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Residential energy consumption patterns: the case of Lebanon

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SUMMARY

In an attempt to fill a significant gap in baseline information, 509 households have been studied to analyse the residential consumption patterns in the urban environment in Lebanon. The average annual household energy consumption has been found to be 6907 kWh, whereas per capita consumption is 1727 kWh. Seasonal and monthly variations are analysed indicating increased energy consumption in the summer months accounting for 28% of total annual consumption. Correlations are indicated for energy consumption with apartment price, area, income and number of residents. Multiple regression analysis indicated statistical significance of income, area and number of residents to the energy consumption. Based on current consumption and electricity generating technologies, 1.6 tons of CO_2, 7.3 kg of SO_2 in addition to other pollutants are generated per resident. Comparative analysis indicates that Lebanon has electricity consumption similar to that of Western Europe, paving the way for significant energy saving potential.

KEY WORDS: household; urban; seasonal; baseline information

1. INTRODUCTION

Lebanon is classified by the World Bank (2004) as an upper middle-income country with a $4040 per capita GNI in 2003 and moderately indebted. The urban population constitutes 90% of the total population, which emphasizes the importance of studying the residential energy consumption.

Electricity generation and distribution is a monopoly of EDL (Electricite du Liban, which is a public utility owned by the government) with some concessions made to smaller companies. In 2001, EDL used 573 071 tons of diesel and 1 355 081 tons of fuel oil (Jizzini, 2002) at a cost of around $500 million. This is used to produce electricity at an average cost of $0.078/kWh. This value varies depending on fossil fuel derivatives market. EDL today suffers from a debt of $2.4 billion and recently a $200 million loan has been passed by the government in an effort to prevent EDL from going bankrupt (Kawas, 2004). The increased costs and spiraling debt have resulted in frequent outages throughout the year, mainly in the summer, damaging the economy and the tourism industry. Despite its troubles, EDL follows a social pricing scheme that

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provides electricity at a low cost for small consumers. Residences pay 2.33 cents for the first 100 kWh consumed per month then the rate increases to 3.67 cents for the fraction from 101 to 300 kWh, 5.33 cents for the fraction from 301 to 400 kWh, 8 cents for the fraction from 401 to 500 kWh and 13.33 cents for any consumption above 500 kWh. According to a UN (2001b) report, Lebanon's installed electricity capacity in 1999 was 2225 MW. However, the full potential is yet to be used due to incomplete grid networking. UN (2001a), World Fact book and EDL in addition to other agencies report various production and consumption data for various years, which are not always in agreement with each other. For the purpose of this research, EDL numbers for 2002 (CAS, 2003) will be used indicating that Lebanon has consumed 10.192 TWh of which 9.514 TWh came from thermal sources while 0.678 TWh came from hydropower. Lebanon produced 9.072 TWh and the rest was imported from Syria.

The annual growth in electricity consumption was 8.5% in 1999, which is second only to Saudi Arabia in the ESCWA (Economic and Social Commission for Western Asia) region. The annual growth in electricity generation was 19% in 1999 (UN, 2001a). This is mainly due to the increased energy demand and large reconstruction work in the energy sector after the end of the civil war. For the year 2010, the consumption is expected to be 12.5 TWh while needed capacity would be 3870 MW (Chedid *et al.*, 2001a). This clearly shows that Lebanon will be at a deficit in energy generation for the foreseeable future. In addition, significant losses on the grid are reported amounting to 56% (in 1997), 15% of which is the technical loss (Chedid *et al.*, 2001a).

Residential sector consumption estimates range from 29 to 60% of total electricity consumption (ESCWA, 2001; Chaaban and Saifur-Rahman, 1998; Chedid *et al.*, 2001a; Climate Change Report, 1999). According to the UN (1999), the residential sector is responsible for 15–25% of primary energy use in OECD (Organization for Economic Co-operation and Development) countries. With the relative lack of heavy industry, a residential energy consumption of over 50% seems more reasonable for Lebanon. Individual household energy consumption estimates vary from 0.45 to 2.2 MWh household^{-1} (Ecodit, 2002; Chaaban and Saifur-Rahman, 1998). Although no studies were found identifying per capita residential energy consumption, several values were obtained for total per capita energy consumption varying from 2.0 to 2.6 MWh capita^{-1} (Chedid *et al.*, 2001a; ESCWA, 2001; Nationmaster, 2003). This variation is mainly due to the speculative nature of the population of Lebanon.

Several studies have tackled the energy sector and electrical energy in Lebanon (Nasr *et al.*, 2000; Nasr *et al.*, 2002; Saab *et al.*, 2001; Badr and Nasr, 2001; Chaaban and Saifur-Rahman, 1998). These studies had gaps in evaluating the basic electrical use of residential consumers and its variations. Specifically, Saab *et al.* (2001) and Nasr *et al.* (2002) dealt with forecasting total electrical energy consumption. Chaaban and Saifur Rahman (1998) studied the overall energy consumption and related it to the residence's altitude above sea level. Consequently, a study dealing with residential energy consumption in a highly urbanized country like Lebanon with no heavy industries is of utmost necessity.

This paper presents a comprehensive field study of residential electricity consumption, and aims at providing a complete picture of the extent and variations of this consumption. The outcome of the study is expected to serve as valuable baseline data for further studies dealing with residential energy consumption. Moreover, it would provide the information needed for any future energy conservation plan and management. Internationally, this work is key in understanding consumption patterns of urbanized countries with similar weather conditions.

2. METHOD

In an attempt to identify basic electricity consumption patterns in residential households, interviewers were dispatched to various areas, and house residents were asked to respond to a series of questions relating to various aspects of their energy use. The basic structure of the questionnaire included questions regarding apartment area (exact number), current market price and overall household income in the form of ranges. These two questions assessed the social status of the house residents. This was followed by a question about the number of residents in the house and their occupancy rate, i.e. if they spend the whole year in the house or they leave it for a given number of months. Finally, in order to avoid any misperception or misrepresentation of their electricity bills, residents were asked to provide copies of their most recent electricity bills showing monthly consumption and cost for a whole year. Of the hundreds of questionnaires filled, 509 questionnaires were considered complete and appropriate for our study. This data was then analysed using Excel and SPSS 9.01 (Statistical Package for Social Sciences software) to provide the following results. The term energy in this paper generally refers to electrical energy.

3. SAMPLING

Based on the questionnaires filled, the average residential density for the sample studied is 4.31 residents per household. This is perfectly in line with the reported household size in the Beirut area (El-Kak, 2000). This reported household average increases in the remote areas of North Lebanon to reach a maximum of 5.5 residents per household. With a third of the Lebanese population living in the greater Beirut area, it is only normal for our numbers to reflect more this section of the population. For comparison, the USA average is 2.76 persons per household (DOE, 1999). The obtained average apartment area is 186.4 m^2. The total number of residents covered by this study is 2195, constituting 0.062% of the Lebanese population (based on a 2001 population estimate of 3.556 Million by ESCWA). Percentage wise, the chosen sample is approximately 8 times the sample studied by the United States Department of Energy every three years (DOE, 1995, 1999). The total overall electricity consumption of residences studied is 3516 MWh constituting 0.033% of all electricity consumed in Lebanon according to UN (2001a) numbers. The houses are typically apartments in multi-storey buildings. These residences are generally family houses either rented for long term or owned. The study was limited to those residents who responded, as generally people are not accustomed to revealing personal details, especially those dealing with finances, to outsiders or researchers. Similar problems have been previously encountered and reported by other researchers (Chaaban and Saifur Rahman, 1998). Home accessibility was also an issue as more remote, inaccessible houses were not included in this survey. Accordingly, the sample is representative of the more urbanized areas in Lebanon, which constitute the majority of residences and residential consumption.

In order to further gauge the representativeness of our sample, we compared the various fractions with sample data obtained from personal communications with EDL. As shown in Table I, it is clear that our sample is best related to the Beirut area. The difference observed in the 0–100 and >500 portions can be attributed to the fact that, in our sample, there was an emphasis on houses with a family living in them rather than empty houses or those occupied by building guards.

Table I. Effect of location on energy consumption.

Sample	District	Samples	% of consumers with indicated average monthly kWh consumption					
			0–100	101–200	201–300	301–400	401–500	> 500
Our sample	N/A	509	3	12	13	16	14	42
Beirut	Beirut	44 533	13	13	14	14	13	32
Chiah	Southern Suburb	6221	17	20	19	19	13	13
Antelias	Northern Suburb	3928	18	19	19	17	12	15
Bekfaya	North Mount Lebanon	20 423	33	25	18	11	6	6
Beitedine	South Mount Lebanon	16 576	41	33	16	6	2	1
Amioun	North Lebanon	2219	31	26	20	13	7	5
Riyak	Biqaa	9492	46	31	15	5	1	1
Zahle	Biqaa	1425	49	27	15	6	2	2
Nabatiye	South Lebanon	25 974	32	25	18	12	6	7

4. DATA AND RESULTS

4.1. Electrical consumption averages

The average residential electrical consumption was found to be 6907 kWh yr^{-1} (or 38.4 kWh m^{-2}) costing the average household \$686 yr^{-1} (Table II). For comparison, the average U.S.A. household consumed 10 212 kWh yr^{-1} in 1997 and spent \$867 (DOE, 1999, 2001). This means that the average household in Lebanon consumes 67.6% of the amount of electricity, and spends 79% of the money spent by the average U.S. household. However, these numbers are far less than those reported by Ghaddar and Bsat (1998) on one (11-floors, 33 apartments) residential building indicating that the annual energy consumption for that specific case is approximately 178 kWh m^{-2} for non-roof houses and 220 kWh m^{-2} for roof houses. The limitation of their sample to an apparently upper class building could have well skewed the averages indicated.

Consumption per person amounted to 1727 kWh yr^{-1} at a cost of \$164 $capita^{-1}$ yr^{-1}. This number indicates that residential energy consumption accounts for 65–73% of the total electrical consumption based on a total consumption of 2350 kWh $capita^{-1}$ in 2000, reported by the World Bank (Nationmaster, 2003) and 2641 kWh $person^{-1}$ reported by ESCWA (2001). A similar but slightly lower percentage was reported by a 1996 study which indicated that 60% of the country's electricity is used by the residential sector (Chaaban and Saifur Rahman, 1998). Both these percentages are far higher than the 29% reported by ESCWA for residential consumption. This percentage is very high and reflects the importance of addressing the residential sector in any future energy management plans.

In order to compare these results to international energy usage, the United Nations Statistics Division (up to 1994) reported per capita household energy consumption of electricity by region and the results are shown in Table III. The obtained consumption of 1727 kWh $person^{-1}$ yr^{-1} places Lebanon among the highest consumers of electricity in Western Europe rather than among geographically neighbouring countries. This is an indication of the relatively high standard of living of the Lebanese population despite a faltering economy; however, it is also an indication of an energy wasteful lifestyle.

Table II. Annual electrical consumption for the 509 residences studied.

Average annual electricity use	Range	Minimum	Maximum	Average
Consumption (kWh) household^{-1}	61 922	148	62 070	6907
Cost ($) household^{-1}	9690	70	9760	686
Consumption (kWh) resident^{-1}	10 308	37	10 345	1727
Cost ($) resident^{-1}	1617	10	1627	164
Consumption (kWh) m^{-2}	142	2	144	38.4
Cost ($) m^{-2}	19	0.25	19	3.59

Table III. UNDP regional estimates.

Region	Per capita household electricity use (kWh) in 1994
Sub Saharan Africa	<278
Developing East-South Asia	<278
Latin America	Approx. 333
Eastern Europe	Approx. 833
Western Europe	Approx. 1667
North America	>3889

4.2. Residential annual consumption

Annual consumption of the studied sample was then analysed indicating that 72% of the population use less than 8 MWh yr^{-1} (Figure 1). One residence consumed 62.07 MWh yr^{-1} and was not included in Figure 1.

EDL adopts a graduated tariff that increases with increasing consumption. This is implemented as a means to alleviate the burden on the poorer section of the population that generally consumes less electricity. Based on this tariff structure, residents using up to 500 kWh month^{-1} actually pay less than the production cost of electricity. In order to be able to understand how this graduated tariff is affecting the studied population, further analysis of the results obtained indicate that 42% of the residences consume more than 500 kWh of electricity per month adding up to 71% of the electricity consumed by the sample studied, and thus pay the 13 cents premium price. Twelve percent of the residences account for 33% of the total electricity consumed by the sample and use more than 1000 kWh per month. This portion of society use a third of the total residential electricity consumed. It is this portion of residents that are the best target for implementation of energy saving technology as maximum returns on time and effort are expected. This portion is also generally wealthier and presumably more educated, which may make it more willing to accept energy saving measures.

4.3. Consumption distribution

Table IV indicates the distribution of the energy consumption over the various fractions of the community. This table indicates that the top 10% of consumers use about 30% of the total residential electricity used, whereas the rest of the population (90%) consumes the remaining 70% of residential electricity. It is also interesting to note that the top half of consumers use about 77% of the electricity while the bottom half uses a mere 23%. Figure 2 illustrates the

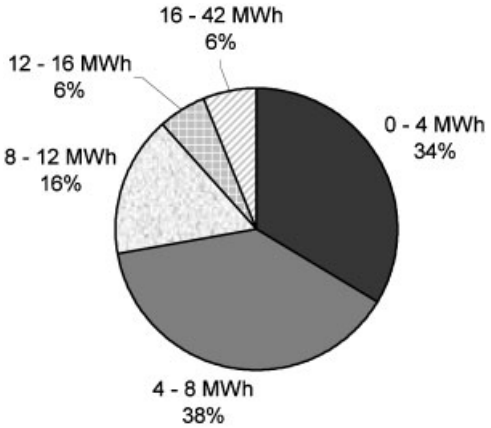

Figure 1. Percentage of residences with a given energy consumption range.

Table IV. Electricity consumption over the society's various fractions.

Fraction of residences (%)	Number of samples	Energy consumption (kWh)	% Energy consumption
Top 10	51	1 040 249	29.6
Top 20	102	1 605 755	45.7
Top 30	153	2 049 151	58.3
Top 50	255	2 700 971	76.8
Bottom 50	254	814 910	23.2
Bottom 30	153	355 785	10.1
Bottom 20	102	186 285	5.3
Bottom 10	51	66 504	1.9

impact of various consumer fractions graphically and shows that the top 10% consumes almost as much as the bottom 60% of the population.

4.4. Monthly consumption variation

With a detailed analysis of the annual consumption of electricity by various residences at hand, we attempted to analyse the monthly and seasonal variations in energy consumption. Figure 3 illustrates the average monthly consumption per household in addition to the incurred cost graphically and clearly shows the increased consumption during summer months. In addition, a statistically significant difference ($p < 0.0001$) was indicated by conducting a paired t-test for summer and winter energy consumption. This observation could be readily attributed to the relatively hot and humid summers, which require significant air conditioning. This fact is in line with previously reported results establishing a clear relationship between increased electrical consumption and both, rising temperature in summer and decreasing temperature in winter, the summer correlation being highly significant (Badr and Nasr, 2001).

4.5. Seasonal consumption and residence period

To further understand the monthly consumption patterns in a more global perspective and to account for residents leaving their houses in summers, Table V illustrates the seasonal variation

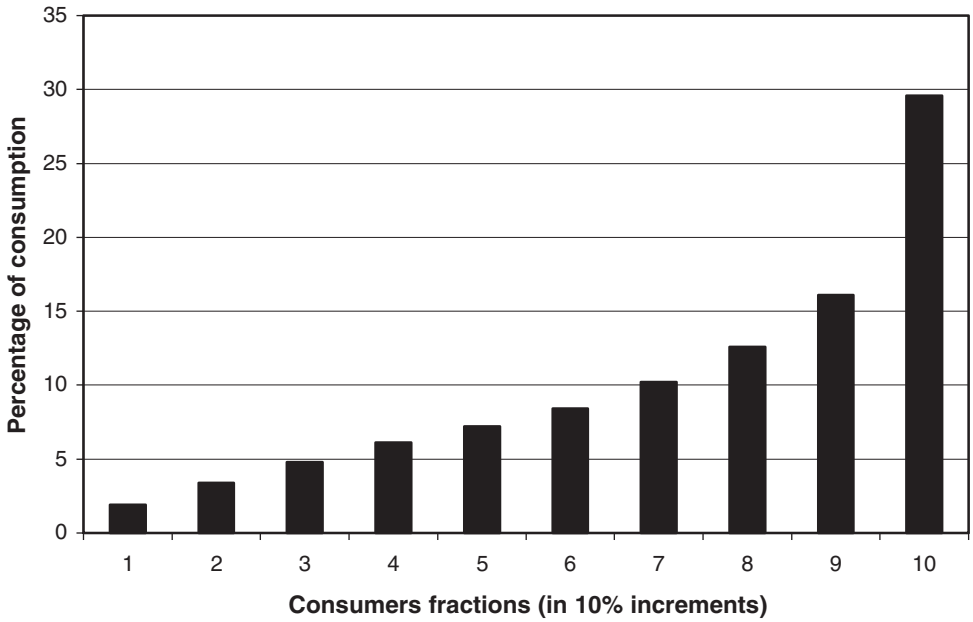

Figure 2. Percent consumption of consumers.

in consumption. In our sample, one household did not report the number of months stayed at home. Based on this seasonal consumption, it is important to notice that residences have increased energy consumption in the summer. As a result, 28% of electricity consumption is in the summer months and the lowest consumption is in the spring at 22%.

While the 9–11 months residents portion generally consumes more electricity than their all-year-residents counterparts (6% more in fall, 12% in winter and 14% in spring), their consumption is 1% less in summer. These data clearly indicate that this section of society that does not spend all the year in their houses have a higher standard of living as illustrated by increasing electrical consumption and generally spend the summer months away. This is fairly common in the coastal areas of Lebanon where people tend to spend their summers in their cool mountain summerhouses or out of the country.

The 'others' item indicated in Table V, and included in the total average, refers to residents spending less than 9 months at home. These are 23 samples, 16 of which spend 8 months at home, one spends 7 months, four spend 6 months and two spend 5 months. This sample seems to be the wealthiest of all, spending 8763 kWh yr^{-1}, which is 27% above the average. This portion could be attributed to families living outside Lebanon and coming for a visit. This is not uncommon in a country like Lebanon with a large portion of the population being immigrants to foreign countries. This argument is supported by a 52% above average consumption in the summer while other seasons vary from 25% in the fall, to 3% in winter and 22% in the spring above average. Despite internal variations, all three categories have increased energy consumption in the summer.

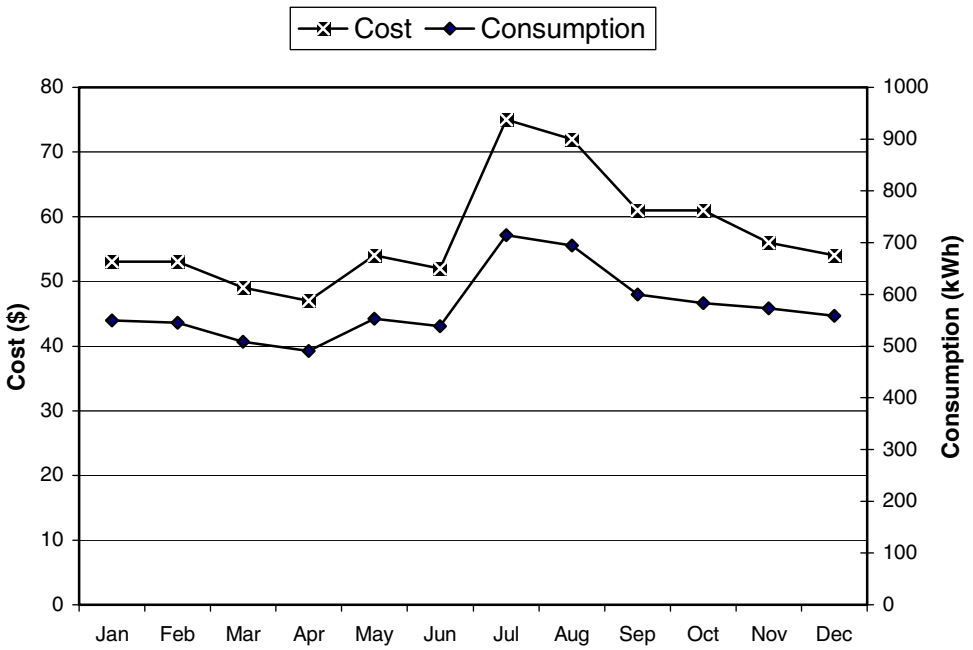

Figure 3. Annual consumption variation.

Table V. Seasonal consumption variations.

	Electrical consumption (kWh)				
	Total average	% of total consumption	All year residents	9–11 months residents	Others
Number of samples	509	509	321	164	23
Fall (Sep–Nov)	1756	25	1701	1803	2203
Winter (Dec–Feb)	1653	24	1585	1783	1703
Spring (Mar–May)	1552	22	1467	1674	1891
Summer (Jun–Aug)	1947	28	1906	1885	2966
Total	6907	100	6659	7146	8763

4.6. Socio-economic factor

Social status is clearly a factor in the consumption of electricity; accordingly, apartment price and household income were used to assess this relationship. From Table VI, one can readily conclude that electricity consumption increases with increasing apartment price; however, the average annual cost remains between 0.54–0.65% of the house value. While apartment price is a function of several variables, it is assumed that a higher apartment price is an indication of a higher standard of living.

The monthly income indicator was also gauged and the relationship was clear and straightforward between increasing income and increasing consumption (Table VII). However, the actual electricity bill constitutes less, percentage wise, of the household income as the latter

Table VI. Average annual bill as a function of house cost.

Apartment price (Thousand $)	Number of samples	Average annual cost ($)	Cost as % of house value	Average cost as % of house value
< 50	77	269	> 0.538	> 0.538
50–75	146	335	0.45–0.67	0.56
76–100	89	559	0.56–0.74	0.65
101–150	82	648	0.432–0.648	0.54
151–200	50	1099	0.55–0.73	0.64
201–300	35	1481	0.494–0.7405	0.617
> 300	28	2464	< 0.821	< 0.821

Table VII. Average annual bill relationship to average yearly income.

Monthly income	No. of samples	Average annual consumption (kWh)	Average annual expenditure ($)	Expenditure as % of average annual income
< $200	0	N/A	N/A	N/A
$201–$700	52	3858	268	5.0
$701–$2000	83	7028	649	4.0
$2001–$5000	29	9552	980	2.3
> $5000	6	22 537	3249	< 5.4

increases. Costs increasing from 2.3% of average monthly income for wealthier people up to 5.0% for poorer people indicate that despite the relief provided by the graduated tariffs implemented by EDL, the poorer portions of the society still feel the impact of electricity costs more than the wealthier portions.

4.7. Regression analysis

To identify the predictors for the energy consumption, a multiple regression analysis was conducted for the dependent and independent variables that showed correlations. The dependent variable was the energy consumption; the independent variables were apartment area and price, income and number of residents (Table VIII). It could be concluded from the regression analysis that energy consumption is related significantly ($p < 0.05$) to income, number of residents and the most significant relation is to the area of the apartment ($p < 0.0001$).

4.8. Environmental impact

In order to put the residential electricity consumption into an environmental perspective, the potential emissions must be estimated. Several studies have dealt with Greenhouse gas emissions and mitigation methods (Chedid and Ghajar, 2004; Chedid *et al.*, 2001b; El-Fadel *et al.*, 2003). With the energy sector producing 74% of the total CO_2 emissions, renewable energy and improving energy efficiency have been presented as appropriate alternatives. To generate electricity, EDL uses a mix of fuels for its various plants. Only 6.7% of electricity is being generated from clean hydropower while the rest is generated by highly polluting thermal plants. Table IX (Bazzi, 2002) summarizes the use of various fossil fuels in thermal plants to generate electricity in Lebanon. Assuming that all power plants are working to capacity (which is not

Table VIII. Regression results of energy consumption.

Independent variable	Coefficients	Standard error	*t*-value	Significance
Constant	−3533.16	1721.16	−2.053	0.042
Income	1156.38	734.67	1.57	0.045
House price	454.16	354.76	1.28	0.202
Resident	548.74	256.89	2.14	0.034
Area	18.51	4.06	4.56	0.000

Table IX. Fuel used for thermal power plants.

Fuel used	Sulphur content	Nominal capacity	% of production	Average fuel consumption (g/kWh)
Fuel oil	2%	331	17	289
Fuel oil	1%	607	31	244
Diesel	N/A	1010	52	286
Total	—	1948	100	—

always the case) and accounting for the hydropower share, the average kWh produced consumes 45.84 g of 2% sulphur fuel oil, 70.57 g of 1% sulphur fuel oil and 138.76 g of diesel. According to the National Atmospheric Emission Inventory (NAEI, 2003), and based on averaged emissions from various power stations, the average residential consumer produces 1.6 tons of CO_2, 7.3 kg of SO_2, 2.7 kg of NO_x and 180 g of PM_{10}. A 15% technical loss is taken as an average in electricity transmission (ESCWA, 2001). The assumed technical grid losses can only be estimated, as Lebanon suffers from a lack of accurate reports and from illegal connections to the grid. According to the UN (2001b), grid losses in the ESCWA region vary between 14 and 22% due to several technical and maintenance problems. Implementation of residential power saving programs can have a significant impact on the local and global environment especially when the lack of appropriate scrubbing technologies at the power plants is taken into consideration.

5. CONCLUSIONS

This paper presents the first field study to be done on such a scale in Lebanon. Results were obtained for 509 houses regarding monthly, seasonal and annual consumption. These numbers were correlated with financial status as gauged by household income and price of residence. With meaningful values obtained for consumption and relationship with social status, this work is expected to serve as a reference for future work. Major findings include the impact of the highest 10% of the population on the electricity consumption, which amounts to around 30%. Also per capita residential consumption was determined to be 1727 kWh.

Lebanon lacks demand-side management plan and although some publications have attempted to address this issue (Chedid *et al*., 2001a; Chaaban and Saifur Rahman, 1998), these studies have not made it to the implementation stage. This work paves the way for directed work on the residential energy consumption emphasizing that it should be mainly focused on the highest consumers to insure maximum return. It is hereby recommended that a new tariff class

be implemented. This tariff should be twice the highest used tariff to date amounting to \$0.27 per kWh and it should apply for those consuming more than 1000 kWh month^{-1}. This will affect 12% of the population, generally the wealthiest, and should generate significant income for EDL. Based on our sample, 35 832 kWh would be billable at the indicated higher rate generating \$9 675, which implies that EDL can increase its revenue by an overall 2.77%. In addition, such a program will aid in motivating energy conservation among consumers while maintaining the social tariff for the impoverished. Further work is in progress to relate various environmental residence conditions and residential choices on the electrical consumption.

Energy conservation is not only a source of financial returns but also will significantly aid in reducing air pollution levels in Lebanon. In addition, energy conservation programs will help the poor improve their living standards while maintaining low energy bills. With relatively old technologies used for burning and the absence of scrubbing technologies, the per capita pollution levels mentioned are expected to make it directly to the surrounding population. Any reduction in electricity consumed will directly translate into cleaner air and a healthier population. Some of the most successful conservation technologies making it to the Lebanese market are compact fluorescent lights and solar water heaters. Both technologies are spreading with no government support but rather based on their own quick financial returns. Such technologies should be encouraged further as the market is far from being saturated. More advanced and costly energy saving features and renewable energy sources should be addressed either concurrently or after the legislative framework for the above is established.

APPENDIX

List of abbreviations

AUB	American University of Beirut
DOE	United States Department of Energy
EDL	Electricite du Liban
ESCWA	Economic and Social Commission for Western Asia
GNI	gross national income
GWh	Giga Watt hour
MW	Mega Watt
NAEI	National Atmospheric Emission Inventory—U.K.
OECD	Organization for Economic Co-operation and Development
TWh	Tera Watt hour
UN	United Nations
UNDP	United Nations Development Program
Yr	Year

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REFERENCES

Badr EA, Nasr GE. 2001. On the relationship between electrical energy consumption and climate factors in Lebanon: co-integration and error correction models. *International Journal of Energy Research* **25**:1033–1042.

Bazzi N. 2002. Electricite du Liban: brief overview. *Presented at the National Meeting on Indicators and Provisions of Energy in Lebanon*, 10 December 2002.

CAS. 2003. *Energy Production*. http://www.cas.gov.lb/addsearch_en.asp

Chaaban F, Saifur-Rahman. 1998. Baseline energy and electricity consumptions in Lebanon and opportunities for conservation. *Energy Policy* **26**(6):487–493.

Chedid R, Ghajar R. 2004. Assessment of energy efficiency option in the building sector of Lebanon. *Energy Policy* **32**:647–655.

Chedid R, Ghaddar N, Chaaban F, Chehab S, Mattar T. 2001a. Assessment of energy efficiency measures: the case of the Lebanese energy sector. *International Journal of Energy Research* **25**:355–374.

Chedid R, Chaaban F, Slamaeh S. 2001b. Policy analysis of greenhouse gas emissions: the case of the Lebanese electricity sector. *Energy Conversion and Management* **42**:373–392.

Climate Change Report. 1999. *Technical Annex* to Lebanon's First National Communication on the National GHG Mitigation Strategy and Assessment in Lebanon's Vulnerability to Climate Change. June 1999.

DOE. 1995. Household energy consumption and expenditure 1993. *Report DOE/EIA-0321 (93)*. Department of Energy: U.S.A. http://tonto.eia.doe.gov/ftproot/consumption/032193.pdf (accessed: 22/9/04).

DOE. 1999. *A Look at Residential Energy Consumption in 1997*. Energy Information Administration at the Department of Energy: U.S.A. http://www.eia.doe.gov/pub/pdf/consumption/063297.pdf (accessed: 22/9/04).

DOE. 2001. *Annual Energy Review*. http://www.eia.doe.gov/emeu/aer/txt/stb0205.xls

Ecodit. 2002. State of the environment in Lebanon. *Report Submitted to the Ministry of Environment*, Lebanon.

EDL. 1994. *Electricite du Liban*. (Electricity in Lebanon).

El-Fadel M, Chedid R, Zeinati M, Hmaidan W. 2003. Mitigating energy-related GHG emissions through renewable energy. *Renewable Energy* **28**:1257–1276.

El-Kak M. 2000. Towards a regionally balanced development. *Proceeding of UNDP Conference on Linking Economic Growth & Social Development in Lebanon*, 11–13 January 2000. Beirut, Lebanon.

ESCWA. 2001. *Improving the Efficiency of Energy Use in the Buildings Sector*. UN: NewYork.

Ghaddar N, Bsat A. 1998. Energy conservation of residential buildings in Beirut. *International Journal of Energy Research* **22**:523–546.

Jizzini N. 2002. LCECP Project database. *Presentation at the National Meeting on Indicators and Provisions of Energy in Lebanon*, 10 December 2002.

Kawas N. 2004. Cabinet Grants Electricite du Liban $99 million loan. *Daily Star*, 17 June 2004.

NAEI. 2003. *National Atmospheric Emission Inventory*: *Power Stations*. http://www.aeat.co.uk/netcen/airqual/naei/annreport/annrep99/app1_23.html

Nasr GE, Badr EA, Dibeh G. 2000. Economic modeling of electricity consumption in post-war Lebanon. *Energy Economics* **22**:627–640.

Nasr GE, Badr EA, Younes MR. 2002. Neural networks in forcasting electrical energy consumption: univariate and multivariate approaches. *International Journal of Energy Research* **26**:67–78.

Nationmaster. 2003. *Lebanon Energy Ranking*. www.nationmaster.com

Saab S, Badr EA, Nasr GE. 2001. Univariate modeling and forcasting of energy consumption: the case of electricity in Lebanon. *Energy: The International Journal* **26**(1):1–14.

SPSS 9.01. *Statistical Package for Social Sciences Software*. SPSS Inc. Headquarters: 233 S, Wacker Drive, Chicago, IL, U.S.A.

UN. 1999. Trends in Consumption and Production: Household Energy Consumption ST/ESA/1999/Dp.6. DESA. *Discussion Paper No.6*. UN: New York.

UN. 2001a. *Potential and Prospects of Electricity Generation from Renewable Energy Sources in the ESCWA Region*: *Part 2 Thermal Solar Systems*. (original: Arabic. E/ESCWA/ENR/2001/4/Add.1). UN: New York.

UN. 2001b. *Options and Opportunities for Greenhouse Gas Abatement in the Energy Sector of the ESCWA Region*. UN: New York.

World Bank. 2004. *Lebanon Data Profile*. http://devdata.worldbank.org/external/CPProfile.asp? CCODE = LBN&P-TYPE = CP.

