The Islamic University Journal (Series of Natural Studies and Engineering)
Vol.18, No.1, pp 77-98 , **2010**, ISSN 1726-6807, http://www.iugaza.edu.ps/ara/research/

Analysis and Prediction of Household Energy Consumption in West Bank and Gaza Strip

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Abstract: Energy sector is considered to be one of the most important components of a country's infrastructure and a key indicator of the standard of living. Energy consumption reflects upon population growth, living standard, and the level of development in all aspects of life. It is of utmost importance to study the current situation of energy consumption for developing energy plans and policies and to provide the decision makers with adequate tools for optimal management of the electrical sectors.
This paper presents the current energy situation in GS and WB. Scenarios for future consumption are developed. The Long-range Energy Alternatives Planning model (LEAP) is the simulation model used for the analysis of the data. The approach for exploring the energy sector in WB and GS consists of a historical retrospective study with a limited-time data series.

Keywords: Energy Consumption, Palestinian Territories, Modeling, LEAP.

تحليل وتوقعات استهلاك الطاقة في القطاع المنزلي في الضفة الغربية وقطاع غزة

ملخص: يعتبر قطاع الطاقة من أهم مكونات البنية التحتية للبلاد و مؤشر مهم لمستوي المعيشة. استهلاك الطاقة يعكس تأثير النمو السكاني والمستوى المعيشي وارتفاع مستوى التنمية في مجالات الحياة المختلفة. دراسة الاتجاه العام الحالي لمؤثرات و طرق استهلاك الطاقة في قطاع غـزة و الضفة الغربية ضروري جدا لتحديد خطط و سياسات الطاقة المستقبلية و لتعطي أصحاب القرار الأدوات الفعالة للإدارة المثلي لقطاع الطاقة.

ورقة العمل هذه تقدم دراسة عن استهلاك الطاقة في قطاع غزة و الضفة الغربية و تقدم تصور عن الاستهلاك المستقبلي. البرنامج المستخدم لتحليل البيانات ودراستها هـو The Long-range Energy Alternatives Planning model (LEAP). سير قطاع الطاقة في قطـاع غـزة و الضفة الغربية اعتمد علي طريقة الاسترجاع التاريخي و المعلومات الزمنية المحدودة.

1. Introduction

Energy sector in the Palestinian Territories suffers from chronic problems as a result of discriminatory policies, negligence and unstable political situation. PT has a very little production of energy. There is some production of biomass,

solar heat and private generation of electricity; however most of the energy consumed is imported from other countries. All petroleum products are imported through Israeli petroleum companies. Until the year 2002; all of electricity consumed is imported from Israel through the IEC. However, the first, private sector, Palestinian electricity generation station started in trial operation in mid 2002, [1]. It was planed to provide all of electricity demand in GS. A very small portion of electric energy requirements in GS (17 MW) is imported from Egypt. The Jericho gets 20MW power supply from National Jordanian Electricity Company since February 2008.

The shortfalls in energy supply worldwide have led to increased interest in studying and controlling energy consumption on the customer's side. In order to predict and compare the effects of alternative demand side management strategies, it is first necessary to understand how, why and when customers use energy. In 1996, Palestinian Central Bureau of Statistics, (PCBS), established an energy statistics program in order to provide data about energy in the PT. Taking into consideration the international recommendations of the United Nations in the field of energy and the special situation of the PT, energy indicators were formulated through a user-producer dialogue workshop held in March 1998. Energy statistics program implemented ten rounds of household energy survey during 1999-2007, [2]. Household energy consumption data provide information on the use of energy in residential housing units, including consumption of electricity, fuel oil, liquefied petroleum gas (LPG), kerosene and wood.

Energy planning models are used to perform demand and supply analysis, develop forecasts, identify gaps in the demand and supply, identify options for intervention, and perform impact assessment. Several models have been developed and used in recent years for planning, mostly at national level. They vary from econometric models using linear programming to techno-economic models that analyze energy consumption of each sector at detailed level, [3]. Of these models, the Long-range Energy Alternatives Planning model (LEAP) is probably the one best known and used in developing countries, [4]. LEAP is a simulation model used to represent the current energy situation for a given area and to develop forecasts for the future under certain assumptions. First, an overview of the current situation should be created. Then interventions can be evaluated by using scenarios developed by asking ‘what if?’ questions, e.g. what if the population growth slows down?

Analysis and Prediction of Household Energy Consumption

Data used for the analysis which is carried out in this paper is obtained from:
1. Household Energy Survey (HES) performed by PCBS;
2. A local Residential Energy Consumption Survey (RECS) of GS housing units,
3. Electric Distribution Companies,
4. Palestinian Ministry of Energy; and
5. Palestinian Fuel Board.

HES are periodically conducted to collect household data from a large nation-wide probability sample of households by the interview method. The survey covers the entire area of the WB and GS. While the PCBS provide detailed data about the energy sector since 1994, there was a problem of updating; sometimes there is an absence of specialized data, [5]. For example, there is no data about electricity consumption according to energy use (heating, refrigeration etc). There is also no data about the size and type of electrical devices in use in the PT.

The local residential energy consumption survey is designed to address the limitation of the HES. 500 households distributed according to the locality in urban areas, in rural areas and in refugee camps were surveyed in GS. Detailed questionnaires were filled in personal interviews with households for information about energy used, how it is used, energy-using appliances, structural features, energy efficiency measures, and demographic characteristics of the household. Physical data were recorded in a number of different physical units, e.g. KWh for electricity, Kg for wood and Kg for LPG. The survey data, including aspects of energy usage behavior and expenditures, income of the household, and energy-related characteristics of households, was taken for testing and analysis.

The aim of this study is to explore the current situation of the energy sector as an important part of the PT infrastructure and, more specifically, the electricity sector. This will permit the construction of contrasting scenarios for energy consumption for the coming years and will provide data for the planning of energy policies.

The paper is organized as follows. Next section presents the general feature of the modeling system. General information about the population and economy is given in section 3. Section 4 concerns with the socio-economic aspects of energy. The importance of energy in daily life for heating and water heating, cooking, baking and space conditioning is discussed. This section shows the different sources of energy used to satisfy energy needs. It shows the role of

seasonal variations and the political instability on energy consumption. This part also gives an idea about the relationship between energy consumption and economic growth using the available data for the previous ten years. Section 5 presents scenarios for electricity demands, where the LEAP demand model for WB and GS is developed passed on the base year 2006. Also, business as usual scenario and a moderate are presented and discussed. Finally, conclusion and references are given.

2. Methodology: Leap Modeling System

LEAP is a deterministic simulation model used to represent the current energy situation for a given area and to develop forecasts for the future under certain assumptions. Based on the assumptions provided by the user, LEAP balances the energy flow equations, thereby identifying the energy transformation and primary energy supply requirements. The requirements are back-calculated from a set of final energy demands, which form the "fixed" side of the first set of the equations of the accounting process. The entire energy system can be included in the model and the level of detail is really decided by the user. The analysis is scenario based, meaning that assumptions for a set of potential futures are compiled. Results are calculated by LEAP and then compared. An insight into how different decisions or events may affect the future can be gained. It is possible to identify gaps and weaknesses in the dataset which could subsequently be attended to through model runs in LEAP, [6]. Scenarios are developed by asking 'what if?' questions, e.g. what if the population growth slows down, what if improved cooking stoves are introduced? None of the scenarios were intended to serve as recommendations, but rather they represented two different views of the future based on expert views and opinions. The scenarios provided valuable insights amongst stakeholders and clearly illustrated the costs implications of their different views and assumptions about the future,

3. General Information

The first step in developing energy scenarios for different interventions is to quantify the current energy usage pattern and supply situation in the PT. Demographic and economic assumptions play a fundamental role in driving patterns of energy resource consumption. The most detailed data available in the PT are those taken in the 1999 and 2007 census.

Analysis and Prediction of Household Energy Consumption

3.1 Population

The Palestinian society is composed mainly of families with an average household size of 6.5 persons in GS and 5.5 persons in WB according to 2007 statistics. While the population in the WB is identically distributed between rural and urban areas, 64% of the population in the GS lives in urban areas while 31% lives in camps. GS is placed among the areas with the highest population density in the world (3,882 persons / Km2) however; the density in the WB is moderately high (426 persons/ km2).

The high rate of population growth compared to international standards is a key feature of the population dynamics of the PT. The annual population growth during the period from 1997 to 2007 is 3.8% (WB 3.5%, and GS 4.2%), but growth declined in recent years (from 4.2% in 1999/1998 to 3.4% in 2005/2004). PCBS projected population increases from 1.1 to 2.9 million people in GS and from 2 to 4.93 million people in WB during the period from 1999 to 2023. The expected average increase is approximately 4% in Gaza Strip and 3.3% in WB [7].

3.2 Economy

Palestine possesses limited natural resources such as minerals and some marine products in addition to the natural gas on the shore of GS that was discovered in December 2000, [8]. The gas reserves are estimated to be around 1.4 TcF, [9], while the needs for gas by the Gaza power station, and industrial, transport and household sectors was stimated at nearly 14.8 (Bcf) per year [10].

The Palestinian economy is to a large extent dependent upon wages and labor work in Israel in addition to remittances from abroad. The World Bank estimated that GDP in 2006 was 9% lower than that in 1995 as given in table 1.

Table 1:- Key Indicators of the Palestinian Economy [11].

	1995	**1999**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
GDP (US$ million)	4,511	4,261	3,816	3,556	3,995	4,248	4,443	4,150
GDP per capita (US$)	1,380	1,478	1,229	1,146	1,221	1,264	1,258	1,134
Real GDP growth (%)	6.1	8.6 -	6.6 -	3.8	8.5	6.3	4.9 -	6.6
Domestic expenditure (% of GDP)	151.8	163.0	143.3	145.8	150.2	150.7	154.5	173
Inflation (CPI - annual %)	10.8	5. 5	1.2	5.7	4.4	3.0	3.6	3.6

3.3 Energy Supply

The supply of fuel to the Palestinians is anchored in agreements between the PA and Israel (Paris Agreement). Imports of petroleum products to WB and GS have been highly correlated with GDP. Import of petroleum products declined by 40% to 50% during first three years of the Intifada (2000-2002) and then increased from 2003 onwards, figure 1. The surge in imports of diesel was partly due to the entry into service of the Gaza power plant in November 2002, but much of the increase from 2003 onwards is allegedly due to diesel being imported into the WB (officially) then being smuggled back to Israel.

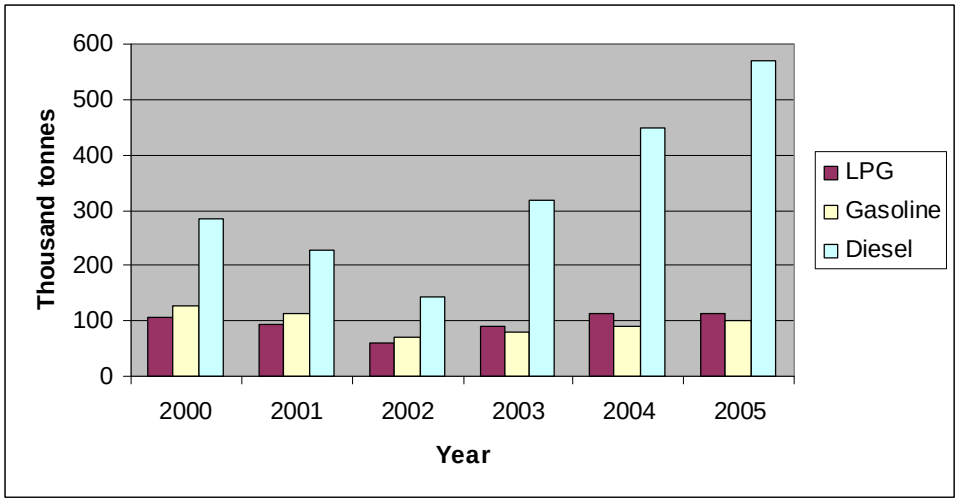

Figure 1:- Import of petroleum products l in WB and GS

WB depends almost entirely on Israeli Electricity Company (IEC) for electricity supply. It is mainly supplied by three 161/33 KV substations located close to the southern center and north part of WB. WB consumption of electricity, as measured by purchases of bulk power from IEC, increased at an average annual rate of 6.4% between 1999 and 2005, figure 2. The pronounced dip in this growth that occurred in 2001 and 2002 is evident due to the eruption of the Intifada, amounting to almost 9% of purchases in 2002. The maximum capacity of electricity supply to the WB is about 550MVA, 30% directly by IEC which supplies electricity in bulk to 215 towns and villages, and 70% indirectly by IEC through Jerusalem electricity distribution company (JEDCO) which supplies electricity to East Jerusalem and in bulk to 165 towns and villages in the WB.

The Palestinian power grid is connected to that of Jordan at Jericho through a 33kV line via King Abdullah Bridge. JEDCO receives 20MW power supply from National Jordanian Electricity Company since February 2008 [12]. Jericho area is disconnected from the Israeli power grid, and JEDCO manages a separate electricity supply system for the customers connected to the electricity supply from Jordan.

GS receives electricity from IEC and from a diesel based power plant which is located inside GS (GPP). GPP is the only major power generating facility in PT with a generating capacity of 140MW. GS also receives a small power supply from Egypt (17MW). Gaza electricity distribution company (GEDCO) distributes electricity within GS. GS's total supply of power (purchased from IEC and GPP) increased by 80% between 1999 and 2005 at about 10% average annual rate, figure 2. Most of this growth took place from 2003 onwards, and it coincided with the advent of power from GPP. This indicates that substantial non served demand for electricity existed in GS, which would explain why power consumption increased so rapidly whilst Gaza's gross domestic production (GDP) grew more slowly at 3.7% per year.

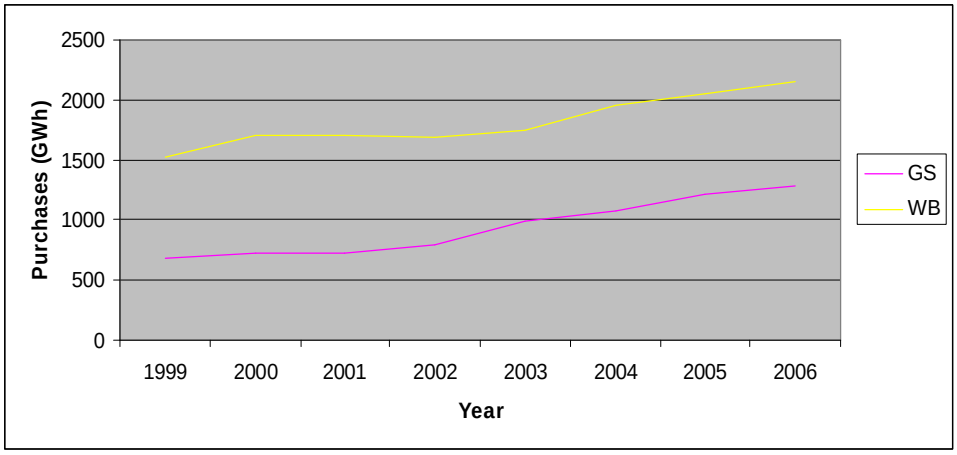

Figure 2:- The electricity purchased in GS and west Bank

Other main sources of energy are LPG for heating and cooking, solar energy for water heating and oil lubricant (Kerosene and Gasoline). The breakdown of final consumption of energy in 2003 by source of energy is shown in table 2.

Table 2:- Breakdown of final consumption in 2003 by source of energy.

LPG	Electricity	Fuel wood	Gasoline	Diesel
23.0%	22.5%	13.7%	16.9%	11.2%
Solar energy	Kerosene	Olive cake	Oil & Lub.	
9.9%	1.8%	0.8%	0.2%	

The household sector contributes the most significantly to the increase in energy consumption due to the expansion of the housing sector. The household sector accounts for 15 to 25% of primary energy use in developed countries and a higher share in developing countries, [3]. The household sector constitutes more than 65% of the total final consumption of electricity in PT, table 3.

Table 3:-Sectoral Composition of Final Energy Consumption

Year	2001	2002	2003
Industry and Construction	8%	7%	6%
Transport	20%	19%	19%
Household and other sectors	72%	74%	75%

The total annual electricity consumption in GS in the period from 1994 to 2005 grows from 446 GWh in 1994 to 1222 GWh in 2005 with an average annual increase of 9.9%, [13]. The total annual electricity consumption in WB in the same period grows from 973 GWh in 1994 to 2190 GWh in 2005 with an average annual increase of 7.5%. This increase is due to the increase in electrical network connections and the increase in penetration of electrical appliances and it is analogous to that of the developed countries prior to 1973. Since 1973, in industrialized countries energy intensities per capita have remained almost constant, or in some cases have declined, in spite of increasing household floor space and increasing penetration of electric appliances. In the United States, for example, final energy use per capita in households declined by 11% between 1972 and 1990, [15] and almost stayed constant since 1995, [16]. Part of the decline reflects the increased use of electricity which is intrinsically more efficient than combusted fossil fuels. Numerous initiatives of governments, utilities, trade associations and other institutions led to new regulations mandating efficiency standards and new products such as compact fluorescent lights, more efficient refrigerators and other appliances, passive solar heating, wider adoptions of double-glazed windows and spectrally selective window glazing.

4. Socio-Economic Aspects of Energy

4.1 Energy in Daily Life

About 99.6% of the households in PT are connected to network by 2006 and the average household consumes 222 KWh of electricity monthly. The average household consumes 17 Kg of LPG, 4 liter of Kerosene in July 2006 and about 66.9% of households are utilizing solar energy by using solar energy heaters. The percentage of households using LPG was approximately equal to the use of electricity, table 4, which indicates the importance of these two sources for the residential sector. Kerosene is used mainly as a heating fuel. It is also used as a dissolvent and thinner. The percentage of households that used this source of energy was 32.2% in January 1999 while it declined to only 12.2% in July 2006.

Water heating needs are normally satisfied either by LPG fuel with a utilization rate which fluctuated between 51% in January 1999 to 16.3% in July 2006. Electricity is considered a complementary source, especially in winter (27% in Jan 2004). In summer, people use solar energy as it is considered the cheapest. It is noted that this percentage differs within the Palestinian regions in July 2006; it was about 79.7% in the GS and 63.8% in the WB. About 10.1% of the households depend on electricity as a main source and 3.9% depend on wood, and 0.2% on kerosene.

Table 4:-Main indicators of household energy use in the Palestinian Territories (PT): 1999, 2004, 2006.

Indicator		1999		2004		2006	
		July	**Jan.**	**July**	**Jan.**	**April**	**July**
Percentage of households	connected to electricity network	97.2	96.8	99.5	99.4	99.3	99.5
	using solar heating	68	63.8	71.2	68.7	66.9	69.2
	using space heating facilities	-	75.2	80.7	86.4		78.7
	using a gas burner for cooking	99.1	98	99.7	99.7	98.9	98.8
	using gasoline		18				
	using kerosene		32.2				12.2
	using LPG		98.5				99.3
	using wood		32.8			29.2	26.4

Average hh consumption of	electricity (kWh)	380	265	264	265	221	227
	gasoline (liter)		21.7		10.7		
	LPG (kg)	21	32	20	32.1	18	17
	Kerosene (liter)	1	11.9	3	23.2	4	4
	Wood (kg)		86.5		207		105

The main results of the household energy survey indicate that 4.2% of households in the PT have used electrical conditioner for the purpose of conditioning, 44.9% of the households used fixed fan, 80.2% of the households used mobile fan in July 2006. 25.0% of households in the PT didn't condition their houses in July 2006, this percent reached to 36.0% in the South of the WB, and 13.9% in GS. And 78.7% of households in the PT depend on electricity as a main fuel for household conditioning, this percent reached to 86.1% of households in GS, and 63.9% in the South of the WB.

Furthermore; 86% of households use a space heating facility in 2004. Winter statistics indicate that for the households using a space heating appliance, 35% used a gas heater, 30% a wood heater, 21% a kerosene heater and 21% an electrical heater (January,1999).The statistics for January 2004 show a high fluctuation from those for 1999. There was a high increase (from 20% in 1999 to 36% in 2004) in the percentage of the households that use electrical heaters. A significant increase can also be seen for gas and wood heaters (41%, 39% respectively), while the percentage of households using kerosene heaters declined to 3% (nearly 6 times lower than before). In general, the percentage of households with central heating was very limited (between 2-4%).

The comparison between periods before and after the Intifada shows some change in energy consumption behavior. This change can be characterized by a higher consumption of wood. Following the closure policy employed by Israel, people searched to replace one energy type with a less expensive and more accessible type, such as wood. Other energy types, such as gasoline, are also influenced by the political situation because they are used for motorized movement which is strictly limited during the closure period.

The typical fuel used for cooking is LPG where in July 2006 the percentage of households using a gas burner was estimated at 98.8%. And 10.9% of the households used wood burner, and 10.0% of the households used electrical ovens, while 0.6% of the households used kerosene burner. Data for July 2006 indicated three main fuel sources for baking needs; electricity, with utilization

of 22.7%, and wood with 20.1% and LPG with 18.4%. Another source which occupies a less important position is olive cake with 0.3% in July 2006. Olive cake is considered a traditional and self-sufficient fuel source. 32.3% of households did not back at all.

4.2. Electricity and Economic Growth

Certain experts think that growth demand of electricity is tuned to economic development; however, the relation between electricity and economic growth is not clear, [17], whereas there is technological interdependence and enhancement between economy sectors. Changes will occur slowly for sectors and areas related to the long-established structures such as transport and energy infrastructures [18]. In a stable market with no more than minor distortions to factors that influence supply and demand for electricity, the observed consumption of electricity can often be used as a proxy measure of efficient demand [19]. This situation does not apply, however, to the power markets of WB and GS for the following factors, [20].

- Substantial amounts of consumption of electricity in WB and GS are not paid for, therefore; do not necessarily reflect demand at the prevailing price for electricity.
- Some of the demand for electricity from the public supply system has not been met because of insufficient supply capacity caused by prolonged underinvestment in the power system as well as heavy damage to supply facilities.
- The power market has experienced unstable economic conditions since 1999 because of disruption to economic life during the Intifada, especially in the period from late 1999 to 2002, and also from early 2006 to the present.

Data analyses before 2000 show that economic growth and electricity consumption increase with time, during the current crisis; however, there is no relation between the two variables; total electricity consumption conserved nearly the same trend, while GDP suffers from a deep decline in 2001. Economic growth, GDP and electricity consumption for the period from1995-2006 show an inelastic demand for electricity, regardless of the level of GDP with the exception of 2001 and 2002 due to the eruption of the Intifada. This result shows the complex relation between GDP and electricity, especially in a situation of conflict. The inelastic demand for electricity is due to the reasons that electricity is not necessarily used for production, as can be explained by the high portion of consumption by the residential sector.

MEDA program, [21], published report indicates that the lack of investment and public expenditure in the electricity sector, high prices and high transmission losses are the fundamental problems for this sector. Moreover, the electricity debt is considered a heavy burden because of the incapacity of consumers to pay the electricity bill, especially during difficult political conditions. Furthermore, according to the report the low rate of energy consumption in the WB is due to the insufficient capacities of power sources, high prices of electrical energy and the inadequate and poor quality of the electrical services.

5. Scenarios for Electricity Demands.

An understanding of the underlying demand for electricity that can be justifiably met in economic terms is important for economic and market analysis. This issue is examined through an analysis of past consumption data to estimate the current effective demand for electricity in WB and GS. Based on the input, a business as usual scenario was developed to act as a general forecast and a reference along with an alternative scenario that represented more progressive policies and greater efficiency improvements. The LEAP model is simulated under different assumptions, to examine the impact of some options. Throughout this research, a single scenario for economic demands has been used.

5.1 The Demand's Modules

LEAP follows an end-use, demand-driven approach, which means that the analysis starts from the end-use of energy. The demand program divides the society in a hierarchical tree structure of four levels: sectors, sub-sectors, end-uses and devices. The household sector is the only sector studied in this paper. An example of one branch of this structure could be households (sector), cooking (end-use) and LPG stove (device). For each device, a fuel type (e.g. electricity, wood, LPG, electricity and Kerosene and the average consumption is specified. Scenarios can be developed by changing the future demand parameters with three different methods: specifying explicit values for certain years, specifying annual growth rates or using drivers (e.g. GDP) and elasticities. The tree structure implemented in this module is shown in table 5. The 100% for cooking means that all households use energy for cooking, 99.9% of them use primary energy for cooking and 17.2% use secondary energy. The percentage distribution of households refer to the share of a

particular energy used for an end-use, e.g. 87.6% of the cooking is done by using LPG stoves with yearly average LPG consumption of 140Kg in GS.

Table 5:- Energy use patterns in WB and GS Households

Households in GS (230000 households) and in WB (391000 households)									
(Elec. & Solar in KWh , LPG & Wood in Kg, Kerosene in Litter)			**Percentage Distribution of hh**					**Annul hh Consumption**	
			GS	**NWB**	**MWB**	**SWB**	**WB**	**GS**	**WB**
Lighting	Primary		99.9	100	100	100	100		
		Electricity	99.8	99.5	99.6	99.6	99.6	584.5	668.8
	Secondary		91	7.9	0.1	0.4	3.2		
		LPG	7.2	0.1	0.1	0	0.1	10	11.2
		Kerosene	27.5	6	0	0.1	2.4	8	20.4
Heating	Primary		100	92.6	91.1	86.6	90.4		
		Electricity	24.1	6.8	18.4	10.2	11.6	1300	1760
		LPG	3.2	38.3	50.1	39.1	42.4	50	55.5
		Kerosene	1.8	11	8.6	5.6	8.7	120	207.9
		Wood	42	36.5	14	31.7	27.7	150	224.6
Cooking	Primary		99.9	100	100	100	100		
		LPG	87.6	98.3	99	91.7	96.7	140	1601
		Wood	11.2	1.2	0	7.3	2.5	450	518
	Secondary		17.2	13.3	4.7	19.9	12.3		
		Electricity	5.1	7.4	3.7	3.3	5	180	189
		LPG	11.4	1.4	0	5.4	2.1	50	54
		Wood	10.7	4.5	1	11.2	5.2	100	159
Water Heating	Primary		99.4	99.6	94.4	99.7	97.9		
		Electricity	11.2	21.4	17.4	8.1	16.4	250	297
		Solar	75	46	53.3	43.2	47.6	2843	2843
		LPG	11.6	22.7	22.4	37.6	26.8	20	25.8
	Secondary		32.6	33.6	34	35.7	34.3		
		Electricity	14.9	9.6	25.4	9.8	14.9	150	188
		LPG	2.8	5.6	4.1	11.6	6.8	10	13.4
		Solar	7.7	15.8	3.9	12	10.8	2000	2000

Backing	Primary		85.2	48.4	55.7	53.7	52.3		
		Electricity	31.4	9.1	11.5	11.5	10.6	350	404
		LPG	27.5	13	20.3	20.3	17.5	80	88
		Wood	26.3	22.9	14.4	14.4	17.7	220	299
	Secondary		50.7	5.6	5.6	5.6	5.6		
		Electricity	22.8	1.4	1.4	1.4	1.4	60	92.5
		LPG	6.6	1.3	1.3	1.3	1.3	24	27.2
Cond.	Primary		100	73.4	84.1	72	76.5		
		Electricity	87.5	73.4	84.1	72	76.5	700	883

It can be seen that the sum of percentages used for cooking by households is higher than 100 per cent, which means that some of these households use more than one device for cooking.

5.2 Reference Scenario:-

This is the business-as-usual scenario where the underlying assumptions are:

1. the Palestinian GDP grows at a moderate rate of 2% until 2030;

2. an annual inflation rate of about 2%;

3. all other variables are assumed to grow at their average historical growth rates.

Of course, each demand segment has its own specific growth pattern in the scenario. This is base scenario where there is no or little official intervention in the consumption pattern or dramatic change in the consumer behaviors.

Under this scenario, energy consumption is predicted to increase significantly to about 73,683 Terajoules (TJ) in 2030 from 20,943 TJ in 2006 in the PT, due mainly to the increase in population and living standard, table 6.

LPG consumption is increasing to about 20,232 TJ in 2030 from 6,144 TJ in 2006 which corresponds to annual increase of 4.9%. Kerosene is viewed as an inferior commodity and its consumption is expected to decline to a very small amount by the end of the forecast period.

The share of oil products in the residential sector is expected to decrease slowly from about 31% in 2006 to about 27% in year 2030. In the same time, the usage of solar energy is expected to decline due to the increase of percentage of apartment buildings.

Table 6:-Reference Scenario, Total Energy demand in Thousand TJ

Years	2010		2015		2025		2030	
	GS	WB	GS	WB	GS	WB	GS	WB
Wood	0.51	0.98	0.44	0.82	0.25	0.45	0.15	0.28
Solar	2.31	3.10	2.72	4.06	3.78	6.78	4.46	8.66
LPG	2.19	5.31	2.87	6.74	4.89	10.90	6.36	13.87
Kerosene	0.03	0.21	0.02	0.13	0.01	0.04	0.00	0.01
Electricity	2.91	7.82	4.03	10.85	7.68	21.05	10.54	29.35
Total	7.95	17.42	10.08	22.59	16.61	39.21	21.52	52.17

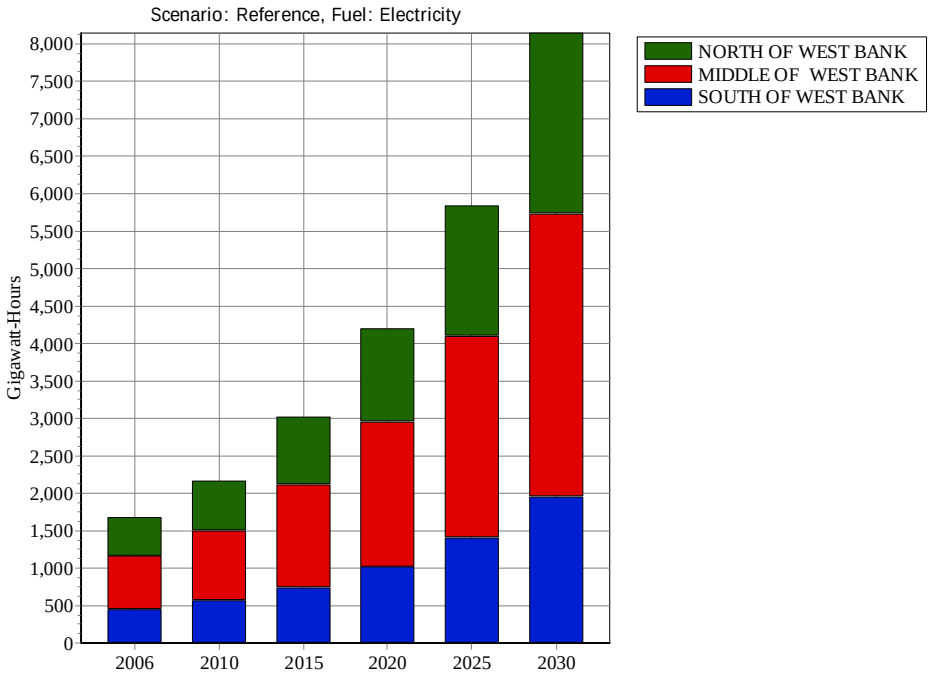

Figure 3:- Forecast of Household electricity consumption in WB

The electricity consumption in north, middle, and south parts of WB are given in figure 3. Electricity within the household sector is anticipated to be the fastest growing fuel (6.5% annual rate) throughout the forecasting period. The projected increase is due to consumers switching from LPG, in cooking, heating

and water heating, to electricity, the easier-to-use fuel and the increasing penetration of electric appliances.

The consumption of electricity for various usages in GS is given in Figure 4. The highest rate of household energy consumption increase will be about 8.3% in heating due to the fast spreading of usage of electric heaters. Also, the spreading of air conditioning systems in new buildings leads to annual increase of about 5.1% in conditioning.

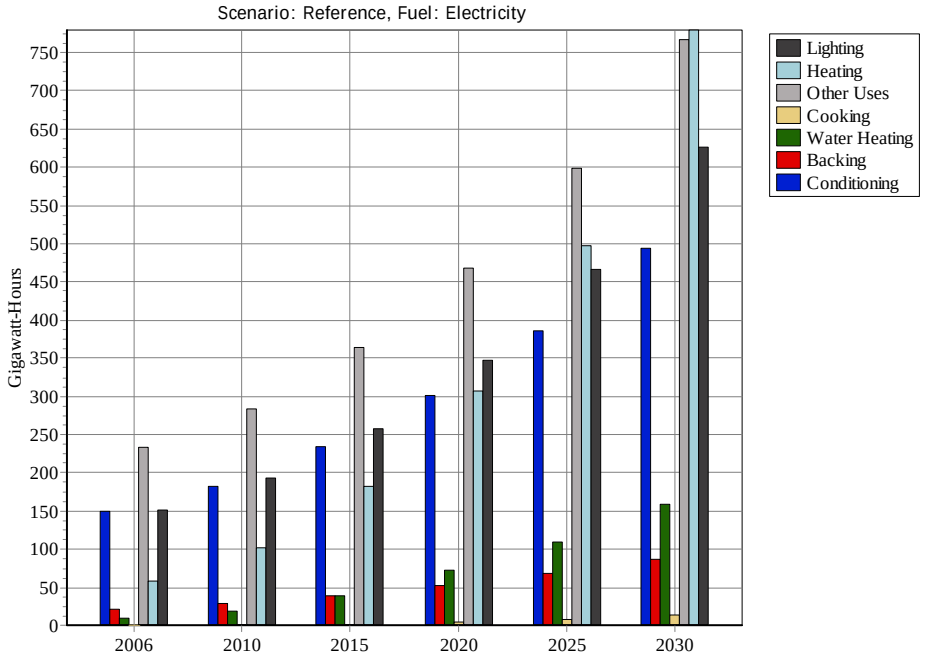

Figure 4:- Forecast of Household electricity consumption for various uses in GS

5.3 A Moderate Scenario:-

Energy sector in the PT suffers from fundamental problems caused by market instability such as the lack of investment and public expenditure, high prices and high transmission losses in electricity sector. The electricity sector suffers from persistence of unserved demand in WB and GS. Estimates of the amount of unserved demand are often based as much on anecdotal accounts as on measurements of consumption that would have occurred but didn't because of interruptions to power supply ("outages"), unsatisfied demand for connections by consumers to the power system, and inadequate supply capacity for the

demand (especially during periods of peak loading on the power system), [20]. Unserved connected demand (from power outages and inadequate supply capacity) may be equivalent to around 5% of total served demand, although this proportion probably varies from year to year. Unconnected demand is relatively small since the connection rate is above 95%. Moreover, reduction for unpaid consumption of electricity and losses (white and black losses) can be estimated from available data for power utilities. Data from GEDCO indicate the reduction could be about 20% mainly by reducing black losses and improving the power network to reduce white losses. Reduction in WB is estimated a bout 15% since the connection ratio in GS is higher than WB and losses in WB are lower than GS. Electricity demand calculation takes into account the unserved demand and the black and white losses in this scenario. Furthermore, the same set of assumptions, which were used for the reference scenario, is also utilized here. One major exception is that the electricity network is assumed to be fully fixed and updated in 2010. Furthermore, the electrical energy resources available are assumed to be adequate for GS.

The aim of this scenario is to reflect the current discussion about the electricity network and the recent government intentions with regard to possible changes in the structure of network. Under this scenario, energy consumption is predicted to increase from 20,943 TJ in 2006 to about 67,793 TJ in 2030 in the PT. The increase in the forecast period under this scenario is 8.7% lower than that of the reference scenario, table 7. Within the household sector, electricity, which is anticipated to be the fastest- growing fuel, is projected to sustain most of the growth at a faster average rate of 5.8% annually, throughout the forecasting period.

Table 7:-Moderate Scenario, Total Energy demand in Thousand TJ.

Years	**2010**		**2015**		**2020**		**2030**	
	GS	**WB**	**GS**	**WB**	**GS**	**WB**	**GS**	**WB**
Wood	0.51	0.98	0.44	0.82	0.35	0.63	0.15	0.28
Solar	2.31	3.1	2.72	4.06	3.2	5.29	4.46	8.66
LPG	2.19	5.31	2.87	6.74	3.75	8.57	6.36	13.87
Kerosene	0.03	0.21	0.02	0.13	0.01	0.08	0	0.01
Electricity	2.58	7.01	3.63	9.84	5.02	13.29	9.6	24.4
Total	7.62	16.62	9.68	21.59	12.33	27.86	20.58	47.22

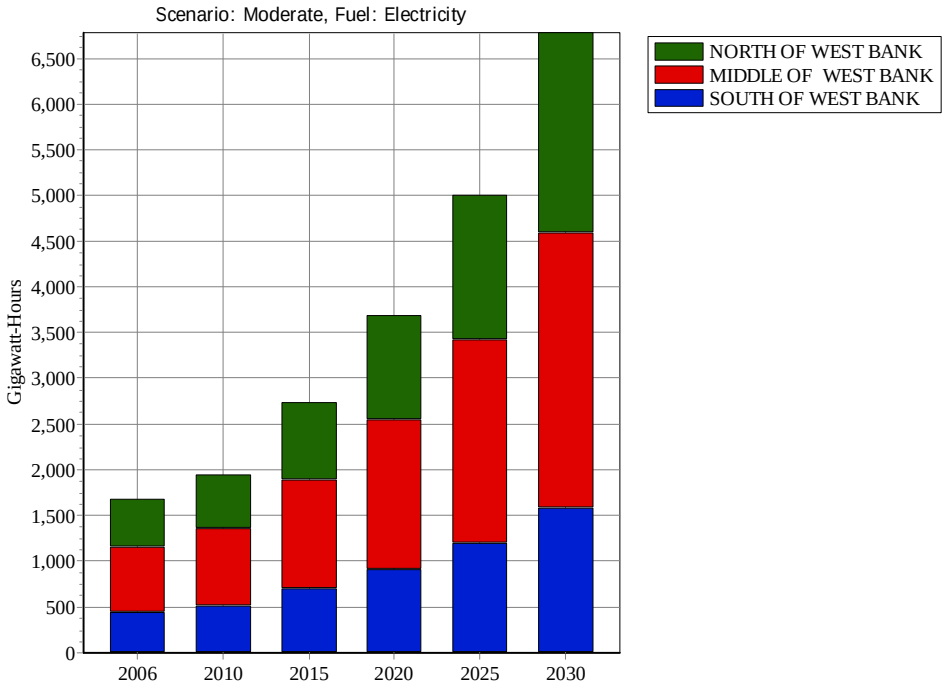

Figure 5**:- Forecast of Household electricity consumption in WB**

LPG consumption is increasing to 20,233 TJ in 2030 from 6,144 TJ in 2006 which corresponds to annual increase of 4.9%. Furthermore, the results show that residential customers are still expected to switch away from oil products (LPG and kerosene) to electricity, in cooking and heating. Kerosene consumption is expected to decline significantly by 2023.

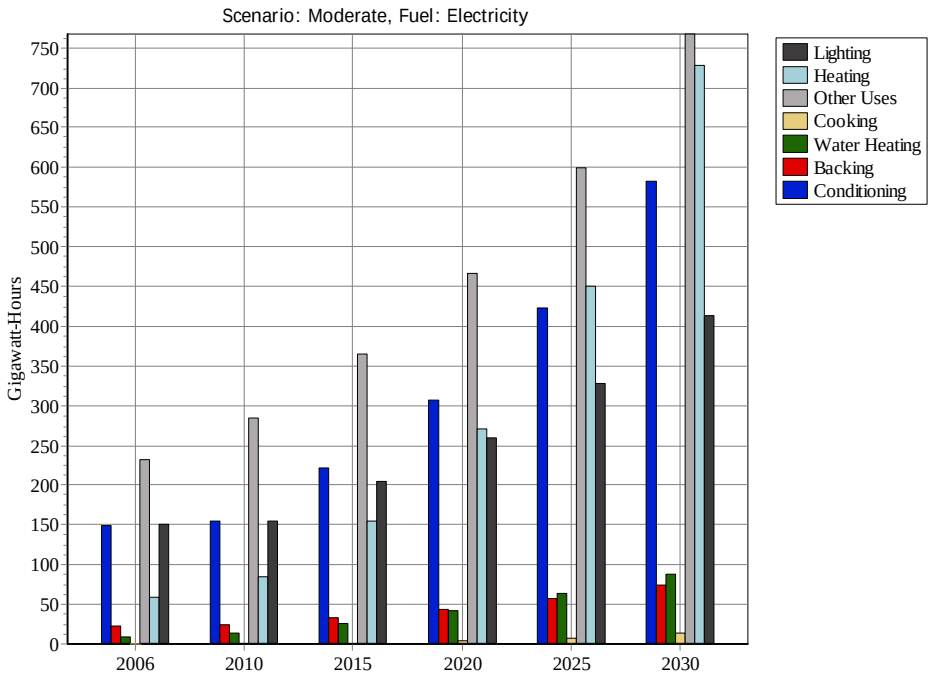

Figure 6:- Forecast of Household electricity consumption for various uses in GS

The share of oil products in the residential sector is expected to stay almost constant throughout the forecast period (31% in 2006 to about 30% in year 2030). In the same time, the share of electricity is expected to increase to 50% from 40% in 2006). The usage of solar energy is expected to decline from about 21.6%in 2006 to about 19.3% in 2030 due to the increase of percentage of apartment buildings.

The electricity consumption in north, middle, and south parts of WB are given in figure 5. Electricity within the household sector is anticipated to be the fastest growing fuel (5.7% annual rate) throughout the forecasting period. The projected increase is due to consumers switching from LPG, in cooking, heating and water heating, to electricity, the easier-to-use fuel and the increasing penetration of electric appliances. The consumption of electricity for various usages in GS is given in figure 6. The highest rate of household energy consumption increase will be about 10.6% in heating due to the fast spreading

of usage of electric heaters. Also, spreading of air conditioning systems in new buildings leads to annual increase of about 5.5% in conditioning.

6. Conclusions

This study assessed total household energy consumption in GS and WB in 2006 and projected the demand until the year 2030 using LEAP simulation program. The current energy situations in GS and WB are studied and data are collected from various sources. The total electricity consumption has increased three fold from 1994 to 2006. Furthermore, the electricity sector suffers from persistence of unserved demand in WB and GS. This is due to the destruction of the infrastructures of the electricity system by Israeli Authorities during the period of Israeli occupation. The results of the model simulation, based on two different scenarios, have raised several important issues.

The reference scenario which is business-as-usual scenario predicted that the demand for energy in the household sector, particularly electricity, will continue to grow at lower-than-historical average levels. The average annual growth rate is 6.5%. The reference scenario reveals the critical importance of having stable electricity resources and upgrading the distribution network to meet the growing demand to electricity in GS.

The moderate scenario predicted lower increase of electricity consumption at an average rate of 5.8% annually. This scenario reveals the importance of developing energy efficiency policy and conservation efforts such as of appliances and buildings to reduce the rate of increase of energy consumptions. In addition, the black and white losses in the power network should be minimized through the enforcement of law and upgrading the electricity network. Furthermore, using passive solar heaters in all building should be mandatory and using 'off-grid' energy sources such as photovoltaic cells should be encouraged.

Acknowledgment

The author gratefully acknowledges the financial support from Denary of scientific research at IUG.

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