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Moving Towards Renewable Energy and Energy Efficiency at Notre Dame University-Louaize: An Economic Feasibility Study

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Approval Certificate

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DECLARATION

I hereby declare that this thesis is entirely my own work and that it has not been submitted as an exercise for a degree at any other University.

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ABSTRACT

This thesis is concerned with a feasibility study made on energy saving and renewable energy at Notre Dame University-Louaize (NDU). The energy saving solution proposed to NDU deals with replacing fluorescent lamps inside offices and classes with LED lamps. This solution will decrease the watt-hour consumption of the university leading to less electrical power cost, less maintenance cost, and longer lamp lifetime. The renewable energy proposition is concerned with installing photovoltaic solar panels at the rooftop of the faculty buildings. The amount of power that the solar photovoltaic panels would produce is equal to the amount of electrical power needed to operate the LED lamps that will replace the fluorescent lamps. The main research question is whether replacing fluorescent lamps with LED lamps inside offices and classes of the faculty buildings and installing photovoltaic solar panels is capable of replacing the existing sources of energy while still having a good return on investment? Three scenarios were designed to answer the research question. The first scenario will examine the cost of replacing fluorescent lamps with LED lamps as well as the difference in watt consumption before and after the replacement. The second scenario examines the installation of solar panels. The third scenario considers replacing fluorescent lamps with LED lamps and at the same time installing solar panels. These three scenarios will be simulated under two cases; the first case is that electricity generation prices remain stable in Lebanon over the lifetime of the project and the second case represents the increase in fuel oil prices. Payback period, net present value (NPV) and benefit-cost ratio (BCR) will be calculated to assess the feasibility study of the three above scenarios. Three rates will be used, 0% is the rate that NDU could get if it presents its studies to the National Energy Efficiency and Renewable Energy Account, the second rate is the social discount factor 3% and the third rate is the market discount factor 6%. The main findings suggest that scenario 1, under both cases, will have a positive NPV. For scenario 2, the results were the least attractive for case 1, while for 3% discount factor case 2 of scenario 2 will have a positive NPV. Case 1 of scenario 3 showed a positive NPV under 3% discount factor while for 6% it had a negative NPV, case 2 of scenario 2 showed a good return on investment while being able to combine both scenarios, 1 and 2, together.

Energy Efficiency, LED Lamps, Renewable Energy, Solar Photovoltaic Panels, Notre Dame University-Louaize, Feasibility Study, Net Present Value, Benefit to Cost Ratio

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CONTENTS

CHAPTER 1

INTRODUCTION

1.1 General Background

Over the past few years, the consumption of fossil fuel has increased drastically due to the increasing population around the globe. Fossil fuel is considered as a necessity in our world today, without which the ordinary lifestyle that people have got used to will not be maintained. Fossil fuel which is made of coal, fuel oil, and natural gas is a non-renewable energy source; therefore, the continuing consumption at this rate will lead to its extinction. Fossil fuel is known to provide more than 85 percent of the world energy demand (Herzog and Golomb, 2004). This demand is subcategorized into manufacturing, power generation plants and transportation.

The massive usage of fossil fuel is playing a major role in the deterioration of the environment. Some of its effects are air pollution and climate change. Air pollution can have short term and long term effect on people's health. The extent to which an individual is harmed depends on the total exposure to this pollutant. An example of direct effect is the power generation plant in Zouk Mosbeh, Lebanon, which is located in an urban congested area with many schools and universities. The continual exposure to air pollution affects the lungs of growing children and may complicate medical conditions in the elderly.

The depletion of fossil fuel has led to fluctuations in the economy and in problems related to sustainability of different countries. Climate change is not only an environmental dilemma but is also an economic and security matter that will take over national policies as its effect becomes more obvious (United Nations Framework Convention on Climate Change, 2007).

Sustainability is defined by the ability to satisfy the needs of the present generation without obstructing the needs of future generations (Brundtland, 1987). The securing of energy for future generations should be deeply thought of as the world witnesses an increase in demand for energy. Mezher (2011) noted that there should be a sense of balance linking economic development, energy efficiency, and prolongation of natural resources so that we may enhance the way of living. Therefore, renewable energy sources should be jointly used with fossil fuel in order to have a continuing sustainability of resources for future generations.

Renewable energy (RE) supplied to Earth is somehow infinite since it is related to sources that were found thousands of years before and are expected to last thousands of years from now, such as the energy coming from the sun and the wind. The most commonly known RE sources include wind, solar, tides and waves, biomass and hydropower energy. Renewable energy is a free source that could be replenished with time after the consumption process. It is crucial to utilize this gratis energy of this world to ensure sustainability.

Renewable energy faced lot of constraints in the beginning of its life cycle. That was due to several reasons such as oil producing companies that didn't want any technology to take place over fossil fuel. But with the continuous increase in pollution and in the prices of fossil fuel, the renewable energy market started to face a booming period. The United Nations Commission on Sustainable Development (2006) has shown that more than 45 countries have placed targets regarding implementation of renewable energy.

Intellectual leadership should be provided by universities, they must project how sustainability can be attained (Probert, 1995). Not only countries must emerge in sustainable development but also institutions. Talloires declaration, 1990, had 22 universities signing a dedication to environmental sustainability (Price, 2005). Since such kinds of projects are considered to have high cost, some institutions may find it hard to engage in such a project without the help of the government. Governments must be leaders in environmental sustainability through setting rules to be achieved by different sectors throughout a given period of time. For example, the Toyne Report that was commissioned by the government of the United Kingdom, in 1993, has set the advices for UK educational institutions to improve and develop their policies concerning the environment (Price, 2005). Table 1.1 shows various examples of some universities in the UK that have started to engage in environmental sustainability in different ways.

Table 1.1: UK Universities and Their Environmental Practices

Good Practice	University
ISO 14001 accreditation for all operations since 2002	Glamorgan
Facilities Management and Purchasing Divisions accredited during 2003	Leeds Metropolitan
ISO 14001 accreditation	University of Wales School of Medicine
Buildings designed for water efficiency and low Maintenance	Buckingham and Lancaster
High energy efficiency and environmentally-friendly accommodation	Linacre College, Oxford University
Low energy-consumption student residences	Sunderland and East Anglia
Low-energy, passively-ventilated School of Engineering building	De Montford
Natural ventilation	Anglia Polytechnic
Photovoltaic-panel cladding retrofit	Northumbria
Dedicated bicycle ways	Lancaster
Re-use of already used envelopes	De Montford and Cranfield
Reduction in number of cleaning agents used	Lancaster
Staff short courses on environmental responsibility	Sunderland
30 per cent of meals served on campus are vegetarian, being less energy intensive to produce	Hertfordshire

Source: Preaching what we practice: experiences from implementing ISO 14001 at the University of Glamorgan, 2005

Lebanon and Notre Dame University-Louaize: General Briefing

The paragraph below will discuss Lebanon and its energy production; further in depth details will be discussed in chapter 2. Lebanon is a country that has an area of 10,452 Km^2, located at the Mediterranean. Lebanon depends on three major sources of energy, Electricite Du Liban, Electricite Du Zahle, and the power that is imported from its neighboring countries mainly Syria. Lebanon suffers from a high number of blackout hours that is affecting its industrial sector as well as its economy. In Lebanon, the electric tariff rates are high with respect to regional standards and in relation to service quality, but at the same time it is too low to cover EDL's costs (World Bank, 2008). The low rated pricing rate is placing high burden on the electric sector. Table 1.2 shows the different pricing rate at different margins of monthly consumption.

Table 1.2: Low- voltage tariff of Lebanon per kWh, since 1994

Monthly consumption [kWh/month]	Rate [LL]	Rate +VAT (10%) [LL]	Rate in USD
0-100	35	38.5	2.55
100-300	55	60.5	4
300-400	80	88	5.84
400-500	120	132	8.75
Over 500	200	220	14.6

Source: EDL official Website

The preferred solutions for the Lebanese citizens to compensate this blackout are through either private generators or through renewable energy. “The informal electricity market serves 58 percent of households with this far more expensive “imperfect substitute.” Generator expenditures (for households that use them) are almost double what households spend on EDL electricity” (World Bank, 2009, p. 9). Different Lebanese climatic regions present different solutions for the production of renewable energy, such as wind, solar power, hydropower energy production, and tides and waves around coastal areas.

Notre Dame University - Louaize (NDU), established in 1987, is a private, Lebanese non-profit Catholic institution of higher education that adopts the American System. NDU accommodates three campuses which are distributed as follows: main campus in Zouk Mosbeh, North Campus in Barsa, and Chouf Campus in Deir El Kamar. It offers 108 degrees, diplomas and certificates to its 7052 enrolled students with 71 bachelor and 31 master degrees, 5 Teaching Diplomas, and 1 Teaching Certificate (Notre Dame University, 2007-2008).

NDU faces EDL blackouts such as any other organization. NDU has obligations towards its students to continue with full operation. This fact obliged the university to install 12 generators, 450 KVA each, on its campus. NDU main campus is located in

Zouk Mosbeh, a coastal area, 15 km north of Beirut at an altitude of 100 m. From December to March, the climate is moderately cold unlike from June to September where it is extremely sunny and hot. The fall and spring seasons are distinguished by their weather which is sunny and cool the overall sunshine period for all seasons is on an average of 300 days each year. NDU could take advantage of this amount of sun through installing photovoltaic solar panels.

1.2 Rationale for the Study

The Lebanese government is trying its best to apply several procedures to help in increasing the efficiency of the electric sector. Implementing these solutions won't be projected in the near future due to political reasons. EDL's failure to supply energy will continue to exist, therefore the function of any organization or residence will be blocked unless any other source of energy is being applied. Privately owned generators, operating on fossil fuel, is the most commonly known substitute of EDL that is able to provide energy for any household and organization. Both sources of energy, EDL or privately owned generators, are affecting the environment around us, causing climate change and health problems.

This study will help present whether Notre Dame University may be one of the first Lebanese institutions that are maintaining their needed electricity through renewable energy sources. Holy Spirit University of Kaslik (USEK) along with CAP are in the process of lunching "Let's Go Green for a Sustainable Future" project that will transform USEK by the year 2025 into the first zero carbon university in the middle east (USEK, 2010).

The foreseen price of fuel shows an increase in rating; due to this fact, generating moderate energy will become very expensive. EDL will reach to a certain point where it won't be able to bare holding the prices at the present low rate. At the same time, producing energy from privately owned generators will be very expensive due to the increased price of fossil fuels. These two reasons, along with others, are applying pressure on institutions, such as NDU, to raise their charging price to compensate the increase in cost. Stabilizing the cost of energy per year and providing better environmental conditions will set a competitive advantage for Notre Dame University over other universities that are providing the same value for students.

1.3 Purpose of the Study

This study aims to prove whether it is efficient to replace fluorescent lamps with LED lamps and install photovoltaic solar panels to decrease EDL bills and generator costs at Notre Dame University, Zouk Mosbeh. The solar panels will mainly supply the lighting points inside classes and offices for each faculty. Deriving the return on such an investment will verify several conclusions. One of the points to be recognized is whether installing renewable energy at NDU profitable at the meantime or it is better to continue with the moderate energy production.

1.4 Overview of All Chapters

Chapter 1 introduces how fossil fuels affect the environment through the process of climate change followed by the consequences of such an alteration on human health. The part to be followed is a brief notation on how the use of such an energy resource may affect the sustainability for future generations and the economy of different countries. The third point will include a general preface on renewable energy and its usage around the world. Lebanon and Notre Dame University profile will be tackled in this chapter. Then a statement on the need and purpose of the study followed by a general conclusion on all chapters.

Chapter 2 is a review of literature that will include details on topics dealt with in chapter 1, as well as researches that are similar, in a way, to the subject dealt with in this thesis. The parts in this chapter will mainly include energy and climate change, economy and sustainability, renewable energy and its market, Lebanese profile and the use of energy, and at last Notre Dame University energy use.

In chapter 3, the modified model of the project report presented in 2009 by Bates et al. that included a solar panel feasibility study at Wesley United Methodist Church, Worcester will be detailed and the adopted variables will be set. The next part will show detailed Notre Dame University energy map and lighting consumption in the six faculty buildings. This chapter will be mainly quantitative; it will illustrate the quoted data that was presented by different companies.

Chapter 4 will include the feasibility study of different scenarios, and then discuss the main results.

The last chapter will be demonstrating the conclusion on the following research question, "Is installing solar photovoltaic energy and LED lamps inside classes and offices of faculties, capable of replacing the existing sources of energy while still having a good return on investment?". At last some limitations on the research question will be addressed.

CHAPTER 2

LITERATURE REVIEW

2.1 Climate Change, Energy and Sustainability

The consumption and production of energy lead to the emissions of noxious gases which have a negative effect on the environment, known by the greenhouse gas (GHG) emissions. The United Nations' Intergovernmental Panel on Climate Change states that the use of fossil fuel energy has resulted in climate change (Mezher, 2011). The emissions resulting from the burning of fossil fuel includes several pollutants which are the main causes of air pollution around the world. The Kyoto protocol, a treaty that went into force on 2005, was an important first step in decreasing global climate change by setting out emission reduction prospects and commitments. GHG is known to be the first accelerator of global warming leading to a climate change. Studies have shown that the effect of climate change, due to GGG, has a negative impact on human health (Oxfam GB Research Report, 2009).

Some of the organizations that are raising claims concerning climate change and its effects include the World Health Organization, Greenpeace, United Nations Development Program. Climate change has a major impact on the environmental, ecological, and biological systems. "Climate change has come to be recognized as one of the most critical challenges ever to face human-kind. The impacts range from sea level rise, melting ice craps and glaciers." (United Nations Framework Convention on Climate Change, 2007). Most of these changes have permanent effect, such as ozone depletion and the world wide spread of infections. The World Health Organization estimated that 160,000 deaths are directly related to climate change (McMichael, 2003). Therefore, GGE and climate change justify the need for renewable energy sources that should be implemented in the near future. "Climate change will force humans to negotiate with their changing environment as never before to find ways to reshape it both for short-term protection and long-term alleviation of health consequences." (Environmental Health Perspectives and the National Institute of Environmental Health Sciences, 2010).

2.2 Sustainability and Economic Efficiency

"The world has recognized that climate change is no longer solely an environmental problem. Rather, it has become an economic, trade and security issue that will increasingly dominate global and national policies as its impacts become more apparent." (United Nations Framework Convention on Climate Change, 2007). Economically speaking, due to the increase in the demand for fossil fuel and the decrease in its existence, market prices of this resource will continue increasing. The economy in poor countries is also affected by climate change that has a direct impact on natural resources such as forestry and agriculture. Adam Smith noted that the physical geography of a region can influence its economic performance (Matutinovic, 2007). Until the mid of 20th century, natural environment was considered as an infinite input source to the economic machinery. Since exploiting the environment was considered as a benefit for the economy of some countries, economists did not include the negative effect that is related to the deterioration of the environment into their economic models.

"Economists are able to explain as rational the actions of people who elect to deplete natural resources and destroy ecosystem. They apply a theory of discounting in which a good is worth more now than later" (Clark, 1995). Millions of decisions that are based on conventional economic understanding of return on investment give a free rein to projects that have direct effect on environment. When debating about sustainability, one should consider that the scale of the human economy and its development must not exceed environment's carrying capacity. The World Bank view sustainable development favorable since it has no threat on the conventional economic development (Clark, 1995).

Energy is fundamental when related to the reduction of poverty and the development of the economy (Commission on Sustainable Development, 2006). Securing energy should be more thought of with the increasing demand on energy and electricity. Natural resources, such as oil reserves, are non-renewable and their existence represents a boundary condition for socioeconomic change and material growth. A balance between economic development, energy efficiency, and preservation of natural resources must be achieved in order to enhance the way of living (Mezher, 2011). Therefore, the concern of availability of fossil fuel for the future generation is directly related to the extent of which we are capable to jointly use conventional and renewable energy sources. Then, it is crucial to link between the benefits of renewable energy (RE) and natural resources such as fossil fuels, "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (Brundtland, 1987).

Sustainability is an economic, social, and ecological concept (Emanuel and Adams, 2011). The approach to problems in sustainability and other problems regarding the concern on the environmental impact has been focusing on market mechanism, economy and technology. Sustainability is an economic state where the demands placed upon the environment by people can be met without reducing the capacity of the environment to provide future generations (Shriberg, 2000). There has always been a complex relationship between environmental conditions, population size, and economic development. By utilizing less polluting technologies, people will be able to preserve the natural environment and maintain economic growth simultaneously (Matutinovic, 2007). The business world is facing challenges regarding sustainable development issues. Despite the benefits of technological and economic development, business is facing increasing criticism for creating social and environmental problems related to sustainability (Dimitrov and Davey, 2011).

To assess costs and benefits related to sustainability projects, Cost Benefit Analysis is used as a tool to improve decision making. The case of discounting future costs and benefits arises from opportunity cost (Harrison, 2010). Different inputs to the net present value equation could either improve or weaken the results of whether the project is profitable or not. In their paper, environmental costs and their impact on the net present value of a hydro-electric project in India, Santhakumar and Chakraborty (2003) incorporated the environmental costs into the cost benefit analysis under different discount rates which enhanced the attractiveness of the project. It is essential to set the appropriate discount rate for any institution when studying a project. Discount rates, social or market, could be applied to different projects. For long-term social projects, it would be more appropriate to consider reducing the social discount factor overtime (Evans and Sezer, 2005).

A good solution for the time being is to produce energy simultaneously from both fossil fuel and renewable energy. This can reduce the green house emissions, increase the durability of fossil fuel existence, and increase market shares of green power generation. Ding and Somani (2010) indicate that applying parallel planning method between conventional fossil fuel and renewable energy is a necessity to attain a sustainable environment for future use. Some think that science and technology will eventually solve most if not all of our problems that are related to economy, society, and environment (Matutinovic, 2007). Another important keyword is sustainable development; one cannot stop the world development in order to attain sustainability. Nature, such as earth, biodiversity, and life support, as well as community: cultures, groups and places are to be sustained; on the other hand, people, economy and society are to be developed (Graedel, 2002).

2.3 The Role of Higher Education Towards Sustainability

Institutions have increased their awareness of and commitment to sustainability regarding energy. Knowledge of sustainable practice is fundamental to its successful implementation. Universities can help create a new generation of economically, socially and ecologically responsible citizens. In the USA, there is a movement towards state and federally funded universities to provide environmental education to their students and practice sustainability through its campus development and everyday applications (Emanuel and Adams, 2011). Institutions and technology are placed at the same hierarchical level; they mutually interact when it comes to economic and environmental activities (Matutinovic, 2007). Institutions of higher education were leaders and innovators in social responsibility when it came to sustainability. Universities should assist in the formulation and promotion of sustainability and environmental initiatives with their community.

Universities, through their educational programs, should monitor progress towards sustainability through indicators and other measures, as well as seeks outside funding for sustainability initiatives (Shriberg, 2000). The University of Texas-Houston Health Science Center, UT-Houston, supported services allocated $1,000,000 for green remodeling, environmentally friendly projects. UT-Houston decreased the electricity consumption by following an energy management program, as well as, they followed a trees program, planting additional trees on campus. UT-Houston also installed a 20 KW photovoltaic system to provide lighting for the parking garage (Shriberg, 2000). In 2008, the University of Michigan launched a six-point plan for environmental sustainability, within the current buildings, which included environmental reporting, renewable energy, alternative transportation, green purchasing, renovation projects, and planet blue (Levy and Marans, 2012).

Humankind is currently facing a challenge in learning how to cope with the environment without endangering the natural resources of Earth. On a personal level, one could recycle, decrease energy consumption and buy eco-friendly products. Universities has a bigger role than just to provide education, they are large, prestigious and influential institutions that have an impact on the environment and on the global communities (Christopher and Anderson, 2001). Universities should stop pretending that they are achieving sustainability through going a little greener but they should adopt a time scale and develop approaches to reach the target. Since leadership is important on both, thought and action, universities should adopt sustainability and implement it on a specific time scale (Graedel, 2002).

Quental et al. (2010) identified the following sustainability principles: the constraints regarding human economy; the focus on societal welfare and development; the understanding that each system has its own viable needs. For the first identification, sustainability depends on ensuring that the scale of human economy is moderate to allow maintenance of life support system. The second initiative is related to the instrumental value of natural resources and economy. The third initiative focuses on the point that each system has its own minimum needs in order to be viable. The university should serve as a model of sustainability in cultural, environmental, and economical terms (Uhl et al., 1996). The world looks at universities as a role model in passing on education and leadership; they can help teach students how to convince other public and private sectors to operate upon sustainable practices.

2.4 Renewable Energy

2.4.1 Constraints and Intervention in Renewable Energy

Political and economical problems made it hard to develop such renewable sources, for instance oil producing companies and countries view the embracement of RE as a threat to their economy. On the other hand, there exists a strong competition between different international petroleum companies to lead the market with RE related products. For example, British Petroleum which is an oil refinery is considered to be one of the top investors in the wind and solar market, while at the same time they are still practicing their oil extraction (Simmons, 2006). One of the reasons behind the recent engagement of these resources in the market is the price increase, fluctuations, and risks of supply of fossil fuel, the main source of energy. Table 2.1 shows the renewable energy electric power consumptions from wind, solar, and wood and waste of different regions of the world.

Table 2.1: Renewable energy data for electric power consumption in billion kWh

Region	2000	2003
North America	93.3	102.1
Latin America and the Carribean	23.5	31.9
Western Europe	75	110.4
Eastern Europe and countries of the former USSR	3.8	4.7
West Asia	0.003	0.01
Africa	0.9	1.01
Asian and the Pacific	53	60
Total	249.5	310.1

Source: Energy Information Administration, United States Department of Energy, June 2005

2.4.2 Renewable Energy Market

The renewable energy sector, recently in its booming period, has presented a new tempting market opportunity for investors around the globe. Investment in the RE division has reached to approximately 180 billion dollars during the past years, while statistics show that it was only 22 billion dollar in 2002 (UNEP, 2009b). The interesting fact is that developing countries are emerging in the investment in RE relative to developed countries that were controlling the largest portion of this industry.

The investment of developing countries reached up to 36.6 billion dollars in 2008, 27 percent increase since 2007, while developed countries witnessed a decrease of 1.7 percent to reach 82.3 billion dollars (UNEP, 2009b). In general, every country, developed or developing, must place plan to alter a certain percentage of its moderate energy production into renewable ones. Hence, green investment for a green world addresses the thought that the financial market of this technology will have a bright future.

The cost of installation and production of renewable energy is expected to drop in the near future making it easier on countries to embrace such technologies. Table 2.2 shows the projected costs of different energy producing technologies for the year 2020. This decrease is due to the present availability of enhanced technology spread over different leading manufacturers. Other cause related to the expected decrease in the cost of this technology is the increase in the claim for such products. Thus, more factories aiming to operational excellence will invest in their production capabilities to cope with the expected demand. The whole customized supply chain will be achieved with less cost, ranging from massive factory production to the supply of end users with renewable energy products.

Leading companies should focus more on customer relationship management. After all, it is not only the technology, but also the business strategy that must lead and guide customers. According to Peelen (2005), companies should have knowledge in customer's background, relationship strategy, and communication. Consumers must be shifted from prospects, to supporters, to partners in green technology.

Table 2.2: Different Costs of Energy

Technology	Current cost (U.S. cents/kWh)	Projected future costs beyond 2020 as the technology matures (U.S. cents/kWh)
Biomass Energy:		
•Electricity	5—15	4—10
•Heat	1—5	1—5
Wind Electricity:		
•Onshore	3—5	2—3
•Offshore	6—10	2—5
Solar Thermal Electricity (insulation of 2500 kWh/m2 per year)	12—18	4—10
Hydro-electricity:		
•Large scale	2—8	2—8
•Small scale	4—10	3—10
Geothermal Energy:		
•Electricity	2—10	1—8
•Heat	0.5--5.0	0.5--5.0
Marine Energy:		
•Tidal Barrage	12	12
•Tidal Stream	8—15	8—15
•Wave	8—20	5—7
Grid connected photovoltaic:		
•1000 kWh/m2 per year (e.g. UK)	50—80	~8
•1500 kWh/m2 per year (e.g. southern Europe)	30—50	~5
•2500 kWh/m2 per year (most developing countries)	20—40	~4
Stand alone systems (incl. batteries), 2,500 kWh/m2 per year.	40—60	~10
Nuclear Power	4—6	3—5
Electricity grid supplies from fossil fuels (incl. T&D)		Capital costs will come down
•Off-peak	2—3	with technical progress, but
•Peak	15—25	many technologies largely
•Average	8—10	mature and may be offset by rising fuel costs
Costs of central grid supplies, excl. transmission and distribution:		Capital costs will come down
•Natural Gas	2—4	with technical progress, but
•Coal	3—5	many technologies already mature and may be offset by rising fuel costs

Source: Renewable Energy Policy Network for the 21st Century, Martinot, 2005, p.56

2.5 Countries and Institutions Going Green

2.5.1 Examples of Countries Shifting to Renewable Energy

Denmark

Denmark revealed its goal to decrease the gas emissions by 34% by 2020, compared to year 1990, as a step toward decreasing the carbon emission and supporting green energy (Danish Ministry of Climate, Energy and Building, 2012). Multiple renewable energy technologies will be used in this project such as wind farms, smart grids, solar panels etc.

"Denmark will once again be the global leader in the transition to green energy. This will prepare us for a future with increasing prices for oil and coal. Moreover, it will create some of the jobs that we need so desperately, now and in the coming years" as declared by the minister for climate, energy and building in Denmark, Martin Lidegaard. The next target for the Danish government set for 2050 is to rely 100% on renewable technologies to supply the heating, electricity, industry and transport sectors.

India

In 2006, the Indian Solar Loan Program was awarded the Energy Globe prize, one of the most recognized environmental prizes. This program helps in establishing help for consumer financing for solar power systems, as shown in Table 2.3. This solar loan program was supported by the United Nations Environment Programme and India's major banking groups including Canara Bank and Syndicate Bank. This program has financed 10,370 loans in one month through 1800 practicing bank branches (Indian Solar Loan Programme, 2005).

The United Nations Environment Program is known to be an international organization that assists developing countries in achieving environmental policies. Some of the main concerns of this program are the green economy, marine, atmosphere... India has 5000 trillion kWh per year of solar energy that it could benefit from (Kothari, 2000)

Table 2.3: The Indian Solar Loan Program

Financing Types	Stakeholders	Amount	Share	Sector
Grant	UN & Shell Foundations	$1.5 million	20%	Renewable Energy
Equity	Banks	$6.1 million	80%	Renewable Energy
Total		$7.6 million	100%	

The $7.6 million project, launched in 2003, encouraged Indians to use renewable energy technologies in their homes and increased their awareness toward environment problems. India is destined to be one of the first countries aiming to sustainable development achieved through a renewable energy movement (Kothari, 2000).

Arab World

Arabs have also joined the race toward "Going Green". Renewable energy, waste management and many others solutions are being considered by many Arab countries as a step toward environmental protection.

Masdar city, located in the United Arab Emirates (UAE), will be the first zero-carbon city in the world. The expected completion date of this project is year 2016. Solar panels, wind turbines along with other new technologies will be implemented to generate the city power. Cars will be replaced by an electric public transit system. The city will cost $22 billion to be finalized. UAE was once known to have the largest carbon footprint but Masdar city will help Abu Dhabi shift into excellence when related to renewable energy (James, 2009).

Recently in January 2012, the Sultanate of Oman revealed its plans to implement a $2 billion solar project in cooperation with foreign investors from Switzerland and Germany. The project solar panels and aluminum frames will be manufactured in Oman. Omanis will be trained to handle up to 2000 green job opportunities resulting from this project. Oman target by 2020 is to produce 10 percent of the country's energy from solar and wind energy (EcoSeed, 2012).

The Kingdom of Saudi Arabia (KSA) announced in beginning of 2012 its plan to generate 5 Gigawatts of solar energy by 2020, which is equivalent to 10% of its electrical power supply. By achieving this target, KSA will be titled as the world's largest source of solar energy (Ameinfo, 2012). Additionally, by 2014, 3,350 metric tons of solar-grade poly-silicon will be produced by constructing a poly-silicon plant along the Gulf Coast.

2.5.2 International Institutions Going Green

United States Universities followed the steps of most worldwide companies and institutions in supporting more sustainable campuses. Colleges and Universities have started implementing major changes in their administrations to support renewable energy, recycling, waste management, and transportation alternatives. By taking the initiative to change toward sustainability, universities are gaining economical and financial benefits in addition to the ethical and moral fulfillment. Moreover, universities are contributing in training the students in sustainable practice to ensure the welfare of resources for the future generations.

Princeton, Yale, Ohio, Cornell, Harvard are examples of US universities who made progress in the sustainability implementation within their campuses. Major environmental problems are being addressed by these universities such as climate changes, global warming and pollution. In September 2010, Yale University issued the "Sustainability Strategic Plan 2010-2013" following the recommendations of the sustainability task force. The main goal of this plan was to improve students and staff quality of life on campus while restructuring universities processes and reorganizing the existing systems to save cost, time and resources.

The strategic plan categorized the university systems into Campus, Earth, and Academic. The Campus system addressed the building design and construction as well as waste management and transportation while the earth system focused on Energy and Greenhouse emissions. The Task force developed a project to evaluate and implement systems for hot water in universities campuses by 2012; this project is one of multiple projects that were initiated to increase energy supply from renewable resources. Yale Target is to obtain 25% of its energy from renewable resources by 2020 and work on decreasing the electricity consumption by 40% by June 2013 (Yale office of sustainability, 2009).

Many universities worldwide are planning to have solar panels installed on their campuses as a way to decrease energy consumption. The University of Florida announced on 2010 the installation of solar panels in the Florida Museum of Natural History, on the roof of Powell Hall as a step toward reducing the electricity consumption. The installed panels will generate one third of the museum's electricity (University of Florida, 2010).

In February 2011, "The University of Maryland, College Park" publicized their plan to mount more than 2,500 solar panels on a building near the main campus. "It's a big step," said Scott Lupin, director of the university's Office of Campus Sustainability (Fears, 2011). Being one of the first largest renewable energy projects, 792 megawatt hours of electricity will be produced each year by this solar system which will reduce the carbon footprint of the university by 600 tons per year.

On July 15th 2011, construction work was finalized on Australia's largest rooftop solar PV on St Lucia campus in The University of Queensland. A sum of 5004 panels was installed to generate 1.22 megawatts power. "The University is focused on reducing carbon emissions and increasing its use of renewable energy," said Professor Greenfield.

The University of Glamorgan in the United Kingdom is a good example on how ISO 14001, environmental management system (EMS), was implemented. ISO 14001 belongs to a large family of regulations. Its aim is to evaluate and improve the performance of organizations regarding their environmental sustainability (Price, 2005). The EMS at Glamorgan has five main elements that include environmental policy, environmental manual, registers of appropriate environmental aspects, environmental handbook, and administrative procedures. The university aims to use renewable energy whenever it is financially possible. In 2003 they implemented a hybrid wind-solar street light system at the university campus near the student accommodation buildings (Price, 2005).

2.5.3 Feasibility Studies for Similar Projects

Peter and Glenn (2008) studied different solar power generation technologies, identified a proper solar technology for the Australian Capital Territory (ACT), and performed an economic feasibility study for a solar power generation facility. The selection of the chosen technologies included factors such as, assessment of the technology, the present status of and commercial experience of the technology, cost. The key financial measures that were used to rank the technologies are the unit cost of electricity and the net present value. The financial evaluation used discounted cash flow to calculate the cost of electricity generation and a net present value analysis to assist in the selection of the solar technology. The project lifetime was 20 years, typical for a project of this nature. Inflation was considered 2.5%, estimate of the long-term consumer price index in Australia.

David and Jennifer (2008) presented their feasibility study report, Alternative Energy Feasibility Study for Campus Use, to the Physical Plant Services at Queen's University. The report was concerned with seven alternative energy technologies that might be implemented on campus to decrease the cost of energy. The seven technologies that were assessed are: deep lake water cooling, fuel cells, geothermal, lake water heating and cooling, solar panels, solar photovoltaic, and wind turbines. The seven technologies were ranked based on comparative system. The comparative system focused on the capital, operational and periodic costs, the net present value, life expectancy and payback period of the project. Concerning the solar photovoltaic energy feasibility study, the operation and maintenance costs were considered 2% of the initial cost, and the life span of the project was 25 years. The net present value of this project showed a negative result which means that over 25 years period the project will be unprofitable, the payback period was approximately at 31 years.

Dalton et al. (2009) performed a feasibility analysis of renewable energy supply for small to medium-scale tourist operations using net present cost, renewable factor and payback period as assessment criteria. Net present cost represents the life cycle cost of the system. The calculation assesses all costs occurring within the project lifetime, including initial set-up costs, component replacements within the project lifetime, operation and maintenance cost. The analysis utilized power load data from accommodations, in Australia, where renewable energy supply connected to hybrid was already installed, and these locations varied in both climatic and geographic characteristics. The analysis demonstrated that renewable energy supply can meet the power demand for stand-alone small to medium-scale tourist accommodations. As well as, results indicated that wind energy conversion system, rather than photovoltaic, were the most economical renewable energy supply for sample hybrid systems. For example, the payback period for wind energy was 3 to 4 years while that of photovoltaic solar panels was 6 to 7 years. In their case, wind energy was identified as the most capable renewable energy source due to its high power return per dollar spent. Solar photovoltaic is technically capable of providing the required power but it is un-competitive from the net present cost perspective, due to its initial high cost.

In a similar paper, but on a larger scale, Dalton et al. (2007) presented an analysis of the technical and financial viability of renewable energy supply combined with an on-grid system for a large scale grid connected hotel (more than 100 beds). As for the assessment criteria, the paper is comprised of three factors, net present cost, renewable fraction and payback time. Results demonstrate that renewable energy supply has the potential to supply significant power for a large scale tourist accommodation, in conjunction with the on-grid electricity supply. The payback period of the project is 14 years and by installing this system, there will be a reduction in greenhouse gas emissions of 65%. Similar to small scale tourist accommodations, the wind energy system, rather than photovoltaic, is the most economically viable renewable energy supply technology. Specifically, large wind energy (over 1000KW) is more efficient and economical than multiple small scale wind energy (0.1 to 100KW). The analysis demonstrates that renewable energy supply is economically feasible as an addition to grid connected supply, and will become more attractive as costs of conventional electricity supply increases.

Bazen and Brown (2007) indicate in their paper the advantages and limitations of solar photovoltaic systems for energy generation. The paper seeks to investigate the impact of alternative energy programs, grants and other incentives on the feasibility of solar photovoltaic systems in several solar regions within Tennessee's poultry industry. The economic analysis includes the discounted and undiscounted payback of the photovoltaic system in years, the benefit to cost ratio, the net present value and the internal rate of return. The study took into consideration the Tennessee Economic and Community Development Energy Division which is offering a grant program for businesses to install renewable energy systems at their facilities. The incentives behind the Tennessee clean energy technology grant amount to 40% of the installed cost for solar photovoltaic systems with a maximum grant of $75,000. The remaining portion of the system cost was financed using a 10 year loan with a 7.5% fixed interest rate. The discount factor rate used for this study was 8.25%. The payback period for the undiscounted photovoltaic system was approximately 4.5 years while that of the discounted was on average 12.5 years. The variables with the largest impact on the net present value of the 20KW solar photovoltaic system include the percent of the grant funding and the installed cost per KW. The electricity escalation rate had the least impact on the net present value. Results show that solar technology is economical under the calculated incentives and prices.

Aagreh and Al-Ghzawi (2013) presented a feasibility study analysis for renewable energy supply for feeding a small hotel in Ajloun City located in the north of Jordan. The technical and economic aspects were investigated in this study. Two scenarios were studied, off-grid and on-grid system. The net present cost and the payback time were used as factors to assess whether the project is profitable or not. The results obtained showed that on-grid small wind turbine scheme is the most feasible supply option to feed the electrical loads for the hotel. For the off-grid system, the result showed that the net present cost is $62.7x103, the payback period is 10.9 years and there will be a reduction of greenhouse gas emissions of 8.8 ton per year. While if on-grid system was applied, the assessment parameters are reduced. The net present cost decreased to $44.3x103 while the payback period became 6.6 years, since electricity was sold back to the grid, and the greenhouse gas emissions was reduced to 0.101 ton per year. The authors suggest that the implementation of standalone configurations, wind and solar energy sources, will increase in the future due to the expectations of the decrease in the costs of the main components consisting these configurations and the increase in the overall efficiency.

2.6 Lebanon Profile

2.6.1 Geographic and Climatic Outline

Lebanon is located in the Mediterranean with an area of 10,452 km^2. The country is located between Latitudes of 33° 03' 20" N and 34° 41' 35" N and Longitudes of 35° 06' 15" E and 36° 37' 21" E (The National Wind Atlas of Lebanon, 2011). The Lebanese population, about 4 million people, is spread over an average length of 220 km, where the highest economic activity exists, and an average width of 48 km. Lebanon has four major climatic zones, the coastal, mid-mountains, high-mountains, and inland. Temperature and climatic differences are shown in Figure 2.1.

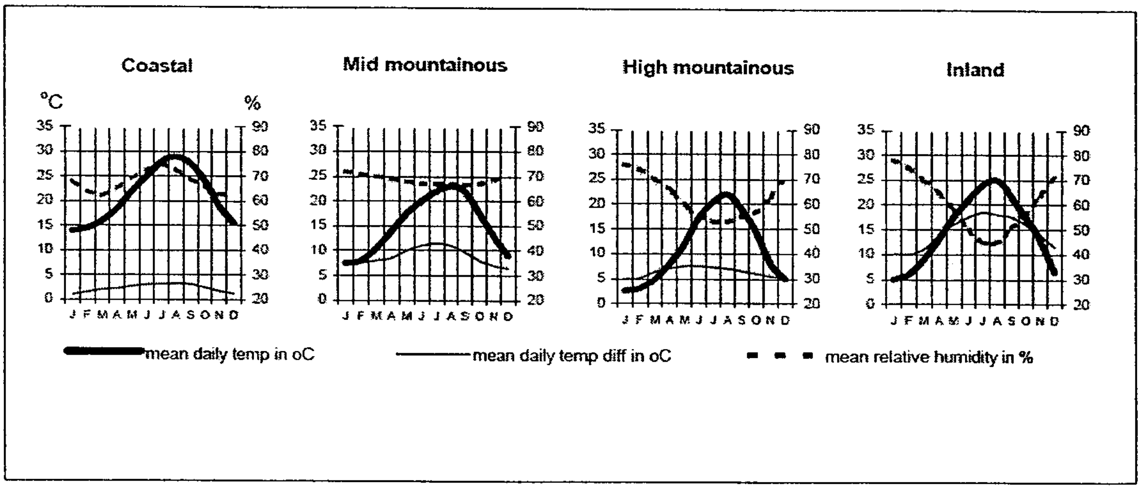

Figure 2.1: Climatic Differences
Source: Renewable Energy Country Profile for Lebanon, 2009

2.6.2 Energy Production

Lebanon is mainly surrounded by oil extracting countries, but unfortunately its land lacks most of the commonly used sources for electric generation such as oil and gas. This conflict forced the Lebanese government to import the energy needed to produce electricity for its residences and factories. Although governments, past and recent, made huge investments in the electricity sector, the required energy still exceeds the supply. Therefore, Lebanon still imports electricity from its neighbors, mostly Syria. The production and supply of electricity in Lebanon is controlled by Electricite Du Liban (EDL) with some preferences made to other companies, such as Electricite Du Zahle (EDZ). The usage of fuel oil, by EDL, is around 1,355,081 tons and diesel around 573,071 tons (Jizzini, 2002). As demand exceeds supply, more blackouts will occur; this will lead to a draw-back in the economy through the direct effect on tourism and industry sectors. In spite of problems faced by Electircite Du Liban, EDL still follows a low rated pricing in order to decrease cost on customers, but this has placed a high burden on this sector.

2.6.3 Substitutes for EDL Shortage

2.6.3.1 Privately Owned Generators

A remarkable fact is that the electricity sector has a heavy dependence on unofficial private power generation that is operating without any governmental supervision. The private power generation is not regulated in Lebanon, but as an advantage they provide electricity to households during blackouts that occur often in cities outside Beirut. This private power generation business has a higher selling and producing cost than EDL. Referring to the World Bank (2009), a survey was conducted in 2008; the results showed that the average bill from a private generator was US$47, compared with US$26 for EDL. Values in Table 2.4 show that the highest consumption of electricity is associated to households and other consumers. The inability of EDL to provide electricity to this sector explains the spread of private generators over the Lebanese territory.

Table 2.4: Energy Statistics for Lebanon, 2008

Commodity – Transaction	Quantity Kilowatt-hours, million
Electricity - gross production, public & self-producer	10,626
Electricity - net production	10,626
Electricity – imports	561
Electricity - conversion, transport & distribution losses	1,678
Electricity - consumption by industry & construction	2,496
Electricity - consumption by other industries and construction	2,496
Electricity - consumption by households and other consumers	7,013
Electricity - consumption by households	3,625
Electricity - consumption by other consumers	3,388
Electricity - total production, public	10,626
Electricity - gross inland availability	11,187
Electricity - net inland availability	9,509

Source: Energy Statistics Database - United Nations Statistics Division

2.6.3.2 Energy Efficiency and Renewable Energy in Lebanon

There exist multiple options that Lebanon could encounter in practicing energy efficiency and renewable energy. Studies for installation of renewable energy (RE) should include cost and return on investment in order to check whether the system to be installed is profitable or not. In Lebanon, the electricity production coming from renewable energy differs among diverse map locations. Due to its diversity of the landscape, different types of renewable energy should be installed in order to achieve the best output with the lowest cost. The increase of the efficient energy use helps different sectors (industrial and economical) permitting the best service for users at a limited energy expense (Konstantinos D., Haris D., John P., 2006). Therefore, taking into consideration the economic growth, citizens need a consistent source of electricity to cope with their daily life needs.

Light Emitting Diodes (LED) Lamp

Nowadays, light emitting diodes are known for their low consumption of energy as compared with other light sources, such as fluorescent lamps, and providing the same light capabilities. The solution presented is simple since there is no need to interchange electronic ballast, and at the same time it is eco-friendly in case of disposal of the ballast. In their paper, Nan and Chung (2010) have reached to a conclusion that a 20W LED lamp can replace a regular 36W T8 fluorescent lamp.

A major step into RE may take place through changing the regular highway lamps into light emitting diode lamps supplied by a hybrid wind-solar power system. In Lebanon, the change from High Pressure Sodium lamp (HPS) into Light emitting diodes (LED) could decrease up to 50% the energy consumption. The addition of self-sustainable highway lights will make the cost of energy expenditure very negligible (Georges and Slaoui, 2011). A sample of the savings that will occur is represented in Table 2.5.

Table 2.5: Cost Comparison between Regular Street lights (HPS) and Led lamps

Daily hours of operation	12	
Days of operation / month	30	
Total hours of operation / month	360	
Power consumption of one Lamp	112 (LED)	250 (HPS)
Total number of installed lamps	10	
Total kWh / month	403.20	900
Cost of operation(125 LP per kWh)	$32.25	$75.00
VAT (10 %)	$3.23	$7.50
Total / month	$35.48	$82.50
Total / year	$425.70	$990.00
Yearly saving	$564.30	

Source: Case Study for Hybrid Wind-Solar Power Systems for Street Lighting, Georges & Slaoui, 2011.

At the same time, the decrease in supply for highway lamps could help reduce blackouts, decrease emissions, and shift the concentration of energy to a more useful sector. In this manner, the Lebanese government will be the role model for institutions to start implementing the self-sustainable LED hybrid solar-wind highway lamps. This first step will encourage the use of renewable energy over the Lebanese territories especially in far regions that lack the basic needs of electricity due to their far distance from the electric grid. The upcoming part will discuss the three most known and usable sources of power generation in Lebanon which are wind, solar, and hydropower energy.

Wind Energy

The source of the wind originates from the sun through the process of unequal dispersed warmth over the whole surface of Earth. This phenomenon is due to the different structure of the planet, ranging from land till water, where each attracts the incoming heat in dissimilar rates. The difference between hot and cold air is the formal standard shape of wind. The speed of wind increases as altitude increase, and achieves its maximum in open areas where wind is not blocked. Wind energy is most suitable in the North and South of Lebanon. These two regions are known to have the maximum wind speed. The south region of Lebanon has the highest wind speed with enough capacity to rotate a wind mill that could generate 5 MW (Beheshti, 2010).

The average wind speed in Lebanon is studied over 9 different locations, Beirut airport, Cedars, Rayak, Ksara, Khalde, Marjayoun, Qlaiat, Tripoli, and Dahr El Baidar. "Good sites for wind plants are the tops of smooth, rounded hills, open plains or shorelines, and mountain gaps that produce wind funneling." (Moubayed. and Outbib, 2007, p. 2)

Table 2.6: Average wind speed in Lebanon

Month	Windiness [%]
January	104.4
February	113.2
March	110
April	109.8
May	102.8
June	102
July	103.4
August	93.4
September	91.1
October	86.2
November	86.9
December	97.1
Annual	100

Source: Wind Atlas for Lebanon

Solar Energy

Radiation and heat coming from the sun are the two main forms of solar energy. By harnessing these sources one could generate electricity from radiations through the process of solar photovoltaic or produce solar heating through solar thermal energy. The amount of energy that could be used differs between regions. In the Mediterranean region the average range of solar power is at least 2000 and at most 3200 kWh/m^2 (GTZ, 2009).

Another type of solar technology is the solar architecture which is considered as a passive technique. It deals with decreasing the energy consumption through adjusting the position of buildings with respect to the Sun. According to Mezher (2011) it is crucial to have a shift in the mindset of construction industries when it comes to the development of future cities.

The disposition of these buildings will result in achieving the highest probable lumens into the floors with the least use of power generation, as well as providing an appropriate air circulation with the least energy consuming process.

Nowadays, Israel and Cyprus are ranked as the two leading countries having the highest percentages in installations of solar heating (GTZ, 2009). Surveys conducted by the United Nations Development Program (UNDP) have shown that the area of solar panels installed in Lebanon witnessed a market growth from 16% to 36% between years 2001 and 2004, and an 18% increase was estimated for the year 2005 as compared to 2004 (UNDP, 2006). There is still a large opportunity of growth with the capacity to reach 2 million m^2 (UNDP, 2006).

Table 2.7: Solar Data Related To Lebanon

Month	Coastal, kWh/m2/day	Interior, kWh/m2/day	Coastal sunshine hours (Hrs)	Interior sunshine hours (Hrs)	Day length (Hrs)
January	2.4	2.4	4.6	4.5	10
February	3.2	3.4	5.6	5.5	10.8
March	4.1	4.4	6.4	6.4	11.8
April	5.5	5.9	7.7	8.5	12.9
May	6.6	7.2	10.1	10.5	13.8
June	7.3	8.5	11.5	13.1	14.2
July	7	8.4	11.4	13.2	14
August	6.3	7.7	10.6	12.4	13.2
September	5.3	6.5	10.4	11:2	12.1

Source: Renewable Energy Country Profile for Lebanon, 2009

The photovoltaic (PV) resource coming from the sun's solar radiant energy has started to gain promotion, in Lebanon, during the past few years. One of the hidden advantages of PV is that they can decrease the cost of cabling from stations till rural households and institutions. Although the cost of installing a complete system of PV has decreased to more than 50%, the Lebanese population did not yet realize the advantages of such renewable energy on their life.

An important note to be considered is that whether energy is being produced from solar PV or from wind turbines, a battery central system is needed to supply electricity whenever there is a shortage in renewable energy.

Hydropower Energy Resource

Hydro electric power generates energy through the mechanism of either gravitational force, example dams, or from flowing water, such as rivers. The cost of producing electricity from hydraulic source is relatively low. According to Houri (2005), the Lebanese government has planned 21 dams costing 547 million dollars where only one is designed for electricity generation. Table 2.8 shows some of the dams that are present in Lebanon and the capacity of future Jannah dam to supply 40-100 MW of electricity.

Table 2.8: Initiated Dams in 2002 and the Future Hydroelectric Dams

Planned Dams	Area	Water Capacity	Use	Electricity Production	Cost (million $)
Shabrouh	Keserwan	8 million	Drinking Water	N/A	48
Qaisamani	Baabda	0.55 million	Drinking Water	N/A	8
Yamouneh	Baalback	1.5 million	Drinking Water/Tourism	N/A	6
Jannah	Byblos	30 million	Drinking/Power	40-100 MW	60

Source: Renewable Energy Sources In Lebanon, Houri, 2005

There exist 3 hydraulic power plants in Lebanon, Litani, Al Bared, and Safa. Litani station, 190 MW, is divided upon 3 units, Awali 108 MW, Joun 48 MW, and Abdel Al 34 MW. Whereas, Al-Bared, 17.2 MW, consists of two plants, Al-Bared1 13.5 MW, and Al-Bared2 3.7 MW. The last location is the Safa power plant which generates 13.4 MW. (The data presented before are shown in Table 2.9 as presented by EDL). Therefore, the total hydraulic power plants sum up to 220.6 MW. The total power supplied by EDL, at 2006, is equal to 2,100 MW of which 1,900 MW are from thermal power and the remaining from hydro plants (World Bank, 2008).

Table 2.9: Hydroelectric Power Plants in Lebanon

Power Plant	Station	Capacity (MW)	Total Capacity (MW)
Litani	Awali	108	190
	Joun	48	
	Abed Al	34	
Al-Bared	Al-Bared1	13.5	17.2
	Al-Bared2	3.7	
Safa	Safa	13.4	13.4
Total			220.6

Source: EDL official website

Other Renewable Energy Sources

There still exist several renewable energy sources that Lebanon could benefit from such as, tides and waves. The variation in tides and waves are negligible for almost all the different seasons of the year due to Lebanon's location in the Mediterranean which is a closed area. Therefore, this technology is not considered to be suitable at the time being. Other renewable energy sources may include hydropower, biomass, and geothermal energy.

2.6.4 Restrictions In Energy Sector

Disadvantages facing RE in Lebanon are related to the lack of proper legislation and policies. Limitations standing in front of energy service companies are focused on legal/political and social dimensions (Konstantinos, Haris, John., 2006). Another drawback is that EDL has a monopoly over this sector which decreases the chances of contribution from other parties.

There exists a single law, referred to Law 462, which deals with the Lebanese energy sector. This law states the role of the government, the rules that organize this sector, and the distribution of produced energy. It also deals with reassigning the electric sector in a total or partial means to the various private sectors (Law of Electricity Sector Organization, 2002). Under this law, it is forbidden to produce electricity and sell it to private users. Therefore, a modification must occur, as a first step, to encourage investing in a long-term profitable renewable energy project.

2.6.5 Facts and Possible Solutions

In this context, one must note that EDL suffers chronic losses in its 2009 financial year was more than one and half billion in U.S. $ (Matar et al,, 2009). Different tactics could be tackled to reach a solution concerning the energy sector in Lebanon. These strategies include the reduction of non-technical losses, such as electric theft and the proposition of modifications to the existing tariff structure.

Lebanon should augment electrical tariff by 100 percent relevant to the existing charge (World Bank, 2009). Other solutions may include the use of green energy as well as renewable resources. Unless a proper study and maintenance of the electric grid occurs, connecting renewable sources to the grid won't generate the expected efficiency. There exist no proper studies related to the losses occurring due to the malfunction of the electric grid, but leaving it as is will help in a faster deterioration of the electric sector through the increased accumulation of costs.

2.7 Notre Dame University-Louazie Profile

2.7.1 NDU Area and Geography

Notre Dame University has a real estate holding of 121750 meters squared of which 83700 meters squared are occupied by the construction area, as shown in Table 2.10. NDU has 6 faculties that occupy 17000m^2 (19.38% of the construction area) and are distributed as follows: Faculty of Architecture, Art and Design, Faculty of Business Administration and Economics, Faculty of Engineering, Faculty of Humanities, Faculty of Natural and Applied Sciences, Faculty of Nursing and Health Sciences, and Faculty Of Political Science, Public Administration and Diplomacy.

The Parking, dormitories, and sports facilities cover an area of 41,150m^2 (46.92%). The academic facilities, library and research centers along with the corridors occupy 14,400m^2 (16.42%). The Admissions, Student and Affairs Office, and Administration cover an area of 4350m^2 (4.96%). The Cafeteria and Theatre has an extension of 5400m^2 (6.16%) to end up with green areas of 1400m^2 (1.6%).

Table 2.10: Notre Dame University Different Area Coverage

Unit Areas	Extension in m^2	Percentage
Parking	18,450	21.04%
Faculties	17,000	19.38%
Dormitories	13,200	15.05%
Sports Facilities	9,500	10.83%
Academic Facilities	5,000	5.70%
Corridors	5,000	5.70%
Library & Research Centers	4,400	5.02%
Division of Continuing Education (DCE)	4,000	4.56%
Restaurant (Cafeteria)	2,900	3.31%
Theatre	2,500	2.85%
Admissions & SAO	2,350	2.68%
Administration	2,000	2.28%
Green Areas	1,400	1.60%
Total	87,700	100%

Source: Notre Dame University Website

2.7.2 NDU Energy Profile

Notre Dame University has two major sources of energy, EDL and private generators. There exist 12 generators that NDU depends on in providing electricity to replace EDL blackouts. These Deutz generators, 1015 series, are similar; they produce the same amount of electricity for a known approximate consumption of diesel fuel. According to Deutz data sheet, the fuel consumption differs at certain loads as shown in Table 2.11. Whereas, Table 2.12, shows the cost of producing 1 kWh at the different loads exerted on the generator, averaging to 0.23$ for every 1 kWh.

Table 2. 11: Generator Fuel Consumption

Specific Fuel Consumption		
LOAD	gram/kWh	Liter/kWh
100%	204	0.240108
75%	199	0.234223
50%	200	0.2354
25%	218	0.256586

Source: Deutz Data Sheet

Table 2. 12: Cost of fuel calculated per generator to produce 1 kWh

Cost of Fuel Consumption (price of 20L = 29400 L.L. = 19.6 USD)				
LOAD	kWh/Liter	kWh/20Liters	L.L./kWh	$/kWh
100%	4.16	83.3	352.96	0.24
75%	4.27	85.39	344.31	0.23
50%	4.25	84.96	346.04	0.23
25%	3.9	77.95	377.18	0.25

The other source that NDU depends on in supplying its electric needs is EDL. EDL has installed a medium-voltage station, MV, at NDU beside the guard room. The tariff rating of electricity for industrial customers differs from that of residential buildings. The tariff also differs on the basis of two durations, summer and winter; this is shown in Table 2.13, and Table 2.14. The administration and classes at NDU start at 8:00 am and stop around 20:30 pm, some courses may extend till 22:00 pm. Therefore, in both summer and winter durations, NDU has approximately 9 peak hours during the 112 L.B.P. tariff and around 5 hours in the 320 L.B.P..

Table 2.13: Electricity Tariffs for Industrial Sector – Summer Duration

	(from April first till September 30)	Tariff / Wh. (L.B.P)	Tariff/Wh. ($)
Summer Duration	At Night (from hour 0 till hour 7)	80	0.0533
	At Day (from hour 7 till hour 18:30)	112	0.0746
	At Peak (from hour 18:30 till hour 21:30)	320	0.2133
	At Day (from hour 21:30 till hour 23)	112	0.0746
	At Night (from hour 23 till hour 24)	80	0.0533

Source: EDL official Website

Table 2.14: Electricity Tariffs for Industrial Sector – Winter Duration

			Tariff /Wh. (L.B.P)	Tariff/Wh. ($)
Winter Duration	(from October first till March 30)			
	At Night	(from hour 0 till hour 7)	80	0.053
	At Day	(from hour 7 till hour 16:30)	112	0.075
	At Peak	(from hour 16:30 till hour 20:30)	320	0.213
	At Day	(from hour 20:30 till hour 23)	112	0.075
	At Night	(from hour 23 till hour 24)	80	0.053

Source: EDL official Website

The remaining hours, where NDU is in its lowest activity, the tariff differs between 80 and 112 L.B.P. A disadvantage that NDU faces is that even though the sun is shining, the lights inside the classes, administration, and offices are switched on. Some solutions may include installation of light sensors in each class to have a better control over the use of lighting fixtures. At the same time, Notre Dame University should raise awareness among its students and employees concerning the habit of using unneeded lighting power.

NDU must search for another source of energy to decrease the costs that it faces all year around. Therefore, due to its geographic positioning, neither located in the North nor in the South where the wind is the best renewable energy resource, NDU could concentrate on solar energy as a renewable energy investment. NDU is constructed on the top of a mountain where there are no obstacles that could block the sun, and as stated before Lebanon has 3,000 hours/year of sunny period.

As for energy efficiency, NDU could replace fluorescent lamps with LED lamps that could decrease the watt consumption and by that decrease the electric bill.

The main question to be addressed is whether installing solar photovoltaic panels and LED lamps inside classes and offices of faculties, capable of replacing the existing sources of energy while still having a good return on investment?

CHAPTER 3

RESEARCH TECHNICAL DESIGN

3.1 General Briefing of Scenarios and Cases

To answer the research questions of this study, two scenarios are needed. The first scenario consists of replacing fluorescent lamps, inside offices and classrooms, with LED lamps. This part will examine the cost of interchanging lamps as well as the difference in watt consumption before and after the replacement. The second scenario includes the installation of solar panels and the calculation of the feasibility of the proposed project. The third scenario is replacing fluorescent lamps with LED lamps and at the same time installing solar panels. These three scenarios will be simulated under two cases; the first case is that electricity generation prices remain stable in Lebanon for both EDL and private owned generators and the second case represents the increase in fuel oil prices leading to an increase in EDL rates and an increase in the cost of imported fuel for the generators.

3.2 Research Questions and Hypotheses

The research questions comprise the following:

1) Would replacing fluorescent lamps with LED lamps inside NDU six major faculty buildings, offices and classes, be considered a good investment?
2) Do installing solar photovoltaic panels at the rooftop of NDU faculty buildings have a good return on investment?

The research hypotheses include:

H1: Replacing fluorescent lamps with LED lamps at NDU will have a good return on investment.

H2: Installing solar photovoltaic panels at NDU, taking into consideration that LED lamps have been installed at an earlier stage as an independent project, will have a good return on investment.

H3: Replacing fluorescent lamps with LED lamps and installing solar photovoltaic panels at the same time will have a good return on investment.

3.3 Theoretical Model

The framework of the project report presented in 2009 by Bates et al. included a solar panel feasibility study at Wesley United Methodist Church, Worcester. They divided the task of the feasibility study of such a project into five sections. The first section was a site analysis to check whether there is available space on the roof top of the church to install the photovoltaic solar panels. The second section dealt with the placement of solar panels and the different types. The third section dealt with the disposition of the panels, tilting angel, and the study of the effect of the different configurations and orientations of the panels. Economic feasibility of the systems, the fourth section, states what economic factors should be included in order to have an accurate economic model. The fifth section considers the social factors that might play a role in helping or hindering the process of installing a solar power system.

The feasibility study was divided into eight main divisions. The first division dealt with the cost of the solar panels per watt, cost of inverters and the cost of other components. The second division dealt with cost of installation and other associated fees. The third division dealt with the lifespan and the maintenance cost of the system. A longer life expectancy will generate a better net present value and a better return on investment. The fourth division dealt with incentives and rebates. The division on financing allows the user to input the down payment, the interest rate and loan period. The next division, energy generation and usage, allowed calculating how much energy will be produced from the solar panels. The last division, analysis, computed typical economic values such as net present value, the breakpoint, and cash flow.

Theoretical Model Discussion

Regarding the first section, a10KW system will be installed on the roof of every faculty building; only five buildings will be needed since the required power is approximately 50KW. In the offer presented to NDU, the size of the panel is around 1.7 m^2, for a 10KW system to be installed on the roof of the building 40 panels will be needed. Therefore a maximum of 100 m^2 will be acquired, taking into consideration the displacement of the panels and the spacing between them if required. Each faculty has around 500m^2 of roof top; hence NDU has sufficient space for the installation of the total system.

Concerning the second section, only one kind of solar panels was quoted. This model has 16.02% of high efficiency, it is also designed for both residential and commercial purposes, they can be implemented on rooftop, and ground, as well as they could be used for on-grid and off grid photovoltaic projects. The quoted model has both International Electrotechnical Commission (IEC) and Underwriters Laboratories (UL) certificates, as well as they are presented with a 25-year output warranty.

Looking into the third section, different locations around the world requires different tilting angels when installing solar panels. The amount of sun is very low in some countries that a precise angle and disposition is needed. Usually on the Lebanese territories, a tilt angle of 30 degrees is required in order to absorb the maximum amount of energy transmitted from the sun; therefore NDU's solar system will also abide to this rule.

The economic feasibility study includes the derivation of the startup cost, operating costs, revenue projections, and the financing options. The startup cost will include the product, installation and certification costs. The product cost will include hardware components of solar panels such as inverters, on-grid system frames to mount the panels, and the solar panels. The operating cost deals with maintaining the efficient operation of the solar system that will be installed over the years. At last typical economic values were presented such as net present value, breakeven point and cash flows. Methods used regarding this study will be included in this chapter while detailed discussion regarding the results of the feasibility study will be examined in chapter 4.

3.4 Methodology

3.4.1 Light Emitting Diodes

3.4.1.1 Structural Overview

NDU consists of six main faculty buildings: Faculty of Architecture, Art & design (FAAD), Faculty of Business Administration & Economics (FBAE), Faculty of Engineering (FE), Faculty of Humanities (FH), Faculty of Natural & Applied Sciences (FNAS), Faculty of Political Science, and Public Administration & Diplomacy (FPSPAD) (above cafeteria). An overview of the whole lighting architectural plan of the six faculty buildings was completed and classes and offices were selected to implement the study. These rooms were found to be the most controllable electrical environment in the buildings where the lighting fixtures may be controlled after each usage. The classes are located in the ground, first and second floor and the offices are mostly located in the second and third floor. Classes comprise the highest electrical consumption in all the buildings due to their extended hourly usage. The number of classes and offices in the six buildings are presented in Table 3.1. The number of offices for FPSPAD (Building 1) is equal to zero since the offices of this faculty are located within the FBAE (Building 2).

Table 3.1: Number of classes and offices in the faculties under study.

Building	Classes	Offices
Building 1 - Faculty of Political Science, Public Administration & Diplomacy (above Cafeteria)	15	0
Building 2 - Faculty of Humanities	7	34
Building 3 - Faculty of Architecture, Art & Design	0	44
Building 4 - Faculty of Business Administration & Economics	6	58
Building 5 - Faculty of Engineering	6	39
Building 6 - Faculty of Natural & Applied Sciences	10	45
Total	44	220

3.4.1.2 Classification of Rooms and Lighting Fixtures

Every class and office inside the faculties was given a sequential number and classified according to the faculty name. The numbers were then presented on the architectural drawings and on excel tables, for further reference and usage during later calculations. Lighting fixtures were then counted in every room and the total sum of every class and office was included relevant to the previously chosen identities. The lighting fixture that is mostly used in these rooms is 2x36 Watt adjacent fluorescent lamp where most is constituted of 120 cm in length.

Figures 2, 3 and 4 are examples of the architectural drawings of classes and offices that show the sum of lighting fixtures and room classifications. All the relevant architectural drawings will be shown in appendix A, Sequential Room Numbering on Architectural Drawings, at the end of this thesis.

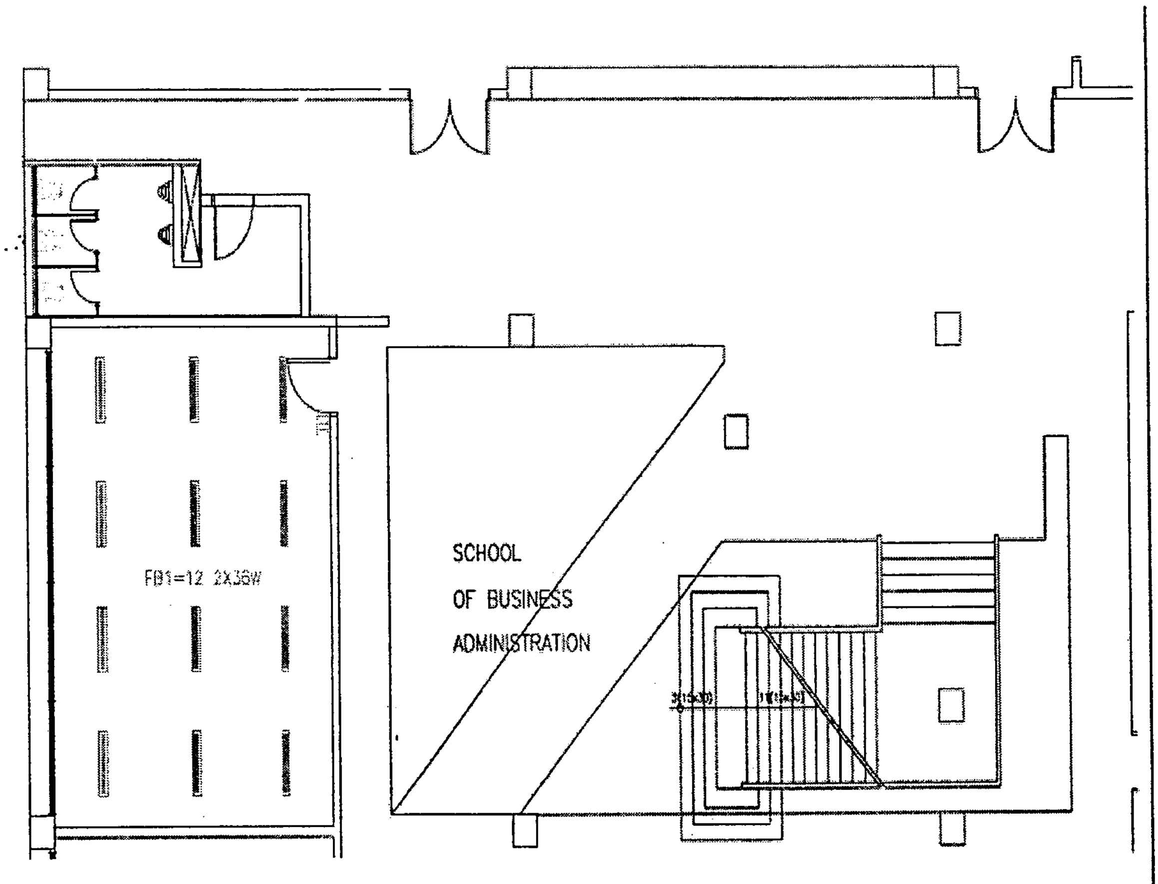

Figure 3.1: Faculty of Business sample of Architectural classification and counting of fixtures.

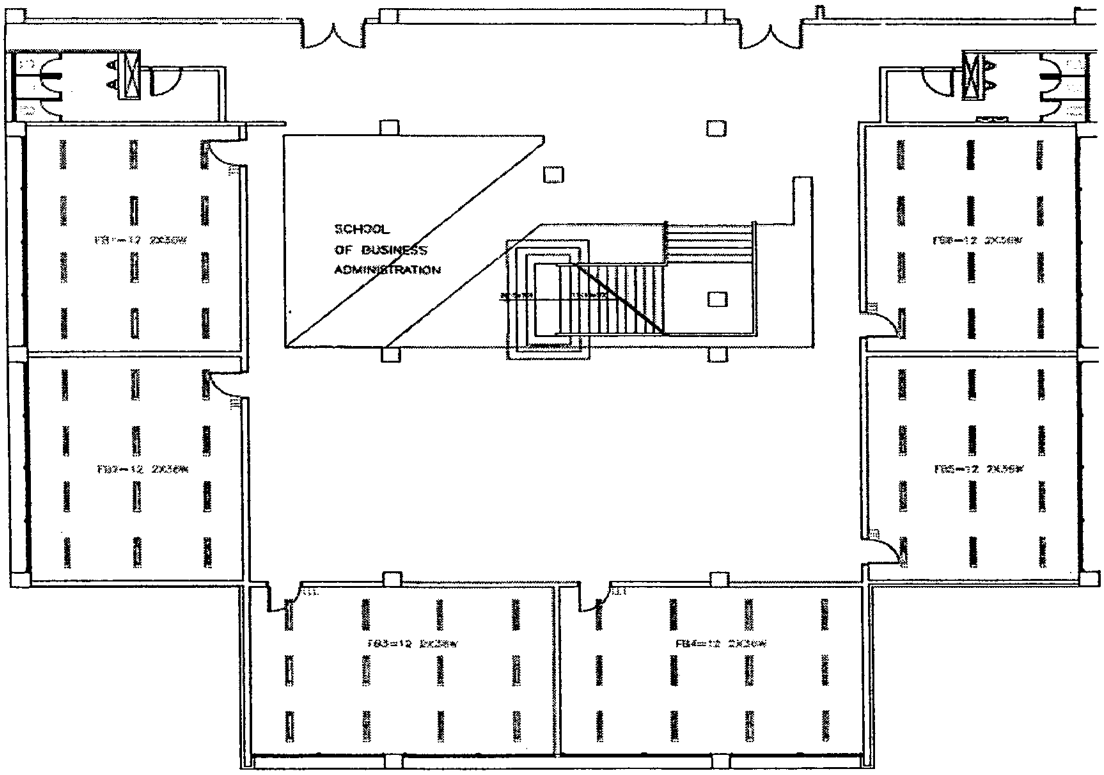

Figure 3.2: Faculty of Business Ground Floor (Architectural Drawing)

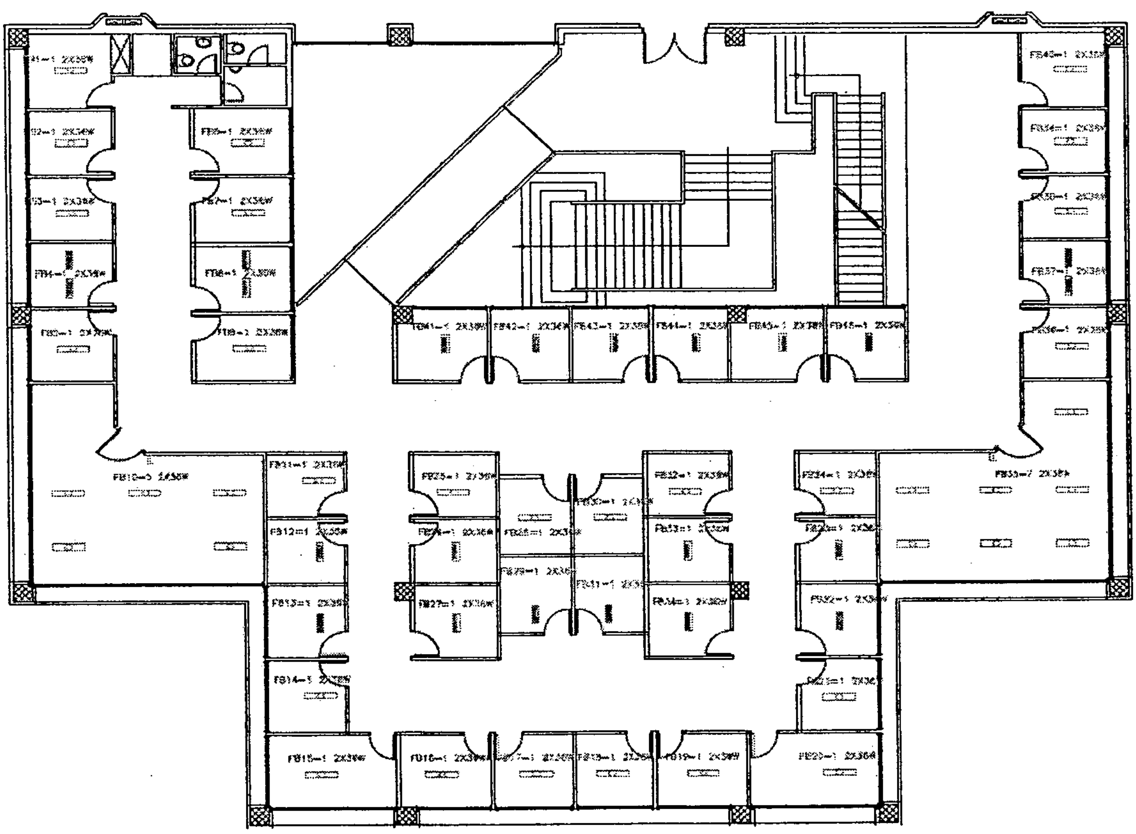

Figure 3.3: Faculty of Business First Floor (Architectural Drawing)

3.4.1.3 Fluorescent Lamps

The 2x36Watt fluorescent fixture has an approximate electrical consumption of 72 Wh. The shape of this lighting fixture is shown in Figure 3.4. Without ballast, a fluorescent lamp cannot function; each ballast has an approximate electrical consumption of 9 WH at its nominal operation. The shape of the ballast is shown in Figure 3.5. Therefore, the sum of each fluorescent lamp and its relative ballast counts for 45 Wh.

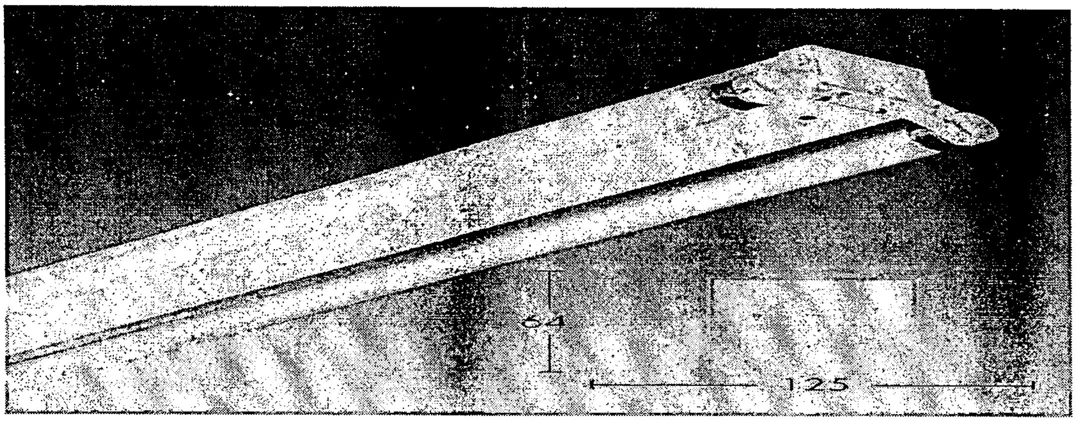

Figure 3.4: Fluorescent Lamp, 2x36 Watts (similar to that installed at NDU)

At NDU, the lighting fixtures have a simple structure where in most places they are placed inside a concrete concaved structure. In order to have a better lighting power, you may notice that the column where the fluorescent lamp (fixture) is installed has a white background to reflect the highest quantity of light emitted by the lighting structure. All the lighting fixtures inside classes and offices are fluorescent lamps, where most of them have a 120 cm length and the minority which could be found in small offices has a 60 cm length.

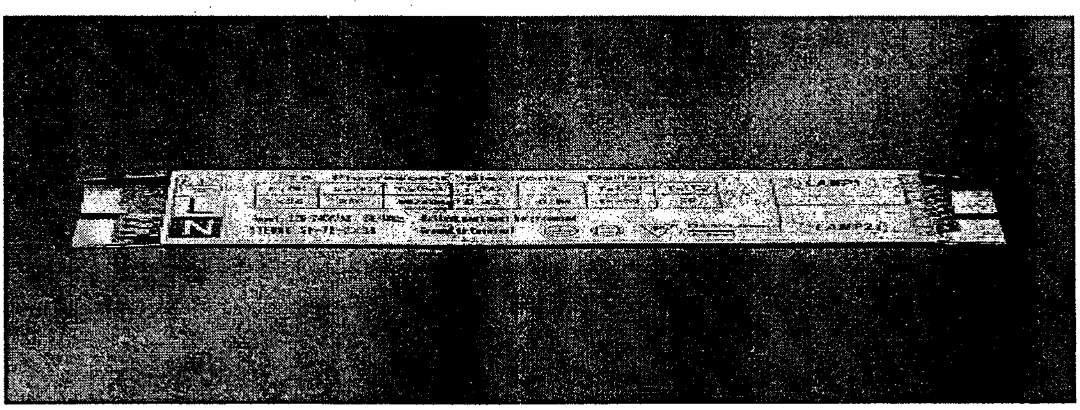

Figure 3.5: Electronic Ballast for Fluorescent Lamp

3.4.1.4 Comparison between Fluorescent and LED lamps

The findings on the drawings were then included in excel sheets to calculate the load consumption of each building through presenting the load calculation of first, second and third floor separately. Each floor in the excel sheet shows the room numbering and its definition; being class or office. The second detail in the excel sheet is to show the number and length of fixtures in each room. The consumption of fluorescent lamps and LED lamps where then stated in the table. The collected data helped forming a comparison table between fluorescent and LED fixtures and present the difference in Wh consumption between the two types of lamps.

These finding are first stated for the rooms in every floor, a total for each floor is then presented and at last a total comparison for the whole faculty is calculated. These three steps are shown for the Business faculty in Tables 18, 19 and 20, representing ground, first and second floor, all other tables will be shown in the appendix B, Summary Tables for Faculty Lighting Consumption.

Table 3.2: Faculty of Business Ground Floor Lighting Consumption

FBAE-RC										
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE (Wh)			LED WATT-HOUR PER FIXTURE (Wh)		TOTAL CONSUMPTION WATT-HOUR (Wh)		
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT	LED	DIFFERENCE
RC-FBAE1	CLASS 1	12	2X36	2X9	90	2X22	44	1080	528	552
RC-FBAE2	CLASS 2	15	2X36	2X9	90	2X22	44	1350	660	690
RC-FBAE3	CLASS 3	12	2X36	2X9	90	2X22	44	1080	528	552
RC-FBAE4	CLASS 4	12	2X36	2X9	90	2X22	44	1080	528	552
RC-FBAE5	CLASS 5	12	2X36	2X9	90	2X22	44	1080	528	552
RC-FBAE6	CLASS 6	12	2X36	2X9	90	2X22	44	1080	528	552
								TOTAL FLUORESCENT	TOTAL LED	TOTAL DIFFERENCE
TOTAL FBAE-RC								6750	3300	3450

Table 3.3: First Floor of Faculty of Business Electrical Lighting Consumption

FBAE-1ST-A										
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT			LED		TOTAL CONSUMPTION WATT-HOUR (Wh)		
			WATT-HOUR PER FIXTURE (Wh)			WATT-HOUR PER FIXTURE (Wh)				
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT	LED	DIFFERENCE
1ST-FBAE1	OFFICE 1	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE2	OFFICE 2	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE3	OFFICE 3	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE4	OFFICE 4	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE5	OFFICE 5	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE6	OFFICE 6	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE7	OFFICE 7	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE8	OFFICE 8	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE9	OFFICE 9	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE10	OFFICE 10	5	2X36	2X9	90	2X22	44	450	220	230
1ST-FBAE11	OFFICE 11	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE12	OFFICE 12	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE13	OFFICE 13	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE14	OFFICE 14	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE15	OFFICE 15	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE16	OFFICE 16	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE17	OFFICE 17	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE18	OFFICE 18	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE19	OFFICE 19	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE20	OFFICE 20	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE21	OFFICE 21	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE22	OFFICE 22	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE23	OFFICE 23	1	2X36	2X9	90	2X22	44	90	44	46

Table 3.3 continued

FBAE-1st-B										
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE (Wh)			LED WATT-HOUR PER FIXTURE (Wh)		TOTAL CONSUMPTION WATT-HOUR (Wh)		
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT	LED	DIFFERENCE
1ST-FBAE24	OFFICE 24	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE25	OFFICE 25	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE26	OFFICE 26	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE27	OFFICE 27	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE28	OFFICE 28	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE29	OFFICE 29	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE30	OFFICE 30	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE31	OFFICE 31	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE32	OFFICE 32	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE33	OFFICE 33	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE34	OFFICE 34	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE35	OFFICE 35	7	2X36	2X9	90	2X22	44	630	308	322
1ST-FBAE36	OFFICE 36	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE37	OFFICE 37	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE38	OFFICE 38	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE39	OFFICE 39	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE40	OFFICE 40	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE41	OFFICE 41	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE42	OFFICE 42	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE43	OFFICE 43	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE44	OFFICE 44	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE45	OFFICE 45	1	2X36	2X9	90	2X22	44	90	44	46
1ST-FBAE46	OFFICE 46	1	2X36	2X9	90	2X22	44	90	44	46
								TOTAL FLUORESCENT	TOTAL LED	TOTAL DIFFERENCE
TOTAL FBAE-1st								5040	2464	2576

Table 3.4: Second Floor of Faculty of Business Electrical Lighting Consumption

FBAE-2nd										
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE (Wh)			LED WATT-HOUR PER FIXTURE (Wh)		TOTAL CONSUMPTION WATT-HOUR (Wh)		
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT	LED	DIFFERENCE
2ND-FBAE1	OFFICE 1	10	2X36	2X9	90	2X22	44	900	440	460
2ND-FBAE2	OFFICE 2	11	2X36	2X9	90	2X22	44	990	484	506
2ND-FBAE3	OFFICE 3	12	2X36	2X9	90	2X22	44	1080	528	552
2ND-FBAE4	OFFICE 4	13	2X36	2X9	90	2X22	44	1170	572	598
2ND-FBAE5	OFFICE 5	2	2X36	2X9	90	2X22	44	180	88	92
2ND-FBAE6	OFFICE 6	2	2X36	2X9	90	2X22	44	180	88	92
2ND-FBAE7	OFFICE 7	2	2X36	2X9	90	2X22	44	180	88	92
2ND-FBAE8	OFFICE 8	2	2X36	2X9	90	2X22	44	180	88	92
2ND-FBAE9	OFFICE 9	4	2X36	2X9	90	2X22	44	360	176	184
2ND-FBAE10	OFFICE 10	6	2X36	2X9	90	2X22	44	540	264	276
2ND-FBAE11	OFFICE 11	4	2X36	2X9	90	2X22	44	360	176	184
2ND-FBAE12	OFFICE 12	6	2X36	2X9	90	2X22	44	540	264	276
								TOTAL FLUORESCENT	TOTAL LED	TOTAL DIFFERENCE
TOTAL FBAE-2ND								6660	3256	3404

Table 3.5 presents the detailed consumption of each faculty in all the three floors if they were to operate on either fluorescent or led lamps. The total lighting electrical consumption of the six faculties if operating on fluorescent lamps counted for 97 kWh while if LED lamps were to be used instead the consumption summed up to 48 kWh. The total difference was 48.89%, with less electricity consumption if LED lamps were to be used rather than fluorescent.

Faculty of science had the highest lighting consumption between the faculties, due to the number of classes that count more than other faculties. Faculty of Architecture, Art & Design, located above Maliks Bookshop, had the lowest consumption due to the lack of existence of classes in it.

Table 3.5: Comparison Table Containing the Six Faculty Buildings

TOTAL				
FACULTY	LEVEL	TOTAL FLUORESCENT CONSUMPTION (Watt-hour)	TOTAL LED CONSUMPTION (Watt-hour)	TOTAL CONSUMPTION DIFFERENCE (Watt-hour)
FBAE	RC	6,750	3,300	3,450
	1ST	5,040	2,464	2,576
	2ND	6,660	3,256	3,404
TOTAL FBAE		18,450	9,020	9,430
FAAD	RC	0	0	0
	1ST	6,300	3,080	3,220
	2ND	5,670	2,772	2,898
TOTAL FAAD		11,970	5,852	6,118
FH	RC	7,830	3,828	4,002
	1ST	3,150	1,540	1,610
	2ND	3,600	1,760	1,840
TOTAL FH		14,580	7,128	7,452
FPSPAD	RC	0	0	0
	1ST	8,640	4,224	4,416
	2ND	6,120	2,992	3,128
TOTAL FPSPAD		14,760	7,216	7,544
FE	RC	6,750	3,300	3,450
	1ST	2,340	1,144	1,196
	2ND	6,030	2,948	3,082
TOTAL FE		15,120	7,392	7,728
FNAS	RC	9,990	4,884	5,106
	1ST	3,060	1,496	1,564
	2ND	8,730	4,268	4,462
TOTAL FNAS		21,780	10,648	11,132
TOTAL SUM OF FACULTIES		96,660	47,256	49,404

The total number of lamps in all the six faculties at NDU sums up to 2,220 lamps. The figures were sent to a well-known company, Philips, in order to quote prices for both fluorescent lamps and LED lamps. This company is known to have a huge line of lighting products and has a high ranking in the international market. The quotation of both, fluorescent and LED lamps, as well as the data sheets for both lamps, are shown in the appendix C, Philips Quotations, at the end of the thesis.

The offers presented by Philips show that the price of a fluorescent lamp is 0.924 USD including VAT while the price of a LED lamp is 80.00 USD including VAT. Philips included a 20% discount on LED lamps therefore, the final price was 70.4 USD including VAT. Table 3.6 shows the difference in lifetime between fluorescent and LED lamps along with the unit price and total price of the 2220 lamps. Table 3.6 also shows that a single change of LED lamps is equivalent to approximately 6 changes of fluorescent lamps (40,000 hrs/6,000 hrs). Philips also provided the prices of ballast for the fluorescent lamps along with their data sheet. The life time of ballast is dependent on both operating time which could reach till 20,000 hours and the frequent on/off usage of the lamps which could reach up to 3,000 button push. Therefore, for every three changes of fluorescent lamp with a lifetime of 6,000 hours, the ballast should be changed. The price of 1,110 dual lamp supply ballasts is 9,157.5 USD including VAT, hence the price per a dual supply ballast is 8.25 USD (4.125 USD for a single supply ballast). Therefore, the total price of a fluorescent lamp and its ballast is 5 USD.

Table 3.6: Philips Price Comparison between Fluorescent and LED Lamps

LAMP	QUANTITY	LIFE TIME (HRS)	NUMBER OF REPLACEMENT	PRICE PER LAMP INCLUDING BALLST (USD)	TOTAL REPLACEMENT COST (USD)
FLUORESCENT	2,220	6,000	6.5	5	11,100
LED	2,220	40,000	1	70.4	156,288
DIFFERENCE IN COST					-145,188

3.4.1.5 Time And Period Breakdown

a) Case 1 – Stable Electricity Generation Prices

Electricité Du Liban (EDL) supplies electricity for NDU through a medium voltage (MV) transformer. In Lebanon, the rating of a MV line differs from that of a low voltage (LV), mainly used for residential buildings, as per Table 1.2 (Chapter 1) and Tables 15 and 16 (chapter 2). NDU does not stop its operation throughout the year;

therefore, both seasonal EDL rates are applicable on NDU's bills. According to its schedule, NDU has three semesters, fall, spring, and summer. In order to have a full coverage of the six faculties during the whole year, a link between both EDL rates and NDU's schedule should be accomplished. The three academic semesters were subdivided into five periods according to EDL rates.

The first period, Period A, is the time range between October first and March 30. For NDU, this time period is composed of the fall semester and a part of the spring semester; while according to EDL, this time period is considered as Winter Duration. The mean operating time of NDU is between 8 am and 20:30 pm, EDL has two rates set for this range of time where the Day Rate starts from 7 am and ends at 16:30 pm, for 112 L.B.P. per kWh, and a Peak Rate starting from 16:30 pm and ending at 20:30 pm, for 320 L.B.P. per kWh.

Period two, Period B, starts around the mid of the spring semester and ends at the beginning of the summer semester, during this time the operation period of NDU is from 8 am till 20:30 pm, full day. The third period, Period C, is the summer semester where the operation of NDU is mainly between 8 till 14:30 pm and master courses from 17:30 pm till 20:30 pm. In the fourth period, Period D, the operation at NDU is restricted to offices, 8 till 14:30 pm; classes won't be in session during this summer time of the year. These three periods compose the Summer Duration for EDL, April first till September 30, where the Day Rates starts at 7 and ends at 18:30, for 112 L.B.P. per kWh, and the Peak Rate starts at 18:30 and ends at 21:30, for 320 L.B.P. per kWh.

In Lebanon, EDL provides electricity to different regions upon specific periods during the day. There exist two main schedules for the presence of electricity by EDL, these two schedules are opposite in timing range, this process is on a yearly basis. The two schedules, presented by Day 1 and Day 2, are on the basis of NDU operating time which is between 8 and 20:30 pm. The electricity presence for Day 1 is from 8 am till 10 am and from 14:00 pm till 18:00 pm, NDU operates on private generators during the gaps from 10 am till 14:00 pm and from 18:00 pm till 20:30 pm. Day 2, the existence of electricity is from 10 am till 14:00 pm and from 18:00 pm till 20:30 pm. During the time 8 am till 10 pm and 14:00 pm till 18:00 pm, NDU operates on private generators. The cost of operating on private generators at NDU has an average value of 350 L.B.P. for each kWh.

All sections are equally divided into two scenarios that represent Day 1 and Day 2. Each period covers different number of days: Period A - 110 days (55 Day 1, 55 Day 2), Period B – 54 days (27 Day 1 – 27 Day 2), Period C – 28 days (14 Day 1, 14 Day 2), and Period D – 28 Days (14 Day 1, 14 Day 2).

Period A and B have similar loads per time frame. Both classes and offices are fully operating from 8 am till 14:00 pm therefore there exist a 100% (all the percentages are assumptions based on to NDU course offerings and NDU operating time) lighting load. After this period, the operation of classes and offices starts to decrease, the load drops to an approximate value of 90% between 14:00 pm and 16:00 pm. Full-time faculty members quit their job at 16:00 pm, therefore most the power consumption after this time will radically decrease to reach an approximate of 65% between 16:00 pm and 18:00 pm. The last time frame is between 18:00 pm and 20:30 pm where only Masters' courses will be in session and the lighting load will decrease to reach a maximum of 35%.

Table 3. 7: Difference in Load for Period A

WINTER TIME - FULL DAY - 55 DAYS											
	START	END	SOURCE OF POWER	TOTAL DIFFERENCE PER HOUR	NUMBER OF HOURS	LOAD	POWER CONSUMPTION	RATE IN L.L.	NUMBER OF DAYS	L.L.	USD
DAY 1	8:00	10:00	ELECTRICITY	49.404	2	100%	98.808	112	55	608,657	406
	10:00	14:00	GENERATORS	49.404	4	100%	197.616	350	55	3,804,108	2,536
	14:00	16:00	ELECTRICITY	49.404	2	90%	88.9272	112	55	547,792	365
	16:00	18:00	ELECTRICITY	49.404	2	65%	64.2252	320	55	1,130,364	754
	18:00	20:30	GENERATORS	49.404	2.5	35%	43.2285	350	55	832,149	555
	TOTAL									6,923,069	4,615
WINTER TIME - FULL DAY - 55 DAYS											
	START	END	SOURCE OF POWER	TOTAL DIFFERENCE PER HOUR	NUMBER OF HOURS	LOAD	POWER CONSUMPTION	RATE IN L.L.	NUMBER OF DAYS	L.L.	USD
DAY 2	8:00	10:00	GENERATORS	49.404	2	100%	98.808	350	55	1,902,054	1,268
	10:00	14:00	ELECTRICITY	49.404	4	100%	197.616	112	55	1,217,315	812
	14:00	16:00	GENERATORS	49.404	2	90%	88.9272	350	55	1,711,849	1,141
	16:00	18:00	GENERATORS	49.404	2	65%	64.2252	350	55	1,236,335	824
	18:00	20:30	ELECTRICITY	49.404	2.5	35%	43.2285	320	55	760,822	507
	TOTAL									6,828,374	4,552
WINTER TIME - FULL DAY - 110 DAYS											
TOTAL DIFFERENCE IN COST										13,751,443	9,168

Table 3.8: Difference in Load for Period B

SUMMER TIME - FULL DAY - 27 DAYS											
	START	END	SOURCE OF POWER	TOTAL DIFFERENCE PER HOUR	NUMBER OF HOURS	LOAD	POWER CONSUMPTION	RATE IN L.L.	NUMBER OF DAYS	L.L.	USD
DAY 1	8:00	10:00	EDL	49.404	2	100%	98.808	112	27	298,795	199
	10:00	14:00	GENERATORS	49.404	4	100%	197.616	350	27	1,867,471	1,245
	14:00	16:00	EDL	49.404	2	90%	88.9272	112	27	268,916	179
	16:00	18:00	EDL	49.404	2	65%	64.2252	112	27	194,217	129
	18:00	20:30	GENERATORS	49.404	2.5	35%	43.2285	350	27	408,509	272
	TOTAL									3,037,909	2,025
SUMMER TIME - FULL DAY - 27 DAYS											
	START	END	SOURCE OF POWER	TOTAL DIFFERENCE PER HOUR	NUMBER OF HOURS	LOAD	POWER CONSUMPTION	RATE IN L.L.	NUMBER OF DAYS	L.L.	USD
DAY 2	8:00	10:00	GENERATORS	49.404	2	100%	98.808	350	27	933,736	622
	10:00	14:00	EDL	49.404	4	100%	197.616	112	27	597,591	398
	14:00	16:00	GENERATORS	49.404	2	90%	88.9272	350	27	840,362	560
	16:00	18:00	GENERATORS	49.404	2	65%	64.2252	350	27	606,928	405
	18:00	20:30	EDL	49.404	2.5	35%	43.2285	320	27	373,494	249
	TOTAL									3,352,111	2,235
SUMMER TIME - FULL DAY - 54 DAYS											
TOTAL DIFFERENCE IN COST										6,390,020	4,260

Period C represents the summer semester at NDU, the working time of the full-time faculty members starts at 8 am and ends at 14:00 pm. Some classes as well as offices won't be operable; therefore, the lighting load during this time frame is approximately 85%. During this time of the year, the Masters courses will still be in session, the load from 17:30 pm till 20:30 pm will approximately range to 35%.

Table 3.9: Difference in Load for Period C

SUMMER TIME - HALF DAY- FULL OPERATION - 14 DAYS											
	START	END	SOURCE OF POWER	TOTAL DIFFERENCE PER HOUR	NUMBER OF HOURS	LOAD	POWER CONSUMPTION	RATE IN L.L.	NUMBER OF DAYS	L.L.	USD
DAY 1	8:00	10:00	ELECTRICITY	49.404	2	85%	83.9868	112	14	131,691	88
	10:00	14:00	GENERATORS	49.404	4	85%	167.9736	350	14	823,071	549
	18:00	20:30	GENERATORS	49.404	2.5	35%	43.2285	350	14	211,820	141
	TOTAL									1,166,582	778
SUMMER TIME - HALF DAY - FULL OPERATION - 14 DAYS											
	START	END	SOURCE OF POWER	TOTAL DIFFERENCE PER HOUR	NUMBER OF HOURS	LOAD	POWER CONSUMPTION	RATE IN L.L.	NUMBER OF DAYS	L.L.	USD
DAY 2	8:00	10:00	GENERATORS	49.404	2	85%	83.9868	350	14	411,535	274
	10:00	14:00	ELECTRICITY	49.404	4	85%	167.9736	112	14	263,383	176
	18:00	20:30	ELECTRICITY	49.404	2.5	35%	43.2285	320	14	193,664	129
	TOTAL									868,582	579
SUMMER TIME - HALF DAY- FULL OPERATION - 28 DAYS											
TOTAL DIFFERENCE IN COST										2,035,163	1,357

Period D constitutes the duration where the university is at a null stage, classes are not in session and full-time faculty members barely attend the university. During this period, the considered time frame is only between 8 am and 14:00 pm since there are no Masters' courses in session. During this time frame, the lighting consumption load will approximately reach 15%.

Table 3.10: Difference in Load for Period D

SUMMER TIME - HALF DAY - NO OPERATION - 14 DAYS											
DAY 1	START	END	SOURCE OF POWER	TOTAL DIFFERENCE PER HOUR	NUMBER OF HOURS	LOAD	POWER CONSUMPTION	RATE IN L.L.	NUMBER OF DAYS	L.L.	USD
	8:00	10:00	ELECTRICITY	49.404	2	15%	14.8212	112	14	23,240	15
	10:00	14:00	GENERATORS	49.404	4	15%	29.6424	350	14	145,248	97
	TOTAL									168,487	112
SUMMER TIME - HALF DAY - NO OPERATION - 14 DAYS											
DAY 2	START	END	SOURCE OF POWER	TOTAL DIFFERENCE PER HOUR	NUMBER OF HOURS	LOAD	POWER CONSUMPTION	RATE IN L.L.	NUMBER OF DAYS	L.L.	USD
	8:00	10:00	GENERATORS	49.404	2	15%	14.8212	350	14	72,624	48
	10:00	14:00	ELECTRICITY	49.404	4	15%	29.6424	112	14	46,479	31
	TOTAL									119,103	79
SUMMER TIME - HALF DAY - NO OPERATION - 28 DAYS											
TOTAL DIFFERENCE IN COST										287,591	192

The calculations made in all the four sections represent the difference in load between fluorescent and led lamps. These results will help calculate the return on investment of replacing fluorescent with led lamps. The summation of all the periods will present the bills that NDU could forfeit per year if led lamps were to be installed at the time being. The total difference reached up to 14,976 USD per year.

b) Case 2 – Increasing Rate of Electricity Generation Prices

This case will consider the fact that the price of oil will increase worldwide leading to an increase in the prices of EDL and the imported fuel for generators. The rate of increase differs over the years since new natural resources could be used after 10 years, such as natural gas in the Mediterranean Sea, therefore the pricing rate of electricity generation will decrease. Table 3.11 shows the rate of increase of prices of electricity generation, EDL and generators, and its relevant savings over the years.

Table 3.11: Rate of Increase of Electricity Generation and the Relevant Increase in Savings

YEAR	RATE OF INCREASE IN PRICES OF EDL AND GENERATORS	SAVINGS (USD)
1	0.0%	14,976
2	2.0%	15,276
3	2.0%	15,581
4	2.0%	15,893
5	2.0%	16,211
6	2.2%	16,567
7	2.2%	16,932
8	2.2%	17,304
9	2.2%	17,685
10	2.2%	18,074
11	2.3%	18,490
12	2.3%	18,915
13	2.3%	19,350
14	2.3%	19,795
15	2.3%	20,250
16	2.4%	20,736
17	2.4%	21,234
18	2.4%	21,744
19	2.4%	22,266
20	2.4%	22,800

3.4.1.6 Lamp Operating Time

Notre Dame University has different operating environments where the life cycle of the lamp at a class will differ from that at an office. The study of the lifetime of lamps at NDU will be conducted on the basis of the loads used before; therefore, the total sum of lamps, 2,220, will be taken into consideration to calculate the average operating time of all the lamps. The lifetime of a regular fluorescent lamp is approximately 6,000 hours while that of led lamps can reach up to 40,000 hours. The results carried out in Table 3.12 shows that the total yearly operating time is 4,040,000 hours for all the lamps. The maximum lamp operating time per year at NDU is 2,456 hrs. The reason why the total number of lamps was multiplied by the load factor is that there exist different loads where the lamps are operating and therefore an average between different classes and offices should be taken into consideration.

Table 3.12: Yearly Operating Time of Lamps at NDU

PERIOD	NUMBER OF LAMPS	PERIODIC LOAD	OPERATING LAMPS PER LOAD	HOURS PER LOAD	NUMBER OF DAYS	NUMBER OF HOURS PER LOAD	LAMPS OPERATING TIME (RELATIVE TO LOAD) (Hrs.)
SUMMER TIME FD	2220	100%	2220	6	54	324	719,280
		90%	1998	2	54	108	215,784
		65%	1443	2	54	108	155,844
		35%	777	2.5	54	135	104,895
SUMMER TIME HD1	2220	85%	1887	6	28	168	317,016
		35%	777	2.5	28	70	54,390
SUMMER TIME HD2	2220	10%	222	6	28	168	37,296
WINTER TIME	2220	100%	2220	6	110	660	1,465,200
		90%	1998	2	110	220	439,560
		65%	1443	2	110	220	317,460
		35%	777	2.5	110	275	213,675
YEAR	TOTAL YEARLY OPERATING (Hrs.)						4,040,400

FD: Full day summer time when the university is in its normal operation
HD1: Half day summer time where classes are still in session
HD2: Half day summer time where only teachers attend the university while students are on a break

The 4,040,000 operating hours of lamps forms 30.33% of the life of 2220 fluorescent lamp (life time of 2220 fluorescent lamps is 6,000 hrs. x 2220 lamp = 13,320,000 hrs.) On the other hand, the average operating hours form only 4.55% of the life of 2220 led lamps (average life time of 2220 LED lamps is 40,000 hrs. x 2220 lamp = 88,800,000). The fluorescent lamp should be replaced every 3 years while the led lamp could reach up to 20 years under NDU's load.

For every replacement of lamps, NDU has to pay installation fees for one main maintenance worker and one helper. The average labor hour of a maintenance worker at NDU is around 3.5 USD while that of a helper is equal to 1.5 USD. These two persons need approximately 15 minutes to change every LED lamp, 30 minutes to change the whole fixture; this timing starts with the entrance to the class or office till the changing of one single fixture. This timing also includes the new wiring of the fixture where the ballast that was used for the fluorescent lamps will be removed. Changing these lamps every time will place additional cost on NDU, for example the first replacement will cost 2,775 USD as maintenance fees and will increase over the years due to the inflation rate and the increase in the labor hour rate of the worker. In the case of LED lamps, the next major maintenance change will be in 20 years, where the needed time will be only 7 minutes. The timing is less than before since the ballast has already been removed during the first replacement.

Whereas, it will take around 15 minutes to change a fluorescent lamp since with every lamp changing, the ballast will be at the end of its life cycle and should also be changed. Therefore, the cost of changing 2220 fluorescent fixture will cost around 2,775 USD. Similar to the case of LED lamps changing fees, the labor hour rate will increase during the upcoming years leading to a higher cost. The difference between LED and fluorescent lamps is that fluorescent fixtures has to be changed at the beginning of every fourth year, this cost will accumulate over the years rather than maintaining the lamps once every 20 years. The cost of changing fluorescent lamps during the next cycle will be more expensive due to inflation.

Table 3.13: Average Cost for Changing a Lighting Fixture

YEAR	WORKERS	RATE PER HOUR ($)	TIME PER FIXTURE (HR.)	COST PER FIXTURE	NUMBER OF FIXTURES	TOTAL COST (USD)
1	1 MAIN	3.5	0.25	0.875	2,220	1,942.5
	1 HELPER	1.5	0.25	0.375	2,220	832.5
TOTAL						2,775

All the above data will be used in chapter 4 and the result for the return on investment of replacing fluorescent with led lamps will be calculated.

3.4.2 Solar System

The study of the installation of solar photovoltaic panels at NDU takes into consideration the same concept of derivation of loads. What differs from the LED study is that the load percentage is multiplied by the lighting power usage using LED lamps, 48 kWh, and not the difference between LED and fluorescent lamps, 49.404 kWh. In order to achieve a better approximation, the study is spread over 12 months due to the fact that the amount of radiation coming from the sun differs among months.

Every month of the year is detailed upon hourly basis, from 8 am till 20:00 pm. A comparison table was set for every month in order to show the difference between operating on the regular power generation, EDL and private generators, and that of solar system. The installed inverter of the photovoltaic system will only allow solar panels to supply electricity when there is sufficient amount of sun that could be converted into a stable 220 volt. According to the presence of sufficient irradiation from the sun, the solar system will be either replacing generators, EDL or both for a specific time interval that differs over the months of the year.

3.4.2.1 Solar Panels Operation

Notre Dame University has 48 kWh of lighting power consumption if operating on LED lamps. Dawtec, a leading company in renewable energy in Lebanon, offered 40 '245 Wp' solar photovoltaic modules, on-grid inverter of 10 KW, panel mounting structure, wiring, combiner boxes and installation for 40,986 USD, as shown in appendix D, Dawtec. In order to cover the whole demand of the six faculty buildings at NDU, the offer received by Dawtec should be multiplied by 5; therefore, the total price for the solar system will reach up to 204,930 USD.

The solar photovoltaic modules presented by Dawtec are made of 6x10 pieces mono-crystalline solar cells series string (156mmx156mm), the dimensions of such a panel is 1640x990x40mm and its weight is 19.1 Kg. Therefore, every 10 KW needs an approximate of 32.47 m^2 which is a sufficient space on the roof of the six faculty buildings.

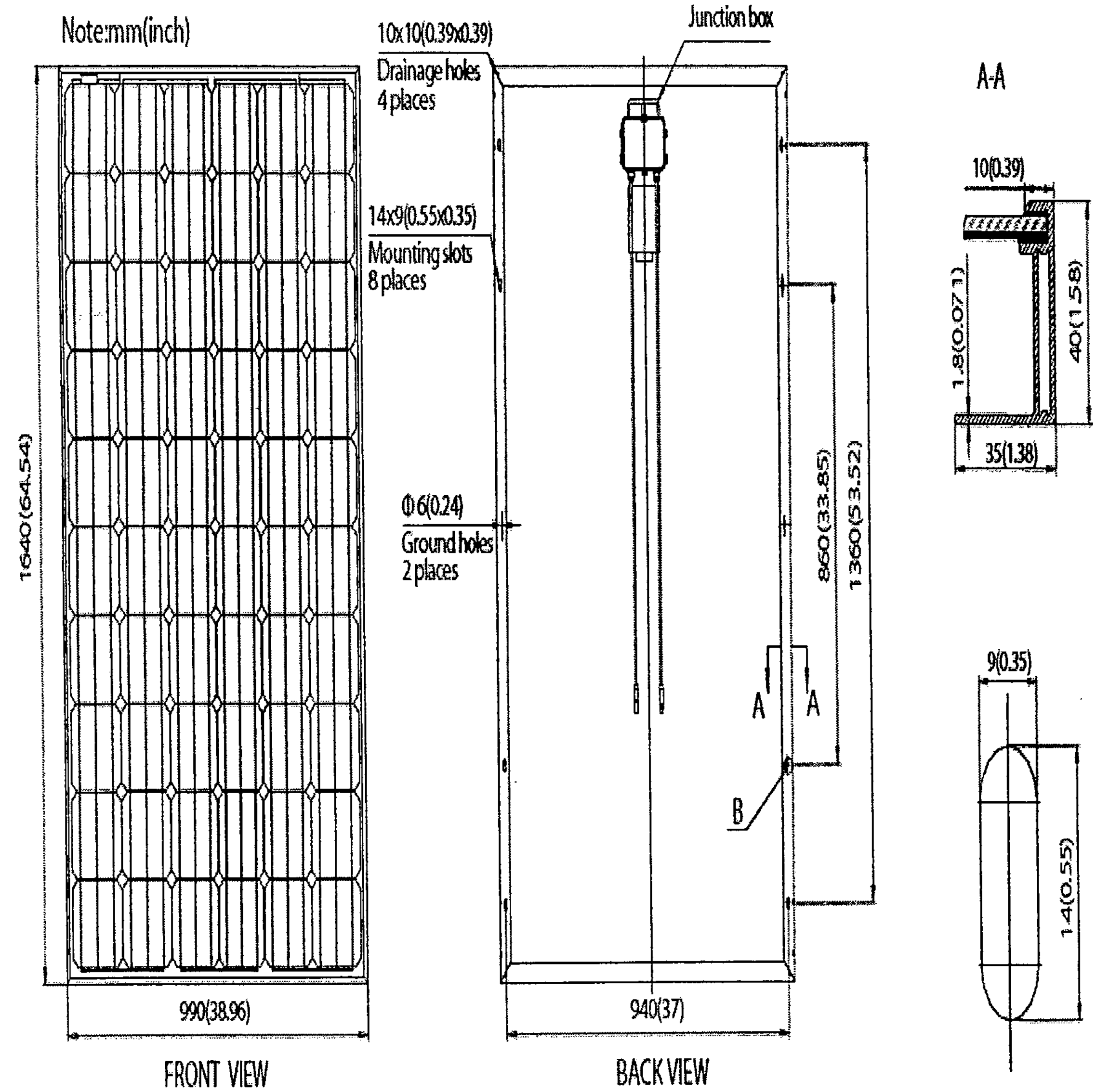

Figure 3.6: Shape and Dimension of Solar Panel

The difference of hourly and monthly radiation of the sun has a direct impact on the maximum daily output that could be achieved by the total solar system. Table 3.14 shows Hd, the average daily sum of global irradiation per square meter received by the modules of the given system, and Ed, the average daily electricity production from the given system.

Table 3.14: Average Daily Output of the Solar System

MONTH	Hd kWh/m2	Ed kWh	NUMBER OF USEFUL SUNLIGHT HOURS PER DAY
January	3.83	200	4
February	4.59	240	4.8
March	5.47	280	5.6
April	6.11	320	6.4
May	6.93	360	7.2
June	7.43	390	7.8
July	7.36	380	7.6
August	7.26	380	7.6
September	6.95	360	7.2
October	5.89	310	6.2
November	4.62	240	4.8
December	3.62	190	3.8

The fourth column in Table 3.14 shows the number of hours that are beneficial for the production of daily electricity for a given month; the average range differs between 4 and 7 hours per day. The number of useful sunlight hours per day used for this study is at the monthly highest rates.

3.4.2.2 Operation of On-Grid System

a) Case 1 – Stable Electricity Generation Prices

Over the past few years, the on-grid system was introduced to the Lebanese market. This system facilitates the usage of the solar photovoltaic panels through being able to directly connect it to the EDL grid. Another advantage of this system is being able to make use of the unneeded power generated from solar panels, example during Saturdays and Sundays. The inverter installed on the on-grid system will allow NDU to sell the unneeded generated solar power to EDL through the connection of the inverter to the EDL meter. The sold power will have the same rating as that of EDL at that time frame of the day, usually 112 L.B.P. since the sun mostly appears during day time.

In the case of NDU, installing batteries could be excluded for several reasons. The first reason is that NDU has its peak power consumption of classes and offices during the day where the sun is approximately covering more than 4 hours daily, depending on the month. The second reason for not installing batteries is their high price and their maintenance over the years. The prices of batteries, 12V/200AH, that last for 3 years cost around 550$ each. Therefore, the cost of batteries that can handle discharging time of 5 hours with a rate of 48KW is approximately 115,000 USD. The number of batteries needed is approximately 210, studied chambers should be considered in order to be able to hold the weight of such a number of batteries even if they were to be divided into different locations at the university. The chambers that include this number of batteries should be cooled down since batteries emit a high rate of temperature while operating. At last, the lighting electrical power consumption of the six university faculty buildings will not reach the cost of batteries if they were to be changed every three years. The third reason is that the rate of discharging of batteries is much faster than that of charging by solar panels; therefore, double the amount of panels and batteries has to be installed in order to provide electricity for two consecutive days. Since these calculations are based on a system where batteries are not supported, due to their high cost, the role of generators and their maintenance fees could not be canceled.

An example of the comparison table used to calculate the difference in price of power consumption, for the month of July, between solar system, after installation, and moderate power generation is presented in Table 3.15 and Table 3.16. Appendix E, Solar Photovoltaic Panels vs. Regular Power Generation, shows the difference over the 12 months of the year.

The number of days of each month is considered to be 30. All the tables are divided into an average monthly basis of 11 days for Day 1 and the same for Day 2 to reach a total of 22 operating days per month. Saturdays and Sundays were divided on an average monthly basis of 4 days each to reach a total of 8 weekend days per month. The reason why Saturdays and Sundays are divided into two cases is that the moderate source of power differs between two consecutive days. The total monthly number of days will sum up to an average of 30 days.

The load of the six faculties during their peak time, of the month of July, is considered to be around 85%, and for late courses around 35%. The load is multiplied by the total lighting power consumption, on hourly basis, to achieve the real electrical power during the different time range. This real lighting power consumption is then calculated under two cases, moderate power generation and solar system power generation.

The grey shaded cells represent the hours where moderate power generation could be replaced with solar systems. The total cost for Day 1 and Day 2, for each given month, is then estimated. Adding the derived costs for the 12 months is then concluded to present the difference between regular lighting power generation and solar system.

The sold electrical power generation to EDL is mainly the unused percentage of load for each given month during the functional hours of solar panels. In the case of July, it is 7 hours multiplied by 35%, the unused power generated from the solar system of the total load, and then multiplied by the EDL rating during these hours 112 L.B.P. In the case of NDU, the sold power generated to EDL is being considered at a rate of 112 L.B.P for all the months of the year.

Table 3.15: Day 1 Comparison between Moderate and Solar Power Generation Cost, Month of July

SUMMER TIME - HALF DAY- FULL OPERATION - JULY											
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER (REGULAR)	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	REGULAR L.L.	SOLAR L.L.	SOLAR SOLD TO EDL L.L.
DAY 1 DURING THE WEEK	8:00	9:00	85%	40.8	EDL	112	112	11	50,266	50,266	
	9:00	10:00	85%	40.8	EDL	112	0	11	50,266	0	8,870
	10:00	11:00	85%	40.8	GENERATORS	350	0	11	157,080	0	8,870
	11:00	12:00	85%	40.8	GENERATORS	350	0	11	157,080	0	8,870
	12:00	13:00	85%	40.8	GENERATORS	350	0	11	157,080	0	8,870
	13:00	14:00	85%	40.8	GENERATORS	350	0	11	157,080	0	8,870
	14:00	15:00	0%	0	EDL	112	0	11	0	0	59,136
	15:00	16:00	0%	0	EDL	112	0	11	0	0	59,136
	16:00	17:00	0%	0	EDL	112	320	11	0	0	
	17:00	18:00	0%	0	EDL	112	320	11	0	0	
	18:00	19:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
	19:00	20:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
DAY 1 WEEKEND	8:00	9:00	0%	0	EDL	112	112	4	0	0	
	9:00	10:00	0%	0	EDL	112	0	4	0	0	21,504
	10:00	11:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	11:00	12:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	12:00	13:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	13:00	14:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	14:00	15:00	0%	0	EDL	112	0	4	0	0	21,504
	15:00	16:00	0%	0	EDL	112	0	4	0	0	21,504
	16:00	17:00	0%	0	EDL	112	112	4	0	0	
	17:00	18:00	0%	0	EDL	112	112	4	0	0	
	18:00	19:00	0%	0	GENERATORS	350	350	4	0	0	
	19:00	20:00	0%	0	GENERATORS	350	350	4	0	0	
	TOTAL								858,211	179,626	313,152

Table 3.16: Day 2 Comparison between Moderate and Solar Power Generation Cost, Month of July

SUMMER TIME - HALF DAY - FULL OPERATION - JULY											
	START	END	FACULTY LOAD	POWER CONSUMPTION	SOURCE OF POWER	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	REGULAR L.L.	SOLAR L.L.	SOLAR SOLD TO EDL L.L.
DAY 2 DURING THE WEEK	8:00	9:00	85%	40.8	GENERATORS	350	350	11	157,080	157,080	
	9:00	10:00	85%	40.8	GENERATORS	350	0	11	157,080	0	8,870
	10:00	11:00	85%	40.8	EDL	112	0	11	50,266	0	8,870
	11:00	12:00	85%	40.8	EDL	112	0	11	50,266	0	8,870
	12:00	13:00	85%	40.8	EDL	112	0	11	50,266	0	8,870
	13:00	14:00	85%	40.8	EDL	112	0	11	50,266	0	8,870
	14:00	15:00	0%	0	GENERATORS	350	0	11	0	0	59,136
	15:00	16:00	0%	0	GENERATORS	350	0	11	0	0	59,136
	16:00	17:00	0%	0	GENERATORS	350	350	11	0	0	
	17:00	18:00	0%	0	GENERATORS	350	350	11	0	0	
	18:00	19:00	35%	16.8	EDL	320	320	11	59,136	59,136	
	19:00	20:00	35%	16.8	EDL	320	320	11	59,136	59,136	
DAY 2 WEEKEND	8:00	9:00	0%	0	GENERATORS	350	350	4	0	0	
	9:00	10:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	10:00	11:00	0%	0	EDL	112	0	4	0	0	21,504
	11:00	12:00	0%	0	EDL	112	0	4	0	0	21,504
	12:00	13:00	0%	0	EDL	112	0	4	0	0	21,504
	13:00	14:00	0%	0	EDL	112	0	4	0	0	21,504
	14:00	15:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	15:00	16:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	16:00	17:00	0%	0	GENERATORS	350	350	4	0	0	
	17:00	18:00	0%	0	GENERATORS	350	350	4	0	0	
	18:00	19:00	0%	0	EDL	320	320	4	0	0	
	19:00	20:00	0%	0	EDL	320	320	4	0	0	
	TOTAL								633,494	275,352	313,152
SUMMER TIME - HALF DAY- FULL OPERATION - JULY											
TOTAL COST- DAY 1 & DAY 2									1,491,706	454,978	626,304

The total lighting cost of power for moderate power generation and solar system power generation, for the 12 months of the year is represented in Table 3.17. The electricity sold to EDL should be decreased from the cost of operating on solar system in order to have an average value of the real cost of operating on solar system. The real cost is when the solar sold to EDL is subtracted from the cost of power generation while using solar.

Table 3.17: Difference in Cost of Lighting Power Consumption between Moderate Power Consumption and Solar System Over 1 Year

MONTH	COST IN L.B.P.	MODERATE POWER GENERATION (L.L./MONTH)	SOLAR SYSTEM (L.L./MONTH)	
		REGULAR	SOLAR	SOLAR SOLD TO EDL
JANUARY	TOTAL COST	2,610,221	1,634,477	172,032
	REAL COST	2,610,221	1,462,445	
FEBRUARY	TOTAL COST	2,610,221	1,414,934	226,867
	REAL COST	2,610,221	1,188,067	
MARCH	TOTAL COST	2,610,221	1,170,998	269,875
	REAL COST	2,610,221	901,123	
APRIL	TOTAL COST	2,467,450	1,170,998	269,875
	REAL COST	2,467,450	901,123	
MAY	TOTAL COST	2,416,044	931,634	317,946
	REAL COST	2,416,044	613,688	
JUNE	TOTAL COST	1,491,706	454,978	787,584
	REAL COST	1,491,706	-332,606	
JULY	TOTAL COST	1,491,706	454,978	626,304
	REAL COST	1,491,706	-171,326	
AUGUST	TOTAL COST	219,542	36,590	1,040,256
	REAL COST	219,542	-1,003,666	
SEPTEMBER	TOTAL COST	219,542	36,590	1,040,256
	REAL COST	219,542	-1,003,666	
OCTOBER	TOTAL COST	2,610,221	1,170,998	269,875
	REAL COST	2,610,221	901,123	
NOVEMBER	TOTAL COST	2,610,221	1,414,934	220,954
	REAL COST	2,610,221	1,193,981	
DECEMBER	TOTAL COST	2,610,221	1,634,477	172,032
	REAL COST	2,610,221	1,462,445	
YEAR	TOTAL REAL COST	23,967,315	6,112,732	
	SAVING FROM MOVING TO SOLAR (L.B.P.)	-17,854,583		
	SAVING FROM MOVING TO SOLAR (USD)	-$11,903		

Table 3.17 shows that if NDU operated its lighting power on solar system instead of moderate power generation, EDL and private power generation, it would have decreased its bills by approximately 11,903 USD per year.

b) Case 2 – Increasing Rate of Electricity Generation Prices

Similar to the LED scenario, the second case to be studied represents an increase in the price of fuel over the lifetime of the project. The same rate of increase is taken into consideration so that the simulation will be similar for all cases. Table 3.18 shows the increase in savings relative to the increase in price of electricity generation, EDL and generators, during the 25 years lifetime of the project.

Table 3.18: Rate of Increase of Electricity Generation and the Relevant Increase in Savings

YEAR	RATE OF INCREASE IN PRICES OF EDL AND GENERATORS	SAVINGS (USD)
1	0.0%	11,903
2	2.0%	12,141
3	2.0%	12,384
4	2.0%	12,632
5	2.0%	12,884
6	2.2%	13,168
7	2.2%	13,457
8	2.2%	13,753
9	2.2%	14,056
10	2.2%	14,365
11	2.3%	14,696
12	2.3%	15,034
13	2.3%	15,379
14	2.3%	15,733
15	2.3%	16,095
16	2.4%	16,481
17	2.4%	16,877
18	2.4%	17,282
19	2.4%	17,697
20	2.4%	18,121
21	2.5%	18,574
22	2.5%	19,039
23	2.5%	19,515
24	2.5%	20,003
25	2.5%	20,503

3.4.3 Methodology Used

Three main scenarios will be discussed in order to present multiple economic feasibility studies for NDU; scenario 1 deals with findings related to LED lamps as a standalone project. Scenario 2 will be based on solar photovoltaic panels in case NDU decides to install them at a later phase, considering LED lamps were installed as an independent project. The third scenario deals with calculating the economic feasibility study of installing both LED lamps and solar panels simultaneously. Each of these three scenarios will include two cases; the first case represents the feasibility of such a project based on today's prices of electricity while the second case considers an increase in the prices of EDL and fuel for generators over the different years of the two scenarios.

The economic feasibility study of the three scenarios will be calculated based on three rates. The first rate, 0%, is the case where NDU could present its studied projects to the National Energy Efficiency and Renewable Energy Account (NEERA). NEERA is dedicated to support the financing of energy efficiency (EE) and renewable energy (RE) projects all over Lebanon. NEERA is the reconciliation between the Lebanese Central Bank and the European Union (EU). It aims for the effective implementation of RE projects by Lebanese commercial banks through offering financial support. The EU has offered Bank Du Liban (BDL) a grant of 11.9 Million Euros to subsidize interests and increase the repayment period of projects, on the other side EU has also offered Kafalat a grant of 2.1 Million Euros to cover the risk of projects during the repayment period. NEERA supports four types of projects where NDU is included as a Type 2 project. This type of projects refers to any existing building that is operational and has an annual energy bill from EDL (El Khoury, 2010). Therefore, NDU could benefit from a loan with a NEERA, 0%, rate that includes no risk.

The second simulation of the NPV is based on a 3% discount factor, considered as the social discount factor. According to Valentim and Prado (2008), discounting helps determining values over different periods of time, while social discounting is the weighing of costs and benefits of social investments over time. Social discount factor is usually used in estimating the value of environmental projects considered as social projects. The final simulation is done using a 6% discount factor, and it is known by the market discount factor. Discount factor takes into account the time value of money, it is the interest rate used in discounted cash flow analysis, charged on a certain project, to calculate the present value of future cash flows.

The life span of the first and third scenarios will stop in year 20, the assumed lifetime of LED lamps, after this period new equipments should be bought, while that of the second scenario will stop at 25 years the lifetime of solar panels. The purchasing of the new equipments and the beginning of the new life cycle is not included in the calculations since these kinds of electrical equipments do not possess any future figures especially over this period of time; this is due to the fast progress and fluctuations of prices related to these technologies.

Three factors will be used in chapter 4 to assess the three scenarios, Payback Period (PB), Net Present Value (NPV), and Benefit-Cost Ratio (BCR). Payback Period is the time required to recover the cost that was invested in a certain project. The disadvantage of PB is that it ignores the time value of money; therefore, it cannot provide a certain image of whether the project is worth investing in. Net present Value is used to evaluate long term projects through comparing the present value of money today to the present value of money in the future through discounting process. Usually, accepting or rejecting a project depends on whether the NPV calculated has a positive or a negative value. Benefit-Cost Ratio summarizes the value of money of a project; it is the ratio of discounted benefits relative to its discounted costs, the higher the BCR the better the chances for the acceptance of a project.

Table 3.19: Summary Table of All the Scenarios and their Relative Cases

Feasibility Study Relative to Scenarios and Cases		Scenario 1: Replacing Fluorescent Lamps with LED Lamps		Scenario 2: Installing Solar PV Panels *(Under the Condition that LED Lamps were Installed Earlier as a Separate Project)*		Scenario 3: Replacing Fluorescent Lamps with LED Lamps and Installing Solar PV Panels Simultaneously	
		Case 1: Current Electricity Prices	Case 2: Increasing Electricity Prices	Case 1: Current Electricity Prices	Case 2: Increasing Electricity Prices	Case 1: Current Electricity Prices	Case 2: Increasing Electricity Prices
NEERA 0%	Difference between Costs and Benefits (USD)						
Social Discount Factor 3%	NPV (USD)						
	BCR						
Market Discount Factor 6%	NPV (USD)						
	BCR						

CHAPTER 4

FINDINGS

4.1 General Briefing

As discussed in chapter 3, this chapter will include detailed assessment of three different scenarios for Notre Dame University-Louaize. The first scenario is installing LED lamps as a standalone project, the second is installing solar PV panels, based on LED lamps watt consumption, and the third scenario is installing both LED lamps and solar PV panels simultaneously. The first case is considered under present electric conditions, the second case is at increasing electricity prices. Payback period, net present value (NPV) and benefit-cost ratio (BCR) will be calculated to assess the feasibility study of the three above scenarios. Three rates will be used to calculate the NPV and BCR, the first, 0%, is the rate that NDU could get if it presents its studies of renewable energy and energy efficiency to NEERA, the second rate is the social discount factor 3% and the third rate is the market discount factor 6%. The lifespan of the first and third scenarios is limited to 20 years which is the lifetime of LED lamps while the lifespan of the second scenario is considered 25 years which is the lifetime of a solar PV panels.

4.2 Feasibility Studies of the Different Scenarios

4.2.1 LED Lamps Feasibility Study

The first scenario deals with installing LED lamps in the six major buildings of NDU.

4.2.1.1 Payback Period for Installing LED Lamps

a) Case 1 – Stable Electricity Generation Prices

The costs and benefits related to the calculation of the payback period for replacing fluorescent lamps with LED lamps are shown in Table 4.1 and Table 4.2. The LED lamps purchasing cost, presented in chapter 3, is the price that Philips quoted for 2,220 LED lamps. The LED installation cost is also presented in chapter 3; it is the cost of time that NDU main worker and a helper are spending in order to replace the 2220 fluorescent lamps with LED lamps. Miscellaneous cost, and as mentioned in

Table 4.1, includes the maintenance cost which is changing damaged or ineffective LED lamps inside the faculty buildings. Miscellaneous cost is considered 1.5% of the total costs. The costs at year 1 of LED lamps, purchasing and installation, is equal to 159,063 USD. This cost will be added yearly over the lifetime of LED lamps.

Table 4.1: Costs Related to LED Lamps Project

TYPE OF COST	AMOUNT (IN USD)
LED LAMPS PURCHASING COST	156,288
LED INSTALLATION COST	2,775
MISCELLANEOUS COST INCLUDING YEARLY MAINTENANCE COST (1.5% OF THE TOTAL COST)	2,386

The first benefit was derived in chapter 3; it is the difference in power consumption between LED and fluorescent lamps over a complete year at NDU. This benefit is included on a yearly basis. The saving from the fluorescent purchasing cost including the cost of ballasts is included every three years, the cost of fluorescent lamps is 2,051 USD and that of ballasts is 9,049 USD, therefore the sum of savings from fluorescent purchasing cost is 11,100 USD. Savings from installation costs, 2,775 USD as found in chapter 3, should be added every three years which is considered to be the lifetime of fluorescent lamps, a 2% inflation rate is included since the labor cost will increase over the 20 years lifespan of the project.

Table 4.2: Benefits Related to LED Lamps Project

TYPE OF BENEFIT	AMOUNT (USD)
DIFFERENCE IN POWER CONSUMPTION (BETWEEN LED AND FLUORESCENT LAMP)	14,976
Saving from FLUORESCENT PURCHASING COST	11,100
Saving from FLUORESCENT INSTALLATION COST (WITH A 2% YEARLY INFLATION RATE)	2,775

The payback period is presented in Table 4.3 which includes all the costs and benefits that were mentioned before.

Table 4.3: Payback Period of LED Lamps Project

YEAR	TYPE OF CASH FLOW	PAYMENT USD	DIFFERENCE USD
YEAR 1	LED LAMPS PURCHASING COST	-156,288	-135,373
	LED INSTALLATION COST	-2,775	
	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	
	DIFFERENCE IN POWER CONSUMPTION	14,976	
	SAVINGS FROM FLUORESCENT PURCHASING COST	11,100	
YEAR 2	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	-122,783
	DIFFERENCE IN POWER CONSUMPTION	14,976	
YEAR 3	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	-110,193
	DIFFERENCE IN POWER CONSUMPTION	14,976	
YEAR 4	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	-83,558
	DIFFERENCE IN POWER CONSUMPTION	14,976	
	SAVINGS FROM FLUORESCENT PURCHASING COST	11,100	
	SAVINGS FROM FLUORESCENT INSTALLATION COST	2,945	
YEAR 5	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	-70,968
	DIFFERENCE IN POWER CONSUMPTION	14,976	
YEAR 6	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	-58,378
	DIFERRENCE PAYMENT	14,976	
YEAR 7	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	-31,563
	DIFFERENCE IN POWER CONSUMPTION	14,976	
	SAVINGS FROM FLUORESCENT PURCHASING COST	11,100	
	SAVINGS FROM FLUORESCENT INSTALLATION COST	3,125	
YEAR 8	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	-18,973
	DIFFERENCE IN POWER CONSUMPTION	14,976	
YEAR 9	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	-6,383
	DIFFERENCE IN POWER CONSUMPTION	14,976	
YEAR 10	**MISCELLANEOUS COST (1.5% TOTAL COST)**	**-2,386**	**20,623**
	DIFFERENCE IN POWER CONSUMPTION	**14,976**	
	SAVINGS FROM FLUORESCENT PURCHASING COST	**11,100**	
	SAVINGS FROM FLUORESCENT INSTALLATION COST	**3,316**	
YEAR 11	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	33,213
	DIFFERENCE IN POWER CONSUMPTION	14,976	
YEAR 12	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	45,803
	DIFFERENCE IN POWER CONSUMPTION	14,976	
YEAR 13	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	73,012
	DIFFERENCE IN POWER CONSUMPTION	14,976	
	SAVINGS FROM FLUORESCENT PURCHASING COST	11,100	
	SAVINGS FROM FLUORESCENT INSTALLATION COST	3,519	
YEAR 14	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	85,602
	DIFFERENCE IN POWER CONSUMPTION	14,976	
YEAR 15	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	98,192
	DIFFERENCE IN POWER CONSUMPTION	14,976	

Table 4.3 – Payback Period of LED Lamps Project - Continued

YEAR	TYPE OF CASH FLOW	PAYMENT USD	DIFFERENCE USD
YEAR 16	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	125,617
	DIFFERENCE IN POWER CONSUMPTION	14,976	
	SAVINGS FROM FLUORESCENT PURCHASING COST	11,100	
	SAVINGS FROM FLUORESCENT INSTALLATION COST	3,735	
YEAR 17	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	140,593
	DIFFERENCE IN POWER CONSUMPTION	14,976	
YEAR 18	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	153,183
	DIFFERENCE IN POWER CONSUMPTION	14,976	
YEAR 19	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	180,836
	DIFFERENCE IN POWER CONSUMPTION	14,976	
	SAVINGS FROM FLUORESCENT PURCHASING COST	11,100	
	SAVINGS FROM FLUORESCENT INSTALLATION COST	3,963	
YEAR 20	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	193,426
	DIFFERENCE IN POWER CONSUMPTION	14,976	

Table 4.3 shows that at year 10 the project, replacing fluorescent lamps with LED lamps, will breakeven. The average life expectancy of a LED lamp is around 20 years, therefore the results shown in Table 4.3 reveals that if such a project was to be implemented at NDU it will breakeven at the midlife of the products installed.

b) Case 2 – Increasing Rate of Electricity Generation Prices

This case considers that the fuel prices will increase over the lifetime of the project as shown in Chapter 3. Table 4.4 represents the payback period of the LED lamps based on the change in electricity generation, both EDL and fuel for generators. The difference in power consumption, savings, is highlighted in grey so that the variation could be noticed. As well as, Table 4.4 shows that the payback period of LED lamps, if increase in price were to be considered, will occur at year 9. This means that a better payback period will result from an increase in electricity generation prices over the years.

Table 4.4: Payback of LED Lamps under the Assumption of Increase in Electricity Generation Prices

YEAR	TYPE OF CASH FLOW	PAYMENT USD	DIFFERENCE USD
YEAR 1	LED LAMPS PURCHASING COST	-156,288	-135,373
	LED INSTALLATION COST	-2,775	
	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	
	DIFFERENCE IN POWER CONSUMPTION	14,976	
	SAVINGS FROM FLUORESCENT PURCHASING COST	11,100	
YEAR 2	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	-122,483
	DIFFERENCE IN POWER CONSUMPTION	15,276	
YEAR 3	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	-109,288
	DIFFERENCE IN POWER CONSUMPTION	15,581	
YEAR 4	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	-81,736
	DIFFERENCE IN POWER CONSUMPTION	15,893	
	SAVINGS FROM FLUORESCENT PURCHASING COST	11,100	
	SAVINGS FROM FLUORESCENT INSTALLATION COST	2,945	
YEAR 5	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	-67,911
	DIFFERENCE IN POWER CONSUMPTION	16,211	
YEAR 6	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	-53,730
	DIFERRENCE PAYMENT	16,567	
YEAR 7	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	-24,959
	DIFFERENCE IN POWER CONSUMPTION	16,932	
	SAVINGS FROM FLUORESCENT PURCHASING COST	11,100	
	SAVINGS FROM FLUORESCENT INSTALLATION COST	3,125	
YEAR 8	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	-10,041
	DIFFERENCE IN POWER CONSUMPTION	17,304	
YEAR 9	**MISCELLANEOUS COST (1.5% TOTAL COST)**	-2,386	5,258
	DIFFERENCE IN POWER CONSUMPTION	17,685	
YEAR 10	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	35,362
	DIFFERENCE IN POWER CONSUMPTION	18,074	
	SAVINGS FROM FLUORESCENT PURCHASING COST	11,100	
	SAVINGS FROM FLUORESCENT INSTALLATION COST	3,316	
YEAR 11	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	51,466
	DIFFERENCE IN POWER CONSUMPTION	18,490	
YEAR 12	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	67,995
	DIFFERENCE IN POWER CONSUMPTION	18,915	
YEAR 13	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	99,578
	DIFFERENCE IN POWER CONSUMPTION	19,350	
	SAVINGS FROM FLUORESCENT PURCHASING COST	11,100	
	SAVINGS FROM FLUORESCENT INSTALLATION COST	3,519	
YEAR 14	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	116,987
	DIFFERENCE IN POWER CONSUMPTION	19,795	
YEAR 15	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	134,851
	DIFFERENCE IN POWER CONSUMPTION	20,250	

Table 4.4 – Payback of LED Lamps under the Assumption of Increase in Electricity Generation Prices - Continued

YEAR	TYPE OF CASH FLOW	PAYMENT USD	DIFFERENCE USD
YEAR 16	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	33,185
	DIFFERENCE IN POWER CONSUMPTION	20,736	
	SAVINGS FROM FLUORESCENT PURCHASING COST	11,100	
	SAVINGS FROM FLUORESCENT INSTALLATION COST	3,735	
YEAR 17	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	54,519
	DIFFERENCE IN POWER CONSUMPTION	21,334	
YEAR 18	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	73,877
	DIFFERENCE IN POWER CONSUMPTION	21,744	
YEAR 19	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	108,820
	DIFFERENCE IN POWER CONSUMPTION	22,266	
	SAVINGS FROM FLUORESCENT PURCHASING COST	11,100	
	SAVINGS FROM FLUORESCENT INSTALLATION COST	3,963	
YEAR 20	MISCELLANEOUS COST (1.5% TOTAL COST)	-2,386	129,234
	DIFFERENCE IN POWER CONSUMPTION	22,800	

4.2.1.2 NPV and BCR of LED Lamps Project

a) Case 1 – Stable Electricity Generation Prices

In order to calculate the NPV and BCR of the project, the costs and benefits were summed up in Table 4.5. This table shows the totals of costs and benefits on a yearly basis. The costs of year 1 are comprised from LED lamps purchasing cost, LED installation cost, and miscellaneous, the total cost of year 1 is equal to 161,499 USD. While, from year 2 till year 20 the only applied cost is the miscellaneous cost which is approximately fixed to 2,386 USD. Looking into the benefits, one could realize that the years that do not include savings from fluorescent purchasing and installation have a fixed value which resembles the savings from the difference in power consumption, 14,976 USD. The savings from fluorescent purchasing cost, including ballast, has no inflation rate applied on it since the price of these products is approximately saturated.

Table 4.5: Yearly Costs and Benefits of Replacing Fluorescent Lamps with LED Lamps

COST / BENEFIT	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12	YEAR 13	YEAR 14	YEAR 15	YEAR 16	YEAR 17	YEAR 18	YEAR 19	YEAR 20
TYPES OF COSTS (IN USD)																				
LED LAMPS PURCHASING COST	156,288	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LED INSTALLATION COST	2,775	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS COST INCLUDING YEARLY MAINTENANCE COST (1.5% OF THE TOTAL COST FROM YEAR 6 TILL YEAR 10)	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386
TOTAL COST PER YEAR	161,449	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386
TYPES OF BENEFITS (IN USD)																				
DIFFERENCE IN POWER CONSUMPTION (BETWEEN LED AND FLUORESCENT LAMP)	14,976	14,976	14,976	14,976	14,976	14,976	14,976	14,976	14,976	14,976	14,976	14,976	14,976	14,976	14,976	14,976	14,976	14,976	14,976	14,976
SAVINGS FROM FLUORESCENT PURCHASING COST	11,100			11,100			11,100			11,100			11,100			11,100			11,100	
SAVINGS FROM FLUORESCENT INSTALLATION COST (WITH A 2% YEARLY INFLATION RATE)	2,775			2,945			3,125			3,316			3,519			3,735			3,963	
TOTAL BENEFIT PER YEAR	28,851	14,976	14,976	29,021	14,976	14,976	29,201	14,976	14,976	29,392	14,976	14,976	29,595	14,976	14,976	29,811	14,976	14,976	30,039	14,976

The total yearly costs and benefits, shown in Table 4.5, are included in Tables 40, 41, and 42 in order to derive the NPVs with NEERA, 0%, rate and both 3% and 6% discount factors, for the 20 years lifetime of LED lamps, while Table 4.6 is a comparison table that summarizes all the rates of this case.

Table 4.6: NPV of LED Lamps Project under NEERA, 0%, Rate

YEAR	BENEFITS (USD)	COSTS (USD)	DIFFERENCE (USD)
1	28,851	161,449	-132,598
2	14,976	2,386	12,590
3	14,976	2,386	12,590
4	29,021	2,386	26,635
5	14,976	2,386	12,590
6	14,976	2,386	12,590
7	29,201	2,386	26,815
8	14,976	2,386	12,590
9	14,976	2,386	12,590
10	29,392	2,386	27,006
11	14,976	2,386	12,590
12	14,976	2,386	12,590
13	29,595	2,386	27,209
14	14,976	2,386	12,590
15	14,976	2,386	12,590
16	29,811	2,386	27,425
17	14,976	2,386	12,590
18	14,976	2,386	12,590
19	30,039	2,386	27,653
20	14,976	2,386	12,590
TOTAL	400,599	206,782	193,817

Table 4.7: NPV of LED Lamps Project With 3% Discount Factor

YEAR	TOTAL BENEFITS (USD)	TOTAL COSTS (USD)	DISCOUNT FACTOR (3%)	DISCOUNTED BENEFITS	DISCOUNTED COSTS	NPV
1	28,851	161,449	0.9709	28,011	156,747	-128,736
2	14,976	2,386	0.9426	14,116	2,249	11,867
3	14,976	2,386	0.9151	13,705	2,183	11,522
4	29,021	2,386	0.8885	25,785	2,120	23,665
5	14,976	2,386	0.8626	12,918	2,058	10,860
6	14,976	2,386	0.8375	12,542	1,998	10,544
7	29,201	2,386	0.8131	23,743	1,940	21,803
8	14,976	2,386	0.7894	11,822	1,883	9,939
9	14,976	2,386	0.7664	11,478	1,829	9,649
10	29,392	2,386	0.7441	21,871	1,775	20,095
11	14,976	2,386	0.7224	10,819	1,724	9,095
12	14,976	2,386	0.7014	10,504	1,673	8,830
13	29,595	2,386	0.6810	20,153	1,625	18,528
14	14,976	2,386	0.6611	9,901	1,577	8,324
15	14,976	2,386	0.6419	9,613	1,531	8,081
16	29,811	2,386	0.6232	18,577	1,487	17,090
17	14,976	2,386	0.6050	9,061	1,444	7,617
18	14,976	2,386	0.5874	8,797	1,401	7,395
19	30,039	2,386	0.5703	17,131	1,361	15,770
20	14,976	2,386	0.5537	8,292	1,321	6,971
TOTAL				298,838	189,927	108,911

Table 4.8: NPV of LED Lamps Project With 6% Discount Factor

YEAR	TOTAL BENEFITS (USD)	TOTAL COSTS (USD)	DISCOUNT FACTOR (6%)	DISCOUNTED BENEFITS	DISCOUNTED COSTS	NPV
1	28,851	161,449	0.9434	27,218	152,310	-125,092
2	14,976	2,386	0.8900	13,329	2,123	11,205
3	14,976	2,386	0.8396	12,574	2,003	10,571
4	29,021	2,386	0.7921	22,987	1,890	21,097
5	14,976	2,386	0.7473	11,191	1,783	9,408
6	14,976	2,386	0.7050	10,557	1,682	8,875
7	29,201	2,386	0.6651	19,420	1,587	17,834
8	14,976	2,386	0.6274	9,396	1,497	7,899
9	14,976	2,386	0.5919	8,864	1,412	7,452
10	29,392	2,386	0.5584	16,413	1,332	15,080
11	14,976	2,386	0.5268	7,889	1,257	6,632
12	14,976	2,386	0.4970	7,443	1,186	6,257
13	29,595	2,386	0.4688	13,875	1,119	12,757
14	14,976	2,386	0.4423	6,624	1,055	5,569
15	14,976	2,386	0.4173	6,249	996	5,253
16	29,811	2,386	0.3936	11,735	939	10,796
17	14,976	2,386	0.3714	5,562	886	4,675
18	14,976	2,386	0.3503	5,247	836	4,411
19	30,039	2,386	0.3305	9,928	789	9,140
20	14,976	2,386	0.3118	4,670	744	3,926
TOTAL				231,171	177,426	53,745

Table 4.9: Comparison Table for the Different Rates of LED Lamps Project

RATE	DIFFERENCE BETWEEN COSTS AND BENEFITS	
NEERA, 0%	193,817 $	
DISCOUNT FACTOR	NPV ($)	BCR
3%	108,911	1.5734
6%	53,745	1.3029

As shown in Table 4.9, for both discount factors the NPV is positive and BCR is greater than 1.

b) Case 2 – Increasing Rate of Electricity Generation Prices

Similar to case 1, difference between costs and benefits as well as NPV and BCR of the project will be calculated but based on an increase in prices. Appendix G shows the tables of the costs and benefits, NPV and BCR under increasing fuel prices. Table 4.10 shows the comparison of the different rates of LED lamps project under increasing fuel prices. The grey color represents the cells showing difference in results from case 1.

Table 4.10: Comparison Table for the Different Rates of LED Lamps under the Condition of Increasing Electricity Generation Prices

RATE	DIFFERENCE BETWEEN COSTS AND BENEFITS	
NEERA, 0%	264,376 $	
DISCOUNT FACTOR	NPV ($)	BCR
3%	155,461	1.8185
6%	85,389	1.4813

4.2.2 Solar PV Panels Feasibility Study

This scenario takes into consideration that fluorescent lamps are already replaced by LED lamps at an earlier stage. In this scenario, the feasibility study will deal with solar PV panels as a standalone project. Similar to the first scenario, payback period, NPV, and BCR will be calculated for both cases; stable prices for electricity generation and increasing prices for electricity generation.

4.2.2.1 Payback Period for Installing Solar PV Panels

a) Case 1 – Stable Electricity Generation Prices

The costs and benefits related to the calculation of the payback period for installing solar photovoltaic panels at NDU are shown in Table 4.11 and Table 4.12. The purchasing cost of solar PV panels, 204,930 USD, was quoted by the company DAWTEC and shown in chapter 3. The solar PV panels' maintenance cost, in case of damage, cleaning, and malfunction was included in the yearly miscellaneous factor that is equal to 1% of the total cost.

Table 4.11: Costs Related to Solar PV Panels Project

TYPE OF COST	AMOUNT (USD)
SOLAR PURCHASING COST	204,930
MISCELLANEOUS COST INCLUDING YEARLY MAINTENANCE COST (1% OF THE TOTAL COST)	2,049

As for the benefits, the only considered benefit, other than the environmental benefits not assessed in this study, is the savings in the difference in power bill when comparing solar panels with both EDL and private generators. This difference, 11,903 USD, was derived in chapter 3; the calculation is made on a yearly basis that includes the different months of the year.

Table 4.12: Benefits Related to Solar PV Panels Project

TYPE OF BENEFIT	AMOUNT (USD)
DIFFERENCE IN POWER BILL (BETWEEN SOLAR AND BOTH "EDL AND PRIVATE GENERATORS")	11,903

Table 4.13 shows the payback period that includes all the above mentioned costs and benefits. The difference between the years is that year 1 includes the solar PV purchasing cost while the other years represent the difference between miscellaneous cost and the savings from the difference in the electric bill. Table 4.13 also shows that the breakeven point of installing solar PV panels' project at NDU to reduce lighting consumption at faculty buildings will occur in year 21. The lifetime of a solar panel is around 25 years, according to DAWTEC data sheet appendix D, therefore in NDU's case the estimated payback of such a project occurs before the life span of the product by approximately 4 years.

Table 4.13: Payback of Solar PV Panels under Stable Fuel Prices

YEAR	TYPE OF PAYMENT	PAYMENT USD	DIFFERENCE USD
YEAR 1	SOLAR PURCHASING COST	-204,930	-195,076
	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 2	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-185,222
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 3	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-175,368
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 4	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-165,514
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 5	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-155,660
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 6	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-145,806
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 7	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-135,952
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 8	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-126,098
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 9	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-116,244
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 10	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-106,390
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 11	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-96,536
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 12	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-86,682
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 13	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-76,828
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 14	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-66,974
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 15	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-57,120
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 16	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-47,266
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 17	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-37,412
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 18	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-27,558
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 19	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-17,704
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 20	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-7,850
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 21	**MISCELLANEOUS COST (1% OF THE TOTAL COST)**	**-2,049**	**2,004**
	DIFFERENCE IN ELECTRIC BILL	**11,903**	
YEAR 22	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	11,858
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 23	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	21,712
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 24	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	31,566
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 25	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	41,420
	DIFFERENCE IN ELECTRIC BILL	11,903	

b) Case 2 – Increasing Rate of Electricity Generation Prices

In this case, the price of electricity generation has an increasing rate that was explained in of Chapter 3. Table 4.14 shows that the payback period for the solar PV panels' project, taking into consideration increase in prices of EDL and fuel for generators will occur at year 17. The grey color represents the cells that show a change in value than previous payback table. The difference between the payback period of case 1 and case 2 is approximately 5 years.

Table 4.14: Payback of Solar PV Panels under the Increasing Electricity Generation Prices

YEAR	TYPE OF PAYMENT	PAYMENT USD	DIFFERENCE USD
YEAR 1	SOLAR PURCHASING COST	-204,930	-195,076
	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	
	DIFFERENCE IN ELECTRIC BILL	11,903	
YEAR 2	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-184,984
	DIFFERENCE IN ELECTRIC BILL	12,141	
YEAR 3	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-174,649
	DIFFERENCE IN ELECTRIC BILL	12,384	
YEAR 4	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-164,066
	DIFFERENCE IN ELECTRIC BILL	12,632	
YEAR 5	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-153,231
	DIFFERENCE IN ELECTRIC BILL	12,884	
YEAR 6	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-142,112
	DIFFERENCE IN ELECTRIC BILL	13,168	
YEAR 7	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-130,704
	DIFFERENCE IN ELECTRIC BILL	13,457	
YEAR 8	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-119,000
	DIFFERENCE IN ELECTRIC BILL	13,753	
YEAR 9	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-106,993
	DIFFERENCE IN ELECTRIC BILL	14,056	
YEAR 10	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-94,677
	DIFFERENCE IN ELECTRIC BILL	14,365	
YEAR 11	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-82,030
	DIFFERENCE IN ELECTRIC BILL	14,696	
YEAR 12	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-69,045
	DIFFERENCE IN ELECTRIC BILL	15,034	
YEAR 13	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-55,715
	DIFFERENCE IN ELECTRIC BILL	15,379	

Table 4.14 – Payback of Solar PV Panels under the Increasing Electricity Generation Prices - Continued

YEAR	TYPE OF PAYMENT	PAYMENT USD	DIFFERENCE USD
YEAR 14	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-42,031
	DIFFERENCE IN ELECTRIC BILL	15,733	
YEAR 15	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-27,985
	DIFFERENCE IN ELECTRIC BILL	16,095	
YEAR 16	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	-13,553
	DIFFERENCE IN ELECTRIC BILL	16,481	
YEAR 17	**MISCELLANEOUS COST (1% OF THE TOTAL COST)**	**-2,049**	**1,275**
	DIFFERENCE IN ELECTRIC BILL	**16,877**	
YEAR 18	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	16,508
	DIFFERENCE IN ELECTRIC BILL	17,282	
YEAR 19	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	32,156
	DIFFERENCE IN ELECTRIC BILL	17,697	
YEAR 20	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	48,228
	DIFFERENCE IN ELECTRIC BILL	18,121	
YEAR 21	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	64,753
	DIFFERENCE IN ELECTRIC BILL	18,574	
YEAR 22	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	81,743
	DIFFERENCE IN ELECTRIC BILL	19,039	
YEAR 23	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	99,209
	DIFFERENCE IN ELECTRIC BILL	19,515	
YEAR 24	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	117,163
	DIFFERENCE IN ELECTRIC BILL	20,003	
YEAR 25	MISCELLANEOUS COST (1% OF THE TOTAL COST)	-2,049	135,617
	DIFFERENCE IN ELECTRIC BILL	20,503	

4.2.2.2 NPV and BCR of Solar PV Panels

a) Case 1 – Stable Electricity Generation Prices

Table 4.15 shows the summation of the costs and benefits that will be used to derive the NPV and BCR of the NEERA, 0%, rate and the 3% and 6% discount factors. Appendix F, Difference between Costs and Benefits and Net Present Value Derivation, shows the calculations of NEERA, 0%, rate along with the NPV of the two discount factors, 3% and 6%. Table 4.16 is a summary table that contains the difference between costs and benefits at NEERA, 0%, rate, and the NPV and BCR of the 3% and 6% discount factors.

Table 4.15: Yearly Costs and Benefits of Installing Solar PV Panels

COST / BENEFIT	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12	YEAR 13	YEAR 14	YEAR 15	YEAR 16	YEAR 17	YEAR 18	YEAR 19	YEAR 20	YEAR 21	YEAR 22	YEAR 23	YEAR 24	YEAR 25
TYPES OF COSTS (IN USD)																									
SOLAR PURCHASING COST	204,930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS COST INCLUDING YEARLY MAINTENANCE COST (1% OF THE TOTAL COST)	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049
TOTAL COST PER YEAR	206,979	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049
TYPES OF BENEFITS (IN USD)																									
DIFFERENCE IN ELECTRIC BILL (BETWEEN SOLAR AND BOTH "EDL AND PRIVATE GENERATORS")	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903
TOTAL BENEFIT PER YEAR	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903	11,903

Table 4.16: Comparison Table for the Different Rates of Solar PV Panels Project

RATE	DIFFERENCE BETWEEN COSTS AND BENEFITS	
NEERA, 0%	41,413	
DISCOUNT FACTOR	NPV	BCR
3%	-27,377	0.8833
6%	-67,367	0.6931

This table shows that taking into consideration the NEERA, 0%, rate or the two discount factors 3% and 6% will have a negative NPV and a less than 1 BCR. This is mainly due to the high cost of the initial investment as well as the low return value per year.

b) Case 2 – Increasing Rate of Electricity Generation Prices

Similar to case 1, the difference between costs and benefits as well as NPV and BCR of the project will be calculated based on the increase in prices. Appendix G shows the tables of the costs and benefits, NPV and BCR under increasing fuel prices. Table 4.17 shows the comparison of the different rates of solar PV panels project under increasing fuel prices. The grey color represents the cells showing difference in results from case 1.

Table 4.17: Comparison Table for the Different Rates of Solar PV Panels under the Condition of Increasing Electricity Generation Prices

RATE	DIFFERENCE BETWEEN COSTS AND BENEFITS	
NEERA, 0%	135,610 $	
DISCOUNT FACTOR	NPV ($)	BCR
3%	28,878	1.1231
6%	-32,278	0.8530

4.2.3 Feasibility Study for Installing LED lamps and Solar PV Panels Simultaneously

The third scenario is a combination of both, replacing fluorescent lamps with LED, and at the same time the installation of solar photovoltaic panels to reduce electric bill. The below sections will present the payback period, NPV, and BCR.

4.2.3.1 Payback Period for Installing LED lamps and Solar PV Panels Simultaneously

a) Case 1 – Stable Electricity Generation Prices

Costs of the two previous cases will be added together, as well as the benefits; therefore, the summation of the difference column in previous payback period of the first two scenarios will result in the table of the payback period. Table 4.18 shows that the breakeven point of engaging with both projects simultaneously occurs at year 14.

Table 4.18: Payback of LED Lamps and Solar PV Panels Simultaneously

YEAR	DIFFERENCE LED LAMPS PROJECT (USD)	SOLAR PV PANELS PROJECT (USD)	TOTAL DIFFERENCE (USD)
YEAR 1	-135,373	-195,076	-330,449
YEAR 2	-122,783	-185,222	-308,005
YEAR 3	-110,193	-175,368	-285,561
YEAR 4	-83,558	-165,514	-249,072
YEAR 5	-70,968	-155,660	-226,628
YEAR 6	-58,378	-145,806	-204,184
YEAR 7	-31,563	-135,952	-167,515
YEAR 8	-18,973	-126,098	-145,071
YEAR 9	-6,383	-116,244	-122,627
YEAR 10	20,623	-106,390	-85,767
YEAR 11	33,213	-96,536	-63,323
YEAR 12	45,803	-86,682	-40,879
YEAR 13	73,012	-76,828	-3,816
YEAR 14	**85,602**	**-66,974**	**18,628**
YEAR 15	98,192	-57,120	41,072
YEAR 16	125,617	-47,266	78,351
YEAR 17	140,593	-37,412	103,181
YEAR 18	153,183	-27,558	125,625
YEAR 19	180,836	-17,704	163,132
YEAR 20	193,426	-7,850	185,576

b) Case 2 – Increasing Rate of Electricity Generation Prices

Table 4.19 shows the payback period of both projects together under the condition that the electricity generation, EDL and fuel for generators, will increase. Similar to case 1, both payback periods of the projects will be summed-up together to reach for a cumulative payback table.

Table 4.19: Payback of LED Lamps and Solar PV Panels Simultaneously under the Condition of Increasing Electricity Generation Prices

YEAR	DIFFERENCE LED LAMPS PROJECT (USD)	SOLAR PV PANELS PROJECT (USD)	TOTAL DIFFERENCE (USD)
YEAR 1	-135,373	-195,076	-330,449
YEAR 2	-122,483	-184,984	-307,467
YEAR 3	-109,288	-174,649	-283,937
YEAR 4	-81,736	-164,066	-245,802
YEAR 5	-67,911	-153,231	-221,142
YEAR 6	-53,730	-142,112	-195,842
YEAR 7	-24,959	-130,704	-155,663
YEAR 8	-10,041	-119,000	-129,041
YEAR 9	5,258	-106,993	-101,735
YEAR 10	35,362	-94,677	-59,315
YEAR 11	51,466	-82,030	-30,564
YEAR 12	67,995	-69,045	-1,050
YEAR 13	**99,578**	**-55,715**	**43,863**
YEAR 14	116,987	-42,031	74,956
YEAR 15	134,851	-27,985	106,866
YEAR 16	168,036	-13,553	154,483
YEAR 17	189,370	1,275	190,645
YEAR 18	208,728	16,508	225,236
YEAR 19	243,671	32,156	275,827
YEAR 20	264,085	48,228	312,313

Table 4.19 shows that the payback period will decrease by 1 year, with respect to case 1, if the price of electricity generation increased.

4.2.3.2 NPV and BCR for Installing LED lamps and Solar PV Panels Simultaneously

a) Case 1 – Stable Electricity Generation Prices

The values of costs and benefits of the two projects that were derived earlier during this chapter are summed up to calculate the NPV and BCR of the third scenario, found in Appendix F. Table 4.20 is a summary table that contains the difference between costs and benefits at NEERA, 0%, rate, and the NPV and BCR of the 3% and 6% discount factors.

Table 4.20: Comparison Table for the Different Rates of LED Lamps and Solar PV Panels Simultaneously

RATE	DIFFERENCE BETWEEN COSTS AND BENEFITS	
NEERA, 0%	185,961 $	
DISCOUNT FACTOR	NPV ($)	BCR
3%	56,548	1.1348
6%	-26,564	0.9326

b) Case 2 – Increasing Rate of Electricity Generation Prices

Similar to case 1, Table 4.21 will present a summary for the difference between costs and benefits, NPV and the BCR for the different rates but under the condition that the rate of electricity generation is increasing.

Table 4.21: Comparison Table for the Different Rates of LED Lamps and Solar PV Panels Simultaneously Under the Condition of Increasing Electricity Generation Prices

RATE	DIFFERENCE BETWEEN COSTS AND BENEFITS	
NEERA, 0%	312,598 $	
DISCOUNT FACTOR	NPV ($)	BCR
3%	140,094	1.3340
6%	30,229	1.0766

4.3 Discussion of the Findings

4.3.1 Case 1 – Stable Electricity Generation Prices

Table 4.22 shows the main results of the three scenarios that include the difference between costs and benefits at NEERA, 0%, rate and the NPV and BCR at 3% and 6% discount factors. Scenario 1 represents LED lamps as a standalone project, Scenario 2 represents solar PV panels as a standalone project, and Scenario 3 represents replacing fluorescent with LED lamps and installing solar PV panels simultaneously.

Table 4.22: Comparison between NPV and BCR of the Three Different Scenarios

SCENARIO	RATE	DIFFERENCE BETWEEN COSTS AND BENEFITS ($)	
1	NEERA, 0%	193,817	
2		41,413	
3		185,961	
SCENARIO	DISCOUNT FACTOR	NPV ($)	BCR
1	3%	108,911	1.5734
2		-27,377	0.8833
3		56,548	1.1348
1	6%	53,745	1.3029
2		-67,367	0.6931
3		-26,564	0.9326

Replacing fluorescent lamps with LED lamps (scenario 1) had the highest difference between costs and benefits as well as the highest NPV and BCR among the three scenarios, taking into consideration that environmental benefits were not assessed in this study. Therefore, hypothesis 1, Chapter 3, is accepted since engaging in such kind of a project will have a good return on investment.

The second scenario, installing solar panels to decrease the lighting consumption of the six buildings showed a good difference between costs and benefits while it resulted in a negative NPV and a less than 1 BCR for 3% and 6%, this is without considering environmental benefits. This project may be considered as an economical solution that could be recommended for NDU. Therefore, hypothesis 2, Chapter 3, is accepted if environmental benefits were to be considered.

The last case, replacing fluorescent lamps with LED lamps and at the same time installing solar PV panels to decrease lighting consumption for the six buildings would be considered as a better project to apply than installing solar panels alone, scenario 2. Scenario 3 has a good difference between costs and benefits at NEERA, 0%, rate, as well as a good NPV and BCR for the 3% discount factor, especially if the environmental benefits were to be considered for this project, for these reasons, the third hypothesis is accepted.

4.3.2 Case 2 – Increasing Rate of Electricity Generation Prices

Table 4.23 shows the main results of the three scenarios that include the difference between costs and benefits at NEERA, 0%, rate and the NPV and BCR at 3% and 6% discount factors. The grey colored cells represent the numbers that shows difference with respect to case 1.

Table 4.23: Comparison between NPV and BCR of the Three Different Scenarios under Increasing Rate for Electricity Generation Prices

SCENARIO	RATE	DIFFERENCE BETWEEN COSTS AND BENEFITS ($)	
1	NEERA, 0%	264,376	
2		135,610	
3		312,598	
SCENARIO	DISCOUNT FACTOR	NPV ($)	BCR
1	3%	155,461	1.8185
2		28,878	1.1231
3		140,094	1.3340
1	6%	85,389	1.4813
2		-32,278	0.8530
3		30,229	1.0766

It is noticeable in Table 4.23 that all the values show better difference between costs and benefits as well as better NPV and BCR.

For case 2, hypothesis 1 is accepted for all the different rates were difference between costs and benefits shows a good result as well as a high NPV and BCR for both 3% and 6% discount factors. Hypothesis 2 is accepted for NEERA, 0%, and 3% rate and rejected for 6% rate. If environmental rate was to be considered, hypothesis 2 would be accepted also for the 6% discount factor. Scenario 3 showed a positive difference between costs and benefits as well as a good NPV and BCR for both 3% and 6% discount factors. Hypothesis 3 is accepted for the three rates.

Table 4.24: Feasibility Study Summary Table

Feasibility Study Relative to Scenarios and Cases		Scenario 1: Replacing Fluorescent Lamps with LED Lamps		Scenario 2: Installing Solar PV Panels (*Under the Condition that LED Lamps were Installed Earlier as a Separate Project*)		Scenario 3: Replacing Fluorescent Lamps with LED Lamps and Installing Solar PV Panels Simultaneously	
		Case 1: Current Electricity Prices	Case 2: Increasing Electricity Prices	Case 1: Current Electricity Prices	Case 2: Increasing Electricity Prices	Case 1: Current Electricity Prices	Case 2: Increasing Electricity Prices
NEERA 0%	Difference between Costs and Benefits (USD)	193,817	264,376	41,413	135,610	185,961	312,598
Social Discount Factor 3%	NPV (USD)	108,911	155,461	[illegible]	28,878	56,548	140,094
	BCR	1.5734	1.8185	[illegible]	1.1231	1.1348	1.3341
Market Discount Factor 6%	NPV (USD)	53,745	85,389	[illegible]	-32,278	-26,584	30,229
	BCR	1.3029	1.4813	[illegible]	[illegible]	[illegible]	1.0766

All the grey colored cells in Table 4.24 represents the failing cases of the scenarios where either the NPV is negative of the BCR is less than 1, under the condition that environmental benefits is not considered in the calculation. As it is noticed, hypothesis 1, replacing fluorescent lamps with LED lamps, represented by scenario 1, is accepted for both cases under the three different rates. Hypothesis 2, installing solar PV panels under the condition that LED lamps was installed earlier as a separate project, represented by scenario 2, is rejected in case 1 for NPV equal to 3% and 6% while for case 2 it is accepted at NEERA and 3% rate, and rejected for NPV equal to 6%. Scenario 3 representing hypothesis 3, replacing fluorescent lamps with LED lamps and installing solar PV panels, is accepted under case 1 for NEERA and 3% rates, and rejected for 6% rate, while under case 2 hypothesis 3 is accepted for all rates.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

This chapter will confer the main results and limitations of this research, and will present recommendations for the administ-ration of Notre Dame University-Louaize concerning energy saving.

5.1 Main Results

Chapter 4 presented the feasibility studies on three different scenarios with two different discount factors (3% and 6%) as well as the NEERA (0% interest rate). The reason behind this number of combinations is to select the best successful project that could be implemented at Notre Dame University-Louaize. Scenario 1 was only involved with replacing fluorescent lamps with LED lamps, while scenario 2 dealt with installing solar PV panels to supply electricity for lighting fixtures. Scenario 3 is concerned with replacing fluorescent lamps with LED lamps as well as installing solar PV panels to supply electricity for lighting fixtures, implementing scenarios 1 and 2 simultaneously. These three scenarios were simulated under two cases. The first case represents the condition where the electricity generation prices remain stable over the lifetime of the project. The second case represents the condition where there exists increase in fuel oil prices and by that affecting EDL rates and fuel for generators rates.

5.1.1 Case 1 – Stable Electricity Generation Prices

Comparing the three scenarios together, it is noticeable that scenario 1 achieved the highest positive difference between benefits and costs at NEERA, 0%, rate as well as the highest NPV and BCR for the 3% and 6% discount factors. The reason behind this pull off is that the benefits of this project outgained the benefits of the other two. Compared to the other two scenarios, the amount of money that NDU-Louaize would save in scenario 1 every year, due to less energy consumption, is high relative to the initial cost of the project. The other highly considered benefit of this project is that NDU will install LED lamps once, during the twenty years duration, rather than purchasing and installing fluorescent lamps every three years. Scenario 2 had the lowest difference between costs and benefits as well as NPVs and BCRs among the three scenarios. This is due to the initial cost of solar PV panels along with the miscellaneous cost, including maintenance, is high relative to the yearly electrical bill savings. Furthermore, the difference between costs and benefits at the NEERA, 0%, rate is the only case that showed a positive rate of difference while the NPV of the 3% and 6% discount factors resulted in a negative value, as well as, the BCRs of the two discount factors were less than one. Note that the NPVs and BCRs of this case would have shown a better result if factors, such as environmental benefits. As stated in chapter 4, the life span of this project was limited to 25 years due to the unknown high fluctuation in prices of green technology over this period of time.

Summing up the costs of scenarios 1 and 2 together, as well as the benefits, it shows that the results of the feasibility study of scenario 3, at NEERA, 0%, rate, showed a better outcome than the other scenarios taking into consideration both projects being implemented simultaneously. If 3% discount factor were to be considered, scenario 3 would have also achieved a positive NPV, while the 6% discount factor resulted in a negative NPV. This is taking into consideration that the lifespan of the project is limited to 20 years.

As a conclusion, scenario 1 showed the best results at the NEERA, 0%, rate and the both discount factors 3%, and 6%; however it is restricted only to LED lamps. While scenario 3, even though it showed a lower difference between costs and benefits as well as a lower NPV than scenario 1, it is more economically feasible since it includes both LED lamps and solar PV panels. NDU should consider scenario 3 if it was selected by the 0% rate NEERA program. If 3% discount factor was to be considered, NDU has the choice to choose either scenario 1 or scenario 3, the latter is more preferable since it has higher environmental benefits. At 6% discount factor, NDU should consider scenario 1 since it has a positive NPV unlike the other scenarios. One should note that environmental benefits of the project are not taken into consideration for all the scenarios.

Thus, hypothesis H1 is supported under the NEERA, 0%, rate and the 3% and 6% discount factors, while H2 is rejected under all conditions. H3 is supported for NEERA, 0%, rate and 3% discount factor but rejected if 6% discount factor was to be considered.

5.1.2 Case 2 – Increasing Rate of Electricity Generation Prices

Similar to case 1, it is noticeable that scenario 1 achieved the highest positive difference between benefits and costs at NEERA, 0%, rate as well as the highest NPV and BCR for the 3% and 6% discount factors. Scenario 2 showed a high difference between costs and benefits and a positive NPV and BCR for the 3% discount factor but a negative NPV for the 6% discount factor. If environmental benefits were to be considered, the second scenario is advisable for Notre Dame University to go through. Summing up the costs of scenarios 1 and 2 together, as well as the benefits, it shows that the results of the feasibility study of scenario 3, at NEERA, 0%, rate, showed a better outcome than the other scenarios taking into consideration both projects being implemented simultaneously. If 3% or 6% discount factors were to be considered, scenario 3 would have also achieved a positive NPV. This is taking into consideration that the lifespan of the project is limited to 20 years.

Scenario 1 showed the best results at both discount factors 3%, and 6%; however it is restricted only to LED lamps. While even though scenario 3 showed a higher difference between costs and benefits as well as a lower NPV than scenario 1, it is more economically feasible since it includes both LED lamps and solar PV panels. NDU should consider scenario 3 if it was selected by the 0% rate NEERA program. If 3% discount factor was to be considered, NDU has the choice to choose either scenario 1 or scenario 3, the latter is more preferable since it has higher environmental benefits. At 6% discount factor, NDU could consider both scenario 1 and scenario 3 since they showed a positive NPV unlike scenario 2. One should note that environmental benefits of the project are not taken into consideration for all the scenarios; otherwise scenario 2 would have showed a positive NPV.

Thus, under the case of increasing prices of electricity generation, hypothesis H1 and H3 are supported under the NEERA, 0%, rate and the 3% and 6% discount factors, while H2 is only supported for the NEERA, 0%, rate and 3% discount factor while rejected for the 6% discount factor.

5.2 Limitations

Several limitations were faced during this study. The first limitation is that Lebanon is one of the countries that are still at their very early stages when it comes to renewable energy. Therefore, the collected data was small when it comes to renewable energy such as solar, wind, tides and waves.

The second limitation is that in case 1 of all the three scenarios the price of watt-hour is considered to be fixed over the 20 years feasibility study, but it is possible that the prices of EDL for the medium voltage customers will increase. The same applies on the price of diesel for private generators where the numbers used in the tables are based on current prices. (Increases in EDL or diesel rates will result in a better NPV since the amount of power saving will be higher).

The third limitation is that several factors could play a major role in changing the results of the hypothesis to a better outcome but this thesis only simulated the increase in electricity generation prices. An example of the factors is that the prices of LED lamps are still not saturated and therefore every year will result in a decrease in price; therefore, new prices will be available but unfortunately at this stage the future prices are unpredictable.

The fourth limitation is that the maps of Notre Dame University-Louaize were not updated by the architect to reflect the location changes of offices and classes as well as rooms added to the buildings.

The fifth limitation is that the percentage of power load consumption considered was done by approximation and not by data supplied from NDU administration.

5.3 Recommendations

I recommend that NDU-Louaize should choose scenario 1 to be implemented as a first phase. Scenario 2 could be implemented at a later phase, few years from now, hoping that the prices of solar panels will decrease leading to a lower cost relative to the returned benefits on such a project.

Several other energy efficiency projects could be implemented at NDU such as placing motion sensors in offices and classes to detect the existence of people; else lights will be turned off automatically. Other solutions may include installing light regulation sensors in each room that will control the operation of lamps, which are to be turned on and off based on the external light. These solutions will decrease the daily power consumption at NDU.

NDU could install solar water heating panels at the roof of every building to decrease the electric heating consumption and thus decreasing the electric bills.
NDU should make students aware of the environmental benefits of renewable energy by giving courses as well as holding conferences and distributing brochures about this subject. NDU could be one of the first, among Lebanese and Arab universities, that will be implementing renewable energy and energy efficiency project of this size, hoping that one day all the NDU buildings will turn green.

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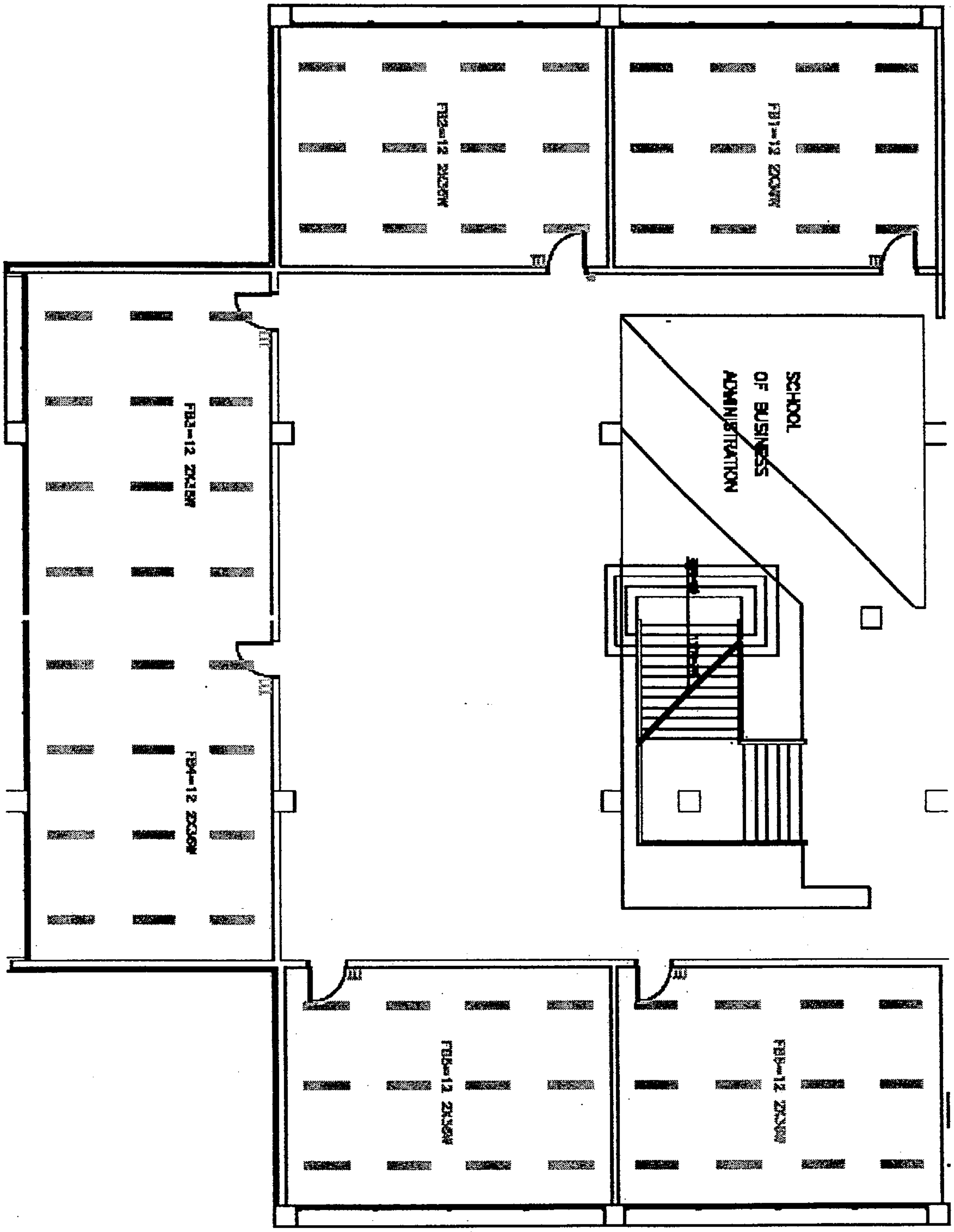
- 1015 – The Genset Engine. Deutz Data Sheet

APPENDIX A

Sequential Room Numbering on Architectural Drawings

Faculty of Business Administration & Economics (FBAE):

1-Ground Floor:



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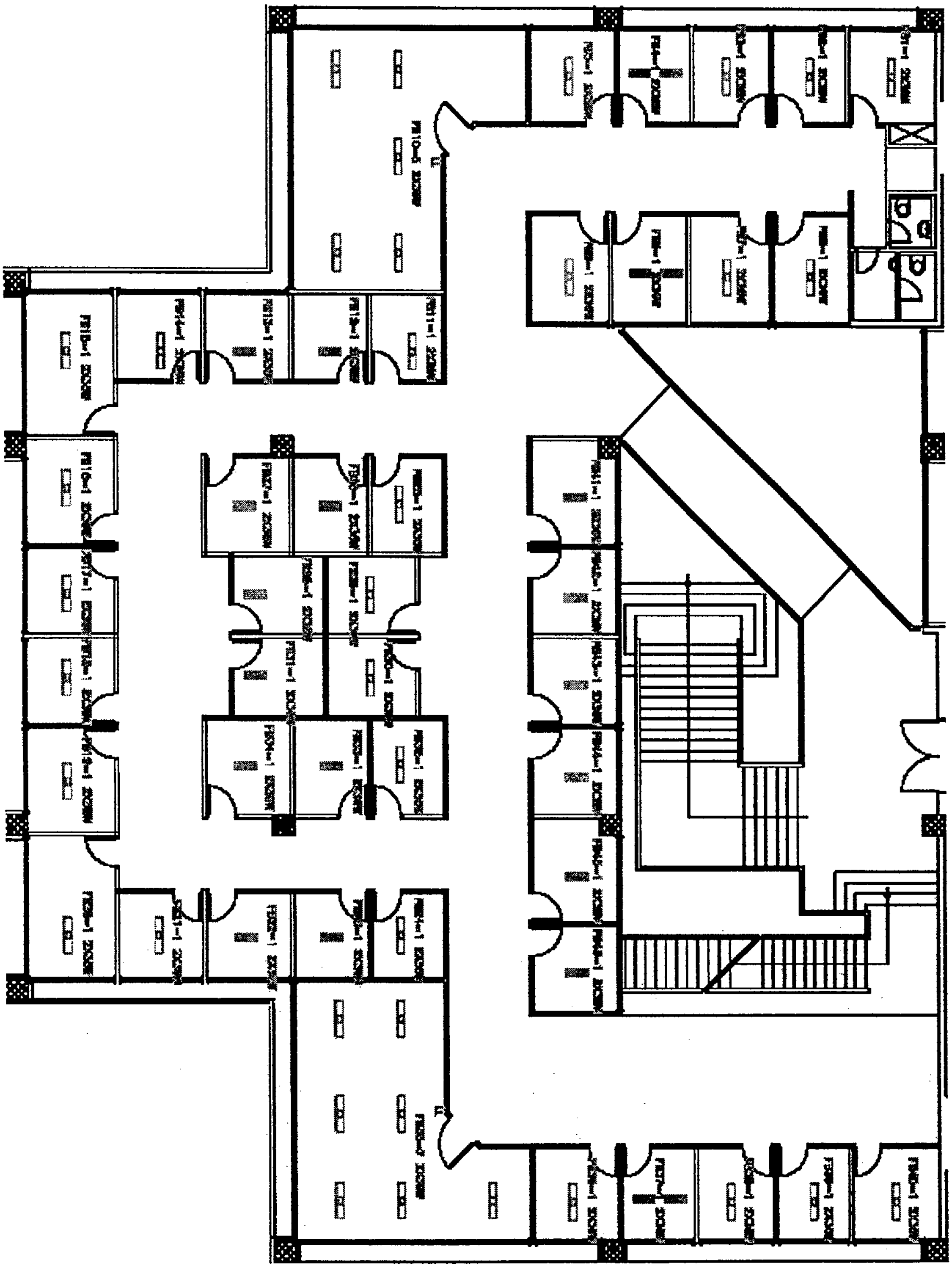

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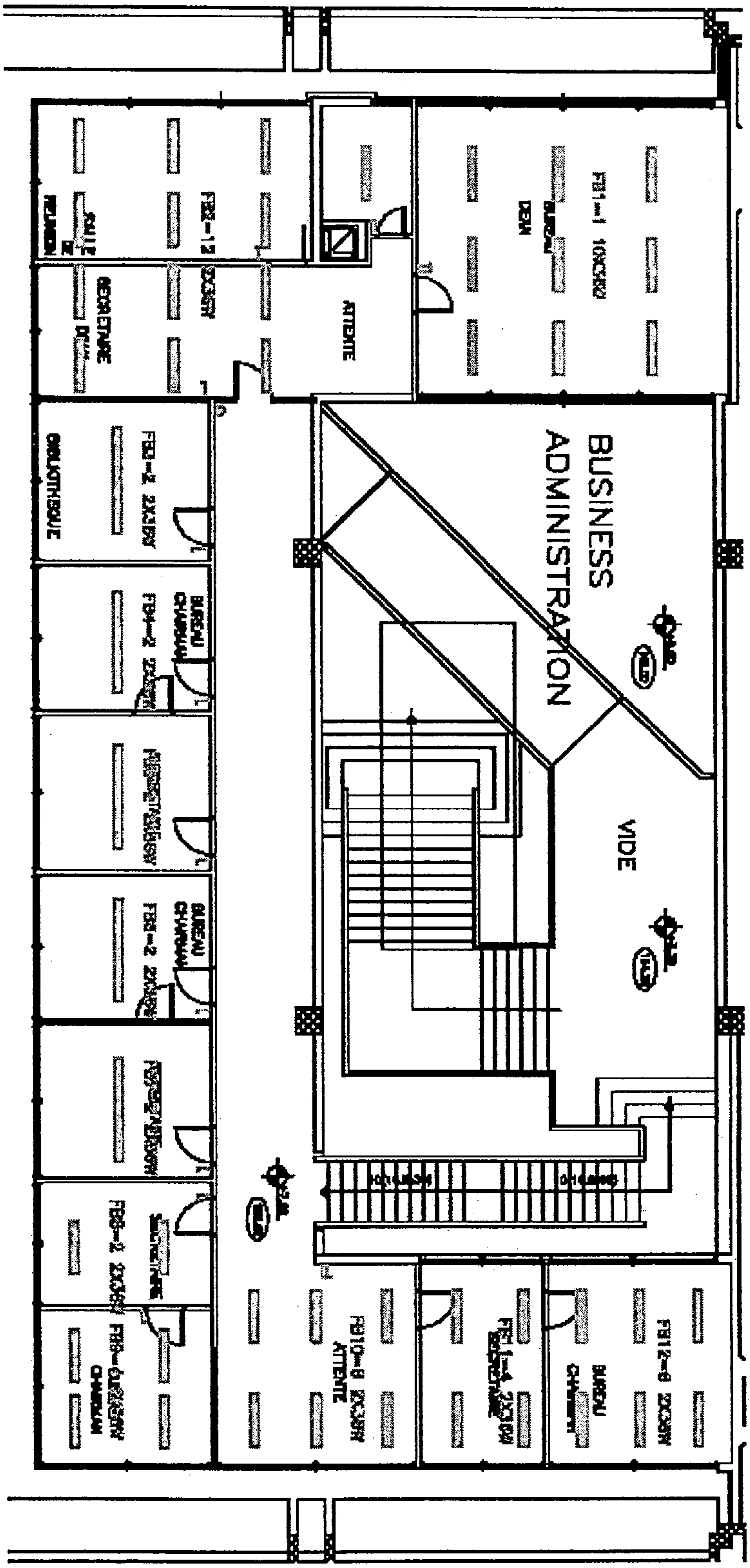
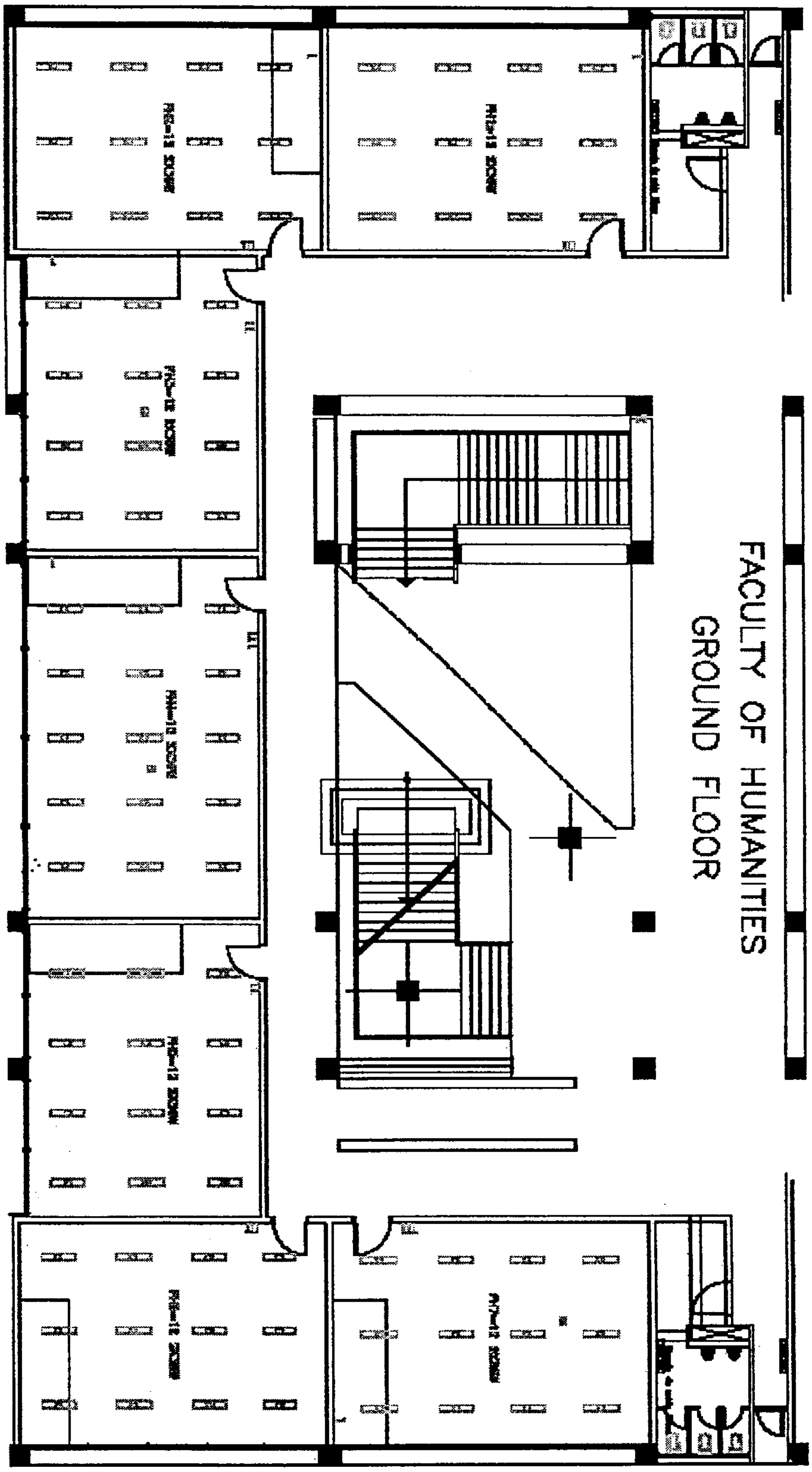


Faculty of Humanities (FH):

1-Ground Floor:



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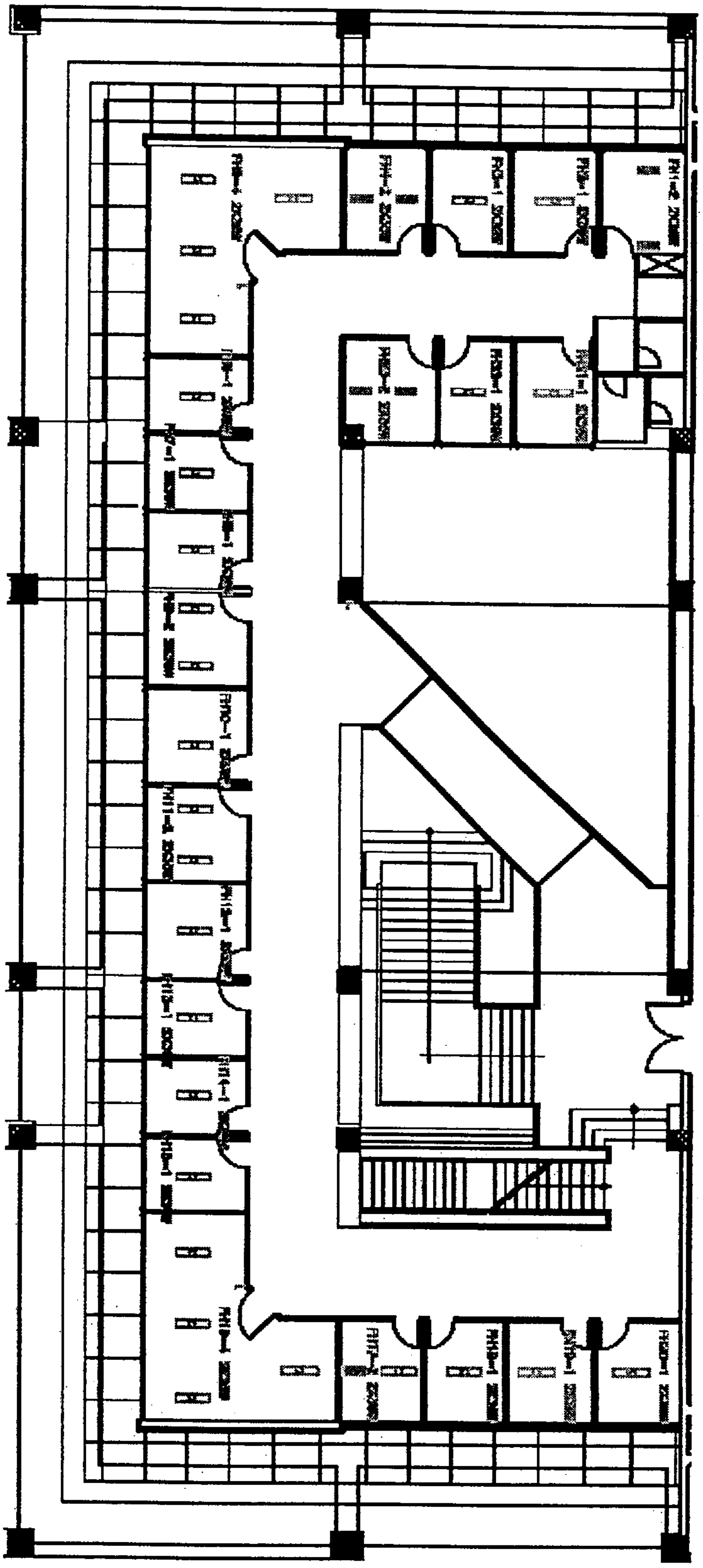

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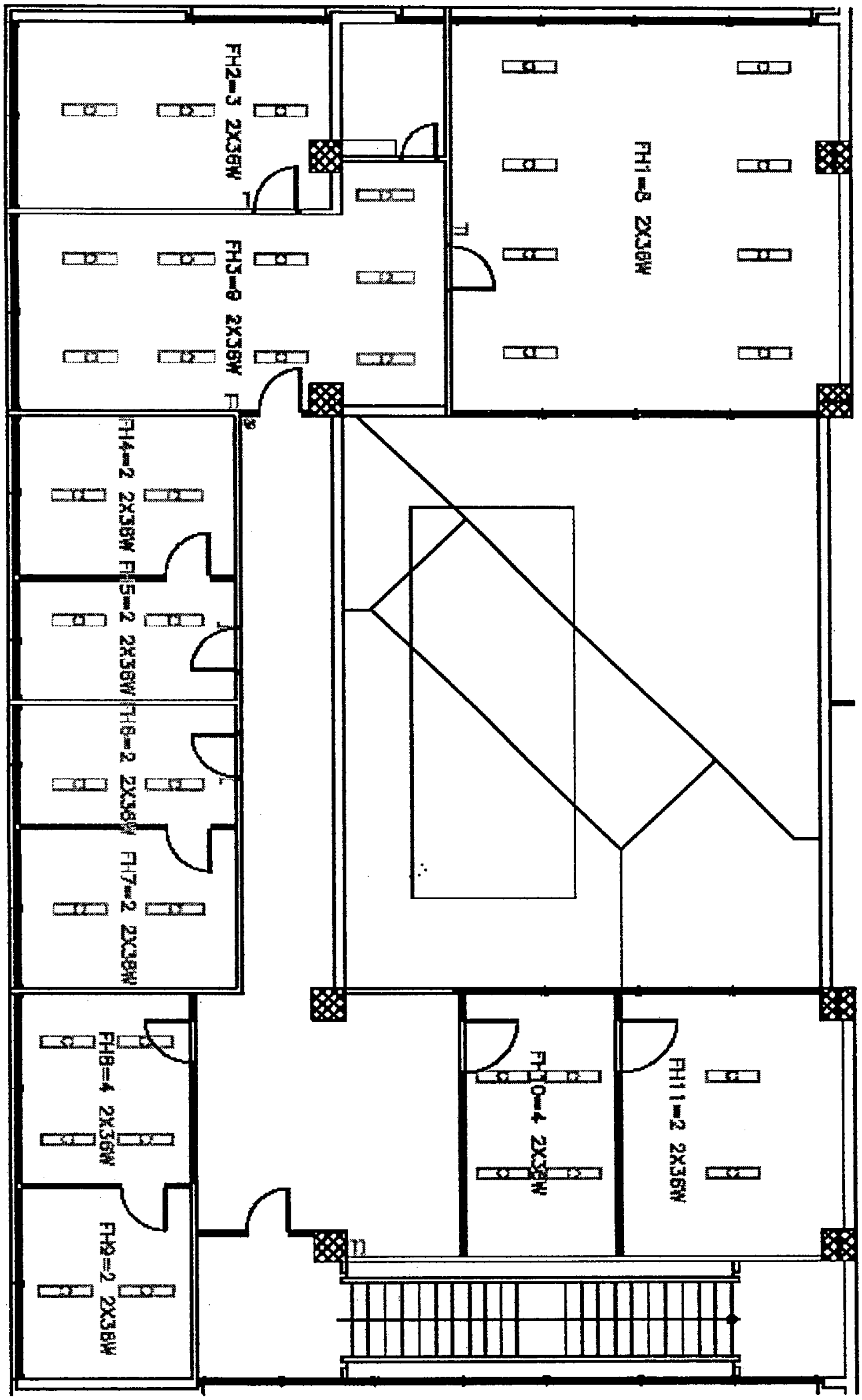
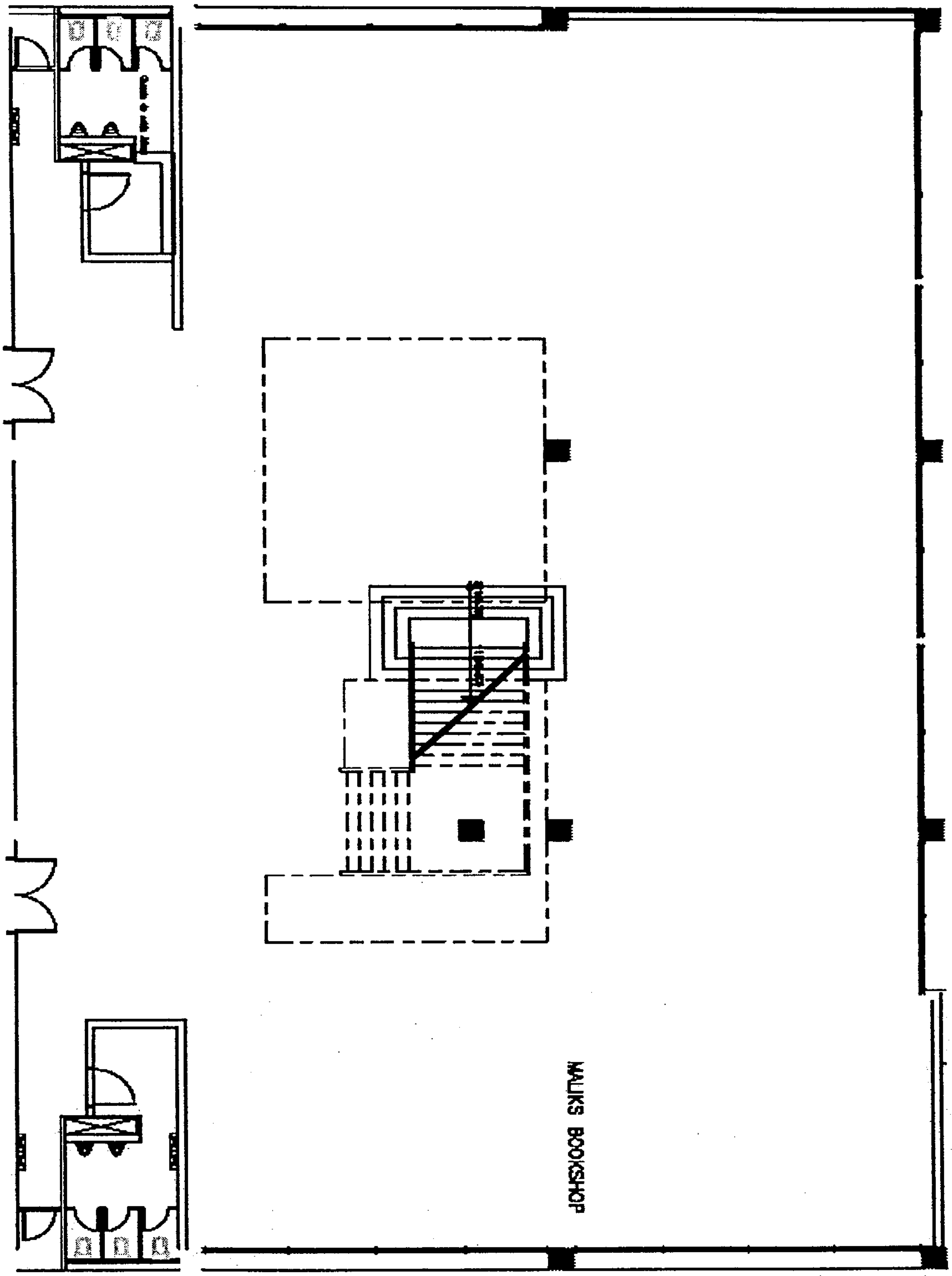


Faculty of Architecture, Art & Design (FAAD):

1-Ground Floor (Maliks Bookshop):



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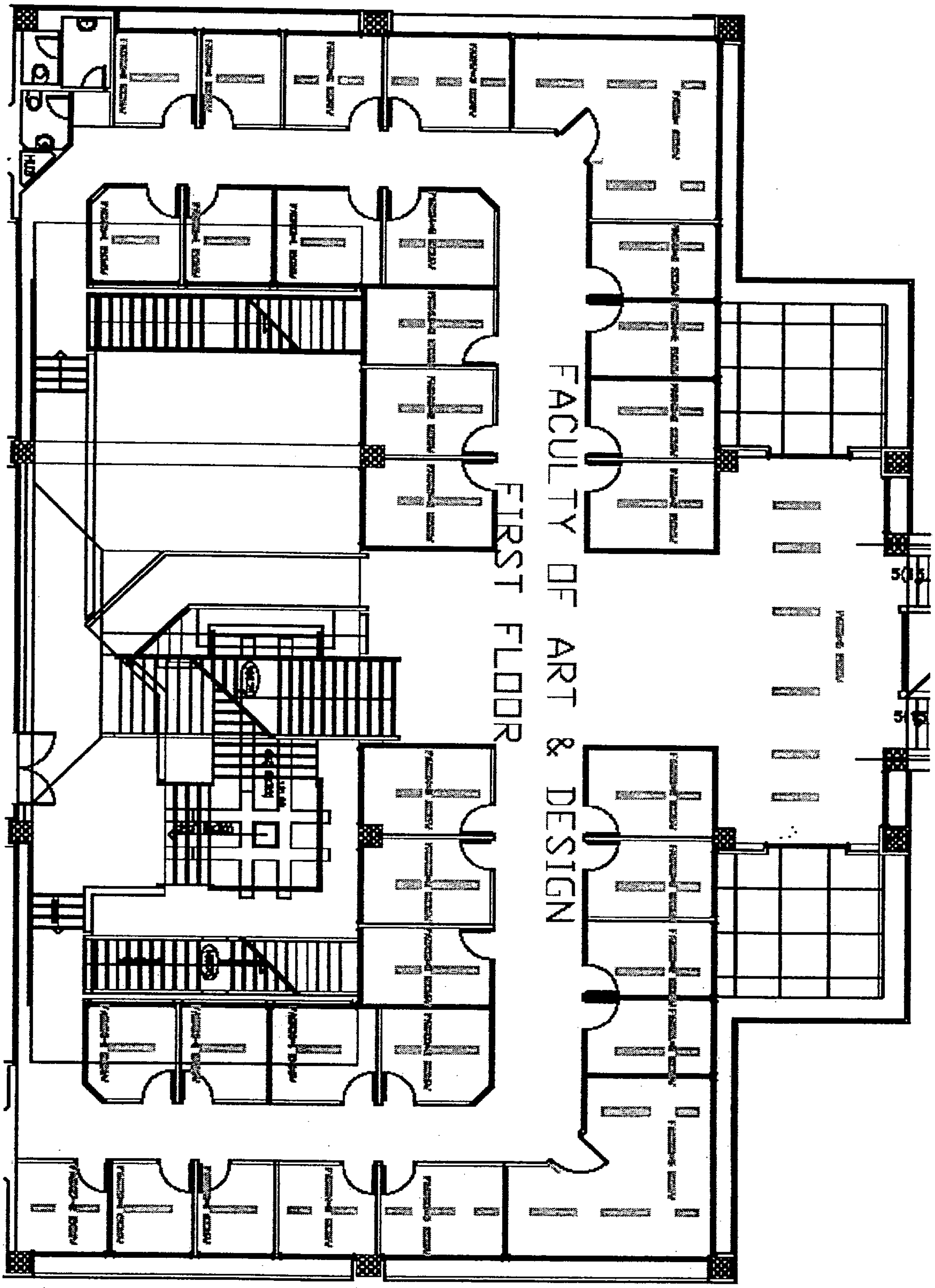

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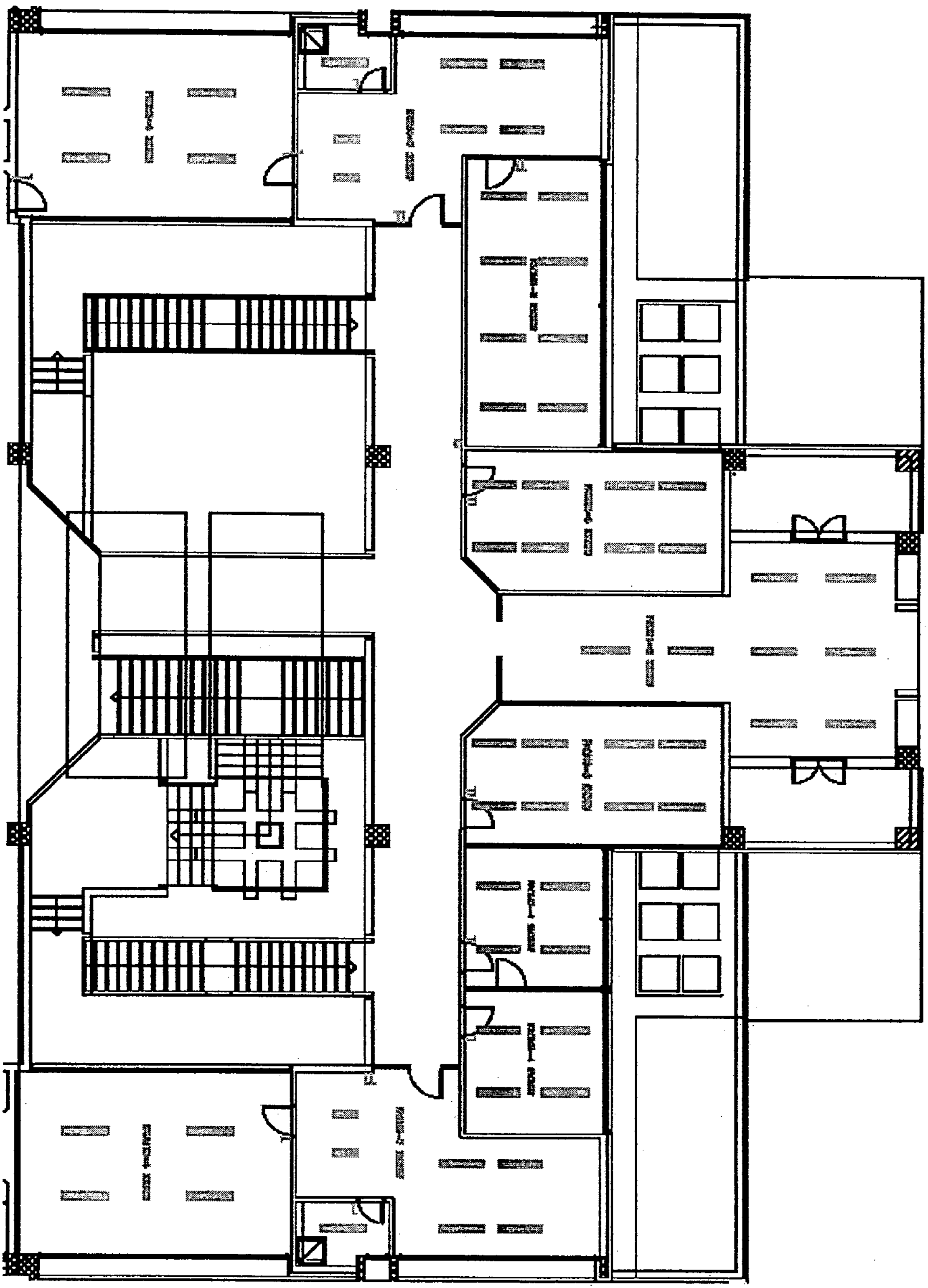
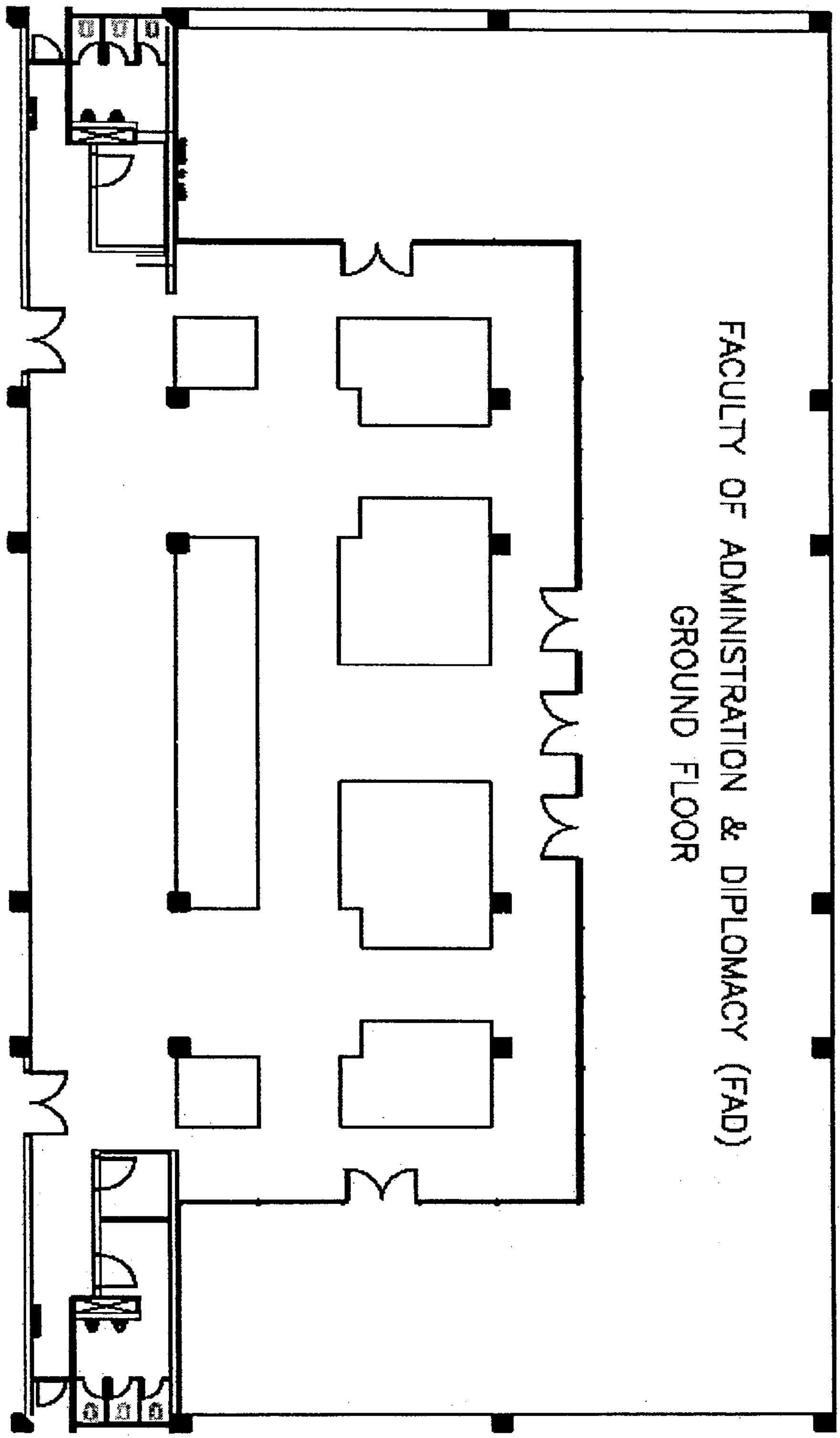


Faculty of Political Science, Public Administration & Diplomacy (FPSPAD):

1-Ground Floor (Cafeteria Floor):



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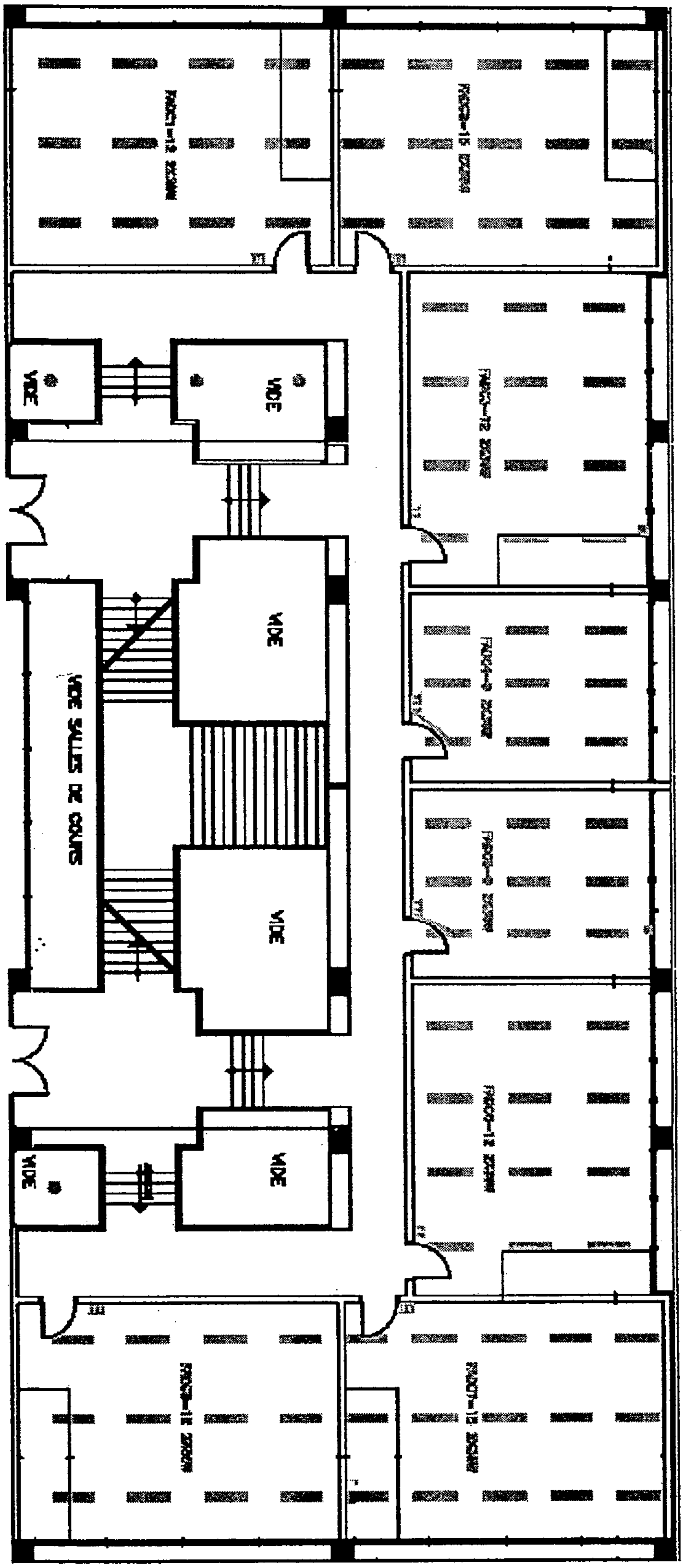

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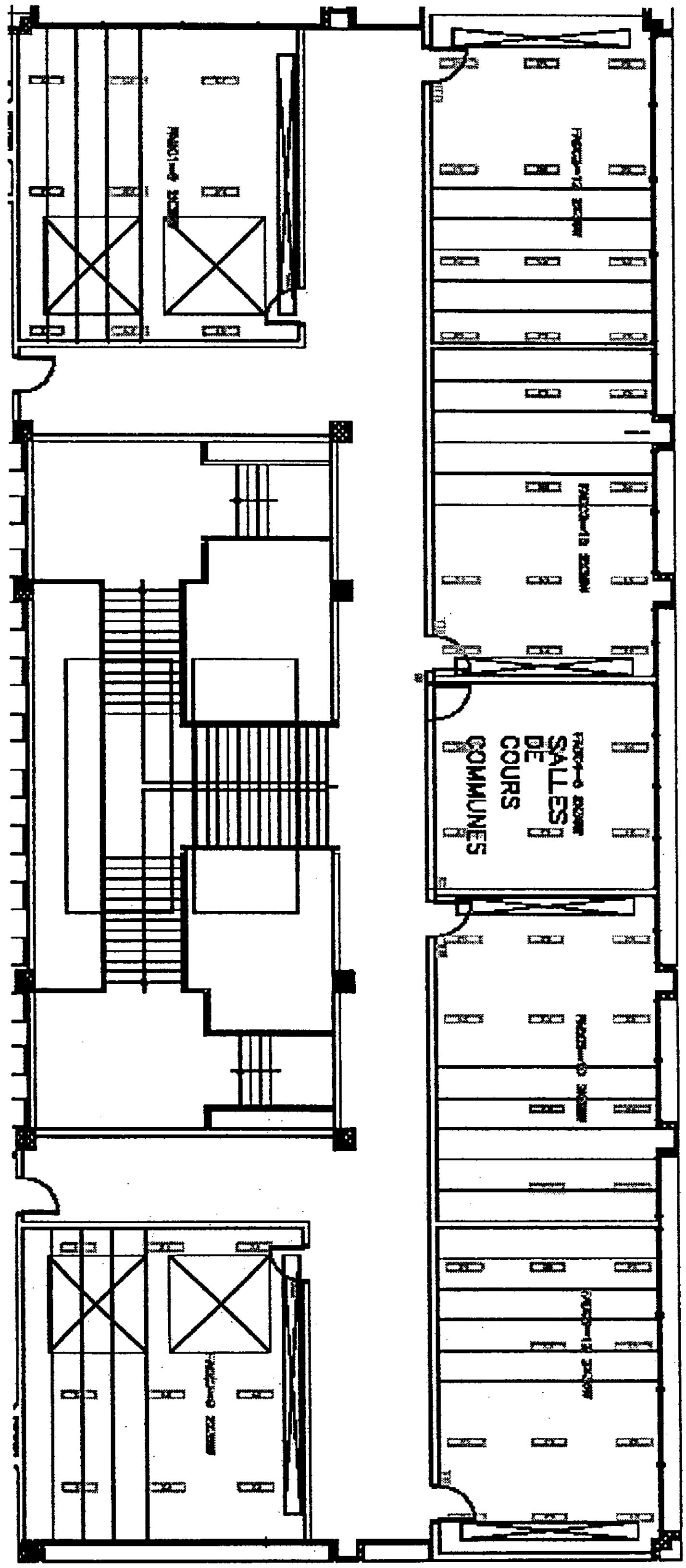

Faculty of Natural & Applied Sciences (FNAS):

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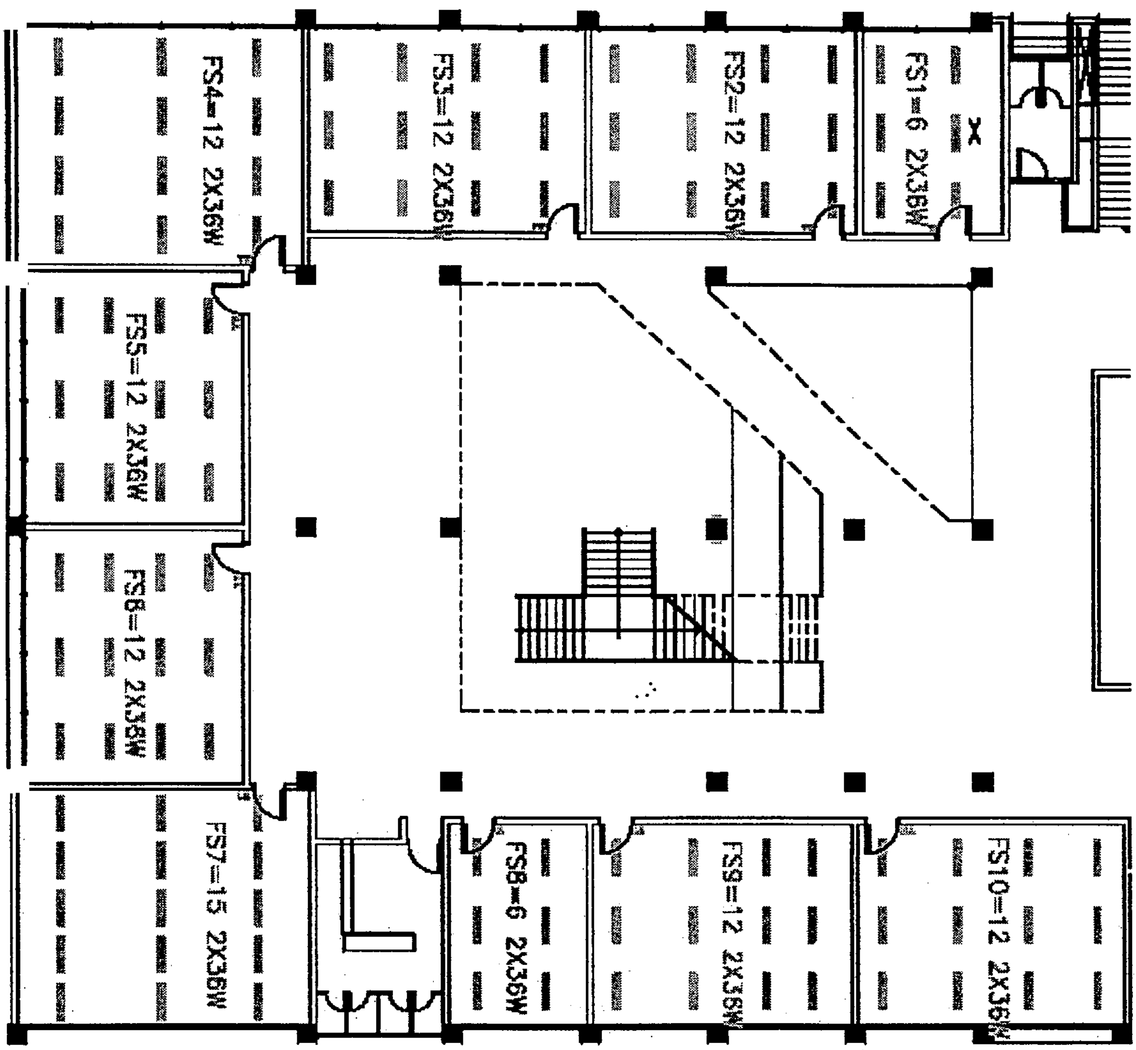

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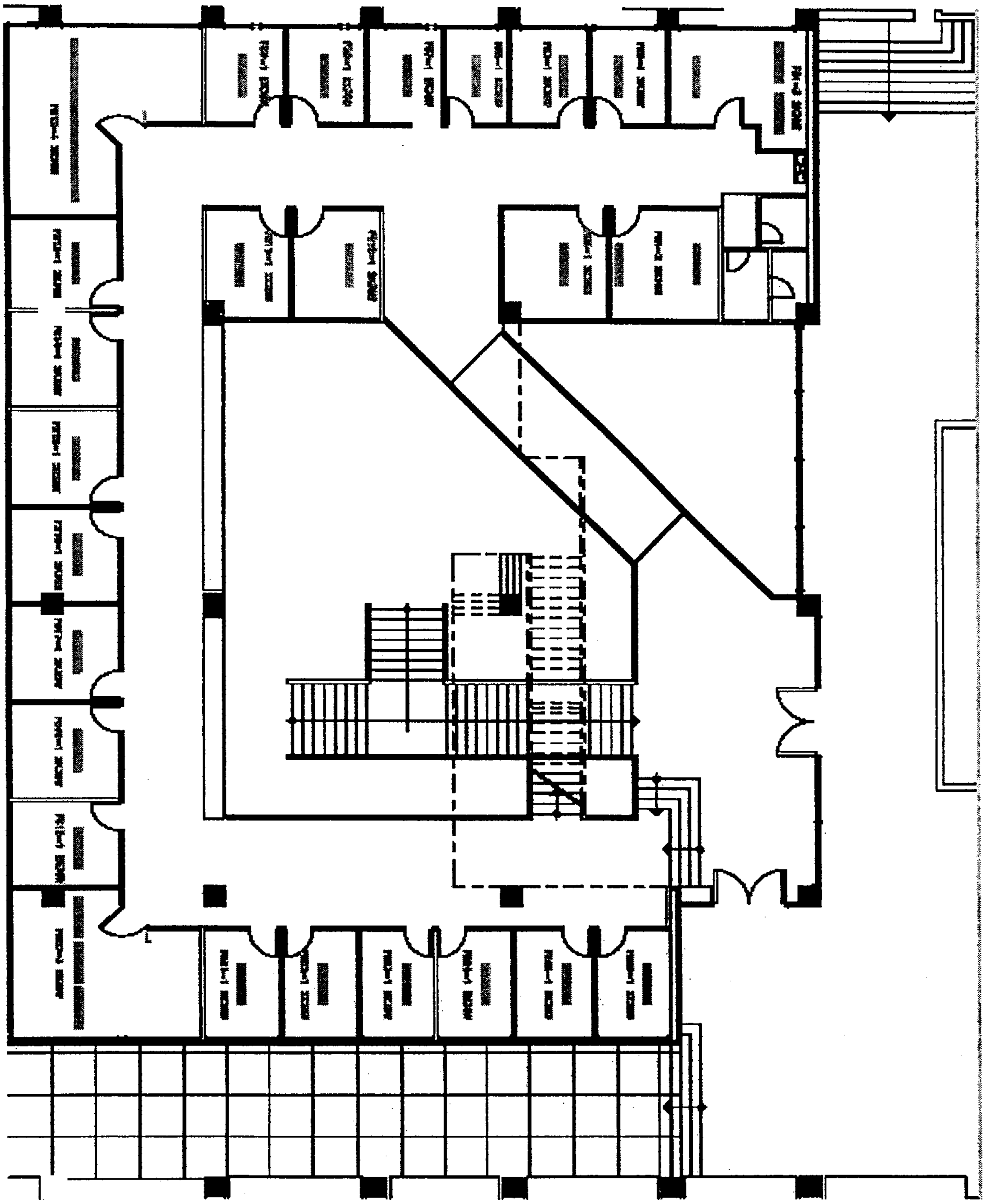
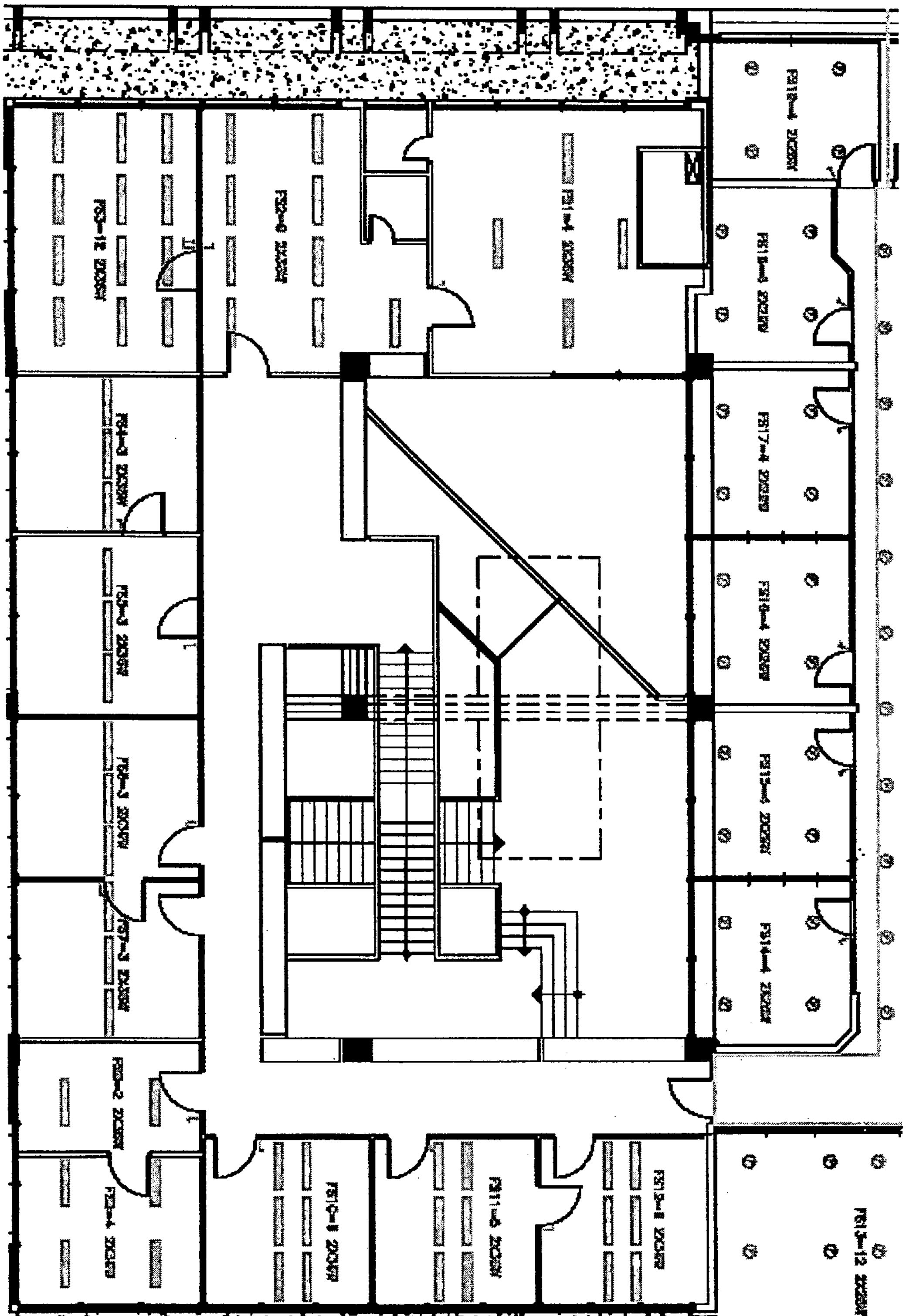
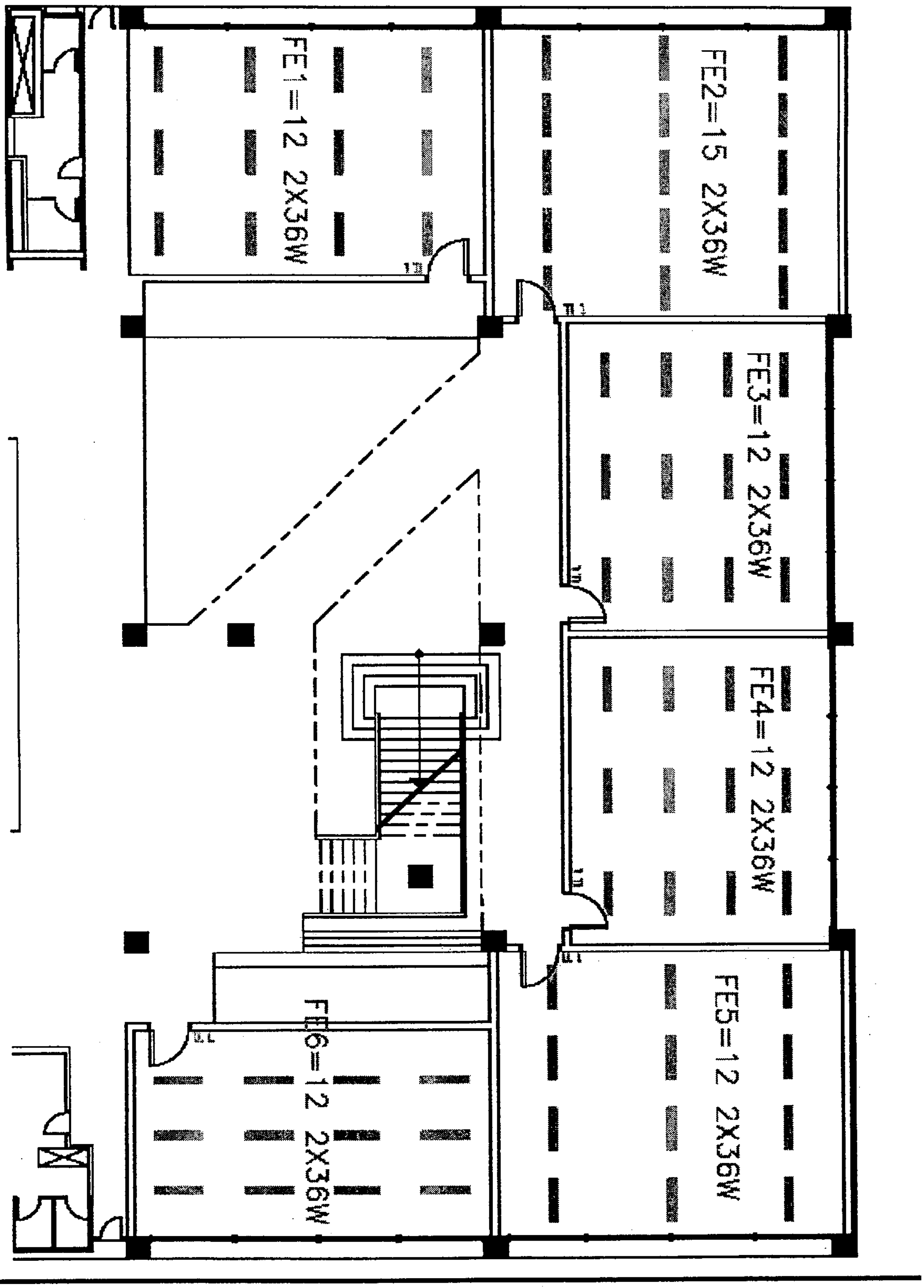


3-Second Floor:

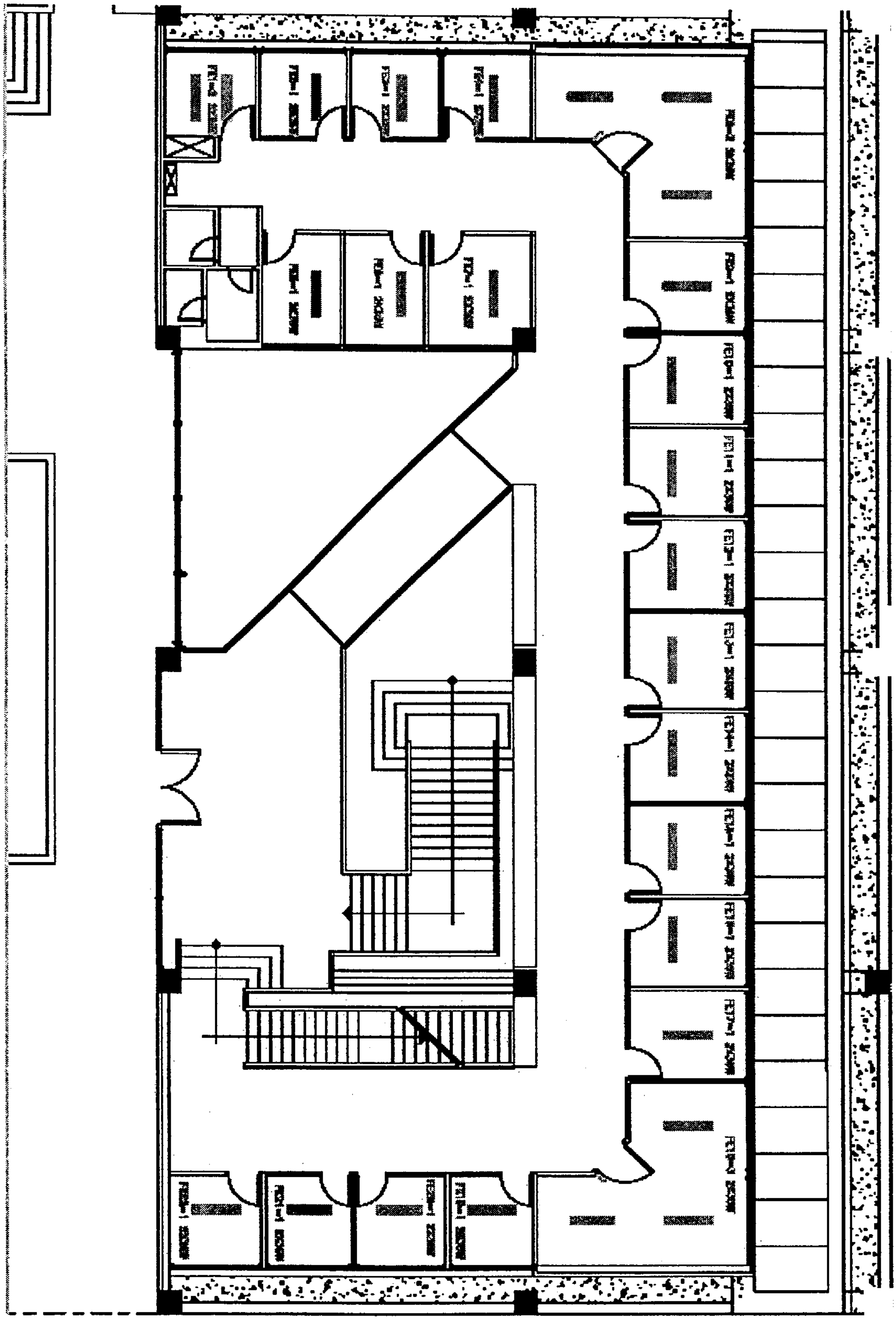


Faculty of Engineering (FE):

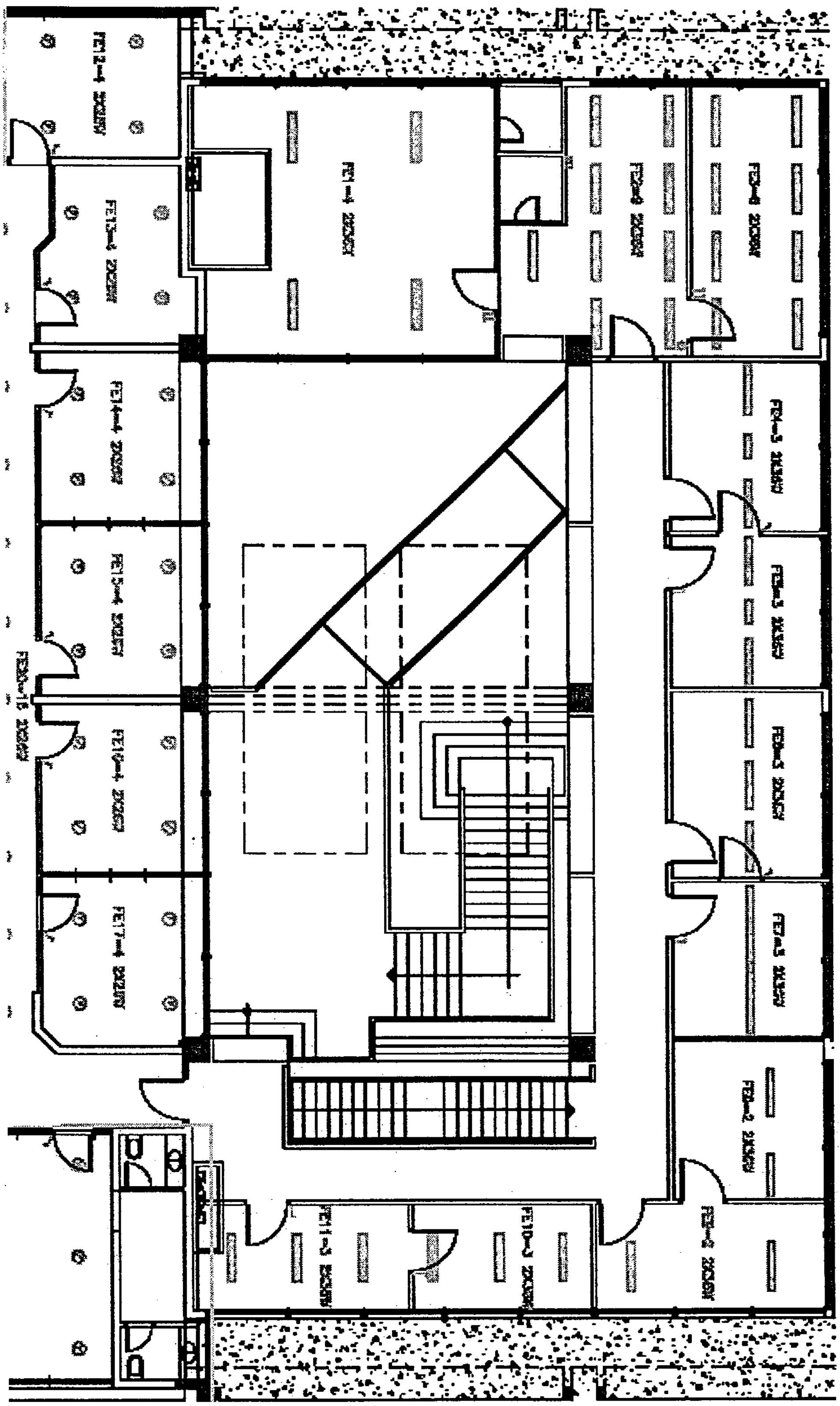
1-Ground Floor:



2-First Floor:



3-Second Floor:



APPENDIX B

Summary Tables for Faculty Lighting Consumption

Faculty of Business Administration & Economics (FBAE):

1-Ground Floor:

FBAE-RC										
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE			LED WATT-HOUR PER FIXTURE		TOTAL CONSUMPTION WATT-HOUR		
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT	LED	DIFFERENCE
RC-FBAE1	CLASS 1	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
RC-FBAE2	CLASS 2	15	2X36	2X9	90	2X22	44	1350 WH	660 WH	690 WH
RC-FBAE3	CLASS 3	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
RC-FBAE4	CLASS 4	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
RC-FBAE5	CLASS 5	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
RC-FBAE6	CLASS 6	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
								TOTAL FLUORESCENT	TOTAL LED	TOTAL DIFFERENCE
TOTAL FB-RC								6750 WH	3300 WH	3450 WH

2-First Floor Part 1:

FBAE-1^{ST}-A										
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE			LED WATT-HOUR PER FIXTURE		TOTAL CONSUMPTION WATT-HOUR		
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT	LED	DIFFERENCE
1ST-FBAE1	OFFICE 1	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE2	OFFICE 2	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE3	OFFICE 3	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE4	OFFICE 4	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE5	OFFICE 5	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE6	OFFICE 6	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE7	OFFICE 7	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE8	OFFICE 8	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE9	OFFICE 9	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE10	OFFICE 10	5	2X36	2X9	90	2X22	44	450 WH	220 WH	230 WH
1ST-FBAE11	OFFICE 11	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE12	OFFICE 12	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE13	OFFICE 13	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE14	OFFICE 14	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE15	OFFICE 15	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE16	OFFICE 16	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE17	OFFICE 17	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE18	OFFICE 18	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE19	OFFICE 19	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE20	OFFICE 20	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE21	OFFICE 21	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE22	OFFICE 22	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE23	OFFICE 23	1	2X36	2X9	90	2X22W	44	90 WH	44 WH	46 WH

2-First Floor Part 2:

FBAE-1st-B										
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE			LED WATT-HOUR PER FIXTURE		TOTAL CONSUMPTION WATT-HOUR		
			LAMP W	BALLAST W	TOTAL W	LAMP W	TOTAL W	FLUORESCENT	LED	DIFFERENCE
1ST-FBAE24	OFFICE 24	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE25	OFFICE 25	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE26	OFFICE 26	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE27	OFFICE 27	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE28	OFFICE 28	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE29	OFFICE 29	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE30	OFFICE 30	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE31	OFFICE 31	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE32	OFFICE 32	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE33	OFFICE 33	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE34	OFFICE 34	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE35	OFFICE 35	7	2X36	2X9	90	2X22	44	630 WH	308 WH	322 WH
1ST-FBAE36	OFFICE 36	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE37	OFFICE 37	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE38	OFFICE 38	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE39	OFFICE 39	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE40	OFFICE 40	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE41	OFFICE 41	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE42	OFFICE 42	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE43	OFFICE 43	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE44	OFFICE 44	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE45	OFFICE 45	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FBAE46	OFFICE 46	1	2X36	2X9	90	2X22W	44	90 WH	44 WH	46 WH
								TOTAL FLUORESCENT	TOTAL LED	TOTAL DIFFERENCE
TOTAL FBAE-1st								5040 WH	2464 WH	2576 WH

3-Second Floor:

FBAE-2nd										
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE			LED WATT-HOUR PER FIXTURE		TOTAL CONSUMPTION WATT-HOUR		
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT	LED	DIFFERENCE
2ND-FBAE1	OFFICE 1	10	2X36	2X9	90	2X22	44	900 WH	440 WH	460 WH
2ND-FBAE2	OFFICE 2	11	2X36	2X9	90	2X22	44	990 WH	484 WH	506 WH
2ND-FBAE3	OFFICE 3	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
2ND-FBAE4	OFFICE 4	13	2X36	2X9	90	2X22	44	1170 WH	572 WH	598 WH
2ND-FBAE5	OFFICE 5	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
2ND-FBAE6	OFFICE 6	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
2ND-FBAE7	OFFICE 7	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
2ND-FBAE8	OFFICE 8	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
2ND-FBAE9	OFFICE 9	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH
2ND-FBAE10	OFFICE 10	6	2X36	2X9	90	2X22	44	540 WH	264 WH	276 WH
2ND-FBAE11	OFFICE 11	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH
2ND-FBAE12	OFFICE 12	6	2X36	2X9	90	2X22	44	540 WH	264 WH	276 WH
								TOTAL FLUORESCENT	TOTAL LED	TOTAL DIFFERENCE
TOTAL FBAE-2ND								6660 WH	3256 WH	3404 WH

Faculty of Humanities (FH):

1-Ground Floor:

FH-RC										
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE			LED WATT-HOUR PER FIXTURE		TOTAL CONSUMPTION WATT-HOUR		
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT	LED	DIFFERENCE
RC-FH1	CLASS 1	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
RC-FH2	CLASS 2	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
RC-FH3	CLASS 3	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
RC-FH4	CLASS 4	15	2X36	2X9	90	2X22	44	1350 WH	660 WH	690 WH
RC-FH5	CLASS 5	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
RC-FH6	CLASS 6	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
RC-FH7	CLASS 7	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
								TOTAL FLUORESCENT	TOTAL LED	TOTAL DIFFERENCE
TOTAL FH-GF								7830 WH	3828 WH	4002 WH

2-First Floor:

FH-1ST										
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT			LED		TOTAL CONSUMPTION WATT-HOUR		
			WATT-HOUT PER FIXTURE			WATT-HOUT PER FIXTURE				
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT	LED	DIFFERENCE
1ST-FH1	OFFICE 1	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FH2	OFFICE 2	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FH3	OFFICE 3	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FH4	OFFICE 4	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FH5	OFFICE 5	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH
1ST-FH6	OFFICE 6	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FH7	OFFICE 7	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FH8	OFFICE 8	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FH9	OFFICE 9	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FH10	OFFICE 10	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FH11	OFFICE 11	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FH12	OFFICE 12	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FH13	OFFICE 13	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FH14	OFFICE 14	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FH15	OFFICE 15	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FH16	OFFICE 16	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH
1ST-FH17	OFFICE 17	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FH18	OFFICE 18	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FH19	OFFICE 19	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FH20	OFFICE 20	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FH21	OFFICE 21	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FH22	OFFICE 22	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FH23	OFFICE 23	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
								TOTAL FLUORESCENT	TOTAL LED	TOTAL DIFFERENCE
TOTAL FH-1ST								3150 WH	1540 WH	1610 WH

3-Second Floor:

FH-2nd											
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE			LED WATT-HOUR PER FIXTURE		TOTAL CONSUMPTION WATT-HOUR			
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT	LED	DIFFERENCE	
2ND-FH1	OFFICE 1	8	2X36	2X9	90	2X22	44	720 WH	352 WH	368 WH	
2ND-FH2	OFFICE 2	3	2X36	2X9	90	2X22	44	270 WH	132 WH	138 WH	
2ND-FH3	OFFICE 3	9	2X36	2X9	90	2X22	44	810 WH	396 WH	414 WH	
2ND-FH4	OFFICE 4	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH	
2ND-FH5	OFFICE 5	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH	
2ND-FH6	OFFICE 6	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH	
2ND-FH7	OFFICE 7	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH	
2ND-FH8	OFFICE 8	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH	
2ND-FH9	OFFICE 9	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH	
2ND-FH10	OFFICE 10	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH	
2ND-FH11	OFFICE 11	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH	
								TOTAL FLUORESCENT	TOTAL LED	TOTAL DIFFERENCE	
TOTAL FH-2nd								3600 WH	1760 WH	1840 WH	

Faculty of Architecture, Art & Design (FAAD):

1-Ground Floor (Maliks Bookshop):

FADM-RC										
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE			LED WATT-HOUR PER FIXTURE		TOTAL CONSUMPTION WATT-HOUR		
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT	LED	DIFFERENCE
-	-	-						0 WH	0 WH	0 WH
								TOTAL FLUORESCENT	TOTAL LED	TOTAL DIFFERENCE
TOTAL FAAD-RC								0 WH	0 WH	0 WH

2-First Floor:

FAAD-1^ST										
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE			LED WATT-HOUR PER FIXTURE		TOTAL CONSUMPTIO WATT-HOUR		
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT	LED	DIFFERENCE
1ST-FAAD1	OFFICE 1	6	2X36	2X9	90	2X22	44	540 WH	264 WH	276 WH
1ST-FAAD2	OFFICE 2	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FAAD3	OFFICE 3	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FAAD4	OFFICE 4	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FAAD5	OFFICE 5	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FAAD6	OFFICE 6	5	2X36	2X9	90	2X22	44	450 WH	220 WH	230 WH
1ST-FAAD7	OFFICE 7	3	2X36	2X9	90	2X22	44	270 WH	132 WH	138 WH
1ST-FAAD8	OFFICE 8	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FAAD9	OFFICE 9	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FAAD10	OFFICE 10	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FAAD11	OFFICE 11	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FAAD12	OFFICE 12	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FAAD13	OFFICE 13	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FAAD14	OFFICE 14	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FAAD15	OFFICE 15	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FAAD16	OFFICE 16	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FADA17	OFFICE 17	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FAAD18	OFFICE 18	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FAAD19	OFFICE 19	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FAAD20	OFFICE 20	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FAAD21	OFFICE 21	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FAAD22	OFFICE 22	5	2X36	2X9	90	2X22	44	450 WH	220 WH	230 WH
1ST-FAAD23	OFFICE 23	3	2X36	2X9	90	2X22	44	270 WH	132 WH	138 WH
1ST-FAAD24	OFFICE 24	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FAAD25	OFFICE 25	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FAAD26	OFFICE 26	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FAAD27	OFFICE 27	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FAAD28	OFFICE 28	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FAAD29	OFFICE 29	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FAAD30	OFFICE 30	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FAAD31	OFFICE 31	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FAAD32	OFFICE 32	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FAAD33	OFFICE 33	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FAAD34	OFFICE 34	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
								TOTAL FLUORESCENT	TOTAL LED	TOTAL DIFFERENCE
TOTAL FAAD-1^ST								6300 WH	3080 WH	3220 WH

3-Second Floor:

FAAD-2ND														
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE			LED WATT-HOUR PER FIXTURE		TOTAL CONSUMPTION WATT-HOUR						
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT		LED		DIFFERENCE		
2ND-FAAD1	OFFICE 1	8	2X36	2X9	90	2X22	44	720	WH	352	WH	368	WH	
2ND-FAAD2	OFFICE 2	8	2X36	2X9	90	2X22	44	720	WH	352	WH	368	WH	
2ND-FAAD3	OFFICE 3	8	2X36	2X9	90	2X22	44	720	WH	352	WH	368	WH	
2ND-FAAD4	OFFICE 4	7	2X36	2X9	90	2X22	44	630	WH	308	WH	322	WH	
2ND-FAAD5	OFFICE 5	5	2X36	2X9	90	2X22	44	450	WH	220	WH	230	WH	
2ND-FAAD6	OFFICE 6	8	2X36	2X9	90	2X22	44	720	WH	352	WH	368	WH	
2ND-FAAD7	OFFICE 7	4	2X36	2X9	90	2X22	44	360	WH	176	WH	184	WH	
2ND-FAAD8	OFFICE 8	4	2X36	2X9	90	2X22	44	360	WH	176	WH	184	WH	
2ND-FAAD9	OFFICE 9	7	2X36	2X9	90	2X22	44	630	WH	308	WH	322	WH	
2ND-FAAD10	OFFICE 10	4	2X36	2X9	90	2X22	44	360	WH	176	WH	184	WH	
								TOTAL FLUORESCENT		TOTAL LED		TOTAL DIFFERENCE		
TOTAL FAAD-2ND								5670	WH	2772	WH	2898	WH	

Faculty of Political Science, Public Administration & Diplomacy (FPSPAD):

1-Ground Floor (Cafeteria Floor):

FPSPAD-RC										
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE			LED WATT-HOUR PER FIXTURE		TOTAL CONSUMPTION WATT-HOUR		
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT	LED	DIFFERENCE
-	-	-						0 WH	0 WH	0 WH
								TOTAL FLUORESCENT	TOTAL LED	TOTAL DIFFERENCE
TOTAL FPSPAD-RC								0 WH	0 WH	0 WH

2-First Floor:

FPSPAD-1ST										
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE			LED WATT-HOUR PER FIXTURE		TOTAL CONSUMPTION WATT-HOUR		
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT	LED	DIFFERENCE
1ST-FPSPAD1	CLASS 1	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
1ST-FPSPAD2	CLASS 2	15	2X36	2X9	90	2X22	44	1350 WH	660 WH	690 WH
1ST-FPSPAD3	CLASS 3	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
1ST-FPSPAD4	CLASS 4	9	2X36	2X9	90	2X22	44	810 WH	396 WH	414 WH
1ST-FPSPAD5	CLASS 5	9	2X36	2X9	90	2X22	44	810 WH	396 WH	414 WH
1ST-FPSPAD6	CLASS 6	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
1ST-FPSPAD7	CLASS 7	15	2X36	2X9	90	2X22	44	1350 WH	660 WH	690 WH
1ST-FPSPAD8	CLASS 8	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
								TOTAL FLUORESCENT	TOTAL LED	TOTAL DIFFERENCE
TOTAL FPSPAD-1ST								8640 WH	4224 WH	4416 WH

3- Second Floor:

FPSPAD-2ND										
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE			LED WATT-HOUR PER FIXTURE		TOTAL CONSUMPTION WATT-HOUR		
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT	LED	DIFFERENCE
2ND-FPSPAD1	CLASS 1	9	2X36	2X9	90	2X22	44	810 WH	396 WH	414 WH
2ND-FPSPAD2	CLASS 2	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
2ND-FPSPAD3	CLASS 3	10	2X36	2X9	90	2X22	44	900 WH	440 WH	460 WH
2ND-FPSPAD4	CLASS 4	6	2X36	2X9	90	2X22	44	540 WH	264 WH	276 WH
2ND-FPSPAD5	CLASS 5	10	2X36	2X9	90	2X22	44	900 WH	440 WH	460 WH
2ND-FPSPAD6	CLASS 6	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
2ND-FPSPAD7	CLASS 7	9	2X36	2X9	90	2X22	44	810 WH	396 WH	414 WH
								TOTAL FLUORESCENT	TOTAL LED	TOTAL DIFFERENCE
TOTAL FPSPAD-2ND								6120 WH	2992 WH	3128 WH

Faculty of Natural & Applied Sciences (FNAS):

1-Ground Floor:

FNAS-RC														
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE			LED WATT-HOUR PER FIXTURE		TOTAL CONSUMPTION WATT-HOUR						
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT		LED		DIFFERENCE		
RC-FNAS1	CLASS 1	6	2X36	2X9	90	2X22	44	540	WH	264	WH	276	WH	
RC-FNAS2	CLASS 2	12	2X36	2X9	90	2X22	44	1080	WH	528	WH	552	WH	
RC-FNAS3	CLASS 3	12	2X36	2X9	90	2X22	44	1080	WH	528	WH	552	WH	
RC-FNAS4	CLASS 4	12	2X36	2X9	90	2X22	44	1080	WH	528	WH	552	WH	
RC-FNAS5	CLASS 5	12	2X36	2X9	90	2X22	44	1080	WH	528	WH	552	WH	
RC-FNAS6	CLASS 6	12	2X36	2X9	90	2X22	44	1080	WH	528	WH	552	WH	
RC-FNAS7	CLASS 7	15	2X36	2X9	90	2X22	44	1350	WH	660	WH	690	WH	
RC-FNAS8	CLASS 8	6	2X36	2X9	90	2X22	44	540	WH	264	WH	276	WH	
RC-FNAS9	CLASS 9	12	2X36	2X9	90	2X22	44	1080	WH	528	WH	552	WH	
RC-FNAS10	CLASS 10	12	2X36	2X9	90	2X22	44	1080	WH	528	WH	552	WH	
								TOTAL FLUORESCENT		TOTAL LED		TOTAL DIFFERENCE		
TOTAL FNAS-RC								9990	WH	4884	WH	5106	WH	

2- First Floor:

FNAS-1ST											
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE			LED WATT-HOUR PER FIXTURE		TOTAL CONSUMPTION WATT-HOUR			
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT		LED		DIFFERENCE	
1ST-FNAS1	OFFICE 1	3	2X36	2X9	90	2X22	44	270 WH	132 WH	138 WH
1ST-FNAS2	OFFICE 2	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS3	OFFICE 3	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS4	OFFICE 4	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
1ST-FNAS5	OFFICE 5	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS6	OFFICE 6	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS7	OFFICE 7	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS8	OFFICE 8	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS9	OFFICE 9	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS10	OFFICE 10	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS11	OFFICE 11	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS12	OFFICE 12	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH
1ST-FNAS13	OFFICE 13	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS14	OFFICE 14	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS15	OFFICE 15	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS16	OFFICE 16	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS17	OFFICE 17	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS18	OFFICE 18	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS19	OFFICE 19	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS20	OFFICE 20	3	2X36	2X9	90	2X22	44	270 WH	132 WH	138 WH
1ST-FNAS21	OFFICE 21	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS22	OFFICE 22	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS23	OFFICE 23	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS24	OFFICE 24	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS25	OFFICE 25	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FNAS26	OFFICE 26	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
								TOTAL FLUORESCENT	TOTAL LED	TOTAL DIFFERENCE
TOTAL FNAS-1ST								3060 WH	1496 WH	1564 WH

3- Second Floor:

FNAS-2ND										
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE			LED WATT-HOUR PER FIXTURE		TOTAL CONSUMPTION WATT-HOUR		
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT	LED	DIFFERENCE
2ND-FNAS1	OFFICE 1	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH
2ND-FNAS2	OFFICE 2	9	2X36	2X9	90	2X22	44	810 WH	396 WH	414 WH
2ND-FNAS3	OFFICE 3	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
2ND-FNAS4	OFFICE 4	3	2X36	2X9	90	2X22	44	270 WH	132 WH	138 WH
2ND-FNAS5	OFFICE 5	3	2X36	2X9	90	2X22	44	270 WH	132 WH	138 WH
2ND-FNAS6	OFFICE 6	3	2X36	2X9	90	2X22	44	270 WH	132 WH	138 WH
2ND-FNAS7	OFFICE 7	3	2X36	2X9	90	2X22	44	270 WH	132 WH	138 WH
2ND-FNAS8	OFFICE 8	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
2ND-FNAS9	OFFICE 9	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH
2ND-FNAS10	OFFICE 10	6	2X36	2X9	90	2X22	44	540 WH	264 WH	276 WH
2ND-FNAS11	OFFICE 11	6	2X36	2X9	90	2X22	44	540 WH	264 WH	276 WH
2ND-FNAS12	OFFICE 12	6	2X36	2X9	90	2X22	44	540 WH	264 WH	276 WH
2ND-FNAS13	OFFICE 13	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
2ND-FNAS14	OFFICE 14	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH
2ND-FNAS15	OFFICE 15	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH
2ND-FNAS16	OFFICE 16	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH
2ND-FNAS17	OFFICE 17	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH
2ND-FNAS18	OFFICE 18	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH
2ND-FNAS19	OFFICE 19	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH
								TOTAL FLUORESCENT	TOTAL LED	TOTAL DIFFERENCE
TOTAL FNAS-2ND								8730 WH	4268 WH	4462 WH

Faculty of Engineering (FE):

1-Ground Floor:

FE-RC										
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE			LED WATT-HOUR PER FIXTURE		TOTAL CONSUMPTION WATT-HOUR		
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT	LED	DIFFERENCE
RC-FE1	CLASS 1	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
RC-FE2	CLASS 2	15	2X36	2X9	90	2X22	44	1350 WH	660 WH	690 WH
RC-FE3	CLASS 3	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
RC-FE4	CLASS 4	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
RC-FE5	CLASS 5	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
RC-FE6	CLASS 6	12	2X36	2X9	90	2X22	44	1080 WH	528 WH	552 WH
								TOTAL FLUORESCENT	TOTAL LED	TOTAL DIFFERENCE
TOTAL FE-RC								6750 WH	3300 WH	3450 WH

2-First Floor:

FE-1ST										
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE			LED WATT-HOUR PER FIXTURE		TOTAL CONSUMPTION WATT-HOUR		
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT	LED	DIFFERENCE
1ST-FE1	OFFICE 1	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FE2	OFFICE 2	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FE3	OFFICE 3	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FE4	OFFICE 4	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FE5	OFFICE 5	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FE6	OFFICE 6	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FE7	OFFICE 7	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FE8	OFFICE 8	3	2X36	2X9	90	2X22	44	270 WH	132 WH	138 WH
1ST-FE9	OFFICE 9	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FE10	OFFICE 10	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FE11	OFFICE 11	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FE12	OFFICE 12	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FE13	OFFICE 13	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FE14	OFFICE 14	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FE15	OFFICE 15	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FE16	OFFICE 16	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FE17	OFFICE 17	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FE18	OFFICE 18	3	2X36	2X9	90	2X22	44	270 WH	132 WH	138 WH
1ST-FE19	OFFICE 19	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FE20	OFFICE 20	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FE21	OFFICE 21	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
1ST-FE22	OFFICE 22	1	2X36	2X9	90	2X22	44	90 WH	44 WH	46 WH
								TOTAL FLUORESCENT	TOTAL LED	TOTAL DIFFERENCE
TOTAL FE-1ST								2340 WH	1144 WH	1196 WH

3-Second Floor:

FE-2ND										
ROOM	DEFINITION	NUMBER OF FIXTURES	FLUORESCENT WATT-HOUR PER FIXTURE			LED WATT-HOUR PER FIXTURE		TOTAL CONSUMPTION WATT-HOUR		
			LAMP	BALLAST	TOTAL	LAMP	TOTAL	FLUORESCENT	LED	DIFFERENCE
2ND-FE1	OFFICE 1	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH
2ND-FE2	OFFICE 2	9	2X36	2X9	90	2X22	44	810 WH	396 WH	414 WH
2ND-FE3	OFFICE 3	8	2X36	2X9	90	2X22	44	720 WH	352 WH	368 WH
2ND-FE4	OFFICE 4	3	2X36	2X9	90	2X22	44	270 WH	132 WH	138 WH
2ND-FE5	OFFICE 5	3	2X36	2X9	90	2X22	44	270 WH	132 WH	138 WH
2ND-FE6	OFFICE 6	3	2X36	2X9	90	2X22	44	270 WH	132 WH	138 WH
2ND-FE7	OFFICE 7	3	2X36	2X9	90	2X22	44	270 WH	132 WH	138 WH
2ND-FE8	OFFICE 8	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
2ND-FE9	OFFICE 9	2	2X36	2X9	90	2X22	44	180 WH	88 WH	92 WH
2ND-FE10	OFFICE 10	3	2X36	2X9	90	2X22	44	270 WH	132 WH	138 WH
2ND-FE11	OFFICE 11	3	2X36	2X9	90	2X22	44	270 WH	132 WH	138 WH
2ND-FE12	OFFICE 12	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH
2ND-FE13	OFFICE 13	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH
2ND-FE14	OFFICE 14	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH
2ND-FE15	OFFICE 15	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH
2ND-FE16	OFFICE 16	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH
2ND-FE17	OFFICE 17	4	2X36	2X9	90	2X22	44	360 WH	176 WH	184 WH
								TOTAL FLUORESCENT	TOTAL LED	TOTAL DIFFERENCE
TOTAL FE-2ND								6030 WH	2948 WH	3082 WH

APPENDIX C

Philips Quotations

Fluorescent Quotation:

PHILIPS

Light Incorporated & Trading s.a.l

QUOTATION

TO MSSERS	: NDU		REF	: LIT-12-210/1
ATTN	: MR. CHARBEL HAJJ		DATE	: 04-May-12
ADDRESS	: ZOUK MOSBEH, LEBANON		CONTACT	: NADIM TRAD
PHONE	: 09-208000			
FAX	: 09-225164			
MOBILE	:			
EMAIL ADD	: purchasing@ndu.edu.lb			
PROJECT	: NDU - FLUO TUBE OFFER			
LOCATION	: ZOUK MOSBEH			

ITEM	CODE	DESCRIPTIONS	QTY	U/PRICE	T/PRICE
1	C400-098	PHILIPS FLUORESCENT LAMP TLD 36W/54	2220	0.84	1,864.80
				SUBTOTAL :	1,864.80
				VAT :	186.48
				TOTAL :	2,051.28

TOTAL : *Two Thousand Fifty One And 28/100 USD Only*

TERMS & CONDITIONS

CURRENCY : USD.
PAYMENT : 50% UPON ORDER CONFIRMATION, 50% UPON DELIVERY.
VALIDITY : 30 CALENDAR DAYS.
DELIVERY : 10 TO 12 WEEKS FROM OFFER CONFIRMATION DATE AND DOWN PAYMENT FULFILLEMENT.

NADIM TRAD
LED PROJECT MANAGER

H. CHAHINE
GENERAL MANAGER

FOR ACCEPTANCE PLEASE SIGN AND RETURN: ....

DATE: ....

C.R.B 44256 - VAT: 1410 - 601

LED Quotation:

PHILIPS

Light Incorporated & Trading s.a.l

QUOTATION

TO MSSERS	: NDU	REF	: LIT-12-209/1
ATTN	: MR. CHARBEL HAJJ	DATE	: 04-May-12
ADDRESS	: ZOUK MOSBEH, LEBANON	CONTACT	: NADIM TRAD
PHONE	: 09-208000		
FAX	: 09-225164		
MOBILE	:		
EMAIL ADD	: purchasing@ndu.edu.lb		
PROJECT	: NDU UPLAMPING - LEDtube OFFER		
LOCATION	: ZOUK MOSBEH		

ITEM	CODE	DESCRIPTIONS	QTY	U/PRICE	T/PRICE
1	C501-155	PHILIPS LEDtube GA 1200mm 22W 865 G13	2220	80.00	177,600.00
				SUBTOTAL :	177,600.00
				DISCOUNT :	20%
				SUBTOTAL :	142,080.00
				VAT :	14,208.00
				TOTAL :	156,288.00

TOTAL : *One Hundred Fifty Six Thousand Two Hundred And Eighty Eight USD Only*

TERMS & CONDITIONS

CURRENCY : USD.
PAYMENT : 50% UPON ORDER CONFIRMATION, 50% UPON DELIVERY.
VALIDITY : 30 CALENDAR DAYS.
DELIVERY : 10 TO 12 WEEKS FROM OFFER CONFIRMATION DATE AND DOWN PAYMENT FULFILLEMENT.

NADIM TRAD
LED PROJECT MANAGER

H. CHAHINE
GENERAL MANAGER

FOR ACCEPTANCE PLEASE SIGN AND RETURN: ....

DATE: ....

1/1

C.R.B 44256 - VAT: 1410 - 601

APPENDIX D

Dawtec

Dawtec Quotation:

dawtec

Quotation

Project	: On-Grid PV Power Generation	Date	:	14-May-12
Attn.	: Mr. Patrick Hajj	Ref.	:	sa/Q-149/12
Phone/Fax	: 03-413744	VAT Reg.	:	375085-601
Email	: phajje@hotmail.com	Page	:	1 of 1

Option A: 5KW Single Phase On-Grid Power Generation by Solar Photovoltaic Panels

Item		Description/Manufacturer	Qty	Unit Price	Total Price
A		5KW Single Phase On-Grid Solar Power Generation			
		5KW Single Phase On-Grid Power Generation by Solar Photovoltaic System includes the following:			
A.1		- 245Wp Solar Photovoltaic Module	20	$ 612.50	$ 12,250.00
A.2		- 5KW On-Grid Inverter	1	$ 3,000.00	$ 3,000.00
A.3		- Panel Mounting Structure			$ 1,200.00
A.4		- Wiring, Combiner Boxes and Installation			$ 2,467.50
			Total:		$ 18,917.50
			VAT:		$ 1,891.75
			Final Price:		$ 20,809.25

Final Price: $ 20,809.25
Only Twenty Thousand Eight Hundred Nine and 25/100 U.S. Dollars

Option B: 10KW Three Phase On-Grid Power Generation by Solar Photovoltaic Panels

Item		Description/Manufacturer	Qty	Unit Price	Total Price
B		10KW Three Phase On-Grid Solar Power Generation			
		10KW Single Phase On-Grid Power Generation by Solar Photovoltaic System includes the following:			
B.1		- 245Wp Solar Photovoltaic Module	40	$ 612.50	$ 24,500.00
B.2		- 10KW On-Grid Inverter	1	$ 5,500.00	$ 5,500.00
B.3		- Panel Mounting Structure			$ 2,400.00
B.4		- Wiring, Combiner Boxes and Installation			$ 4,860.00
			Total:		$ 37,260.00
			VAT:		$ 3,726.00
			Final Price:		$ 40,986.00

Final Price: $ 40,986.00
Only Forty Thousand Nine Hundred Eighty Six U.S. Dollars

Notes:

1- **Payment facilities for up to 14 years with zero down payment and zero interest rate**
2- Prices were quoted at the present exchange rate (1USD = 1507.5LBP). In case of any fluctuations in the current exchange rate, our prices will be adjusted accordingly

Terms and Conditions

Offer validity: 30 days
Delivery: 50 days from downpayment
Payment: 60% upon confirmation, 20% upon delivery and 20% upon installation

Clients Signature for Approval: ____________________

Date: ____________________

Data Sheet CSUN250 – 60M Module:

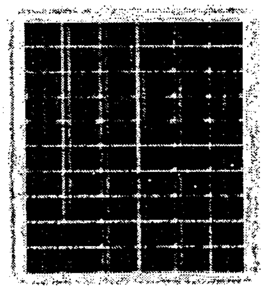
CSUN

CSUN250 -60M

Highest Module Efficiency: 16.02%

Our standard modules are designed, developed and manufactured for both residential and commercial, rooftop and ground-mounted, as well as on-grid and off-grid photovoltaic projects.

Quality of our products is the reason of CSUN's life. We select the best raw materials and conduct regular testing to ensure that they can meet our rigorous quality standards. Every module has been tested before delivery to make sure the efficiency tolerance is in a narrow range. Each link is strictly controlled to ensure the benefit of our customers.



Features

- 60 High-Efficiency Monocrystalline Solar Cells;
- Passing mechanical load test of 5400Pa according to IEC 61215 (advanced test);
- Tested to withstand hails with maximum diameter of 25mm with impact speed of 23m/s;
- The high-transperency low-iron tempered glass allows maximum light permeability while enhancing stiffness and impact resistance;
- Integrated bypass diodes to protect the solar cell circuit from hot spots during partial shadowing;
- Our module technology avoids any problems of water freezing and warping;
- Black backsheet or black frame is also available.

Quality and Certificates

- 10-year limited product warranty;
- 25-year power output warranty.*
- Certifications**:

Certification Authority	Test Standard	Power Range
TÜV Rheinland	IEC61215 IEC61730	210W-270W
Intertek	UL1703	210W-270W
CEC	IEC61215 UL1703	210W-270W
FSEC	IEC61215 UL1703	210W-270W
MCS	IEC61215 IEC61730	210W-270W
CGC	IEC61215 IEC61730	255W-305W

* 12 year at 90% of the minimal rated power output, 20 year at 83%, and 25 year at 80%
**Note: All specifications, warranties, certifications about module of "CSUN" series also apply to that of "SST"

China Sunergy (Nanjing) Co., Ltd. www.chinasunergy.com

Specifications

Type	250-60M	245-60M	240-60M	235-60M
	Electrical typical data			
Pmpp [W]	250	245	240	240
Voc [V]	37.3	37.2	37.0	37.0
Isc [A]	8.78	8.69	8.62	8.62
Vmpp [V]	30.1	30.0	29.8	29.8
Impp [A]	8.31	8.17	8.05	8.06
Practical module efficiency	17.44%	17.09%	16.74%	16.39%
Module efficiency	15.40%	15.02%	14.78%	14.47%
Maximum system voltage [V]	1000			
Voltage temperature coefficient	-0.320%/K			
Current temperature coefficient	+0.030%/K			
Power temperature coefficient	-0.423%/K			
Series fuse rating[A]	20			
Cells	6x10 pieces monocrystalline solar cells series strings (156mm×156mm)			
Junction box	with 6 bypass diodes			
Cable	length 900 mm, 1×4 mm²			
Front glass	white toughened safety glass, 3.2 mm			
Cell encapsulation	EVA (Ethylene-Vinyl-Acetate)			
Back sheet	composite film			
Frame	Anodized aluminum profile			
Dimensions	1640x990x40mm (LxWxH)			
Maximum surface load capacity	5,400 Pa			
Hail	maximum diameter of 25 mm with impact speed of 23 m·s⁻¹			
Temperature range	– 40 °C to + 85 °C			
Weight	19.1kg			

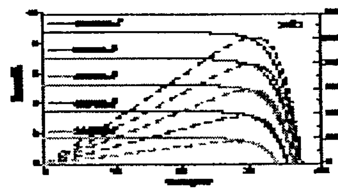
The electrical data relates to standard test conditions (STC): 1,000 W/m², AM 1.5, 25°C.
performance deviation of Pmpp: ±3%, performance deviation of Voc[V], Isc[A], Vmpp[V] and Impp[A]: ±10%.
certified in accordance with IEC 61215, IEC 61730-1/2 and UL 1703.

Operating Condition & Packaging

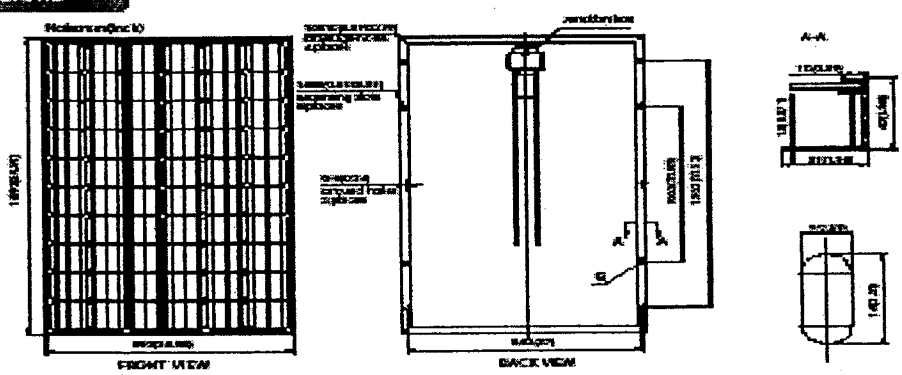
Maximum surface load capacity	tested up to 5,400 Pa according to IEC 61215
Hail	maximum diameter of 25 mm with impact speed of 23 m/s (51.2mph)
Temperature range	– 40 °C to + 85 °C

Dimensions(LxWxH)	Container 20'	Container 20'HC	Container 40'	Container 40'HC
1640x990x40mm	300	324	5,700	756

IV-Curves



Dimensions



APPENDIX E

Solar Photovoltaic Panels Vs. Regular Power Generation

Month of January:

Day 1:

WINTER TIME - FULL DAY - JANUARY											
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER (REGULAR)	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 1 DURING THE WEEK	8:00	9:00	100%	48	EDL	112	112	11	59,136	59,136	
	9:00	10:00	100%	48	EDL	112	112	11	59,136	59,136	
	10:00	11:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	11:00	12:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	12:00	13:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	13:00	14:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	14:00	15:00	90%	43.2	EDL	112	112	11	53,222	53,222	
	15:00	16:00	90%	43.2	EDL	112	112	11	53,222	53,222	
	16:00	17:00	65%	31.2	EDL	320	320	11	109,824	109,824	
	17:00	18:00	65%	31.2	EDL	320	320	11	109,824	109,824	
	18:00	19:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
	19:00	20:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
DAY 1 WEEKEND	8:00	9:00	0%	0	EDL	112	112	4	0	0	
	9:00	10:00	0%	0	EDL	112	112	4	0	0	
	10:00	11:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	11:00	12:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	12:00	13:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	13:00	14:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	14:00	15:00	0%	0	EDL	112	112	4	0	0	
	15:00	16:00	0%	0	EDL	112	112	4	0	0	
	16:00	17:00	0%	0	EDL	320	320	4	0	0	
	17:00	18:00	0%	0	EDL	320	320	4	0	0	
	18:00	19:00	0%	0	GENERATORS	350	350	4	0	0	
	19:00	20:00	0%	0	GENERATORS	350	350	4	0	0	
	TOTAL								1,312,925	573,725	86,016

Day 2:

WINTER TIME - FULL DAY - JANUARY											
	START	END	FACULTY LOAD	POWER USAGE (kw)	SOURCE OF POWER	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 2 DURING THE WEEK	8:00	9:00	100%	48	GENERATORS	350	350	11	184,800	184,800	
	9:00	10:00	100%	48	GENERATORS	350	350	11	184,800	184,800	
	10:00	11:00	100%	48	EDL	112	0	11	59,136	0	0
	11:00	12:00	100%	48	EDL	112	0	11	59,136	0	0
	12:00	13:00	100%	48	EDL	112	0	11	59,136	0	0
	13:00	14:00	100%	48	EDL	112	0	11	59,136	0	0
	14:00	15:00	90%	43.2	GENERATORS	350	350	11	166,320	166,320	
	15:00	16:00	90%	43.2	GENERATORS	350	350	11	166,320	166,320	
	16:00	17:00	65%	31.2	GENERATORS	350	350	11	120,120	120,120	
	17:00	18:00	65%	31.2	GENERATORS	350	350	11	120,120	120,120	
	18:00	19:00	35%	16.8	EDL	320	320	11	59,136	59,136	
	19:00	20:00	35%	16.8	EDL	320	320	11	59,136	59,136	
DAY 2 WEEKEND	8:00	9:00	0%	0	GENERATORS	350	350	4	0	0	
	9:00	10:00	0%	0	GENERATORS	350	350	4	0	0	
	10:00	11:00	0%	0	EDL	112	0	4	0	0	21,504
	11:00	12:00	0%	0	EDL	112	0	4	0	0	21,504
	12:00	13:00	0%	0	EDL	112	0	4	0	0	21,504
	13:00	14:00	0%	0	EDL	112	0	4	0	0	21,504
	14:00	15:00	0%	0	GENERATORS	350	350	4	0	0	
	15:00	16:00	0%	0	GENERATORS	350	350	4	0	0	
	16:00	17:00	0%	0	GENERATORS	350	350	4	0	0	
	17:00	18:00	0%	0	GENERATORS	350	350	4	0	0	
	18:00	19:00	0%	0	EDL	320	320	4	0	0	
	19:00	20:00	0%	0	EDL	320	320	4	0	0	
	TOTAL								1,297,296	1,060,752	86,016
JANUARY											
TOTAL COST – DAY 1 & DAY 2									2,610,221	1,634,477	172,032

Month of February:

Day 1:

WINTER TIME - FULL DAY - FEBRUARY											
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER (REGULAR)	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 1 DURING THE WEEK	8:00	9:00	100%	48	EDL	112	112	11	59,136	59,136	
	9:00	10:00	100%	48	EDL	112	112	11	59,136	59,136	
	10:00	11:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	11:00	12:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	12:00	13:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	13:00	14:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	14:00	15:00	90%	43.2	EDL	112	0	11	53,222	0	5,914
	15:00	16:00	90%	43.2	EDL	112	112	11	53,222	53,222	
	16:00	17:00	65%	31.2	EDL	320	320	11	109,824	109,824	
	17:00	18:00	65%	31.2	EDL	320	320	11	109,824	109,824	
	18:00	19:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
	19:00	20:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
DAY 1 WEEKEND	8:00	9:00	0%	0	EDL	112	112	4	0	0	
	9:00	10:00	0%	0	EDL	112	112	4	0	0	
	10:00	11:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	11:00	12:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	12:00	13:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	13:00	14:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	14:00	15:00	0%	0	EDL	112	0	4	0	0	21,504
	15:00	16:00	0%	0	EDL	112	112	4	0	0	
	16:00	17:00	0%	0	EDL	320	112	4	0	0	
	17:00	18:00	0%	0	EDL	320	112	4	0	0	
	18:00	19:00	0%	0	GENERATORS	350	350	4	0	0	
	19:00	20:00	0%	0	GENERATORS	350	350	4	0	0	
	TOTAL								1,312,925	520,502	113,434

Day 2:

WINTER TIME - FULL DAY - FEBRUARY											
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 2 DURING THE WEEK	8:00	9:00	100%	48	GENERATORS	350	350	11	184,800	184,800	
	9:00	10:00	100%	48	GENERATORS	350	350	11	184,800	184,800	
	10:00	11:00	100%	48	EDL	112	0	11	59,136	0	0
	11:00	12:00	100%	48	EDL	112	0	11	59,136	0	0
	12:00	13:00	100%	48	EDL	112	0	11	59,136	0	0
	13:00	14:00	100%	48	EDL	112	0	11	59,136	0	0
	14:00	15:00	90%	43.2	GENERATORS	350	0	11	166,320	0	5,914
	15:00	16:00	90%	43.2	GENERATORS	350	350	11	166,320	166,320	
	16:00	17:00	65%	31.2	GENERATORS	350	350	11	120,120	120,120	
	17:00	18:00	65%	31.2	GENERATORS	350	350	11	120,120	120,120	
	18:00	19:00	35%	16.8	EDL	320	320	11	59,136	59,136	
	19:00	20:00	35%	16.8	EDL	320	320	11	59,136	59,136	
DAY 2 WEEKEND	8:00	9:00	0%	0	GENERATORS	350	350	4	0	0	
	9:00	10:00	0%	0	GENERATORS	350	350	4	0	0	
	10:00	11:00	0%	0	EDL	112	0	4	0	0	21,504
	11:00	12:00	0%	0	EDL	112	0	4	0	0	21,504
	12:00	13:00	0%	0	EDL	112	0	4	0	0	21,504
	13:00	14:00	0%	0	EDL	112	0	4	0	0	21,504
	14:00	15:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	15:00	16:00	0%	0	GENERATORS	350	350	4	0	0	
	16:00	17:00	0%	0	GENERATORS	350	350	4	0	0	
	17:00	18:00	0%	0	GENERATORS	350	350	4	0	0	
	18:00	19:00	0%	0	EDL	320	320	4	0	0	
	19:00	20:00	0%	0	EDL	320	320	4	0	0	
	TOTAL								1,297,296	894,432	113,434
FEBRUARY											
TOTAL COST – DAY 1 & DAY 2									2,610,221	1,414,934	226,867

Month of March:

Day 1:

WINTER TIME - FULL DAY - MARCH											
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER (REGULAR)	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 1 DURING THE WEEK	8:00	9:00	100%	48	EDL	112	112	11	59,136	59,136	
	9:00	10:00	100%	48	EDL	112	0	11	59,136	0	0
	10:00	11:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	11:00	12:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	12:00	13:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	13:00	14:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	14:00	15:00	90%	43.2	EDL	112	0	11	53,222	0	5,914
	15:00	16:00	90%	43.2	EDL	112	112	11	53,222	53,222	
	16:00	17:00	65%	31.2	EDL	320	320	11	109,824	109,824	
	17:00	18:00	65%	31.2	EDL	320	320	11	109,824	109,824	
	18:00	19:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
	19:00	20:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
DAY 1 WEEKEND	8:00	9:00	0%	0	EDL	112	112	4	0	0	
	9:00	10:00	0%	0	EDL	112	0	4	0	0	21,504
	10:00	11:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	11:00	12:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	12:00	13:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	13:00	14:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	14:00	15:00	0%	0	EDL	112	0	4	0	0	21,504
	15:00	16:00	0%	0	EDL	112	112	4	0	0	
	16:00	17:00	0%	0	EDL	320	112	4	0	0	
	17:00	18:00	0%	0	EDL	320	112	4	0	0	
	18:00	19:00	0%	0	GENERATORS	350	350	4	0	0	
	19:00	20:00	0%	0	GENERATORS	350	350	4	0	0	
	TOTAL								1,312,925	461,366	134,938

Day 2:

WINTER TIME - FULL DAY - MARCH											
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER	REGULAR RATE IN L.L	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 2 DURING THE WEEK	8:00	9:00	100%	48	GENERATORS	350	350	11	184,800	184,800	
	9:00	10:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	10:00	11:00	100%	48	EDL	112	0	11	59,136	0	0
	11:00	12:00	100%	48	EDL	112	0	11	59,136	0	0
	12:00	13:00	100%	48	EDL	112	0	11	59,136	0	0
	13:00	14:00	100%	48	EDL	112	0	11	59,136	0	0
	14:00	15:00	90%	43.2	GENERATORS	350	0	11	166,320	0	5,914
	15:00	16:00	90%	43.2	GENERATORS	350	350	11	166,320	166,320	
	16:00	17:00	65%	31.2	GENERATORS	350	350	11	120,120	120,120	
	17:00	18:00	65%	31.2	GENERATORS	350	350	11	120,120	120,120	
	18:00	19:00	35%	16.8	EDL	320	320	11	59,136	59,136	
	19:00	20:00	35%	16.8	EDL	320	320	11	59,136	59,136	
DAY 2 WEEKEND	8:00	9:00	0%	0	GENERATORS	350	350	4	0	0	
	9:00	10:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	10:00	11:00	0%	0	EDL	112	0	4	0	0	21,504
	11:00	12:00	0%	0	EDL	112	0	4	0	0	21,504
	12:00	13:00	0%	0	EDL	112	0	4	0	0	21,504
	13:00	14:00	0%	0	EDL	112	0	4	0	0	21,504
	14:00	15:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	15:00	16:00	0%	0	GENERATORS	350	350	4	0	0	
	16:00	17:00	0%	0	GENERATORS	350	350	4	0	0	
	17:00	18:00	0%	0	GENERATORS	350	350	4	0	0	
	18:00	19:00	0%	0	EDL	320	320	4	0	0	
	19:00	20:00	0%	0	EDL	320	320	4	0	0	
	TOTAL								1,297,296	709,632	134,938
MARCH											
TOTAL COST – DAY 1 & DAY 2									2,610,221	1,170,998	269,875

Month of April:

Day 1:

SUMMER TIME - FULL DAY - APRIL											
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER (REGULAR)	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 1 DURING THE WEEK	8:00	9:00	100%	48	EDL	112	112	11	59,136	59,136	
	9:00	10:00	100%	48	EDL	112	0	11	59,136	0	0
	10:00	11:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	11:00	12:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	12:00	13:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	13:00	14:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	14:00	15:00	90%	43.2	EDL	112	0	11	53,222	0	5,914
	15:00	16:00	90%	43.2	EDL	112	112	11	53,222	53,222	
	16:00	17:00	65%	31.2	EDL	112	320	11	38,438	109,824	
	17:00	18:00	65%	31.2	EDL	112	320	11	38,438	109,824	
	18:00	19:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
	19:00	20:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
DAY 1 WEEKEND	8:00	9:00	0%	0	EDL	112	112	4	0	0	
	9:00	10:00	0%	0	EDL	112	0	4	0	0	21,504
	10:00	11:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	11:00	12:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	12:00	13:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	13:00	14:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	14:00	15:00	0%	0	EDL	112	0	4	0	0	21,504
	15:00	16:00	0%	0	EDL	112	112	4	0	0	
	16:00	17:00	0%	0	EDL	112	112	4	0	0	
	17:00	18:00	0%	0	EDL	112	112	4	0	0	
	18:00	19:00	0%	0	GENERATORS	350	350	4	0	0	
	19:00	20:00	0%	0	GENERATORS	350	350	4	0	0	
	TOTAL								1,170,154	461,366	134,938

Day 2:

SUMMER TIME - FULL DAY - APRIL											
	START	END	FACULTY LOAD	POWER CONSUMPTION	SOURCE OF POWER	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 2 DURING THE WEEK	8:00	9:00	100%	48	GENERATORS	350	350	11	184,800	184,800	
	9:00	10:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	10:00	11:00	100%	48	EDL	112	0	11	59,136	0	0
	11:00	12:00	100%	48	EDL	112	0	11	59,136	0	0
	12:00	13:00	100%	48	EDL	112	0	11	59,136	0	0
	13:00	14:00	100%	48	EDL	112	0	11	59,136	0	0
	14:00	15:00	90%	43.2	GENERATORS	350	0	11	166,320	0	5,914
	15:00	16:00	90%	43.2	GENERATORS	350	350	11	166,320	166,320	
	16:00	17:00	65%	31.2	GENERATORS	350	350	11	120,120	120,120	
	17:00	18:00	65%	31.2	GENERATORS	350	350	11	120,120	120,120	
	18:00	19:00	35%	16.8	EDL	320	320	11	59,136	59,136	
	19:00	20:00	35%	16.8	EDL	320	320	11	59,136	59,136	
DAY 2 WEEKEND	8:00	9:00	0%	0	GENERATORS	350	350	4	0	0	
	9:00	10:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	10:00	11:00	0%	0	EDL	112	0	4	0	0	21,504
	11:00	12:00	0%	0	EDL	112	0	4	0	0	21,504
	12:00	13:00	0%	0	EDL	112	0	4	0	0	21,504
	13:00	14:00	0%	0	EDL	112	0	4	0	0	21,504
	14:00	15:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	15:00	16:00	0%	0	GENERATORS	350	350	4	0	0	
	16:00	17:00	0%	0	GENERATORS	350	350	4	0	0	
	17:00	18:00	0%	0	GENERATORS	350	350	4	0	0	
	18:00	19:00	0%	0	EDL	320	320	4	0	0	
	19:00	20:00	0%	0	EDL	320	320	4	0	0	
	TOTAL								1,297,296	709,632	134,938
APRIL											
TOTAL COST – DAY 1 & DAY 2									2,467,450	1,170,998	269,875

Month of May:

Day 1:

SUMMER TIME - FULL DAY - MAY											
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER (REGULAR)	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 1 DURING THE WEEK	8:00	9:00	100%	48	EDL	112	112	11	59,136	59,136	
	9:00	10:00	100%	48	EDL	112	0	11	59,136	0	0
	10:00	11:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	11:00	12:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	12:00	13:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	13:00	14:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	14:00	15:00	90%	43.2	EDL	112	0	11	53,222	0	5,914
	15:00	16:00	90%	43.2	EDL	112	0	11	53,222	0	5,914
	16:00	17:00	65%	31.2	EDL	112	320	11	38,438	109,824	
	17:00	18:00	65%	31.2	EDL	112	320	11	38,438	109,824	
	18:00	19:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
	19:00	20:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
DAY 1 WEEKEND	8:00	9:00	0%	0	EDL	112	112	4	0	0	
	9:00	10:00	0%	0	EDL	112	0	4	0	0	21,504
	10:00	11:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	11:00	12:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	12:00	13:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	13:00	14:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	14:00	15:00	0%	0	EDL	112	0	4	0	0	21,504
	15:00	16:00	0%	0	EDL	112	0	4	0	0	21,504
	16:00	17:00	0%	0	EDL	112	112	4	0	0	
	17:00	18:00	0%	0	EDL	112	112	4	0	0	
	18:00	19:00	0%	0	GENERATORS	350	350	4	0	0	
	19:00	20:00	0%	0	GENERATORS	350	350	4	0	0	
	TOTAL								1,170,154	408,144	162,355

Day 2:

SUMMER TIME - FULL DAY - MAY											
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 2 DURING THE WEEK	8:00	9:00	100%	48	GENERATORS	350	350	11	184,800	184,800	
	9:00	10:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	10:00	11:00	100%	48	EDL	112	0	11	59,136	0	0
	11:00	12:00	100%	48	EDL	112	0	11	59,136	0	0
	12:00	13:00	100%	48	EDL	112	0	11	59,136	0	0
	13:00	14:00	100%	48	EDL	112	0	11	59,136	0	0
	14:00	15:00	90%	43.2	GENERATORS	350	0	11	166,320	0	5,914
	15:00	16:00	90%	43.2	GENERATORS	350	0	11	166,320	0	5,914
	16:00	17:00	65%	31.2	GENERATORS	350	350	11	120,120	120,120	
	17:00	18:00	65%	31.2	GENERATORS	350	350	11	120,120	120,120	
	18:00	19:00	35%	16.8	EDL	320	320	11	59,136	59,136	
	19:00	20:00	35%	16.8	EDL	320	320	11	59,136	59,136	
DAY 2 WEEKEND	8:00	9:00	0%	0	GENERATORS	350	350	4	0	0	
	9:00	10:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	10:00	11:00	0%	0	EDL	112	0	4	0	0	21,504
	11:00	12:00	0%	0	EDL	112	0	4	0	0	21,504
	12:00	13:00	0%	0	EDL	112	0	4	0	0	21,504
	13:00	14:00	0%	0	EDL	112	0	4	0	0	21,504
	14:00	15:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	15:00	16:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	16:00	17:00	0%	0	GENERATORS	350	350	4	0	0	
	17:00	18:00	0%	0	GENERATORS	350	350	4	0	0	
	18:00	19:00	0%	0	EDL	320	320	4	0	0	
	19:00	20:00	0%	0	EDL	320	320	4	0	0	
	TOTAL								1,297,296	543,312	162,355
MAY											
TOTAL COST – DAY 1 & DAY 2									2,467,450	951,456	324,710

Month of June:

Day 1:

SUMMER TIME - HALF DAY- FULL OPERATION - JUNE											
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER (REGULAR)	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 1 DURING THE WEEK	8:00	9:00	85%	40.8	EDL	112	112	11	50,266	50,266	
	9:00	10:00	85%	40.8	EDL	112	0	11	50,266	0	8,870
	10:00	11:00	85%	40.8	GENERATORS	350	0	11	157,080	0	8,870
	11:00	12:00	85%	40.8	GENERATORS	350	0	11	157,080	0	8,870
	12:00	13:00	85%	40.8	GENERATORS	350	0	11	157,080	0	8,870
	13:00	14:00	85%	40.8	GENERATORS	350	0	11	157,080	0	8,870
	14:00	15:00	0%	0	EDL	112	0	11	0	0	59,136
	15:00	16:00	0%	0	EDL	112	0	11	0	0	59,136
	16:00	17:00	0%	0	EDL	112	0	11	0	0	59,136
	17:00	18:00	0%	0	EDL	112	320	11	0	0	
	18:00	19:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
	19:00	20:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
DAY 1 WEEKEND	8:00	9:00	0%	0	EDL	112	112	4	0	0	
	9:00	10:00	0%	0	EDL	112	0	4	0	0	21,504
	10:00	11:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	11:00	12:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	12:00	13:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	13:00	14:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	14:00	15:00	0%	0	EDL	112	0	4	0	0	21,504
	15:00	16:00	0%	0	EDL	112	0	4	0	0	21,504
	16:00	17:00	0%	0	EDL	112	0	4	0	0	21,504
	17:00	18:00	0%	0	EDL	112	112	4	0	0	
	18:00	19:00	0%	0	GENERATORS	350	350	4	0	0	
	19:00	20:00	0%	0	GENERATORS	350	350	4	0	0	
	TOTAL								858,211	179,626	393,792

Day 2:

SUMMER TIME - HALF DAY - FULL OPERATION - JUNE											
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 2 DURING THE WEEK	8:00	9:00	85%	40.8	GENERATORS	350	350	11	157,080	157,080	
	9:00	10:00	85%	40.8	GENERATORS	350	0	11	157,080	0	8,870
	10:00	11:00	85%	40.8	EDL	112	0	11	50,266	0	8,870
	11:00	12:00	85%	40.8	EDL	112	0	11	50,266	0	8,870
	12:00	13:00	85%	40.8	EDL	112	0	11	50,266	0	8,870
	13:00	14:00	85%	40.8	EDL	112	0	11	50,266	0	8,870
	14:00	15:00	0%	0	GENERATORS	350	0	11	0	0	59,136
	15:00	16:00	0%	0	GENERATORS	350	0	11	0	0	59,136
	16:00	17:00	0%	0	GENERATORS	350	0	11	0	0	59,136
	17:00	18:00	0%	0	GENERATORS	350	350	11	0	0	
	18:00	19:00	35%	16.8	EDL	320	320	11	59,136	59,136	
	19:00	20:00	35%	16.8	EDL	320	320	11	59,136	59,136	
DAY 2 WEEKEND	8:00	9:00	0%	0	GENERATORS	350	350	4	0	0	
	9:00	10:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	10:00	11:00	0%	0	EDL	112	0	4	0	0	21,504
	11:00	12:00	0%	0	EDL	112	0	4	0	0	21,504
	12:00	13:00	0%	0	EDL	112	0	4	0	0	21,504
	13:00	14:00	0%	0	EDL	112	0	4	0	0	21,504
	14:00	15:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	15:00	16:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	16:00	17:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	17:00	18:00	0%	0	GENERATORS	350	350	4	0	0	
	18:00	19:00	0%	0	EDL	320	320	4	0	0	
	19:00	20:00	0%	0	EDL	320	320	4	0	0	
	TOTAL								633,494	275,352	393,792
SUMMER TIME - HALF DAY- FULL OPERATION - JUNE											
TOTAL COST – DAY 1 & DAY 2									1,491,706	454,978	787,584

Month of July:

Day 1:

SUMMER TIME - HALF DAY- FULL OPERATION - JULY											
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER (REGULAR)	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 1 DURING THE WEEK	8:00	9:00	85%	40.8	EDL	112	112	11	50,266	50,266	
	9:00	10:00	85%	40.8	EDL	112	0	11	50,266	0	8,870
	10:00	11:00	85%	40.8	GENERATORS	350	0	11	157,080	0	8,870
	11:00	12:00	85%	40.8	GENERATORS	350	0	11	157,080	0	8,870
	12:00	13:00	85%	40.8	GENERATORS	350	0	11	157,080	0	8,870
	13:00	14:00	85%	40.8	GENERATORS	350	0	11	157,080	0	8,870
	14:00	15:00	0%	0	EDL	112	0	11	0	0	59,136
	15:00	16:00	0%	0	EDL	112	0	11	0	0	59,136
	16:00	17:00	0%	0	EDL	112	320	11	0	0	
	17:00	18:00	0%	0	EDL	112	320	11	0	0	
	18:00	19:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
	19:00	20:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
DAY 1 WEEKEND	8:00	9:00	0%	0	EDL	112	112	4	0	0	
	9:00	10:00	0%	0	EDL	112	0	4	0	0	21,504
	10:00	11:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	11:00	12:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	12:00	13:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	13:00	14:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	14:00	15:00	0%	0	EDL	112	0	4	0	0	21,504
	15:00	16:00	0%	0	EDL	112	0	4	0	0	21,504
	16:00	17:00	0%	0	EDL	112	112	4	0	0	
	17:00	18:00	0%	0	EDL	112	112	4	0	0	
	18:00	19:00	0%	0	GENERATORS	350	350	4	0	0	
	19:00	20:00	0%	0	GENERATORS	350	350	4	0	0	
	TOTAL								858,211	179,626	313,152

Day 2:

	START	END	FACULTY LOAD	POWER CONSUMPTION	SOURCE OF POWER	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
SUMMER TIME - HALF DAY - FULL OPERATION - JULY											
DAY 2 DURING THE WEEK	8:00	9:00	85%	40.8	GENERATORS	350	350	11	157,080	157,080	
	9:00	10:00	85%	40.8	GENERATORS	350	0	11	157,080	0	8,870
	10:00	11:00	85%	40.8	EDL	112	0	11	50,266	0	8,870
	11:00	12:00	85%	40.8	EDL	112	0	11	50,266	0	8,870
	12:00	13:00	85%	40.8	EDL	112	0	11	50,266	0	8,870
	13:00	14:00	85%	40.8	EDL	112	0	11	50,266	0	8,870
	14:00	15:00	0%	0	GENERATORS	350	0	11	0	0	59,136
	15:00	16:00	0%	0	GENERATORS	350	0	11	0	0	59,136
	16:00	17:00	0%	0	GENERATORS	350	350	11	0	0	
	17:00	18:00	0%	0	GENERATORS	350	350	11	0	0	
	18:00	19:00	35%	16.8	EDL	320	320	11	59,136	59,136	
	19:00	20:00	35%	16.8	EDL	320	320	11	59,136	59,136	
DAY 2 WEEKEND	8:00	9:00	0%	0	GENERATORS	350	350	4	0	0	
	9:00	10:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	10:00	11:00	0%	0	EDL	112	0	4	0	0	21,504
	11:00	12:00	0%	0	EDL	112	0	4	0	0	21,504
	12:00	13:00	0%	0	EDL	112	0	4	0	0	21,504
	13:00	14:00	0%	0	EDL	112	0	4	0	0	21,504
	14:00	15:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	15:00	16:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	16:00	17:00	0%	0	GENERATORS	350	350	4	0	0	
	17:00	18:00	0%	0	GENERATORS	350	350	4	0	0	
	18:00	19:00	0%	0	EDL	320	320	4	0	0	
	19:00	20:00	0%	0	EDL	320	320	4	0	0	
	TOTAL								633,494	275,352	313,152
SUMMER TIME - HALF DAY- FULL OPERATION - JULY											
TOTAL COST – DAY 1 & DAY 2									1,491,706	454,978	626,304

Month of August:

Day 1:

SUMMER TIME - HALF DAY - NO OPERATION - AUGUST												
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER (REGULAR)	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 1 DURING THE WEEK	8:00	9:00	15%	7.2	EDL	112	112	11	8,870	8,870	
	9:00	10:00	15%	7.2	EDL	112	0	11	8,870	0	50,266
	10:00	11:00	15%	7.2	GENERATORS	350	0	11	27,720	0	50,266
	11:00	12:00	15%	7.2	GENERATORS	350	0	11	27,720	0	50,266
	12:00	13:00	15%	7.2	GENERATORS	350	0	11	27,720	0	50,266
	13:00	14:00	15%	7.2	GENERATORS	350	0	11	27,720	0	50,266
	14:00	15:00	0%	0	EDL	112	0	11	0	0	59,136
	15:00	16:00	0%	0	EDL	112	0	11	0	0	59,136
	16:00	17:00	0%	0	EDL	112	320	11	0	0	
	17:00	18:00	0%	0	EDL	112	320	11	0	0	
	18:00	19:00	0%	0	GENERATORS	350	350	11	0	0	
	19:00	20:00	0%	0	GENERATORS	350	350	11	0	0	
DAY 1 WEEKEND	8:00	9:00	0%	0	EDL	112	112	4	0	0	
	9:00	10:00	0%	0	EDL	112	0	4	0	0	21,504
	10:00	11:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	11:00	12:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	12:00	13:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	13:00	14:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	14:00	15:00	0%	0	EDL	112	0	4	0	0	21,504
	15:00	16:00	0%	0	EDL	112	0	4	0	0	21,504
	16:00	17:00	0%	0	EDL	112	112	4	0	0	
	17:00	18:00	0%	0	EDL	112	112	4	0	0	
	18:00	19:00	0%	0	GENERATORS	350	350	4	0	0	
	19:00	20:00	0%	0	GENERATORS	350	350	4	0	0	
	TOTAL								128,621	8,870	520,128

Day 2:

SUMMER TIME - HALF DAY - NO OPERATION - AUGUST											
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 2 DURING THE WEEK	8:00	9:00	15%	7.2	GENERATORS	350	350	11	27,720	27,720	
	9:00	10:00	15%	7.2	GENERATORS	350	0	11	27,720	0	50,266
	10:00	11:00	15%	7.2	EDL	112	0	11	8,870	0	50,266
	11:00	12:00	15%	7.2	EDL	112	0	11	8,870	0	50,266
	12:00	13:00	15%	7.2	EDL	112	0	11	8,870	0	50,266
	13:00	14:00	15%	7.2	EDL	112	0	11	8,870	0	50,266
	14:00	15:00	0%	0	GENERATORS	350	0	11	0	0	59,136
	15:00	16:00	0%	0	GENERATORS	350	0	11	0	0	59,136
	16:00	17:00	0%	0	GENERATORS	350	350	11	0	0	
	17:00	18:00	0%	0	GENERATORS	350	350	11	0	0	
	18:00	19:00	0%	0	EDL	320	320	11	0	0	
	19:00	20:00	0%	0	EDL	320	320	11	0	0	
DAY 2 WEEKEND	8:00	9:00	0%	0	GENERATORS	350	350	4	0	0	
	9:00	10:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	10:00	11:00	0%	0	EDL	112	0	4	0	0	21,504
	11:00	12:00	0%	0	EDL	112	0	4	0	0	21,504
	12:00	13:00	0%	0	EDL	112	0	4	0	0	21,504
	13:00	14:00	0%	0	EDL	112	0	4	0	0	21,504
	14:00	15:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	15:00	16:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	16:00	17:00	0%	0	GENERATORS	350	350	4	0	0	
	17:00	18:00	0%	0	GENERATORS	350	350	4	0	0	
	18:00	19:00	0%	0	EDL	320	320	4	0	0	
	19:00	20:00	0%	0	EDL	320	320	4	0	0	
	TOTAL								90,922	27,720	520,128
SUMMER TIME - HALF DAY - NO OPERATION - AUGUST											
TOTAL COST – DAY 1 & DAY 2									219,542	36,590	1,040,256

Month of September:

Day 1:

SUMMER TIME - HALF DAY - NO OPERATION - SEPTEMBER											
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER (REGULAR)	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 1 DURING THE WEEK	8:00	9:00	15%	7.2	EDL	112	112	11	8,870	8,870	
	9:00	10:00	15%	7.2	EDL	112	0	11	8,870	0	50,266
	10:00	11:00	15%	7.2	GENERATORS	350	0	11	27,720	0	50,266
	11:00	12:00	15%	7.2	GENERATORS	350	0	11	27,720	0	50,266
	12:00	13:00	15%	7.2	GENERATORS	350	0	11	27,720	0	50,266
	13:00	14:00	15%	7.2	GENERATORS	350	0	11	27,720	0	50,266
	14:00	15:00	0%	0	EDL	112	0	11	0	0	59,136
	15:00	16:00	0%	0	EDL	112	0	11	0	0	59,136
	16:00	17:00	0%	0	EDL	112	320	11	0	0	
	17:00	18:00	0%	0	EDL	112	320	11	0	0	
	18:00	19:00	0%	0	GENERATORS	350	350	11	0	0	
	19:00	20:00	0%	0	GENERATORS	350	350	11	0	0	
DAY 1 WEEKEND	8:00	9:00	0%	0	EDL	112	112	4	0	0	
	9:00	10:00	0%	0	EDL	112	0	4	0	0	21,504
	10:00	11:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	11:00	12:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	12:00	13:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	13:00	14:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	14:00	15:00	0%	0	EDL	112	0	4	0	0	21,504
	15:00	16:00	0%	0	EDL	112	0	4	0	0	21,504
	16:00	17:00	0%	0	EDL	112	112	4	0	0	
	17:00	18:00	0%	0	EDL	112	112	4	0	0	
	18:00	19:00	0%	0	GENERATORS	350	350	4	0	0	
	19:00	20:00	0%	0	GENERATORS	350	350	4	0	0	
	TOTAL								128,621	8,870	520,128

Day 2:

SUMMER TIME - HALF DAY - NO OPERATION - SEPTEMBER											
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 2 DURING THE WEEK	8:00	9:00	15%	7.2	GENERATORS	350	350	11	27,720	27,720	
	9:00	10:00	15%	7.2	GENERATORS	350	0	11	27,720	0	50,266
	10:00	11:00	15%	7.2	EDL	112	0	11	8,870	0	50,266
	11:00	12:00	15%	7.2	EDL	112	0	11	8,870	0	50,266
	12:00	13:00	15%	7.2	EDL	112	0	11	8,870	0	50,266
	13:00	14:00	15%	7.2	EDL	112	0	11	8,870	0	50,266
	14:00	15:00	0%	0	GENERATORS	350	0	11	0	0	59,136
	15:00	16:00	0%	0	GENERATORS	350	0	11	0	0	59,136
	16:00	17:00	0%	0	GENERATORS	350	350	11	0	0	
	17:00	18:00	0%	0	GENERATORS	350	350	11	0	0	
	18:00	19:00	0%	0	EDL	320	320	11	0	0	
	19:00	20:00	0%	0	EDL	320	320	11	0	0	
DAY 2 WEEKEND	8:00	9:00	0%	0	GENERATORS	350	350	4	0	0	
	9:00	10:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	10:00	11:00	0%	0	EDL	112	0	4	0	0	21,504
	11:00	12:00	0%	0	EDL	112	0	4	0	0	21,504
	12:00	13:00	0%	0	EDL	112	0	4	0	0	21,504
	13:00	14:00	0%	0	EDL	112	0	4	0	0	21,504
	14:00	15:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	15:00	16:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	16:00	17:00	0%	0	GENERATORS	350	350	4	0	0	
	17:00	18:00	0%	0	GENERATORS	350	350	4	0	0	
	18:00	19:00	0%	0	EDL	320	320	4	0	0	
	19:00	20:00	0%	0	EDL	320	320	4	0	0	
	TOTAL								90,922	27,720	520,128
SUMMER TIME - HALF DAY - NO OPERATION - SEPTEMBER											
TOTAL COST – DAY 1 & DAY 2									219,542	36,590	1,040,256

Month of October:

Day 1:

WINTER TIME - FULL DAY - OCTOBER											
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER (REGULAR)	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR POWER	L.L. USING SOLAR	L.L. SOLAR SOLD TO EDL
DAY 1 DURING THE WEEK	8:00	9:00	100%	48	EDL	112	112	11	59,136	59,136	
	9:00	10:00	100%	48	EDL	112	0	11	59,136	0	0
	10:00	11:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	11:00	12:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	12:00	13:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	13:00	14:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	14:00	15:00	90%	43.2	EDL	112	0	11	53,222	0	5,914
	15:00	16:00	90%	43.2	EDL	112	112	11	53,222	53,222	
	16:00	17:00	65%	31.2	EDL	320	320	11	109,824	109,824	
	17:00	18:00	65%	31.2	EDL	320	320	11	109,824	109,824	
	18:00	19:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
	19:00	20:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
DAY 1 WEEKEND	8:00	9:00	0%	0	EDL	112	112	4	0	0	
	9:00	10:00	0%	0	EDL	112	0	4	0	0	21,504
	10:00	11:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	11:00	12:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	12:00	13:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	13:00	14:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	14:00	15:00	0%	0	EDL	112	0	4	0	0	21,504
	15:00	16:00	0%	0	EDL	112	112	4	0	0	
	16:00	17:00	0%	0	EDL	320	320	4	0	0	
	17:00	18:00	0%	0	EDL	320	320	4	0	0	
	18:00	19:00	0%	0	GENERATORS	350	350	4	0	0	
	19:00	20:00	0%	0	GENERATORS	350	350	4	0	0	
	TOTAL								1,312,925	461,366	134,938

Day 2:

WINTER TIME - FULL DAY - OCTOBER											
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 2 DURING THE WEEK	8:00	9:00	100%	48	GENERATORS	350	350	11	184,800	184,800	
	9:00	10:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	10:00	11:00	100%	48	EDL	112	0	11	59,136	0	0
	11:00	12:00	100%	48	EDL	112	0	11	59,136	0	0
	12:00	13:00	100%	48	EDL	112	0	11	59,136	0	0
	13:00	14:00	100%	48	EDL	112	0	11	59,136	0	0
	14:00	15:00	90%	43.2	GENERATORS	350	0	11	166,320	0	5,914
	15:00	16:00	90%	43.2	GENERATORS	350	350	11	166,320	166,320	
	16:00	17:00	65%	31.2	GENERATORS	350	350	11	120,120	120,120	
	17:00	18:00	65%	31.2	GENERATORS	350	350	11	120,120	120,120	
	18:00	19:00	35%	16.8	EDL	320	320	11	59,136	59,136	
	19:00	20:00	35%	16.8	EDL	320	320	11	59,136	59,136	
DAY 2 WEEKEND	8:00	9:00	0%	0	GENERATORS	350	350	4	0	0	
	9:00	10:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	10:00	11:00	0%	0	EDL	112	0	4	0	0	21,504
	11:00	12:00	0%	0	EDL	112	0	4	0	0	21,504
	12:00	13:00	0%	0	EDL	112	0	4	0	0	21,504
	13:00	14:00	0%	0	EDL	112	0	4	0	0	21,504
	14:00	15:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	15:00	16:00	0%	0	GENERATORS	350	350	4	0	0	
	16:00	17:00	0%	0	GENERATORS	350	350	4	0	0	
	17:00	18:00	0%	0	GENERATORS	350	350	4	0	0	
	18:00	19:00	0%	0	EDL	320	320	4	0	0	
	19:00	20:00	0%	0	EDL	320	320	4	0	0	
	TOTAL								1,297,296	709,632	134,938
OCTOBER											
TOTAL COST – DAY 1 & DAY 2									2,610,221	1,170,998	269,875

Month of November:

Day 1:

WINTER TIME - FULL DAY - NOVEMBER												
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER (REGULAR)	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 1 DURING THE WEEK	8:00	9:00	100%	48	EDL	112	112	11	59,136	59,136	
	9:00	10:00	100%	48	EDL	112	112	11	59,136	59,136	
	10:00	11:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	11:00	12:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	12:00	13:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	13:00	14:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	14:00	15:00	90%	43.2	EDL	112	0	11	53,222	0	5,914
	15:00	16:00	90%	43.2	EDL	112	112	11	53,222	53,222	
	16:00	17:00	65%	31.2	EDL	320	320	11	109,824	109,824	
	17:00	18:00	65%	31.2	EDL	320	320	11	109,824	109,824	
	18:00	19:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
	19:00	20:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
DAY 1 WEEKEND	8:00	9:00	0%	0	EDL	112	112	4	0	0	
	9:00	10:00	0%	0	EDL	112	112	4	0	0	
	10:00	11:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	11:00	12:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	12:00	13:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	13:00	14:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	14:00	15:00	0%	0	EDL	112	0	4	0	0	21,504
	15:00	16:00	0%	0	EDL	112	112	4	0	0	
	16:00	17:00	0%	0	EDL	320	320	4	0	0	
	17:00	18:00	0%	0	EDL	320	320	4	0	0	
	18:00	19:00	0%	0	GENERATORS	350	350	4	0	0	
	19:00	20:00	0%	0	GENERATORS	350	350	4	0	0	
	TOTAL								1,312,925	520,502	113,434

Day 2:

WINTER TIME - FULL DAY - NOVEMBER											
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 2 DURING THE WEEK	8:00	9:00	100%	48	GENERATORS	350	350	11	184,800	184,800	
	9:00	10:00	100%	48	GENERATORS	350	350	11	184,800	184,800	0
	10:00	11:00	100%	48	EDL	112	0	11	59,136	0	0
	11:00	12:00	100%	48	EDL	112	0	11	59,136	0	0
	12:00	13:00	100%	48	EDL	112	0	11	59,136	0	0
	13:00	14:00	100%	48	EDL	112	0	11	59,136	0	0
	14:00	15:00	90%	43.2	GENERATORS	350	0	11	166,320	0	
	15:00	16:00	90%	43.2	GENERATORS	350	350	11	166,320	166,320	
	16:00	17:00	65%	31.2	GENERATORS	350	350	11	120,120	120,120	
	17:00	18:00	65%	31.2	GENERATORS	350	350	11	120,120	120,120	
	18:00	19:00	35%	16.8	EDL	320	320	11	59,136	59,136	
	19:00	20:00	35%	16.8	EDL	320	320	11	59,136	59,136	
DAY 2 WEEKEND	8:00	9:00	0%	0	GENERATORS	350	350	4	0	0	
	9:00	10:00	0%	0	GENERATORS	350	350	4	0	0	21,504
	10:00	11:00	0%	0	EDL	112	0	4	0	0	21,504
	11:00	12:00	0%	0	EDL	112	0	4	0	0	21,504
	12:00	13:00	0%	0	EDL	112	0	4	0	0	21,504
	13:00	14:00	0%	0	EDL	112	0	4	0	0	21,504
	14:00	15:00	0%	0	GENERATORS	350	0	4	0	0	
	15:00	16:00	0%	0	GENERATORS	350	350	4	0	0	
	16:00	17:00	0%	0	GENERATORS	350	350	4	0	0	
	17:00	18:00	0%	0	GENERATORS	350	350	4	0	0	
	18:00	19:00	0%	0	EDL	320	320	4	0	0	
	19:00	20:00	0%	0	EDL	320	320	4	0	0	
	TOTAL								1,297,296	894,432	107,520
NOVEMBER											
TOTAL COST – DAY 1 & DAY 2									2,610,221	1,414,934	220,954

Month of December:

Day 1:

WINTER TIME - FULL DAY - DECEMBER											
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER (REGULAR)	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 1 DURING THE WEEK	8:00	9:00	100%	48	EDL	112	112	11	59,136	59,136	
	9:00	10:00	100%	48	EDL	112	112	11	59,136	59,136	
	10:00	11:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	11:00	12:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	12:00	13:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	13:00	14:00	100%	48	GENERATORS	350	0	11	184,800	0	0
	14:00	15:00	90%	43.2	EDL	112	112	11	53,222	53,222	
	15:00	16:00	90%	43.2	EDL	112	112	11	53,222	53,222	
	16:00	17:00	65%	31.2	EDL	320	320	11	109,824	109,824	
	17:00	18:00	65%	31.2	EDL	320	320	11	109,824	109,824	
	18:00	19:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
	19:00	20:00	35%	16.8	GENERATORS	350	350	11	64,680	64,680	
DAY 1 WEEKEND	8:00	9:00	0%	0	EDL	112	112	4	0	0	
	9:00	10:00	0%	0	EDL	112	112	4	0	0	
	10:00	11:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	11:00	12:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	12:00	13:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	13:00	14:00	0%	0	GENERATORS	350	0	4	0	0	21,504
	14:00	15:00	0%	0	EDL	112	112	4	0	0	
	15:00	16:00	0%	0	EDL	112	112	4	0	0	
	16:00	17:00	0%	0	EDL	320	320	4	0	0	
	17:00	18:00	0%	0	EDL	320	320	4	0	0	
	18:00	19:00	0%	0	GENERATORS	350	350	4	0	0	
	19:00	20:00	0%	0	GENERATORS	350	350	4	0	0	
	TOTAL								1,312,925	573,725	86,016

Day 2:

WINTER TIME - FULL DAY - DECEMBER											
	START	END	FACULTY LOAD	POWER USAGE (KW)	SOURCE OF POWER	REGULAR RATE IN L.L.	SOLAR RATE IN L.L.	NUMBER OF DAYS	L.L. REGULAR	L.L. SOLAR	L.L. SOLAR SOLD TO EDL
DAY 2 DURING THE WEEK	8:00	9:00	100%	48	GENERATORS	350	350	11	184,800	184,800	
	9:00	10:00	100%	48	GENERATORS	350	350	11	184,800	184,800	
	10:00	11:00	100%	48	EDL	112	0	11	59,136	0	0
	11:00	12:00	100%	48	EDL	112	0	11	59,136	0	0
	12:00	13:00	100%	48	EDL	112	0	11	59,136	0	0
	13:00	14:00	100%	48	EDL	112	0	11	59,136	0	0
	14:00	15:00	90%	43.2	GENERATORS	350	350	11	166,320	166,320	
	15:00	16:00	90%	43.2	GENERATORS	350	350	11	166,320	166,320	
	16:00	17:00	65%	31.2	GENERATORS	350	350	11	120,120	120,120	
	17:00	18:00	65%	31.2	GENERATORS	350	350	11	120,120	120,120	
	18:00	19:00	35%	16.8	EDL	320	320	11	59,136	59,136	
	19:00	20:00	35%	16.8	EDL	320	320	11	59,136	59,136	
DAY 2 WEEKEND	8:00	9:00	0%	0	GENERATORS	350	350	4	0	0	
	9:00	10:00	0%	0	GENERATORS	350	350	4	0	0	
	10:00	11:00	0%	0	EDL	112	0	4	0	0	21,504
	11:00	12:00	0%	0	EDL	112	0	4	0	0	21,504
	12:00	13:00	0%	0	EDL	112	0	4	0	0	21,504
	13:00	14:00	0%	0	EDL	112	0	4	0	0	21,504
	14:00	15:00	0%	0	GENERATORS	350	350	4	0	0	
	15:00	16:00	0%	0	GENERATORS	350	350	4	0	0	
	16:00	17:00	0%	0	GENERATORS	350	350	4	0	0	
	17:00	18:00	0%	0	GENERATORS	350	350	4	0	0	
	18:00	19:00	0%	0	EDL	320	320	4	0	0	
	19:00	20:00	0%	0	EDL	320	320	4	0	0	
	TOTAL								1,297,296	1,060,752	86,016
DECEMBER											
TOTAL COST – DAY 1 & DAY 2									2,610,221	1,634,477	172,032

APPENDIX F

Difference between Cost and Benefit, Net Present Value, and Benefit to Cost Ratio Derivation Under the Condition of Stable Electricity Generation Prices

Scenario 2: Solar Photovoltaic Panels as a Standalone Project

Difference between Cost and Benefit At NEERA, 0%, Rate:

YEAR	BENEFITS (IN USD)	COSTS (IN USD)	DIFFERENCE (IN USD)
1	11,903	206,979	-195,076
2	11,903	2,049	9,854
3	11,903	2,049	9,854
4	11,903	2,049	9,854
5	11,903	2,049	9,854
6	11,903	2,049	9,854
7	11,903	2,049	9,854
8	11,903	2,049	9,854
9	11,903	2,049	9,854
10	11,903	2,049	9,854
11	11,903	2,049	9,854
12	11,903	2,049	9,854
13	11,903	2,049	9,854
14	11,903	2,049	9,854
15	11,903	2,049	9,854
16	11,903	2,049	9,854
17	11,903	2,049	9,854
18	11,903	2,049	9,854
19	11,903	2,049	9,854
20	11,903	2,049	9,854
21	11,903	2,049	9,854
22	11,903	2,049	9,854
23	11,903	2,049	9,854
24	11,903	2,049	9,854
25	11,903	2,049	9,854
TOTAL	297,575	256,163	41,413

NPV at 3% Social Discount Factor:

YEAR	TOTAL BENEFITS (IN USD)	TOTAL COSTS (IN USD)	DISCOUNT FACTOR (3%)	DISCOUNTED BENEFITS	DISCOUNTED COSTS	NPV
1	11,903	206,979	0.970873786	11,556	200,951	-189,394
2	11,903	2,049	0.942595909	11,220	1,932	9,288
3	11,903	2,049	0.915141659	10,893	1,875	9,018
4	11,903	2,049	0.888487048	10,576	1,821	8,755
5	11,903	2,049	0.862608784	10,268	1,768	8,500
6	11,903	2,049	0.837484257	9,969	1,716	8,252
7	11,903	2,049	0.813091511	9,678	1,666	8,012
8	11,903	2,049	0.789409234	9,396	1,618	7,779
9	11,903	2,049	0.766416732	9,123	1,571	7,552
10	11,903	2,049	0.744093915	8,857	1,525	7,332
11	11,903	2,049	0.722421277	8,599	1,480	7,119
12	11,903	2,049	0.70137988	8,349	1,437	6,911
13	11,903	2,049	0.68095134	8,105	1,395	6,710
14	11,903	2,049	0.661117806	7,869	1,355	6,514
15	11,903	2,049	0.641861947	7,640	1,315	6,325
16	11,903	2,049	0.623166939	7,418	1,277	6,141
17	11,903	2,049	0.605016446	7,202	1,240	5,962
18	11,903	2,049	0.587394608	6,992	1,204	5,788
19	11,903	2,049	0.570286027	6,788	1,169	5,619
20	11,903	2,049	0.553675754	6,590	1,135	5,456
21	11,903	2,049	0.537549276	6,398	1,102	5,297
22	11,903	2,049	0.521892501	6,212	1,070	5,143
23	11,903	2,049	0.506691748	6,031	1,038	4,993
24	11,903	2,049	0.491933736	5,855	1,008	4,847
25	11,903	2,049	0.477605569	5,685	979	4,706
TOTAL				**207,269**	**234,646**	**-27,377**

NPV at 6% Market Discount Factor:

YEAR	TOTAL BENEFITS (IN USD)	TOTAL COSTS (IN USD)	DISCOUNT FACTOR (6%)	DISCOUNTED BENEFITS	DISCOUNTED COSTS	NPV
1	11,903	206,979	0.943396226	11,229	195,263	-184,034
2	11,903	2,049	0.88999644	10,594	1,824	8,770
3	11,903	2,049	0.839619283	9,994	1,721	8,273
4	11,903	2,049	0.792093663	9,428	1,623	7,805
5	11,903	2,049	0.747258173	8,895	1,531	7,363
6	11,903	2,049	0.70496054	8,391	1,445	6,946
7	11,903	2,049	0.665057114	7,916	1,363	6,553
8	11,903	2,049	0.627412371	7,468	1,286	6,182
9	11,903	2,049	0.591898464	7,045	1,213	5,832
10	11,903	2,049	0.558394777	6,647	1,144	5,502
11	11,903	2,049	0.526787525	6,270	1,080	5,191
12	11,903	2,049	0.496969364	5,915	1,018	4,897
13	11,903	2,049	0.468839022	5,581	961	4,620
14	11,903	2,049	0.442300964	5,265	906	4,358
15	11,903	2,049	0.417265061	4,967	855	4,112
16	11,903	2,049	0.393646284	4,686	807	3,879
17	11,903	2,049	0.371364419	4,420	761	3,659
18	11,903	2,049	0.350343791	4,170	718	3,452
19	11,903	2,049	0.33051301	3,934	677	3,257
20	11,903	2,049	0.311804727	3,711	639	3,072
21	11,903	2,049	0.294155403	3,501	603	2,899
22	11,903	2,049	0.277505097	3,303	569	2,734
23	11,903	2,049	0.261797261	3,116	537	2,580
24	11,903	2,049	0.246978548	2,940	506	2,434
25	11,903	2,049	0.232998631	2,773	477	2,296
TOTAL				152,160	219,527	-67,367

Scenario 3: LED Lamps and Solar Photovoltaic Panels Installed Simultaneously

Difference between Cost and Benefit At NEERA, 0%, Rate:

YEAR	BENEFITS (IN USD)	COSTS (USD)	DIFFERENCE (USD)
1	40,754	368,428	-327,674
2	26,879	4,435	22,444
3	26,879	4,435	22,444
4	40,924	4,435	36,489
5	26,879	4,435	22,444
6	26,879	4,435	22,444
7	41,104	4,435	36,669
8	26,879	4,435	22,444
9	26,879	4,435	22,444
10	41,295	4,435	36,860
11	26,879	4,435	22,444
12	26,879	4,435	22,444
13	41,498	4,435	37,063
14	26,879	4,435	22,444
15	26,879	4,435	22,444
16	41,714	4,435	37,279
17	26,879	4,435	22,444
18	26,879	4,435	22,444
19	41,942	4,435	37,507
20	26,879	4,435	22,444
TOTAL	638,659	452,698	185,961

NPV at 3% Social Discount Factor:

YEAR	TOTAL BENEFITS (IN USD)	TOTAL COSTS (IN USD)	DISCOUNT FACTOR (3%)	DISCOUNTED BENEFITS	DISCOUNTED COSTS	NPV
1	40,754	368,428	0.970873786	39,567	357,697	-318,130
2	26,879	4,435	0.942595909	25,336	4,181	21,155
3	26,879	4,435	0.915141659	24,598	4,059	20,539
4	40,924	4,435	0.888487048	36,360	3,941	32,420
5	26,879	4,435	0.862608784	23,186	3,826	19,360
6	26,879	4,435	0.837484257	22,511	3,714	18,796
7	41,104	4,435	0.813091511	33,421	3,606	29,815
8	26,879	4,435	0.789409234	21,219	3,501	17,717
9	26,879	4,435	0.766416732	20,601	3,399	17,201
10	41,295	4,435	0.744093915	30,728	3,300	27,427
11	26,879	4,435	0.722421277	19,418	3,204	16,214
12	26,879	4,435	0.70137988	18,852	3,111	15,742
13	41,498	4,435	0.68095134	28,258	3,020	25,238
14	26,879	4,435	0.661117806	17,770	2,932	14,838
15	26,879	4,435	0.641861947	17,253	2,847	14,406
16	41,714	4,435	0.623166939	25,995	2,764	23,231
17	26,879	4,435	0.605016446	16,262	2,683	13,579
18	26,879	4,435	0.587394608	15,789	2,605	13,183
19	41,942	4,435	0.570286027	23,919	2,529	21,390
20	26,879	4,435	0.553675754	14,882	2,456	12,427
TOTAL				475,925	419,377	56,548

NPV at 6% Market Discount Factor:

YEAR	TOTAL BENEFITS (IN USD)	TOTAL COSTS (IN USD)	DISCOUNT FACTOR (6%)	DISCOUNTED BENEFITS	DISCOUNTED COSTS	NPV
1	40,754	368,428	0.943396226	38,447	347,574	-309,127
2	26,879	4,435	0.88999644	23,922	3,947	19,975
3	26,879	4,435	0.839619283	22,568	3,724	18,844
4	40,924	4,435	0.792093663	32,416	3,513	28,902
5	26,879	4,435	0.747258173	20,086	3,314	16,771
6	26,879	4,435	0.70496054	18,949	3,127	15,822
7	41,104	4,435	0.665057114	27,337	2,950	24,387
8	26,879	4,435	0.627412371	16,864	2,783	14,081
9	26,879	4,435	0.591898464	15,910	2,625	13,284
10	41,295	4,435	0.558394777	23,059	2,477	20,583
11	26,879	4,435	0.526787525	14,160	2,336	11,823
12	26,879	4,435	0.496969364	13,358	2,204	11,154
13	41,498	4,435	0.468839022	19,456	2,079	17,377
14	26,879	4,435	0.442300964	11,889	1,962	9,927
15	26,879	4,435	0.417265061	11,216	1,851	9,365
16	41,714	4,435	0.393646284	16,420	1,746	14,675
17	26,879	4,435	0.371364419	9,982	1,647	8,335
18	26,879	4,435	0.350343791	9,417	1,554	7,863
19	41,942	4,435	0.33051301	13,863	1,466	12,397
20	26,879	4,435	0.311804727	8,381	1,383	6,998
TOTAL				367,697	394,262	-26,564

APPENDIX G

Difference between Cost and Benefit, Net Present Value, and Benefit to Cost Ratio Derivation Under the Condition of Increasing Rate for Electricity Generation Prices

Scenario 1: LED Lamps

Cost and Benefit over the Lifetime of the Project:

COST / BENEFIT	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12	YEAR 13	YEAR 14	YEAR 15	YEAR 16	YEAR 17	YEAR 18	YEAR 19	YEAR 20
TYPES OF COSTS (IN USD)																				
LED LAMPS PURCHASING COST	156,288	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LED INSTALLATION COST	2,775	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS COST INCLUDING YEARLY MAINTENANCE COST (1.5% OF THE TOTAL COST)	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386
TOTAL COST PER YEAR	161,449	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386	2,386
TYPES OF BENEFITS (IN USD)																				
DIFFERENCE IN POWER CONSUMPTION (BETWEEN LED AND FLUORESCENT LAMP)	14,976	15,276	15,581	15,893	16,211	16,567	16,932	17,304	17,685	18,074	18,490	18,915	19,350	19,795	20,250	20,736	21,234	21,744	22,266	22,800
SAVINGS FROM FLUORESCENT PURCHASING COST	11,100			11,100			11,100			11,100			11,100			11,100			11,100	
SAVINGS FROM FLUORESCENT INSTALLATION COST (WITH A 2% YEARLY INFLATION RATE)	2,775			2,945			3,125			3,316			3,519			3,735			3,963	
TOTAL BENEFIT PER YEAR	28,851	15,276	15,581	29,938	16,211	16,567	31,157	17,304	17,685	32,490	18,490	18,915	33,969	19,795	20,250	35,571	21,234	21,744	37,329	22,800

Difference between Cost and Benefit At NEERA, 0%, Rate:

YEAR	BENEFITS (USD)	COSTS (USD)	DIFFERENCE (USD)
1	28,851	161,449	-132,598
2	15,276	2,386	12,890
3	15,581	2,386	13,195
4	29,938	2,386	27,552
5	16,211	2,386	13,825
6	16,567	2,386	14,181
7	31,157	2,386	28,771
8	17,304	2,386	14,918
9	17,685	2,386	15,299
10	32,490	2,386	30,104
11	18,490	2,386	16,104
12	18,915	2,386	16,529
13	33,969	2,386	31,583
14	19,795	2,386	17,409
15	20,250	2,386	17,864
16	35,571	2,386	33,185
17	21,234	2,386	18,848
18	21,744	2,386	19,358
19	37,329	2,386	34,943
20	22,800	2,386	20,414
TOTAL	471,158	206,782	264,376

NPV at 3% Social Discount Factor:

YEAR	TOTAL BENEFITS (USD)	TOTAL COSTS (USD)	DISCOUNT FACTOR (3%)	DISCOUNTED BENEFITS	DISCOUNTED COSTS	NPV
1	28,851	161,449	0.9709	28,011	156,747	-128,736
2	15,276	2,386	0.9426	14,399	2,249	12,150
3	15,581	2,386	0.9151	14,259	2,183	12,075
4	29,938	2,386	0.8885	26,599	2,120	24,480
5	16,211	2,386	0.8626	13,984	2,058	11,926
6	16,567	2,386	0.8375	13,875	1,998	11,876
7	31,157	2,386	0.8131	25,334	1,940	23,394
8	17,304	2,386	0.7894	13,660	1,883	11,776
9	17,685	2,386	0.7664	13,554	1,829	11,725
10	32,490	2,386	0.7441	24,176	1,775	22,401
11	18,490	2,386	0.7224	13,358	1,724	11,634
12	18,915	2,386	0.7014	13,267	1,673	11,593
13	33,969	2,386	0.6810	23,131	1,625	21,507
14	19,795	2,386	0.6611	13,087	1,577	11,509
15	20,250	2,386	0.6419	12,998	1,531	11,466
16	35,571	2,386	0.6232	22,167	1,487	20,680
17	21,234	2,386	0.6050	12,847	1,444	11,403
18	21,744	2,386	0.5874	12,772	1,401	11,371
19	37,329	2,386	0.5703	21,288	1,361	19,928
20	22,800	2,386	0.5537	12,624	1,321	11,303
TOTAL				345,388	189,927	155,461

NPV at 6% Market Discount Factor:

YEAR	TOTAL BENEFITS (USD)	TOTAL COSTS (USD)	DISCOUNT FACTOR (6%)	DISCOUNTED BENEFITS	DISCOUNTED COSTS	NPV
1	28,851	161,449	0.9434	27,218	152,310	-125,092
2	15,276	2,386	0.8900	13,596	2,123	11,472
3	15,581	2,386	0.8396	13,082	2,003	11,079
4	29,938	2,386	0.7921	23,714	1,890	21,824
5	16,211	2,386	0.7473	12,114	1,783	10,331
6	16,567	2,386	0.7050	11,679	1,682	9,997
7	31,157	2,386	0.6651	20,721	1,587	19,134
8	17,304	2,386	0.6274	10,857	1,497	9,360
9	17,685	2,386	0.5919	10,468	1,412	9,055
10	32,490	2,386	0.5584	18,142	1,332	16,810
11	18,490	2,386	0.5268	9,740	1,257	8,483
12	18,915	2,386	0.4970	9,400	1,186	8,214
13	33,969	2,386	0.4688	15,926	1,119	14,808
14	19,795	2,386	0.4423	8,755	1,055	7,700
15	20,250	2,386	0.4173	8,450	996	7,454
16	35,571	2,386	0.3936	14,002	939	13,063
17	21,234	2,386	0.3714	7,886	886	6,999
18	21,744	2,386	0.3503	7,618	836	6,782
19	37,329	2,386	0.3305	12,338	789	11,549
20	22,800	2,386	0.3118	7,109	744	6,365
TOTAL				262,815	177,426	85,389

Scenario 2: Solar Photovoltaic Panels as a Standalone Project

Cost and Benefit over the Lifetime of the Project:

COST / BENEFIT	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11	YEAR 12	YEAR 13	YEAR 14	YEAR 15	YEAR 16	YEAR 17	YEAR 18	YEAR 19	YEAR 20	YEAR 21	YEAR 22	YEAR 23	YEAR 24	YEAR 25
TYPES OF COSTS (IN USD)																									
SOLAR PURCHASING COST	204,930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS COST INCLUDING YEARLY MAINTENANCE COST (1% OF THE TOTAL COST)	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049
TOTAL COST PER YEAR	206,979	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049	2,049
TYPES OF BENEFITS (IN USD)																									
DIFFERENCE IN ELECTRIC BILL (BETWEEN SOLAR AND BOTH "EDL AND PRIVATE GENERATORS")	11,903	12,141	12,384	12,632	12,884	13,168	13,457	13,753	14,056	14,365	14,696	15,034	15,379	15,733	16,095	16,481	16,877	17,282	17,697	18,121	18,574	19,039	19,515	20,003	20,503
TOTAL BENEFIT PER YEAR	11,903	12,141	12,384	12,632	12,884	13,168	13,457	13,753	14,056	14,365	14,696	15,034	15,379	15,733	16,095	16,481	16,877	17,282	17,697	18,121	18,574	19,039	19,515	20,003	20,503

Difference between Cost and Benefit At NEERA, 0%, Rate:

YEAR	BENEFITS (IN USD)	COSTS (IN USD)	DIFFERENCE (IN USD)
1	11,903	206,979	-195,076
2	12,141	2,049	10,092
3	12,384	2,049	10,335
4	12,632	2,049	10,583
5	12,884	2,049	10,835
6	13,168	2,049	11,119
7	13,457	2,049	11,408
8	13,753	2,049	11,704
9	14,056	2,049	12,007
10	14,365	2,049	12,316
11	14,696	2,049	12,647
12	15,034	2,049	12,985
13	15,379	2,049	13,330
14	15,733	2,049	13,684
15	16,095	2,049	14,046
16	16,481	2,049	14,432
17	16,877	2,049	14,828
18	17,282	2,049	15,233
19	17,697	2,049	15,648
20	18,121	2,049	16,072
21	18,574	2,049	16,525
22	19,039	2,049	16,990
23	19,515	2,049	17,466
24	20,003	2,049	17,954
25	20,503	2,049	18,454
TOTAL	391,772	256,163	135,610

NPV at 3% Social Discount Factor:

YEAR	TOTAL BENEFITS (IN USD)	TOTAL COSTS (IN USD)	DISCOUNT FACTOR (3%)	DISCOUNTED BENEFITS	DISCOUNTED COSTS	NPV
1	11,903	206,979	0.970873786	11,556	200,951	-189,394
2	12,141	2,049	0.942595909	11,444	1,932	9,512
3	12,384	2,049	0.915141659	11,333	1,875	9,458
4	12,632	2,049	0.888487048	11,223	1,821	9,403
5	12,884	2,049	0.862608784	11,114	1,768	9,346
6	13,168	2,049	0.837484257	11,028	1,716	9,312
7	13,457	2,049	0.813091511	10,942	1,666	9,276
8	13,753	2,049	0.789409234	10,857	1,618	9,239
9	14,056	2,049	0.766416732	10,773	1,571	9,202
10	14,365	2,049	0.744093915	10,689	1,525	9,164
11	14,696	2,049	0.722421277	10,617	1,480	9,136
12	15,034	2,049	0.70137988	10,545	1,437	9,107
13	15,379	2,049	0.68095134	10,472	1,395	9,077
14	15,733	2,049	0.661117806	10,401	1,355	9,047
15	16,095	2,049	0.641861947	10,331	1,315	9,015
16	16,481	2,049	0.623166939	10,270	1,277	8,993
17	16,877	2,049	0.605016446	10,211	1,240	8,971
18	17,282	2,049	0.587394608	10,151	1,204	8,948
19	17,697	2,049	0.570286027	10,092	1,169	8,924
20	18,121	2,049	0.553675754	10,033	1,135	8,899
21	18,574	2,049	0.537549276	9,984	1,102	8,883
22	19,039	2,049	0.521892501	9,936	1,070	8,867
23	19,515	2,049	0.506691748	9,888	1,038	8,850
24	20,003	2,049	0.491933736	9,840	1,008	8,832
25	20,503	2,049	0.477605569	9,792	979	8,814
TOTAL				263,524	234,646	28,878

NPV at 6% Market Discount Factor:

YEAR	TOTAL BENEFITS (IN USD)	TOTAL COSTS (IN USD)	DISCOUNT FACTOR (6%)	DISCOUNTED BENEFITS	DISCOUNTED COSTS	NPV
1	11,903	206,979	0.943396226	11,229	195,263	-184,034
2	12,141	2,049	0.88999644	10,805	1,824	8,982
3	12,384	2,049	0.839619283	10,398	1,721	8,677
4	12,632	2,049	0.792093663	10,006	1,623	8,382
5	12,884	2,049	0.747258173	9,628	1,531	8,096
6	13,168	2,049	0.70496054	9,283	1,445	7,838
7	13,457	2,049	0.665057114	8,950	1,363	7,587
8	13,753	2,049	0.627412371	8,629	1,286	7,343
9	14,056	2,049	0.591898464	8,320	1,213	7,107
10	14,365	2,049	0.558394777	8,021	1,144	6,877
11	14,696	2,049	0.526787525	7,742	1,080	6,662
12	15,034	2,049	0.496969364	7,471	1,018	6,453
13	15,379	2,049	0.468839022	7,210	961	6,249
14	15,733	2,049	0.442300964	6,959	906	6,052
15	16,095	2,049	0.417265061	6,716	855	5,861
16	16,481	2,049	0.393646284	6,488	807	5,681
17	16,877	2,049	0.371364419	6,268	761	5,506
18	17,282	2,049	0.350343791	6,055	718	5,337
19	17,697	2,049	0.33051301	5,849	677	5,172
20	18,121	2,049	0.311804727	5,650	639	5,011
21	18,574	2,049	0.294155403	5,464	603	4,861
22	19,039	2,049	0.277505097	5,283	569	4,715
23	19,515	2,049	0.261797261	5,109	537	4,572
24	20,003	2,049	0.246978548	4,940	506	4,434
25	20,503	2,049	0.232998631	4,777	477	4,300
TOTAL				187,249	219,527	-32,278

Scenario 3: LED Lamps and Solar Photovoltaic Panels Installed Simultaneously

Difference between Cost and Benefit At NEERA, 0%, Rate:

YEAR	BENEFITS (IN USD)	COSTS (IN USD)	DIFFERENCE (IN USD)
1	40,754	368,428	-327,674
2	27,417	4,435	22,982
3	27,965	4,435	23,530
4	42,570	4,435	38,135
5	29,095	4,435	24,660
6	29,735	4,435	25,300
7	44,614	4,435	40,179
8	31,057	4,435	26,622
9	31,741	4,435	27,306
10	46,855	4,435	42,420
11	33,186	4,435	28,751
12	33,949	4,435	29,514
13	49,348	4,435	44,913
14	35,528	4,435	31,093
15	36,345	4,435	31,910
16	52,052	4,435	47,617
17	38,111	4,435	33,676
18	39,026	4,435	34,591
19	55,026	4,435	50,591
20	40,921	4,435	36,486
TOTAL	765,296	452,698	312,598

NPV at 3% Social Discount Factor:

YEAR	TOTAL BENEFITS (IN USD)	TOTAL COSTS (IN USD)	DISCOUNT FACTOR (3%)	DISCOUNTED BENEFITS	DISCOUNTED COSTS	NPV
1	40,754	368,428	0.970873786	39,567	357,697	-318,130
2	27,417	4,435	0.942595909	25,843	4,181	21,663
3	27,965	4,435	0.915141659	25,592	4,059	21,533
4	42,570	4,435	0.888487048	37,823	3,941	33,882
5	29,095	4,435	0.862608784	25,098	3,826	21,272
6	29,735	4,435	0.837484257	24,903	3,714	21,188
7	44,614	4,435	0.813091511	36,275	3,606	32,669
8	31,057	4,435	0.789409234	24,517	3,501	21,015
9	31,741	4,435	0.766416732	24,327	3,399	20,928
10	46,855	4,435	0.744093915	34,865	3,300	31,565
11	33,186	4,435	0.722421277	23,974	3,204	20,770
12	33,949	4,435	0.70137988	23,811	3,111	20,700
13	49,348	4,435	0.68095134	33,604	3,020	30,584
14	35,528	4,435	0.661117806	23,488	2,932	20,556
15	36,345	4,435	0.641861947	23,328	2,847	20,482
16	52,052	4,435	0.623166939	32,437	2,764	29,673
17	38,111	4,435	0.605016446	23,058	2,683	20,374
18	39,026	4,435	0.587394608	22,924	2,605	20,318
19	55,026	4,435	0.570286027	31,381	2,529	28,851
20	40,921	4,435	0.553675754	22,657	2,456	20,201
TOTAL				559,471	419,377	140,094

NPV at 6% Market Discount Factor:

YEAR	TOTAL BENEFITS (IN USD)	TOTAL COSTS (IN USD)	DISCOUNT FACTOR (6%)	DISCOUNTED BENEFITS	DISCOUNTED COSTS	NPV
1	40,754	368,428	0.943396226	38,447	347,574	-309,127
2	27,417	4,435	0.88999644	24,401	3,947	20,454
3	27,965	4,435	0.839619283	23,480	3,724	19,756
4	42,570	4,435	0.792093663	33,719	3,513	30,206
5	29,095	4,435	0.747258173	21,741	3,314	18,427
6	29,735	4,435	0.70496054	20,962	3,127	17,835
7	44,614	4,435	0.665057114	29,671	2,950	26,721
8	31,057	4,435	0.627412371	19,486	2,783	16,703
9	31,741	4,435	0.591898464	18,787	2,625	16,162
10	46,855	4,435	0.558394777	26,164	2,477	23,687
11	33,186	4,435	0.526787525	17,482	2,336	15,146
12	33,949	4,435	0.496969364	16,872	2,204	14,667
13	49,348	4,435	0.468839022	23,136	2,079	21,057
14	35,528	4,435	0.442300964	15,714	1,962	13,752
15	36,345	4,435	0.417265061	15,165	1,851	13,315
16	52,052	4,435	0.393646284	20,490	1,746	18,744
17	38,111	4,435	0.371364419	14,153	1,647	12,506
18	39,026	4,435	0.350343791	13,673	1,554	12,119
19	55,026	4,435	0.33051301	18,187	1,466	16,721
20	40,921	4,435	0.311804727	12,759	1,383	11,376
TOTAL				424,490	394,262	30,229