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Impacts of Energy Management & Conservation on Electrical Energy Planning in the West Bank

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Preface

Energy plays a major role in our modern life. Level of development and quality of life can be evaluated by the amount of energy consumed by that society. Energy in all of its forms is a very important factor for industrial, commercial and residential development and prosperity.

After the energy crisis in the seventies, developed countries paid a great attention to minimizing their energy imports such as oil and coal. These countries tried hardly to depend on renewable energy such as hydropower, solar and wind energies as an alternative to classical energy sources. However, renewable energy share could not exceed a limited percentage of energy shares for these countries due to technology limitations and high costs. Energy management and conservation became under focus in early eighties of the twenty-century. Great efforts were made to reduce energy consumption by improving efficiency and minimizing energy losses. The result was very great as the increase in energy consumption was minimized and even reduced to zero in many countries for several years. Reducing energy consumption by introducing renewable energy and implementing energy management techniques will result in reduction of energy costs and environmental pollution.

Energy consumption in Palestine is relatively very low. This is due to weak industrial sector and high costs of energy compared to the low income of the Palestinian population. Despite this fact, a high percentage of the consumed energy is wasted as a loss (technical and non-technical) or by the lack of efficiency in usage. These losses added extra costs to all types of energy sources.

The Palestinian Energy Authority (PEA) realized the previous fact and tried to solve that problem as much as possible. During the past six years, great efforts were made to reduce electric losses and to improve system efficiency. Also, at this time the PEA is implementing a project supported by GEF/UNDP to implement energy management and energy conservation in Palestine to reduce gas emissions and greenhouse effects. If these efforts succeed to implement their objectives then a reduction in energy consumption will be noticed in the nearest future. As a result of this, all forecasts of the energy consumption based on historical consumption will be much higher than the actual ones. In this study, an effort is made to forecast electrical consumption for the next two decades if energy management and conservation are implemented.

Abstract

Electrical consumption in the West Bank is relatively low. However, a high percentage of it is wasted as losses. It is estimated that electric energy losses (technical and non-technical) may exceed 25% in some areas. In addition to that, energy consumption in the residential and industrial sectors is done in inefficient way. A high percentage of the home appliances (mainly refrigerators and air conditioners) are old and consume energy much higher than the newly high efficient ones. Also, the wide usage of incandescent lamps in all sectors made electric energy consumption for lighting much higher than expected if florescent or CFL lamps are used.

The Palestinian Energy Authority (PEA) has carried out different projects to improve the electric networks to minimize losses, and also to improve consumption efficiency. Some of these projects are completed now, and others are under implementation at this moment. The PEA has succeeded so far in different areas such as reducing losses to 12% in the electric networks and to improve power factor (PF) to 0.9 or more in many areas in the West Bank. Energy conservation and efficiency improvement project is being carried out at this time. If all objectives of this project are achieved, then reduction ranges between 2-50% are expected in all types of energy consumption.

After the establishment of the PEA, another type of work was carried out. Planning for the coming two decades was given a special attention by the PEA. Also, many researchers at local centers and educational institutions tried hardly to make such studies in order to forecasts energy

needs and to plan for the future. These studies are much difficult than similar ones for any other country in the world for two reasons. First, the lack of accurate and integrated data about energy consumption for any previous year. Second, to the great uncertainties concerning the demographic, economical and political future of the Palestinian territories.

In this study, an effort was made to evaluate the efforts made to improve electric efficiency and apply energy management and conservation in the West Bank. This evaluation was based on the expectations of the results of the ongoing projects carried out by the PEA. These results were used to generate a new forecast for energy consumption for the next two decades. This study is a follow up of a previous study carried at An-Najah N. University for planning for the electric energy in the West Bank based on historical data. However, this work took all expected results of the energy management projects and uses them to modify the historical data by subtracting losses believed to be eliminated in the future. This new modified data was used to forecast energy consumption in the future with four different scenarios (according to the demographic and economical expectations).

Comparing the results new forecasts with energy management with previously achieved ones show that it is possible to reduce peak power for the year 2020 by more than 8% and around 18% of total electric energy consumed.

Chapter 1

Introduction

Introduction

1.1 Scope

Since the establishment of the Palestinian National Authority, a great interest has a raised for the electrical energy sector. Many studies were done to forecast the energy demand for the next decades. In addition to that, Palestinian Energy Authority (PEA) has conducted many rehabilitation projects the local electric network. Also, a great interest by the PEA for energy management due to the fact those high losses noticed in the local consumption. A project funded by GEF/UNDP is carried out by PEA for energy conservation and energy management in the PNA.

Energy losses in our systems are very huge. According to PEA, these losses ranges between 15% and 40% of total consumption. Minimizing these losses will reduce demand and cost of electric power in the future. Also, applying energy management rules will increase efficiency and hence reduce demand.

Electrical energy price to consumer in the West Bank are very high, Israel is the only suppler of electrical energy in the West Bank (nearly 95% of total electrical energy), economic situation of the Palestinian people are very bad, political and social situation uncertainty because of Israel occupation. Due to bad situation of all these factors above, we must take all the possible efforts to reduce electrical energy consumption in our country because decreasing the consumption affects the economy and becomes independent partially of Israel occupation and his electrical company (IEC).

Apply energy management elements and factors on the consumption of electrical energy demand will have great impacts on energy forecasted. In addition to that, the success of the energy management project yields a lower need for high capacities in the next decades as expected by the forecasts.

Intifada of year 2000 has effected sharply the electrical energy consumption in the Palestinian areas due to the following facts:

- Set-back of local industry.
- Low consumption of tourism sector.
- Lower street lighting.
- Low income of the population.
- Lower investment projects.
- Sharp reduction of returnees to the West Bank.

The impacts of intifada on energy sector will last for a long time despite the time of its end.

Finally in this study, we will try to reduce losses in the electric system, estimate possible savings of energy, and reductions due to energy management plans. Evaluate energy management impacts on energy forecasts and energy planning. Results will be used to Re-plan for future needs and demands of electric power in Palestine for the next 20 years.

1.2 Aims of Study

In this study we will concentrate on the following activities.

- Study all plans done by other researches and different consultants for the PEA for the energy sector.
- Identify all types of loads in the electric system in the West Bank and apply energy management techniques to minimize the amount of electrical energy consumed by these loads.
- Estimate possible savings and reduction of electrical energy due to energy management plans.
- Study of different energy management rules that can be implemented and their impacts on energy demand.
- Development of expert system shell to investigate and evaluate impacts on historic data for the energy loads for 1993-now.
- Generate new energy forecasts for future demand based on previous results with applied energy management and conservation techniques.

1.3 Methodology

In this study, our methodology was the evaluation of different possible energy management techniques and applying them to the Palestinian types of loads in the West Bank. Also, we developed new formulas to forecast electrical energy consumption and maximum peak power demand for the 20 years ahead including all possible energy management impacts. These forecasts were based on historical electrical energy data loads from 1992 until now. This study also includes a survey of previous work and studies done by other researches, PEA and consulting companies.

1.4 Outline of Study

This thesis is divided into 7 chapters including this introductory chapter.

Chapter 2 presents the current situation and historical data of the electrical system in the West Bank. It includes all the factors effecting the electrical system, such as projection of population from 1997 to 2020, areas in the West Bank with regard to electricity supply, sectors of electrical consumers, historical values of GDP which gives an indication of situation of electrical consumptions, types of losses in electrical system, and achievements of PEA in the West Bank under the obstacles of Israel occupation.

Chapter 3 presents a discussion on energy management principles, which include all the techniques of load shaping and the effect of implementing these techniques to end uses applications.

Chapter 4 discusses all efforts to implement energy management in the West Bank, such as the project of energy efficiency improvements and greenhouse gas reduction; this project funded by GEF/UNDP is carried out by PEA. Also, this chapter includes an overview on other factors affecting energy consumption such as, solar energy, wind energy and the effect of thermal insulation of houses in energy conservation and managements.

Chapter 5 presents possible savings in electrical energy consumption in the West Bank and the effect of these savings to utility load. In this chapter we suggest eight possible savings cases and implement these cases for tow years (1993 & 1999) to calculate the total possible savings as a base data to modify formulas that will be used to forecast electrical energy consumption with applied energy management principles for the next 20 years. Moreover, in this chapter many suggestions will be provided to electrical appliances and consumptions in order to reduce the amount of electrical energy consumed.

Also, chapter 5 includes an analysis of implementing energy management in lighting, the ways to decrease losses in electrical system, how to improve efficiency in power distribution systems elements (Transformers, conductors, transmission lines), correcting power factor and the effect of it's correction in the electrical utility and networks, and the possible savings after improving electric motors efficiency.

Chapter 6 present forecasting of electrical energy consumption and maximum power demand for the West Bank according to the previous studies formulas depending on four scenarios of future demography and future economy in the West Bank. According to the possible savings percentage calculated in chapter 5 new modified formulas would be generated to forecast electrical energy consumption and maximum power demand for the coming 20 years, based on demographic and economic scenarios.

Finally chapter 7 presents the results and recommendations of this study that will be presented to the decision-maker, electrical energy planner, and researchers.

Chapter 2

Electrical Energy Demand & Consumption in the W.B

Electrical Energy Demand & Consumption in the W.B

Electrical energy is considered of a great importance due to its role in reflecting the economy, the people welfare and style of living.

The energy sector is composed of three aspects: generation transmission, and distribution. As far as the first two are concerned, generation and transmission are not yet achieved in the West Bank's electric sector. The distribution network consisting of 22kV grid, 33kV grid and the 0.4kV network was not maintained or rehabilitated for years and caused not only frequent electricity disconnection, but also high percentage of losses in electric supply as well.

The Palestine power supply system composes of the West Bank system and Gaza system, due to the current political situation. The electrical power system in Palestine is vested with the municipal departments or village councils, except for the central area where served by Jerusalem districts electric company (JEDCO).

The electrical network has many problems such as:

- 95% of electrical energy with high kWh price is imported from the Israeli electric corporation (IEC).
- High percentage of electricity loss (more than 12%), the lack of knowledge and understanding of the power factor and its effect. The IEC is penalizing the Palestinian electrical utilities of about 4 million dollars per year due to the low power factor.
- High kWh prices, average price is 0.5NIS.
- Debts on the electricity consumers.

- Unavailability of continuous and reliable electricity to a relatively high percentage of Palestinian people and a high percentage of the industrial sector.
- Unavailability of national program of energy management and conservation.

In this chapter we disused the existing situation of electric system in the West Bank and the factors affecting this system. These factors include population and its growth rate, energy consumption, maximum power demand, power losses, achievements of Palestine energy authority, prices of electricity and cross domestic product (GDP).

2.1 Projection of Population and Its Growth Rate

Population is the most important factor affecting demand of electrical energy. There are many factors that influence population growth rates, such as: Age, distribution groups, fertility, mortality, immigration, natural catastrophes, standard of living and education.

The projection of population growth from 1997 to 2020 is shown in table2.1. The graph of population growth from 1997 to 2020 according to the data in table 2.1 is shown in figure2.1.

We note from the data in table 2.1 that the number of population increase and this increase in number of population needs increasing in electrical energy supply, using energy management and conservation planning options helped to decrease the amount of energy required.

Table2.1: The population and growth rate in the West Bank between 1997-2020.

Year	Total Population in Midyear	Growth Rate (%)
1997	1,787,562	3.81
1998	1,857,872	3.9
1999	1,932,632	3.99
2000	2,011,930	4.05
2001	2,102,360	4.72
2002	2,202,641	4.6
2003	2,304,825	4.47
2004	2,408,795	4.35
2005	2,514,480	4.24
2006	2,621,817	4.13
2007	2,730,750	4.02
2008	2,841,288	3.92
2009	2,953,433	3.82
2010	3,067,120	3.73
2011	3,167,583	2.73
2012	3,254,226	2.67
2013	3,341,343	2.62
2014	3,429,030	2.57
2015	3,517,154	2.51
2016	3,605,573	2.46
2017	3,694,140	2.40
2018	3,783,034	2.36
2019	3,872,403	2.31
2020	3,962,036	2.26
Source: PCBs, Population, Housing and establishment Census-1997, summary statistics of the W.B		

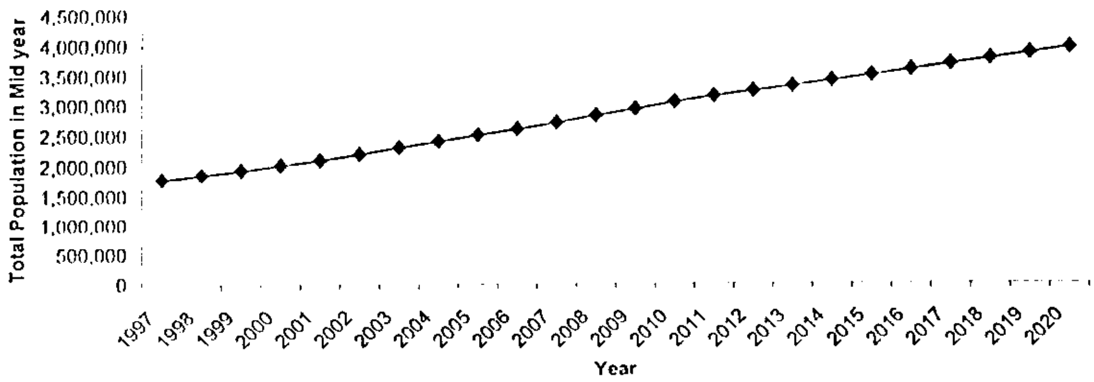


Figure 2.1: Projection of population in the West Bank From 1997 to 2020

2.2 Electrical Energy Supply in West Bank

The West Bank is divided into three areas with regard to electricity supply. The first area is without any electricity supply, the second is partially supplied with electricity from small diesel generators operating for a few hours a day, and the third area is connected to the electricity grid and thus receives electricity continuously.

2.2.1 Areas without Electricity

The areas without any electricity are concentrated in the southern Hebron and northern Jenen districts. As shown in table 2.2 the total population of these areas is estimated to be approximately 36162 people, constituting about 2.27 percent of the total population of West Bank, excluding the Bedouin population. In these areas, people depend on kerosene and dry batteries to operate radios and small electrical equipments.

2.2.2 Areas with Small Diesel Generators

Most of the southern Hebron and northern Jenin districts obtain their electricity from small diesel generators. These generators operate only a few hours a day, mainly during the evening hours. As shown in table 2.2 the total populations of these areas are approximately 53478, constituting about 3.35 percent of the total population of West Bank.

Electricity prices in villages served by a central diesel generator system, operating four to six hours at night, range from US$0.25-0.5/kWh. For small household diesel generator systems, electricity prices can be as high as US$0.7/kWh.

2.2.3Areas Connected to the Grid

Areas connected to the electric grid are mainly in the cities and large towns throughout Palestine. Electricity was generated from large diesel generators using heavy fuels, similar to the generator Jerusalem Electricity Company (JEDCo) and large municipalities. Today, however, these generators no longer generate electricity and serve only as distributors of electricity bought from the Israeli Electricity Company (IEC). As shown in table 2.2 the total population of these areas is approximately 1,502,951 , constituting about 94.28 percent of the total population of West Bank.

Electricity fees for these areas vary from US$0.14/kWh in the Jerusalem area to US$0.22/kWh in the Nablus area.

Lists of governorate in the West Bank with regard to electricity supply shown in table 2.2.

Table 2.2: Situation of population with regard to electrical energy supply in each governorate of the West Bank

Governorate	Number of people connected to Public Network	Number of people connected to privet Generation	Number of people without electricity	Total people
Jenin	176579	13269	5195	195171
Tubas	22539	10346	2286	35216
Tulkarm	126299	1808	715	128880
Qalqiliya	62052	5743	1381	69251
Salfit	44599	1675	344	46637
Nablus	246037	2382	2436	251114
Ramallah& Al-Bireh	198404	2901	2559	204044
Jerusalem*	108889	896	2948	112818
Jericho	25333	2053	2974	30429
Beth Lehem	126824	1116	2949	130970
Hebron	365396	11289	12371	389468
Total	1502951	53478	36162	1593998
Percent	94.28	3.35	2.27	100%

***Jerusalem does not include those parts, which were annexed by Israel in1967**

Source: PCBS, Population, Housing, and Establishment census-1997, Housing report, Table6

2.3 Electrical Energy Consumption and Max Power Demand

Table 2.3 shows historical data of energy consumption, maximum power demand and load factor, from 1993 to 1999 in the West Bank.

Load factor (L.F) normally not less than 50%and calculated according to the equation 2.1.

$$L.F = \frac{\text{Total Energy Consumption (GWH/Year)}*1000}{\text{Peak Power Load (MW)}*8760} \quad \text{..........2.1}$$

Table 2.3: Historical data of energy consumption, power and L.F in the W.B from 1993 to 1999

Year	Energy Consumption GWH	Max Power Demand MW	Load factor %
1993	818	162	57.6
1994	916	176	59.0
1995	1008	199	57.8
1996	1104	218	57.8
1997	1223	244	57.2
1998	1411	274	58.8
1999	1509	297	58.0

Sources of data:

- 1993 – 1998 , (Source: Said, Nidal Lafi : **Electrical Energy Planning for the West Bank Under Uncertainties.** (Master's Thesis). An-Najah National University. Nablus. Palestine, 1999)
- 1999 , (PEA)

Electrical consumers in the West Bank are divided into five sectors, such as:

1. **Domestic sector**: This sector covers all electrical energy consumed by households for housing purposes (water heating, heating, lighting, cooking, space conditioning…etc).
2. **Commercial consumers**: Includes all electrical energy commercial establishments.
3. **Industrial sector:** Includes all electrical energy consumed in industrial activities.
4. **Agricultural sector.**
5. **General services sector:** Includes all energy consumed by service establishments such as education, tourism, health and social services.

2.3.1 Domestic Sector

The most important sector is a domestic sector in the West Bank.

2.3.1.1 Energy Sources in Domestic Sector

There are two main sources of energy in this sector.

1. Electricity

In the West Bank 98% of the households are connected to the public electricity net work while 1.1% have no electricity services while 0.8% of Palestinian households depend on private generators to cover electricity needs as shown in PCBS, household energy survey during January 1999.

2. Solar Energy(Water heaters)

According to Population, Housing and established census-1997, 56.4% of West Bank households are utilizing solar energy by using solar energy heaters. Chapter 4 includes more details about utilizing SWH in W.B.

2.3.1.2 Electrical energy uses in different household activities

According to PCBS, household energy survey during January 1999 There are 98.8% of household in West Bank electricity in different activitiesas the following:

1. **Cooking:** 6.8% households use electricity as an auxiliary source while0.3% as a main source of fuel in cooking

2. **Space heating:** 12.7% of West Bank households depend on electricity as a main source of heating, while 4.1% of households depend on electricity as an auxiliary source of heating.
3. **Water heating**: 20.2% of the households in the W.B depend on electricity as a main source for water heating. While 4.3%of households depends on electricity as an auxiliary source of water heater.
4. **Refrigerator**: 81.6% of the households in the W.B have refrigerator
5. **Lighting:** 98.5% of the households in West Bank depend on electricity as a main source of lighting.

2.3.1.3 Expenditure on energy in domestic sector

The Average monthly household expenditure on energy types according PCBS, household energy survey during January 1999 was 277.4NIS. This expenditure was composed at 122.4 NIS. for electricity.

2.4 Gross Domestic Product (GDP)

This is an important factor in economic and in electrical energy analysis. However, in Palestine because of the Israeli occupation and the lack of independent economy historical values of GDP may not be due to inflation or due to donation money. GDP gives an indication of situation of each sector of energy consumption in residential, industrial, commercial and other sectors. High GDP values indict that all the scoters are active. The historical data of GPD per capital from 1992 to 1999 are shown in table 2.4.

Table 2.4: Historical data of GDP per capital in the West Bank for the period 1992-1999

Year	GDP per capital ($)
1992	1314
1993	1368
1994	1409
1995	1624
1996	1690
1997	1740
1998	1775
1999	1811

Source of data: (Said, Nidal Lafi : **Electrical Energy Planning for the West Bank Under Uncertainties**. (Master's Thesis). An-Najah National University. Nablus. Palestine, 1999)

2.5 Power Losses

Power losses in the West Bank electrical system can be classified into two main categories:

1. Technical losses
2. Non- technical losses

2.5.1 Technical losses

The technical power loss resulted from the generation, transmission and distribution of electricity to consumers. In normal electrical systems the percentage of loss up to the consumers will not exceed 6 percent of the total generated power.

The important loss comes from penalty added to the consumers invoice, due to the low power factor (PF). The inductive loads connected to the electrical supply, like motors and fluorescent lamps, create the low values PF. In West Bank the acceptable power factor to the electricity suppliers is 0.92. PEA made several electrifying projects and losses reduction programs to decrease technical losses from 15.6% to 12% in1998. This loss reduction program will save alot of money because reduction in losses can balance the demand growth and so will decrease the need for adding new generation units or the need for buying electricity at high prices.

2.5.2 Non- Technical losses

These losses are not controlled because this losses from the behavior of consumer and their culture.

These losses equal the difference between total losses and technical losses and classified into two types:

–Commercial losses.

–Illegal consumption.

More details of power losses discussed in chapter 5.

2.6 Prices of Electricity

IEC is the only supplier of electricity to the West Bank; electricity prices in the W.B are very high compared with prices in Israel and neighboring countries nearly 0.5 NIS/kwh. (No signal tariff)

2.7 PEA and Its Achievements in W.B

PEA was established on 14, November,1994 to be in charge of energy sector. Since that date PEA studied the electrical status, and enhanced the degraded situation through network rehabilitation projects to resolve technical problems and minimize losses.

Achievements of PEA can be summarized in the following points:

1. Rehabilitation projects in northern West Bank: the objectives of the project focus on the following:
   - Upgrading the existing electrical network.
   - Constructing new electric networks in addition to the old grid.
   - Minimizing the network technical losses and the fines resulting from lower power factor vales.
   - Building new distribution transformer substations to serve metropolitan areas.

2. Beth Lahem2000: the objectives of the project are the rehabilitation of the electrical network in Beth-Lahem and Beitsahor and Betjala through:
   - Stepping the voltage up from 6.6KV to11KV.
   - Connecting non-electrified villages through 33KV and 22KV.
   - The rehabilitation of the main distribution substation in Beitsahor.

3. Rural electrification:
   - Tobas project: the objective of this project to electrify 19 village on four stages, the project is to serve 50,561 in habitants.
   - Northern region rural electrification project: The project is to connect about 29 village in the northern region of the W. B. New lines of 33KV metering rooms, low voltage network, and distribution transformers will be installed.
   - Jenen and Yata villages' electrification: The project is focused on low voltage networks. The PEA designed and prepared the tender documents and supervised about 50km of LV network. The total served population is 9365 in habitants.
   - Saer and Al-Shuyoukh project: There are 15000 in habitants and 1700 consumers in these towns. The project will provide the people

by a permanent electric source to be used for water pumping and stones industry, in addition to the domestic and commercial purposes.

- Noba project: This village was connected to the electricity grid by 33kV overhead line with a length of about 1.2km. Two transformers with a total capacity of 1.2MVA have been installed. The project serves about 3500 inhabitants.

Chapter 3

Principles of Energy Management and Conservation

Principles of Energy Management and Conservation

Demand side management is usually defined as the planning and implementation of utility activities designed to influence customer use of electricity in ways that will reduce desired changes in the utility load shape (i.e. changes in the time pattern and magnitude of utility's load). Utility programs falling under the umbrella of demand side-management include load management, new uses, strategic conservation, electrification, customer generation and adjustments in market share.

Load management is the set of utility activities defined to influence the timing and magnitude of customer use of electricity. A number of methods exist for modifying system load patterns to more closely match electric energy use with supply.

The success of any project of load management program depends on whether the benefits out weigh costs or not. Because of the wide variation in the shape and composition of load pattern curves among utility systems as well as geographical variations capacity and fuel costs. Each utility is likely to make its own load management analysis.

3.1 Objective of Load management

Around the world, in industrial and non-industrial nations alike, there is a growing marine at the central role played by energy in the economy, food supply and national productivity. Energy management concepts promise to be of increasing importance in enabling mankind to meet the challenges of the future: Providing employment, food and security for future generations.

The most effective load control is possible only when the load management systems of a number of major consumes are some how integrated and the diversities of their operations are taken into account. The implementation of this concept would require an integrated and intelligent control system.

Load management refers to the supply end of the system and encompasses those activities taken by utilities to manipulate the load seen by their generating systems in order to:

1. Improve system efficiency.
2. Shift fuel dependency from limited to more a abundant energy resources.
3. Reduce reserve requirements (generation, transmission and distribution).
4. Improve reliability of essential loads.

Figure 3.1 illustrates how load management can reduce the requirements for peaking capacity and increase the utilization of more efficient base low capacity (i.e. nuclear and coal). The upper graph shows the typical annual load duration curve without load management (the solid line). In the same graph the dotted line represents the modified load duration curve after moving energy from the hour of high demand to the hour of low demand. The lower graph is a screening curve representation of the levelized annual cost of operating various types of generating units. As the number of hours of operation increases the total cost increase because of fuel, operation and maintenance cost. Efficient base load units (unit three and four) generally have higher capital costs , but the cost curves have a flatter slope because of the increased efficiency, unit one and two represent less efficient intermediate and peaking generation with lower capital costs. The cost curves of these units size more rapidly as hours of operation.

However, the development of load management comes as a result of different factors such as the oil crisis and the high oil prices, the environmental constrains in expanding existing or establishing new power plants and the concern about safety in nuclear power plants. These factors have motivated the development of the following methods as alternatives:

1. Developing new planning models and strategies.
2. Improving the system utilization.
3. Developing methods to control the rate of peak load growth.

While the last two methods form the set of major functions of load management, our concern in this study will be focused on the last one.

Generally speaking the peak load increases as the demand for electric energy goes up. As the generation capacity requirements are directly proportional to the peak load, the reduction of this peak will result in retaining the revenue base while reducing the additional capacity requirements. The load factor (LF) which is calculated using equation 3.1 measures the ratio of the average real system load to the peak load.

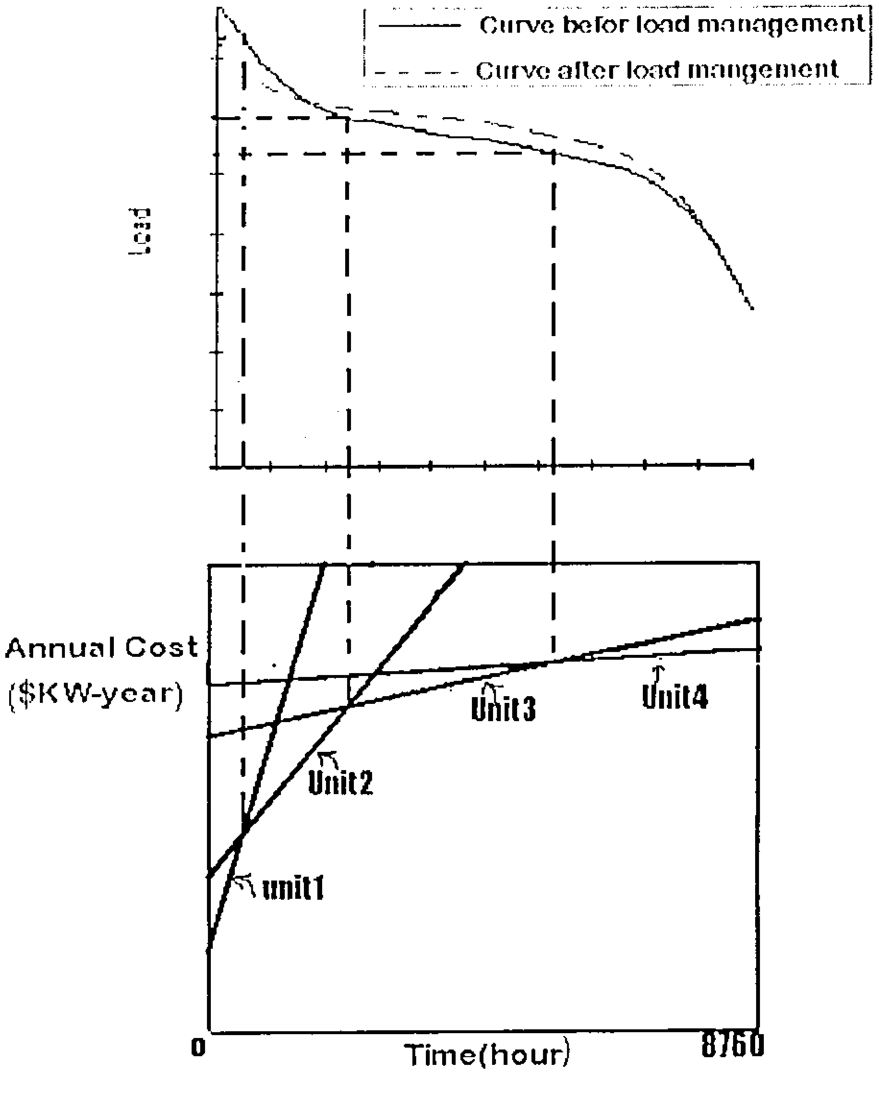
$$\text{Load factor} = \frac{\int_{1}^{2} L(t)dt}{T * Peak\_load} \quad \text{......................3.1}$$

T: time period and equals (t_2-t_1)

L(t): electric load as a function of time

It is in the interest of the electric utility to have a high load factor (closed to unity) because this will reduce the capacity requirements. The improvement of the load factor can be achieved by two methods

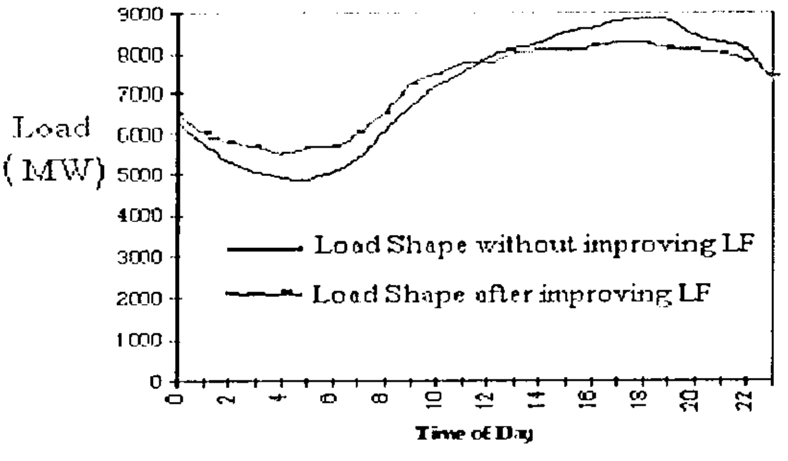
1. The improvement of the sales during off-peak hours.
2. Shaving the load peak.



Source: Baba, Mutasem : **Intellgent and Integrated Load Management System,** (PHD Thesis) . Virginia University. USA, 1987.

Figure 3.1: Reducing the requirements for peaking capacity using load management

Figure 3.2 illustrates the idea of improving the load factor by increasing off-peak demand and reducing the peak load.



Source: Baba, Mutasem : **Intellgent and Integrated Load Management System,** (PHD Thesis) . Virginia University. USA, 1987.

Figure 3.2: Comparison between typical load curve before and after LF improvement

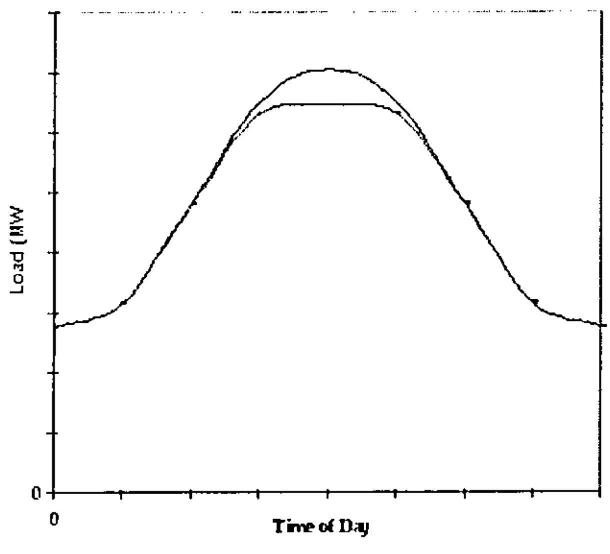
3.2 Techniques of Load Shaping

In the case of load management, there are three basic load shaping techniques; peak clipping, valley filling and load shifting. There are another techniques such as; strategic conservation, strategic load growth and flexible load shape. The load shape techniques reflect the desired and result associated with a load management alternative.

With the load shape defined, the remainder of the evaluation process is directed toward selecting the method for achieving that objective. Naturally the load shape for a utility can vary depending on the time of day, season, and time frame under study and can also change as the utility's business conditions change.

3.2.1 Peak Clipping

Peak clipping, or the reduction of the system peak loads, embodies one of the classic forms of load management. Peak clipping is generally considered as the reduction of peak load by using direct load control. Direct load control is most commonly practiced by direct utility control of customer's appliances. While many utilities consider this as a means to reducing peaking capacity or purchases and consider control only during the most probable days of system peak, direct load control can be used to reduce operating cost and dependence on critical fuels by economic dispatch.



Source: Battelle – Columbs division, **Demand Side Management for Rural Electric Systems**, USA, 1986

Figure 3.3: Idea of Peak Clipping

Because of the high capital cost of new generating capacity, as well as the cost of the distribution system, most utilities charge for some type of "coincidental peak" demand. Coincidental peak demand refers to the customer's contribution to the utility's peak for the month. Therefor it is in the interest of the customer as well as for the utility to undertake additional demand-side management programs aimed at reducing demand during peak-load hours.

Since peak clipping is usually activated on days with probable system peak only, then the magnitude of this peak clipping impact is uncertain. However, for the customers purchasing their electrical energy from utilities charging for coincidental peak, the possibility of saving money by reducing their contribution to the peak is very high. The success of this process depends heavily on the ability of the customer to predict the exact time of the peak.

It is very important to note that reductions in the peak demand using direct load control are followed by increases in demand. This increase in demand usually referred to by "payback" or "restrike" demand. The load control strategy must be selected carefully in order to avoid a shifted peak due to the payback demand. Figure 3.4 illustrates the idea of peak reduction and payback demand in the system load.

For the general electric utility curve shown in figure 3.4, if the peak was reduced by peak clipping methods then the electric utility will be affected by:

1- The peak load is reduced, requiring less on-line capacity to serve it. Further if this reduction is constant over an extended period of time such as a planning horizon, then the additional capacity requirements are also reduced.
2- The average load is higher i.e., the load factor is closer to unity.

As the load factor approaches unity, the implications are:

- The generation, transmission and distribution system is more effectively utilized, thus improving the economics.
- Additional capacity requirements are reduced.

3- If the increase in demand for energy due to payback was equal or greater than the reduction due to load control, then, more electric energy has been served than before. In most cases the opposite happens, that is there is a reduction in the total sales of electrical energy in days with load control.

For existing load management systems, there are four methods, which can be used to reduce the peak demand. These methods are:

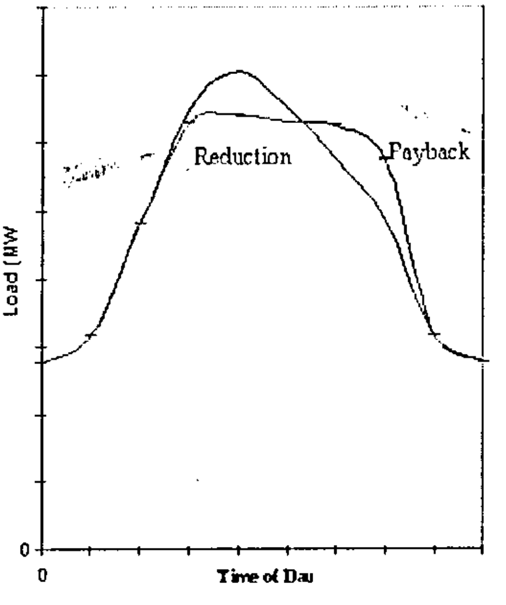
- Off-peak schedules;
- Energy storage;
- Demand limiting control; and
- Computer demand control systems.

Off-peak scheduling applies to loads such as irrigation water pumps, which can be scheduled to operate at night or other times of low demand.

Energy Storage can also be considered to reduce on-peak demand. Water heaters can be operated off-peak and can store hot water for several hours. Buildings can be precooled at night (using the thermal mass of the building to store energy) to reduce daytime peak energy.

Demand Limiting Control can be designed to provide an indication of the demand and can open relays, preventing a pre-established limit from being exceeded.

Computer Demand Controllers can go a step further by projecting the load demand for the next demand interval, and if it appears that the demand limit (threshold value of the month) will be exceeded, automatically drop certain nonessential loads from the line. Once the demand decreases, these loads will be restored automatically.



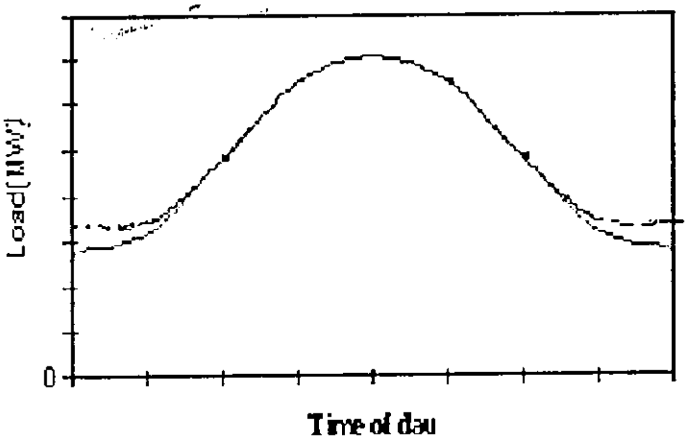
Source: Battelle – Columbs division, **Demand Side Management for Rural Electric Systems**, USA, 1986

Figure 3.4: Peak clipping and payback demand

The last approach will be considered for the design of the intelligent and integrated load management system. Significant developments in mini and microcomputers and the low prices of this equipment make this approach practical and economical.

3.2.2 Valley Filling

The second classic form of load management. Valley filling encompasses building off-peak loads. This may be particularly desirable when the long-run incremental cost is less than the average price of electricity. Adding properly priced off-peak load under those circumstances decreases the average price. Valley filling can be accomplished in several ways, one of the most popular of which is new thermal energy storage (water heating and/or space heating) that displaces loads served by fossil fuels.

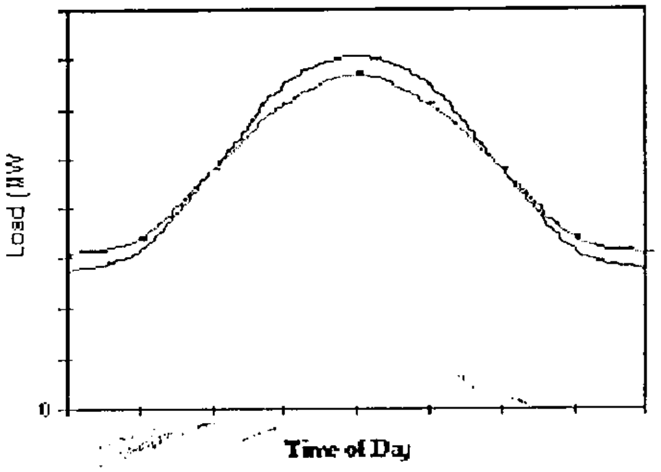


Source: Battelle – Columbs division, **Demand Side Management for Rural Electric Systems**, USA, 1986

Figure 3.5: Idea of Valley Filling

3.2.3 Load Shifting

The last classic form of load management this involves shifting load from on-peak to off-peak periods. Popular applications include use of storage water heating, storage space heating, coolness storage, and customer load shifts. In this case, the load shift from storage devices involves displacing what would have been conventional appliances served by electricity.

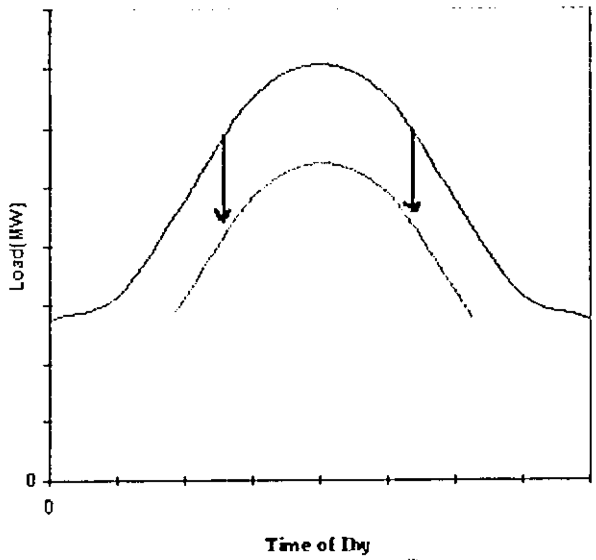


Source: Battelle – Columbs division, **Demand Side Management for Rural Electric Systems**, USA, 1986

Figure 3.6: Idea of Load Shifting

3.2.4 Strategic Conservation

The load shape change that results from utility-simulated programs directed at end-use consumption. Not normally considered load management, the change reflects a modification of the load shape involving a reduction in sales as well as a change in the pattern of use. In employing energy conservation the utility planner must consider what conservation actions would occur naturally and then evaluate the cost-effectiveness of possible intended utility programs to accelerate or simulate those actions. Examples include weatherization and appliance efficiency improvement.

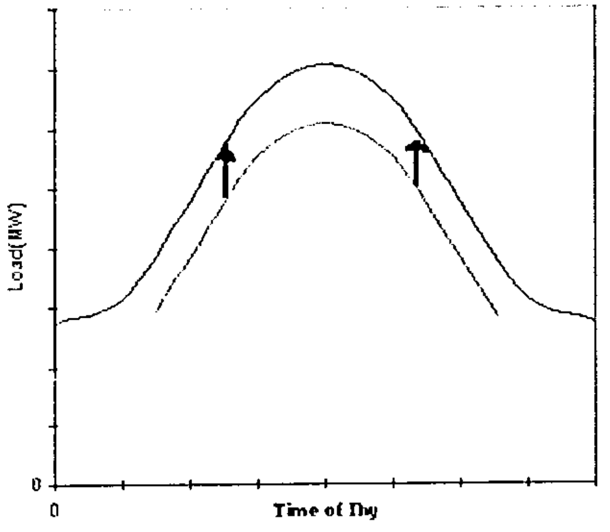


Source: Battelle – Columbs division, **Demand Side Management for Rural Electric Systems**, USA, 1986

Figure 3.7: Idea of Strategic Conservation

3.2.5 Strategic Load Growth

The load shape change that refers to a general increase in sales beyond the valley filling described previously. Load growth may involve increased market share of loads that are, or can be, served by competing fuels, as well as area development. In the future, load growth may include electrification. Electrification is the term currently being employed to describe the new emerging electric technologies surrounding electric vehicles, industrial process heating, and automation. This rise in intensity may be motivated by reduction in the use of fossil fuels and raw materials resulting in improved overall productivity.

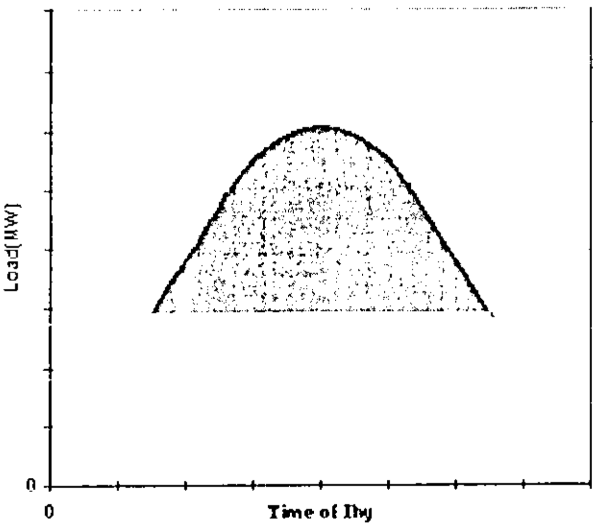


Source: Battelle – Columbs division, **Demand Side Management for Rural Electric Systems**, USA, 1986

Figure 3.8: Idea of Strategic Load Growth

3.2.6 Flexible Load Shape

A concept related to reliability, a planning constraint. Once the anticipated load shape, including demand-side activities, is forecast over the corporate planning horizon, the power supply planner studies the final optimum supply-side options. Among the many criteria he uses is reliability. Load shape can be flexible if customers are presented with options as to the variations in quality of service that they are willing to allow in exchange for various incentives. The programs involved can be variations of interruptible or curtailable load; concepts of pooled, integrated energy management systems; or individual customer load control devices offering service constraints.



Source: Battelle – Columbs division, **Demand Side Management for Rural Electric Systems**, USA, 1986

Figure 3.9: Idea of Flexible Load Shape

3.3 End-Use Categories

Once the load shape objective has been established, the second dimension of DSM alternatives involves selecting appropriate end use (e. g., residential space heating or domestic water heating) whose energy demand and consumption characteristics can generally be matched to requirements of the objectives.

The following deals with the nine major residential end-uses of electricity. These are:

1. Space heating.
2. Space cooling.
3. Domestic water heating.
4. Lighting.
5. Refrigeration.
6. Cooking.
7. Clothes washing and dishwashing.
8. Other uses (e.g., entertainment and home repair).

Each of these end-uses provides a different set of opportunities for meeting some of the typical load shape objectives that have been discussed. Some of the more applicable relationships between load shape objectives and residential end-uses are discussed in this chapter in order to help a cooperative manager identify possible areas of focus for DSM programs. Of course, specific conditions of a cooperative and its consumers will have a bearing on choosing a specific end-uses.

Several factors are important in determining the applicability of a particular end-uses to a cooperative's load shape objectives, and in estimating the subsequent benefits to the cooperative and its consumers. An important consideration is the relative need for the end-use within the service area. Related considerations include the extent of existing saturation of various types of equipment to serve the end-uses, the availability of competing fuels, and equipment and energy costs for electric versus non-electric options.

The following subsections discuss some of the potential relationships among the various end-uses and load shape modification objectives, and indicate some of the parameters normally considered in selecting a target end-use. These end-use discussions are intended to be used as guides to a selection process, indicating important general considerations.

3.3.1 Space Heating

Electric space heating can be potentially useful in meeting any of several load shape objectives for both summer- and winter-peaking cooperatives. Under the proper circumstances, space heating can provide peak clipping, load shifting, strategic conservation, and strategic load growth benefits.

Peak clipping can be achieved through load control, dual-fuel furnace, thermal storage and other options. Often, load shifting can also be accomplished by using thermal-storage space heating systems. Flexible load shape objectives can be achieved using dual-fuel furnaces designed to allow either consumer or cooperative control without consumer discomfort.

Strategic load growth opportunities may be achieved through promotion of efficient space heating options, such as new or add-on heat pumps, dual-fuel furnaces, and electric resistance task heaters. By employing appropriate consumer space heating options, for example, a summer-peaking cooperative might fill part of its winter valley. Similarly, thermal storage options can be used for daily valley filling.

Strategic conservation possibilities to improve efficiency, lower energy costs, and improve the overall competitiveness of electricity may also exist when electric heating saturation's are large. This is especially true when there are large numbers of older, poorly insulated houses in the service area.

3.3.2 Space Cooling

Because nearly all currently available residential space cooling systems are electrically driven, there is high potential for both the cooperative and consumer to benefit from DSM options with this end use.

A cooperative with a sufficient cooling load can obtain summer peak clipping and flexible load shape benefits using any of several spaces cooling options. Utility experience to date indicates that many consumers will allow a substantial degree of air conditioner cycling control, resulting in significant potential for cost-effective load relief.

Daily valley filling and load shifting with residential space cooling loads often exhibit a high degree of coincidence with cooperative daily peak periods. Thermal-storage options are being developed to allow peak period cooling demands to be met by energy consumed during off-peak periods. Although equipment for residential off-peak cooling is not commercially available at present, storage cooling systems are available for, and are being successfully used by, commercial and industrial class consumers. Residential prototype systems have been tested. Planned system development work in residential storage cooling may lead to the commercial availability of space cooling options for use in daily valley filling and load shifting programs.

Strategic conservation possibilities exist where residential space cooling is prevalent, and several options, including high efficiency equipment, window treatments, and insulation, are available. Some strategic load growth opportunities may also exist, particularly where existing saturation's of cooling equipment are relatively low and high efficiency equipment can be shown to offer affordable comfort to consumers who might not have purchased air conditioners in the past.

3.3.3 Domestic Water Heating

Domestic water heating can provide opportunities to meet more load shape modification objectives than most of the other residential end-uses. Electric water heaters have relatively high load factors and are used throughout the year. Thus, water heaters are good target end-uses for load shape modification for both winter-and summer-peaking cooperatives. Most have a built-in water storage tank to minimize consumer inconvenience, and high-efficiency and efficiency-improvement options are available. Additionally, domestic water heating is universally required. As a result, there can be DSM opportunities with domestic water heating under a wide variety of circumstances.

Peak clipping benefits can be obtained through controlling domestic water heaters, with the extent of the benefits, again, contingent on cooperative and consumer variables.

The thermal-storage capability of standard electric water heaters makes them useful in meeting load shifting requirements. Some domestic water heating options are suitable for valley filling in that they replace competing fuels with off-peak resistance heating and storage.

The high percentage of installations of all types of water heaters and the availability of efficient electric water heating options often make domestic water heating well suited to strategic load growth. This is, of course, highly dependent on the existing saturation of electric water heaters, the availability and relative cost of competing fuels, and other factors.

Strategic conservation objectives can often be achieved using domestic water heating options, such as heat pump or heat recovery systems and tank wraps, when there is a high saturation of electric water heaters. A related consideration is that several other end-uses of potential interest in residential DSM require hot water. For example, the largest portion of clothes washing and dishwashing energy (about 90 percent) is used for water heating. As a result, it is often desirable to combine aspects of programs dealing with such related end-uses to maximize load impact results.

Domestic water heating can be an excellent tool for achieving flexible load shape goals. Water heaters can be turned off for very long periods (typically 4 hours or more) without adversely affecting consumers' usage. This allows a very wide range of both direct cooperative control and local control options and of control strategies for achieving the desired load shape modifications. Control flexibility also arises from the ability to control either heating element separately or both elements together. This allows the control period and average load impact to be adjusted to meet the load shape objective and successfully obtain consumer impact trade-off.

3.3.4 Lighting

Lighting constitutes a significant percentage of total residential electric energy consumption, and is used by virtually all consumers. However, because of its particular usage characteristics, residential lighting as a target and-use is suitable mainly for achieving strategic conservation objectives. To this end, several energy efficient lighting options are available to consumers possibly resulting in a noticeable reduction in demand.

3.3.5 Refrigeration

As an end-use, refrigeration accounts for about 25 percent of residential electric energy consumption. Residential refrigeration loads represent load shape modification possibilities similar to those of lighting` thus, it is best suited for strategic conservation.

Several utilities have been investigating the possibility of some form of residential refrigerator/freezer control, because the devices do have some inherent cool storage capacity and might produce mutually acceptable cooperative and consumer results.

The extremely large market makes consideration of high efficiency option important. An increasing number of utilities are offering rebates or other incentives to encourage consumers to purchase high efficiency models or to discontinue using older, inefficient refrigerators as second units.

3.3.6 Cooking

Residential cooking loads can be used to some extent to meet several load shape modification objectives. There are cooking options that can serve strategic conservation, strategic load growth, and flexible load shape goals to varying degrees.

For example, energy efficient appliances, such as microwave or convection ovens, can reduce cooking energy consumption. Microwave ovens can also replace portions of cooking loads served by other fuels, thereby helping to achieve load growth.

At present, peak clipping and load shifting via residential cooking loads are generally not practical because the ability to defer these loads depends to large extent on modifying consumer behavior (e.g., waiting until off-peak hours for dinner) rather than on inherent device characteristic.

Additionally, residential cooking loads are not well suited to daily valley filling because there is no thermal-storage cooking hardware and there are limits to the extent to which consumers will reschedule their mealtimes.

3.3.7 Clothes Washing and Dishwashing

Clothes washing and dishwashing loads can also be used to meet several of the load shape objectives-in particular, strategic conservation and flexible load shape. Both laundry and dishwashing tend to be naturally deferrable' that is, consumers will more readily adopt alternative schedules for washing clothes or dishes than they will for cooking. As a result, these end-uses offer some potential for meeting flexible load shape and load shifting objectives.

Laundry loads have a potential for load shifting because they can be deferred. A program aimed at load shifting would effectively be asking consumers to change their use habits and would likely require incentives.

Energy efficient washers and dishwashers are available for use in strategic conservation programs. As mentioned in the water heating discussion, because the major portion of washing energy is used for heating water, washing options can often be combined with water heating options to produce larger per-installation load impacts.

3.3.8 Other Uses

Very few other residential uses of electricity currently represent significant opportunities for load shape modification. End-uses such as gardening, home entertainment and recreation, and house and car maintenance might offer opportunities to some utilities. Increasing sales of new types of home appliances may lead to increased energy demand, and home computers and electric lawn mowers could conceivably be used as a strategic load growth target.

Chapter 4

Energy Management for Palestine

Energy Management for Palestine

Two types of energy management are being applied in West Bank, one direct and the other indirect. The indirect types of EM include solar water heater (SWH) by the residential sector and solar cells. No enforcement's are applied to motivate such application. However, the beneficiaries and energy savings are very clear to all Palestinian customers. Also, the awareness of savings by purchasing energy efficient refrigerators and air conditions represents are the example of indirect energy management.

The indirect EM enforcement is represented by the project "Energy Efficiency Improvements and Green House Gas Reduction" carried out by the Energy Authority and funded by GEF/UNDP.

This project concentrate on energy savings by reducing losses in power lines, improving PF, increasing efficiency of lighting, motors, refrigerators,.. etc.

4.1 Energy Efficiency Improvements and Greenhouse Gas Reduction Project Carried by PEA

4.1.1 Energy Management Attempts in Palestine

The Palestinian Authority has no economic domestic supplies of primary energy, with the exception of some solar and biomass energy that supplies about 9% of the Palestinian authority's total energy. The Palestinian authority has no economically recoverable oil, gas, or coal reserves and must import all of its 470 Thousand Tones (Metric) of oil (MTOE) of energy resources (about10, 00 barrels/day). It uses equivalent no hydroelectric energy and lacks any significant hydroelectric potential.

Furthermore, the Palestinian authority lacks supplies of secondary energy in that it imports more than 95% of its electricity from the Israel Electric Company (IEC) in Israel.

The lack of available energy supplies also contributes to relatively high prices for all forms of energy. Petroleum prices are $4/ GJ; gas prices are $5/GJ. The typical electrical user pays an average of 14c/kWh for electricity at the retail level. Retail electricity prices range from9.5c/kWh in East Jerusalem to more than 19c/kWh in Jenin.

The gross national product in 1994 was approximately $3,500 million, with a per capita income of $1,350. This is less than one-tenth the per capita Gross Domestic Product (GDP) of Israel. The combination of the lack of local energy resources and the low income of the population. The Palestinian Authority uses a relatively small amount of energy per capita. Its energy consumption per person is only about 350kgoe, making among the lesser energy intensive economies in the developing world. Per capita electricity consumption is only 600 kWh per person, equivalent to the continuous operation of a 70watt light bulb fore each resident. The Palestinian Authority's electricity consumption is 30%less than that of Syria and 40%less than that of Egypt. The Palestinian Authority's per capita electricity consumption is only about1/8 that of Israel.

Electricity prices are likely to increase even more in the future, when Israel implements time-of-use rates for wholesale power purchases by the electric distribution companies. Currently, the Palestinian Authority buys electricity at an average wholesale rate of 8-10 c/kWh that dose not vary by time of day. These rate doses not take into account the fact that the Palestinian Authority consumes a higher percentage of its energy at peak.

periods than do Israeli consumers. In this regard and all other things being equal, consumers in Israel are subsidizing consumers in the Palestinian Authority. This cross-subsidization will end when time-of-use rates are implemented. Electricity rate increases in the Palestinian Authority will accompany electricity rate reduction in Israel.

In spit of its low level of energy use and relatively high electricity prices, a relatively low level of efficiency characterizes the Palestinian Authority. The Palestinian Authority uses about 0.45kg of oil per unit of Gross Domestic Product (GDP), a level that is twice as high as the world average. Energy efficiency has become worse as energy consumption has grown steadily during the 1990's, despite a decline in the Palestinian Authority's economy since1994.

4.1.2 Potential for Energy Efficiency

There has so far been little or no research on the potential of energy efficiency that is possible within the PA. The low degree of energy efficiency in practice, as measured by energy use per unit of GDP, is indicative of a substantial amount of remaining energy efficiency potential to be tapped. Furthermore, the limited research that has been conducted so far, combined with information on the characteristics of energy using equipment in place, are also indicative of a very high level of remaining energy efficiency potential in the PA.

Discussions held in July 1997 by the United Nations Development Program /Global Environmental Facility mission team revealed that at least 40% of consumers buy older models of used equipment from the Israeli market. In Gaza this may by as high as 80%, while in the West Bank it may by around 20%. These have much lower efficiency than the more energy efficient new models available on world markets (and probably from the Israeli market). The most energy efficient new refrigerators manufactured for industrialized countries may consume as little as 27%(a 73% savings) of the energy consumption of the older models bought on the second-hand market. Compared to the typical new models sold in industrialized countries, new energy efficient models can still save 44% of electric consumption since households consume 68% of all PA electricity, and refrigerators account for40-70%of this electricity, refrigerators alone account for 30-40% of the PA's entire electric consumption. If households adopted compact fluorescent lamps in place of incandescent lamps, lighting energy could be reduced by 66%-80% per light fixture. The saving would be 50-60% in fixtures that now use fluorescent tube lamps if these were changed to compact fluorescent light, and by 25% if watt-saver lamps and energy efficient ballast's were used.

Residential electric consumers pay 0.33 to 0.52 Shekels (NIS) per kWh (the equivalent of US $ 0.10-0.15 per kWh) for electricity. One might think that such high electricity prices, relative to local incomes, would provide significant consumer motivation to use energy efficient appliances and equipment.

However, this does not appear to be the case in Palestine. Purchases of energy efficient household appliances and equipment do not occur due four barriers:

- Energy efficient equipment is not readily available in the local market.

- Lack of consumer awareness of the benefits of energy efficient models in reduced running and energy costs, and there is a lack of consumer demand for these models.
- Lack of product labeling information to help the consumer determine if a model of certain equipment (e.g. refrigerator, water heater) is energy efficient or not.
- Tendency of consumers to buy on first cost basis, and ignore the promise of long term savings in running costs from energy efficient models; in parallel, limited use of credit or installment payment terms to remove the first cost barrier of buying energy efficient models.

Industrial and commercial sector customers use little energy efficient equipment, because of difficulties in maintaining this higher-technology equipment properly. The pumps used for domestic water supply and irrigation are largely old and inefficient. In most countries facing these conditions, it is typical to identify the potential for non-residential facilities to improve their energy efficiency by 15-20%, and even higher in many commercial facilities such as office buildings, hotels, retail and food stores. One study of street lighting performed by Palestinian Energy Research and Conservation Center (PEC) found a potential for a 67% improvement in street lighting around parking lots and factories in the Nablus area.

The PA's low level of energy efficiency has resulted from the relatively low priority that has been given to energy efficiency and to several important barriers to greater efficiency.

Improving the efficiency of energy at the end-user level has not been a priority for either the private or public sectors in the PA. In the public sector, government agencies and multilateral development banks have focused most of their attention upon two issues:

1. Reducing distribution losses, which have been until recently as high as 40%. The World Bank and development banks in Italy, Norway, and other countries have so far disbursed about $20milion of commitments have been approved for other regions in the West Bank.
2. Obtaining a supply of energy that is independent of the state of Israel. PEA just concluded a 15-year Build Own Transfer (BOT) agreement for electricity supply from a Palestinian investment group.

In the private sector, few if any customers have given much attention to improving energy end-use efficiency. In meetings held with industrial and commercial sector energy end-users, customers stated that their energy use decisions were nearly all focused upon supply side options such as obtaining back-up generation to obtain electricity service at a lower cost or with greater reliability. Businesses had to be repeatedly reminded that energy efficiency was even an option for helping to solve energy problems.

4.1.3 PEA Project Objectives

By the 2010, the four objectives will reduce energy consumption by a total of 14% compared to current levels and reduce CO_2 emissions by 265,000 tons per year.

Objective 1

To improve industrial, commercial, and residential sector energy efficiency by 17%by reducing awareness, information, financial, business, technology, and other barriers to energy efficiency, eliminating nearly 80, 000 tons of CO_2 per year.

To reduce energy consumption by 10% in the industrial, commercial, and government sectors by the year 2005 through a four year program to: increase energy efficiency awareness; promote development of an energy services industry; expand energy-efficient equipment availability; and encourage energy-efficient consumer behavior.

Objective 2

To improve residential sector energy efficiency by 11% by reducing information, financial, equipment, and other barriers to energy efficiency, thereby reducing CO_2 emissions by more than 140,000 tons of CO_2 per year.

- Improve unit refrigerator efficiency by an average of 55%, to be achieved for an average 15% penetration of the annual market of replaced and new refrigerators during years 2-4 of the refrigerator program. Expect penetration of 5% in year2, 15%in year3, and 25%in year4. Establish market support to increase penetration in successive years to rise to 70%of annual market by the 6^{th} year anniversary of the start of the refrigerator program.
- Improve average household lighting efficiency by 40-50% for an initial 20,000 households (5-6 percent of the estimated 360,000 total households in the West Bank and Gaza Strip) by the end of year 3 of the lighting leasing program, with subsequent penetration of 40% of

households by the 5th year anniversary of the lighting leasing program's commencement.

Together, these outputs are expected to reduce electricity consumption by an average of 119,000MWh, or 7% of total 1996 electric consumption by the year 2005, through a program that expands the inventory of energy efficient equipment in stores, builds consumer awareness of energy efficiency cost-savings opportunities, creates a system to identify the expected energy use of individual appliances, and develops financing mechanisms that assist consumers to purchase energy efficient equipment.

Objective 3

To facilitate a 2% reduction in electricity distribution line losses by identifying and evaluating potential priority projects for multilateral development bank or other funding, therefore reducing nearly45, 000 tons of CO_2 per year.

Objective 4

To facilitate the achievement of the energy demand reductions estimated under Objectives 1-3 and therefore facilitate the realization of the estimated 265 million tons of CO_2 per year by the year 2010. This will be achieved through a three-year promotion program, institutionalized on a sustainable basis through an energy efficiency center. This will aim to

1. Increase customer /consumer awareness of-and strategic action on energy efficiency issues by public and private sector energy market participants such as potential energy service providers, equipment

vendors and manufacturers, energy industry/ sector professionals and energy end users.

2. Incorporate the findings on the impacts, emissions benefits and associated costs of end use efficiency improvements into power sector resource and investment planning methods.

4.2 Solar Energy in Palestine

The annual daily average of solar radiation intensity on horizontal plane in Palestine is estimated to 5.4 kWh/m^2.day. The average of solar radiation intensity during the 4 winter months estimated to 3.5 kWh/m^2.day and exceeds 6.2 kWh/m^2.day in the remaining period of the year. The annual average of daily sunshine duration is estimated to 9.2h. from the above mentioned figures, it can be concluded that Palestine has a high potential of solar energy which can be considered as a reliable energy source, even during winter season.

4.2.1 Solar Water Heaters

Solar water heaters enable the user to uses the Sun.'s "free" heat energy to produce hot water for daily use. Solar water heaters, sometimes called solar domestic hot water systems, may be a good investment for any customer. Solar water heaters are cost competitive in many applications when account for the total energy costs over the life of the system. Al though the initial cost of solar water heaters is higher than that of conventional water heaters, the fuel (sunshine) is free. Plus, they are environmentally friendly. To take advantage of these heaters , the customer must have an unshaded, south –facing location (a roof, for example) on your property.

Solar water heater can operate in any climate. Performance varies depending, in part, on how much solar energy is available at the site, but also on how cold the water coming the system is the colder the water, the more efficiently the system operates. In almost all climates, you will need a conventional back up system. In fact, many building codes require you to have conventional water heater as the back up.

4.2.1.1 Technology of Solar Water Heater in the W.B

Residential solar water heaters (SWH) have been widely used in the W.B with much success. The system used is the simple thermosiphone open system. SWH were introduced to the West Bank market in the sixties. In Palestine market there are 27 small and medium size firms that product solar water heaters. The lack of fossil fuel and the high electricity price contributed positively to the fast penetration of this technology in the Palestine market. The pay back period for SWH is reported to be less than two years in many houses. This leads to a highly competitive market and a strong solar heater industry. It should be noted that during the development of this industry no regulations were in effect that sets standards for this industry. This lead to a large variation in the quality of the products available in Palestine market.

Table 4.1 shows the availability of solar water heaters in the West Bank.

Table 4.1: Household in W.B by availability of SWH

	Number	Percentage (%)
Available of SWH	148,037	56.4
Not available of SWH	113,474	43.2
Not stated	1,057	0.4

Source: Population, Housing and Establishing Census-1997

More than 95% of the system installed in Palestine are made locally.

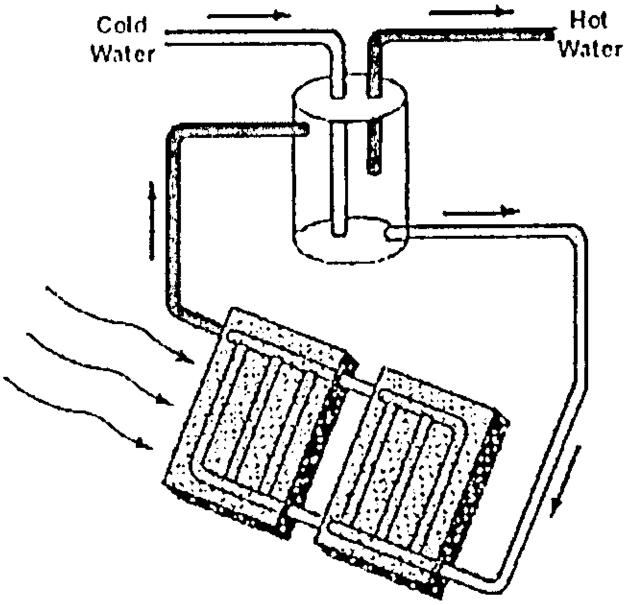
Taking the average collectors currently area for the system to be 4.25 m^2, the collectors area needed for the data in the table 4.1 is close to 629157.25 (4.25 * 148,037) m^2 for the average solar collector currently in use in Palestine, the average annual solar thermal energy output per square meter is about 500 kWh/m^2.

This puts the total energy production of SWH in west bank (W.B) at 314,578,620 kWh/year (500 * 629157.25) kWh/m^2 year. If we take the average price of the electricity in W.B (0.4 NIS/kWh), then if electric power is used instead of SWH, the cost will be around 126 million NIS annually. This great saving of energy per year on the national level.

For large families the SWH usually includes three collectors and a 200 liter hot water tank. For small families, two collector are used and a 150 liter tank. The size of each collector is 1.7 m^2. The energy rating of the collectors also vary considerably depending on the quality of the collector. The average retail price for the system manufactured locally is $300.

4.2.1.2 Thermosyphon System

The thermosyphoning utilizes flat collector to heat the water that is then returned to a storage tank, located above the collector. Cold, denser water flows through the collector heating up and is then returned to the tank. As the heated water is less dense, it rises to the top of the tank. In full sun, a single pass through the collector can heat the water by much as 20C°. Roof mounted flat plate collectors which utilize thermosyphoning are extremely popular in the Middle East with 70% of the population using water heated by these system. Figure 4.1 shows a typical.



Source:
http://wwwphys.murdoch.edu.au/acre/refiles/lowtemp/text.html

Figure 4.1: Thermosiphon water heater

4.2.1.3 Benefits of solar water heater

There are many benefits to owning a solar water heater, and number one is economics. Solar water heaters economic compare quite favorably with those of electric water heater, while the economics aren't quit so attractive when compared with those of gas water heaters. Heating water with the sun also means long term benefits, such as being cushioned from future fuel shortages and price increases, and environmental benefits.

4.2.1.3.1 Economic Benefits

Many homebuilders choose electric water heaters because they are easy to install and relatively inexpensive to purchase. Household with an electric water heater spends about 25% of its home energy costs on heating water. Solar water-heater saves as much as 50% to 85% annually utility bills over the cost of electric water heating.

The initial installed cost of local solar water heater is about $300. Solar water heater can be more economical over the lifetime of the system than heating water with electricity, fuel oil, propane, or even natural gas because the fuel (sunshine) is free.

Paybacks vary widely, but you can expect a simple payback of 2 to 5 years (Simple payback is the length of time required to recover your investment through reduced or avoided energy costs.) You can expect shorter paybacks in areas with higher energy costs. After the payback period, you accrue the savings over the life of the system, which ranges from 12 to 15 years.

You can determine the simple payback of a solar water heater by first determining the net cost of the system. After you calculate the net cost of the system, calculate the annual fuel savings and divide the net investment by this number to determine the simple payback.

An example: Your total utility bill averages $50 per month and your water heating costs are averages (25% of your total utility costs) at $12.5 per month. If you purchase a solar water heater for $300 that provides an average of 60% of your hot water each year, that system will save you $7.5 per month ($12.5 x 0.60 = $7.5) or $90 per year (12 x $7.5 = $90). This system has a simple payback of less than 3.5years ($300 ÷ $90 = 3.33). For the remainder of the life of the solar water heater, 60% of your hot water will be free, saving you $90 each year.

4.2.1.3.2 Environmental Benefit

Solar water heaters do not pollute. By investing in one, you will be avoiding carbon dioxide, nitrogen oxides, sulfur dioxide, and the other air pollution and wastes created when your utility generates power.

When fossil fuel is used to produce one kWh of electrical energy , the amount of CO_2 emission to atmosphere is 0.85 metric tons. A accordingly, the amount of CO_2 emission that results from the production of the energy saved by solar water heater saves the environment from being polluted with this large amount of CO_2.

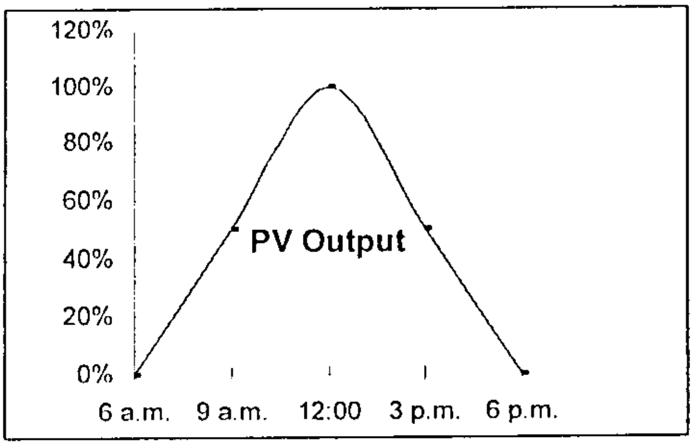
4.2.1.3.3 Long-Term and A Bright Future Benefits

Solar water heaters offer long-term benefits that go beyond simple economics. In addition to having free hot water after the system has paid for itself in reduced utility bills, you and your family will be cushioned from future fuel shortages and price increases. It minimizes the environmental effects of enjoying a comfortable, modern lifestyle. In addition, they provide insurance against energy price increases, help reduce our dependence on Israel fuel and energy, and are investments in everyone's future.

4.2.2 Solar Cell

The solar cell convert the inexhaustible energy of sun light into electric energy, thereby saving electricity and fossil fuel resources.

The amount of solar radiation varies with time in a day, the system of solar cell generates electricity from 6:00 a.m. to around 6:00 p.m., and the power generation values have a nearly normal distribution against the time axis, as shown in figure 4.2.



Source: Author

Figure 4.2: PV output over the time of the day

The cost of electricity from PV is generally high compared to that from fossil fuels and other renewable energy sources, the cost of 1kw of complete system is $15-$20 in Palestine. PV is extremely environmental friendly form of generating electric power. The main filed of application is providing electric power in areas not connected to public grid.

4.2.2.1 Advantages Photovoltaic (PV)

There are many advantages of solar cell systems such as:

- No fuel requirements.

  In remote areas diesel or kerosene fuel supplies are erratic and often very expensive. The current costs of operating

- Modular

  A solar array is composed of individual PV modules so each system can be sized to meet the particular demand.

- Improvement of life quality

The provision of lighting in aural school allows evening educational or community activities for examples refrigeration at a health center improves effectiveness of immunization programs.

- Highly reliable

The reliability of PV modules is significantly higher than of diesel generators and wind generators.

- Easy to maintain

Operation and routine maintenance requirements are simple.

- Long life

There is little degradation in performance over15years.

- National economic benefits

Reliance on imported fuels such as coal and oil is reduced.

- Environmentally benign

There is no harmful pollution and noiseless through the use of a PV system and no contribution to green house gases.

- Economically viable

On a life cycle cost basis and a higher reliability of PV, many small-scale applications can be more economically powered by PV than with diesel system or other small power supplies.

4.2.2.2 Common Photovoltaic Applications

PV is best suited for remote site applications that have small to moderate power requirements, or small power consuming applications even where the grid is in existence. The large market for this technology is for stand-alone (off grid) applications. Some common PV applications are as follows:

- **Water Pumping**

PV cells may be used to power a pump for irrigation, drinking water, or water for industrial purposes. Agricultural watering needs are usually greatest during summer periods when more water can be pumped with a solar system. PV powered pumping systems are excellent for small to medium scale pumping needs (e.g., livestock tanks) and rarely exceed applications requiring more than a 2 hp motor. PV pumping systems main advantages reliable are that no fuel is required and little maintenance is needed.

PV powered water pumping system is similar to any other pumping system, only the power source is solar energy; PV pumping systems have, as a minimum, a PV array, a motor, and a pump. PV water pumping arrays are fixed mounted or sometimes placed on passive trackers (which use no motors) to increase pumping time and volume. AC and DC motor with centrifugal or displacement pumps are used with PV pumping systems.

Many rural wells and springs in Palestine can be exploited using PV application to provide villager with drinking water. Considering the current price of PV and diesel applications in Palestine, it is safe to conclude that pumping capacities less than $100m^3$/day, are most feasibly powered by PV applications. These figures correspond to a daily hydraulic energy equivalent of 5000 $m^{3,}$ which corresponds to PV peak power of 7kw, assuming annual daily average radiation of 5.4kwh/ m^2 .day.

Utilization of PV applications for water pumping will improved the standard of living and health conditions in remote villages that lack water nets. Such applications will also reduce air and water pollution caused by the operation of diesel motors.

PV applications have been successfully applied in Jordan, which has similar weather and solar radiation conditions as in Palestine. Many PV pumping stations were built over desert wells in Jordan, with pumping capacities of 40 – 180 m^3/day from 15 – 80 meter heads.

- **Lighting**

PV powered lighting systems are reliable and a low cost. Typical applications include billboards, highway signs, outdoor lighting, rural installations, parking lots, and vacation cabins. Lamps can be controlled by timers or photocells which how dark it is outside. It's often cheaper to put in a PV lighting system as opposed to installing a grid lighting system that requires a new transformer, trenching across parking lots, etc.

Most stand-alone PV lighting systems operate at 12 or 24 volts DC. Efficient fluorescent or sodium lamps are recommended for their high efficiency of lumens per watt. Batteries are required for PV lighting systems. Deep cycle batteries specifically designed for PV applications should be used for energy storage for lighting systems. Batteries should be located in protective enclosures, and manufacturer's installation and maintenance instructions should be followed. Batteries should be regulated with a quality charge controller. Lighting system prices vary depending on the size.

- **Electrification of Remote Villages**

A residence located far from the electric grid can install a PV system more inexpensively than extending the electric grid. The first rule with

PV is always energy efficiency. A PV system can provide enough power for an energy efficient refrigerator, lights, television, stereo, and other common household appliances.

PEC and PEA makes more studies concerning the electric energy supply Palestinian residents in various parts of the W.B there is 75 villages are not electrified. These villages were categorized according the following criteria:

- Village distance from the nearest electric grid point exceeds 4Km.
- Less than 70 consumer houses in the village.
- Houses of the village are spread a part.
- An annual daily average of solar radiation in the village more than 5 kWh/m^2day.

Implementation of such a project requires a feasibility that takes into account the poor financial situation of most of the villages.

- **PV Electrification of Clinics in Rural Villages**

The average electric load in a clinic amount to approximately 2.4 kWh/day, and is utilized for lighting, medicinal refrigeration and the operation of medical testing equipment since a large number of clinics located in remote village have no electricity at all, such electricity load can be easily and reliably covered a small generator with a peak power of only 400 W and a storage battery block capacity of 7.2 kWh PV system very reliable solution in such cases in Palestine villages.

- **Communications**

This was one of the early important markets for PV technologies; specific applications include microwave repeaters, mobile radio system, remote control system, radio communication, telephones, and emergency call boxes. Systems range in size from a few watts for emergency call system to several kilowatts for communications repeater stations.

- **Others Applications of Photovoltaic**

1. Battery charging

If batteries are not used from time to time, their capacity gradually diminishes. To prevent this self discharge problem, photovoltaic system can provide a small but constant current to the batteries PV cells are a cheap and very reliable solution in this case.

2. Consumer Electronics

Consumer electronics that have low power requirements are one of the most common uses for PV technologies today. Solar powered watches, calculators, and cameras are all everyday applications for PV technologies. Typically, these applications use amorphous PV technologies that work well even in artificial light environments such as offices and classrooms.

1. Warning signals

The military, transpiration, utility, and oil industries all use photovoltaic system to power warring signals such as beacons a top smokestacks or transmission tower, navigational beacons, audible emergency signals, highway warning signs, and railroad signals.

2. Remote monitoring

Monitory is one of the largest applications for photovoltaic today. These systems are used to monitor the weather, water, temperature and flow rates, factory emissions, and pipe lines.

3. Remote switching

Remotely operated switches, particularly those on electric power transmission lines, are ideal application for photovoltaic power. PV power is ideal because the switches require very little power throughout the year, the power from the transmission line cannot be used because the switch must operate when the line is out of service, and the transformer necessary to connect the switch to the grid is far more expensive than a PV array.

4.2.3 Thermal Insulation of Buildings

The proper use of Thermal insulation is vitally important of successful operation of any energy management program. Good engineering design of insulation systems will reduce undesirable heat loss (gain) at lest 90% in most application and improve environmental conditions in many.

Insulation consists of materials that reduce the flow of energy through the surfaces of buildings. This includes materials to reduce both conduction and radiation of energy without insulation, the energy flow in buildings would usually be too great to maintain comfortable conditions by passive means that's, without the use of mechanical devices for heating and cooling.

Thermal resistance (R) is a measure of the effectiveness of the insulating material. The larger the (R-vale) of materiel, the better, R-values are measured in mm/C°/ W.

For purpose of calculation of total energy transfer, the reciprocal of the thermal resistance is used. This is the (U-value), and is measured in W/ C°/mm. The smaller the U-value, the larger thermal resistance.

4.2.3.1 Heat Transfer, Thermal Conductivity, Resistance

There are three basic modes of heat transfer. They are conduction, convection, and radiation. Each is defined as follows;

- **Conduction:** Heat transfer from a hot side to a cooler side through a dividing medium. The hot side heats the molecules in the dividing medium and causes them to move rapidly, heating adjacent molecules until the cool side be heated. Transfer stops when the temperature of the hot side equals that of the cool side.
- **Convection:** Heat transfer between a moving liquid or gas and some conducting surface. Usually the heated fluid rises, causing cooler fluid to come in contact, which is then heated and rises, etc.
- **Radiation:** heat transfer based on the properties of light so no transfer medium is necessary for example, the sun heats by radiation.

The thermal conductivity (K) of a material is its ability to conduct heat. It is measured by the amount of Energy (Btus) per hour that can pass through 1 f^2 (m^2*C°/ watts) of surface 1in.thick for a 1^0 F temperature deference between the two environments being separated. The rate of heat transfer is directly proportional to the temperature difference as shown in equation below and inversely proportional the resistance against heat flow:

$$Q \,\alpha\, (\Delta t / R)$$

Where Q= rate of heat transfer per ft^2 of surface.
Δt= Temperature difference.
R= resistance.

Thermal resistance (R) is related to the K value follows:

$$R = (d / k)$$

Where: d= thickness of material
K= thermal conductivity

For mediums of several materials, the total thermal resistance (R_{total}) is simply the sun of the individual components:

$$R_{total} = R_1+R_2+R_3+\dots\dots\dots+R_{N-1}+R_N$$

Where Ri =thermal resistance of the i component,

i= 1,2, 3, …N

The overall conductance (U) of the total structure is :

$$U = (1 / R_{total\_})$$

It is important to note that only the resistance are additive. It is wrong to convert each R to a U value and then add. The final relation ships are as follows:

$$Q = (1 / (R_1+R_2+R_3+\dots\dots\dots+R_{N-1}+R_N))\,\Delta t$$

$$Q = (1 / R_{total})$$

$$Q = U\,\Delta t$$

$$Q_{total} = U\,A\,\Delta t$$

Where:
Q_{total}= rate of heat transfer for total surface area involved.
A= area of heat transfer surface.

The concept of thermal equilibrium is very important in many types of calculations in thermal equilibrium simply says that the total heat flow through system is equal to the heat flow through any part of the system.

For a system of two insulating media, Thermal equilibrium states that:

$$Q_{total} = (t_h - t_a) / (R_{i1} + R_{i2} + R_5)$$

$$= (t_h - t_{i1}) / R_{i1}$$

$$= (t_{i1} - t_{i2}) / R_{i2}$$

$$= (t_{i2} - t_a) / t_5$$

$$= (t_{i1} - t_{1a}) / (R_{i2} + R_5)$$

Where:

Q_{total} = total rate of heat flow
th = temperature on "hot" side
ta = ambient temperature
R_{i1} = resistance of first section of insulation
R_{i2} = resistance of second section of insulation
R_5 = resistance of out side surface
t_{i1} = temperature of inside surface of insulation 20 outside surface temperature of insulation 1
t_{i2} = temperature of outside surface.

Insulation for the home has R- values usually in the range of R- 10 up to R-30

The units of measurement for R-value are

(square feet * hour * degree F) /BTU in the English system and

(square meters * degree C) / watts in the metric system

The R value is proportional to the thickness of the material. For example, if you doubled the thickness, the R-value doubles.

The following table 4.2 shows different materials with the English measurement of R-value

Table 4.2: R-values of different types of insulation materials

Material	R-value
Hard wood side (1 inch thick)	0.91
Wood shingles (lapped)	0.87
Brick (4 inch thick)	4.00
Concrete block (filled cores)	1.93
Fiber glass batting (3.5 inch thick)	10.9
Fiber glass board (1 inch thick)	4.35
Fiber glass batting (6.0 inch thick)	18.8
Cellulose fiber (1 inch thick)	3.7
Flat glass (0.125 inch thick)	0.89
Insulting glass (0.25 inch space)	1.54
Air space (3.5 inch chick)	1.01
Free stagnant air layer	0.17
Dry wall (0.5 inch thick)	0.45
Sheathing (0.5 inch thick)	1.32

Source:
www.school-for-champions.com/science/thermalinsulation.htm

4.2.3.2 Insulation Type

Before selection the proper type of insulation for particular, it is important to understand the properties or parameters involved.

4.2.3.2.1 Insulation Properties

Some of the more important insulation properties include the following:

- **Cell structure**: cell structures are either open or closed. A closed cell is relative impervious moisture, especially in a moderate environment, so on additional moisture barrier may be needed. Open cells pass moisture freely and therefore probably require vapor barriers. On extremely cold applications there a lot of condensation occurs, a vapor barrier is probably required regardless of structure.

- **Temperature use.** Various insulating materials react to extreme temperatures in different ways. In some cases, high temperatures might destroy binders rendering the insulation useless. All insulation material then has a temperature range for which they are recommended. Usually the restriction occurs on the upper end rather than the cold end.

- **Thermal conductivity (K).** As mentioned earlier (K) values vary with the temperature --sometimes significantly. The energy manager must be familiar with the different types of insulation, there (k) value, and how temperature a facts the (K) value.

- **Fire hazard.** Fire hazard ratings measure the product's contributions to a fire in flame spread and smoke development .It is measured on a frame spread-smoke spread scale where 100/100 is that of redoak.

- **Forms.** Insulation can be made available in a number of different forms. Flexible blankets, bats, rigid board, blocks, and pipe half sections are some of the more popular ones. Insulation is also available in number of size and thickness. For example, fiberglass bat insulation with a Kraft paper vapor barrier is available in 15 and 23 in. widths for thickness of 3 and 6 in.

4.2.3.2.2 Insulating materials

Some of the more popular types of materials with a discussion of their properties are given here:

- **Fiberglass.** Probably the most popular types of insulation, fiberglass can be obtained in blankets, bats, and pipe covering. Although organic binders are frequently used, limiting temperature ranges some what, cell structure is such that the limitations can sometimes be exceeded and still have acceptable results.

- **Foams.** Several foam types of insulation are available, some types have problems meeting fire hazard classifications but have very good (K) values, and other might meet the fire hazard requirements but not offer very good (k) values. Foams are particularly applicable to cold application.

- **Calcium silicate.** A very popular type of insulation for high temperature use, calcium silicate is spun from lime and silica. It is extremely durable and offers a high thermal resistance.

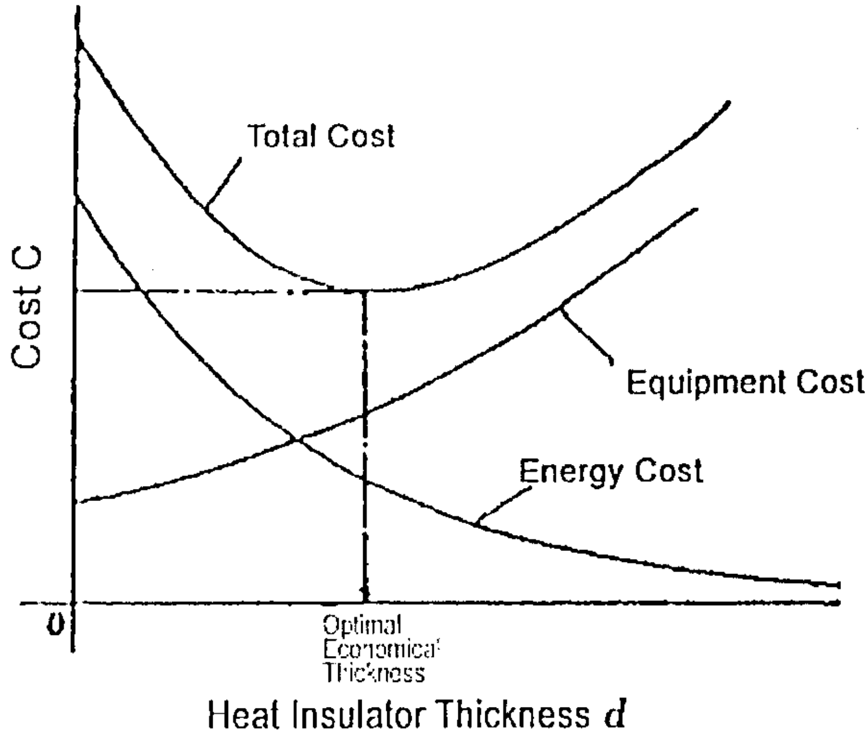
- **Refractors- fire brick.** Firebricks are made for high temperature application. Made of refractory clay with organic binders who are burned out during manufacture they offer good thermal resistance's low storage of heat.

- **Other**. Other types of insulation include cellular glass, perlite, and diatomaceous earth. Each has it's advantages and disadvantages with which the energy manager must become familiar.

4.2.3.3 Economic Insulation Thickness

The optimum thickness of insulation will depend on a number of factors. Insulation efficiency is important in areas with large heating loads, but is not very effective in cooling and sometimes has even an adverse effect, lessening the cooling effect of nighttime outside air.

Consider figure 4.3 which relationship between heat insulator thickness and cost.



Source:
http://nett21.unep.or.jp/EBS_DATA/Tech.html

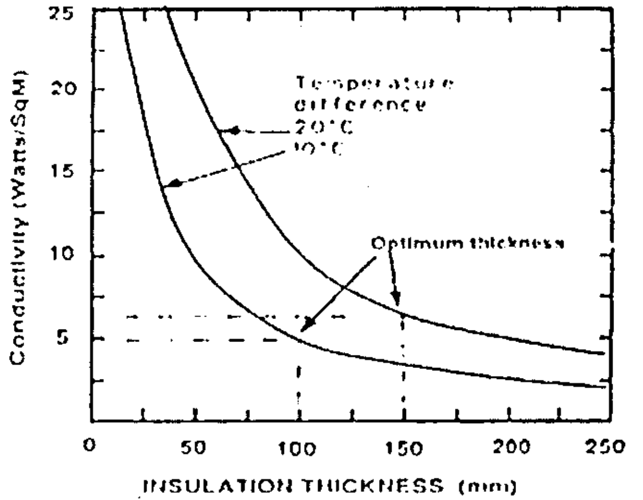
Figure 4.3: Relation between Heat Insulator Thickness and Cost

As more and more insulation is added, the first coast of material and installation goes up, some times in discrete jumps as multiple layer are required. The coast of lost energy, on the other hand, goes down but at a decreasing rate. At some point, the total cost, which is of the lost energy cost and material cost, reaches a minimum point. That is the economic thickness.

It is important to note that the total cost curve is relatively flat in the immediate neighborhood of the economic thickness. This means the energy manager need only get close to the optimum. A small deviation either way won't affect the resulting annual equivalent cost very much.

To determine this economic thickness, the energy manager needs to construct cost flow diagrams for the different alternative thickness and calculate the annual equivalent cost for each increment. Since the cash flows include future fuel costs, careful handling of inflation is required.

It is difficult to attain comfortable conditions with a passive design if the total energy flow through the wall or ceiling exceed about 5 w/m^2 for any extended period. This would be the case for example, if the temperature difference a cross the insulated surface was 10C° with less than 100 mm of bulk insulation R2(U= 0.5)



Source:

http://wwwphys.murdoch.edu.au/acre/refiles/built/text.html

Figure 4.4: the optimum thickness of insulation depends on the temperature difference involved. 100 mm of bulk insulation (R2) is a adequate in the temperature difference is about 10C° . If the temperature difference is 20C° then the extra insulation is required for an acceptable heat transfer rate.

Figure 4.4 shown that there is little benefit for insulation thickness greater than 100mm with 10C° temperature difference. At this thickness the energy flow is reduced to about 25% of that of an uninstalled wall or ceiling. However if the temperature difference is increase to 20 C° then the energy flow with insulating material is about 10 w/m^2. or about twice the optimum level. Although this could be reduced to 5 w/m^2 with 200 mm of the same insulation the thermal resistance at 150 mm would usually be adequate. Sustained temperature difference of 20 C° of more usually occurs in summer in unventilated, low pitched dark colored roofs, or dark colored unshaded west facing walls. The optimum thickness will also depend on the cost of energy if active heating or cooling is used (eg electric, gas, or wood heating in winter and air conditioning in summer). The cost of extra thickness of insulation should then be balanced against the reduced cost of heating or cooling. Again, the benefit of extra insulation diminishes rapidly beyond a certain point. For example, it would cost about $12 a day to heat a 150 m^2 uninsulated double brick, if this house has R2 insulation in the ceiling and wall as well as heavy curtains, the heating cost would be reduced to about $4. By doubling all of the insulation.(if it were possible) the cost would be reduced to about $2. Therefore doubling the insulation cost only provided a further 17% reduction in heating costs. However, there practical limitations to the thickness of wall insulation, window insulation and reduction in air change rates.

4.2.4 Wind Energy

Much has been said about wind energy and it's potential. In Palestine wind energy has not utilized by the Palestinians in Palestine. In the west bank, PEC data indicates that at high mountainous elevations of over 1000 meters, annual wind speeds may surpass 5 m/s. this means that the of wind energy is applicable for small-scale electricity generation, battery charging and perhaps even wind diesel systems and water pumping. However, there are no such applications in the West Bank at present, although numerous villages in the West Bank are still not connected to the electricity grid.

The power density of wind given by:

$$P/A = 0.5 * \rho * V^3$$

Where:

A: area normal the wind

P: power contained in the wind

V: velocity of air

ρ: density of air (about 1.2 kg/m^3)

Wind turbines have been erected in jordan ,syria,egypt and israel. Israel has also erected such turbines in certain location of the west bank such as a setllement near nablus and dismantled after ten year of operation.

The advantages of wind plant generator as follows:

- Fuel economy (elimination at petroleum coal and gas using).
- Important ecological benefits. No natural environment pollution.
- Constant unitray cost of obtained electrical energy.
- Minimization of the losses caused by energy transmission.

Chapter 5

Possible Savings of Electrical Energy in the W.B

Possible Savings of Electrical Energy in the W.B

Electrical consumers in W.B. divided into tow categories, almost all the electrical consumers in the first category are residential consumers. The other consumers classified in the second category are commercial, industrial and others.

In this chapter we discussed the ways to conservation and management electrical energy in households, motors, lighting, electrical system and the effect of power factor correction.

In all calculations that made at this chapter we take years 1993 and 1999 as a reference to develop a new and modified load forecasts (chapter6), after we calculate the possible saving in all the items that effect the energy consumption in the West Bank electrical system. Also we assume many cases to conserve electrical energy as detailed later.

Table 5.1 shows the percentage of how much each sector consumed electrical energy for the two years (1993, 1999).

Table 5.1: Percentage of electrical consumption in each sector in W.B. for both years 1993 and 1999.

Sector	Consumption in 1993	Consumption in 1999
Residential	70%	55%
Commercial	17%	15%
Industrial	7%	18%
Others	6%	12%

Source of Data:

- Year 1993, ("Energy and Environmental Conference" , Nablus, Palestine, October 1997)
- Year 1999, (Dr.Baba'a, "Special Technical Paper", 2000)

5.1 Home's Electrical Energy

Records of the PCBS, "Household Energy Survey", January 1999, show that typical Palestinian family spend close to 1500 NIS a year on their home's electrical bills?

By using a few inexpensive tips, consumers can reduce their electrical energy bills by 10% to 50% and, some time, help reduce air pollution.

In order to get a general estimate of how much electricity home appliances consume; refer to table 5.2 below, which provides the energy consumption (wattage) of some typical home appliances.

By using the following formula we can estimate the amount of electrical energy a specific appliance consumes (Daily Kilowatt-Hour consumption) :

KWh = (Wattage X Hours used per day) / 1000

Multiplying KWh consumed by the number of days the appliance used during the year for annual consumption.

Then calculating the annual cost to run an appliance by multiplying the KWh per day by the local utility's rate per KWh consumed.

Usually we can find the wattage of most appliances stamped on the bottom or back of the appliance, or on its "nameplate". The wattage listed is the maximum power drawn by the appliance. Since many appliance have a range of settings (for example, the volume on a radio), the actual amount of power consumed depends on the setting used at any one time.

If the label only gives the number of amps and not the number of watts, then just multiplying the amps by 220V to get the number of watts. (Amps X Volts = Watts)

Table 5.2: Electrical consumed in home appliances

Home Appliances	**Wattage Consumption (W)**
Clothes Washer	350-550
Radio	50-75
Clothes Dryer	1800-5000
Clothes Iron	1000-1800
Video	15-25
Hair Dryer	400-1800
Mixer	150-200
Water Pumping	250-1200
Central Air Conditioner	3500-5000
Microwave Oven	700-1500
Coffee Maker	900-1200
Window Unit Air Conditioner	600-1500
Electric Oven	500-1000
Refrigerator	500-2000
Heater	750-1600
Television	80-150
Fans	40-250
Personal Computer CPU Monitor	 awake / 120, sleep / 30 W or less awake / 150, sleep / 30 W or less

Source: Author

A few caveats:

1. The amount of electricity listed on the label is the maximum amount that the appliance will use. For example, a 500-watt refrigerator will only run at 500 watts when the compressor's

running (which is when it makes that humming sound, indicating that it's actually chilling the air inside). Most of the time the fridge just sits there, using only 5-10 watts or so for its electronics. Further down we'll cover how to measure the actual amount being used by a device.

2. Many consumer items are advertised according to their power output, not input. That means the stereo that says 30 watts on the box might actually take 50 watts to make 30 watts of sound (assuming the volume was cranked), and your 900-watt microwave oven might actually use 1400 watts (on its highest setting). That's because all electrical devices are inefficient -- they have to use some extra energy to do what the do.

3. Knowing how much electricity a device uses at a given moment doesn't tell you how much it's using in a month, because it's probably not running 24/7 (and if it is running 24/7 like a fridge, it's probably not using the maximum amount of electricity, as we discussed earlier). To measure how much electricity something uses for a certain period of time (like a week or a month), you can use a wattmeter.

4. Some devices use a small amount of electricity even when they're not on. For example, TV's, Videos and microwaves draw a small amount to power the time display. This amount is often 5 watts or less. Devices that run off transformers also draw a small amount of power.

After identifying where the home is losing electrical energy, we will save more electricity by dealing with the biggest electricity rather than worrying about items that don't use much electricity. It is more important to turn off your air conditioner (1000 watts) than the radio in your alarm clock (5 watts). But another way, turning your air conditioner off for an hour saves as much as electricity as turning your clock radio off for 200 hours. With that in mind, we will first want to address lighting, then refrigerators, then AC's.

5.2 Refrigerators

Refrigerator is considered that one of the biggest consuming electricity appliances in the home. 23% of home electricity consumed by refrigerator. 214338 (81.6%) of the households in the West Bank have refrigerator. In spite of this large number of refrigerators in the West Bank we can decrease the consumption of energy in the refrigerator/ freezer by following some no cost practices: -

1. Location is important. We must not place either refrigerator or freeze in direct sunlight or near any source of warm air such as the range, dish washer or heating ducts.
2. What's inside counts, too. Refrigerators work more efficiently when food is arranged to allow air to circulate. Freezers, however, work more efficiently when they are packed full.
3. Set the temperature for only as cold as you need it. Refrigerator should between 36 and 38 F°, freezer, between o and 5 F°. Leave a thermometer inside for 15 minutes to test, and read it immediately when you open the door refrigerator set lodgers lower than needed can increase energy use by as much as 25%.
4. Avoid opening refrigerator and freezer doors too frequently. Plan ahead so you can take out every thing you need at one time.

5. Cleaning is important. Every three months clean the condenser, coils, fins and evaporator pan. Refer to your owner's manual for other cleaning maintenance.
6. Don't put hot foods in refrigerator, let them cool off first.
7. Make sure door gaskets are tight. Replace worn, dirty, cracked or poor fitting gaskets to prevent air leaks and maintain top efficiency.
8. If your refrigerator was made for more than 10 years old. Replacing it with anew high- efficiency refrigerator. Old refrigerators use up to 50% more energy than new energy – efficient models.
9. If you must manually defrost your refrigerator, doesn't let more than ¼ inch of ice build up. Efficiency drops as ice builds up.
10. Don't get a side- by –side model. Side –by- side models use up to 45% more energy than those do with the freezer on top.

5.2.1 Possible Savings in Refrigerators

Case 1

According to GEF project around 20% of all refrigerators in West Bank are old used Refrigerator with low efficiency. If new ones with high-energy efficiency replace these ones then possible savings in each will reach 73%. However, our goal will be to reduce total percentage of used refrigerator to 10% in the next decade.

Possible savings = 10% X 73%

=7.3% of the total energy consumed by refrigerator

But refrigerator consumes 23% of domestic consumption

Total saving in domestic = 23 % X 7.3%

= 1.68%

Domestic consumption of total was 70% in 1993 and 55% in 1999.

Possible saving in 1993 = 1.68% X 70%

= **1.17%** of total electricity consumed

Possible saving in 1999 = 1.67% X 55%

= **0.9%** of total electricity consumed

Case2

If 22% of the refrigerators in the W.B. will replaced by new high efficient models instead of standard models

According to PCB's data 81.6% of the households in the West Bank have refrigerators.

Percentage of household replace their refrigerators

=81.6% X 22%

= 18%

High efficient refrigeratar consumed energy by 30% less than standard models.

Possible savings = 18%X 30%

= 5.4% of total energy consumed by refrigerator

Refrigerator consumes 23% of domestic consumption

Total saving in domestic = 23%X5.4%

= 1.24%

Domestic consumption of total was 70% in 1993 and 55% in 1999

Possible savings in 1993 = 1.24% X 70%

= 0.87%

Possible savings in 1999 =1.24% X 55%

= 0.69% of total electricity consumed.

5.3 Air Conditioning

In 1993 air conditioning loads represent around 4% of total residential loads and 16% of commercial loads. However the number of installed AC units in both sectors have increased shapely in the last six years. In year 1999 it is estimated that the number of AC units has increased by 300% compared to 1993. This assumes an increase to overall 16% of domestic consumption, and 10% of commercial share of total energy consumption.

A great way to save energy and reduce your electric bill is to insulate your building. Heat loss through the ceiling and walls in your building could by very large if the insulation levels are less than the recommended minimum. The higher the R-value, the better the material insulates. Choose an insulation material (or a combination of materials) that satisfies the R-value needed for the job at hand. In chapter 4 we explained the insulation needed for your building. Insulating your building will save nearly 50%of your electrical energy uses in heating and cooling.

There are many strategies to reduce the amount of energy which use in heating and cooling.

For both central AC and window units:

1. Use a timer. Set the timer or thermostat to turn off about the time you leave for the day. And to turn back on a half-hour before you get home.
2. Install ceiling fans if you don't have them.
   Fans can make the temperature seem 10 degrees cooler. Tremendously reducing your need for Ac. Most people are even able to install them themselves using the instruction provided. Ceiling fans use very little energy. Atypical 36" /48"/52" ceiling fans uses about 55/ 75/ 90 watts of electricity respectively (less on slower speeds)
3. Make sure your fan blades are spinning the right way. Fans have a summer direction and a winter direction. In summer, the fan blows air down onto you, removing the hot air that surrounds your body, making you feels cooler. In winter, the fan blows up ward, pushing the warm air that's on the ceiling down towards the living area.
4. Raise the temperature. Try cooling your home to only 80 degrees (or war mer) instead of the 70's. This is especially easy to do if you have ceiling fans. Each degree below 78 will increase your energy use by 6-8%
5. Clean the filter. Clean or replace your Ac filter every month. Dirty filter makes your AC work harder, which uses more electricity.
6. Isolate unused rooms. Why pay to cool a room that you are not in? But note that if you close too many vents in a central AC system, the pressure in the system could cause leaks in the ducts. For window units, just close the doors to rooms you don't need to cool.
7. Make sure your doors and windows are well sealed. You will pay a lot more to cool your home when the cold air easily escapes. Do-it- your self weather stripping for doors and caulk for window is

easy to install, and cheap. Also make sure to caulk around the holes where pipes go into the wall under sinks. Also. Close the damper to the five places when you are not using it other wise, cool air will escape through the damper.

8. Reduce heat from lighting. A light creates a lot of heat, which your Ac system has to remove. Replace your lights with compact fluorescent bulbs, which use 75%, less energy and create 70-90% less heat at the same time. What ever kind of lighting you have, turn it off when you are not using it . It is not just using electricity, it is adding heat.

9. Use drapes or blinds to block sunlight. Drapes block sunlight and heat better than blinds. The less heat gets into your home, the less you have to remove it.

10. Put solar screens on the windows. Solar screening is a special mesh that reflects much more sunlight than regular screening. It can block 60-70% of sun light / heat

11. Install reflective film on windows. Reflective film reflects the sun's heat from your windows, and can block 40-60% of heat and modern films reflect heat away without blocking the light too, so you can still have nice, bright rooms.

12. Use storm windows doors. If you are ambitions, install storm windows and doors. They can reduce the amount of cooling or heating lost through single pane glass by 50%.

13. Paint the exterior with a light color. The next time you have your home a light color. Dark outside colors absorbs 70-90% more of the radiant heat that hits the walls.

14. Use shade trees. Well- positioned shade trees can reduce indoor temperatures by up to 20 degrees and energy used by up 40%.

15. Try doing without an Ac, or just using it less.

For central AC only:

1. Replace old systems. New Ac system use up to 40% less electricity than older models.
2. Shade the outside condenser unit. Condensers in the shade use up to 10% less electricity than those in direct.
3. Don't block the condenser unit tall grass and other debris on or around the condenser can restrict airflow and use more electricity.
4. Clean the condenser/ evaporator coils at the beginning of each season. You can wash the fin coils on the outside with a garden hose. Unless you know what you are doing have the coils on the inside serviced by an Ac specialist.

For window units AC:

1. Make sure you are using an energy- efficient model if you have an old, inefficient unit, buying a new one will pay for itself quickly in lower electricity bills.
2. Make sure your Ac is the right size for your room .A unit that is too big or too small is inefficient and wastes energy.

5.3.1 Fans

Fans don't make the air cooler! They work by blowing away the envelope of warm air that surrounds your body.

Human bodies generate heat. As that heat slowly radiates away from human body. It creates a pocket of hot air that surrounds there, and they will be insulated by invisible bubbles of heat. Fans do is to push that hot surrounding air out of the way.

This is why blowing on hot food cools it off. It is not that breath is especially cool, it is that the breath blows the heat off the food.

Now that we know that fans do not make the air cooler, so it is clear that there is no advantage to leaving the fan on when we leave the room. Fans do not lower the temperature in the room at all.

5.3.2 Possible Savings in Air Conditioning

<u>Case 3</u>

We assume that 5% of the buildings in both commercial and domestic sector make thermal insulation to their buildings this option will save 50% of the electricity used in AC.

According to PEA data, residential consumed 4% and commercial consumption 16% of total electricity used in AC in year 1993.

Possible savings in domestic sector in year 1993.

= 50% X 5% X 4%

= 0.1 % of electricity used by AC.

In 1993 domestic sector consumed 70% of total electricity in the W.B.

Savings = 0.1% X 70%

= 0.07%

Possible savings in commercial sector in year 1993.

= 50% X 5% X 16%

= 0.4 % of electricity used by AC.

In 1993 commercial sector consumed 17% of total electricity in the W.B.

Savings = 17% X 0.4%

= 0.068%

Total savings in 1993 for both sectors (commercial & domestic)

= 0.068% + 0.07%

= **0.14%** of total electricity consumed in W.B.

In year 1999 residential consumed 16% and commercial consumed 10% of total electricity used in AC. In year 1999 the number of AC units increased by 300%.

Possible savings in domestic sector in year 1999.

= 50% X 5% X 16 % X 300%

= 1.2 % of electricity used by AC.

In 1999 domestic sector consumed 55% of total electricity in the W.B.

Savings = 1.2% X 55%

= 0.66%

Possible savings in commercial sector in year 1999.

= 50% X 5% X 10% X 300%

= 0.75 % of electricity used by AC.

In 1999 commercial sector consumed 15% of total electricity in the W.B.

Savings = 15% X 0.75%

= 0.11%

Total savings in 1999 for both sectors (commercial & domestic)

= 0.11% + 0.66%

= **0.77%** of total electricity consumed in W.B.

<u>Case 4</u>

If we assume that 20% of the AC units in W.B. were replaced by new ones. In this case new AC units use up to 40% less electricity than older models.

In this case we use the same percentages used in case1.

Possible savings in domestic sector in year 1993.

= 40% X 20% X 4%

= 0.32%

Savings of total electricity consumed in W.B.

= 0.32% X 70%

= 0.22%

Possible savings in commercial sector in year 1993.

= 40% X 20% X 16%

= 1.3%

Savings of total electricity consumed in W.B.

= 1.3% X 17%

= 0.21%

Total savings in 1993for both sectors (commercial & domestic)

= 0.21% + 0.22%

= **0.43%** of total electricity consumed in W.B.

Possible savings in domestic sector in year 1999.

= 40% X 20% X 16% X 300%

= 3.84%

Savings of total electricity consumed in W.B.

= 3.84% X 55%

= 2.11%

Possible savings in commercial sector in year 1999.

= 40% X 20% X 10% X 300%

= 2.4%

Savings of total electricity consumed in W.B.

= 15% X 2.4%

= 0.36%

Total savings in 1999 for both sectors (commercial & domestic)

= 0.36% + 2.11%

= **2.47%** of total electricity consumed in W.B.

5.4 Electric Water Heaters

Water heating is one of the largest emerge in local homes. It typically accounts for about 5% of home electrical bill. In Palestine, two types of electric water heaters are used; tank-less water heaters (instant heaters) and tank-storage water heaters.

According to PCB's Housedholds Energy survey (January-march 1999) Round 20.2% of the households depend on electricity as the main source of fuel used for water heating, and 4.3% of the house holds depend on electricity as the auxiliary fuel used for water heating.

There are many ways to cut water heating bills. Use less hot water, turn down the thermostat on water heaters, insulate water heater, and use more efficient water heater, look for the Energy Guide label that tells how much energy the water heater uses in one year. Also look for the first hour rating of the water heater. This measures the maximum hot water the heater will deliver in the first hour of use. If the customer needs a lot of hot water at once. The first hour rating will be important. Siting is also important when selecting a water heater.

As shown in chapter 4 nearly 56.4% of homes in the West Bank have invested in solar water heating systems. Solar water heaters systems has a good economical investment. SWH systems are also good for the environment, as it is avoiding the harmful greenhouses gas emissions. During a so year period, one solar heater (SWH) can avoid over 50 tons of carbon dioxide emissions.

Here are some tips to save energy for water heating.

1- Trade the electric tanks heater for a tank less system (Atmor). New tank less systems heat the water instantly when you turn on the faucet, rather than keeping a tank full of hot water, whether it is used or not. Tank less heaters run on either electricity or gas, but either is more efficient than an electric tank.

Tank less water heaters has other advantages over tank heaters:

- The user will not run out of hot water by using all the hot water in the tank, because there is no tank.
- The unit should last about 20 year vs. about 10 for a tank heater. That will help the tank less heater pay for itself.

- Leaks are rare with tank less systems, while all tank systems leak eventually.

2- Replace electric tank heater for a gas tank heater. In most cases, replace electric tank heater for a tank less system (described in point1) is more economical for users.

3- Timed water heater will save huge amount of energy as the timer will shut it off when not needed.

4- Turn the thermostat down to the lowest temperature you're comfortable with. When it is set on scalding hot you have to mix in cold water in your shower to lower the temperature, and why make your heater boil the water if you don't need it that hot?

5- Insulate water heater by using a special tank blanket. Insulating water heaters will reduce energy use by 10-15%, and could pay for itself in one year or less.

6- Insulate the room where the heater is. If it is in a garage and it is cold outside, keep the garage door closed.

7- customers must turn it off when they are out of town. For electric heaters with out a switch, it can be turned it off at the breaker box.

5.4.1 Possible Savings in Water Heaters

Case 5

If 50% of the (20.2%) of house hold that depend electricity as the main source of hot water install solar water heaters. Possible savings in this case of electricity are nearly 70%. These households depend on electricity as auxiliary source of hot water by percentage 30% (in winter months)

Possible savings:

= 70% X 50% X 20.2%

= 7.07% of household install SWH

Hot water consumes about 5% of home bill. Savings in the home:

= 7.07% X 5%

= 0.35% of domestic sector.

Possible savings of total consumption

In 1993 domestic sector consumed 70% of total electrical energy

Saving in 1993 = 0.35% X 70%

= 0.24%

In 1999 domestic sector consumed 55%of total electrical energy

Saving in 1999 = 0.35% X 55%

= 0.19%

Case 6

If we replace electric water heater by Gas water heater, possible savings nearly 15%, let 50% of the house hold that use electric water heater replace it by gas water heater, the percentage of the houses hold which depend in electricity as the main source of water heating is nearly 20.2%.

Possible savings

=50% X 20.2% X 15%
=1.51%

But electrical consumption by water heater in the house holds a bout 5%.

Possible savings in domestic sector

= 1.51% X 5%

= 0.07%

Possible savings of total consumption

In 1993 domestic sector consumed 70% of electrical energy

Savings in 1993 =0.0757% X 70%

= 0.05%

In 1999 domestic sector consumed 55% electrical energy

Savings in 1999 = 0.07% X 55%

= 0.04%

5.5 Ovens

With today's high-energy costs it is essential to conserve and save energy everywhere it is possible. That full size conventional oven may be costing a lot of money if it is used to cook small meals. With some of the innovative new ovens available today is possible prepare meals much more efficiently.

One of the most efficient, even cooking ovens available is the convection. Convection ovens utilize a system of forced air to circulate the heat evenly around the food. Because of the circulating hot air user can bake more in a convection oven at one time with excellent results.

PCBS household energy survey, (January- march1999) Round report, shows that 11.3% of the house hold in the west Bank use electrical oven in cooking.

Purchasing a second oven such as a convection oven can save on energy bills, keeping the conventional oven for larger meals.

Here are some tips that apply to all ovens:

- Keep the preheat time to a minimum.
- Avoid opening the door often.
- Using microwave cooking when ever possible. Although the microwave oven saves energy when it replaces surface cooking, it saves the greatest amount of energy when it replaces oven cooking.
- Stagger pans for best heat circulation.
- Use the oven to cook more than one thing at time (full capacity).
- Make a double batch and freeze the remainder.
- Use glass bake ware it cooks just a quickly at a slightly lower temperature.
- Avoid over cooking.
- Keep the oven clean. Dirty ovens consume more energy because dirt and grease build upon heat transfer surface.

Getting a second smaller oven or convection oven makes good energy saving sense.

5.6 Microwave Ovens

Microwave ovens are an energy efficient home appliance. They are easy to operate and fast cooking. Meals can be prepared in a fraction of the time that it takes on a standard range. There are many options to be considered.

- Microwaves in the 1000 watt and below range are best for reheating operations with things like sandwiches, rolls or TV-dinners. These smaller units are simple to operate and will have a very reasonable price tag. This makes them ideal for the single person or family that wants to save on their energy costs.
- Microwaves in the 1200 to 1500 watt rang will take less time to cook a meal. These are probably best for homes where they will see more use (larger families). They will also have more features built in like programmable memory pads or a range of power levels.
- Microwaves above the 1700-watt range are probably not needed or recommended for the home.

5.7 Clothes Washers

Having an Energy Efficient Launder System has become imperative with today's high electric bill clothes most of the energy is used for heating water. The best way to save energy here is to use less water and by lowering the temperature of the water used.

PCB's, Population, Housing and Establishment census 1997, shows that 189562 of the household in the west Bank have available a washing machine (nearly 72.2% of the household in W.B)

All washing machines must display the Energy Guide label. You can compare the energy efficiency of various models with these. They are good for comparing models of the same capacity, but a smaller model will have a better rating compared to the larger one. This may mean you will have to wash clothes more often making it less efficient. Don't base your decision solely on the Energy Guide label. Take into consideration the size of your family, amount of launder you do per week and the room you have in your home or apartment.

Efficient models will let you select smaller sized loads, this will save you money in the long run. Use warm water or cold whenever possible, these will clean clothes just fine in most cases. Use of a presoak with a good detergent should get clothes clean and a cold water rinse is just as good as warm water.

Some washing tips:

- Water levels should match the load size.
- Wash during off-peak periods
- Never overload the washer.
- Use the shortest cycle that will clean the clothes.
- Pre-treat and pre-soak for cleaner clothes.
- Use warms or water for washing.
- Always use cold water rinse.
- Run your washing machine with large loads. Check instructions so you don't over- load your machine.

5.8 Televisions

PCB's, Population, Housing and Establishment census, 1997 report show's the 86.4% of households in the West Bank have available of TV. TV's consumed nearly 4 % of total home electricity. The total numbers of hour operation by the day nearly 8 hours. A TV set may be costing you nearly 120 NIC a year or more by leaking electricity. Some older TV's are using 10 to 18W even when turned off. This power usage is for your remote control, instant on and feature like these. Most new models require only 4 to 5 watts. There are some models available that use as little as 1 watt or less.

Low leak TV's is available now. Replacing old TV can save energy in the long run.

5.9 Lighting

Lighting has been one of the prime targets of mandatory standards to reduce energy consumption. Energy for lighting accounts for about 40% in domestic sector, 15%in industrial sector, and 50% in commercial sector.

Increasing lighting efficiency is one of the fastest ways to decrease energy bills. There are several ways to reduce energy use without sacrificing lighting quality. The most way to save energy for lighting is to use compact fluorescent light bulbs (CFL's). These low wattage bulbs are based on florescent tube technology but are about the size of a "normal" incandescent bulb. One CFL rated at 20 watts gives the same light output as a 75 watt incandescent bulb. CFL not only offer dramatic energy savings, up to 80% over incandescent bulbs, they also offer long life, and silent operation

To save energy in light we take several technical advanced lighting options as follows:

1. Use compact fluorescent light bulbs (CFL's)
   These cost more than regular light bulbs ($10- 20), but use nearly 70-80% less electricity and last years longer (10 times longer).

Over the life of CFL, is possible to avoid replacing nearly up to 13 incandescent bulbs. CFL's emit the same amount of light as standard bulbs, but have lower wattage rating because they use less energy.

Table 5.3 shows the equivalent CFL's with compared to incandescent lamps.

CFL's start dim and take a few seconds to warm up to full brightness, and most of them can't be used on dimmer switches.

CFL's have another advantage: they run cooler. Regular height bulbs generate a lot of heat, making you spend more on air conditioning in the summer. CFL's not only use less electricity to provide light, but they don't dump extra heat into home. Only 5% of the energy used by incandescent lamps contributes to light, the other 95% is wasted to heat.

Table 5.3: Equivalent Incandescent lamps to CFL lamps

CFL (Watt)	Incandescent (Watt)
20-23	100
15	75
11	60
7 or 9	40
5	25

مصدر المعلومات:

د.محمود، مروان : *ترشيد استهلاك الطاقة المستخدمه في الانارة* . المهندس الفلسطيني، القدس، العدد ٤٦ / كانون اول ٢٠٠٠ . صفحة ٧٤ .

2. For outside lighting, install a motion sensor that turns the lights on automatically when some body walks up, and turns the lights off automatically after 1-5 minutes. Sensors reduce lighting costs in

offices, conference rooms, copier rooms, and computer areas by 35-60% with sensors that automatically turn lights off when not in use. Sensors can even be installed in stairwells, corridors, training or classrooms, kitchens, break rooms, rest room or any area where is intermittent usage.

3. For any lights to be "ON" all nigh (e.g.: stairways), it is recommended to replace the bulbs with the lowest, convenient wattage bulbs. Replacing 75 W bulbs with 15w bulbs reduces energy usage by 80%.

4. For lights to be "ON" all night which are in areas that get some sunlight, it is better to use a screw –in light sensor. They'll turn off automatically in the morning and then turn on automatically at night.

5. Install reflectors: Reflectors save 50% to 75% of lighting energy, cut maintenance costs by nearly half and greatly reduce air conditioning bills.

6. Clean luminaries to Increase Illumination. Dirt and dust collect on luminaries over a period of time, causing attenuation of light transmission. Removing dirt increases light out put; this may increase productivity and will bring illumination back to design levels. If illumination is excessive, cleaning means fewer lamps will be needed and some lamps can be eliminated.

7. Improve room color and reflectivity. Sense darker color light, the color and reflectivity of walls, ceilings, and floors affect the actual illumination levels in a room. This can be tested by the simple technique of taking a light source into rooms of deferent colors and measuring the illumination levels at similar distances from the source. Illumination can often be improved in industrial facilities by cleaning the walls or repainting them with lighter colors.

8. In areas that don't need bright illumination, such as hallways or storage areas, use lower –wattage bulbs.
9. Use one higher- wattage bulb gives the same amount of light as two 60-watt bulbs, but uses 17% less energy. Just make sure you don't exceed the manufacturers recommended wattage for the fixture.
10. Avoid using long-life bulbs. They are the least efficient of incandescent bulbs. They cost more and provide less light. Use them only in areas where bulbs are difficult to replace, such as high ceilings, hallways or stairs.
11. Use task lighting: instead of brightly lighting an entire room, focus the light where you need it. For example, use fluorescent under-cabinet lighting for kitchen sinks and countertops under cabinet.

5.9.1 Outdoor Lighting

Many homeowners use outdoors lighting for decoration and security. There is a variety of products for outdoor lighting, from low-voltage pathway lighting to high- sodium motion- detector floodlights. lights powered by small photovoltaic (PV) modules that convert sunlight directly into electricity are also available; PV-powered lights are recommended for areas that are not close to an existing power supply line.

Incandescent or mercury vapor outdoor lights are generally inefficient and should be evaluated for conversion. Energy-efficient options include the lamp, types listed below and solar-powered lamps.

- Low- temperature fluorescent lights. CFL's with low-temperature operating characteristics have recently been introduced. When combined with the proper electronic ballast's, these lamps will start at temperatures as low as –40 F° some full size fluorescent lamps will start as low as – 20 F°. they are an excellent choice for porch lights, lanterns, landscape lighting, sign lights and compact flood lights.

- Metal halide lamps. These exterior, use high-intensity discharge (HID) lamps offer good color rendering and are available in sizes ranging from 70 to 150w for small applications (e.g. Pole lights, canopy down lights, and medium flood lights) up to 175 to 1000w for large applications (e.g. large parking lots, and road ways, sports fields). These lamps are 1.5 times more efficient than mercury vapor lamps but require a 3 to 5 minute warm up period.

- High-pressure sodium and low-pressure sodium lapms. These lamps use sodium vapor instead of mercury vapor and are roughly twice as efficient. High-pressure sodium lamps are suitable for floodlight type applications. They last as long as mercury vapor lamps but tend to give out a yellowish light. They require a 2 to 3 minute warm up period.

Outdoor lighting Tips

- Use outdoor lights with a photocell unit or a timer so they will turn off during the day.
- Turn off decorative outdoor gas lamps: just eight gas lamps burning year round use as much natural gas as it takes to heat an average-size home during an entire winter.
- Exterior lighting is one of the best places to use CFL's because of their long life. If you live in a cold climate, be sure to buy a lamp with cold weather ballast.

5.9.2 Possible Savings in Lighting

Case 7

If we change incandescent lamps to CFL's.

According to the data of table 5.3, the saving will be around 75% If we change incandescent lamps to CFL's.

Lighting accounts 40% in domestic sector, 50% in commercial sector, 15% in industrial sector.

The persant of incandescent lamps to florescent lams is nearly 20% of total lighting in all sectors of the West Bank.

Let 50%of each sector change incandescent lamps to CFL's

Possible savings in domestic sect

= 50% X 40% X 75% X20%

= 3 %

Possible saving is in commercial sector

= 50% X 50% X 75% X20%

= 3.75%

Possible saving in industrial sector

=15% X 50% X 75% X20%

=1.12%

Domestic consumption of total 70% in 1993 and 55% in 1999

Industrial consumption of total 7% in 1993 and 18%1999

Commercial consumption of total 17% in 1993 and 15%1999

Total saving in 1993 =70% X 3%+7% X 3.75%+17% X 1.12%

= 2.552%

Total saving in 1999 = 55% X 3%+18% X 3.75%+15% X 1.12%

= 2.493%

5.10 Losses in Electrical System

Electricity flows from the electrical generators through wires to the end-users, wires have some small amount of resistance, which works against the flow of current. The electric grid itself consumes a small amount of power, the power consumed in this way is refereed to as "losses".

Losses are equal in the power grid, of the square of the current (I) flowing through any resistance, times the value of the resistance (R):

$$\textbf{Losses} = I^2 . R$$

Losses in electricity is difference between the electricity on the output of transformers on the generation unit and the electricity consumed actually by the consumers which counted by the KWh meters.

The value of electrical losses differ from country to other depend on the voltage level high voltage transmission lines, low voltage distribution lines, types of conductors, capacity of transformers, the percent of load in transformers, and the distance between transformers and end-users.

The following table 5.4 shows the losses in electricity in different Arab countries in year 1995.

Table 5.4: losses for some Arab countries in year 1995

Country	Losses in 1995
Syria	31.8%
KSA	20%
Libya	18.4%
Palestine	22.5%
Jordan	15%

مصدر المعلومات:

م.العمري هشام : *الفاقد الفني والفاقد التجاري*. المهندس الفلسطيني، القدس، العدد ٤٥/ نيسان ٢٠٠٠ . صفحة ٧٠ .

According to PEA data, losses in electrical system in West Bank are very high; nearly 30% in some district areas such as in Jenin, PEA carried out several projects to reduce the percentage of technical losses to become 12% in 1998. Technical losses in 1995 nearly 14%. The present project carried out by PEA " Energy Efficiency Improvement and Greenhouse Gas Reduction" is supposed to reduce the distribution losses by 2%.

Technical losses in low voltage systems in the W.B. are very high, in some countries exceed 10%. In the W.B. possible improvements can be made in this side of the system (distribution side), because IEC is the only supplier of electricity.

There are two types of losses:

1- Technical losses
2- Non-technical losses

1- Technical losses: Which known as the electrical losses, which are consumed in the element of the network such as transmission lines, transformers, capacitors, control and protection, and metering equipment. These losses can not be eliminated completely but can be reduced by improving the electrical system and power factor. The important loss comes from penalties added to the consumers invoice due to the low power factor. Improving PF shown in section 5.11.4.

2- Non- technical losses: these losses equal the difference between total losses in the system and technical losses, this kind of losses have tow types:

A- Commercial losses: this kind of losses result from inaccuracy of kWh meter, this can be avoided by choosing the accurate kWh meters with the well-known meters manufacturers.

B- Illegal consumption: this is the electricity that consumed actually but not counted by the kWh meters. This losses classified into:

- Electrical energy that consumed actually but not counted by kWh meters result to stop kWh meters purposely.
- Electrical energy which consumed without complications between consumers and electrical company or municipalities.

These problems can be avoided by:

1- Securing the kWh meters by fixing the meter in a secured transparent box.

2- Hiding the connection to consumers kWh meters in away that the consumers can no get an access to the cable.

3- Employing a technical staff for periodic check up of the kWh meters and the connections to consumers.

4- Change the old kWh meters (more than 25 years old) by new ones.

The acceptable percentage of losses in the developed countries rang from 5% to 9%.

After PEA complete the project " Energy Efficiency Improvements and Greenhouse Gas Reduction", it is expected that the distribution system losses will be reduced by 2%.

5.11 Power Distribution Systems and Power Factor Correction

The term power distribution system describes an arrangement of electrical equipment and components installed in residential, commercial, industrial, or other type of facility that provides the necessary electrical power to operate processes or to provide the desired service in a safe and reliable manner. The components usually include, but are not limited to, the following elements:

- Transformers
- Conductors (wire, cable, or bus duct)
- Switches
- Protective devices (fuses, circuit breakers, and relays with voltage and current sensing elements)
- Metering (either electro-mechanical or electronic)
- Line reactors, harmonic filters, and resistors
- Power factor correction capacitors
- Motors drive systems, power and lighting panels, heaters, lights, and other system loads.

5.11.1 Transformers

Transformers are very efficient pieces of equipment, usually in the range of 95 percent to 98 percent. The purpose of a transformer is to change voltage from one level to another. The first question is whether a transformer is needed at all. A transformer is almost never turned off. The expected life of a distribution transformer is 30 to 40 years if operated at full load for 365 days each year. Just connecting a transformer to distribution system results in energy being used by the transformer due to the losses from primary magnetizing power. The amount of energy required depends on the supply voltage. Losses with no load on the transformer secondary increase or decrease as the voltage increases or decreases at a rate approximately equal to the voltage squared. These no-load losses are not affected by the amount of load being supplied by the transformer. So the no-load losses affect the electric bill by adding power to the kilowatt (kW) demand charge and electrical energy to the kilowatt hour (energy charge) portion of the electric bill.

The current flowing through the secondary coil wires causes transformer load losses. A distribution transformer peak load is usually coincident with the facility peak, so the peak loss can be used to determine the demand portion of the electric bill.

Temperature ratings of transformer insulation are based on the temperature rise, given in degrees C. Energy savings can be obtained over the estimated 30-year transformer life by using a lower temperature rise design and insulation. For example, an 80 degree C rise transformer will be more efficient than a 140 degree C rise unit since less heat is generated within the windings. Of course the cooler transformer initially will cost more to purchase. The economics will depend on transformer cost vs. efficiency and the cost of electricity at the facility.

Conductor losses, also known as coil losses or load losses, should not be overlooked for one reason because such losses vary by the square of the load. That means a fully loaded transformer has four times the load losses compared with one running at 50% of its design load. But even at lower load factors, if the units not efficient (and many are not), losses mount rapidly.

Thus, the continuing costs of transformers losses should be balanced with the savings to be gained from efficient units (savings which go on year after year) quickly paying back the extra first cost.

Transformer efficiency is influenced by many factors. Primary influences include the choice and quantity of the conductor used in the windings in addition to the quality of the core material. The better the conductor, the lower the heat or I^2R losses. Copper is a more efficient conductor than aluminum; an enlarged cross-sectional area of copper results in lower resistance and, therefore, lower I^2R losses.

5.11.2 Conductors (wire, cable, busbars....)

Copper is a better electrical conductor than any other metal except silver. Another way of saying the same thing is that electricity flowing through copper wires meets far less resistance than it would in, say, aluminum or steel of the same diameter. That's why most electrical and communications wire is made from copper. Copper wires result in lower electrical losses, which appear as unwanted heat. Engineers call these resistive losses or, from a familiar formula I^2R losses.

The ease which electricity flows through any conductor depends on the conductor size. Large-diameter wires permit easier current flow and, consequently, lower losses.

By upsizing wire in a new installation, real savings to the customer as well as the advantages of lower generated heat and increased flexibility of the installation. In addition, when less heat is generated the result is reduced energy requirements for fans and air conditioning systems.

There are many factors that must be considered in any installation. But for most new applications, where the cost of labor and conduit for the installation outweigh the cost of wire, the increased size of the wire can pay for itself in less than two years. At the same time, increased wire size is insurance against changing future needs and assures lower voltage drops, reduced power losses offset the cost of the wire and produce savings on energy costs.

Wasteful energy losses in busbars usually stem from inadequate sizing. High conductivity copper busbars have inherently low losses if they are large enough for the job, and if they are designed with life-cycle costs in mind. But a busbar's size can be a significant cost factor. The designer's job is therefore to optimize the busbar's installed cost with respect to it's expected service life.

5.11.3 Electrical Power Transmission Lines

Electrical transmission lines are used to send electricity over long distances from the point of generation to cities and towns.

High voltage transmission lines interconnect utilities, generating stations, major load centers, and transfer power between utilities.

High percent of electric energy is lost between generation facilities and end use. If these transmission and distribution system losses can be reduced, less electricity needs to be generated to meet end use demands, which would reduce greenhouse gas emissions. Institutional and technological changes in transmission system engineering and operation are forthcoming and hold the potential for increased capacity and efficiency of the transmission grid.

In addition, due to load diversity between utilities and geographic regions, improved transmission links can often reduce the need for total installed generation and spinning reserve requirements.

5.11.4 Power Factor

Many factories are often billed by their electric utility for having large inductive loads at their facilities. Inductive loads results from the storage of energy in magnetic fields, which occurs in coils or wire, such as in motor windings. To decrease high electricity bills resulting from this large inductive load, capacitors may be installed at the facility to increase the power factor (PF)

Power factor (PF) is the ration between the kW and the kV A drawn by an electrical load power and the KVA is the apparent load power , or the cosine of the phase angle between the voltage and current. It is a measure of how effectively the current is being converted into useful work out put and more particularly is a good indicator of the effect of the load current on the efficiency of the supply system.

Power factor can be calculated as follows:

Power factor = Real power (kW) /Apperant power supplied (kVA)

When the load is inductive, as an induction motor, the current lags the applied voltage, and the power factor is said to be a lagging power factor.

When the load is capacitive as asynchronous motor or a capacitive network, the current leads the applied voltage, and the power factor is said to be a leading power factor.

Power factors other than unity have deleterious effects on power transmission systems, including excessive transmission losses and reduced system capacity.

All current wills cause losses in the supply and distribution system. A load with a power factor of 1 results in the most efficient loading of the supply and a load with a power factor of less 0.8 will result in much higher losses in the supply system.

A poor power factor can be the result of either a significant phase difference between the voltage and current at the load terminals, or it can be due to a high harmonic content or distorted/ discontinuous current waveform.

A poor PF due to an inductive load can be improved by the addition of power factor correction, but, a poor power factor due to a distorted current waveform requires an change in equipment design or expensive harmonic filters to gain an a appreciable improvement.

Low power factor is usually not that much of problem in residential homes. It doses however become a problem in industry where multiple large motors are used. Power factor correction capacitors are normally used to try to correct this problem.

5.11.4.1 Why Correct the Power Factor

Power factor in many municipalities and electricity distribution companies is nearly between 80% - 85% And they pay nearly 3 million dollar each year as penalties to IEC. IEC requires a PF of 92% as an acceptable value. Possible savings according to this percentage ranges between 7%-12% of the electricity supplied by IEC.

Also improving power factor can result in the following benefits:

- Lower voltage drop in transformers and conductors, given the same load. You can increase the load and still obtain satisfactory voltage values.
- Reduction in plant current upstream of capacitors. This allows you to increase the load without the need to install new transformers or conductors with bigger cross- sections.
- No further need to pay a penalty to electrical power supplier (IEC) for a low power factor value. This represents substantial savings.
- Reduce high power losses by dropping current through out the plant, and in so doing, can even increase plant load.
- Reducing demand and increasing efficiency of a motor load.
- Immediate savings on your next electric bill.
- Typical pay back on a PF project is usually one year or less.

5.11.4.2 Correcting Power Factor

Since to reactive components of power at industrial facilities is usually inductive, and since inductive and capacitive reactive power cancel one another out, a solution that is often applied is to install capacitors at the facility to reduce the inductive load, therefore reducing the overall amount of reactive power used. Capacitors are generally installed in on of three places:

1. Together at any point past the utility metering (usually at the service entrance switch gear)

2. Among electrical centers of power feeders and divided according to capacitor requirement.
3. At the terminals of each motor and / on inductive load producing piece of equipment.

Given the reactive load component (X_{load}), you can calculate the capacitance to exactly match it using the equation:

$$X_c=1/(2*\pi*f*c)$$

Where f= frequency

For 50 Hz, $X_c = 1/(314*c)$

Or rearranging: **$c=1/(314X_c)$**

By using the following equation we can determine the value of reactive power.

Apparent power (S) = V * I

Active power (P) = PF*V *I

Reactive power (Q) sqrt (Apparent power)^2 - (Active power)^2

Reactive power (Q) = (V^2/X_C)

Power factor correction capacitors are often rated in K var, instead of μF, because that is how the Power Company works.

Tuned harmonic filters consisting of inductors and capacitors can be used to provide power factor correction where harmonics are present. Filters can be tuned to specific harmonic frequencies, allowing harmonic currents to flow into and out of the filter and thus reduce their effects on the rest of the system. Or they may be tuned to reduce harmonic current flow through the filter, thereby protecting capacitors from over-current conditions.

5.11.5 The Effects of Improving Power Factor and Reducing Losses in Electrical System in the W. B

The most effective way to reducing technical losses in the electrical system of the West Bank is achieved by improving power factor and by making more rehabilitation projects. The amount of savings in such projects depends on the amount of money we invest, because this problems needs sustainable fund and efforts to keep the system efficient all the time.

The amount of non-technical losses in the W.B. in the electrical system are very high. This can solved by implementing strong measures in this side. However, the needed found required to solve this problem is relatively low with compared of the found needed to solve technical problems. The possible savinges in these cases can be as high as 5% of all losses.

In the last 5 years, the PEA has carried out several rehabilitation projects to improve network efficiency, to decrease losses and to improve PF. Preliminary resultes have shown that some of these projects succeeded to reduce losses from 27% in some areas to as low as 12%. The overall savings in technical and non-technical losses in the W.B. exceeded 12%. In addition to that, improving Pf has saved hundreds of thousands of dollars annually for the electrical system in the W.B.

That means we can save more electrical energy and increasing the load in the future without increasing the amount of electrical energy purchased from IEC, and avoiding pay a penalty to IEC due to low power factor.

5.12 Electric Motors

Motors consumed around 70% of electrical energy used in the industrial sector. In commercial sector motors accounted for nearly half of all electricity used, while in residential sector motors account nearly 20% of electrical energy. Therefore any plan to reduce the energy losses should encourage the use of motors that operate as efficiently as possible.

Most of the rewinded motors used generally tend to have lower operating efficiency, and substantial energy savings can obtained by replacing these rewinded motors with new ones. The additional investment for a high-efficiency motor can realize returns as high as 100% to 300% per year. Those returns continue in the form of lower power costs for the life of the motor.

An energy-efficient motor produces a given amount of work with less energy than a standard motor. When you consider that I^2R losses in the windings of a motor can constitute more than 50 % of its total losses, the need for an efficient conductor metal becomes clear.

For example, using copper instead of aluminum in the windings, and increasing conductor cross-sectional area, lowers a motor's I^2R losses. Better grades and thinner gages of steel laminations also reduce losses. Improved fans and bearings, reduced air gaps between stator and rotor, and closer machining tolerances are a few of the methods to build more efficient motors.

The first cost of energy efficient motors is generally higher than for standard motors, slightly depending on the motor, manufacturer and market competition. But their life-cycle costs can make them far more economical because of savings they generate in operating expense.

An often overlooked savings results from the fact that energy efficient motors run cooler than their standard counterparts, resulting in increased motor, insulation and bearing life. In general, an efficient motor is also a more reliable motor: fewer winding failures, longer periods between needed maintenance, and fewer forced outages.

Other benefits typically include extended lubrication cycles, better tolerance to thermal (and electrical) stresses resulting from stalls or frequent starting, ability to operate in higher ambient temperatures, fewer failures under conditions of impaired ventilation, and more resistance to abnormal operating conditions such as under voltage, over voltage or phase imbalance.

When a motor has a higher horsepower rating than is required by the load it is driving, the motor operates at part load. Motor efficiency begins to drops rapidly when operation falls below 50% of full load capacity. Also, power factor considerably declines below about 50% of full load, so lightly loaded motors can increase utility power factor charges. Oversized, under-loaded motors should be replaced with smaller energy-efficient motors in most instances.

The more horsepower a motor delivers, and the more hours per year it runs, the greater the operating cost and the more important the motor's efficiency turns out to be. Small motors, and motors that used infrequently or only for short period, don't cost a lot to run even if they are inefficient. But when a large horsepower motor operates for thousands of hours per year, the operating cost is substantial. And, the motor's efficiency can have a significant effect on the company's bottom line.

Variable frequency drives (VFDs) are the most common type of adjustable speed drives. VFDs are electronic systems that control the speed of AC induction motors by changing the frequency and voltage supplied to the motor. VFDs can result in substantial energy savings, especially for centrifugal loads with varying demands. Small reductions in speed can yield substantial energy savings. For example, a 20% reduction in fan speed can reduce energy consumption by nearly 50%. Pump, fan and compressor systems with variable loads should be considered for retrofit with VFDs.

5.12.1 Possible Savings in Electric Motors

Case8

Replacing rewinded motors with new high efficient ones. Assume 20% of old motors will replaced.

In this case 50% of electrical energy used by new motors will saved.

But motors consumed about 70% of electricity used in industrial sector, 50% of electricity used in commercial sector, and 20% of electricity used in residential sector.

Residential consumed 70% of electrical energy in the W.B. in 1993 and 55% in 1999.

Commercial consumed 17% of electrical energy in the W.B. in 1993 and 15% in 1999.

Industrial consumed 7% of electrical energy in the W.B. in 1993 and 18% in 1999.

Possible savings in year 1993:

Savings in residential sector = 70% X 50% X 20% X 20%

= 1.4%

Savings in commercial sector = 17% X 50% X 50% X 20%

= 0.85%

Savings in residential sector = 7% X 50% X 70% X 20%

= 0.49%

Total savings in 1993 = 1.4% + 0.85% + 0.49%

= **2.74%** of total electrical energy in W.B.

Possible savings in year 1999:

Savings in residential sector = 55% X 50% X 20% X 20%

= 1.1%

Savings in commercial sector = 15% X 50% X 50% X 20%

= 0.75%

Savings in residential sector = 18% X 50% X 70% X 20%

= 1.26%

Total savings in 1999 = 1.1% + 0.75% + 1.26%

= **3.11%** of total electrical energy in W.B.

Summary of all calculations that shows the possible savings in different areas in W.B. for both years 1993 & 1999 as in table 5.5.

Table 5.5: Possible savings in different cases in W.B for (1993, 1999).

Case Number	Possible Savings in 1993	Possible Savings in 1999
1	1.17%	0.9%
2	0.87%	0.69%
3	0.14%	0.77%
4	0.43%	2.47%
5	0.24%	0.19%
6	0.05%	0.04%
7	2.55%	2.49%
8	2.74%	3.11%
Total	8.2%	10.67%

Which cases defind as:

Case1: Reduce the old refrigerators in the W.B.by 10%.

Case2: If 22% of the refrigerators in the W.B. will replaced by new high efficient models instead of standard models.

Case3: If 5% of the buildings in both commercial and residential sectors in W.B. install thermal insulation.

Case4: If 20% of AC units in the W.B. replaced by new ones.

Case5: If 50% of household in the W.B. that depend in electrical water heaters as main source of hot water install solar water heaters.

Case6: If 50% of electrical water heaters in the W.B. replaced by gas water heaters.

Case7: If 50% of incandescent lamps changed to CFL lamps.

Case8: If 20% of rewinded motors replaced by new ones.

Chapter 6

Electrical Energy Demand Forecast

Electrical Energy Demand Forecast

Many efforts were done to forecast electrical demand of the W.B. for the next 20 years. However, this problem is extremely difficult due to the unlimited number of uncertainties in this area. This includes demographic, economic, political, and social uncertainties.

Previous studies were done to develop planning scenarios for energy forecast under such uncertainties. Also, PEA has conducted studies to make such planning.

In this chapter, we include the results of those studies will be briefed and discussed.

6.1 Electrical Load Forecasting

Load forecasting is a major tool for power generation systems and energy management. Long-term (years) load forecast and short-term (hours and days) forecast can be used for the following purposes:

- Power system planning.
- Power future demands (increasing capacity).
- Peak power demand.
- Maintenance schedule.
- Unit commitment.
- Operation schedules.
- Interconnections and sales schedule.
- Energy management plans.

Great efforts are used by the electric utilities to develop accurate load forecast for these systems. However, load forecast techniques that were developed in the last twenty years can be grouped into two categories:

1. Time-series based algorithms.
2. Expert systems or Ruler-based algorithms.

6.1.1 Time Series Approach

This is the old way to do load forecasting using computers. In this method, huge databases of all kinds of variables that may affect load demand by time are used to generate the forecast. These variables may include:

1. At least 10 years of load data (hour by hour).
2. At least 10 years of weather data (hour by hour).
   - Temperature.
   - Humidity.
   - Wind speed and direction.
   - Sky conditions (cloud percentage).
3. Economical data for the area (over 10 years or more):
   - Industrial development rate.
   - Agricultural development rate.
   - Electric prices.
   - Other energy sources 'prices.
   - Average income of family.
4. Demographically changes:
   - Population changes in the area in the last 10 years or more.
   - Concentration changes.

Huge databases of these variables are fed into a mainframe computer. Special statistical software algorithms are used to study the correlation between load, time of day, day of year and the specific variable. Finally a correlation equation is developed by the statistical software to predict the demanded power (load) for any hour of any day of the coming year.

This technique has proved to be very successful for long-term load forecast with average errors less than or equal to 2%. However, it may not work very well for short-term load forecasts.

It is very important to note that this technique can be used in countries with computerized data acquisition systems, where we can find data for many years for all the previous variables. However such systems are not available (or not accurate) for most of the third world countries such as ours. Thus, we may not be able to use such techniques in countries other than the developed ones.

6.1.2 Rule-Based Algorithm

The rule-based algorithm is based on emulating the knowledge, experience and analogical thinking of experienced system operators. It also uses relationships that exist between day-to-day load and weather conditions.

This section provides a summary of the algorithm for 1 to 24-hour load forecast for an electric utility. The knowledge base is the (electric utility) hourly load data for a year which is used to extract relationships between expected and historical load, and between load and weather conditions. The on-line database is limited to one week's hourly load, ambient temperature, and wind speed. To minimize the on-line computational requirements for the generating 24-hour forecast, a reference day is chosen from the database along with a set of rules, which are based on expected weather conditions. The similarity of weather conditions between the chosen historical day and the target day is not essential for this algorithm to work. A rule revising mechanism is built into the algorithm such that the pre-selected rules and factors can be modified if the average of the peak forecast errors is larger than 5% for three consecutive days. This feature is especially useful during the days of season changeover.

6.2 Forecast Electrical Demand Scenarios

Previous study [27], was done to forecast maximum power demand and energy consumption to the next 20 years will take four different scenarios of population and GDP projection.

The assumptions for each scenario are as follows:

Scenario 1:

-Population: This scenario is based on natural population growth and zero immigration.

-GDP:

- (1997 - 2010), GDP = (GDP of previous year + the average of the change in the GDP of the previous 5 years).
- (2010 – 2020), GDP = (1.02 * GDP of the previous year)

(GDP growth is assumed to be 2% per year like the situation in Jordan)

Scenario 2:

-Population: This scenario is based on assumption that 3000 returnees per year are expected for the period (1997-2020).

-GDP:

- (1997 - 2010), GDP = (GDP of previous year + the average of the change in the GDP of the previous 5 years + GDP of previous year X migration rate).
- (2010 – 2020), GDP = (1.02 X GDP of the previous year)

(GDP growth is assumed to be 2% per year like the situation in Jordan)

Scenario 3:

-Population: This scenario is based on the assumption that during the period (1997-2020) 275,000 are expected as follows: [(3000/year (1997-2002), 20000/ year (2002-2012), 1000/year (2012-2017), 3000/year (2017-2020)]

-GDP:

- (1997 - 2010), GDP = (GDP of previous year + the average of the change in the GDP of the previous 5 years + GDP of previous year X migration rate).
- (2010 – 2020), GDP = (1.02 X GDP of the previous year)

(GDP growth is assumed to be 2% per year like the situation in Jordan)

Scenario 4:

-Population: This scenario is based on the assumption that during the period (1997-2020) 975,000 are expected as follows [

3000/year (1997-2002), 60000/year (2002-2017), 20000/year (2017-2020)].

-GDP:

- (1997 - 2007), GDP = (GDP of previous year + the average of the change in the GDP of the previous 5 years + GDP of previous year X migration rate).
- (2007 – 2012), GDP = 1.04 X GDP of the previous year.
- (2012 – 2020), GDP = 1.03 X GDP of the previous year.

The author at the previous study used the econometric load forecast model to find the relationship between the independent variables (total population and GDP per capita) and the dependent variables that are the peak demand and energy consumption, by using historical data about the four variables from 1992 to 1998.

Equation 6.1 shows the relationship between GDP per capita, population (independent variables) and forecasting peak demand (dependent variable).

$$Y = 840.7268 + .001737*X - 2.783115*Z - 4.94303E\text{-}10*X^2 + 9.033E\text{-}4*Z^2 \quad .....(6.1)$$

Where Y: Predicted peak demand in MW.
X: Total population.
Z: GDP per capita.

Equation 6.2 shows the relationship between GDP per capita, population (independent variables) and forecasting energy consumption (dependent variable).

$$E = .00001 + .00001*X - 207.287*Z + 7.47E\text{-}7*X^2 - .1105298*Z^2 ....(6.2)$$

Where E: Forecasted energy consumption in GWH.
X: Total population.
Z: GDP per capita.

Applying equations 6.1 and 6.2 to the data of population and GDP projections according scenarios 1,2,3 and 4, the forecasting results of peak demand and energy consumption from 1992 to 2020 shown in tables 6.1, 6.2, 6.3, and 6.4 .

Figure 1 in Appendix shows the graphs of forecasted peak demand in the West Bank for the four scenarios.

Figure 2 in Appendix shows the graphs of forecasted energy consumption in the West Bank for the four scenarios.

6.3 Forecast for Electrical Demand with Applied Energy Management

Chapter 5 presents many-sided of energy management and conservation that can decrease electrical energy demand and save money in the West Bank for all sectors, residential, commercial, industrial and other sectors.

Eight possible saving cases were presented and applied for the both years 1993 and 1999 as a references to generate new and modified formulas, which can be used to forecast peak demands and energy consumptions for the next 20 years.

As shown in chapter 5, energy management and conservation's possible savings in year 1993 were 8.2% and in year 1999 were 10.67% of the total electricity consumed in the W.B.

Table 6.1: Forecasted of electrical energy consumption and peak demand in the West Bank – Scenario 1

Year	Total Population	GDP/ capita ($)	Forecasted Energy (GWH)	Forecasted Peak Demand (MW)
1992	1271724	1314	744	152
1993	1323360	1368	817	156
1994	1397212	1409	946	174
1995	1488785	1624	1027	193
1996	1579151	1690	1136	221
1997	1600100	1740	1217	246
1998	1657384	1775	1366	267
1999	1711418	1811	1450	287
2000	1769949	1858	1573	313
2001	1830481	1900	1710	336
2002	1898076	1940	1873	356
2003	1952930	1982	2003	379
2004	2008979	2024	2142	401
2005	2066637	2065	2291	423
2006	2125949	2106	2449	443
2007	2186777	2147	2617	462
2008	2242515	2188	2773	484
2009	2300372	2230	2941	505
2010	2359952	2271	3119	524
2011	2421075	2316	3305	547
2012	2487267	2362	3515	567
2013	2549600	2410	3714	594
2014	2616909	2458	3938	616
2015	2686258	2507	4176	638
2016	2758250	2557	4430	659
2017	2838642	2608	4726	672
2018	2899295	2661	4945	710
2019	2968878	2714	5207	739
2020	3040132	2768	5483	768

*Note: Completely or partially non-electrified population are not include in energy consumption and peak demand forecasting

Source: Said, Nidal Lafi : **Electrical Energy Planning for the West Bank Under Uncertainties**. (Master's Thesis). An-Najah National University. Nablus. Palestine, 1999.

Table 6.2: Forecasted of electrical energy consumption and peak demand in the West Bank – Scenario 2

Year	Total Population	GDP/ capita ($)	Forecasted Energy (GWH)	Forecasted Peak Demand (MW)
1992	1271724	1314	744	152
1993	1323360	1368	817	156
1994	1397212	1409	946	174
1995	1488785	1624	1027	193
1996	1579151	1690	1136	221
1997	1600100	1740	1217	246
1998	1657384	1775	1366	267
1999	1714065	1811	1456	287
2000	1775428	1861	1586	314
2001	1838988	1907	1729	340
2002	1913865	1952	1910	362
2003	1970505	2000	2043	390
2004	2028832	2050	2185	420
2005	2088885	2101	2336	451
2006	2151552	2153	2499	483
2007	2219020	2208	2681	518
2008	2275268	2263	2831	560
2009	2336018	2322	2999	607
2010	2399090	2381	3179	656
2011	2463866	2428	3379	686
2012	2536260	2477	3613	713
2013	2599216	2526	3817	748
2014	2670695	2577	4059	779
2015	2743872	2628	4315	808
2016	2819328	2682	4586	840
2017	2905151	2735	4910	858
2018	2968702	2789	5145	903
2019	3042325	2845	5429	941
2020	3117778	2902	5728	980

*Note: Completely or partially non-electrified population are not include in energy consumption and peak demand forecasting

Source: Said, Nidal Lafi : **Electrical Energy Planning for the West Bank Under Uncertainties**. (Master's Thesis). An-Najah National University. Nablus. Palestine, 1999.

Table 6.3: Forecasted of electrical energy consumption and peak demand in the West Bank – Scenario 3

Year	Total Population	GDP/ capita ($)	Forecasted Energy (GWH)	Forecasted Peak Demand (MW)
1992	1271724	1314	744	152
1993	1323360	1368	817	156
1994	1397212	1409	946	174
1995	1488785	1624	1027	193
1996	1579151	1690	1136	221
1997	1600100	1740	1217	246
1998	1657384	1775	1366	267
1999	1714065	1811	1456	288
2000	1775428	1861	1586	315
2001	1838988	1906	1729	340
2002	1913865	1954	1919	365
2003	1985635	2020	2075	405
2004	2060096	2092	2252	452
2005	2137350	2169	2442	508
2006	2217500	2254	2747	578
2007	2307365	2345	2994	658
2008	2384893	2444	3514	765
2009	2465025	2551	3874	897
2010	2547604	2665	4457	1056
2011	2633204	2729	4801	1119
2012	2715889	2784	5150	1165
2013	2794650	2839	5491	1213
2014	2875695	2890	5858	1249
2015	2959090	2954	6237	1313
2016	3047863	3010	6663	1350
2017	3128159	3073	7049	1415
2018	3203235	3135	7417	1485
2019	3280113	3198	7804	1558
2020	3358836	3262	8211	1631

*Note: Completely or partially non-electrified population are not include in energy consumption and peak demand forecasting

Source: Said, Nidal Lafi : **Electrical Energy Planning for the West Bank Under Uncertainties**. (Master's Thesis). An-Najah National University. Nablus. Palestine, 1999.

Table 6.4: Forecasted of electrical energy consumption and peak demand in the West Bank – Scenario 4

Year	Total Population	GDP/ capita ($)	Forecasted Energy (GWH)	Forecasted Peak Demand (MW)
1992	1271724	1314	744	152
1993	1323360	1368	817	156
1994	1397212	1409	946	174
1995	1488785	1624	1027	193
1996	1579151	1690	1136	221
1997	1600100	1740	1217	246
1998	1657384	1775	1366	267
1999	1714065	1811	1456	288
2000	1775428	1861	1586	315
2001	1838988	1906	1729	340
2002	1913865	1954	1919	365
2003	2019510	2051	2156	424
2004	2131189	2153	2434	492
2005	2249044	2261	2744	572
2006	2373640	2375	3092	662
2007	2515233	2494	3521	760
2008	2627412	2593	3876	849
2009	2745120	2697	4266	948
2010	2867553	2830	4670	1115
2011	2996019	2917	5160	1175
2012	3138544	3034	5711	1294
2013	3263772	3125	6230	1368
2014	3394322	3218	6794	1439
2015	3530096	3315	7407	1513
2016	3671299	3414	8072	1582
2017	3825860	3517	8837	1636
2018	3913605	3587	9275	1707
2019	4011445	3660	9781	1768
2020	4111731	3733	10315	1824

*Note: Completely or partially non-electrified population are not include in energy consumption and peak demand forecasting

Source: Said, Nidal Lafi : **Electrical Energy Planning for the West Bank Under Uncertainties**. (Master's Thesis). An-Najah National University. Nablus. Palestine, 1999.

6.3.1 Modified Formula to Forecast Electrical Demand with Applying Energy Management

In order to forecast the peak demand and energy consumption for the next 20 years in the W.B, we will use the econometric model.

This model goes through four steps as the following

- Defining the driving variables.
- Defining the best relationship between the independent and the dependent variables, which called the curve fit technique, based on historical data from 1993 to1999.
- Perform multiple regression analysis in SPSS to find parameters of relationship.
- Testing.

In our study the independent variables are total populations and GDP per capita, while dependent variables are peak demand and energy consumption.

In order to modify the formulas shown in section 6.1, which shows the relation between the total population and GDP per capita as the dependent variables and the maximum power demand and energy consumption as dependent variables, to forecast electrical demand for the next 20 years, we used the historical data of power demand, energy consumption, total population and GDP per capita in the both years 1993 and 1999.

The historical data for dependent variables (peak demand and energy consumption) in table 2.3 in chapter 2 will modified according to the possible savings calculated in chapter 5 in both years 1993 and 1999, the data from the period 1994 to 1998 will modified according to linear equation to forecast the consumption of electrical energy taking into account that the possible savings in year 1993 is 8.2% and in year 1999 is 10.67% after applying energy management and conservation techniques. The forecasted data shown in table6.5.

Table 6.5: Forecasted electrical consumption with applied energy management and conservation techniques from the period 1993 to 1999.

Year	Actual Peak (MW)	Forecasted Peak with EM (MW)	Actual Energy Consumption (GWH)	Forecasted Energy Consumption with EM (GWH)
1993	162	148	818	750
1994	167	160	916	837
1995	199	181	1008	917
1996	218	197	1104	1000
1997	244	219	1223	1102
1998	274	245	1411	1266
1999	297	265	1509	1348

According to the previous study [27], the best relationship between the variables is the quadratic function, because it gives the highest value of R^2 between the variables, R^2 is defined as the proportion of the variation of the data about the mean explained by regression equation, that is explained variation divided by the total variation.

The general form of quadratic function between the independent and dependent variables as the following:

$$Y = A + B * X + C * Z + D * X^2 + E * Z^2$$

Where:

Y: dependent variables

X, Z: independent variables

A, B, C, D, E: equation coefficients

To find the equation coefficients we will applied non-linear regression techniques of the SPSS software to the historical data in table 6.5 of dependent variables and the historical data of GDP and total population.

The results of regression analysis gave the coefficients values of the equation s as shown in equations 6.3 and 6.4.

Equation 6.3 shows the relationship between GDP per capita, population (independent variables) and forecasting peak demand with applied energy management (dependent variable).

$$Y_{EM}=790.96 + .0016563*X - 2.614489*Z - 4.8259E\text{-}10*X^2 + 8.47887E\text{-}4*Z^2 \quad \text{....(6.3)}$$

Where Y_{EM}: Forecasted peak demand with applied energy management in MW.

X: Total population.

Z: GDP per capita.

Equation 6.4 shows the relationship between GDP per capita, population (independent variables) and forecasting energy consumption after applied energy management (dependent variable).

$$E_{EM}= 1028.8 + 2.218257E\text{-}3*X - 3.56512*Z - 1.21E\text{-}10*X^2 + 1.001537E\text{-}3*Z^2 \quad \text{.....(6.4)}$$

Where E_{EM}: Forecasting energy consumption with applied energy management in GWH

X: Total population.

Z: GDP per capita.

Testing equation 6.3, forecasting peak with applied energy management by calculating the absolute percentage error for the two years 1993 and 1999 shown in table 6.6.

Table 6.6: Estimated values of Peak demand with applied Energy Management in the West Bank (1993, 1999)

Year	1993	1999
Total Population	1323360	1711418
GDP/ capita ($)	1368	1811
Actual Peak (MW)	162	297
Estimated Possible Saving Percent	8.2%	10.67%
Estimated peak with EM (MW)	148.7	265.31
Forecasted Peak with EM equation 6.3 (MW)	147.82	258.09
Absolute error (MW)	0.87	7.21
% error	0.58	2.72

Testing equation 6.4, forecasting energy consumption with applied energy management by calculating the absolute percentage error for the two years 1993 and 1999 shown in table 6.7.

Table 6.7: Estimated values of Energy consumption with applied Energy Management in the West Bank (1993, 1999)

Year	1993	1999
Total Population	1323360	1711418
GDP/ capita ($)	1368	1811
Actual Energy Consumption (GWH)	817	1509
Estimated Possible Saving Percent	8.2%	10.67%
Estimated Energy Consumption with EM (GWH)	749.92	1347.98
Forecasted Energy Consumption with EM equation 6.4 (GWH)	749.6637	1299.091
Absolute error (GWH)	0.26	48.9
% error	0.0347	3.62

As shown in table 6.6 and table 6.7 values of percentage error is between 0.372% and 2.72% in peak demand forecasting and between 0.03475% and 3.627% in forecasting energy consumption, which are relatively very low and are relatively and lower than 5%.

To forecast electrical energy consumption and maximum power demand with applied energy management and conservation for the period from year 2000 to 2020. The data of the total population and GDP per capita of the four scenarios in tables 6.1, 6.2, 6.3, and 6.4 to will apply to the two equations 6.3 and 6.4.

The results of these calculations had shown in the following tables.

Figures 3,4,5 and 6 in Appendix show the savings of peak demand after applying energy management and conservation in the West Bank for the four scenarios (1,2,3 and 4).

Figures 7,8,9 and 10 in Appendix show the savings of energy consumption after applying energy management and conservation in the West Bank for the four scenarios (1,2,3 and 4).

Table 6.8: Forecasted of peak demand with applied energy management and conservation in the West Bank – Scenario 1

Year	Forecasted Peak Power (MW)	Forecasted Peak Power with EM (MW)	Saving (MW)	Percent of Saving (%)
1992	152	145	7	4.61
1993	156	147	9	5.77
1994	174	162	12	6.90
1995	193	177	16	8.29
1996	221	206	15	6.79
1997	246	223	23	9.35
1998	267	241	26	9.74
1999	287	258	29	10.10
2000	313	280	33	10.54
2001	336	299	37	11.01
2002	356	315	41	11.52
2003	379	333	46	12.14
2004	401	352	49	12.22
2005	423	369	54	12.77
2006	443	385	58	13.09
2007	462	400	62	13.42
2008	484	416	68	14.05
2009	505	433	72	14.26
2010	524	447	77	14.69
2011	547	465	82	14.99
2012	567	480	87	15.34
2013	594	500	94	15.82
2014	616	516	100	16.23
2015	638	532	106	16.61
2016	659	546	113	17.15
2017	672	552	120	17.86
2018	710	583	127	17.89
2019	739	604	135	18.27
2020	768	625	143	18.62

Note: Completely or partially non-electrified population are not include in peak demand forecasting

Table 6.9: Forecasted of peak demand with applied energy management and conservation in the West Bank – Scenario 2

Year	Forecasted Peak Power (MW)	Forecasted Peak Power with EM (MW)	Saving (MW)	Percent of Saving (%)
1992	152	145	7	4.61
1993	156	147	9	5.77
1994	174	162	12	6.90
1995	193	177	16	8.29
1996	221	206	15	6.79
1997	246	223	23	9.35
1998	267	241	26	9.74
1999	287	258	29	10.10
2000	314	281	33	10.51
2001	340	302	38	11.18
2002	362	320	42	11.60
2003	390	343	47	12.05
2004	420	368	52	12.38
2005	451	394	57	12.64
2006	483	421	62	12.84
2007	518	450	68	13.13
2008	560	486	74	13.21
2009	607	527	80	13.18
2010	656	568	88	13.41
2011	686	592	94	13.70
2012	713	613	100	14.03
2013	748	641	107	14.30
2014	779	665	114	14.63
2015	808	687	121	14.98
2016	840	711	129	15.36
2017	858	721	137	15.97
2018	903	758	145	16.06
2019	941	787	154	16.37
2020	980	817	163	16.63

Note: Completely or partially non-electrified population are not include in peak demand forecasting

Table6.10: Forecasted of peak demand with applied energy management and conservation in the West Bank – Scenario 3

Year	Forecasted Peak Power (MW)	Forecasted Peak Power with EM (MW)	Saving (MW)	Percent of Saving (%)
1992	152	145	7	4.61
1993	156	147	9	5.77
1994	174	162	12	6.90
1995	193	177	16	8.29
1996	221	206	15	6.79
1997	246	223	23	9.35
1998	267	241	26	9.74
1999	288	258	30	10.42
2000	315	281	34	10.79
2001	340	301	39	11.47
2002	365	321	44	12.05
2003	405	355	50	12.35
2004	452	396	56	12.39
2005	508	444	64	12.60
2006	578	505	73	12.63
2007	658	574	84	12.77
2008	765	670	95	12.42
2009	897	789	108	12.04
2010	1056	932	124	11.74
2011	1119	985	134	11.97
2012	1165	1022	143	12.27
2013	1213	1062	151	12.45
2014	1249	1088	161	12.89
2015	1313	1141	172	13.10
2016	1350	1168	182	13.48
2017	1415	1222	193	13.64
2018	1485	1281	204	13.74
2019	1558	1341	217	13.93
2020	1631	1403	228	13.98

Note: Completely or partially non-electrified population are not include in peak demand forecasting

Table 6.11: Forecasted of peak demand with applied energy management and conservation in the West Bank – Scenario 4

Year	Forecasted Peak Power (MW)	Forecasted Peak Power with EM (MW)	Saving (MW)	Percent of Saving (%)
1992	152	145	7	4.61
1993	156	147	9	5.77
1994	174	162	12	6.90
1995	193	177	16	8.29
1996	221	206	15	6.79
1997	246	223	23	9.35
1998	267	241	26	9.74
1999	288	258	30	10.42
2000	315	281	34	10.79
2001	340	301	39	11.47
2002	365	321	44	12.05
2003	424	372	52	12.26
2004	492	430	62	12.60
2005	572	498	74	12.94
2006	662	576	86	12.99
2007	760	657	103	13.55
2008	849	732	117	13.78
2009	948	817	131	13.82
2010	1115	963	152	13.63
2011	1175	1009	166	14.13
2012	1294	1108	186	14.37
2013	1368	1165	203	14.84
2014	1439	1219	220	15.29
2015	1513	1274	239	15.80
2016	1582	1323	259	16.37
2017	1636	1356	280	17.11
2018	1707	1412	295	17.28
2019	1768	1458	310	17.53
2020	1824	1498	326	17.87

Note: Completely or partially non-electrified population are not include in peak demand forecasting

Table 6.12: Forecasted of energy consumption with applied energy management and conservation in the West Bank – Scenario 1

Year	Forecasted energy consumption (GWH)	Forecasted energy consumption with EM (GWH)	Saving (GWH)	Percent of Saving (%)
1992	744	698	46	6.18
1993	817	749	68	8.32
1994	946	857	89	9.41
1995	1027	914	113	11.00
1996	1136	1065	71	6.25
1997	1217	1097	120	9.86
1998	1366	1200	166	12.15
1999	1450	1299	151	10.41
2000	1573	1409	164	10.43
2001	1710	1525	185	10.82
2002	1873	1656	217	11.59
2003	2003	1767	236	11.78
2004	2142	1883	259	12.09
2005	2291	2005	286	12.48
2006	2449	2131	318	12.98
2007	2617	2263	354	13.53
2008	2773	2389	384	13.85
2009	2941	2521	420	14.28
2010	3119	2658	461	14.78
2011	3305	2805	500	15.13
2012	3515	2964	551	15.68
2013	3714	3123	591	15.91
2014	3938	3293	645	16.38
2015	4176	3471	705	16.88
2016	4430	3659	771	17.40
2017	4726	3864	862	18.24
2018	4945	4048	897	18.14
2019	5207	4249	958	18.40
2020	5483	4459	1024	18.68

Note: Completely or partially non-electrified population are not include in energy consumption forecasting

Table 6.13: Forecasted of energy consumption with applied energy management and conservation in the West Bank – Scenario 2

Year	Forecasted energy consumption (GWH)	Forecasted energy consumption with EM (GWH)	Saving (GWH)	Percent of Saving (%)
1992	744	698	46	6.18
1993	817	749	68	8.32
1994	946	857	89	9.41
1995	1027	914	113	11.00
1996	1136	1065	71	6.25
1997	1217	1097	120	9.86
1998	1366	1200	166	12.15
1999	1456	1303	153	10.51
2000	1586	1419	167	10.53
2001	1729	1542	187	10.82
2002	1910	1688	222	11.62
2003	2043	1805	238	11.65
2004	2185	1931	254	11.62
2005	2336	2065	271	11.60
2006	2499	2208	291	11.64
2007	2681	2366	315	11.75
2008	2831	2510	321	11.34
2009	2999	2672	327	10.90
2010	3179	2843	336	10.57
2011	3379	3007	372	11.01
2012	3613	3190	423	11.71
2013	3817	3362	455	11.92
2014	4059	3553	506	12.47
2015	4315	3752	563	13.05
2016	4586	3963	623	13.58
2017	4910	4193	717	14.60
2018	5145	4395	750	14.58
2019	5429	4621	808	14.88
2020	5728	4857	871	15.21

Note: Completely or partially non-electrified population are not include in energy consumption forecasting

Table 6.14: Forecasted of energy consumption with applied energy management and conservation in the West Bank – Scenario 3

Year	Forecasted energy consumption (GWH)	Forecasted energy consumption with EM (GWH)	Saving (GWH)	Percent of Saving (%)
1992	744	698	46	6.18
1993	817	749	68	8.32
1994	946	857	89	9.41
1995	1027	914	113	11.00
1996	1136	1065	71	6.25
1997	1217	1097	120	9.86
1998	1366	1200	166	12.15
1999	1456	1303	153	10.51
2000	1586	1419	167	10.53
2001	1729	1542	187	10.82
2002	1919	1688	231	12.04
2003	2075	1841	234	11.28
2004	2252	2010	242	10.75
2005	2442	2196	246	10.07
2006	2747	2405	342	12.45
2007	2994	2650	344	11.49
2008	3514	2900	614	17.47
2009	3874	3184	690	17.81
2010	4457	3506	951	21.34
2011	4801	3760	1041	21.68
2012	5150	3998	1152	22.37
2013	5491	4233	1258	22.91
2014	5858	4468	1390	23.73
2015	6237	4741	1496	23.99
2016	6663	5008	1655	24.84
2017	7049	5286	1763	25.01
2018	7417	5559	1858	25.05
2019	7804	5844	1960	25.12
2020	8211	6142	2069	25.20

Note: Completely or partially non-electrified population are not include in energy consumption forecasting

Table 6.15: Forecasted of energy consumption with applied energy management and conservation in the West Bank – Scenario 4

Year	Forecasted energy consumption (GWH)	Forecasted energy consumption with EM (GWH)	Saving (GWH)	Percent of Saving (%)
1992	744	698	46	6.18
1993	817	749	68	8.32
1994	946	857	89	9.41
1995	1027	914	113	11.00
1996	1136	1065	71	6.25
1997	1217	1097	120	9.86
1998	1366	1200	166	12.15
1999	1456	1303	153	10.51
2000	1586	1419	167	10.53
2001	1729	1542	187	10.82
2002	1919	1688	231	12.04
2003	2156	1916	240	11.13
2004	2434	2173	261	10.72
2005	2744	2464	280	10.20
2006	3092	2794	298	9.64
2007	3521	3180	341	9.68
2008	3876	3511	365	9.42
2009	4266	3876	390	9.14
2010	4670	4326	344	7.37
2011	5160	4711	449	8.70
2012	5711	5201	510	8.93
2013	6230	5619	611	9.81
2014	6794	6063	731	10.76
2015	7407	6539	868	11.72
2016	8072	7043	1029	12.75
2017	8837	7594	1243	14.07
2018	9275	7955	1320	14.23
2019	9781	8347	1434	14.66
2020	10315	8752	1563	15.15

Note: Completely or partially non-electrified population are not include in energy consumption forecasting

6.4 Forecasting the Electrical Demand Made by PEA

PEA made hard efforts to forecast electrical demand of the W.B. for the next 15 years. One of these efforts is study to forecast electrical demand for three scenarios low, medium and high forecast from 1995 to 2015.

The results of the forecasted peak power demand and electrical energy consumption from 1995 to 2015 for the three scenarios shown in tables 6.16 and 6.17.

Figure 11 in Appendix shows peak demand forecast (Low, Medium, and High), in W.B from 1995 to 2015

Figure 12 in Appendix shows energy consumption forecast (Low, Medium, and High), in W.B from 1995 to 2015

6.5 Energy Consumption and Max Power Demand Forecast Due to Connecting Non or Partially Electrified Villages to the Grid

The percent of population who are completely or partially not connected to electricity grid is about 12.7% of total population in year 1999.

PEA made many planning to connect this percent of population to electricity grid during the period from 2001 to 2005. PEA forecast that the power demands after connect this percent of population to the grid will increase nearly by 25 MW will supplied by the grid in 5 years, equally, that is 5 MW each year due to connecting non-electrified villages to the grid.

To calculate energy consumption we assume L.F for this period will be 0.58 like that in 1998, and then we applied the following formula to calculate energy consumption.

Energy = Peak Power Demand X 8760 X L.F.

= 25 MW X 8760 X 0.58

= 12.7 GWH During the period 2001 to 2005

Table 6.16: Peak demand forecast (Low, Medium, and High), in W.B from 1995 to 2015

	Peak Demand Forecast (MW)		
Year	**Low Forecast**	**Medium Forecast**	**High Forecast**
1995	199	199	199
1996	216	218	221
1997	238	244	251
1998	263	274	285
1999	288	306	323
2000	313	338	364
2001	333	367	402
2002	354	398	443
2003	376	430	487
2004	397	464	535
2005	419	499	585
2006	436	530	633
2007	454	562	682
2008	471	595	734
2009	488	629	788
2010	505	663	843
2011	522	698	901
2012	539	734	960
2013	556	770	1020
2014	573	806	1082
2015	590	843	1144

(Source: PEA, March 1997)

Table 6.17: Energy consumption forecast (Low, Medium, and High), in W.B from 1995 to 2015

Year	Energy Consumption Forecast (MWH)		
	Low Forecast	Medium Forecast	High Forecast
1995	1008234	1008234	1008234
1996	1089446	1104340	1118225
1997	1190504	1222651	1255838
1998	1352142	1411116	1469057
1999	1520131	1614324	1708868
2000	1691345	1827643	1968434
2001	1806417	1989654	2178291
2002	1925015	2161251	2407948
2003	2045413	2340756	2653936
2004	2166212	2530668	2919404
2005	2290684	2727615	3201678
2006	2385444	2897569	3459926
2007	2480584	3073949	3731209
2008	2575694	3254322	4015425
2009	2668151	3437865	4308203
2010	2763389	3626913	4612435
2011	2855913	3817178	4927931
2012	2948520	4011457	5249644
2013	3041339	4209614	5578224
2014	3135286	4409361	5915772
2015	3228981	4610178	6257451

(Source: PEA, March 1997)

Chapter 7

Results and Recommendations

Results and Recommendations

7.1 Results & Conclusion

In this study, we have evaluated different possible electrical energy management techniques and applying them to the West Bank of Palestinian types of loads to reduce environmental pollutions and also can reduce customer's costs and peak maximum load demand of utility.

In this study also, we developed a new modified formulas to forecast electrical energy consumption and maximum peak power demand with applied energy management and conservation techniques, the final formulas are shown in equations 6.3 and 6.4 in chapter 6. These equations were modifying according to the possible savings percentage calculated in chapter 5 for both years 1993 and 1999. These calculations were based on eight cases, these cases will assume to calculate possible savings electrical demand and energy consumption in the West Bank. We note that the possible savings of total electricity consumed in the West Bank in year 1993 is nearly 8.2% and in 1999 nearly 10.67%.

Regarding the four scenarios discussed in chapter 6 of population and GDP per capita as independent variables, we implement the data of the four scenarios in equations 6.3 and 6.4 to forecast the possible savings of electrical energy consumption and maximum power demand for the next 20 years ahead. The possible savings after implementing the data of the four scenarios in the equations are shown in table 7.1 and 7.2.

From the results tabulated in table 7.1, we can conclude that for the four scenarios, the average of peak demand reduction in utility capacity range from 43 MW in year 2002 to 215 MW in year 2020.

According to the market prices, each 1MW capacity of generation costs approximately one million US dollars. According to this possible savings range nearly from 43 million US dollars in year 2002 and nearly 215 US dollars in year 2020.

From the results in table 7.2, we can conclude that for the four scenarios the average of the electrical energy consumption reduction from 225 GWH in year 2002 to 1382 GWH in year 2020.

Also, according to market prices of KWh, the average price of KWh is approximately 10 cent of US dollars. The expected possible savings for this is rang nearly from 22.5 million US dollars in year 2002 and 138.2 million US dollars in year 2020.

Finally implementing energy management and conservation techniques should the following benefits:

1. Minimize utility capacity and consumer costs.
2. Increase population income.
3. Increase system reliability.
4. Defer the need for generation unit projects.
5. Increase the investments in industrial sector.
6. Reduce critical fuel dependency.
7. Minimize cost of purchased power.
8. Reduce of dependent to IEC.
9. Help to modified new development planes.
10. Protect the environment through reducing gas emission.

Table 7.1: Forecasted Savings in Peak Power Demand in the West Bank for the four scenarios

	Savings in Peak Demand (MW)				
Year	**scenario1**	**scenario2**	**scenario3**	**scenario4**	**Average of 4 scenarios**
1992	7	7	7	7	7.0
1993	9	9	9	9	9.0
1994	12	12	12	12	12.0
1995	16	16	16	16	16.0
1996	15	15	15	15	15.0
1997	23	23	23	23	23.0
1998	26	26	26	26	26.0
1999	29	29	30	30	29.5
2000	33	33	34	34	33.5
2001	37	38	39	39	38.3
2002	41	42	44	44	42.8
2003	46	47	50	52	48.8
2004	49	52	56	62	54.8
2005	54	57	64	74	62.3
2006	58	62	73	86	69.8
2007	62	68	84	103	79.3
2008	68	74	95	117	88.5
2009	72	80	108	131	97.8
2010	77	88	124	152	110.3
2011	82	94	134	166	119.0
2012	87	100	143	186	129.0
2013	94	107	151	203	138.8
2014	100	114	161	220	148.8
2015	106	121	172	239	159.5
2016	113	129	182	259	170.8
2017	120	137	193	280	182.5
2018	127	145	204	295	192.8
2019	135	154	217	310	204.0
2020	143	163	228	326	215.0

Table 7.2: Forecasted Savings in Electrical Energy Consumption in the West Bank for the four scenarios

	Savings in Electrical Energy Consumption (GWH)				
Year	scenario1	scenario2	scenario3	scenario4	Average Of 4 Scenarios
1992	46	46	46	46	46.0
1993	68	68	68	68	68.0
1994	89	89	89	89	89.0
1995	113	113	113	113	113.0
1996	71	71	71	71	71.0
1997	120	120	120	120	120.0
1998	166	166	166	166	166.0
1999	151	153	153	153	152.5
2000	164	167	167	167	166.3
2001	185	187	187	187	186.5
2002	217	222	231	231	225.3
2003	236	238	234	240	237.0
2004	259	254	242	261	254.0
2005	286	271	246	280	270.8
2006	318	291	342	298	312.3
2007	354	315	344	341	338.5
2008	384	321	614	365	421.0
2009	420	327	690	390	456.8
2010	461	336	951	344	523.0
2011	500	372	1041	449	590.5
2012	551	423	1152	510	659.0
2013	591	455	1258	611	728.8
2014	645	506	1390	731	818.0
2015	705	563	1496	868	908.0
2016	771	623	1655	1029	1019.5
2017	862	717	1763	1243	1146.3
2018	897	750	1858	1320	1206.3
2019	958	808	1960	1434	1290.0
2020	1024	871	2069	1563	1381.8

7.2 Recommendations

According to the findings of this research, the researcher believes that more work must be done. The following suggestions are strongly recommended:

1. After the completion of the project for energy efficiency improvement carried out by PEA, an evaluation of the results must be done. This evaluation must compare the outputs of the project to those indicated in the project proposal. As this work was based on the expected outputs of this project, then the results of this work can be adjusted.

2. Building insulation and solar design of buildings must be considered in the nearest future. If this is the case then extra savings in energy can be achieved and our forecast can be modified lately.

3. The data used in this work did not take into considerations the impacts of the new uprising "Intifadat Al-Aqsa" broke out on Sep. 28. 2000. This Intifada has changed all expectations for economical and demographic changes for the nearest future. Since this Intifada is far from ending, it is extremely difficult to evaluate its impacts on the all sectors in Palestine, mainly the energy sector.

4. It is recommended to emphasis on implementing solar designs in our plans for local development in the construction sector. More dependency on solar energy for space and water heating is good not for the energy sector but also to our environment and to the global environment.

5. For an integral study and planning for Palestine, Gaza strip must be studied thoroughly and comprehensively. Gaza strip was not included in our study for different reasons such as lack of data and complicated demographic status.

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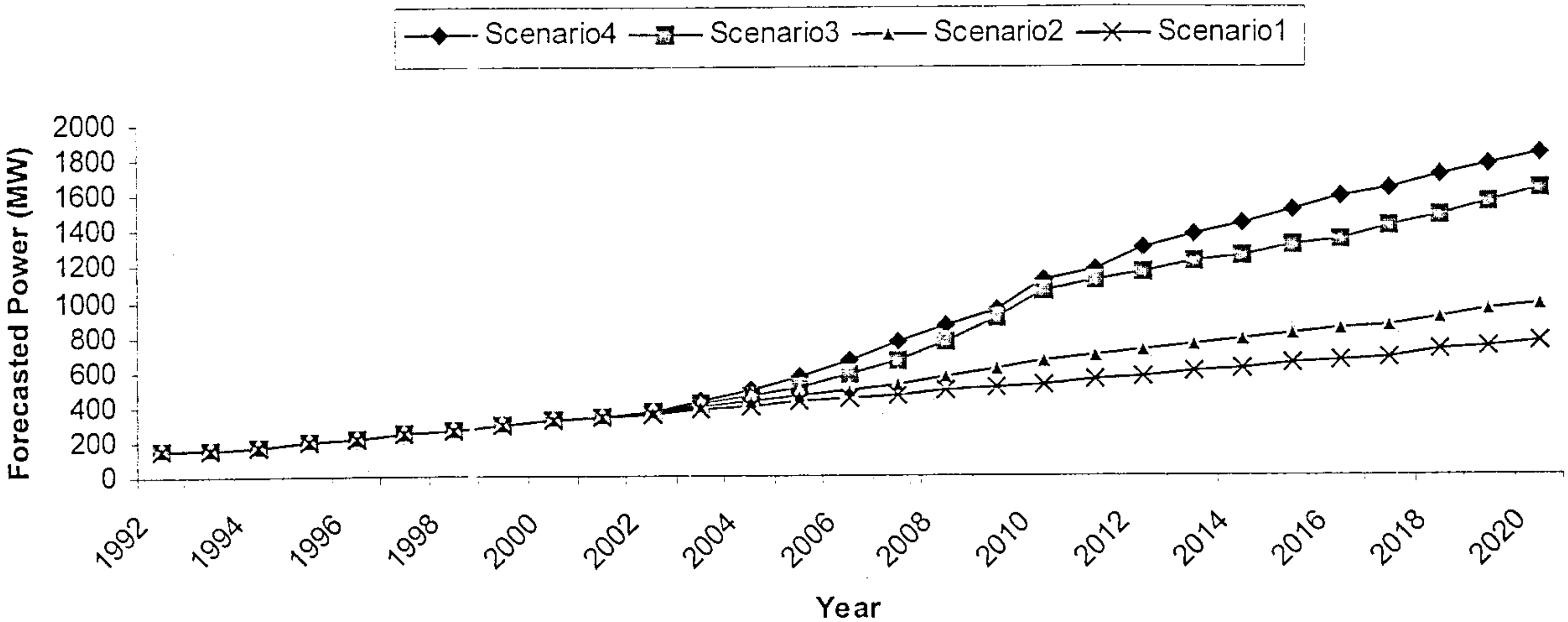

Figure 1: Forecasted Peak Demand of the West Bank for the Four Scenarios.

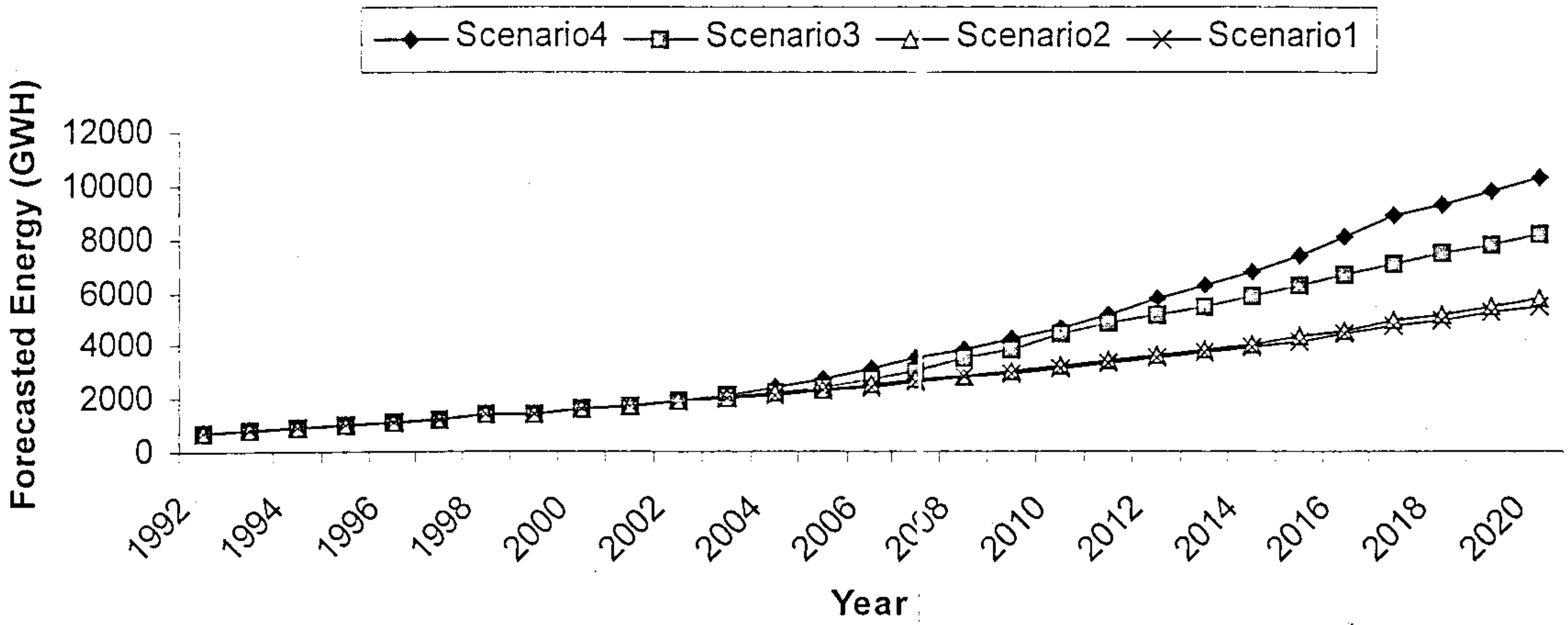

Figure 2: Forecasted Energy Consumption of the West Bank for the Four Scenarios.

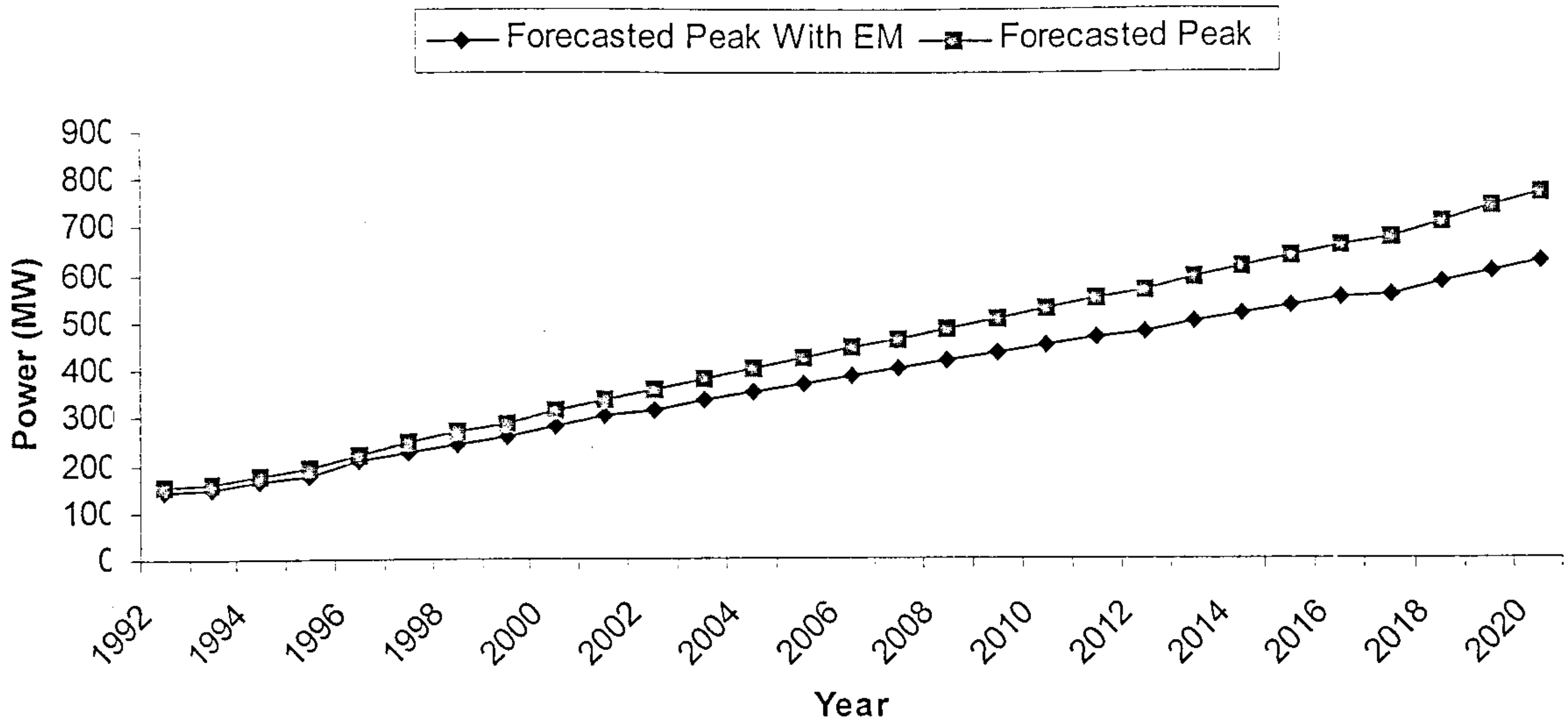

Figure 3: Estimated Saving of Peak Power Demand in W.B with applying energy management – Scenario1

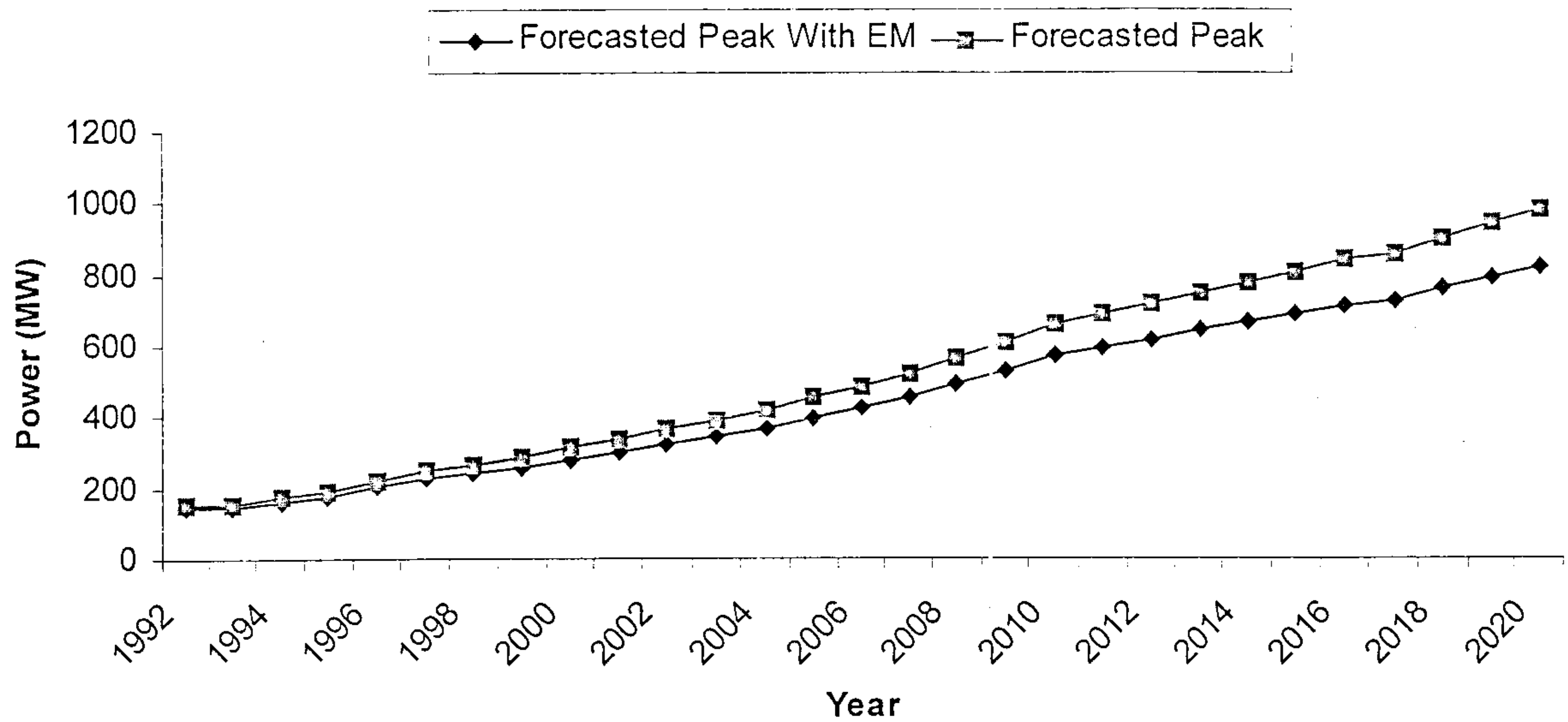

Figure 4: Estimated Saving of Peak Power Demand in W.B with applying energy management – Scenario2

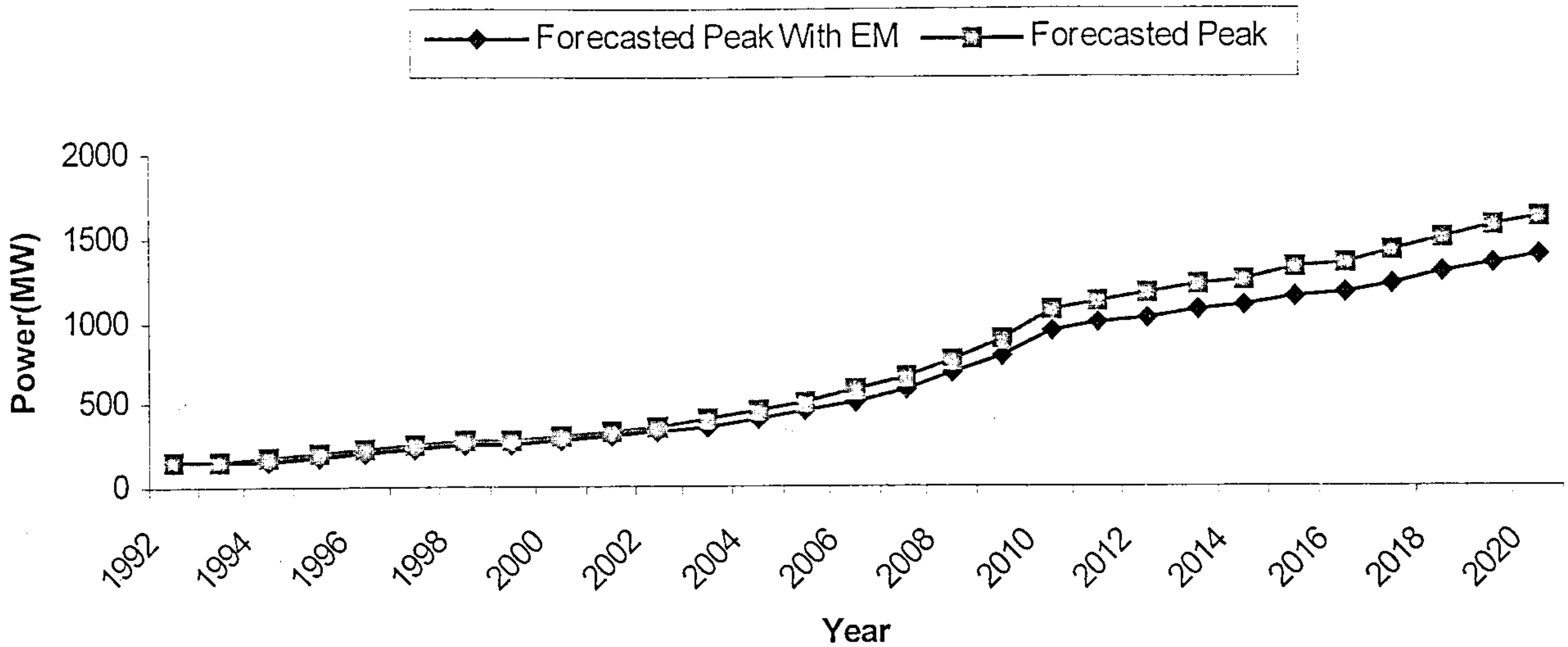

Figure 5: Estimated Saving of Peak Power Demand in W.B with applying energy management – Scenario3

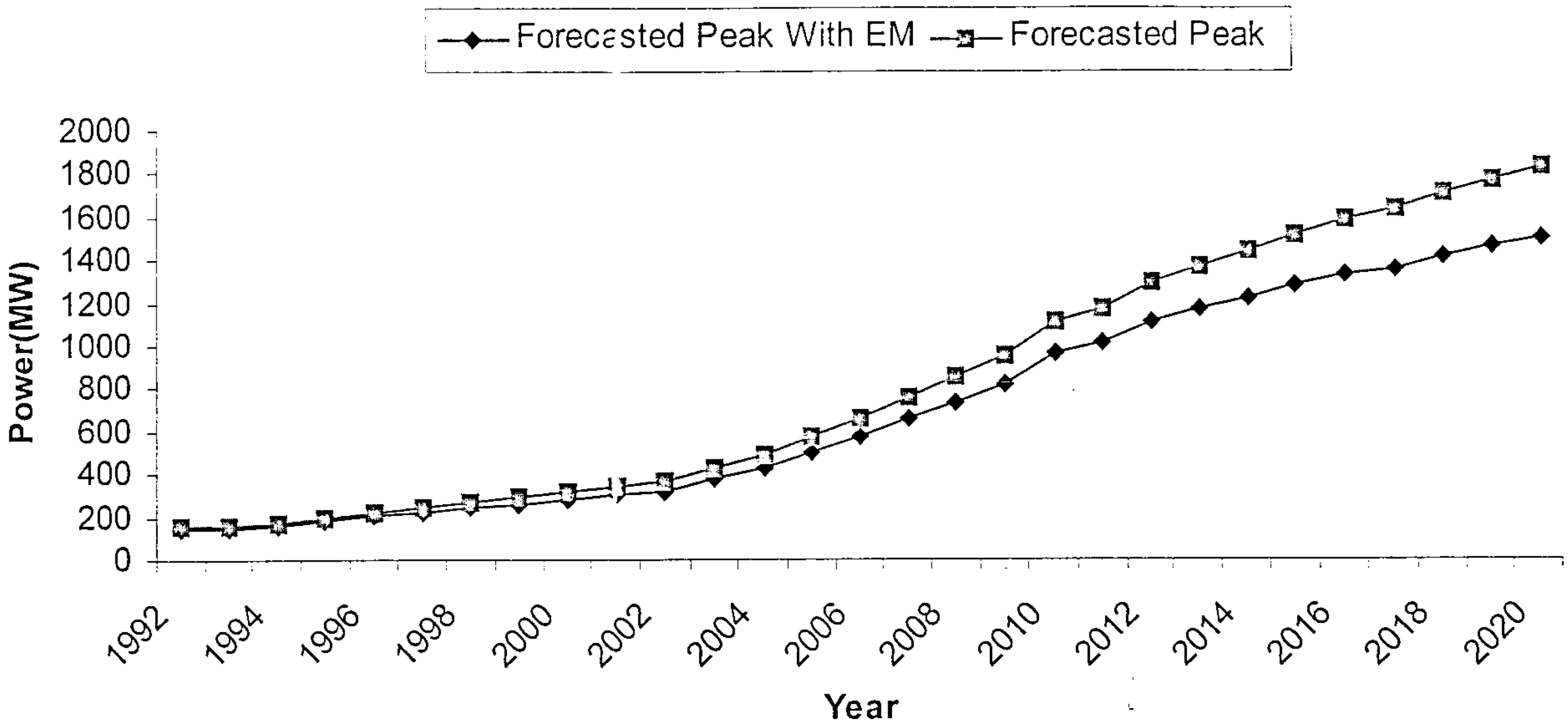

Figure 6: Estimated Saving of Peak Power Demand in W.B with applying energy management – Scenario4

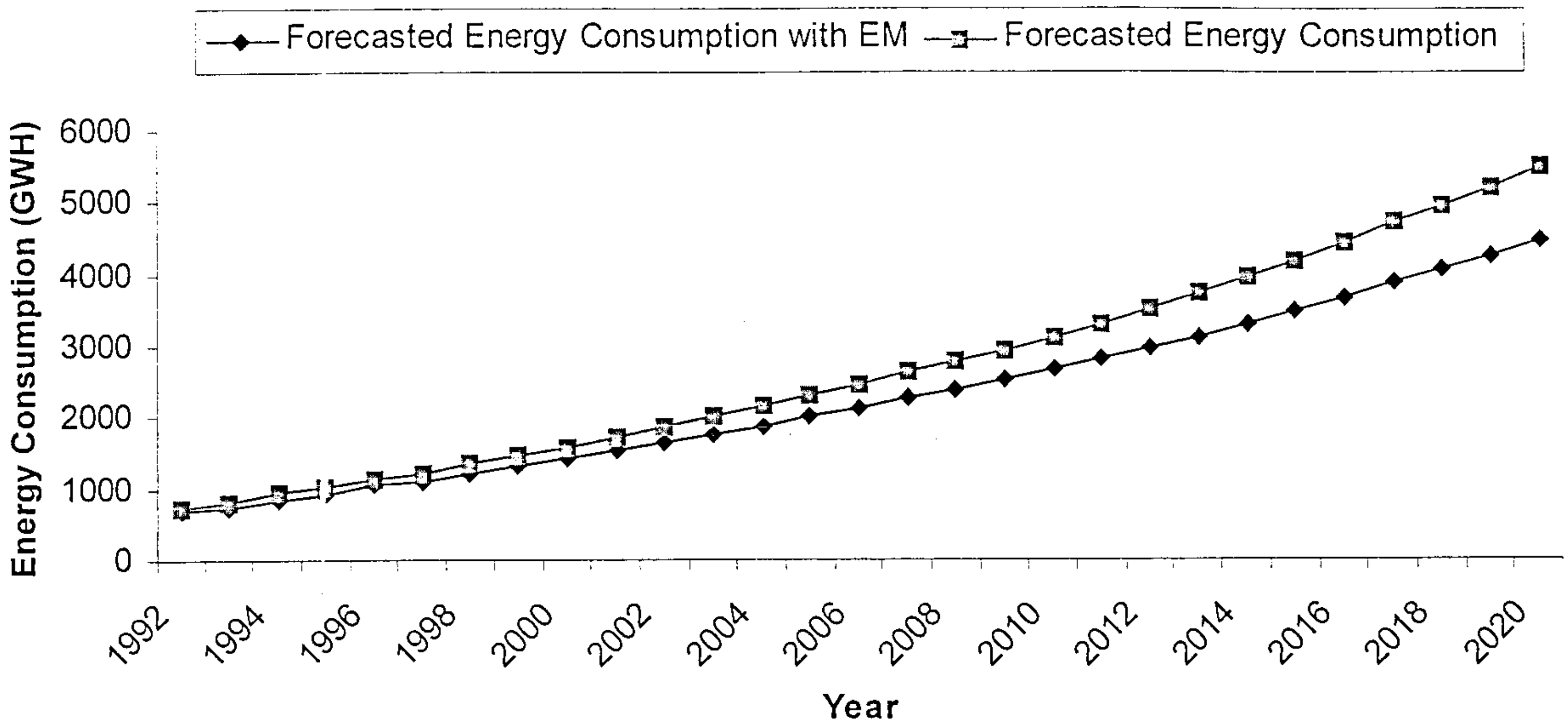

Figure 7: Estimated Saving of Energy Consumption in W.B with applying energy management – Scenario1

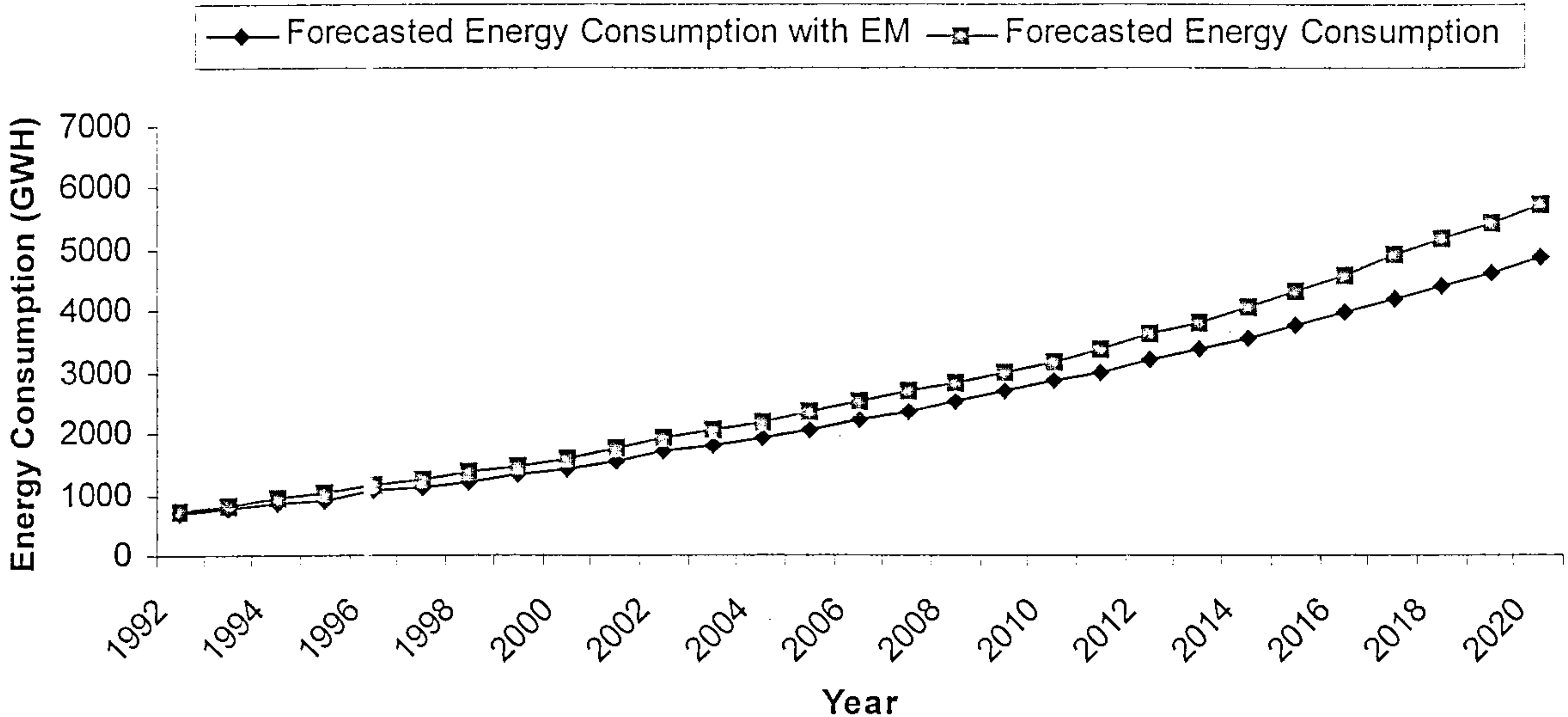

Figure 8: Estimated Saving of Energy Consumption in W.B with applying energy management – Scenario2

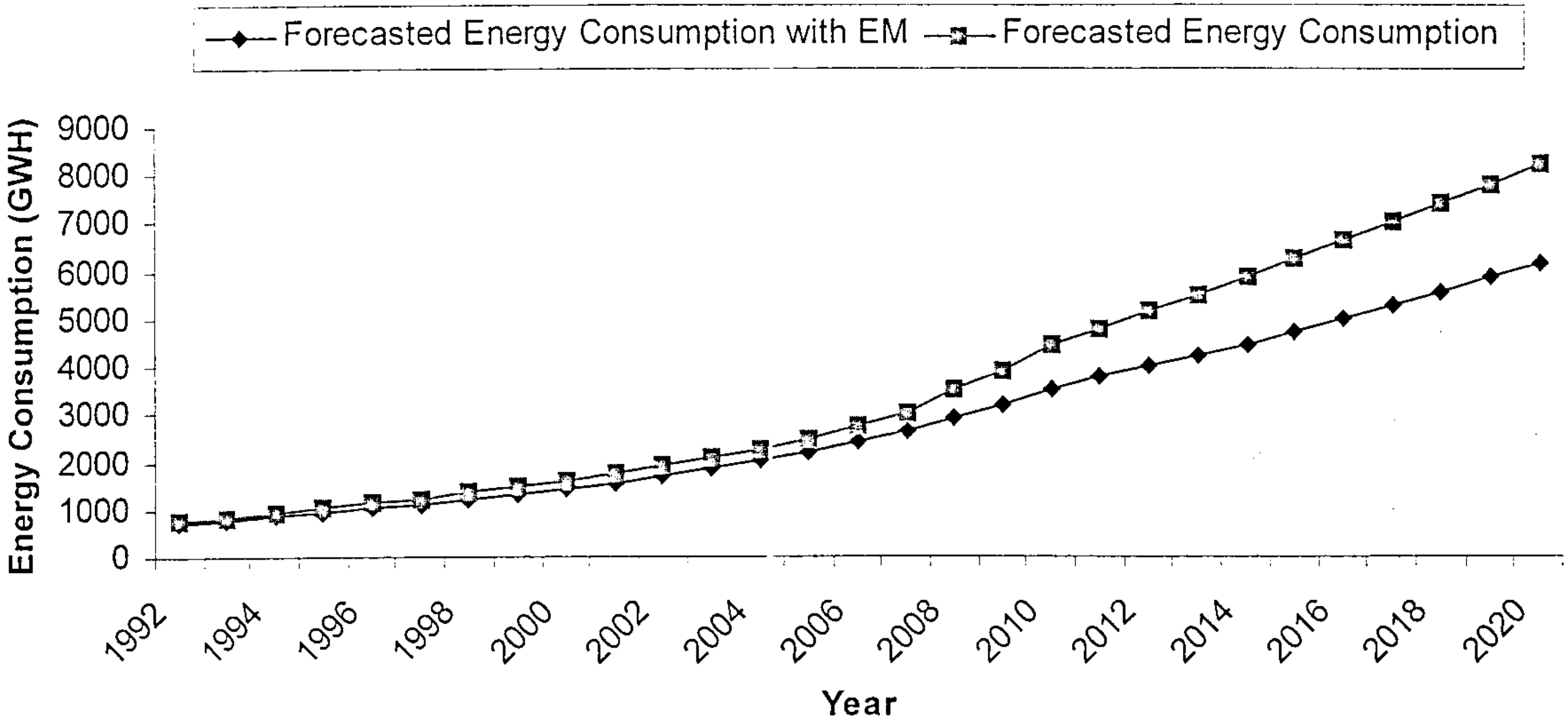

Figure 9: Estimated Saving of Energy Consumption in W.B with applying energy management – Scenario3

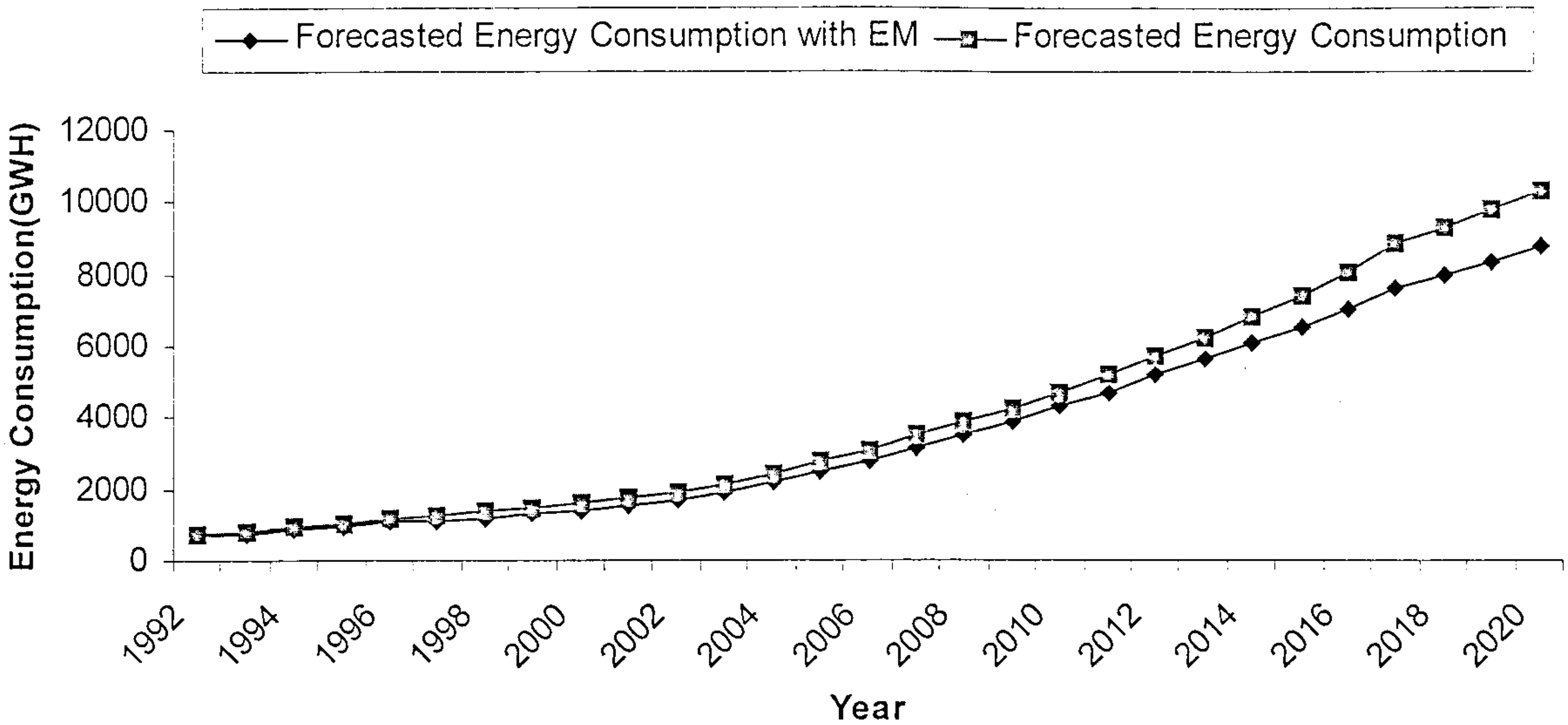

Figure 10: Estimated Saving of Energy Consumption in W.B with applying energy management – Scenario4

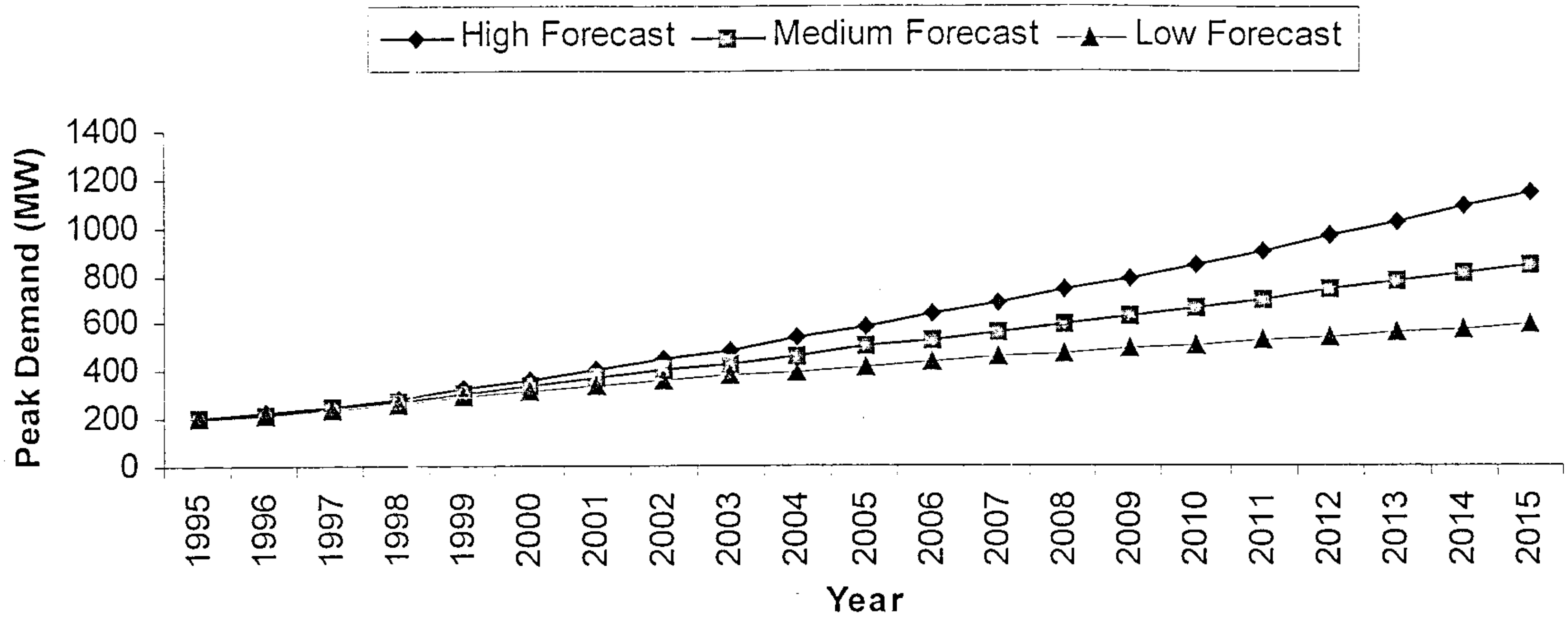

Figure 11: Peak Demand Forecast (Low, Medium, and High) in the W.B from 1995 to 2015

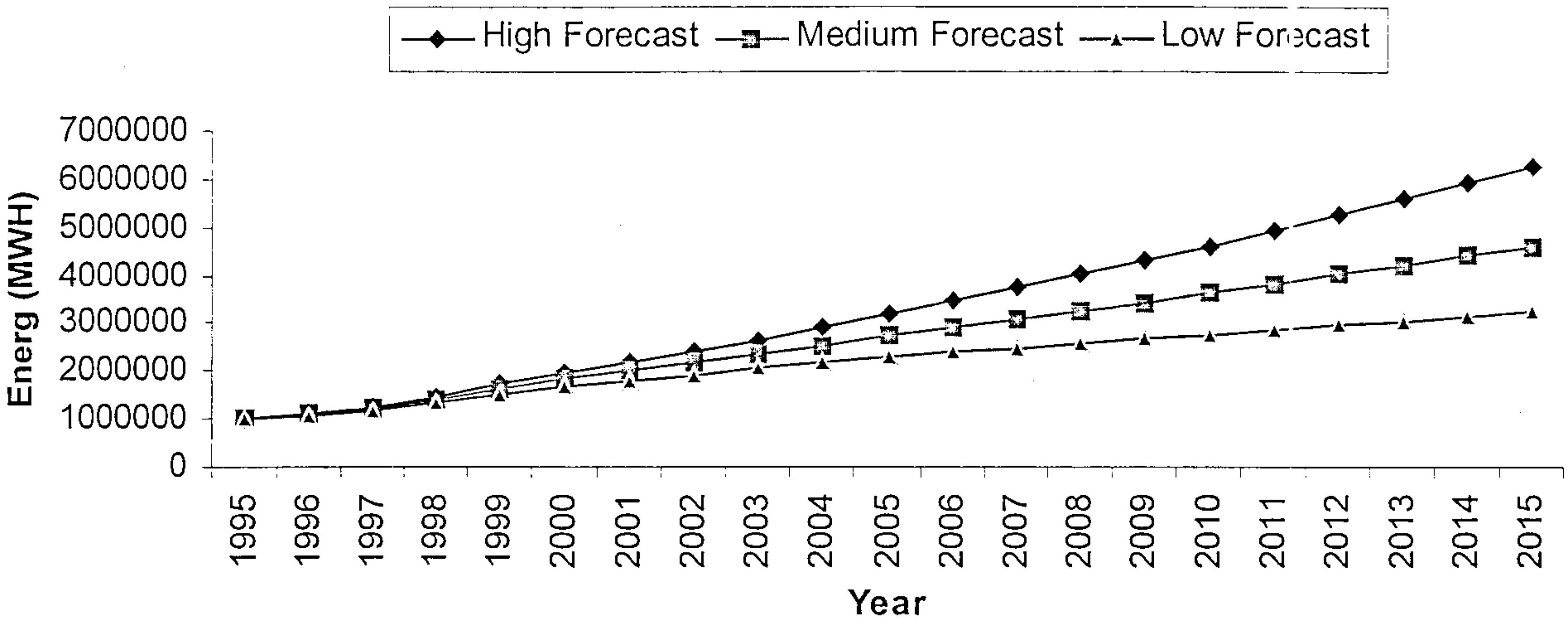

Figure 12: Energy Consumption Forecast (Low, Medium, and High) in the W.B from 1995 to 2015

Abstract in Arabic

عنوان الأطروحة:

أثر ترشيد وادارة الطاقة على تخطيط الطاقة الكهربائية في الضفة الغربية

أعداد الطالب: عبد السلام إبراهيم محمد

أشراف: الدكتور معتصم بعباع

الملخص

إن استهلاك الطاقة الكهربائية في الضفة الغربية نسبيا قليل، نسبة كبيرة من هذه الطاقة تضيع كخسائر فنية وغير فنية وهذه الخسائر تتجاوز في كثير من المناطق الفلسطينية ٢٥% من الطاقة الكلية. بالإضافة إلى ذلك فأن استهلاك الطاقة الكهربائية في قطاع الصناعة والقطاع المنزلي يتم بطريقة غير فعالة حيث أن كفاءة كثير من الأجهزة والمعدات متدنية.

قام الباحث في هذه الدراسة بدراسة قطاع الطاقة في الضفة الغربية وكافة العناصر المؤثرة على استهلاك الطاقة الكهربائية في كافة القطاعات (المنزلي والصناعي والتجاري) حيث تبين ان نسبة كبيرة من الاستهلاك تذهب في استهلاك الثلاجات والمكيفات والمحركات والإنارة في كافة القطاعات. تم خلال هذه الدراسة تطبيق طرق ترشيد وادارة الطاقة الكهربائية على كافة تلك القطاعات لمعرفة تأثيرها على استهلاك الطاقة في الأعوام السابقة من عام ١٩٩٣ الى عام ١٩٩٩، وذلك من اجل توقع استهلاك الطاقة للسنوات العشرين القادمة أخذين بعين الاعتبار الآثار الناتجة عن تطبيق وسائل ترشيد الطاقة على كافة القطاعات في الضفة الغربية.

عملية توقع استهلاك الطاقة في الاراضي الفلسطينية عملية معقدة وليست بالسهلة لعدة متغيرات أهمها الاقتصادية والسكانية والسياسية، وقد اعتمد الباحث في هذه الدراسة على أربع سيناريوهات، وتعتمد هذه السيناريوهات على المتغيرات السكانية والاقتصادية وذلك من اجل توقع استهلاك الطاقة للسنوات العشرين القادمة.

بعد مقارنة النتائج المتوقعة لاستهلاك الطاقة الكهربائية بدون ترشيد وادارة الطاقة مع النتائج التي تم التوصل اليها من خلال تطبيق ترشيد وادارة الطاقة الكهربائية تبين ان هناك توفير واضح في استهلاك الطاقة الكهربائية يتراوح بين ٨% ويصل الى اكثر من ١٨% حتى العام ٢٠٢٠.

من أسعار الكهرباء في الضفة الغربية وحيث أن الشركة القطرية الإسرائيلية تزود الأراضي الفلسطينية بالطاقة بأسعار المستهلك السياحي تبين أن هناك جدوى اقتصادية واضحة عند تطبيق مشاريع ترشيد الطاقة على النظام الكهربائي في الضفة الغربية. بالإضافة إلى الفوائد الاقتصادية فأن هناك فوائد لا تقل أهمية تنجم عن تنفيذ مثل تلك المشاريع وهي الفوائد البيئية وما يترتب على عملية تخفيض الاستهلاك من تقليل نسبة التلوث البيئي الناجم عن توليد الطاقة واستهلاكها.