300	1600	0.576	921.6	8	0.432	691.2	0.144	259.2
			HL	4	1	50				0.200	320	2	0.100	160	0.100	160
3200	OFFICE	18	FL	6	4	18	610	250	600	0.432	259.2	8	0.288	172.8	0.144	86.4
3201	OFFICE	25	FL	6	4	18	570	250	600	0.432	259.2	8	0.288	172.8	0.144	86.4
3210	OFFICE	8	FL	3	4	18	675	250	600	0.216	129.6	6	0.108	64.8	0.108	64.8
3220	OFFICE	8	FL	3	4	18	720	250	600	0.216	129.6	6	0.108	64.8	0.108	64.8
3230	OFFICE	8	FL	3	4	18	700	250	600	0.216	129.6	6	0.108	64.8	0.108	64.8
3240	OFFICE	9	FL	3	4	18	730	250	600	0.216	129.6	6	0.108	64.8	0.108	64.8
3560	OFFICE	58	FL	9	3	36	790	250	600	0.972	583.2	9	0.648	388.8	0.324	194.4
3250	OFFICE	9	FL	3	4	18	770	250	600	0.216	129.6	6	0.108	64.8	0.108	64.8
3260	OFFICE	8	FL	3	4	18	780	250	600	0.216	129.6	6	0.108	64.8	0.108	64.8
3270	OFFICE	9	FL	3	4	18	720	250	600	0.216	129.6	6	0.108	64.8	0.108	64.8
3280	OFFICE	9	FL	3	4	18	700	250	600	0.216	129.6	6	0.108	64.8	0.108	64.8
3570	OFFICE	58	FL	9	3	36	620	250	600	0.972	583.2	9	0.648	388.8	0.324	194.4
3290	OFFICE	9	FL	3	4	18	680	250	600	0.216	129.6	6	0.108	64.8	0.108	64.8
3300	OFFICE	9	FL	3	4	18	700	250	600	0.216	129.6	6	0.108	64.8	0.108	64.8
3310	OFFICE	8	FL	3	4	18	720	250	600	0.216	129.6	6	0.108	64.8	0.108	64.8
3320	OFFICE	9	FL	3	4	18	700	250	600	0.216	129.6	6	0.108	64.8	0.108	64.8
3330	GUEST	38	FL	6	3	18	650	300	1800	0.324	583.2	6	0.216	388.8	0.108	194.4
3340	COUNCIL	49	FL	8	4	18	600	600	1800	0.576	1,037	0	0.576	1,036.8	0	0
3350	COUNCIL	49	FL	8	4	18	560	600	1800	0.576	1,037	0	0.576	1,036.8	0	0
	Corridor	386	FL	56	3	18	400	150	1800	3.024	5,443	84	1.512	2,721.6	1.512	2,722
3140	W.C	15	FL	2	1	36	250	100	1800	0.072	129.6	0	0.072	129.6	0	0
			FL	4	1	18				0.072	129.6	2	0.036	64.8	0.036	64.8

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ Year
3150	W.C	15	FL	2	1	36	220	100	1800	0.072	129.6	0	0.072	129.6	0	0
			FL	4	1	18				0.072	129.6	2	0.036	64.8	0.036	64.8
3360	W.C	15	FL	2	1	36	260	100	1800	0.072	129.6	0	0.072	129.6	0	0
			FL	4	1	18				0.072	129.6	2	0.036	64.8	0.036	64.8
3370	W.C	15	FL	2	1	36	240	100	1800	0.072	129.6	0	0.072	129.6	0	0
			FL	4	1	18				0.072	129.6	2	0.036	64.8	0.036	64.8
2nd Floor																
2020	CLASS	78	FL	9	3	36	720	300	1600	0.972	1,555	9	0.648	1,036.8	0.324	518.4
2170	CLASS	78	FL	9	3	36	630	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
2160	STUDIO	76	FL	9	3	36	726	300	1600	0.972	1,555	9	0.648	1,036.8	0.324	518.4
2030	CLASS	76	FL	9	3	36	710	300	1600	0.972	1,555	9	0.648	1,036.8	0.324	518.4
2040	CLASS	78	FL	9	3	36	690	300	1600	0.972	1,555	9	0.648	1,036.8	0.324	518.4
2060	CLASS	78	FL	9	3	36	590	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
2070	CLASS	78	FL	9	3	36	690	300	1600	0.972	1,555	9	0.648	1,036.8	0.324	518.4
2090	CLASS	76	FL	9	3	36	515	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
2100	CLASS	78	FL	9	3	36	570	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
2080	STUDIO	69	FL	8	3	36	580	300	1600	0.864	1,382	6	0.756	1,209.6	0.216	345.6
2110	STUDIO	63	FL	9	3	36	620	300	1600	0.972	1,555	9	0.648	1,036.8	0.324	518.4
2120	STUDIO	63	FL	9	3	36	590	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
2100	STUDIO	64	FL	9	3	36	540	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
2130	STUDIO	62	FL	9	3	36	485	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
2140	STUDIO	79	FL	9	3	36	490	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
2150	STUDIO	70	FL	8	3	36	560	300	1600	0.864	1,382	6	0.648	1,036.8	0.216	345.6
2200	OFFICE	20	FL	2	2	36	305	250	600	0.144	86.4	0	0.144	86.4	0	0
	Corridor	376	FL	52	3	18	350	150	1800	2.808	5,054	78	1.404	2,527.2	1.404	2,527
2050	W.C	13	FL	3	1	36	310	100	1800	0.108	194.4	1	0.072	129.6	0.036	64.8
			FL	4	1	18				0.072	129.6	2	0.036	64.8	0.036	64.8

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
2180	W.C	13	FL	3	1	36	300	100	1800	0.108	194.4	1	0.072	129.6	0.036	64.8
			FL	4	1	18				0.072	129.6	2	0.036	64.8	0.036	64.8
1st Floor																
1060	CLASS	80	FL	9	3	36	620	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
1040	CLASS	80	FL	9	3	36	770	300	1600	0.972	1,555	9	0.648	1,036.8	0.324	518.4
1030	STUDIO	65	FL	9	3	36	760	300	1600	0.972	1,555	12	0.540	864	0.432	691.2
1020	STUDIO	65	FL	9	3	36	800	300	1600	0.972	1,555	12	0.540	864	0.432	691.2
1280	STUDIO	65	FL	9	3	36	630	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
1250	STUDIO	65	FL	9	3	36	550	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
1320	MARSAM	39	FL	3	2	36	420	500	1600	0.216	345.6	0	0.216	345.6	0	0
1330	STORE	31	FL	3	2	36	420	200	100	0.216	21.6	2	0.144	14.4	0.072	7.2
1310	Office	22	FL	2	2	36	501	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
1050	STUDIO	65	FL	9	3	36	800	300	1600	0.972	1,555	9	0.648	1,036.8	0.324	518.4
1070	STUDIO	66	FL	9	3	36	630	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
1130	STUDIO	6	FL	1	4	18	330	300	1600	0.072	115.2	0	0.072	115.2	0	0
1140	STUDIO	6	FL	1	4	18	310	300	1600	0.072	115.2	0	0.072	115.2	0	0
1150	STUDIO	5	FL	1	4	18	340	300	1600	0.072	115.2	0	0.072	115.2	0	0
1160	STUDIO	5	FL	1	4	18	325	300	1600	0.072	115.2	0	0.072	115.2	0	0
1170	STUDIO	6	FL	1	4	18	330	300	1600	0.072	115.2	0	0.072	115.2	0	0
1180	STUDIO	5	FL	1	4	18	360	300	1600	0.072	115.2	0	0.072	115.2	0	0
1190	STUDIO	5	FL	1	4	18	370	300	1600	0.072	115.2	0	0.072	115.2	0	0
1200	STUDIO	6	FL	1	4	18	380	300	1600	0.072	115.2	0	0.072	115.2	0	0
1210	STUDIO	5	FL	1	4	18	350	300	1600	0.072	115.2	0	0.072	115.2	0	0
1220	STUDIO	6	FL	1	4	18	340	300	1600	0.072	115.2	0	0.072	115.2	0	0
1230	STUDIO	6	FL	1	4	18	320	300	1600	0.072	115.2	0	0.072	115.2	0	0
1240	STUDIO	5	FL	1	4	18	330	300	1600	0.072	115.2	0	0.072	115.2	0	0
1410	STUDIO	6	FL	1	4	18	300	300	1600	0.072	115.2	0	0.072	115.2	0	0

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
1420	STUDIO	6	FL	1	4	18	310	300	1600	0.072	115.2	0	0.072	115.2	0	0
1430	STUDIO	5	FL	1	4	18	315	300	1600	0.072	115.2	0	0.072	115.2	0	0
1450	STUDIO	5	FL	1	4	18	345	300	1600	0.072	115.2	0	0.072	115.2	0	0
1460	STUDIO	6	FL	1	4	18	355	300	1600	0.072	115.2	0	0.072	115.2	0	0
1470	STUDIO	6	FL	1	4	18	360	300	1600	0.072	115.2	0	0.072	115.2	0	0
1480	STUDIO	6	FL	1	4	18	340	300	1600	0.072	115.2	0	0.072	115.2	0	0
1490	STUDIO	6	FL	1	4	18	320	300	1600	0.072	115.2	0	0.072	115.2	0	0
1500	STUDIO	6	FL	1	4	18	330	300	1600	0.072	115.2	0	0.072	115.2	0	0
1510	STUDIO	6	FL	1	4	18	300	300	1600	0.072	115.2	0	0.072	115.2	0	0
1520	STUDIO	6	FL	1	4	18	310	300	1600	0.072	115.2	0	0.072	115.2	0	0
1530	STUDIO	6	FL	1	4	18	315	300	1600	0.072	115.2	0	0.072	115.2	0	0
1540	STUDIO	6	FL	1	4	18	345	300	1600	0.072	115.2	0	0.072	115.2	0	0
1550	STUDIO	6	FL	1	4	18	355	300	1600	0.072	115.2	0	0.072	115.2	0	0
1560	STUDIO	6	FL	1	4	18	360	300	1600	0.072	115.2	0	0.072	115.2	0	0
1080	W.C	13	FL	3	1	36	320	100	1800	0.108	194.4	1	0.072	129.6	0.036	64.8
			FL	4	1	18				0.072	129.6	2	0.036	64.8	0.036	64.8
1570	W.C	13	FL	3	1	36	330	100	1800	0.108	194.4	1	0.072	129.6	0.036	64.8
			FL	4	1	18				0.072	129.6	2	0.036	64.8	0.036	68
	Corridor	384	FL	58	3	18	320	150	1800	3.132	5,638	87	1.566	2,818.8	1.566	2,819
Ground Floor																
110	CLASS	79	FL	9	3	36	560	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
120	CLASS	77	FL	9	3	36	545	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
10	CLASS	84	FL	9	3	36	600	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
20	COM-LAB	78	FL	9	3	36	510	500	1800	0.972	1,750	0	0.972	1,750	0	0
30	COM-LAB	77	FL	9	3	36	540	500	1800	0.972	1,750	0	0.972	1,750	0	0
50	CAFTERI.	195	FL	18	3	36	410	150	1800	1.944	3,499	18	1.296	2,333	0.648	1,166
60	CLASS	80	FL	9	3	36	550	300	1600	0.972	1,555	9	0.648	1,036.8	0.324	518.4

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
70	MOSQUE	60	FL	12	4	18	350	100	1800	0.864	1,555	16	0.576	1,036.8	0.288	518.4
80	CLASS	76	FL	9	3	36	560	300	1600	0.972	1,555	6	0.756	1,209.6	0.216	345.6
90	SHOP	30	FL	3	2	36	465	150	1800	0.216	388.8	3	0.108	194.4	0.108	194.4
100	CONCIL	45	FL	9	3	36	470	500	600	0.972	583.2	0	0.972	583.2	0	0
130	Lecture Hall	120	FL	24	4	18	900	300	1600	1.728	2,765	28	1.224	1,958.4	0.504	806.4
			CFL	20	1	26				0.520	832	2	0.468	748.8	0.052	83.2
40	STORE	20	FL	2	2	36	500	200	100	0.144	14.4	3	0.036	57.6	0.108	10.8
150	Exhibition Hall	195	HL	12	1	50	700	600	600	0.600	360	4	0.4	240	0.2	120
160	W.C	21	FL	3	1	36	300	100	1800	0.108	194.4	1	0.072	129.6	0.036	64.8
			FL	3	1	18				0.054	97.2	1	0.036	64.8	0.018	32.4
120	W.C	21	FL	3	1	36	380	100	1800	0.108	194.4	1	0.072	129.6	0.036	64.8
			FL	3	1	18				0.054	97.2	1	0.036	64.8	0.018	32.4
	Corridor	35	PL	9	1	26	350	150	1800	0.234	421.2	6	0.078	140.4	0.156	280.8
	Corridor	70	HL	12	1	75	500	150	1800	0.900	1,620	8	0.3	540	0.6	1,080
	Corridor	261	FL	44	3	18	400	150	1800	2.376	4,277	66	1.188	2,138	1.188	2,138
B1 Floor																
B04	Music Chamber	95	FL	16	4	18	650	350	800	1.152	921.6	10	0.972	777.6	0.18	144
B05	Music Chamber	450	FL	24	4	18	520	350	800	1.728	1,382	10	1.548	1,238.4	0.18	144
B06	Mechanical Room	248	FL	14	2	36	300	150	100	1.008	100.8	12	0.576	57.6	0.432	43.2
B10	Store	48	FL	4	2	36	200	200	100	0.288	28.8	2	0.216	21.6	0.072	7.2
B11	Electrical Room	32	FL	3	2	36	180	150	100	0.216	21.6	0	0.216	21.6	0	0

Area #	Area Type	Area m²	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
B13	Generator Room	52	FL	6	2	36	250	150	100	0.432	43.2	4	0.288	28.8	0.144	14.4
B14	Transform. Room	57	FL	6	2	36	230	150	100	0.432	43.2	2	0.36	3.6	0.072	7.2
B12	Main Elec. Room	69	FL	8	2	36	170	150	50	0.576	28.8	2	0.504	25.2	0.072	3.6
B09	Store	21	FL	2	2	36	300	200	100	0.144	14.4	2	0.072	7.2	0.072	7.2
B15	Changing Room	15	FL	2	2	36	360	350	800	0.144	115.2	0	0.144	115.2	0	0
B01	Changing Room	18	FL	3	2	36	400	350	800	0.216	172.8	2	0.144	115.2	0.072	57.6
B02	Actor	10	FL	2	2	36	530	500	800	0.144	115.2	0	0.144	115.2	0	0
B07	Actor	10	FL	2	2	36	550	500	800	0.144	115.2	0	0.144	115.2	0	0
B08	Store	8	FL	1	2	36	330	200	100	0.072	7.2	0	0.072	7.2	0	0
B03	Store	22	FL	2	2	36	400	200	100	0.144	14.4	2	0.072	7.2	0.072	7.2
B15	Workshop	63	FL	8	2	36	370	300	1800	0.576	1.037	0	0.576	1.037	0	0
	Corridor	56	FL	8	3	18	300	150	1800	0.432	777.6	12	0.216	388.8	0.216	388.8
	Corridor	226	FL	30	2	36	250	150	1800	2.160	3,888	30	1.08	1,944	1.08	1,944
Restaurant																
	Restaurant	1600	PL	260	1	26	400	150	1800	6.76	12168	60	5.2	9,360	1.56	2,808
			HL	190	1	50			500	9.5	4,750	90	5	2,500	4.5	2,250
Total				**1,493**	**3,473**					**78.07**	**106,270**	**1,126**	**64.044**	**84,343**	**30.28**	**38,85**

Faculties of Pharmacy, and Medicine

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
2nd Floor																
2030	OFFICE	10	FL	4	2	36	520	250	600	0.288	172.8	3	0.18	108	0.108	64.8
2040	OFFICE	10	FL	4	2	36	530	250	600	0.288	172.8	3	0.18	108	0.108	64.8
2270	OFFICE	12	FL	2	2	36	370	250	600	0.144	86.4	0	0.144	86.4	0	0
2280	OFFICE	9	FL	2	2	36	345	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2290	OFFICE	10	FL	2	2	36	371	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2050	OFFICE	16	FL	4	2	36	840	250	600	0.288	172.8	3	0.18	108	0.108	64.8
2060	OFFICE	8	FL	4	2	36	480	250	600	0.288	172.8	3	0.18	108	0.108	64.8
2300	OFFICE	10	FL	2	2	36	300	250	600	0.144	86.4	0	0.144	86.4	0	0
2070	OFFICE	18	FL	4	2	36	520	250	600	0.288	172.8	3	0.18	108	0.108	64.8
2310	OFFICE	9	FL	2	2	36	405	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2320	OFFICE	10	FL	2	2	36	420	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2080	OFFICE	20	FL	4	2	36	825	250	600	0.288	172.8	3	0.18	108	0.108	64.8
2120	OFFICE	24	FL	4	4	18	900	250	600	0.288	172.8	8	0.144	86.4	0.144	86.4
2130	OFFICE	8	FL	4	2	36	320	250	600	0.288	172.8	3	0.18	108	0.108	64.8
2140	OFFICE	8	FL	4	2	36	330	250	600	0.288	172.8	3	0.18	108	0.108	64.8
2330	OFFICE	10	FL	4	2	36	540	250	600	0.288	172.8	3	0.18	108	0.108	64.8
2340	OFFICE	8	FL	2	2	36	490	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2150	OFFICE	20	FL	4	2	36	491	250	600	0.288	172.8	4	0.144	86.4	0.144	86.4
2160	OFFICE	16	FL	4	2	36	770	250	600	0.288	172.8	4	0.144	86.4	0.144	86.4
2360	OFFICE	7	FL	2	2	36	745	250	600	0.144	86.4	1	0.108	64.8	0.036	21.6
2370	OFFICE	9	FL	2	2	36	670	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2170	OFFICE	26	FL	4	4	18	530	250	600	0.288	172.8	8	0.144	86.4	0.144	86.4
2180	OFFICE	23	FL	4	4	18	960	250	600	0.288	172.8	10	0.108	64.8	0.180	108

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
2120	CLASS	17	FL	6	2	36	545	300	1600	0.432	691.2	4	0.288	460.8	0.144	230.4
2221	ROOM	6	FL	1	2	36	220		1600	0.072	115.2	0	0.072	115.2	0	0
2223	OFFICE	10	FL	2	2	36	490	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
2222	ROOM	10	FL	2	2	36	460		1600	0.144	230.4	2	0.072	115.2	0.072	115.2
2241	OFFICE	44	FL	10	2	36	986	250	600	0.720	432	10	0.36	216	0.36	216
2230	MEETING	84	FL	12	2	36	420		800	0.864	691.2	0	0.864	691.2	0	0
2010	VIDEO CONFER.	76	FL	18	4	18	1050	700	100	1.296	129.6	32	0.72	7.2	0.576	57.6
2090	W.C	17	PL	6	2	18	320	100	1800	0.216	388.8	6	0.108	194.4	0.108	194.4
			PL	2	1	13				0.026	46.8	0	0.026	46.8	0	0
2350	W.C	20	PL	7	2	18	390	100	1800	0.252	453.6	7	0.126	226.8	0.126	226.8
			PL	3	1	13				0.039	70.2	1	0.026	46.8	0.013	23.4
	Corridors	200	PL	28	2	18	460	150	1800	1.008	1,814	28	0.504	907.2	0.504	907.2
	Lobby	50	PL	14	2	18	510	150	1800	0.504	907.2	10	0.324	583.2	0.18	324
1st Floor																
1010	LECTURE HALL	107	FL	18	4	18	500	300	1600	0.648	1,037	12	0.432	691.2	0.216	345.6
			HL	8	1	100				0.800	1,280	4	0.4	640	0.4	640
1020	LAB	46	FL	8	4	18	880	500	1800	0.576	1,037	8	0.432	777.6	0.144	259.2
1030	OFFICE	19	FL	4	2	36	820	250	600	0.288	172.8	4	0.144	86.4	0.144	86.4
1270	OFFICE	10	FL	2	3	36	645	250	600	0.216	129.6	3	0.108	64.8	0.108	64.8
1040	OFFICE	15	FL	4	2	36	960	250	600	0.288	172.8	4	0.144	86.4	0.144	86.4
1280	STORE	9	FL	2	2	36	480	200	100	0.144	14.4	2	0.072	7.2	0.072	7.2
1050	SEMINAR	10	FL	2	2	36	450	400	1000	0.144	144	0	0.144	144	0	0
1300	OFFICE	9	FL	2	3	36	810	250	600	0.216	129.6	3	0.108	64.8	0.108	64.8
1060	SEMINAR	8	FL	2	2	36	805	400	1000	0.144	144	2	0.072	72	0.072	72
1310	OFFICE	9	FL	2	2	36	900	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
1070	SEMINAR	19	FL	4	2	36	730	400	1000	0.288	288	2	0.072	72	0.072	72

Area #	Area Type	Area m²	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
1080	SEMINAR	18	FL	4	2	36	780	400	1000	0.288	288	2	0.216	216	0.072	72
1320	OFFICE	9	FL	2	2	36	810	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
1120	OFFICE	23	FL	4	4	18	690	250	600	0.288	172.8	8	0.144	86.4	0.144	86.4
1130	OFFICE	23	FL	4	2	36	875	250	600	0.288	172.8	4	0.144	86.4	0.144	86.4
1140	OFFICE	19	FL	4	2	36	470	250	600	0.288	172.8	2	0.216	129.6	0.072	43.2
1330	OFFICE	23	FL	4	2	36	720	250	600	0.288	172.8	4	0.144	86.4	0.144	86.4
1340	OFFICE	10	FL	2	2	36	770	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
1150	OFFICE	15	FL	4	2	36	640	250	600	0.288	172.8	4	0.144	86.4	0.144	86.4
1160	OFFICE	18	FL	4	2	36	560	250	600	0.288	172.8	2	0.216	129.6	0.072	43.2
1360	OFFICE	10	FL	2	2	36	840	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
1370	OFFICE	10	FL	2	2	36	440	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
1170	OFFICE	16	FL	4	3	36	665	250	600	0.432	259.2	6	0.216	129.6	0.216	129.6
1180	OFFICE	16	FL	4	3	36	560	250	600	0.432	259.2	6	0.216	129.6	0.216	129.6
1222	OFFICE	10	FL	2	2	36	420	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
1223	OFFICE	10	FL	2	2	36	650	250	600	0.144	86.4	2	0.072	43.2	0.072	43.2
1241	OFFICE	49	FL	10	2	36	640	250	600	0.720	432	6	0.504	302.4	0.216	129.6
1240	OFFICE	16	FL	4	2	36	790	250	600	0.288	172.8	4	0.144	86.4	0.144	86.4
1250	W.C	17	PL	6	2	18	400	100	1800	0.216	388.8	6	0.108	194.4	0.108	194.4
			PL	2	1	13				0.026	46.8	0	0.026	46.8	0	0
1260	W.C	20	PL	7	2	18	410	100	1800	0.252	453.6	7	0.126	226.8	0.126	226.8
			PL	3	1	13				0.039	70.2	1	0.026	46.8	0.013	23.4
1090	W.C	6	PL	2	2	18	250	100	1800	0.072	129.6	0	0.072	129.6	0	0
	Corridors	204	PL	28	2	18	540	150	1800	1.008	1,814	26	0.54	972	0.468	842.4
	Lobby	50	PL	14	2	18	610	150	1800	0.504	907.2	12	0.288	518.4	0.216	388.8
Ground Floor																
G0150	MOSQUE	72	FL	9	2	36	320	100	1800	0.648	1,166	8	0.288	518.4	0.288	28.8
G0140	MOSQUE	72	FL	9	2	36	350	100	1800	0.648	1,166	8	0.288	518.4	0.288	28.8

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
G0030	COMP LAB	60	FL	9	2	36	510	500	1800	0.648	1,166	0	0.648	1,166	0	0
G0010	CLASS	71	FL	6	2	36	720	300	1600	0.432	691.2	4	0.288	460.8	0.144	230.4
G0011	CLASS	60	FL	6	2	36	850	300	1600	0.432	691.2	6	0.216	345.6	0.216	345.6
G0080	CLASS	78	FL	9	2	36	470	300	1600	0.648	1,037	6	0.432	691.2	0.216	345.6
G0090	CLASS	80	FL	9	2	36	450	300	1600	0.648	1,037	4	0.504	806.4	0.144	230.4
G0070	CLASS	85	FL	12	4	18	870	300	1600	0.864	1,382	16	0.576	921.6	0.288	460.8
G0160	CLASS	86	FL	12	2	36	645	300	1600	0.864	1,382	6	0.648	1,036.8	0.216	345.6
G0100	Comp-Lab	120	FL	12	4	18	740	500	1800	0.864	1,555	12	0.648	1,166.4	0.216	388.8
G0110	ROOM	10	FL	2	4	18	300	200	100	0.144	14.4	2	0.108	10.8	0.036	3.6
G0180	W.C	28	PL	6	2	18	380	100	1800	0.216	388.8	5	0.126	226.8	0.09	162
			PL	2	1	13				0.026	46.8	0	0.026	46.8	0	0
G0190	W.C	30	PL	7	2	18	420	100	1800	0.252	453.6	7	0.126	226.8	0.126	226.8
			PL	3	1	13				0.039	70.2	1	0.026	46.8	0.013	23.4
	Corridors	183	PL	26	2	18	610	150	1800	0.936	1,685	26	0.468	842.4	0.468	842.4
	Lobby	50	PL	14	2	18	700	150	1800	0.504	907.2	14	0.252	453.2	0.252	453.6
B1 Floor																
B1030	Comp-Lab	45	FL	9	2	36	440	500	1800	0.648	1,166	0	0.648	1,166	0	0
B1040	Comp-Lab	60	FL	9	2	36	670	500	1800	0.648	1,166	4	0.504	907.2	0.144	259.2
B1090	CLASS	72	FL	9	2	36	390	300	1600	0.648	1,037	4	0.504	806.4	0.144	230.4
B1160	CLASS	72	FL	9	2	36	480	300	1600	0.648	1,037	6	0.432	691.2	0.216	345.6
B1170	CLASS	78	FL	12	2	36	570	300	1600	0.864	1,382	8	0.576	921.6	0.288	460.8
B1110	CLASS	79	FL	12	4	18	405	300	1600	0.864	1,382	16	0.576	921.6	0.288	460.8
B1090	CLASS	71	FL	9	2	36	420	300	1600	0.648	1,037	4	0.504	806.4	0.144	230.4
B1080	CLASS	92	FL	12	4	18	920	300	1600	0.864	1,382	16	0.576	921.6	0.288	460.8
B1020	CLASS	85	FL	12	2	36	480	300	1600	0.864	1,382	6	0.648	1,036.8	0.216	345.6
B1010	STORE	8	FL	1	2	36	250	200	100	0.072	7.2	0	0.072	7.2	0	0

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
B1030	LAB	108	FL	11	2	36	630	500	1800	0.792	1,426	6	0.576	1,036.8	0.216	388.8
B1050	W.C	29	PL	7	2	18	410	100	1800	0.252	543.6	7	0.126	226.8	0.126	226.8
			PL	2	1	13				0.026	46.8	0	0.026	46.8	0	0
			PL	2	1	75				0.150	270	0	0.150	270	0	0
	Corridors	200	PL	22	2	18	500	150	1800	0.792	1,426	20	0.0.432	777.6	0.36	648
	Lobby	42	PL	8	2	18	600	150	1800	0.288	518.4	8	0.144	259.2	0.144	259.2
B2 Floor																
B2110	LAB	59	FL	9	4	18	295	500	1800	0.648	1,166	0	0.648	1,166	0	0
B2101	STORE	24	FL	3	2	36	320	200	100	0.216	21.6	2	0.144	14.4	0.072	7.2
B2100	LAB	66	FL	9	2	36	395	500	1800	0.648	1,166	0	0.648	1,166	0	0
B2090	LAB	66	FL	9	2	36	310	500	1800	0.648	1,166	0	0.648	1,166	0	0
B2081	LAB	59	FL	3	2	36	340	500	1800	0.216	388.8	0	0.216	388.8	0	0
B2080	LAB	62	FL	9	4	18	410	500	1800	0.648	1,166	0	0.648	1,166	0	0
B2040	LAB	68	FL	9	2	36	385	500	1800	0.648	1,166	0	0.648	1,166	0	0
B2031	STORE	24	FL	3	2	36	285	200	100	0.216	21.6	2	0.144	14.4	0.072	7.2
B2050	STORE	22	FL	3	2	36	290	200	100	0.216	21.6	2	0.144	14.4	0.072	7.2
B2030	LAB	60	FL	9	2	36	310	500	1800	0.648	1,166	0	0.648	1,166	0	0
B2020	LAB	64	FL	12	4	18	520	500	1800	0.864	1,555	0	0.864	1,555	0	0
B2210	STORE	30	FL	3	2	36	400	200	100	0.216	21.6	2	0.144	14.4	0.072	7.2
B2200	STORE	16	FL	2	2	36	420	200	100	0.144	14.4	2	0.072	7.2	0.072	7.2
B2070	LAB	62	FL	9	2	36	330	500	1800	0.648	1,166	0	0.648	1,166	0	0
B2060	LAB	61	FL	9	2	36	350	500	1800	0.648	1,166	0	0.648	1,166	0	0
B2010	W.C	30	PL	7	2	18	380	100	1800	0.252	453.6	7	0.126	226.8	0.126	226.8
			PL	4	1	13				0.052	93.6	2	0.026	46.8	0.026	46.8
	Corridors	198	PL	20	2	18	520	150	1800	0.720	1,296	18	0.396	712.8	0.324	583.2
	Lobby	42	PL	8	2	18	600	150	1800	0.288	518.4	8	0.144	259.2	0.144	259.2

Area #	Area Type	Area m^2	Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Measur. Lux	Stand. Lux	Annual Oper. Hours	Consumption		Recommended Condition			Saving	
										kW	kWh/ year	Removed Lamps	Consump. kW	Consump. kWh/year	kW	kWh/ year
B3 Floor																
B3020	LAB	22	FL	4	4	18	880	500	1800	0.288	518.4	4	0.216	388.8	0.072	129.6
B3050	LAB	30	FL	6	4	18	930	500	1800	0.432	777.6	8	0.288	518.4	0.144	259.2
B3010	DISSECT. HALL	40	FL	6	4	18	1050	700	1000	0.432	432	8	0.288	288	0.144	144
B3120	LECTURE HALL	69	FL	16	4	18	860	300	1600	1.152	1,843	20	0.792	1,267.2	0.36	576
B3040	Generator Room	17	FL	4	2	36	320	150	100	0.288	28.8	2	0.216	21.6	0.072	7.2
B3060	Boiler Room	41	FL	6	2	36	400	150	100	0.432	43.2	4	0.288	28.8	0.144	14.4
B3140	Transform. Room	12	FL	2	2	36	280	150	100	0.144	14.4	0	0.144	14.4	0	0
B3150	Electrical Room	9	FL	2	2	36	350	150	100	0.144	14.4	2	0.072	7.2	0.072	7.2
B3130	STORE	13	FL	2	2	36	260	200	100	0.144	14.4	0	0.144	14.4	0	0
B3160	DOCTOR ROOM	18	FL	4	4	18	440	400	1800	0.288	518.4	0	0.288	518.4	0	0
B3190	IDENIFI.	12	FL	2	4	18	350	300	1000	0.144	1444	2	0.108	108	0.036	36
B3180	DARK ROOM	6	FL	1	2	36	180	250	100	0.072	7.2	0	0.072	7.2	0	0
B3070	W.C	14	PL	4	2	18	340	100	1800	0.144	259.2	4	0.072	129.6	0.072	129.6
			PL	2	1	13				0.026	46.8	0	0.026	46.8	0	0
	Corridors	50	PL	5	4	18	800	150	1800	0.360	648	8	0.216	388.8	0.144	259.2
	Lobby	45	PL	15	1	28	620	150	1800	0.420	756	7	0.224	403.2	0.196	352.8
Total				**1,463**	**2,104**					**53.185**	**68,978.8**	**678**	**36.324**	**49,167**	**16.861**	**19,811.8**

Exterior lights

Lamp Type	No. of Fixtures	No. of lamps /Fixture	Rating W	Annual Oper. Hours	Consumption	
					kW	kWh/ year
HPS Projectors	27	1	400	4000	10.8	43,200
MH Projectors	2	1	150	4000	0.3	1,200
Ground Spot light	18	1	150	4000	2.7	10,800
Yards light	45	1	100	4000	4.5	18,000
Yards light	48	2	100	4000	9.6	38,400
HPS Projectors	16	1	75	4000	1.2	4,800
2D	24	1	28	4000	0.672	2,688
Side lamps	18	2	18	4000	0.648	2,592
Total	**198**	**264**			**30.42**	**121,680**

Appendix 3

Measured Weekly Load Curve

Faculty of Engineering

Date & Time	St/ Avg (VA)	Pt/ Avg (W)	Qt/ Avg (VAR)	V1 Avg (V)	V2 Avg (V)	V3 Avg (V)	I1 Avg (A)	I2 Avg (A)	I3 Avg (A)	Inull Avg (A)	Pft+ Avg ()
12/02/2007 15:08	94200	88740	31620	229	228.9	226.9	156.9	108.6	147.8	57.2	0.94
12/02/2007 16:08	47440	45460	13570	228	227.3	225.3	68.76	47.93	92.92	38.6	0.96
12/02/2007 17:08	21010	19010	8936	228	227.4	224.7	29.89	23.57	39.68	21.7	0.9
12/02/2007 18:08	20690	18890	8420	230	229.6	226.6	29.16	22.94	38.85	21.7	0.91
12/02/2007 19:08	20270	18160	9017	231	230.7	227.7	27.65	24.39	36.65	18.1	0.89
12/02/2007 20:08	19650	17470	8984	234	233.3	230.4	30.6	21.38	32.93	16.9	0.89
12/02/2007 21:08	18470	16480	8321	232	232.4	229.1	27.53	21.13	31.68	16.5	0.89
12/02/2007 22:08	18890	16750	8737	232	232.1	228.9	28.53	21.08	32.62	16.8	0.89
12/02/2007 23:08	18310	16270	8403	231	231.1	228.3	26.67	20.97	32.36	17.7	0.89
13/02/2007 00:08	18440	16200	8803	232	232.5	230	26.02	21.14	32.82	17.7	0.88
13/02/2007 01:08	19760	17330	9491	230	230.2	228.5	29.22	22.62	34.58	17.4	0.88
13/02/2007 02:08	18610	16480	8644	230	230	228.3	27.85	20.96	32.59	17.1	0.88
13/02/2007 03:08	19310	17310	8548	230	230.4	228.8	28.11	20.91	35.38	19	0.9
13/02/2007 04:08	19100	17090	8516	230	229.9	228.2	29.81	20.9	32.99	18.5	0.89
13/02/2007 05:08	18430	16390	8424	228	227.5	225.7	28.04	20.74	32.77	17.1	0.89
13/02/2007 06:08	20210	18320	8534	227	226.3	224.1	27.15	20.22	43.21	26.4	0.91
13/02/2007 07:08	34530	32770	10860	228	227.6	225.5	56.29	25.22	71.52	43.1	0.95
13/02/2007 08:08	91540	88510	23360	227	226.1	224.9	144.6	109.6	151	44.7	0.97
13/02/2007 09:08	119500	115700	29920	224	223.1	221.7	195	152.5	189	54.5	0.97
13/02/2007 10:08	128500	125000	29400	224	223	221.6	219.5	157.7	199.6	70.8	0.97
13/02/2007 11:08	138000	134200	32320	222	221.4	220.8	248.1	173.2	201.9	88.6	0.97
13/02/2007 12:08	44950	42690	13800	124	123.3	122.5	122.4	75.78	85.06	52.1	0.98
13/02/2007 13:08	144700	140000	36560	226	225.7	224.6	265	176.8	199.9	102	0.97
13/02/2007 14:08	134400	130400	32520	227	226.7	225.5	231.8	158	204	75.9	0.97
13/02/2007 15:08	112000	108000	29760	230	229.2	227.2	171.2	144.6	174.1	44.2	0.96
13/02/2007 16:08	45230	43190	13430	233	232.3	229.8	61.75	52.36	81.28	32.8	0.95
13/02/2007 17:08	20320	19180	6699	231	230.4	227.4	22.5	23.46	43.02	19.7	0.94
13/02/2007 18:08	16640	15510	6011	230	228.7	225.9	19.5	21.12	32.82	14.3	0.93
13/02/2007 19:08	14310	12880	6223	231	230.4	227.3	19.45	16.58	26.55	11.3	0.9
13/02/2007 20:08	13420	11880	6236	234	233.2	230.1	18.46	14.47	25.13	12.9	0.88
13/02/2007 21:08	13190	11710	6074	231	231.2	228.1	18.3	14.47	24.84	12.8	0.89
13/02/2007 22:08	12920	11470	5940	230	230.5	227.4	17.77	14.29	24.56	12.5	0.89
13/02/2007 23:08	12940	11540	5852	228	229.1	226.1	18.12	14.42	24.54	12.9	0.89
14/02/2007 00:08	13250	11660	6277	231	231	228.8	18.41	14.59	24.83	12.8	0.88
14/02/2007 01:08	13330	11640	6499	232	232.4	230.5	18	14.75	25.07	12.7	0.87
14/02/2007 02:08	13170	11630	6177	230	230.3	228.5	18.09	14.65	24.83	13.2	0.88
14/02/2007 03:08	13200	11680	6157	231	231.2	229.5	18.16	14.58	24.77	12.8	0.88
14/02/2007 04:08	14120	12440	6680	230	229.9	228.1	19.85	15.89	26.09	12.8	0.88
14/02/2007 05:08	12730	11360	5741	227	226.8	224.8	17.55	14.44	24.55	13.3	0.89
14/02/2007 06:08	13770	12100	6591	230	230	227.6	17.59	14.09	29.02	17.6	0.88
14/02/2007 07:08	32410	31150	8956	229	228.7	226.5	38.22	32.51	71.97	38.6	0.96
14/02/2007 08:08	107100	100500	37030	225	224.6	222.8	169.8	130.7	178.1	42.4	0.94
14/02/2007 09:08	135700	128700	42990	223	222.8	221.1	255.8	154.5	201	92.3	0.95
14/02/2007 10:08	148500	141100	46110	228	227	225.8	256.1	187.1	211.4	76.8	0.95
14/02/2007 11:08	160500	153000	48400	226	225.9	224.9	279.1	197.7	234.5	84.4	0.95
14/02/2007 11:18	156200	150000	43510	224	223	222.1	272.6	196	231.8	77.1	0.96
14/02/2007 12:08	144800	139300	39500	226	224.6	223.5	240.4	184.9	219.6	60.6	0.96

14/02/2007 13:08	144400	138600	40290	226	225.1	224	236.6	177.6	227.8	67.4	0.96
14/02/2007 14:08	108600	105100	27480	227	227.1	225.6	177.7	121.1	180.5	63.5	0.97
14/02/2007 15:08	87650	84340	23850	229	228.1	226.5	138.8	106.7	139.2	45.3	0.96
14/02/2007 16:08	43010	40970	13100	228	227.6	226	54.79	49.37	85.34	33.2	0.95
14/02/2007 17:08	14620	13220	6235	228	227.2	225.3	20.6	17.09	26.93	10.5	0.9
14/02/2007 18:08	13010	11490	6094	229	228.6	225.7	19.88	14.3	23.13	9.18	0.88
14/02/2007 19:08	13280	11660	6356	231	230.7	227.9	19.96	14.6	23.39	9.93	0.88
14/02/2007 20:08	13310	11610	6500	234	233.2	230.2	19.9	14.12	23.5	9.84	0.87
14/02/2007 21:08	13270	11540	6549	233	232.6	229.8	20.48	13.8	23.19	9.85	0.87
14/02/2007 22:08	12980	11420	6167	230	229.3	226.2	20.5	13.53	23.02	10.2	0.88
14/02/2007 23:08	14880	12970	7285	233	232.8	229.7	22.42	16.26	25.77	9.6	0.87
15/02/2007 00:08	13270	11790	6096	229	229	226.8	19.68	14.28	24.37	9.77	0.89
15/02/2007 01:08	13300	11730	6259	230	230.4	228.4	19.91	13.63	24.57	10.4	0.88
15/02/2007 02:08	13600	11950	6504	230	229.7	228.1	20.44	14.42	24.68	10.2	0.88
15/02/2007 03:08	13370	11800	6277	232	231.1	229.6	19.9	13.3	24.96	11.1	0.88
15/02/2007 04:08	13450	11860	6339	231	230.8	229.2	20.46	13.39	24.74	10.5	0.88
15/02/2007 05:08	13010	11570	5951	230	229	227.7	19.49	13.06	24.49	10.6	0.89
15/02/2007 06:08	14340	12880	6324	227	226.5	224.8	19.56	12.29	32.17	17.6	0.9
15/02/2007 07:08	21220	19950	7244	229	228.9	226.9	29.09	15.07	49.37	31	0.94
15/02/2007 08:08	24770	23370	8216	227	225.9	224.3	34.11	20.3	55.87	29.8	0.94
15/02/2007 09:08	34340	32760	10290	229	228.4	226.6	53.51	28.9	68.38	36.4	0.95
15/02/2007 10:08	31310	29510	10460	231	230	227.6	44.25	23.36	69.29	40.6	0.94
15/02/2007 11:08	32300	30330	11100	231	230.2	228.3	45.27	29.45	65.99	33.7	0.94
15/02/2007 12:08	33520	31780	10660	232	230.4	228.3	44.55	31.45	69.89	35.4	0.95
15/02/2007 13:08	28720	27350	8769	231	229.9	227.9	44.23	23.15	58	30.4	0.95
15/02/2007 14:08	24300	22990	7863	232	231.3	229.1	33.77	21.49	50.27	24.5	0.95
15/02/2007 15:08	21690	20540	6966	229	228	225.8	29.12	15.51	51.22	29.3	0.95
15/02/2007 16:08	18440	17210	6646	228	227.5	225.1	26.12	12.73	43.12	27.2	0.93
15/02/2007 17:08	12810	11170	6273	230	229.6	226.7	19.77	11.9	24.87	12	0.87
15/02/2007 18:08	11640	9645	6517	231	229.8	226.9	18.59	12.98	19.5	6.51	0.83
15/02/2007 19:08	11780	9658	6744	233	232.5	228.8	18.26	13.3	19.64	7.15	0.82
15/02/2007 20:08	11360	9415	6366	230	229.1	226.4	17.7	12.9	19.42	6.75	0.83
15/02/2007 21:08	11670	9592	6648	231	231.4	228.6	17.9	13.3	19.72	6.55	0.82
15/02/2007 22:08	12610	10410	7119	229	228.8	226.2	19.62	14.68	21.29	7.37	0.82
15/02/2007 23:08	12180	10140	6744	233	232.6	230.3	17.99	11.71	23.36	9.77	0.83
16/02/2007 00:08	11870	9847	6640	232	231.4	229.4	17.8	11.69	22.39	8.59	0.83
16/02/2007 01:08	12010	10350	6087	230	229.6	227.8	20.6	11.6	20.9	10.8	0.86
16/02/2007 02:08	11270	9188	6530	231	230.9	229.2	17.84	11.69	19.69	7.72	0.81
16/02/2007 03:08	11070	9002	6446	230	230.3	228.7	17.23	11.64	19.59	7.52	0.81
16/02/2007 04:08	11000	8943	6415	230	230.3	228.6	17.03	11.65	19.5	7.68	0.81
16/02/2007 05:08	10960	8964	6319	229	229	227.4	17.3	11.51	19.46	7.59	0.82
16/02/2007 06:08	12310	10750	5992	228	227.3	225.4	15.82	9.77	29.85	17.9	0.87
16/02/2007 07:08	12160	10350	6391	231	231.1	228.9	15.26	9.58	29.25	17.3	0.85
16/02/2007 08:08	12130	10580	5947	226	226.8	224.2	15.18	9.33	30.61	18.6	0.87
16/02/2007 09:08	11970	10530	5701	227	226.8	224.4	14.7	9.31	30.49	18.9	0.88
16/02/2007 10:08	11160	9348	6103	230	230.1	227.4	14.63	9.36	25.75	14.8	0.84
16/02/2007 11:08	9164	7022	5888	231	230.4	227.7	14.81	9.39	16.14	7.72	0.76
16/02/2007 12:08	9281	7013	6079	233	233.3	230.2	14.52	9.6	16.27	7.95	0.75
16/02/2007 13:08	8981	7025	5595	228	227.9	225.1	14.61	9.37	16	7.61	0.78
16/02/2007 14:08	9517	7340	6058	230	230.4	227.5	15.56	9.97	16.38	7.7	0.77
16/02/2007 15:08	9519	7246	6173	233	233	230.4	15.27	9.82	16.35	7.55	0.76
16/02/2007 16:08	9027	6961	5747	230	229.6	227	14.7	9.58	15.58	7.47	0.77

16/02/2007 17:08	8647	6789	5356	227	227.4	224.5	13.85	9.46	15.3	7.59	0.78
16/02/2007 18:08	10600	8724	6037	228	227.5	224.9	16.96	11.22	18.93	7.67	0.82
16/02/2007 19:08	10600	8672	6110	229	228.2	225.7	16.9	11.38	18.63	7.38	0.82
16/02/2007 20:08	10930	8793	6495	230	230.1	227.5	17.82	11.31	18.84	7.6	0.8
16/02/2007 21:08	11280	9043	6747	232	232.4	229.3	18.07	11.88	19.16	7.77	0.8
16/02/2007 22:08	11050	8842	6635	231	231.5	228.4	17.81	11.61	18.88	7.64	0.8
16/02/2007 23:08	11850	9614	6934	233	233.1	230	20.98	11.62	18.96	10.5	0.81
17/02/2007 00:08	11220	8900	6835	233	233.2	230.8	17.34	12.02	19.25	7.28	0.79
17/02/2007 01:08	10890	8830	6384	229	229.4	227.5	17.33	11.7	18.9	7.99	0.81
17/02/2007 02:08	10620	8649	6166	230	230	228.2	16.97	11.61	18.03	6.69	0.81
17/02/2007 03:08	11050	8910	6545	231	231	229.3	17.31	11.72	19.24	7.39	0.8
17/02/2007 04:08	12280	9932	7223	230	230.5	228.8	19.64	13.29	20.75	7.82	0.81
17/02/2007 05:08	10870	8830	6341	229	229.1	227.4	17.38	11.52	18.92	7.64	0.81
17/02/2007 06:08	11580	9728	6292	226	226.2	224.3	14.54	9.5	28.09	16.4	0.84
17/02/2007 07:08	28160	26150	10430	230	229.9	227.8	35.53	23.22	64.73	36.3	0.93
17/02/2007 08:08	106900	100500	36580	225	224.4	223.1	170.1	134.5	172.4	45.4	0.94
17/02/2007 09:08	144300	138300	41090	223	222.1	220.7	255.7	164.9	229.9	86.5	0.96
17/02/2007 10:08	154900	148800	43230	226	224.8	223.8	260.7	180.5	248.2	88.1	0.96
17/02/2007 11:08	163500	155300	50950	228	227.5	226.1	288.5	186.3	245.4	111	0.95
17/02/2007 12:08	154900	149300	41210	224	223.6	222.5	262.1	196.5	234.6	84.1	0.96
17/02/2007 13:08	143900	138400	39520	225	224.7	223.9	245.6	178.5	216.9	78.4	0.96
17/02/2007 14:08	123900	120000	31060	228	228.3	226.9	217	138.4	189.1	93	0.97
17/02/2007 15:08	107500	102400	32630	227	227	226.1	184.3	128.8	160.9	66	0.95
17/02/2007 16:08	59660	57770	14880	227	226.7	225.2	96.39	71.13	96.31	35.1	0.97
17/02/2007 17:08	20610	19000	7983	229	229.1	226.8	29.77	24.22	36.54	17.2	0.92
17/02/2007 18:08	16380	14760	7084	232	231.3	228.8	23.4	19.06	28.96	13.7	0.9
17/02/2007 19:08	14830	13400	6352	232	231.9	228.9	20.08	15.77	28.88	15.5	0.9
17/02/2007 20:08	14990	13410	6712	234	233.3	230.3	20.59	16.4	27.98	14.1	0.89
17/02/2007 21:08	14660	13180	6437	232	231.1	228.1	20.56	15.8	27.8	14.5	0.9
17/02/2007 22:08	14580	13100	6403	230	229.9	227.1	19.38	17.03	27.67	14.4	0.9
17/02/2007 23:08	14740	13160	6641	233	232.8	230.3	20.2	15.87	27.9	14.2	0.89
18/02/2007 00:08	15810	14150	7045	232	231.4	229.4	20.31	19.15	29.44	14.7	0.89
18/02/2007 01:08	15820	14290	6800	228	227.6	225.8	21.65	17.74	30.72	14.5	0.9
18/02/2007 02:08	15220	13750	6516	230	229.6	228.2	18.97	18.49	29.27	15.2	0.9
18/02/2007 03:08	14530	13230	6020	231	231.1	229.9	18.76	16.05	28.58	14.9	0.91
18/02/2007 04:08	15110	13640	6513	231	230.8	229.4	19.66	17.06	29.27	14.8	0.9
18/02/2007 05:08	14940	13500	6396	229	228.5	227	19.44	17.29	29.16	15.5	0.9
18/02/2007 06:08	13850	12540	5864	230	229.5	227.9	16.03	13.11	32.14	21.9	0.9
18/02/2007 07:08	39480	38210	9928	226	224.9	222.8	55.82	35.44	85.19	46.2	0.97
18/02/2007 08:08	124800	119000	37600	225	224.4	222.9	197.8	153.1	205.9	53.8	0.95
18/02/2007 09:08	144500	139000	39670	223	222.1	220.7	241.3	179.7	230.5	60.5	0.96

Faculties of Pharmacy and Medicine

Date & Time	St/ Avg (VA)	Pt/ Avg (W)	Qt/ Avg (VAR)	V1 Avg (V)	V2 Avg (V)	V3 Avg (V)	I1 Avg (A)	I2 Avg (A)	I3 Avg (A)	Inull Avg (A)	Pfti+ Avg ()
18/02/2007 11:26	66400	65240	12360	225.7	224.6	223.6	103.2	87.74	104.6	35.55	0.98
18/02/2007 11:36	68920	67740	12690	226.6	225.5	224.4	106.7	91.39	107.5	36.91	0.98
18/02/2007 11:46	67870	66510	13520	227.8	226.8	225.8	100.1	94.21	105	35.07	0.98
18/02/2007 11:56	63910	63590	6309	228.5	227.8	226.8	105.6	90.72	93.57	31.11	0.99
18/02/2007 12:06	70430	69250	12840	228.1	227.2	226.1	110.6	96.5	102.8	33.23	0.98
18/02/2007 13:06	59920	59760	4372	229.9	228.8	227.7	82.06	90.85	88.22	32.13	1
18/02/2007 14:06	49480	49470	696.6	231.5	230.8	229.5	67.09	70.48	79.85	33.38	1
18/02/2007 15:06	35350	35350	0	227.5	227.1	225.6	44.28	56.16	58.09	28.26	1
18/02/2007 16:06	14220	14220	24.22	231	230.9	228.7	20	22.61	20.6	9.04	1
18/02/2007 17:06	7809	7802	4.44	229.6	229.2	227.3	13.02	8.74	11.25	5.67	1
18/02/2007 18:06	11400	11400	21.47	232.6	232.1	229.4	27.67	12.59	9.74	16.27	1
18/02/2007 19:06	9479	9479	4.58	233.1	232.9	229.8	18.85	13.12	10.02	7.34	1
18/02/2007 20:06	9340	9340	0	233.4	233.3	230.1	17.87	13.29	10.5	7.03	1
18/02/2007 21:06	8887	8887	0	231.8	232	229	17.67	13.14	8.96	6.93	1
18/02/2007 22:06	9069	9069	0	229.4	229.5	226.4	18.43	12.67	9.47	7.48	1
18/02/2007 23:06	8779	8779	0	228.9	229	226.4	17.29	12.56	9.48	6.84	1
19/02/2007 00:06	10960	10960	0	233	233	230.9	26.47	12.73	8.92	15.54	1
19/02/2007 01:06	8913	8913	8.65	229.5	229.3	227.7	18.47	12.61	8.85	8.17	1
19/02/2007 02:06	8913	8913	0	231.7	231.7	230	17.44	12.71	9.38	7.02	1
19/02/2007 03:06	8685	8685	0	230.9	231	229.3	17.36	12.45	8.86	7.11	1
19/02/2007 04:06	9166	9166	0	230.5	230.4	229	18.47	12.57	9.73	7.75	1
19/02/2007 05:06	8733	8733	8.36	228	227.7	226	17.24	12.4	9.72	6.37	1
19/02/2007 06:06	6215	6213	0	226.6	226.1	224.6	13.8	6.1	8.12	6.42	1
19/02/2007 07:06	8480	8422	107.5	229.5	229.1	227	18.05	10.11	9.6	9.71	1
19/02/2007 08:06	36010	35360	6797	226.9	226.7	225	60.22	46	53.39	17.23	0.98
19/02/2007 09:06	43660	43580	2586	230.8	230	228.8	77.64	49.56	64.37	31.06	1
19/02/2007 10:06	49040	48740	5395	229.4	228.6	227.9	73.65	61.73	79.79	33.87	0.99
19/02/2007 11:06	53260	53060	4641	225.2	224.6	224.1	82.73	67.07	88.98	35.35	0.99
19/02/2007 12:06	54520	54410	3521	226.3	225.7	224.9	89.97	68.5	83.74	32.88	1
19/02/2007 13:06	50480	50470	1302	226.5	225.9	224.9	76.2	68.41	80.45	30.89	1
19/02/2007 14:06	23830	23590	29.39	230.9	230.7	228.9	32.88	29.24	42.1	21.81	1
19/02/2007 15:06	19220	19220	5.81	231.4	231.3	229.6	23.34	24.51	36.2	18.54	1
19/02/2007 16:06	11080	11080	9.74	229.8	229.6	227.5	16.21	11.44	22.13	12.31	1
19/02/2007 17:06	7038	6682	1724	227	227	225.1	10.86	9.03	12.75	9.25	0.96
19/02/2007 18:06	10250	10250	3.01	230.7	230.1	227.2	22.21	12.16	11.25	9.42	1
19/02/2007 19:06	9287	9287	7.02	233.2	233	229.9	17.87	12.35	10.94	6.18	1
19/02/2007 20:06	9287	9287	7.02	233.2	233	229.9	17.87	12.35	10.94	6.18	1
19/02/2007 21:06	9592	9592	7.93	231.2	231.3	228.7	18.63	12.55	11.55	6.09	1
19/02/2007 22:06	9983	9983	0.87	231.1	231.4	228.4	18.99	12.76	12.71	5.98	1
19/02/2007 23:06	9119	9119	2.62	230.4	230.8	228	17.49	12.23	10.99	5.84	1
20/02/2007 00:06	9921	9921	5.97	230.5	230.7	228.8	21.29	11.62	11.15	9.08	1
20/02/2007 01:06	9020	9020	3.32	228.1	228.1	226.3	17.06	11.53	12.04	5.64	1
20/02/2007 02:06	9482	9482	3.36	230.8	230.7	229.3	18.33	11.79	11.92	5.86	1
20/02/2007 03:06	9181	9181	3.62	230	230.1	228.7	17.07	12.06	11.9	5.21	1
20/02/2007 04:06	9314	9314	3.39	229.6	229.7	228.3	17.13	12.01	12.57	5.56	1
20/02/2007 05:06	5988	5983	5.25	227.6	227.4	225.9	6.27	8.47	12.32	8.96	1
20/02/2007 06:06	6331	6324	7.65	231.1	231.3	229.6	8.78	6.9	11.48	8.69	1

20/02/2007 07:06	6127	6124	19.87	230.4	230.4	228.2	6.64	7.82	13.54	10.91	1
20/02/2007 08:06	38710	38710	0	227.5	227.3	225.5	65.1	48.51	58.22	19.8	1
20/02/2007 09:06	41360	41330	0	224.7	223.9	222.6	65.92	49.08	71.05	27.36	1
20/02/2007 10:06	45610	45220	0	226.1	225.7	224.7	71.66	50.97	77.92	34.89	1
20/02/2007 11:06	50420	50390	0	227.4	226.8	226.2	95.9	47.71	78.84	45.1	1
20/02/2007 12:06	49950	49890	0	227.6	227.1	226.7	96.73	49.36	73.82	43.61	1
20/02/2007 13:06	46070	45680	0	228.4	227.4	227.1	83.57	46.03	71.91	41.84	1
20/02/2007 14:06	40070	39770	0	229.4	228.6	228.1	65.82	43.71	65.65	30.15	1
20/02/2007 15:06	26870	26470	0	230.9	230.3	229.3	38.5	31.43	46.76	23.55	1
20/02/2007 16:06	15870	15870	3.29	229.3	229.1	227.3	20.46	20.56	29.39	13.06	1
20/02/2007 17:06	4807	4679	44.42	228.3	227.7	225.9	5.47	6.88	9.7	7.38	1
20/02/2007 18:06	11180	11180	3.11	231.1	230.4	228	26.07	15.63	8.04	13.28	1
20/02/2007 19:06	9613	9613	3.52	233.2	233.1	230.6	17.76	15.92	9.09	6.7	1
20/02/2007 20:06	9395	9395	7.7	231.4	231.2	228.6	17.71	15.39	8.96	7.17	1
20/02/2007 21:06	9031	9031	7.1	230.4	230.3	227.6	17.4	15.34	8.02	7.94	1
20/02/2007 22:06	9399	9399	3.27	230.6	230.2	228	17.28	15.32	9.61	6.62	1
20/02/2007 23:06	9347	9347	7.82	229.7	229.4	227.4	18.3	15.24	8.39	8.53	1
21/02/2007 00:06	11320	11320	7.67	232.8	232.7	231.1	26.2	15.66	8.1	13.92	1
21/02/2007 01:06	9359	9359	5.46	229.3	229	227.6	17.04	15.68	9.41	6.34	1
21/02/2007 02:06	9656	9656	4.36	231.7	231.6	230.4	18.4	15.49	8.95	8.16	1
21/02/2007 03:06	9146	9146	2.72	230.7	230.6	229.4	17.11	15.3	8.4	7.53	1
21/02/2007 04:06	9412	9412	3.39	230.9	230.8	229.3	17.12	15.31	9.47	6.72	1
21/02/2007 05:06	9240	9240	7.08	228.2	227.8	226.4	18.06	15.17	8.36	8.49	1
21/02/2007 06:06	7197	7197	11.17	231.3	230.8	228.9	15.18	8.88	8.19	6.63	1
21/02/2007 07:06	9134	9129	291.1	228.7	228.4	226.7	12.98	15.06	14.1	6.84	1
21/02/2007 08:06	34000	33970	0	228.1	227.2	226.1	53.72	43.41	53.57	18.35	1
21/02/2007 09:06	39800	39510	0	225	223.7	222.8	70.14	45.58	61.42	31.21	1
21/02/2007 10:06	46160	46130	0	229.2	228.5	227.4	84.1	46.77	72.79	42.33	1
21/02/2007 11:06	46680	46260	0	230.7	229.4	229	80.57	48.5	73.51	38.49	1
21/02/2007 12:06	47090	46880	0	230.9	229.9	229.5	84.17	49.51	70.06	38.3	1
21/02/2007 13:06	42570	42310	0	227.3	226.4	226	72.1	47.25	67.65	32.18	1
21/02/2007 14:06	36380	36380	0	227.4	226.8	225.9	56.81	34.3	71.14	38.46	1
21/02/2007 15:06	17710	17710	1.88	231.2	230.7	229.8	27.29	22.95	28.62	15.35	1
21/02/2007 16:06	10210	10040	1678	231.6	231.3	230	21.67	11.35	11.47	9.82	0.98
21/02/2007 17:06	5234	4715	1263	231.1	231	229.9	8.2	5.69	7.88	4.36	0.96
21/02/2007 18:06	8300	7957	2306	228.1	227.5	225.1	23.2	8.74	8.19	14.97	0.96
21/02/2007 19:06	9009	8932	1176	229.9	229.1	226.9	18.89	12.23	9.26	9.47	0.98
21/02/2007 20:06	9459	9378	1235	231.8	231.3	229.1	20.19	12.32	9.55	10.01	0.98
21/02/2007 21:06	9338	9267	1151	230.3	230	227.8	20.13	12.53	9.12	9.83	0.98
21/02/2007 22:06	9011	8943	1100	231	230.7	228.2	18.93	12.4	9.03	8.99	0.98
21/02/2007 23:06	9126	9071	1001	230.6	230.4	228.4	18.75	12.09	10.1	8.94	0.99
22/02/2007 00:06	11190	11120	1245	230.6	230.5	228.7	27.61	12.07	10.43	17.75	0.99
22/02/2007 01:06	9183	9129	995.1	229.4	229.3	227.8	19.76	12.08	9.35	10.41	0.99
22/02/2007 02:06	9300	9256	900.6	230.6	230.4	229.1	18.58	12.42	10.25	8.31	0.99
22/02/2007 03:06	9093	9076	555	231.8	231.7	230.4	18.34	12.6	9.36	8.12	0.99
22/02/2007 04:06	9148	9141	360.1	231.5	231.3	230	19.23	12.37	8.98	9.31	1
22/02/2007 05:06	8987	8987	22.18	230.1	229.6	228.4	17.78	12.09	10.16	7.83	1
22/02/2007 06:06	6793	6776	467.4	232.6	232.7	230.9	14.39	6.7	8.65	7.44	0.99
22/02/2007 07:06	7955	7892	492.5	228	227.9	226.7	18.57	7.21	9.86	11.19	1
22/02/2007 08:06	11850	11840	5.45	225.1	224.7	223.4	16.05	14.66	22.57	10.07	1
22/02/2007 09:06	12850	12840	181.3	226.2	225.5	223.9	18.84	14.86	25.09	12.71	1
22/02/2007 10:06	12430	12420	568.6	226.1	225.3	223.9	27.4	12.07	16.76	14.57	1

22/02/2007 11:06	11960	11900	1213	227.9	227	225.9	20.17	12.1	21.53	11.44	0.99
22/02/2007 12:06	14110	14110	90.97	229.9	229	228.2	29.45	12.86	20.21	12.78	1
22/02/2007 13:06	12410	12410	139.8	230.4	229.7	228.3	21.67	12.97	21.05	9	1
22/02/2007 14:06	10680	10580	1411	232.8	232.3	230.7	19.4	13.18	14.59	7.23	0.99
22/02/2007 15:06	5121	5090	523.5	231	230.7	229.2	7.51	5.46	10.68	5.9	0.99
22/02/2007 16:06	4875	4860	97.22	232.4	232.1	230.5	6.12	5.57	10.1	6.8	1
22/02/2007 17:06	9142	9047	1316	230.1	229.4	228.2	18.35	12.1	10.55	7.71	0.99
22/02/2007 18:06	10530	10520	324	228.5	227.9	225.9	26.83	11.76	8.64	16.11	1
22/02/2007 19:06	8643	8643	7.13	230.2	229.6	227.1	18.83	11.94	7.94	9.2	1
22/02/2007 20:06	8595	8595	8.14	231.3	231.1	228.8	17.86	12.05	8.45	7.86	1
22/02/2007 21:06	8559	8541	560.6	230	230.1	227.6	18.78	12.34	7.63	8.83	0.99
22/02/2007 22:06	8923	8923	15.7	230.4	230.1	227.8	18.75	12.37	8.73	7.72	1
22/02/2007 23:06	8546	8546	4.28	229.6	229.8	227.6	17.6	11.98	8.65	7.54	1
23/02/2007 00:06	10600	10600	19.48	230.3	230.1	228.5	26.51	11.97	8.58	15.53	1
23/02/2007 01:06	8712	8704	368.9	228.9	228.8	227.6	18.54	11.96	8.51	8.65	1
23/02/2007 02:06	8672	8671	121.3	230.6	230.5	229.2	17.77	12.01	8.91	7.6	1
23/02/2007 03:06	8839	8835	256.1	231.1	231.1	229.6	17.98	12.45	9.12	7.23	1
23/02/2007 04:06	5152	5034	1097	231.3	231.1	229.6	7.26	7.68	8.36	5.13	0.97
23/02/2007 05:06	5000	4916	912.9	230	229.7	228.3	7.12	7.32	8.33	4.91	0.98
23/02/2007 06:06	6949	6911	724.9	230.3	230.3	228.7	16	7.01	8.35	7.9	0.99
23/02/2007 07:06	4060	4043	372.9	230.9	231.4	230.3	4.18	7.21	8.06	6.89	0.99
23/02/2007 07:16	4013	4013	6.37	230.8	231.5	230.4	3.58	7.23	7.4	6.99	1
23/02/2007 07:26	1119	1070	327.2	76.55	76.75	76.36	2.51	2.5	2.99	1.67	0.98
23/02/2007 14:06	3023	3003	346.4	190.2	189.7	190.7	6.29	5.39	4.34	5.52	0.99
23/02/2007 15:06	4806	4473	1759	230.2	233	231.6	6.48	7.93	6.38	4.25	0.93
23/02/2007 16:06	4849	4620	1472	224.6	227.2	226.6	7.13	6.93	7.47	4.1	0.95
23/02/2007 17:06	3806	3599	1238	227.3	230.2	228.9	2.26	7.21	7.2	7.15	0.94
23/02/2007 18:06	8131	8130	136	227.1	230.2	228.7	16.78	12.47	7.36	7.84	1
23/02/2007 19:06	8776	8511	2141	228	231.3	229.5	18.02	12.18	8.08	8.92	0.97
23/02/2007 20:06	8247	8226	588.9	230.1	233.2	231.5	17.3	12.19	7.23	8.85	0.99
23/02/2007 21:06	8157	8156	158.9	225.7	228.4	226.9	17.13	12.44	8.06	8.35	1
23/02/2007 22:06	8185	8183	194.3	228.7	231.2	229.8	16.95	12.53	7.28	7.93	1
23/02/2007 23:06	8524	8488	785.3	228	230.6	229.6	18.54	12.27	7.49	9.43	0.99
24/02/2007 00:06	8901	8626	2191	226.8	228.9	228.3	18.2	13.43	7.47	9.88	0.97
24/02/2007 01:06	8465	8444	607.3	228.2	230.2	229.5	17.15	13.47	7.92	8.63	0.99
24/02/2007 02:06	8374	8345	696.5	225.8	227.4	227.1	17	13.64	7.33	8.34	0.99
24/02/2007 03:06	8368	8337	713.7	224.7	226.4	226.1	17.11	13.45	7.86	8.32	0.99
24/02/2007 04:06	8911	8716	1855	224.9	226.7	226.3	18.27	13.21	8.2	9.62	0.98
24/02/2007 05:06	8175	8134	823.1	223.6	225.3	224.8	17.13	13.17	7.24	9.44	0.99
24/02/2007 06:06	4401	4189	1349	226.3	228.2	227.4	2.9	8.46	8.19	8.1	0.95
24/02/2007 07:06	6747	6491	1839	223.2	225.4	224.5	10.59	10.18	9.44	5.39	0.96
24/02/2007 08:06	32420	32330	0	222.6	225.4	224.6	52.01	38.38	54.92	20.34	1
24/02/2007 09:06	42250	41970	0	224.8	228	226.9	74.13	46.44	67.25	32.89	1

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Date & Time	St/ Avg (VA)	Pt/ Avg (W)	Qt/ Avg (VAR)	V1 Avg (V)	V2 Avg (V)	V3 Avg (V)	I1 Avg (A)	I2 Avg (A)	I3 Avg (A)	Inull Avg (A)	Pfti+ Avg ()
24/02/2007 10:09	115000	111400	28560	224	224	222	167.2	169.6	177.9	47.96	0.97
24/02/2007 11:09	119200	115900	27970	226	226	224	170.8	183.9	175.4	46.64	0.97
24/02/2007 12:09	124200	119900	32380	227	227	226	175	203.9	169.4	67.21	0.96
24/02/2007 13:09	126900	121900	35030	227	228	226	190.8	195.9	172.8	65.24	0.96
24/02/2007 14:09	132700	127300	37440	227	227	226	206.5	185.6	194.4	49.92	0.96
24/02/2007 15:09	83180	79870	23240	225	225	224	127.6	132.6	110.2	49.11	0.96
24/02/2007 16:09	60680	57200	20270	226	227	226	109.5	83.87	75.02	47.38	0.94
24/02/2007 17:09	53930	50890	17840	224	224	223	98.3	64.48	78.77	39.62	0.94
24/02/2007 18:09	35970	32580	15240	227	227	225	60.64	45.29	52.93	17.63	0.9
24/02/2007 19:09	34600	31920	13350	226	226	225	54.47	45.74	53.4	14.9	0.92
24/02/2007 20:09	34550	31610	13930	230	229	228	55.18	45.78	50.2	14.98	0.92
24/02/2007 21:09	32590	30300	11980	227	227	226	54.26	44.19	45.46	15.8	0.93
24/02/2007 22:09	33860	31220	13110	230	230	229	53.28	46.96	47.36	14.33	0.92
24/02/2007 23:09	34130	31490	13170	228	228	227	54.49	48.42	47.14	15.02	0.92
25/02/2007 00:09	33550	30930	12990	228	228	228	54.32	45.98	46.98	13.7	0.92
25/02/2007 01:09	34560	31960	13160	229	229	229	51.97	44.43	54.86	15.22	0.92
25/02/2007 02:09	35740	32830	14110	231	231	231	54.47	45.1	55.5	14.86	0.92
25/02/2007 03:09	36140	33300	14050	230	231	230	55.57	46.31	55.46	14.57	0.92
25/02/2007 04:09	35010	32340	13390	229	230	229	52.73	44.72	55.36	15.37	0.92
25/02/2007 05:09	33440	30800	13010	227	228	227	52.96	45.34	48.87	14.82	0.92
25/02/2007 06:09	24520	22520	9686	225	225	224	37.84	39.55	32.23	15.3	0.92
25/02/2007 07:09	33700	31830	11060	224	225	224	47.21	55.25	48.75	19.99	0.94
25/02/2007 08:09	37890	35680	12740	227	227	226	59.6	52.13	56.16	15.72	0.94
25/02/2007 09:09	37400	35370	12150	224	224	223	55.62	55.44	56.86	15.91	0.94
25/02/2007 10:09	34710	32780	11410	225	225	224	46.89	52.18	56.38	15.4	0.94
25/02/2007 11:09	37010	34740	12740	226	227	226	48.12	55.08	61.66	17.33	0.94
25/02/2007 12:09	34220	31720	12860	227	227	226	48.77	42.02	61.27	11.75	0.93
25/02/2007 13:09	34580	32050	12970	226	227	226	50.5	42.77	60.57	11.85	0.93
25/02/2007 14:09	47110	45480	12290	227	227	226	65.04	66.73	77.7	16.69	0.96
25/02/2007 15:09	31780	29450	11950	228	228	227	43	43.57	53.6	11.54	0.93
25/02/2007 16:09	31230	28360	13080	231	231	230	45.86	44.91	45.28	13.48	0.91
25/02/2007 17:09	40020	37530	13900	226	225	224	54.96	62.07	61.08	21.43	0.94
25/02/2007 18:09	32400	30090	12000	230	229	228	48.32	43.89	49.55	12.3	0.93
25/02/2007 19:09	36660	34530	12300	231	230	229	50.34	42.35	67.36	19.42	0.94
25/02/2007 20:09	33740	31810	11240	228	227	226	48.59	41.71	58.7	14.33	0.94
25/02/2007 21:09	35220	33130	11940	229	229	228	46.96	43.93	63.76	18.97	0.94
25/02/2007 22:09	36050	33790	12570	230	230	229	49.2	44.23	64.36	17.67	0.94
25/02/2007 23:09	36580	34260	12820	231	231	230	48.39	45.48	65.47	19.43	0.94
26/02/2007 00:09	34980	32980	11650	227	227	227	47.69	43.34	63.5	19.45	0.94
26/02/2007 01:09	35110	32960	12080	228	229	228	47.19	43.79	63.25	18.58	0.94
26/02/2007 02:09	33100	30750	12240	230	230	230	48.99	43.97	51.33	12.81	0.93
26/02/2007 03:09	34320	32420	11280	226	227	226	53.97	38.13	60.1	16.29	0.94
26/02/2007 04:09	33280	31290	11320	225	226	225	46.3	38.83	63.15	18.13	0.94
26/02/2007 05:09	32300	30530	10530	223	224	223	44.02	36.83	64.28	21.46	0.94
26/02/2007 06:09	27240	25280	10160	227	228	227	31.77	38.68	50.19	14.75	0.93
26/02/2007 07:09	26660	24420	10690	227	228	227	33.06	29.47	55.69	20.48	0.92
26/02/2007 08:09	23370	21010	10230	226	227	226	32.65	23.98	47.18	17.01	0.9

26/02/2007 09:09	24270	21930	10400	227	228	226	32.47	34.52	40.36	8.32	0.9
26/02/2007 10:09	23570	21160	10370	226	227	225	33.63	32.97	38.05	5.81	0.9
26/02/2007 11:09	23460	21160	10130	226	226	225	32.67	32.64	39.17	5.57	0.9
26/02/2007 12:09	21700	19380	9765	225	226	224	31.8	24.85	40.05	10.34	0.89
26/02/2007 13:09	23140	20940	9862	224	225	223	33.71	32.25	37.68	5.01	0.9
26/02/2007 14:09	25990	23760	10530	228	228	226	34.62	32.7	47.7	9.89	0.91
26/02/2007 15:09	24960	22360	11090	229	230	228	35.64	34.61	39.4	7.36	0.89
26/02/2007 16:09	24500	22330	10090	226	227	226	32.75	31.34	44.75	10.08	0.91
26/02/2007 17:09	28480	26280	10970	226	226	225	43.89	31.22	51.41	16.28	0.92
26/02/2007 18:09	32530	30440	11470	228	228	226	46.66	34.38	62.65	21.93	0.94
26/02/2007 19:09	34790	32760	11700	229	229	228	46.48	42.1	64.29	18.86	0.94
26/02/2007 20:09	34200	32090	11820	227	227	226	48.64	41.81	60.78	14.02	0.94
26/02/2007 21:09	35360	33230	12070	229	229	228	48.45	43.69	63.05	15.86	0.94
26/02/2007 22:09	37690	35700	12090	231	231	230	46.33	42.91	74.95	27.94	0.95
26/02/2007 23:09	34480	32260	12190	230	231	230	49.76	38.88	61.45	17.5	0.94
27/02/2007 00:09	33360	31320	11490	227	227	226	47.62	39.74	60.43	15.86	0.94
27/02/2007 01:09	33490	31340	11800	228	229	228	48.48	38.27	60.72	15.96	0.94
27/02/2007 02:09	32930	30560	12270	230	231	230	50.13	32.63	61.06	19.07	0.93
27/02/2007 03:09	33080	31110	11250	225	226	225	48.23	38.96	59.99	15.08	0.94
27/02/2007 04:09	30900	28990	10680	224	225	224	46.44	32.06	59.62	20.28	0.94
27/02/2007 05:09	32010	29850	11570	227	228	227	48.57	32.38	60.41	19.41	0.93
27/02/2007 06:09	22650	20510	9606	224	225	224	31.63	23.28	46.44	16.81	0.9
27/02/2007 07:09	30830	28580	11570	226	226	225	42.86	36.15	57.97	16.97	0.93
27/02/2007 08:09	95050	89120	33050	222	223	221	149.6	136.4	142.9	38.99	0.94
27/02/2007 09:09	105700	99650	35240	223	223	221	173.7	158.8	142.9	54.67	0.94
27/02/2007 10:09	114400	107000	40460	227	227	225	180	167.2	158.6	55.11	0.94
27/02/2007 11:09	119800	112400	41540	227	227	226	187	186.9	155.1	66.7	0.94
27/02/2007 12:09	117100	110400	38960	224	224	222	178.6	177.4	168.5	51.72	0.94
27/02/2007 13:09	118100	111200	39550	224	224	222	179.6	173.4	175.8	48.42	0.94
27/02/2007 14:09	101700	100300	15730	228	227	226	160.5	153.5	149	47.22	0.98
27/02/2007 15:09	83180	79870	23240	225	225	224	127.6	132.6	110.2	49.11	0.96
27/02/2007 16:09	56780	53570	18800	230	230	228	81.61	97.87	69.02	42.12	0.94
27/02/2007 17:09	34800	33120	10680	225	225	224	43.54	58.83	53.11	21.17	0.95
27/02/2007 18:09	31940	30230	10300	226	225	224	44.41	51.67	46.15	17.25	0.95
27/02/2007 19:09	30400	28650	10170	228	228	227	41.08	45.8	47.02	13.11	0.94
27/02/2007 20:09	34260	32440	11020	230	229	228	45.83	47.64	56.44	13.64	0.95
27/02/2007 21:09	33160	31330	10870	226	226	225	42.34	52.49	52.68	16.1	0.94
27/02/2007 22:09	34660	32450	12180	230	230	229	44.66	55.52	51.14	17.95	0.94
27/02/2007 23:09	33290	31350	11190	229	229	228	42.47	48.51	54.9	15.82	0.94
28/02/2007 00:09	30930	28980	10820	226	227	226	41.16	41.34	54.38	15.96	0.94
28/02/2007 01:09	30400	28300	11100	228	228	228	40.83	40.15	52.87	17.86	0.93
28/02/2007 02:09	33290	31110	11850	230	231	230	51.34	40.06	53.45	14.17	0.93
28/02/2007 03:09	33140	30990	11740	230	230	230	52.08	39.73	52.71	13.21	0.94
28/02/2007 04:09	33370	31230	11730	229	230	229	51.94	41.22	52.76	12.48	0.94
28/02/2007 05:09	31080	29270	10430	227	228	227	50	40.66	46.04	10.4	0.94
28/02/2007 06:09	21210	19550	8226	225	225	224	25.37	35.96	33.37	13.57	0.92
28/02/2007 07:09	23530	21510	9535	229	230	228	30.59	33.51	39.15	12.17	0.91
28/02/2007 08:09	27550	24950	11700	229	229	228	38.63	40.92	41.3	8.44	0.9
28/02/2007 09:09	30820	28310	12190	225	225	224	47.96	40.35	49.28	8.31	0.92
28/02/2007 10:09	30490	28450	10950	224	225	223	47.44	32.28	56.83	14.52	0.93
28/02/2007 11:09	27190	25100	10460	225	225	224	39.6	34.06	48.07	7.95	0.92
28/02/2007 12:09	25440	23650	9373	225	225	224	32.1	30.02	51.59	16.88	0.93

28/02/2007 13:09	24970	23020	9666	226	227	226	32.45	34.5	44.08	11.14	0.92
28/02/2007 14:09	22120	19950	9543	228	229	228	30.36	30.15	36.74	7.27	0.9
28/02/2007 15:09	20000	17880	8947	226	227	226	30.22	27.1	31.24	5.45	0.89
28/02/2007 16:09	18790	16730	8553	226	227	226	25.56	26.73	30.94	5.28	0.89
28/02/2007 17:09	28190	26420	9820	226	227	225	37.81	36.74	50.56	14.12	0.94
28/02/2007 18:09	29520	27600	10460	227	226	225	42.05	43.07	45.81	12.98	0.93
28/02/2007 19:09	30650	28650	10900	230	230	229	40.85	45.11	47.77	14.79	0.93
28/02/2007 20:09	29680	27970	9925	226	226	225	41.6	39.47	50.78	12.24	0.94
28/02/2007 21:09	29750	27750	10740	230	230	229	43.88	39.63	46.11	11.15	0.93
28/02/2007 22:09	29570	27370	11190	230	230	230	42.83	40.3	45.7	10.78	0.93
28/02/2007 23:09	30520	28650	10500	229	230	229	47.96	40.09	45.14	9.99	0.94
01/03/2007 00:09	30370	28200	11280	230	230	229	46.27	40.46	45.68	10.84	0.93
01/03/2007 01:09	30060	28000	10930	230	231	230	42.67	40.28	47.99	11.32	0.93
01/03/2007 02:09	31280	29470	10480	229	230	229	41.18	39.98	55.56	15.03	0.94
01/03/2007 03:09	29200	27210	10590	230	231	230	41.21	39.17	46.64	10.65	0.93
01/03/2007 04:09	28970	27010	10470	230	230	230	40.49	38.7	47.04	11.33	0.93
01/03/2007 05:09	28040	26130	10170	228	229	228	39.63	38.6	44.69	10.12	0.93
01/03/2007 06:09	20520	18440	8991	228	228	227	27.16	28.84	34.46	8.01	0.9
01/03/2007 07:09	24850	22300	10960	227	228	227	32.47	32.15	45.28	13.3	0.9
01/03/2007 08:09	23520	21320	9930	223	223	222	30.99	33.43	41.64	13.44	0.91
01/03/2007 09:09	25090	22800	10480	223	223	222	31.2	37.39	44.57	16.26	0.91
01/03/2007 10:09	26640	24810	9701	227	227	226	32.43	34.09	52.04	18.71	0.93
01/03/2007 11:09	29650	27730	10500	227	226	225	41.4	41.34	49.02	9.35	0.94
01/03/2007 12:09	33140	31580	10050	228	228	227	47.23	41.52	57.41	9.52	0.95
01/03/2007 13:09	24270	22600	8844	230	230	228	32.08	32.68	41.86	11.88	0.93
01/03/2007 14:09	23400	21880	8312	226	226	224	32.87	32.06	40	11.76	0.93
01/03/2007 15:09	25170	23410	9252	226	227	225	35.82	36.06	40.36	11.96	0.93
01/03/2007 16:09	19240	17470	8052	228	228	227	26.57	30.03	28.55	11.6	0.91
01/03/2007 17:09	27110	25530	9141	227	228	226	42.34	38.37	38.93	11.64	0.94
01/03/2007 18:09	29460	27850	9590	227	226	225	42.55	39.2	49.15	13.28	0.94
01/03/2007 19:09	29990	28390	9689	228	228	227	41.4	40.69	50.3	14.95	0.95
01/03/2007 20:09	31750	29960	10490	232	231	230	48.02	40.19	49.9	12.71	0.94
01/03/2007 21:09	29770	28230	9447	227	227	226	41.44	39.25	51.38	14.59	0.95
01/03/2007 22:09	32060	30410	10140	229	229	228	43.23	39.67	58.37	17.35	0.95
01/03/2007 23:09	30980	29540	9353	226	227	226	42.04	39.03	56.65	17.07	0.95
02/03/2007 00:09	29270	27490	10040	229	229	228	41.77	38.77	48.12	12.05	0.94
02/03/2007 01:09	29170	27520	9681	228	228	227	40.83	39.25	48.66	13.48	0.94
02/03/2007 02:09	29320	27600	9883	230	231	230	39.92	39.2	48.69	14.27	0.94
02/03/2007 03:09	28170	26440	9709	229	229	229	44.49	36.92	42.11	10.84	0.94
02/03/2007 04:09	27660	25910	9705	229	230	229	41.11	38.55	41.44	11.65	0.94
02/03/2007 05:09	27540	25710	9875	228	228	228	42.62	36.87	41.76	10.64	0.93
02/03/2007 06:09	18540	16620	8230	229	229	229	26.38	27.89	27.08	9.32	0.9
02/03/2007 07:09	19600	17700	8437	228	228	227	28.49	28.23	30.1	9.64	0.9
02/03/2007 08:09	18790	16920	8184	225	225	224	27.71	28.06	28.2	8.25	0.9
02/03/2007 09:09	19150	17140	8539	227	227	227	28.05	28.56	28.12	8.81	0.89
02/03/2007 10:09	22540	20940	8351	225	225	225	28.07	39.83	33.14	18.31	0.93
02/03/2007 11:09	19340	17660	7874	224	224	223	26.35	29.72	30.76	11.61	0.91
02/03/2007 12:09	18100	16200	8072	226	226	225	26.29	27.32	26.89	7.3	0.89
02/03/2007 13:09	20270	18520	8246	227	227	226	26.15	36.71	27.01	16.33	0.91
02/03/2007 13:59	22840	21170	8567	228	228	227	27.43	36.7	36.92	15.37	0.93
02/03/2007 14:09	23400	21720	8708	229	229	228	27.57	38.43	37.24	16.52	0.93
02/03/2007 15:09	20160	18160	8748	228	228	227	28.44	28.7	31.98	9.45	0.9

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Date & Time	St/ Avg (VA)	Pt/ Avg (W)	Qt/ Avg (VAR)	V1 Avg (V)	V2 Avg (V)	V3 Avg (V)	I1 Avg (A)	I2 Avg (A)	I3 Avg (A)	Inull Avg (A)	Pfti+ Avg ()
14/03/2007 10:45	238600	231200	58990	224	223	222	334	325.2	412	138.4	0.97
14/03/2007 11:45	247900	240600	59500	224	223	221	337	336.1	441.2	153.7	0.97
14/03/2007 12:45	246800	239600	59150	222	221	220	334	338.4	444.2	157.4	0.97
14/03/2007 13:45	207800	202200	48010	223	222	220	272	275.2	392.6	158	0.97
14/03/2007 14:45	153600	147900	41510	226	225	224	191	209.6	282.7	121.4	0.96
14/03/2007 15:45	84930	81050	25360	230	229	227	104	106.9	160.8	72.64	0.95
14/03/2007 16:45	56930	54300	17120	230	229	228	73.7	67.54	107.6	46.97	0.95
14/03/2007 17:45	46620	43260	17390	226	224	223	63.7	51.89	92.78	40.59	0.93
14/03/2007 18:45	52380	48270	20340	227	225	224	72.1	58.2	103.2	40.94	0.92
14/03/2007 19:45	54120	49460	21960	230	228	227	73.9	59.77	104.1	39.87	0.91
14/03/2007 20:45	54370	49540	22390	230	228	228	73.4	60.38	104.4	39.74	0.91
14/03/2007 21:45	54590	49720	22520	231	229	229	74.2	60.41	103.7	38.36	0.91
14/03/2007 22:45	53580	48950	21790	228	227	227	72.5	60.47	102.9	38.79	0.91
14/03/2007 23:45	54590	49600	22800	230	229	228	73.3	61.38	104.3	37.96	0.91
15/03/2007 00:45	53840	49060	22170	228	228	227	72.9	60.89	102.9	37.81	0.91
15/03/2007 01:45	57100	51770	24080	230	229	229	77	65.16	107.4	38.63	0.91
15/03/2007 02:45	61490	55760	25910	229	229	228	84.2	71.18	113.9	39.29	0.91
15/03/2007 03:45	54460	49600	22470	229	229	228	73.9	61.81	103.1	38.64	0.91
15/03/2007 04:45	51600	47580	19970	227	227	226	67.6	58.51	102.1	42.12	0.92
15/03/2007 05:45	42870	40300	14610	226	226	225	52.4	51.22	86.47	45.74	0.94
15/03/2007 06:45	65150	62990	16640	226	226	225	82.2	90.29	117.1	44.89	0.97
15/03/2007 07:45	122100	118600	28940	225	224	223	163	177.7	204.1	68.35	0.97
15/03/2007 08:45	171300	166000	42470	225	224	223	244	240.9	280.8	85.9	0.97
15/03/2007 09:45	184200	178500	45650	224	224	222	264	251.4	309.2	95.18	0.97
15/03/2007 10:45	193800	187900	47490	225	224	223	270	270.5	325.8	100.3	0.97
15/03/2007 11:45	171100	166400	39970	224	223	222	242	242.4	282.8	92.73	0.97
15/03/2007 12:45	160100	155000	40040	225	224	223	213	221.8	279.7	105.5	0.97
15/03/2007 13:45	169700	162700	48030	227	226	224	226	245.5	280.2	99.64	0.96
15/03/2007 14:45	105900	100600	33080	229	228	226	125	159.4	181.1	79.29	0.95
15/03/2007 15:45	51450	49290	14740	229	227	226	61.2	69.37	95.83	43.41	0.96
15/03/2007 16:45	38300	36700	10940	227	225	224	57.2	50.13	63.1	23.25	0.96
15/03/2007 17:45	41320	38010	16210	230	228	228	66.3	47.68	67.27	25.26	0.92
15/03/2007 18:45	47120	42630	20070	231	228	228	74.6	54.61	76.93	27.13	0.9
15/03/2007 19:45	47200	42660	20200	230	228	228	73.9	54.85	77.97	26.27	0.9
15/03/2007 20:45	47290	42730	20270	230	228	228	73.4	55.02	78.64	25.66	0.9
15/03/2007 21:45	54080	48740	23430	230	229	228	83.6	65.5	87.45	24.09	0.9
15/03/2007 22:45	47310	42940	19850	229	228	227	74	55.93	77.88	24.67	0.91
15/03/2007 23:45	47690	43000	20610	229	229	228	74	56.6	78.17	22.72	0.9
16/03/2007 00:45	47250	42640	20360	229	228	227	73.2	56.32	77.87	23.16	0.9
16/03/2007 01:45	47210	42710	20130	228	228	228	73.2	56.61	77.5	23.71	0.9
16/03/2007 02:45	47580	43000	20370	228	228	228	73.3	56.65	78.95	24.12	0.9
16/03/2007 03:45	47310	42730	20290	228	228	227	74.2	56.33	77.45	24.88	0.9
16/03/2007 04:45	43820	40230	17370	227	227	227	68.1	53.39	72.1	23.34	0.92
16/03/2007 05:45	35090	33230	11280	228	227	227	51.8	45.83	57.04	20.93	0.95
16/03/2007 06:45	35030	33300	10870	227	226	226	51.8	47.82	55.7	20.37	0.95
16/03/2007 07:45	34880	33290	10400	227	226	226	51.3	46.37	56.94	20.62	0.95
16/03/2007 08:45	35330	33660	10710	228	226	226	51.9	47.7	56.89	20.19	0.95

16/03/2007 09:45	34800	33200	10430	229	227	227	52.2	44.61	56.45	19.27	0.95
16/03/2007 10:45	34470	33000	9964	227	225	224	51.8	44.25	57.28	20.31	0.96
16/03/2007 11:45	34150	32630	10070	228	226	225	51.7	44.57	54.74	18.94	0.95
16/03/2007 12:45	35180	33420	10980	230	229	229	51.8	45.25	56.71	19.36	0.95
16/03/2007 13:45	35480	33710	11040	231	230	230	51.5	45.48	57.21	20.03	0.95
16/03/2007 14:45	34820	33250	10350	228	226	226	51.3	45.52	56.97	19.98	0.95
16/03/2007 15:45	34470	32890	10300	228	227	226	51.4	45.02	55.59	19.51	0.95
16/03/2007 16:45	36920	34940	11910	231	229	228	55.7	47.84	57.65	19.51	0.95
16/03/2007 17:45	40520	37370	15660	229	227	226	63.7	47.93	67.25	23.34	0.92
16/03/2007 18:45	47230	42780	20030	231	229	228	74	54.26	78.27	25.75	0.9
16/03/2007 19:45	47150	42640	20120	231	229	228	73.1	55.47	77.38	24.76	0.9
16/03/2007 20:45	55020	49440	24140	230	229	228	87	65.04	88.36	25.03	0.9
16/03/2007 21:45	46760	42340	19830	230	229	228	73.6	54.61	76.41	25.03	0.9
16/03/2007 22:45	46460	42070	19720	229	227	227	73.2	55.62	75.65	22.82	0.9
16/03/2007 23:45	47300	42620	20500	229	228	228	73.5	56.05	77.92	22.71	0.9
17/03/2007 00:45	47430	42790	20440	229	228	227	75.2	55.92	77.25	24.03	0.9
17/03/2007 01:45	47680	42850	20890	230	229	229	75.6	56.9	75.89	23.67	0.9
17/03/2007 02:45	47930	42960	21250	231	230	230	74.6	56.95	76.94	24.32	0.9
17/03/2007 03:45	48220	43320	21170	230	230	229	74.1	57.5	78.56	23.76	0.9
17/03/2007 04:45	44900	41010	18280	230	229	229	68.6	53.86	74.12	22.87	0.91
17/03/2007 05:45	34980	33270	10790	228	227	226	52.3	45.47	56.61	20.89	0.95
17/03/2007 06:45	70000	67820	17330	228	227	226	88.8	93.24	126.7	47.67	0.97
17/03/2007 07:45	160600	156100	37840	224	223	222	227	212	282.3	84.77	0.97
17/03/2007 08:45	193300	187800	46090	223	222	221	286	275.4	310.5	79.03	0.97
17/03/2007 09:45	227900	220900	56060	225	223	223	333	321.2	365.6	102.2	0.97
17/03/2007 10:45	236600	228800	60180	225	224	223	334	327.9	394.2	119.1	0.97
17/03/2007 11:45	260100	252100	64050	225	224	223	376	362.9	421.7	113.8	0.97
17/03/2007 12:45	254800	247400	60960	225	224	223	354	355.6	429.4	131.8	0.97
17/03/2007 13:45	235300	228000	58120	225	224	223	333	332	385.4	118.1	0.97
17/03/2007 14:45	177200	170200	49160	228	226	225	249	244.2	290.8	95.35	0.96
17/03/2007 15:45	107500	102100	33610	230	228	228	154	143.9	172.3	51.71	0.95
17/03/2007 16:45	53700	51590	14880	229	228	227	84.1	71.66	79.61	25.08	0.96
17/03/2007 17:45	50760	47350	18280	230	228	227	80.4	62.72	79.79	27.96	0.93
17/03/2007 18:45	52760	48200	21460	232	229	229	86	61.55	82.17	31.56	0.91
17/03/2007 19:45	51620	47330	20600	230	228	227	84.6	60.69	81.17	31.68	0.92
17/03/2007 20:45	52480	47780	21710	232	230	230	85.3	61.17	81.6	31.45	0.91
17/03/2007 21:45	51440	47100	20690	229	228	228	83.8	60.86	80.88	29.76	0.92
17/03/2007 22:45	51190	46890	20540	228	228	227	83.2	61	80.79	29.59	0.92
17/03/2007 23:45	51190	46750	20840	227	227	226	83.3	61.88	80.63	28.23	0.91
18/03/2007 00:45	51040	46660	20680	227	226	226	83.3	61.6	80.8	28.17	0.91
18/03/2007 01:45	52150	47390	21760	229	228	228	83.7	63.57	81.46	28.17	0.91
18/03/2007 02:45	51860	47220	21440	229	229	229	83.4	62.59	80.57	29.06	0.91
18/03/2007 03:45	51640	47120	21140	229	228	228	83.9	62.48	80	30.19	0.91
18/03/2007 04:45	48610	44960	18490	227	227	227	78.1	59.28	77.15	27.03	0.92
18/03/2007 05:45	39550	37840	11530	226	226	226	62.4	51.58	61.3	21.5	0.96
18/03/2007 06:45	71510	69410	17180	227	226	226	96.4	108.5	111	39.17	0.97
18/03/2007 07:45	178100	171600	47860	226	225	224	246	247.6	298.2	92.78	0.96
18/03/2007 08:45	207400	200600	52850	223	222	221	303	299.6	331.4	96.03	0.97

Appendix 4

Sample of Measured Illumination

Sample of Measured Illumination

Date / Time	Lux
05/17/08 10:00:05	1524
05/17/08 10:00:15	1520
05/17/08 10:00:25	1522
05/17/08 10:00:35	1527
05/17/08 10:00:45	1525
05/17/08 10:00:55	1524
05/17/08 10:01:05	1518
05/17/08 10:01:15	1518
05/17/08 10:01:25	1521
05/17/08 10:01:35	1523
05/17/08 10:01:45	1513
05/17/08 10:01:55	1512
05/17/08 10:02:05	1518
05/17/08 10:02:15	1515
05/17/08 10:02:25	1507
05/17/08 10:02:35	1504
05/17/08 10:02:45	1508
05/17/08 10:02:55	1512
05/17/08 10:03:05	1508
05/17/08 10:03:15	1508
05/17/08 10:03:25	1511
05/17/08 10:03:35	1507
05/17/08 10:03:45	1505
05/17/08 10:03:55	1505
05/17/08 10:04:05	1512
05/17/08 10:04:15	1505
05/17/08 10:04:25	1510
05/17/08 10:04:35	1511
05/17/08 10:04:45	1509
05/17/08 10:04:55	1508
05/17/08 10:05:05	1515
05/17/08 10:05:15	1520
05/17/08 10:05:25	1522
05/17/08 10:05:35	1520
05/17/08 10:05:45	1528
05/17/08 10:05:55	1526
05/17/08 10:06:05	1525
05/17/08 10:06:15	1522
05/17/08 10:06:25	1524
05/17/08 10:06:35	1523
05/17/08 10:06:45	1527
05/17/08 10:06:55	1523
05/17/08 10:07:05	1522
05/17/08 10:07:15	1525
05/17/08 10:07:25	1522
05/17/08 10:07:35	1521
05/17/08 10:07:45	1519
05/17/08 10:07:55	1519
05/17/08 10:08:05	1520

Date / Time	Lux
05/17/08 10:08:15	1520
05/17/08 10:08:25	1515
05/17/08 10:08:35	1518
05/17/08 10:08:45	1511
05/17/08 10:08:55	1512
05/17/08 10:09:05	1516
05/17/08 10:09:15	1517
05/17/08 10:09:25	1514
05/17/08 10:09:35	1530
05/17/08 10:09:45	1521
05/17/08 01:09:55	1522
05/17/08 10:10:05	1524
05/17/08 10:10:15	1525
05/17/08 10:10:25	1524
05/17/08 10:10:35	1523
05/17/08 10:10:45	1525
05/17/08 10:10:55	1527
05/17/08 10:11:05	1527
05/17/08 10:11:15	1527
05/17/08 10:11:25	1529
05/17/08 10:11:35	1526
05/17/08 10:11:45	1533
05/17/08 10:11:55	1528
05/17/08 10:12:05	1518
05/17/08 10:12:15	1520
05/17/08 10:12:25	1519
05/17/08 10:12:35	1517
05/17/08 10:12:45	1510
05/17/08 10:12:55	1520
05/17/08 10:13:05	1534
05/17/08 10:13:15	1518
05/17/08 10:13:25	1522
05/17/08 10:13:35	1518
05/17/08 10:13:45	1510
05/17/08 10:13:55	1511
05/17/08 10:14:05	1508
05/17/08 10:14:15	1508
05/17/08 10:14:25	1510
05/17/08 10:14:35	1508
05/17/08 10:14:45	1508
05/17/08 10:14:55	1512
05/17/08 10:15:05	1513
05/17/08 10:15:15	1519
05/17/08 10:15:25	1522
05/17/08 10:15:35	1524
05/17/08 10:15:45	1524
05/17/08 10:15:55	1521
05/17/08 10:16:05	1523
05/17/08 10:16:15	1521

Date / Time	Lux
05/17/08 10:16:25	1523
05/17/08 10:16:35	1524
05/17/08 10:16:45	1525
05/17/08 10:16:55	1526
05/17/08 10:17:05	1529
05/17/08 10:17:15	1528
05/17/08 10:17:25	1526
05/17/08 10:17:35	1526
05/17/08 10:17:45	1527
05/17/08 10:17:55	1528
05/17/08 10:18:05	1532
05/17/08 10:18:15	1528
05/17/08 10:18:25	1528
05/17/08 10:18:35	1525
05/17/08 10:18:45	1525
05/17/08 10:18:55	1526
05/17/08 10:19:05	1527
05/17/08 10:19:15	1525
05/17/08 10:19:25	1525
05/17/08 10:19:35	1525
05/17/08 10:19:45	1523
05/17/08 10:19:55	1517
05/17/08 10:20:05	1514
05/17/08 10:20:15	1510
05/17/08 10:20:25	1507
05/17/08 10:20:35	1499
05/17/08 10:20:45	1498
05/17/08 10:20:55	1501
05/17/08 10:21:05	1500
05/17/08 10:21:15	1505
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Date / Time	Lux
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Date / Time	Lux
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Date / Time	Lux
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Date / Time	Lux
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Date / Time	Lux
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05/17/08 11:07:05	812

Date / Time	Lux
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Date / Time	Lux
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Date / Time	Lux
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Date / Time	Lux
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Date / Time	Lux
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Date / Time	Lux
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05/17/08 12:01:55	1583
05/17/08 12:02:05	1584
05/17/08 12:02:15	1586
05/17/08 12:02:25	1583
05/17/08 12:02:35	1582
05/17/08 12:02:45	1582
05/17/08 12:02:55	1581
05/17/08 12:03:05	1580
05/17/08 12:03:15	1581
05/17/08 12:03:25	1582
05/17/08 12:03:35	1584
05/17/08 12:03:45	1581
05/17/08 12:03:55	1584
05/17/08 12:04:05	1583
05/17/08 12:04:15	1582
05/17/08 12:04:25	1585
05/17/08 12:04:35	1580
05/17/08 12:04:45	1580
05/17/08 12:04:55	1579
05/17/08 12:05:05	1578
05/17/08 12:05:15	1580
05/17/08 12:05:25	1579
05/17/08 12:05:35	1578
05/17/08 12:05:45	1578
05/17/08 12:05:55	1580
05/17/08 12:06:05	1581
05/17/08 12:06:15	1584
05/17/08 12:06:25	1582
05/17/08 12:06:35	1582

Date / Time	Lux
05/17/08 12:06:45	1580
05/17/08 12:06:55	1580
05/17/08 12:07:05	1580
05/17/08 12:07:15	1581
05/17/08 12:07:25	1579
05/17/08 12:07:35	1578
05/17/08 12:07:45	1577
05/17/08 12:07:55	1578
05/17/08 12:08:05	1579
05/17/08 12:08:15	1580
05/17/08 12:08:25	1582
05/17/08 12:08:35	1584
05/17/08 12:08:45	1583
05/17/08 12:08:55	1584
05/17/08 12:09:05	1585
05/17/08 12:09:15	1585
05/17/08 12:09:25	1583
05/17/08 12:09:35	1586
05/17/08 12:09:45	1587
05/17/08 12:09:55	1584
05/17/08 12:10:05	1583
05/17/08 12:10:15	1587
05/17/08 12:10:25	1588
05/17/08 12:10:35	1589
05/17/08 12:10:45	1590
05/17/08 12:10:55	1588
05/17/08 12:11:05	1587
05/17/08 12:11:15	1589
05/17/08 12:11:25	1586
05/17/08 12:11:35	1588
05/17/08 12:11:45	1587
05/17/08 12:11:55	1588
05/17/08 12:12:05	1589
05/17/08 12:12:15	1590
05/17/08 12:12:25	1590
05/17/08 12:12:35	1591
05/17/08 12:12:45	1589
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05/17/08 12:14:15	1591
05/17/08 12:14:25	1589
05/17/08 12:14:35	1588
05/17/08 12:14:45	1590
05/17/08 12:14:55	1589
05/17/08 12:15:05	1592

Date / Time	Lux
05/17/08 12:15:15	1591
05/17/08 12:15:25	1593
05/17/08 12:15:35	1590
05/17/08 12:15:45	1592
05/17/08 12:15:55	1594
05/17/08 12:16:05	1596
05/17/08 12:16:15	1595
05/17/08 12:16:25	1595
05/17/08 12:16:35	1593
05/17/08 12:16:45	1594
05/17/08 12:16:55	1592
05/17/08 12:17:05	1594
05/17/08 12:17:15	1596
05/17/08 12:17:25	1597
05/17/08 12:17:35	1598
05/17/08 12:17:45	1596
05/17/08 12:17:55	1594
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05/17/08 12:18:25	1596
05/17/08 12:18:35	1595
05/17/08 12:18:45	1595
05/17/08 12:18:55	1594
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05/17/08 12:22:25	1600
05/17/08 12:22:35	1601
05/17/08 12:22:45	1601
05/17/08 12:22:55	1601
05/17/08 12:23:05	1601
05/17/08 12:23:15	1602
05/17/08 12:23:25	1600
05/17/08 12:23:35	1599

Date / Time	Lux
05/17/08 12:23:45	1598
05/17/08 12:23:55	1599
05/17/08 12:24:05	1598
05/17/08 12:24:15	1599
05/17/08 12:24:25	1599
05/17/08 12:24:35	1600
05/17/08 12:24:45	1601
05/17/08 12:24:55	1602
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05/17/08 12:26:25	1605
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05/17/08 12:26:55	1602
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05/17/08 12:27:15	1599
05/17/08 12:27:25	1598
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05/17/08 12:30:55	1602
05/17/08 12:31:05	1605
05/17/08 12:31:15	1604
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05/17/08 12:31:35	1604
05/17/08 12:31:45	1603
05/17/08 12:31:55	1602
05/17/08 12:23:45	1598

Date / Time	Lux
05/17/08 12:32:05	1603
05/17/08 12:32:15	1600
05/17/08 12:32:25	1601
05/17/08 12:32:35	1603
05/17/08 12:32:45	1604
05/17/08 12:32:55	1605
05/17/08 12:33:05	1607
05/17/08 12:33:15	1608
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05/17/08 12:33:45	1610
05/17/08 12:33:55	1609
05/17/08 12:34:05	1605
05/17/08 12:34:15	1607
05/17/08 12:34:25	1606
05/17/08 12:34:35	1607
05/17/08 12:34:45	1608
05/17/08 12:34:55	1609
05/17/08 12:35:05	1607
05/17/08 12:35:15	1609
05/17/08 12:35:25	1608
05/17/08 12:35:35	1610
05/17/08 12:35:45	1611
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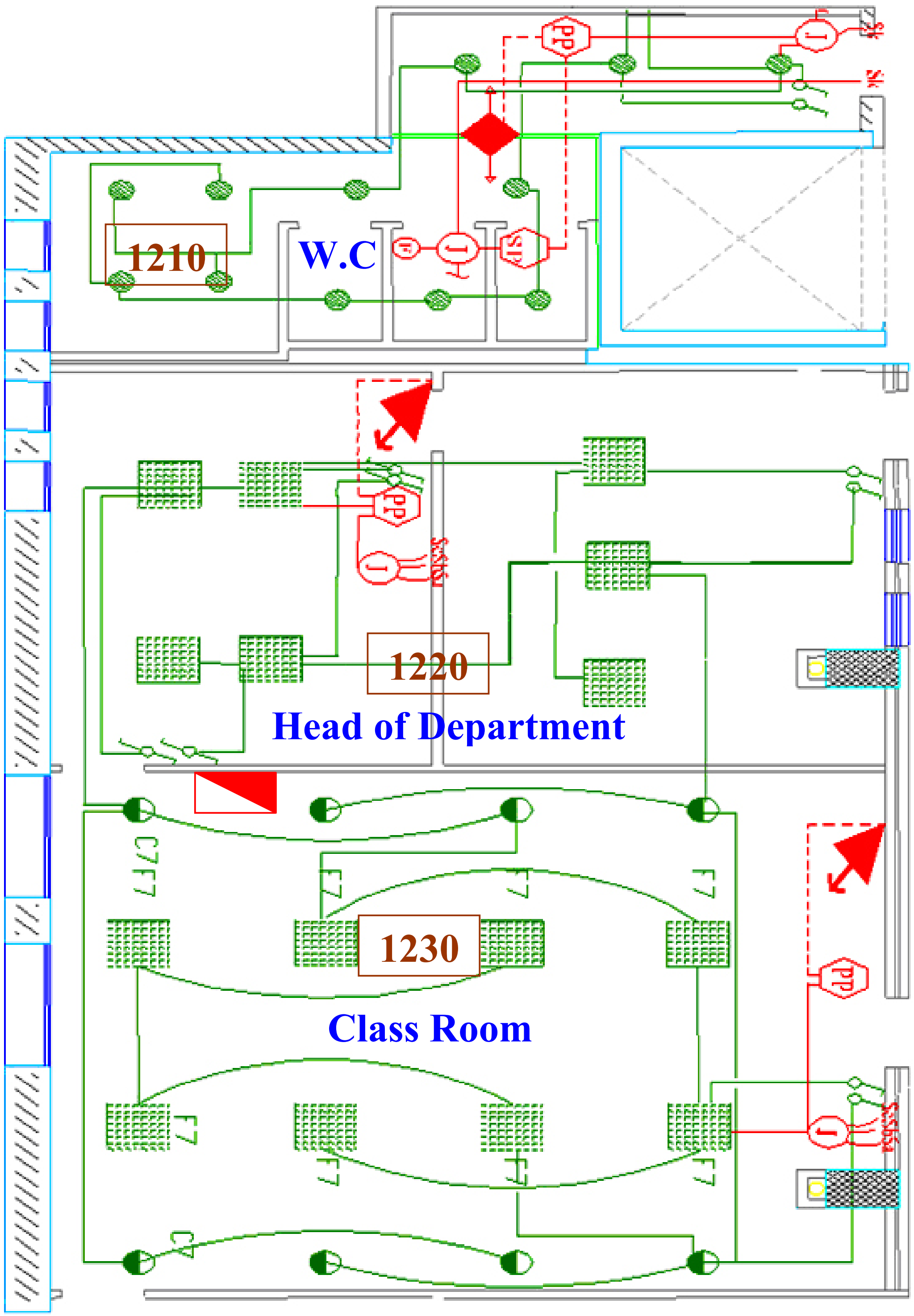
05/17/08 12:39:25	1610
05/17/08 12:39:35	1611
05/17/08 12:39:45	1612
05/17/08 12:39:55	1613
05/17/08 12:40:05	1614
05/17/08 12:40:15	1609
05/17/08 12:32:05	1603

Appendix 5

Sensors Drawing



First Floor	Legend			
Faculty of Engineering		DT200 Dual Technology Sensor,		Lighting Panel
An-Najah National University		with Light Level	J	Junction Box
New Campus		WT1105 Ultrasonic Sensor	S	Wall Switch
Eng. Mohammad Mubayed	PP	B220E-P Power Pack		Low Voltage Wire
1/100	SP	S120/220/400-P Slave Pack		Line Voltage Wire

Appendix 6

XPort Direct+ Data Sheet

XPort Direct+ Integration Guide/Data Sheet

Description and Specifications

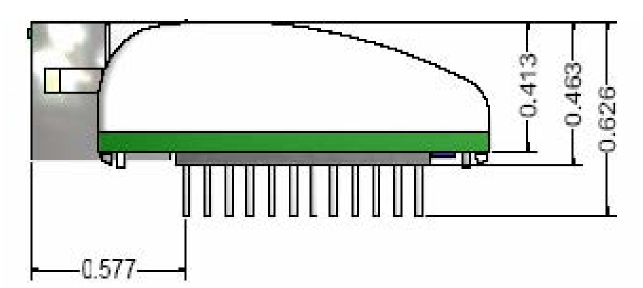
The XPort Direct+ embedded device server is a complete network-enabling solution enclosed within a compact, integrated package. This miniature serial-to-Ethernet converter enables original equipment manufacturers (OEMs) to quickly and easily go to market with networking and web page-serving capabilities built into their products.

The XPort Direct+

The XPort Direct+ contains Lantronix's own DSTni-EX CPU, which has 256 KB zero wait-state SRAM, 16 Kbytes of boot ROM, and an integrated 10/100 Ethernet MAC/PHY.

The following diagram shows the side view of the XPort Direct+ with measurements in inches.

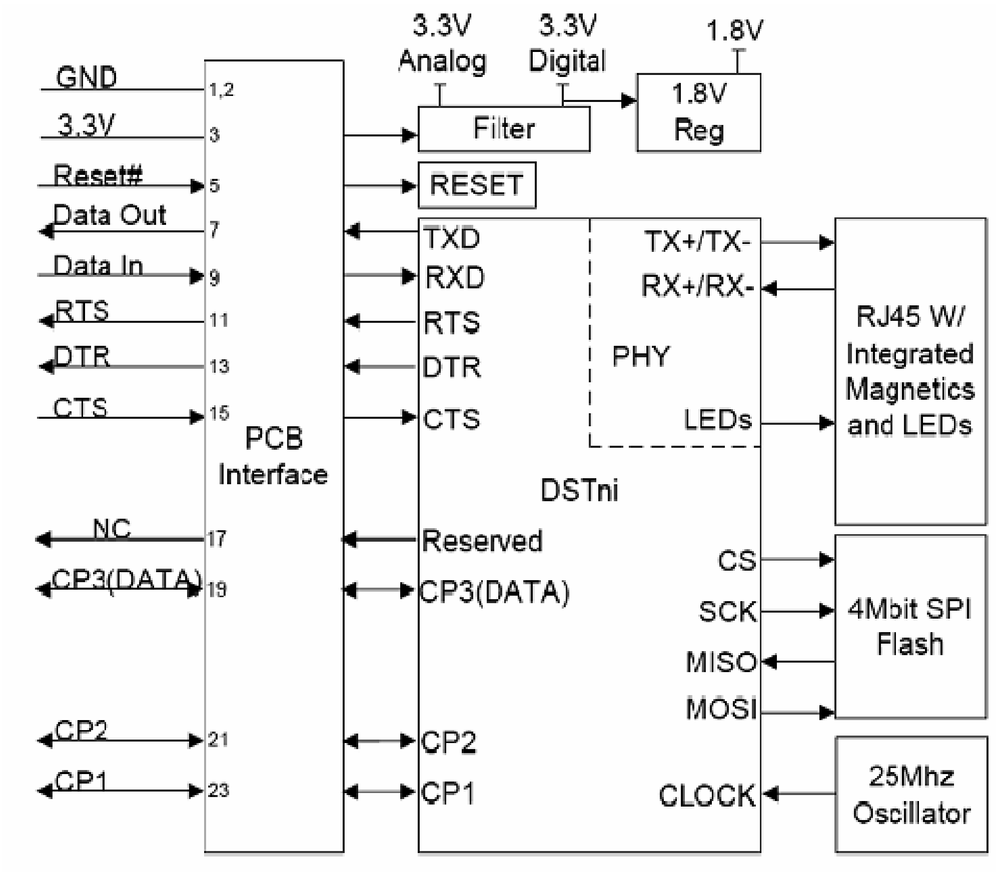
Figure 1: XPort Direct+ Block Diagram



XPort Direct+ Block Diagram

The following drawing is a block diagram of the XPort Direct+ showing the relationships of the components.

Figure 2: XPort Direct+ Block Diagram



PCB Interface

The XPort Direct+ has a serial port compatible with data rates up to 921 Kbaud. The serial interface pins include +3.3V, ground, and reset. The serial signals usually connect to an internal device, such as the UART port of the host device's microcontroller. For applications requiring an external cable running with RS-232 or RS422/485 voltage levels, the XPort Direct+ must interface to a serial transceiver chip.

Table 1: PCB Interface Signals

Signal Name	Direct Pin #	Primary Function
GND	1,2	Circuit ground
3.3V	3	+3.3V power in
Reset#	5	External reset in
Data Out	7	Serial data out (driven by DSTni's built-in UART)
Data In	9	Serial data in (read by DSTni's built-in UART)
RTS	11	Flow control out: RTS (Request to Send) output driven by DSTni's built-in UART for connection to CTS of attached device. RTS is used as transmit enable in RS485 mode.
DTR	13	Modem control: DTR (Data Terminal Ready) output driven by DSTni's built-in UART for connection to DCD of attached device.
CTS	15	Flow control in: CTS (Clear to Send) input read by DSTni's built-in UART for connection to RTS of attached device.
NC	17	Reserved
CP3 (DATA)	19	General Purpose IO pin
CP2	21	General Purpose IO pin
CP1	23	General Purpose IO Pin
Chassis	24	Chassis Ground Pin
NC	10,22	No Connect Pins
Reserved	4,6,8,12, 14,16,18, 20	Reserved Pins, Do not connect

The Ethernet interface magnetics, RJ45 connector, and Ethernet status LEDs are all integrated in the XPort Direct+.

Figure 3: RTS Connection for RS485 Mode

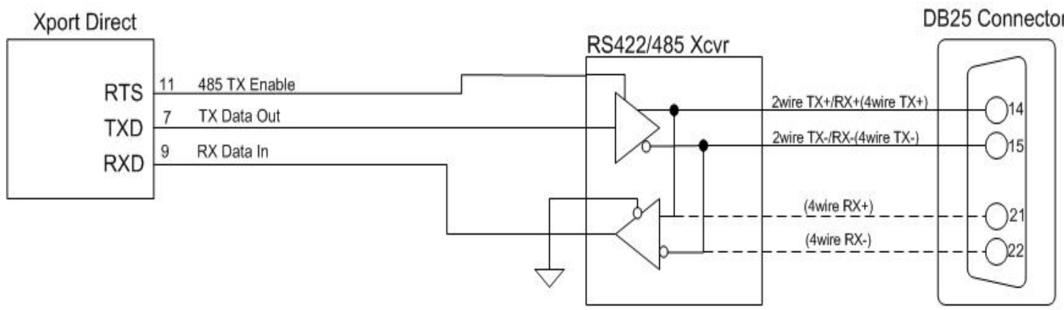


Table 2: Ethernet Interface Signals (Industry Standards)

Signal Name	DIR	Contact	Primary Function
TX+	Out	1	Differential Ethernet transmit data +
TX-	Out	2	Differential Ethernet transmit data -
RX+	In	3	Differential Ethernet receive data +
RX-	In	6	Differential Ethernet receive data -
Not used		4	Terminated
Not used		5	Terminated
Not used		7	Terminated
Not Used		8	Terminated
SHIELD			Chassis ground

LEDs

The XPort Direct+ contains the following LEDs:

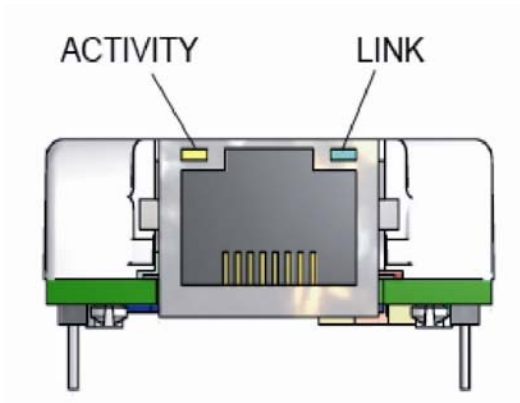
- Link (Green LED)
- Activity (Yellow LED)

Table 3: LEDs

Link LED	
Status	**Meaning**
Off	No link
Green	Link established

Link LED	
Status	**Meaning**
Off	No Activity
Blink yellow	Activity

Figure 4: XPort Direct+ LEDs



Dimensions

The following drawings show the dimensions of the XPort Direct+ (in inches):

Figure 5: Front View

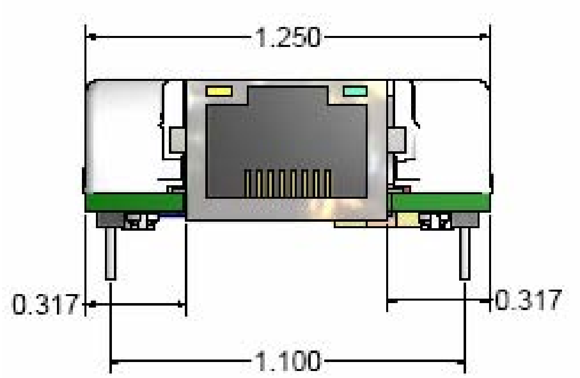


Figure 6: Bottom View

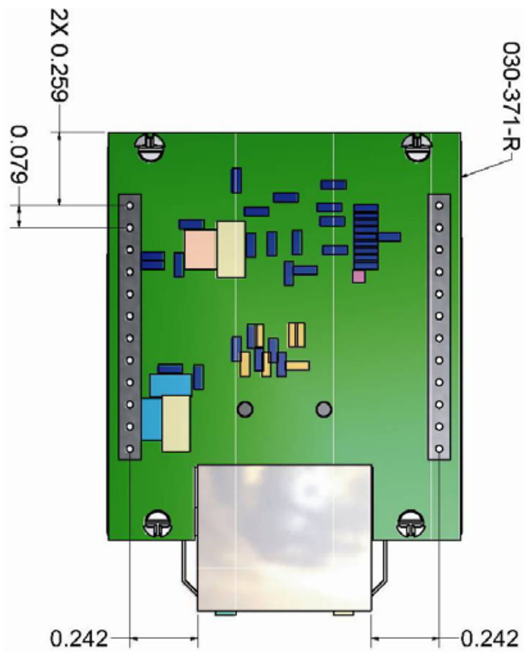
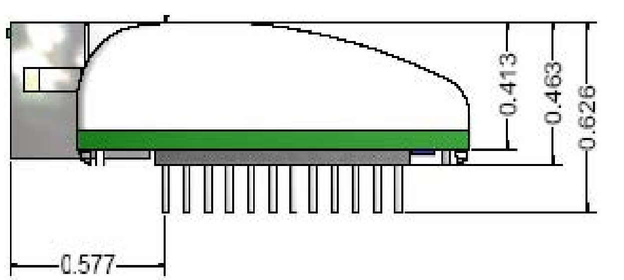


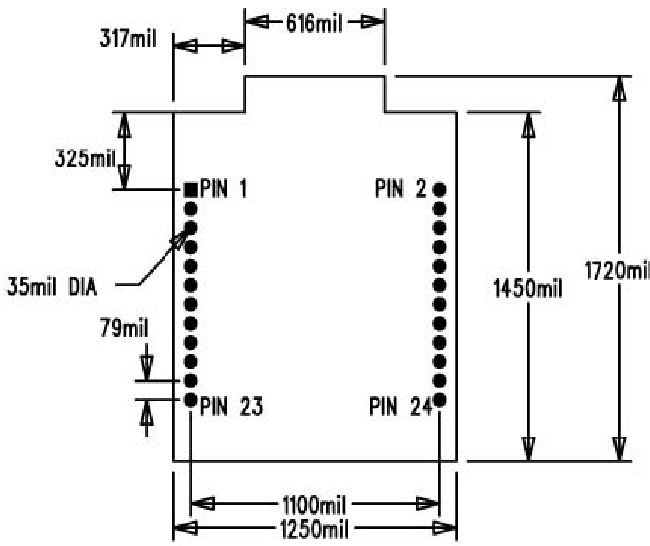
Figure 7: Side View



Recommended PCB Layout

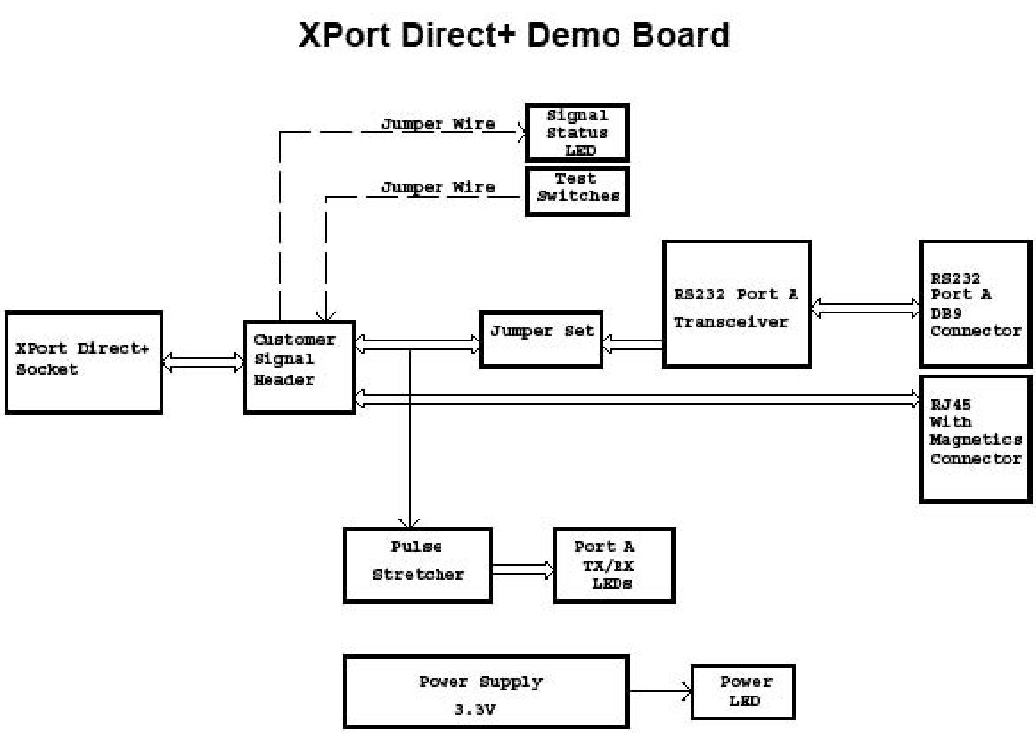
The following drawing shows the hole pattern and mounting dimensions for the XPort Direct+.

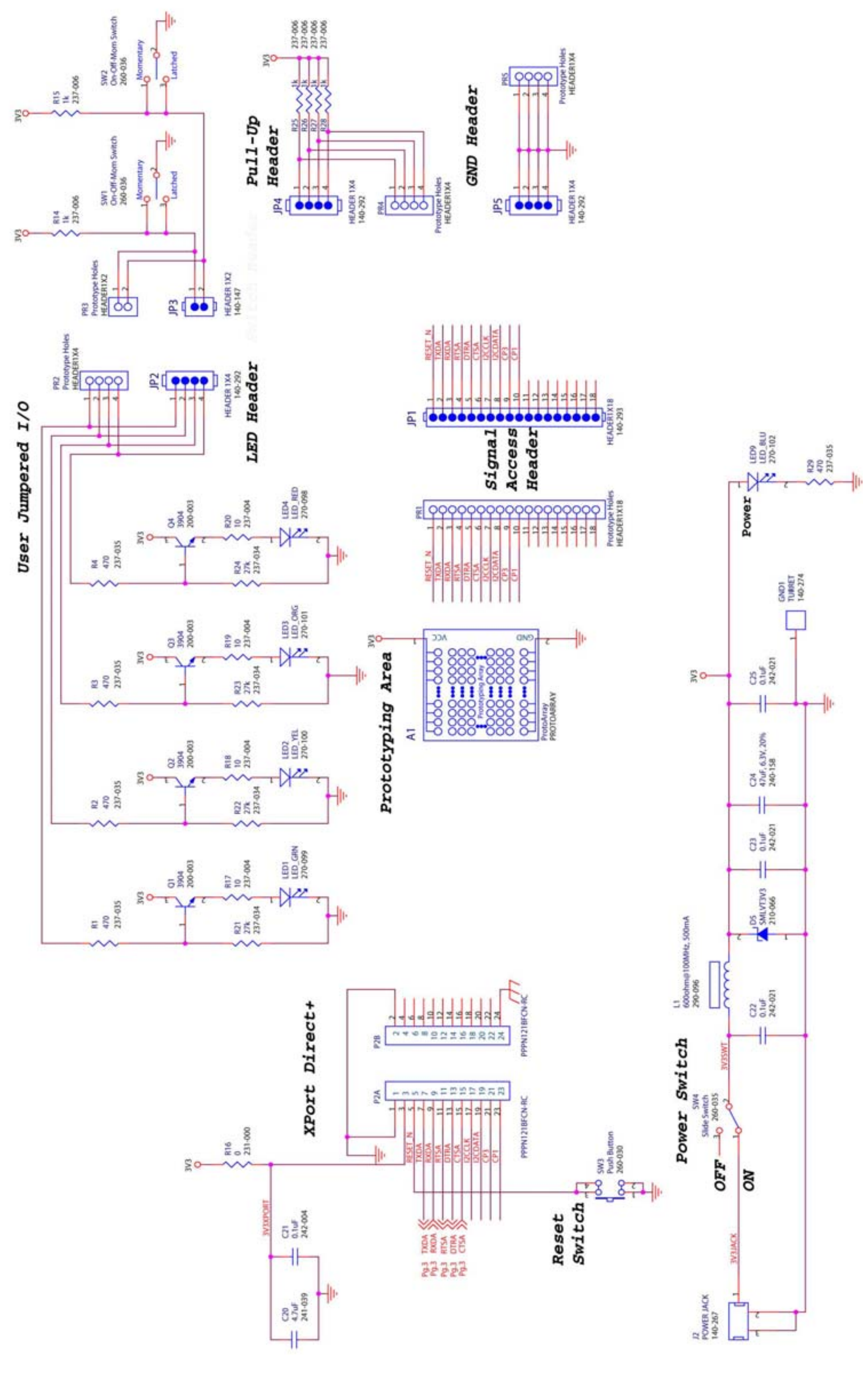
Figure 8: PCB Layout (Top View)

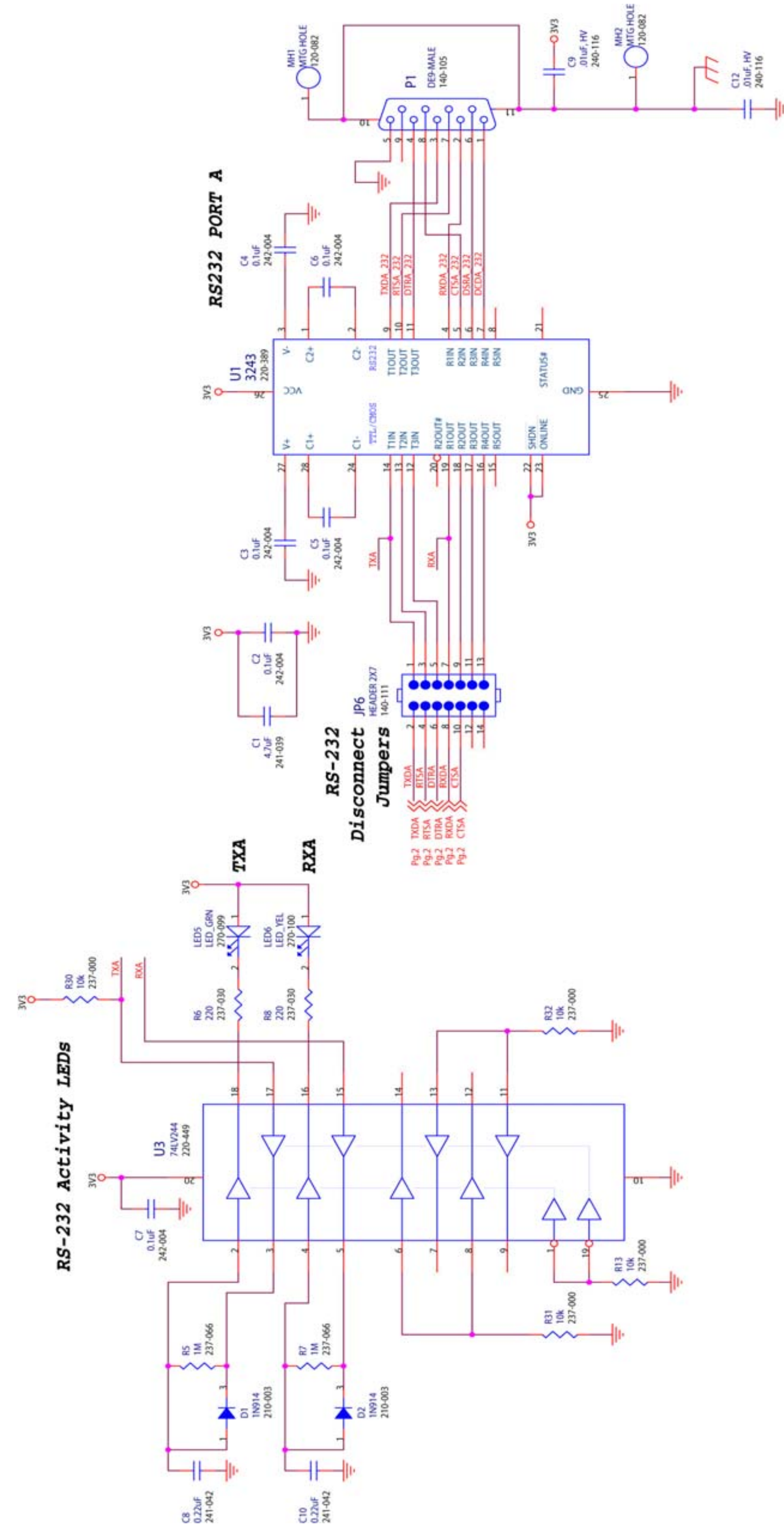


Demo Board Schematics Technical Specifications

Figure 9: XPort Direct+ Demo Board




User Jumpered I/O
LED Header
Pull-Up Header
GND Header
Signal Access Header
Prototyping Area
XPort Direct+
Power Switch
Reset Switch
Power
OFF
ON


RS232 PORT A
RS-232 Disconnect Jumpers
RS-232 Activity LEDs
TXA
RXA
U1 3243 220-389
P1 DE9-MALE 140-105
JP6 HEADER 2X7 140-111
U3 74LV244 220-449

Technical Specifications

Table 4: Technical Specifications

Category	Description
CPU, Memory	Lantronix DSTni-EX 186 CPU, 256 KB zero wait state SRAM, 4 Mbit SPI Flash,
	16 KB boot ROM operating at up to 88 Mhz
Firmware	Upgradeable via TFTP and serial port
Reset Circuit	Reset is initiated when the power input drops below 2.6V or when pin Reset# is
	asserted low. Reset is extended for ~200ms after power returns or Reset# is de-
	asserted.
Serial Interface	CMOS (Asynchronous) 3.3V-level signals
	Rate is software selectable: 300 bps to 921Kbps
Serial Line Formats	Data bits: 7 or 8
	Stop bits: 1 or 2
	Parity: odd, even, none
Data Rates	300 bps to 921 Kbps
Modem Control	DTR, modem_control_in
Flow Control	XON/XOFF (software), CTS/RTS (hardware), None
Network Interface	RJ45 Ethernet 10Base-T or 100Base-TX (auto-sensing)
Compatibility	Ethernet: Version 2.0/IEEE 802.3 (electrical), Ethernet II frame type
Protocols Supported	ARP, UDP/IP, TCP/IP, Telnet, ICMP, DHCP, BOOTP, TFTP, Auto IP, HTTP,
	SMTP, Email
LEDs	10Base-T and 100Base-TX Link Activity, Full/half duplex
Management	Serial login, Telnet login
Security	Password protection, locking features
Weight	15.5g (0.55 oz)
Material	Plastic shell
Temperature	-40°C to 85°C (-40°F to 185°F) operating temperature
	-40°C to 85°C (-40°F to 185°F) storage temperature
Shock/Vibration	Non-operational shock: 500 g's
	Non-operational vibration: 20 g's
Warranty	One year limited warranty
Included Software	Windows™ 98/NT/2000/XP-based Device Installer configuration software and
	Windows™-based Com Port Redirector
EMI Compliance	Radiated and conducted emissions - complies with Class A limits of EN
	55022:1998
	Direct & Indirect ESD - complies with EN55024:1998
	RF Electromagnetic Field Immunity - complies with EN55024:1998
	Electrical Fast Transient/Burst Immunity - complies with EN55024:1998
	Power Frequency Magnetic Field Immunity - complies with EN55024:1998
	RF Common Mode Conducted Susceptibility - complies with EN55024:1998

Configuration Using Web Manager

You must configure the unit so that it can communicate on a network with your serial device. For example, you must set the way the unit will respond to serial and network traffic, how it will handle serial packets, and when to start or close a connection.

The unit's configuration is stored in nonvolatile memory and is retained without power. You can change the configuration at any time. The unit performs a reset after you change and store the configuration.

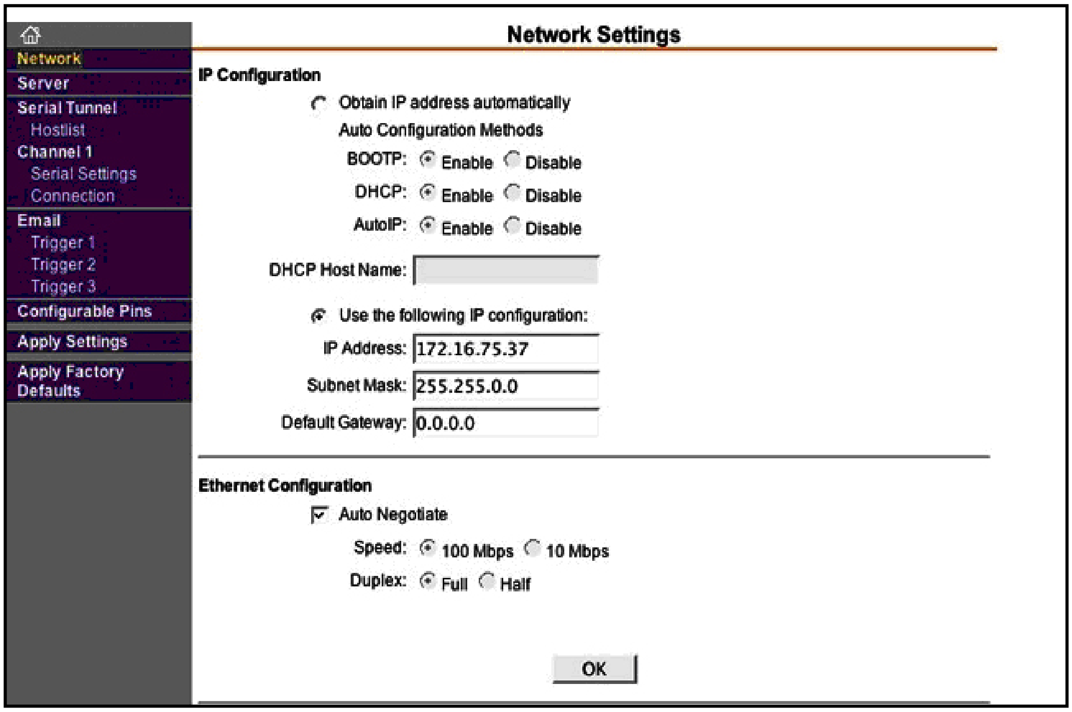
Figure 10: Lantronix Web-Manager

The main menu is in the left pane of the Web-Manager window.

Network Configuration

The unit's network values display when you select Network from the main menu. The following sections describe the configurable parameters on the Network Settings page.

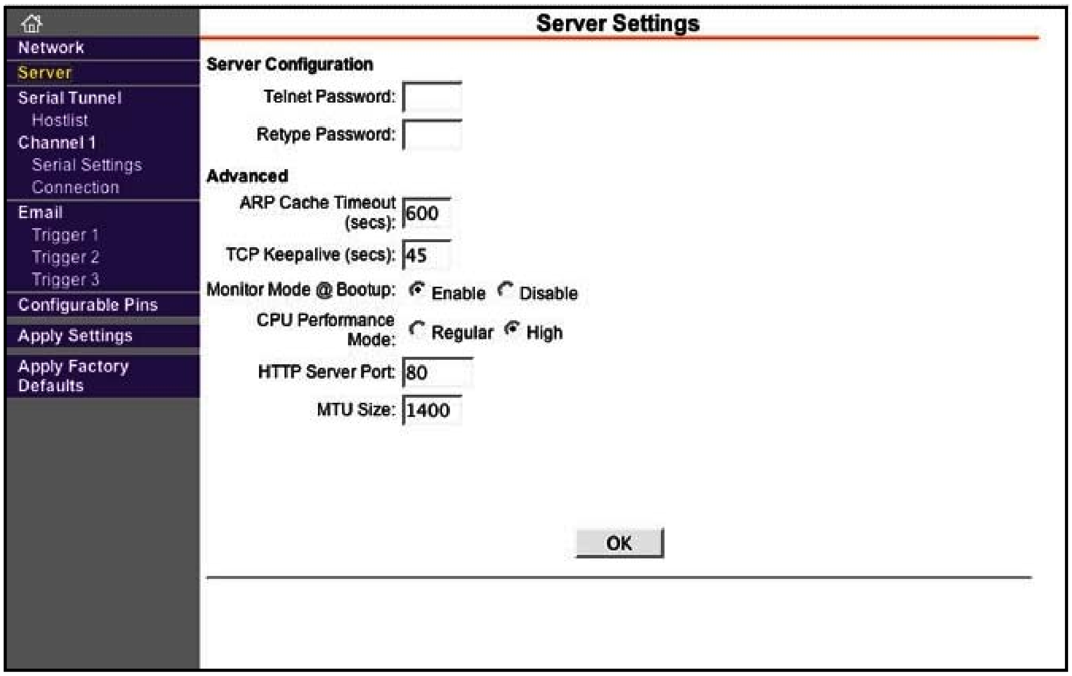
Figure 11: Network Settings



Server Configuration

The unit's server values display when you select Server from the main menu. The following sections describe the configurable parameters on the Server Settings page.

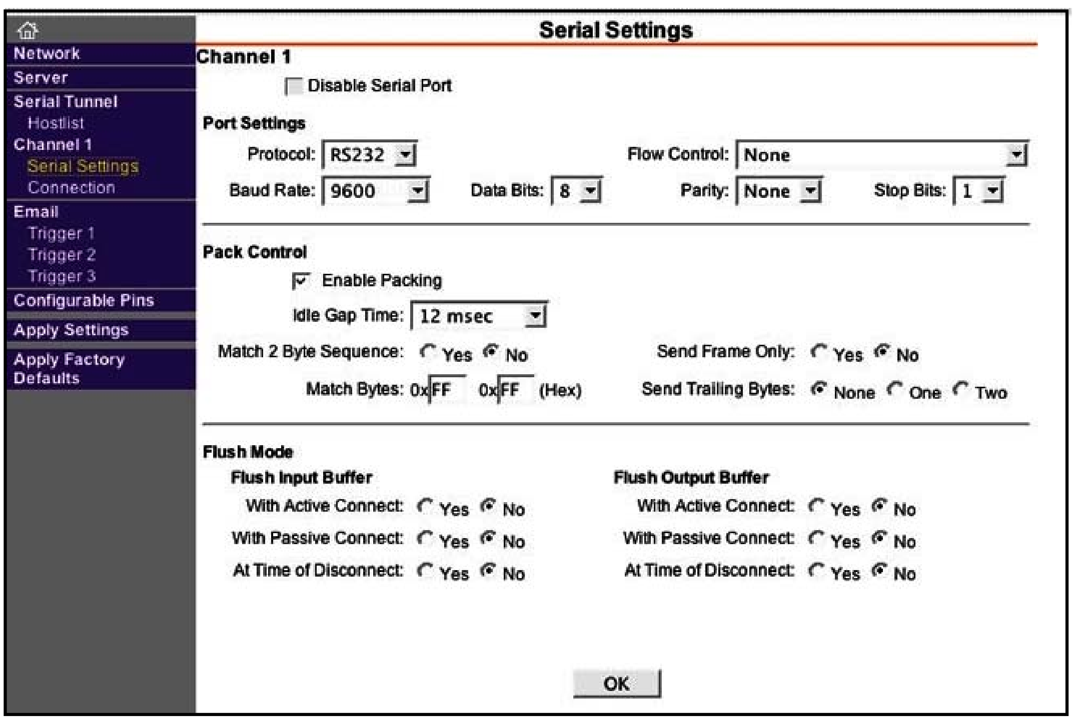
Figure 12: Server Settings



Channel Serial Configuration

The Channel 1 configuration defines how the serial port responds to network and serial communication.

Figure 13: Channel Serial Settings



Appendix 7

DT-200 Occupancy Sensor Data Sheet

DT-200

version 2

Dual Technology • Low Voltage Occupancy Sensor with Light Level, Isolated Relay and Manual On features

SPECIFICATIONS

Voltage . . . . .18-28VDC/VAC, half wave rectified AC
Current Consumption 43mA
Power Supply . . . . .The Watt Stopper Power Packs
Isolated Relay Rating . . . . .1A @ 30VDC/VAC
Operating Temperature . . . . .32° to 131°F (0° to 55°C)
Light Level One-Step Adjustment .10FC to 300FC)
Time Delay Adjustment . . . . .5 to 30 minutes
Walk-Through Mode . . . . .3 minutes if no activity after 30 sec.
Test Mode . . . . .5 sec. upon initial power-up or DIP switch reset
PIR Coverage (Typical) . . . . .1000 ft^2
Sensitivity Adjustment . . . . .Automatic or Low (DIP switch setting)
Ultrasonic Coverage (Typical) . . . . .800-1200 ft^2
Sensitivity Adjustment . . . . .Minimum to Maximum (trimpot)
Frequency 40kHz

UNIT DESCRIPTION

The Watt Stopper DT-200 Dual Technology occupancy sensors combine advanced passive infrared (PIR) and ultrasonic technologies into one unit. The combination of these technologies helps to eliminate false triggering problems even in difficult applications.

The DT-200 turns lighting systems on and off based on occupancy and ambient light levels. The light level feature can be used to keep lights from turning on if the ambient light level is sufficient.

SmartSet™ technology allows the sensor to be installed with minimal adjustments. SmartSet automatically adjusts the time delay and PIR sensitivity to usage patterns in the controlled space.

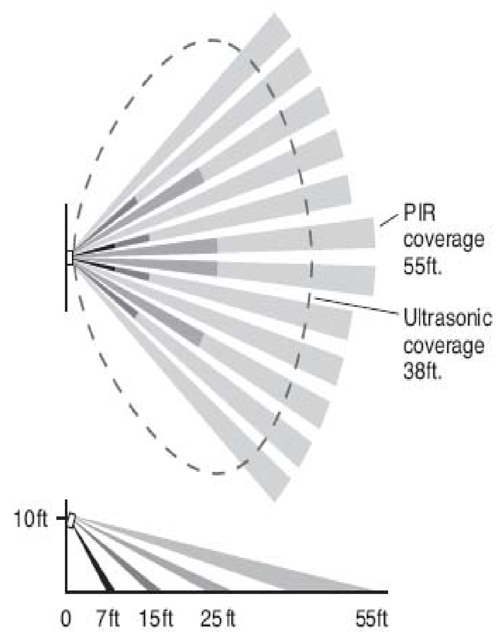
The DT-200 offers numerous operating modes that can be combined to create the ideal custom control. The sensors can be configured to turn lighting on, and hold it on as long as either or both technologies detect occupancy. After no movement is detected for the user specified time or SmartSet time (5 to 30 minutes) the lights are switched off. A "walk-through" mode can turn lights off after only 3 minutes, if no activity is detected after 30 seconds of an occupancy detection.

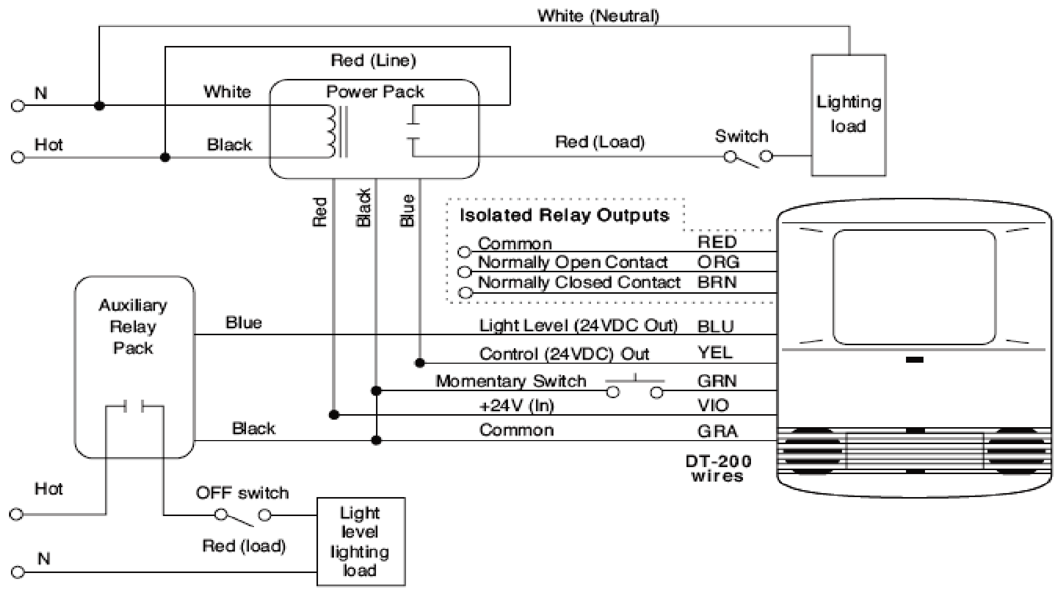
The DT-200 operates on 24VDC supplied by The Watt Stopper Power Packs. DT-200 sensors also have an isolated relay with Normally Open and Normally Closed contacts for interfacing with HVAC or EMS.

COVERAGE PATTERN

The DT-200 provides an elliptical coverage pattern. The coverage shown represents walking motion at a mounting height of 10 feet. For building spaces with lower levels of activity or with obstacles and barriers, coverage size may decrease.

Dense Wide Angle Lens
up to 2000 sq ft for walking motion
up to 1000 sq ft for desktop motion





LIGHT LEVEL FEATURE

The Light Level feature holds lights off upon initial occupancy if adequate ambient light exists. It will not turn the lights off if they are on. The default setting is for maximum, meaning that even the brightest ambient light will not hold the lights off. When the light level is set it is written to memory so that in the event of a power failure the setting is not lost.

• Avoid mounting the sensor close to lighting fixtures.
• Adjust during daylight hours when ambient light in the area is at desired level.

1. Open the Front Cover and locate the Light Level pushbutton. (See Sensor
Adjustment.)
2.Momentarily press the Light Level pushbutton. Do not exceed 4 seconds.*
The sensor enters setup mode, as indicated by the rapidly flashing Red LED. The LED will flash throughout the setup process. Occupancy indications from the LEDs are disabled during setup.
3. Move away from the sensor to avoid interference with light level detection. The sensor measures the light level for a 25 second period, then averages the
readings and automatically sets the light level function.
4. When the Red LED stops flashing, replace the Front Cover.
* Pressing the pushbutton for 5 seconds or more resets the light level to the default. The Green LED flashes rapidly for 10 seconds after the setting has changed.

MOUNTING THE SENSOR

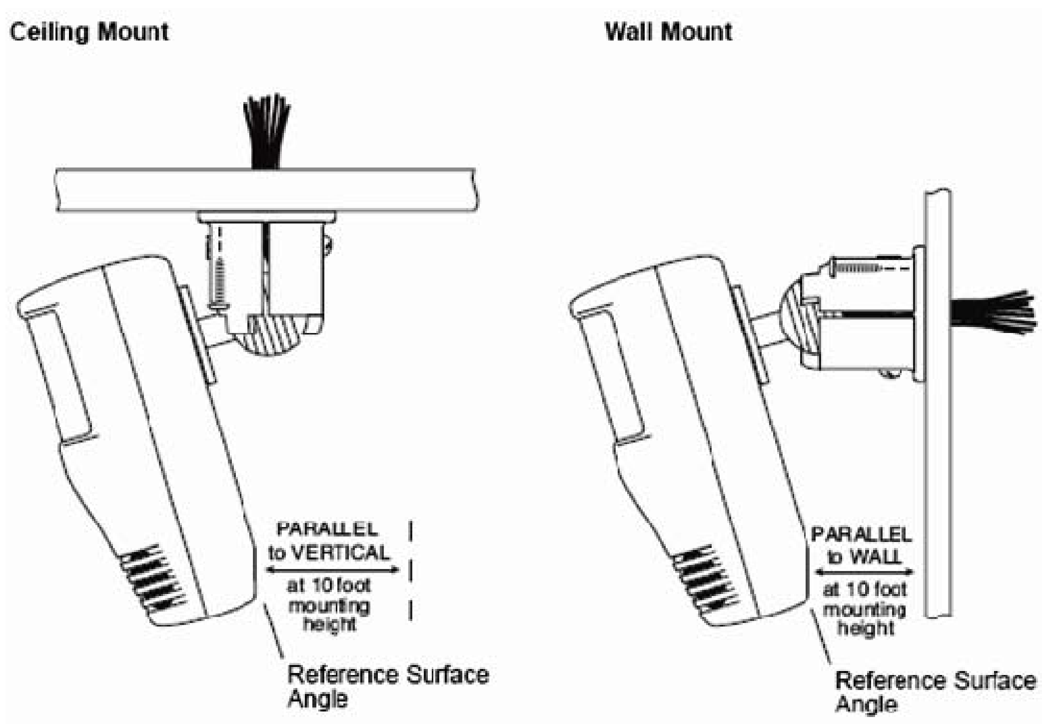
The DT-200 sensors can be mounted to walls or ceilings with the supplied swivel bracket, and the supplied junction box cover plate if necessary. Mounting at fixture height is most effective.

Ceiling: It is best to leave approximately six inches between the sensor and the wall so that the Tightening Screw can be easily accessed. Orient the Base Bracket's Half-Circle Notch in the direction that the sensor will point.

Wall: Orient the Base Bracket's Half-Circle Notch, up.

Sensor Angle Adjustment

While watching the LEDs for flashes (Red LED indicates activation from the PIR sensor; Green LED indicates activation from the ultrasonic sensor), have a person walk back and forth at the far end of the space. Increase or decrease mounting angle as needed until the desired coverage is achieved. Tighten the Tightening Screw to hold this position.



Override

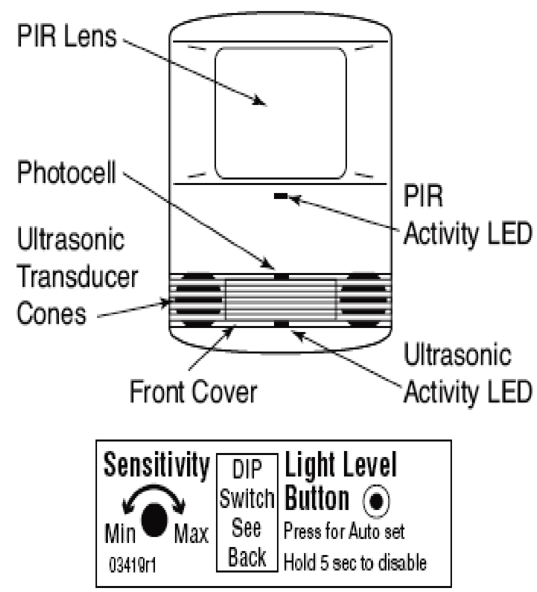
To override all sensor functions, set the Ultrasonic Sensitivity trimpot to the fully counterclockwise (Override) position. This bypasses the occupancy and light level control functions of the sensor, but still allows the lights to be manually controlled with a light switch, if one is installed.

SENSOR ADJUSTMENT

The sensors are factory preset to allow for quick installation in most applications. Verification of proper wiring or coverage, or customizing the sensor's settings can be done using the following procedures. To make adjustments, open the Front Cover with a small screwdriver.

There is a 30 second warm-up period when power is first applied.

Before making adjustments, Make sure the office furniture is installed, lighting circuits are turned on, and the HVAC systems are in the overridden/on position. VAV systems should be set to their highest airflow. Set the Logic Configuration and Time Delay to the desired settings.



Adjustments under the front cover

To Test Occupancy Sensors

1. Ensure the PIR and Ultrasonic Activity LEDs are enabled (DIP switch 7 ON) and PIR Sensitivity is set to MAX (DIP switch #8 ON).
2. Ensure the Time Delay is set for **Test Mode*** using the "5 seconds/SmartSet" setting. (DIP switches 4, 5, & 6 are OFF).
3. Ensure that the Light Level is at default (maximum). See the Light Level Feature section of this document for instructions.
4. Ensure that the Ultrasonic Sensitivity trimpot is set to about 90%, clockwise.
5. Remain still. The red and green LEDs should not flash. The lights should turn off after 5 seconds. (If not, see "Troubleshooting.")
6. Move about the coverage area. The lights should come on. Adjust the Ultrasonic Sensitivity as necessary to provide the desired coverage (Green LED indicates activation from the ultrasonic sensor).

When testing and adjustment is complete, reset DIP Switches and Light Level to the desired settings, and replace the cover on the sensor.

* If you need to invoke the **Test Mode** and the DIP switches are already set for 5 seconds/SmartSet, toggle DIP switch #5 ON then back to the OFF position. This provides a 5 minute test period. During the test period, the Time Delay is only 5 seconds.

OCCUPANCY LOGIC

The DT-200 has 8 logic configurations for Occupancy triggers, set with DIP switches 1, 2 & 3. Determine the appropriate Occupancy Logic Option using the Trigger matrix, then set the DIP switches accordingly.

Initial Occupancy: The method that activates a Change from “Standby” (area unoccupied and loads are off) to “Occupied” (area occupied and loads are on).

• **Both** requires detection by PIR and Ultrasonic.
• **Either** requires detection by only one technology.
• **PIR** requires detection by the PIR.
• **Ultra** requires detection by the Ultrasonic.
• **Man.** requires activation of the Manual Switch.

Maintain Occupancy: The method indicating that The area is still occupied and the lights remain on.

Re-trigger: After the time delay elapses and the Lights turn off, detection by the selected technology Within number of seconds indicated turns the lights back on.

Time Delay: Switches 4, 5, 6

The sensor will hold the lights on as long as occupancy is detected. The time delay countdown starts when no motion is detected. After no motion is detected for the length of the time delay, the sensor will turn the lights off. The sensor can select the time delay using SmartSet, or you can select a fixed time delay.

• SmartSet records occupancy patterns and uses this history to choose an optimal time delay from 5 to 30 minutes. SmartSet behavior starts immediately and is refined continually as history is collected.

🚶Walk-through mode turns the lights off three minutes after the area is initially occupied, if no motion is detected after the first 30 seconds. If motion continues beyond the first 30 seconds, the selected time delay applies.

Logic Configuration Chart

Occupancy Logic: Trigger	Initial Occupancy	Maintain Occupancy	Re-trigger (seconds duration)
Standard	Both	Either	Either(5)
Option 1	Either	Either	Either(5)
Option 2	PIR	Either	Either(5)
Option 3	Both	Both	Both(5)
Option 4	PIR	PIR	PIR(5)
Option 5	Ultra	Ultra	Ultra(5)
Option 6	Man.	Either	Either(30)
Option 7	Man.	Both	Both(30)

◄ = Factory Setting
● = ON
– = OFF

Occupancy Logic	Switch# 1	2	3	
Standard	–	–	–	◄
Option 1	●	–	–	
Option 2	–	●	–	
Option 3	●	●	–	
Option 4	–	–	●	
Option 5	●	–	●	
Option 6	–	●	●	
Option 7	●	●	●	

Time Delay	4	5	6	
5 sec/SmartSet 🚶	–	–	–	◄
5 minutes	–	–	●	
10 min. 🚶	–	●	–	
10 minutes	–	●	●	
15 min. 🚶	●	–	–	
15 minutes	●	–	●	
20 minutes	●	●	–	
30 min. 🚶	●	●	●	

🚶 = walk-through mode

LEDs	7	
Disabled	–	
Enabled	●	◄

PIR Sensitivity	8	
Minimum	–	
Max./SmartSet	●	◄

Appendix 8

Software Sample Codes

index.htm

```
<? setcookie("JOB",9,time()+3700);?>
<HTML dir="rtl">
<HEAD>
<meta HTTP-EQUIV="Content-Type" CONTENT="text/html; charset=windows-1252">
<meta http-equiv="Content-Language" content="ar-sa">
<TITLE>MRS</TITLE>
<base target="_self">
</HEAD>
<BODY background="start1.jpg" style="text-align: center">
<H1> </H1>
<H1> </H1>
<p> </p>
<p> </p>
<p> </p>
<H1><span lang="en-us">

Please Identify your Username &amp; Password</span></H1>
<FORM METHOD="POST" ACTION="checkname.php"> <!--WEBBOT-SELF-->
<!--WEBBOT BOT=SaveResults
    U-File="D:\Master Project\_private\formrslt.htm"
    S-Format="HTML/DL"
    B-Label-Fields="TRUE"
--><P>
 </P>
  <BLOCKQUOTE>
<TABLE>
<TR>
<TD ALIGN="center">
<p dir="ltr"><span dir="ltr">
<INPUT TYPE=TEXT NAME="Personal_FullName" SIZE=35></span></TD>
<TD align="center">
<span dir="ltr"> </span><span lang="en-us">Name</span></TD>
</TR>
</TABLE>
<TABLE id="table1">
<tr>
  <ltr><TD ALIGN="left" dir="ltr">
<p dir="ltr"><span dir="ltr">
<INPUT TYPE=password NAME="Personal_password" SIZE=28 style="text-align: left;
direction: ltr"></span></TD>
<TD ALIGN="left" dir="ltr">
<span lang="en-us" dir="ltr">Password</span></TD>
</tr>
</TABLE>
</BLOCKQUOTE>
  <span lang="en-us"><a href="MRS/Gate.php"></span><INPUT TYPE=submit
VALUE="Accept"></a>
<INPUT TYPE=reset VALUE="Clear">
</FORM>
<H5 dir="ltr">
 </H5>
<H5 dir="ltr">
<span lang="en-us">All Rights Reserved</span> <span lang="en-us">to
</span>[<span lang="en-us">
Eng. Mohammad Sa'di </span>]<span lang="en-us"> </span>© .<span lang="en-
us">2008</span></H5>
</BODY>
</HTML>
```

checkroom.php

```
<?php
$dayofthemonth_now=date(d);
$dayname_now=gmdate(D);
$year_now=date(Y);
$month_now=date(m);
$hour_now=date(G)-1;
$min_now=date("i");

settype($dayofthemonth_now,integer);
settype($year_now,integer);
settype($month_now,integer);
settype($min_now,integer);
// TAKE ROOM NO.
$roomno =$_POST[roomno];
//echo $roomno,"<br>";
//---------------------------------------------
//Connect with MYSQL Ports
$connect = mysql_pconnect("localhost","root","") or die(mysql_error());
//Determine Data Base
mysql_select_db("mrs",$connect);
// MYSQL
$sql = "SELECT * FROM mrs.roomstimetable where ROOMNUMBER like '%$roomno%'";
// inquiry execution
$query = mysql_query($sql, $connect) or die(mysql_error());
// import data from the table and replicated
$ONorOFF=0;

while($row=mysql_fetch_assoc($query)){
// echo $row['DATE'];
$OnorOff=0;
if (($dayname_now==$row['DAY']) && (($hour_now>=$row['START'])
&&($hour_now<=$row['END'])) && (($min_now>=$row['minstart']) &&
($min_now<$row['minend']))) $ONorOFF=1;}
 echo '<input type="hidden" name="onoroff" value='.$OnorOff.'>';
 $totalRows = mysql_num_rows($query);
//echo $OnorOff;
//echo $hour_now;
if ($_COOKIE['status']== "On")
    {if (($ONorOFF == 1) && (($hour_now <= 10) | ($hour_now >=14)) )
    {  include('L_Eng-ff-33G.html');     }
    elseif (($ONorOFF == 1) && ($hour_now < 14))
    {  include('L_Eng-ff-3G.html'); }
    else
    {include('L_Eng-ff-333G.html');}
    }
else
    {include('L_Eng-ff-333G.html');}

?>
```

checkname.php

```
<?php
 $username =$_POST[userName];
 $password =$_POST[Personal_password];
  //conect to MYSQL
  $connect = mysql_pconnect("localhost","root","") or die(mysql_error());
  //Choose DB
mysql_select_db("mrs",$connect);
//SQL order
$sql = "SELECT * FROM mrs.permission where USERNAME like '%$username%'";
// inquaiary
$query = mysql_query($sql, $connect) or die(mysql_error());
//import data from the table and replicated
$searchresult=0;
while($row=mysql_fetch_assoc($query))
{
  if (($password == $row['PASSWORD'] ) & ($password <> ""))
  {     $searchresult=1;
        $_COOKIE['JOB']=$row['JOB'];
}}; //End While
if ($searchresult==1)
{ echo $_COOKIE['JOB'];
  include('Gate.php');
  }
else
{ include('index.htm'); }
?>
```

Sys_accounts.php

```
<html dir="ltr" xmlns:v="urn:schemas-microsoft-com:vml" xmlns:o="urn:schemas-
microsoft-com:office:office" xmlns="http://www.w3.org/TR/REC-html40">

<head>
<meta http-equiv="Content-Language" content="en-us">
<meta http-equiv="Content-Type" content="text/html; charset=windows-1252">
<title>Lighting Controls</title>
</head>

<body>

<p></p>
<table border="1" width="950" id="table1">
  <tr>
    <td bgcolor="#008080"><b><font size="7">Lighting Controls</font></b></td>
  </tr>
</table>
<table border="1" width="950" id="table2">
  <tr>
    <td bgcolor="#000080" align="center"><b><font color="#FFFFFF">
    <a href="Gate.php">Home</a></font></b></td>
    <td bgcolor="#000080" align="center"><b><font color="#FFFFFF">
    <a href="P_choosefaculty_first.php">Panels</a></font></b></td>
    <td bgcolor="#000080" align="center"><b><font color="#FFFFFF">
    <a href="G_MonitorControl.htm">Groups</a></font></b></td>
    <td bgcolor="#000080" align="center"><b><font color="#FFFFFF">
    <a href="S_Calender.htm">Scheduler</a></font></b></td>
    <td bgcolor="#FF0000" align="center"><b><font color="#FFFFFF"><a href =
'Sys_accounts.php'>System</font></b></a></td>
  </tr>
</table>
<table border="1" width="950" id="table3">
  <tr>
    <td bgcolor="#000000"><b>  
    <span style="background-color: #FFFF00">  
    Accounts   </span><font
color="#FFFFFF">           &nbs
style="background-color: #000000">
    <a href="Sys_download.htm">Download Time
Table</a>      </span>     &nbs
    <a
href="Sys_accountsSetting.htm">Settings </a>      &
Help</font></b></td>
  </tr>
</table>
<table border="1" width="950" id="table4">
  <tr>
    <td bgcolor="#00FFFF">
    <p align="center"><font size="6"><b>Account</b></font></p>
    <table border="1" width="650" id="table5">
      <tr>
        <td>
<!--    -->



<?
```

P_MonitorControlengineering.php

```
<html dir="ltr" xmlns:v="urn:schemas-microsoft-com:vml" xmlns:o="urn:schemas-
microsoft-com:office:office" xmlns="http://www.w3.org/TR/REC-html40">
<head>
<meta http-equiv="Content-Language" content="en-us">
<meta http-equiv="Content-Type" content="text/html; charset=windows-1252">
<title>Lighting Controls</title>
</head>

<body>
<p></p>
<table border="1" width="91%" id="table1">
  <tr>
    <td bgcolor="#008080"><b><font size="7">Lighting Controls</font></b></td>
  </tr>
</table>
<table border="1" width="91%" id="table2">
  <tr>
    <td bgcolor="#000080" align="center"><b><font color="#FFFFFF"><A
HREF="Gate.php">Home</font></b></td>
    <td bgcolor="#FF0000" align="center"><b><font color="#FFFFFF">
    Panels</font></b></td>
    <td bgcolor="#000080" align="center"><b><font color="#FFFFFF">
    <a href="G_MonitorControl.htm">Groups</a></font></b></td>
    <td bgcolor="#000080" align="center"><b><font color="#FFFFFF">
    <a href="S_Calender.htm">Scheduler</a></font></b></td>
    <td bgcolor="#000080" align="center"><b><font color="#FFFFFF"><a href =
'Sys accounts.php'>System</font></a></b></td>
  </tr>
</table>
<table border="1" width="91%" id="table3">
  <tr>
    <td bgcolor="#000000"><b><span style="background-color: #FFFF00">
    Monitor Control </span><font
color="#FFFFFF">         <a
href="P_MonitorControlfineart_addNew.php">

Add/Edit</a>            &n

    Help</font></b></td>
  </tr>
</table>
<table border="1" width="91%" id="table4">
  <tr>
    <td bgcolor="#00FFFF">
    <p align="center"><b><font size="6">Faculty of Engineering</font></b></p>
    <table border="1" width="100%" id="table5">
      <tr>
        <td>
        <table border="1" width="100%" id="table6">
          <tr>
            <td bgcolor="#0000FF">
            <p align="center"><b><font
color="#FFFF00">Area        
            Room#      Status   
            </font></b> </td>
          </tr>
          <tr>
            <td bgcolor="#0000FF">
```

Dailyloadcurve.php

```
<HTML>
<HEAD>
<TITLE>Dailyloadincome</TITLE>
<META HTTP-EQUIV="Content-Type" CONTENT="text/html; charset=windows-1256">
</HEAD>
<BODY BGCOLOR=#FFFFFF LEFTMARGIN=0 TOPMARGIN=0 MARGINWIDTH=0 MARGINHEIGHT=0>
<!-- ImageReady Slices (Dailyloadincome.psd) -->
<?
   $daytime[0]=0;
   $daytime[1]=0;
   $daytime[2]=0;
   $daytime[3]=0;
   $daytime[4]=0;
   $daytime[5]=0;
   $daytime[6]=0;
   $daytime[7]=0;
   $daytime[8]=0;

   $daytime2[0]=0;
   $daytime2[1]=0;
   $daytime2[2]=0;
   $daytime2[3]=0;
   $daytime2[4]=0;
   $daytime2[5]=0;

   $energyconsumbtion=0;
   $energyconsumbtion15=0;
$room = $_POST[roomno];
if (empty($room))
{$room="1230";}

if ($room <> "")
{
      //Connect with MYSQL Ports
      $connect = mysql_pconnect("localhost","root","") or die(mysql_error());
      //Determine Data Base
      mysql_select_db("mrs",$connect);
      // MYSQL
      $sql = "SELECT * FROM mrs.roomstimetable where ROOMNUMBER like '%$room%'";
      // inquiry execution
      $query = mysql_query($sql, $connect) or die(mysql_error());

      $i=0;
      while($row=mysql_fetch_assoc($query)){
      if ($row['DAY']=="Sun")
      { if ($row['START']==8)    $daytime[0]=1;
        if ($row['START']==9)    $daytime[1]=1;
        if ($row['START']==10)   $daytime[2]=1;
        if ($row['START']==11)   $daytime[3]=1;
        if ($row['START']==12)   $daytime[4]=1;
        if ($row['START']==13)   $daytime[5]=1;
        if ($row['START']==14)   $daytime[6]=1;
        if ($row['START']==15)   $daytime[7]=1;
        if ($row['START']==16)   $daytime[8]=1;
        }
      };//End While

      // MYSQL
      $sql = "SELECT * FROM mrs.roomstimetable where ROOMNUMBER like '%$room%'";
```

جامعة النجاح الوطنية
كلية الدراسات العليا

دراسة وتصميم نظام تحكم آلي لإدارة الطاقة الكهربائية- دراسة حالة جامعة النجاح الوطنية

إعداد
محمد خليل سعدي "رشيد المبيض"

إشراف
د. سامر ميالة

قدمت هذه الأطروحة استكمالا لمتطلبات نيل درجة الماجستير في هندسة الطاقة النظيفة وإستراتيجية الترشيد بكلية الدراسات العليا في جامعة النجاح الوطنية، نابلس – فلسطين.
2008

دراسة وتصميم نظام تحكم آلي لإدارة الطاقة الكهربائية-

دراسة حالة جامعة النجاح الوطنية

إعداد

محمد خليل سعدي "رشيد المبيض"

إشراف

د. سامر ميالة

الملخص

حالة الطاقة في فلسطين، كفاءة استخدام الطاقة، وحفظ الطاقة في الجامعات، ليس في وضع أفضل من معظم البلدان النامية. وضعنا في هذه الأطروحة خطوة البداية نحو كفاءة استخدام الطاقة وحفظ الطاقة في العديد من الجامعات من خلال إجراء تدقيقات الطاقة في بعض كليات جامعة النجاح الوطنية ، التي تعتبر مستهلكه عالية للطاقة وإمكانية تخصيص الفرص المتاحة لتحقيق التوفير في الطاقة.

لقد نجحنا في هذه الأطروحة في إثبات أن هناك إمكانات كبيرة لتوفير الطاقة في قطاع الجامعات الفلسطينية (15-25٪)، من خلال تنفيذ بعض إجراءات حفظ الطاقة (مع أو بدون تكلفة استثمار) على أكثر المعدات استهلاكاً للطاقة مثل المراجل، مكيفات الهواء، ونظام الإنارة، حيث حققنا نسبة توفير 24٪ في نظام الإنارة (تكلفة منخفضة)، 7٪ في نظام التبريد (بدون تكلفة)، و5٪ في نظام التدفئة (بدون تكلفة).

بالإضافة إلى ذلك ، نجحنا في تطوير برنامج جديد لإدارة الطاقة والذي يستخدم لتقدير إجمالي توفير الطاقة من كل حالة في هذه الدراسة، ولهذا البرنامج عدة مزايا من خلال جدولة كميات كبيرة من بيانات استخدام الطاقة، والتقليل إلى أدنى حد من الأخطاء الحسابية ، وتقديم بيانات موثوقة ومرتبة ومنظمة لاستخدامها في تحليل واستكشاف الأخطاء وإصلاحها.

في هذه الأطروحة أيضاً قمنا بتصميم وتنفيذ نظام آلي للمراقبة والتحكم بنظام الإنارة عن طريق الإنترنت، من اجل الحد من استهلاك الإضاءة ، مع مراعاة الجدول الزمني للقاعات الدراسية، مجسات الحركة، وتوزيع ضوء النهار، هذا النظام أدى إلى توفير إضافي بلغ 45٪.