Notebook

Notebook provides data not easily found elsewhere, background descriptions of important aspects of the energy system and reports on new developments. Contributions are invited.

Residential Lighting Energy Use in Canada

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1. Introduction

The total end-use energy consumption in Canada is about 7,000 Petajoules, 20% of which is for residential use (Statistics Canada, 1995). Since lighting energy consumption constitutes a part of the residential energy consumption, it is necessary to develop an accurate estimate of the residential lighting energy consumption in Canada.

A methodology is presented here to estimate the residential energy consumption for lighting in Canada based on statistical data. Using this methodology, the average residential lighting energy consumption (kWh/yr.) is determined for all dwellings in Canada. In addition, lighting energy consumption is calculated by category according to:

- dwelling type (single, double, row, duplex, flat apartment, high-rise apartment, mobile home);
- year of construction;
- livable and heated area;
- household income;
- occupancy type (own or rent);
- type of lighting (incandescent, fluorescent and

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halogen); and,

- application (indoors and outdoors).

A summary of results is presented in this paper. More detailed results can be found elsewhere (Fung and Ugursal, 1995).

Methodology

In 1993, Statistics Canada in collaboration with Natural Resources Canada conducted the Survey of Household Energy Use (SHEU) (Statistics Canada, 1993). SHEU is a comprehensive mail and telephone survey consisting of about 380 questions regarding the various aspects of residential energy consumption. The 1993 survey, which is the last one conducted so far, contains data on 10,982 households in Canada. The data on lighting include the following for each household:

- number of halogen light bulbs, indoors and outdoors;
- number of fluorescent light bulbs, indoors and outdoors;
- total number of incandescent light bulbs indoors, outdoors and in the garage; and,
- number of incandescent light bulbs in the kitchen, living/dining area, bedrooms/closets, family room, bathroom, hallways, basement, attic, and in other areas inside the house.

To estimate the lighting energy consumption using the SHEU data, information on two key parameters are needed: i) average wattage of each type of lighting (incandescent, florescent and halogen) used in residences, and ii) average number of hours of usage for each type of lighting. In a study published by Lawrence Berkeley Laboratories (Hanford, 1994), the average number of hours of usage for an incandescent light bulb is given to be 2.1 hours/ day, and the average wattage of an incandescent light bulb is given to be 67.1 W/bulb. For fluorescent, the average wattage is 41.1 W/bulb and the average daily use is 3.8 hours/day. Following discussions with researchers at Natural Resources Canada (Miller and Moisan, 1996) and Ontario Hydro (Bartoszek, 1996), it appeared that the 2.1 hours/day average usage for each incandescent bulb is probably lower than the actual value for Canadian residences. It was suggested that the average 2.74 hours/day usage (corresponding to 1,000 hours/yr.) is more representative of the actual usage for incandescent bulbs in Canada. Therefore, 2.74 hours/day is used in this study. Also, since there is no data on halogens, the same numbers are used for halogens as those given for fluorescent in the Lawrence Berkeley Laboratories study (average wattage of 41.1 W/bulb and the average use of 3.8 hours/day).

The calculation procedure for the annual electricity consumption for a given category is then straightforward: from SHEU database, the number of bulbs for each category is obtained. Then, this value is multiplied by the average wattage of the type of bulb, the average number of hours of usage per day, and the number of days per year to give the annual electricity consumption, i.e., annual electricity consumption for a given category = (number of bulbs in that category) x (average wattage of bulbs) x (average number of hours of usage/day) x (365 days/yr.).

The average electricity consumption per household for each category is then calculated by summing the electricity consumption of all households in that category and then dividing the total by the number of households.

Results and Discussion

The average number of bulbs of each type of lighting (i.e., incandescent, florescent and halogen) per household for each province and for Canada are given in Table 1. These are categorized according to the location of usage, i.e., indoors, outdoors and total of indoors and outdoors. Data on the distribution of incandescent lights among the different rooms of a dwelling are available elsewhere (Ugursal and Fung, 1995). Using the data in Table 1, and the average wattage, and average number of hours of usage given above, the annual electricity consumption values were calculated and the results are given in Table 2.

The following observations can be made from Tables 1 and 2:

- Halogens are not commonly used in Canadian residences, with an average of less than 0.4 halogens per dwelling. They are most commonly used in Quebec (1.02/dwelling) and in PEI (0.6/dwelling), whereas Newfoundland has the lowest number (0.13/dwelling). Halogens are mostly used for indoor lighting.
- Use of fluorescent in Canada is more than five times as much as that of halogens with 2.18

Table 1: Average number of bulbs of each type of lighting (incandescent, florescent and halogen) per household for each province and for Canada

	Halogen			Fluorescent			Incandescent			
	Indoor	Outdoor	Total	Indoor	Outdoor	Total	Indoor	Outdoor	Garage	Total
NF	0.08	0.05	0.13	0.88	0.04	0.92	20.0	2.19	0.24	22.4
PE	0.52	0.08	0.60	1.30	0.10	1.40	19.7	2.20	0.49	22.4
NS	0.16	0.11	0.27	1.48	0.20	1.67	20.8	2.43	0.51	23.8
NB	0.21	0.14	0.36	1.45	0.12	1.57	21.2	2.45	0.71	24.4
QU	0.91	0.11	1.02	1.29	0.17	1.46	17.7	2.36	0.51	20.5
ON	0.32	0.13	0.46	2.43	0.22	2.65	24.0	2.54	0.77	27.4
MA	0.20	0.10	0.30	2.23	0.16	2.39	20.4	2.15	1.09	23.6
SA	0.18	0.12	0.30	2.92	0.19	3.10	22.3	2.37	1.20	25.9
AB	0.21	0.17	0.38	2.72	0.17	2.89	23.2	2.29	1.06	26.5
BC	0.26	0.18	0.44	2.77	0.31	3.07	24.1	2.74	0.81	27.7
Canada	0.27	0.12	0.39	2.01	0.17	2.18	21.5	2.37	0.78	24.6

Abbreviations: AB–Alberta; BC–British Columbia; MA–Manitoba; NB–New Brunswick; NF–Newfoundland; NS–Nova Scotia; ON–Ontario; PE–Prince Edward Island; QU–Quebec; SA–Saskatchewan

Table 2: Average annual lighting energy consumption per dwelling (kWh/yr.)

	Halogen			Fluorescent			Incandescent				Total Dwellings
	Indoor	Outdoor	Total	Indoor	Outdoor	Total	Indoor	Outdoor	Garage	Total	
NF	3.9	2.2	6.1	41.8	2.0	43.8	1334	146	16.2	1497	1547
PE	24.5	3.8	28.3	61.5	4.9	66.5	1319	147	32.9	1499	1594
NS	7.7	5.1	12.8	70.1	9.4	79.5	1392	162	34.3	1588	1681
NB	10.2	6.7	16.9	68.7	5.8	74.5	1420	164	47.2	1631	1722
QU	43.2	5.4	48.6	61.4	7.9	69.2	1181	158	34.1	1373	1491
ON	15.3	6.3	21.7	115.4	10.3	125.7	1605	170	51.7	1829	1976
MA	9.7	4.7	14.4	106.1	7.6	113.8	1362	144	72.8	1579	1707
SA	8.6	5.5	14.1	138.5	8.9	147.4	1490	158	80.0	1729	1890
AB	10.0	8.0	18.0	129.3	8.0	137.4	1550	153	70.6	1774	1929
BC	12.2	8.7	21.0	131.4	14.6	145.9	1614	183	54.0	1851	2018
Canada	12.9	5.6	18.5	95.3	8.1	103.4	1434	159	52.2	1645	1767

fluorescent bulbs per dwelling. Fluorescent use west of Ontario is close to twice as much compared to that in Quebec and eastern provinces. Fluorescents are predominantly used indoors, with outdoor use representing less than 10% of total usage.

- Canadian households predominantly use incandescent bulbs for lighting. The average number of incandescent bulbs per dwelling in Canada is close to 25. About 10% of this is for outdoor use and the rest is for indoors. While Quebec has the least number of incandescents per household (20.5), BC and Ontario have the most (27.7 and 27.4, respectively).
- On the average, electricity consumption by halogens is about 18.5 kWh/yr./dwelling in Canada, whereas at 103.4 kWh/yr., electricity consumption by fluorescent is more than five times the consumption by halogens. Dwellings in Ontario and provinces further west use significantly more electricity with fluorescents than those in Quebec and other eastern provinces. In Saskatchewan, where fluorescent usage is highest, annual electricity use by fluorescent is 147.4 kWh/dwelling. This is more than three times that used in Newfoundland where fluorescent usage is lowest (43.8 kWh/dwelling).
- Annual electricity consumption per dwelling in Canada by incandescent bulbs is 1,645 kWh, which is almost 16 times that consumed by fluorescents. The variation of electricity consumption from one province to another is quite small with British Columbia showing the highest per dwelling electricity consumption by incandescents (1,851 kWh/yr.) and Quebec the lowest (1,373 kWh). The average annual electricity consumption for residential lighting in Canada is about 1,770 kWh/yr./dwelling.

Table 3: Average annual lighting energy consumption by dwelling type (kWh/yr.).

	Single	Double	Row	Duplex	Flat/Apt	Hi-rise	Mobile
NF	1669	1017	1190	1351	735	522	956
PE	1805	1421	974	1349	701	n/a	1090
NS	1918	1364	1084	1312	814	970	1163
NB	1958	1379	970	1477	860	682	1283
QU	1967	1357	1317	1252	888	725	1202
ON	2397	1585	1570	1034	865	1094	1428
MA	2033	1344	992	1068	800	785	1347
SA	2182	1212	1549	973	813	856	1593
AB	2484	1548	1449	1154	815	992	1313
BC	2485	1601	1648	1557	874	774	1263
Canada	2074	1402	1338	1268	830	934	1268

Table 4: Average Annual Lighting Energy Consumption per m^2 of Heated Area ($kWh/m^2/yr.$)

	Heated Area (m^2)					
	37	75	117	164	210	256
NF	27.2	17.0	15.8	14.6	15.2	10.3
PE	31.8	18.9	16.8	13.6	11.5	11.7
NB	31.3	20.4	18.2	15.4	12.8	10.3
NS	29.6	19.9	18.3	15.7	14.4	9.4
QU	40.8	21.7	17.6	13.3	11.3	7.7
ON	36.6	22.8	18.8	15.9	15.7	16.5
MA	24.8	20.1	18.8	17.4	16.7	11.1
SK	27.6	20.7	19.8	18.8	18.3	10.9
AB	34.7	20.9	18.5	19.8	16.6	15.7
BC	32.2	19.3	19.7	17.4	15.2	14.2
Canada	30.6	20.2	18.5	16.4	15.0	12.0

- On a per dwelling basis, dwellings in BC, Alberta and Ontario consume the most electricity for lighting, whereas dwellings in Quebec use the least (about 2,000 kWh/yr. vs. about 1,500 kWh/yr.).

The annual average electricity consumption for lighting in each type of dwelling (single, double, row, duplex, flat apartment, high-rise apartment, mobile home) were calculated for each province and for all of Canada. The results presented in Table 3 (above) indicate that on a per dwelling basis, single houses consume more electricity for lighting than any other type of dwelling, whereas flat and high-rise apartments use the least amount. The electricity consumption of a single house for lighting is more than double the electricity consumption of an apartment. Average lighting electricity consumption of double, row, duplex and mobile dwellings are close to each other.

The annual average electricity consumption per m^2 of heated area for each dwelling category was calculated using the median area for the category (for example, for the dwelling area category of 140-185 m^2, 163 m^2 was used). The results given in Table 4 for each province and for Canada indicate that as dwelling area increases the energy consumption per m^2 decreases for most provinces and for Canada.

The annual average electricity consumption for lighting in dwellings, categorized according to the household income, is presented in Table 5 for each province and for Canada. The annual average electricity consumption per $1,000 of household annual income (kWh/$1,000 income/yr.) was calculated for each income category using the median income for the category (for example, for the household income category of $15-$20,000, $17,500 was used). It can be observed from Table 5 that the average annual electricity consumption per $1,000 of annual income is the highest for the lowest income bracket. As income decreases, the average annual electricity consumption per $1,000 of annual income increases. This indicates that a larger portion of household income is spent for lighting as household income decreases.

The total annual residential lighting electricity consumption for all households in each province and in Canada is given in Table 6. As shown in the table, the total electricity consumption in Canada for residential lighting is about 18.3 TWh, or 65.9 Petajoules. This is about 5% of the total annual residential end-use energy consumption in Canada.

Table 5: Average annual lighting energy consumption per $1,000 of household income (kWh/yr./$1,000)

	Annual Income (000s)										
	$7.5	$12.5	$17.5	$22.5	$27.5	$32.5	$37.5	$45.0	$55.0	$70.0	$90.0
NF	125	82	68	60	55	47	47	44	41	33	39
PE	101	86	69	55	58	53	47	43	44	39	32
NS	121	91	81	62	59	55	49	50	43	38	31
NB	119	90	75	61	58	55	51	47	42	38	36
QU	100	74	66	61	56	45	41	40	38	32	28
ON	132	104	75	69	54	52	51	48	46	37	35
MA	117	93	79	60	62	56	52	45	43	33	38
SA	128	92	89	77	68	60	54	49	47	43	37
AB	124	112	87	69	51	61	51	53	44	36	36
BC	143	103	87	72	55	55	49	52	44	42	37
Canada	121	92	78	65	59	54	50	47	44	37	35

Table 6: Annual lighting energy consumption

	Lighting (kWh/ dwelling/yr.)	No. of Dwellings	Total Consumption	
			(TWh/yr)	(PJ/yr)
NF	1,547	186,070	0.3	1.0
PE	1,594	45,736	0.1	0.3
NS	1,681	336,080	0.6	2.0
NB	1,722	260,915	0.4	1.6
QU	1,491	2,710,836	4.0	14.6
ON	1,976	3,810,478	7.5	27.1
MA	1,707	402,524	0.7	2.5
SA	1,890	368,270	0.7	2.5
AB	1,929	934,816	1.8	6.5
BC	2,018	1,303,492	2.6	9.5
Canada	1,767	10,359,217	18.3	65.9

Conclusion

A methodology is presented to estimate the annual lighting energy consumption in Canada. Using this methodology and statistical data, average values of residential lighting energy consumption were calculated for different lighting and dwelling types. The results indicate that the total lighting energy consumption is about 18.3 TWh, or 65.9 Petajoules, which is close to 5% of the residential energy consumption in Canada.

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The Future of Kuwait Domestic Energy Demand

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I. Introduction

Kuwait has experienced significant structural changes since the beginning of oil experts in 1946. These changes have induced rapid increases in the consumption of energy domestically. The consumption of energy in Kuwait has grown consistently since the 1970s at a rate of about 3.5% annually. The increase in energy consumption has been due to a number of factors, such as rising incomes, low real energy prices, and population growth.

Since 1978, residential and commercial consumers in Kuwait were charged a flat rate of 2 *fils* per kilowatt/hour of electricity (kWh) when, in fact, the cost of producing each kWh has been estimated at 14 to 26 *fils*, a subsidy of 12 to 24 *fils*/kWh.[1] Furthermore, domestic energy prices have been declining in real terms since 1975. For example, the nominal price of a litre of gasoline at the pump is 40 *fils*, the same as it cost in 1980; however, in real terms it costs only about 20 *fils* per litre today. In other words, there is no real price incentive for consumers to conserve.

In recent years, the Kuwaiti government has considered measures and policies on several fronts to reduce inefficiency and waste in energy consumption. Currently, policy makers are considering raising the price of domestic refined products, a major departure from the policy of maintaining artificially low energy prices. Furthermore, in an effort to reduce costs and inefficiency, plans for privatizing gasoline retail operations are in the final stages.

The government's efforts to conserve on energy use by setting higher domestic energy prices and improving technical fuel efficiency of equipment and machines may introduce shocks into the system and increase uncertainty in forecasting future energy demand patterns.

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1/ The conversion rate of the *dinar*, the Kuwaiti currency unit where 1 *dinar* = 1,000 *fils*, is approximately 1 *dinar* = US $3.35 as of the publication date.

The Kuwait Energy Demand Model (KEDM) was built to assess the possible impacts of those policy options, and forecast future energy demand under various scenarios. These forecasts will provide policy makers with valuable information upon which they can set effective economic policies (Eltony, 1995). Furthermore, KEDM takes advantage of recent advances in econometrics and computer software in order to make economic analysis easily accessible to policy analysts and decision-makers. With this model, economic consequences of adopting different energy pricing schemes can be tested, analyzed and compared. The aim of this paper is to present the model simulations under various policy options (scenarios), analyze and compare the result, and assess the economic impacts of these policy options.

II. An Overview of the Model

KEDM has extensive sectoral coverage and the specified equations are well grounded in economic theory. The statistics of the estimated equations are quite reasonable, and the model is robust. The model's ability to adequately explain historical energy consumption provides a sound basis upon which to build forecasts and analyze policy options (Eltony & Al-Ramadhan, 1996).

The model considers only the demand side of the energy market in Kuwait and describes the response of the final demand sectors, i.e. end-use, the secondary demand and the primary demand sectors by type of energy. The model determines the demand for energy by various sectors, given the state of technology, incomes and energy prices. The model does not consider the supply side and assumes that for all purposes the supply of energy for domestic use is perfectly elastic.

The main sectors include residential, governmental, commercial, transportation, industrial and non-energy demand sectors. The industrial sector consists of the oil-based industries such as oil and gas production, refining, LPG plant, petrochemical and electricity generations.

Road and air transport energy requirements have been modelled as separate blocks in the transportation sector. The consumption of the non-energy sector of energy products consists of separate demand equations for asphalt, lubricants and greases and natural gas in the petrochemical industry as feed stocks.

The model is essentially dynamic and non-linear in nature, given the presence of lagged variables plus the use of market share ratios and a log-linear functional form. Also, the use of error correction and co-integration techniques have provided useful information about how the consuming sectors adjust to long run equilibrium (Eltony & Chishti, 1997).

In general, most of the equations in the model are estimated using Ordinary Least Squares techniques (OLS) with auto-correlation correction when applicable (Maddala, 1992). There are three sub-models, names, gasoline, and aviation fuel consumption in the transportation sector, and energy requirement for the production of electricity and water by the industrial sector. These sub-models have been estimated simultaneously using Generalized Least Square techniques (GLS) (Kamenta, 1986). The model consists of 23 behavioural equations (stochastic), 21 definition identities, and 11 process type-relationships.

III. The Scenarios

Simulation refers to the determination of the behaviour of a model based on the calculation of values from the estimated equations. The model is simulated under different assumptions to evaluate its sensitivity to a variety of inputs. Each simulation exercise represents an experiment performed on the model, determining values of endogenous variables based on alternative assumption regarding policy variables, stochastic disturbance terms, and parameter values (Intrilligator, 1978).

Assumption of the future values of exogenous variables, together with estimated values of parameters, is used to calculate the values of the endogenous variables from the model's equations. *Ex ante* projection simulation of the model's endogenous variables beyond the estimation period is the concern of this paper. The *ex ante* projection simulation covers the period for 1998-2010.

Three scenarios are utilized to solicit the model's response to long run changes into key variables. The three scenarios are:

III.1 The Baseline Scenario:

The baseline scenario projects current trends and serves as a benchmark for the remaining scenarios. For the most part, the baseline scenario represents the status quo. It also gives a long run projection of existing conditions regarding domestic energy consumption of oil products, natural gas and electricity, but with relatively slower economic rates of real growth. A simple set of assumptions is utilized to measure the changes in the key exogenous variables with no changes in domestic energy prices. The main assumptions include:

- an annual growth rate of 1.5% for the real Gross Domestic Production (GDP);
- an annual growth rate of 3.5% for the Kuwaiti population, which is in line with historical rates. Furthermore, an annual growth rate of 4% for total population, which is slightly lower than the historical rate, to reflect the anticipated expatriate labour constraint policy;
- all domestic nominal energy prices to remain constant throughout the forecast period;
- an improvement in the technical fuel efficiency of automobiles of 1% annually that is expected by the International Energy Agency (1995) for the Middle East and Gulf regions; and,
- an annual inflation rate of about 2% annually.

All other exogenous variables are assumed to grow at their historical rates for the 1975-1995 period.

III.II The Moderate Scenario

This scenario aims at determining domestic consumption when energy prices double. Essentially the same set of assumptions that were used for the baseline scenario is utilized here. The major exception is that all domestic nominal energy prices are assumed to increase by 100% immediately in 1998 and then remain constant throughout the forecast period. The aim of this scenario is to reflect the current government intention of increasing domestic energy prices as early as 1998 and to examine the consequences of such price adjustments on the carious sector for the economy.

III.III The Extreme Scenario

This scenario elicits the model's response to a deliberate shock of a 200% increase in the future path of energy prices. The same set of assumptions that was applied to the moderate scenario is also applied to this scenario, with the only exception that all domestic nominal energy prices are assumed to upsurge immediately by 200% in 1998 and remain constant throughout the forecast period. The aim of this scenario is to examine the response by various sectors to a deliberate shock in energy prices.

IV. Simulation Results

a) Baseline Scenario

The baseline scenario projects a compound annual growth in total domestic energy consumption of 3.1%. The growth in the total energy consumption manifests itself mainly in an increase in the consumption of oil products. The model forecasts that consumption of oil products will reach about 80.4 million barrels of oil equivalent (mboe) in 2010, up from 43 mboe in 1995 at an annual growth rate of about 4.2% throughout the forecast period. The model also predicts a growth in natural gas consumption of about 1.6% annually, which is lower than the historical level. Moreover, the consumption of electricity is predicted to increase at a growth rate of about 3.8% annually (see Table 1).

The aggregate growth rate in domestic energy consumption is determined by the growth rates in individual sectors. The residential sector is anticipated to record the highest rates of growth among all the sectors, followed by the industrial and commercial sectors.

In sum, if the current situation continues and the nominal prices of all types of energy remain the same causing the real prices to decline over time, and despite the slower growth in GDP, aggregate energy consumption will continue growing for years to come. In other words, under the assumption of the baseline scenario, there will be no incentives for energy conservation.

b) Moderate Scenario

This scenario projects a compound annual growth in aggregate domestic energy consumption of only 1.5% annually throughout the forecast period. The model forecast indicates domestic consumption will reach nearly 101.4 mboe in 2000, which is lower than the baseline scenario by about 17%.

Table 1: Results of the Baseline Scenario (Mboe)

Sector	Variable	1995	1998	2000	2005	2010	Growth rate (%)
Total	Electricity	9.700	11.146	11.976	14.248	16.870	3.76
	Oil Products	43.300	50.814	59.453	78.337	80.387	4.21
	Natural Gas	45.435	49.542	51.601	54.432	57.445	1.58
	Grand Total	98.435	111.502	123.030	147.017	154.702	3.06
Residential	Total	7.400	8.393	9.091	11.012	13.214	3.94
Industrial	Total	68.600	78.407	88.809	109.925	114.402	3.47
Transportation	Total	18.400	18.443	18.583	18.912	19.241	0.30

Consumption will reach 118.5 mboe and 123.9 mboe in 2005 and 1020, respectively, which is lower than baseline scenario by about 20%.

The model simulation indicates that consumption of oil products will reach about 62.8 mboe in 2010 up from 43.3 mboe in 1995, which will amount to an annual growth rate of about 2.5% throughout the forecast period. Meanwhile, the consumption of electricity is predicted to slightly increase by about 1.2% annually throughout the forecast period. The model also predicts a slow growth in natural gas consumption of only 0.6% annually (see Table 2).

In short, if the nominal prices of all types of energy rise immediately by 100%, the rate of growth in aggregate energy will slow down significantly and the volume of energy use will be at least 20 % lower than in the Baseline scenario by the year 2010. The results of the moderate scenario suggest that an increase in energy prices will induce all sectors to conserve on their consumption of all fuel types.

c) Extreme Scenario

The extreme case scenario projects a compound annual growth rate for aggregate energy consumption of only 1.0%. The model forecast indicates that aggregate energy consumption will reach 114.6 mboe in 2010, which is lower than the baseline scenario by at least 26% (Table 3 and Figures 1-4).

V. Conclusions and Some Policy Implications

The results of the model forecasts, which are based on three scenarios, address several important issues. With nominal energy prices staying the same and inflation and economic growth continuing to expand (i.e., baseline scenario), all sectors are expected to have a growing demand for energy, particularly electricity and oil products. Industrial, residential and commercial demand sectors are likely to record the highest growth rate for energy demand. For the most part, this result indicates the short- and long-run energy consumption and economic activities are interrelated. The model forecasts show that, for all sectors, energy consumption varies directly with economic growth and inflation rates.

Furthermore, based on the results of the baseline scenario, it appears that a lower than historical average economic growth rate, in the short run, may not reduce rates of growth in energy consumption in Kuwait. The high real per capita incomes, the affluent living standards, the large stock of automobiles and relatively larger dwelling units contribute to extravagant energy consumption patterns. It is unlikely, under the current energy price structure, that short-run economic adjustment will moderate contemporary lifestyles with respect to energy consumption.

However, in the long run, persistent lower economic growth will lead to a reduction in the per capita income, which would result in slower rates of growth in energy consumption per capita. However, the lower economic growth by itself may no reduce total energy demand as population growth is projected to grow by about 4% annually and real energy prices are expected to decline.

In view of the fact that the industrial and commercial sectors are quite energy-intensive, the macro-economic effects of using a deliberate energy price shock, as in the case of the extreme sce-nario, may substantially reduce real rates of economic growth in these two sectors without having a marginally large impact on total energy consumption. For example, a rise in energy prices by 100% will reduce energy consumption by 20%,

Table 2: Results of the Moderate Scenario (Mboe)

Sector	Variable	1995	1998	2000	2005	2010	Growth rate (%)
Total	Electricity	9.700	9.207	8.328	9.702	11.526	1.16
	Oil Products	43.400	39.585	45.216	60.150	62.782	2.51
	Natural Gas	45.435	46.154	47.813	48.742	48.641	0.59
	Grand Total	98.435	94.945	101.357	118.594	123.949	1.55
Residential	Total	7.400	7.302	6.648	7.886	9.461	1.65
Industrial	Total	68.600	64.277	71.999	87.727	90.974	1.90
Transportation	Total	18.400	18.249	17.843	17.868	18.050	-0.13

Table 3: Results of the Extreme Scenario (Mboe)

Sector	Variable	1995	1998	2000	2005	2010	Growth rate (%)
Total	Electricity	9.700	7.521	6.180	7.098	8.423	-0.94
	Oil Products	43.400	38.194	43.571	56.929	58.798	2.06
	Natural Gas	45.435	41.411	42.798	44.998	47.339	0.27
	Grand Total	98.435	87.126	92.549	109.025	114.560	1.02
Residential	Total	7.400	6.358	5.229	6.128	7.350	-0.05
Industrial	Total	68.600	60.378	67.543	82.457	85.730	1.50
Transportation	Total	18.400	15.737	15.486	15.895	16.562	-0.70

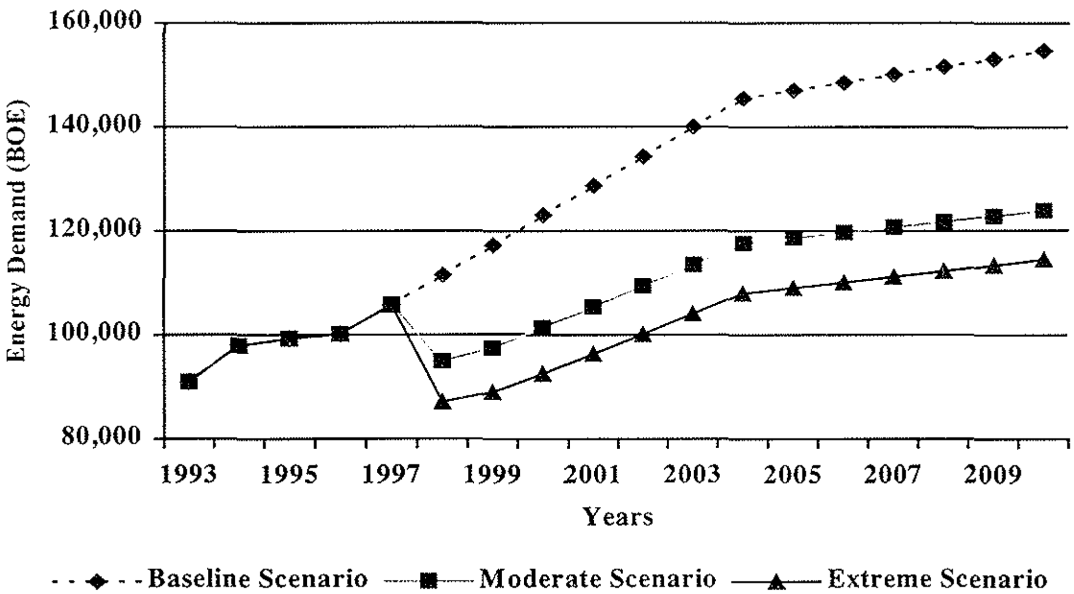

Figure 1: Energy Demand in Kuwait – Different Scenarios

and a rise by 200% will result in a further reduction in energy consumption by only 6% (26% instead of 20%).

The moderate scenario shows that the potential for energy conservation with minimal adverse impact on the economic activities of key sectors, such as the industrial and commercial sectors, exists in the economy of Kuwait.

The model also reveals that there are definite long run advantages to introducing an upward energy price adjustment. The greatest potential energy savings exist in the transportation, residential and industrial sectors. The moderate scenario show that the transport sector will observe a slight nega-

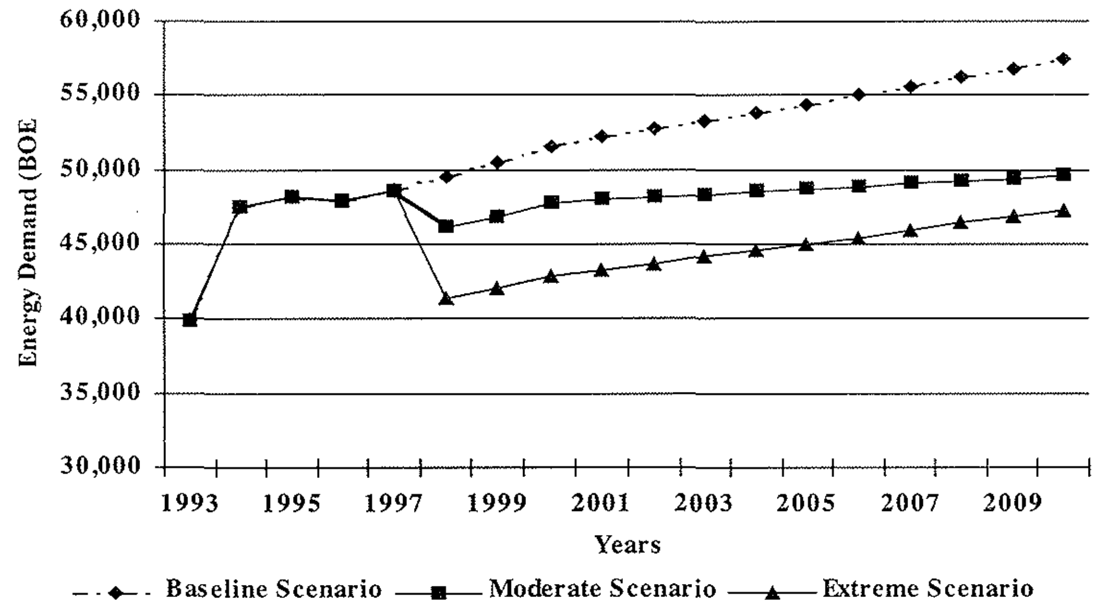

Figure 2: Natural Gas Demand in Kuwait – Different Scenarios

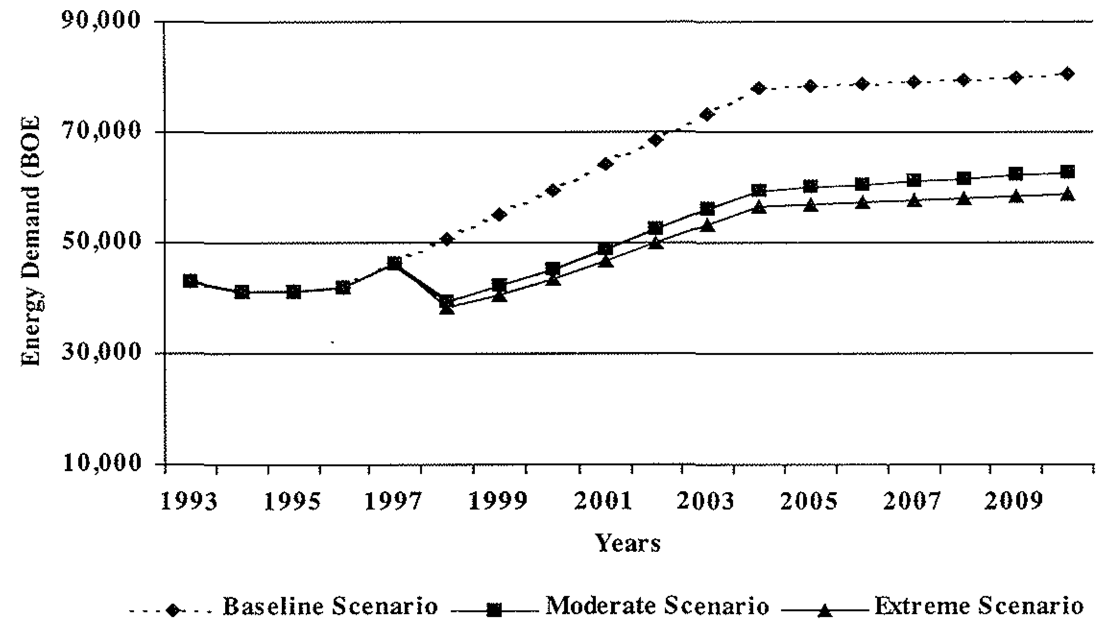

Figure 3: Oil Demand in Kuwait – Different Scenarios

tive growth of about 0.1% annually. The size of automobiles and improvements in technical fuel efficiency will contribute significantly in this direction. Moreover, energy conservation is also expected from all other sectors in the long run as a result of renovation, modernization and improved insulation.

The results have indicated that changing the

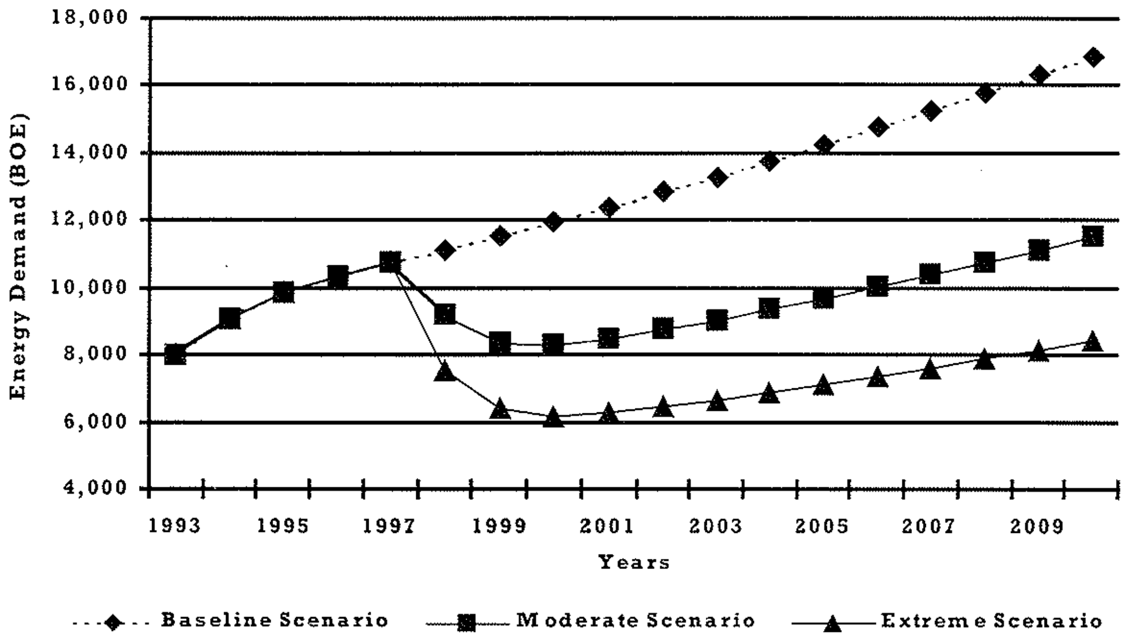

Figure 4: Electricity Demand in Kuwait – Different Scenarios

price structure of energy types should be done in a comprehensive manner. In other words, electricity prices should be adjusted with the adjustment of oil product prices, otherwise an inter-fuel substitution will occur in all sectors. The end results of such inter-fuel substitution will not be desirable.

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1997 Carbon Dioxide Fact Sheet

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The 1997 issue of the 'Carbon Dioxide Fact Sheet' follows the same format as in the previous year (*Energy Studies Review*,8:2:174-76). Energy consumption data for the world and its principal regions and nations is taken from the *BP Statistical Review of World Energy* and converted to emissions of carbon dioxide using standard factors. This well-accepted source of energy statistics is now posted on the World Wide Web at http://www.bp .com/bpstats. The *Review* is normally published in the latter part of June of the following year and so provides a means of estimating emissions of carbon dioxide from the fossil fuels on a consistent basis throughout the world as early as six months after the relevant year-end.

The conversion of one million tonnes of oil equivalent (MTOE), the basic energy unit employed in the *Review*, was taken here as 41.868 petajoules, and the specific factors applied to the three fossil fuels were those employed by the International Energy Agency: for oil — 19.9 million tonnes of carbon (not the dioxide) per exajoule (MTC/EJ); for natural gas — 13.8 MTC/EJ; and for coal — 24.1 MTC/EJ, calculated on the basis of the higher heating value. Should it be desired to express emissions in terms of carbon dioxide rather than the carbon convention used in this note, the factor is 3.67. The limitations on the use of energy consumption data for the estimation of carbon dioxide emissions have been noted previously (Walsh, *ESR*, 5:2:131-5).

In 1997, world emissions of carbon dioxide increased by 1.2% while the corresponding primary energy consumption (excluding biomass and non-commercial forms of energy as is the practice in the *Review*) grew 1.0%, a decrease from the growth of 2.8% in emissions and 3.0% in primary energy consumption reported in 1996. Fossil fuels accounted for 90.1% of the world's energy consumption in 1997.

As listed in Table 1, Canadian emissions increased 3.9% and accounted for 2.1% of the world's total. Canada's per capita emissions of 4.42 tonnes C/person/year were narrowly exceeded by Australia (4.77), but both countries' per

Table 1: 1997 Carbon Dioxide Emissions from Selected Countries and Regions

	1996				1997				% Change & C/person		
Country Region	Oil MTC/%	Nat. Gas MTC/%	Coal MTC/%	Total MTC/%	Oil MTC/%	Nat. Gas MTC/%	Coal MTC/%	Total MTC/%	% In-crease	% of World	Tonnes C/Person
World	2770 44.6%	1144 18.4%	2295 37.4%	6209 100%	2829 45.0%	1142 18.2%	2314 36.8%	6285 100%	+1.2%	100%	1.07
Canada	64.5 50.0%	38.7 29.9%	25.9 20.1%	129.1 100%	68.4 51.0%	38.9 29.0%	26.7 20.0%	134.0 100%	+3.9%	2.1%	4.42
U.S.A.	697.0 45.1%	328.5 21.2%	521.6 33.7%	1547.1 100%	705.3 45.0%	328.9 21.0%	532.7 34.0%	1566.9 100%	+1.3%	24.9%	5.85
E.U. (15)	515.7 56.1%	176.1 19.1%	227.9 24.8%	919.7 100%	519.7 57.0%	174.6 19.2%	216.6 23.8%	910.9 100%	-1.0%	14.5%	2.45
E.Eur. +FSU	219.3 25.9%	310.3 36.6%	317.6 37.5%	847.2 100%	222.6 27.0%	291.2 35.3%	310.8 37.7%	824.6 100%	-2.7%	13.1%	2.03
Australia	29.9 35.4%	10.3 12.2%	44.3 52.4%	84.5 100%	30.7 34.9%	10.2 11.5%	47.1 53.6%	88.0 100%	+4.0%	1.4%	4.77
Brazil	64.0 82.2%	2.8 3.7%	11.0 14.1%	77.8 100%	69.0 82.7%	3.1 3.7%	11.4 13.6%	83.5 100%	+7.2%	1.3%	0.51
China	145.3 17.4%	9.2 1.1%	683.0 81.5%	837.5 100%	154.6 18.1%	10.1 1.2%	687.9 80.7%	852.6 100%	+1.8%	13.6%	0.70
France	75.8 68.8%	18.8 17.1%	15.5 14.1%	110.1 100%	76.6 71.0%	18.0 16.7%	13.3 12.3%	107.9 100%	-2.0%	1.7%	1.84
India	66.2 30.5%	11.3 5.2%	139.5 64.3%	217.0 100%	69.2 30.2%	12.7 5.5%	147.7 64.3%	229.6 100%	+5.9%	3.7%	0.24
Japan	224.9 64.5%	34.4 9.9%	89.1 25.6%	348.4 100%	222.0 64.1%	33.8 9.8%	90.6 26.1%	346.4 100%	-0.6%	5.5%	2.76
Rest-of -World	742.4 61.8%	222.9 18.6%	235.0 19.6%	1200.3 100%	767.6 61.5%	239.0 19.1%	242.5 19.4%	1249.1 100%	+4.1%	19.9%	0.55

capita emissions were less than those from the US, which were valued at 5.85.

Emissions continued to decline in Eastern Europe (a category here that includes all the former members of the old Soviet Union), but at -2.7% the rate was somewhat greater than the -2.4% experienced last year. The 15 nations of the European Union also experienced a decline of 1.0% in emissions in 1997 in comparison with an increase of 2.2% the previous year. Although a member of the EU, France was listed separately because of the importance of nuclear power in that country, which provided 76.1% of its electrical generation in 1996 (only nuclear generation in tiny Lithuania was higher at 85.6%). Nuclear energy also accounted for 41.8% of its primary energy supply in 1997 (computed on the equivalent fuel-input basis) when emissions fell 2.0%.

On the world basis, consumption of nuclear-derived energy decreased for the first time in 25 years, though only by 0.6%, reflecting less generation in both the US and Canada. In both Canada and France, natural gas was a larger source of carbon dioxide emissions than coal.

The United States remains the largest contributor of emissions, accounting for 24.9% of the world total in 1997. The continuing growth in emissions in the large developing countries of Brazil and India is noteworthy at 7.2% and 5.9% respectively, although emissions growth in China fell to 1.8% as compared to 4.7% in the previous year. Per capita emissions remain low in all three countries.

In the rather heterogeneous category of the Rest-of-World (calculated by deducting all the countries or regions specifically listed in Table 1 from the world total), emissions rose 4.1% (a decrease from the 4.7% reported for 1996), but per capita emissions were low at 0.55 tonnes C/person/year.

Primary energy consumption fell generally across Eastern Europe in 1997—including a decrease of 4.1% in the Russian Federation—except for small increases in Slovakia and Ukraine. This contraction in energy consumption reflects the continuing economic difficulties in that region. With a measure of recovery, world emissions of carbon dioxide would be expected to increase more rapidly.

After arduous negotiations at the Third Conference of the Parties (COP 3) to the United Nations Framework Convention on Climate Change held in Kyoto, December 1-10, 1997, Canada committed itself to reduce combined CO_2, CH_4 and N_2O emissions by 6% below 1990 levels, and combined HFC, PFC and SF_6 emissions by 6% below 1995 levels between 2008 and 2012. Because of economic and population growth expected in the intervening period, Canada needs, in effect, to reduce its emissions about 21% below what they would otherwise be in 2010. A new climate change secretariat led by Mr. David Oulton was established by the federal government after this meeting to coordinate this difficult task.

Further information on the subject of world emissions of greenhouse gases may be obtained from the Carbon Dioxide Information Analysis Center of Oak Ridge National Laboratory, which may be reached on the web at http://cdiac.esd.ornl.gov/.