INDUSTRIAL ENERGY POLICY:
A CASE STUDY OF THE DEMAND IN KUWAIT

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Abstract

The purpose of building the industrial energy demand model was to assess the impact of possible policy options and forecast future energy demand under various assumptions including the impact of the possible removal of energy subsidies in accordance with the WTO agreement. The forecasting results of the three scenarios raise several important issues. With nominal energy prices staying the same (the status quo) and inflation and economic growth continuing to expand (i.e., baseline scenario), all industries are expected to have growing demand for energy. The consumption of energy in the industrial sector is projected to grow at an annual growth rate of about 3.5% throughout the forecast period. In the case of the moderate scenario, the consumption of energy in the industrial sector is projected to grow by only 1.9% annually throughout the forecast period. If all the energy subsidies are removed, as in the extreme scenario, the consumption of energy in the industrial sector is projected to grow by only 1.5% annually throughout the forecast period. Moreover, as for inter-fuel substitution, the model forecast indicates that the consumption of electricity and natural gas will decline while the consumption of oil products will increase in all scenarios. The results indicate that changing the price structure of energy resources should be done in a comprehensive manner. In other words, electricity prices should be adjusted upwards instantly with the adjustment of oil products and natural gas prices, otherwise, a massive inter-fuel substitution will occur within the various industries.

ملخص

كان الهدف من بناء نموذج الطلب الصناعي على الطاقة هو تقييم تأثير خيارات السياسة المحتملة وتنبؤ الطلب المستقبلي على الطاقة في ظل تقديرات متنوعة تتضمن تأثير احتمال رفع الدعم عن الطاقة تماشياً مع إتفاقية منظمة التجارة العالمية. وتثير نتائج التقديرات الخاصة بالثلاث سيناريوهات عدة قضايا هامة. فمع بقاء الأسعار الاعتبارية للطاقة ثابتة (الوضع الحالي) واستمرار زيادة التضخم والنمو الاقتصادي (أي السيناريو الأساسي)، من المتوقع أن يزيد طلب جميع الصناعات على الطاقة. ومن المتوقع أن يزيد استهلاك الطاقة في القطاع الصناعي بمعدل نمو سنوي يصل إلى حوالي 3.5% خلال فترة التنبؤ. وفي حالة السيناريو المعتدل، من المتوقع أن يزيد استهلاك الطاقة في القطاع الصناعي بمعدل1.9% سنوياً خلال فترة التبؤ. أما في حالة رفع جميع أشكال الدعم على الطاقة كما في السيناريو المتطرف، فمن المتوقع أن يزيد استهلاك القطاع الصناعي للطاقة بمعدل 1.5% سنوياً فقط خلال فترة التنبؤ. فضلاً عن ذلك، فيما يتعلق بالتبادل بين أنواع الوقود، فتشير التوقعات إلى انخفاض استهلاك الكهرباء والغاز الطبيعي بينما يزيد استهلاك منتجات النفط في جميع السيناريوهات. وتشير النتائج إلى أن تغيير هيكل أسعار مصادر الطاقة يجب أن يتم بطريقة شاملة. أو بمنى آخر، يجب أن يتم تعديل أسعار الكهرباء بالزيادة فور تعديل أسعار منتجات النفط والغاز الطبيعي، وإلا فسيحدث تبادل كبير بين أنواع الوقود داخل الصناعات المختلفة.

1. Introduction

Kuwait's domestic energy consumption has a significant impact on the performance of its economy and on the standard of living of its citizens. The intensity of energy consumption is one of the most striking features of modern life in Kuwait. As a resource-based economy, Kuwait has experienced significant structural changes since the beginning of exporting oil in 1946. These changes have induced rapid increases in the demand for energy domestically, as the consumption of energy in Kuwait has grown consistently since the 1960s.

Energy consumption in Kuwait has also grown consistently since the 1970s at rapid annual growth rates. The domestic demand for energy is mainly met by electricity, oil products, and natural gas. The domestic demand for energy represents a small but increasing fraction of the total energy production. It represented only about 6% of oil production in 1975, however, in 2003 it represented a staggering 18% of oil production. The increase in energy consumption has been due to a number of factors, including economic factors such as higher incomes and low energy prices, and demographic and urban factors such as population growth and the use of land for residential, commercial, and industrial urban purposes. In addition, there are technological factors which encompass a host of variables that have a direct impact on Kuwait's energy intensity consumption patterns.

More importantly, consumers in Kuwait are charged a flat rate of 2 fils per Kilowatt/hour of electricity (kwh), when in fact, the cost of producing each Kilowatt/hour has been estimated at 14 to 26 fils, which means that there is a subsidy of 12 to 24 fils per kwh. Furthermore, energy prices have been declining in real terms since 1975. For example, the nominal price for a litre of gasoline is 80 fils, however, in real terms, based on the year 2000; it costs only about 35 fils per litre. In other words, there is no real price incentive for consumers to conserve their consumption. The government is considering various measures to reduce the subsidy and induce consumers to conserve their energy use. However, removing the subsidies may drive prices of energy upward, which would have serious consequences on the economic performance of the various sectors, and in particular, the industrial sector.

Energy models are constructed in order to be used as tools for evaluating past experiences, assessing the impact of possible policy options, and forecasting future energy demand under various assumptions. Thus, the purpose of this paper is to develop and estimate a model for energy demanded by the industrial sector in Kuwait. Moreover, using the estimated equations and making assumptions about the future course of key explanatory variables, the model, then, can be simulated to assess the impact of possible policy options and forecast future energy demand under various assumptions including the impact of the possible removal of energy subsidies in accordance with the WTO agreement.

Unfortunately, data for the industrial sector's consumption of energy by fuel type, especially for the non-oil industries, are difficult to obtain. Because of this data problem, time series data provided by the Ministry of Energy and the Annual Survey of Industrial Establishments for the period 1980 to 2003 have been used as the basis for these data. In the next section, an overview of the industrial sector energy consumption patterns are discussed and analysed. Section III presents the empirical results and their implications, followed by the simulation of the estimated model under various scenarios about future energy prices in section IV. The conclusions and some policy implications are given in the final section.

2. An Overview

The industrial sector in Kuwait is heavily concentrated in oil-based industries. This sector also includes one of the most important energy supply industries, namely the generation of electricity and water distillation. The consumption of energy by this industry is not in the final demand sector in the sense that it uses other energy fuels to produce electricity, which is another type of fuel. Electricity produced by the industry is then consumed by other sectors such as residential, commercial, governmental ... etc. The consumption of electricity in these sectors is considered to be of the final demand type. Previous studies placed the Electricity & Waters industry by itself and not as part of the industrial sector to avoid this problem. However, for the current study the industrial sector is structured into two main groups of industries:

a) Oil Industries. This includes: 1.Oil & Gas Extraction Industry; 2.Oil Refining Industry; 3.Petrochemicals Industry; 4.Liquefied Petroleum Gas Industry; 5.Electricity & Water Industry.

b) Non-Oil Industries.

The main source for data on this sector was that provided by the Ministry of Energy. An attempt to utilize the Annual Survey of Establishments - The Industrial Sector, which is published by the Central Statistical Office of the Ministry of Planning for the non-oil industries was made. However, due to inconsistency in the data definition and time series, and also due to the fact that various years' data are missing or incomplete, the use of data from that survey was abandoned. The Statistical Yearbook of the Ministry of Electricity & Water was also the source of data on electricity generation. The time period chosen depended on how far back consistent statistics exist, however, most of the time series cover the period from 1980 to 2003. Moreover, all energy types are consumed by the industrial sector. This includes the three main fuels, electricity, natural gas, and oil. Oil is defined to include diesel fuel, heavy fuel oil, light fuel oil, and LPG.

Total energy consumption in the industrial sector grew substantially from 40.75 million barrels of oil equivalent (mboe) in 1980, of which 21.35 mboe is secondary demand consumed at the electricity generation plant, to about 68.55 mboe and 74.93 mboe for 1995 and 2003 respectively, of which 42.94 and 46.93 mboe are secondary consumption for 1995, 2003 respectively. The total energy consumption in the industrial sector grew at an annual rate of about 3.5 percent for the time period. Inter-fuel substitution occurs largely with the introduction of new technology. For example, the adoption of the electric arc process in the seventies in the base metal industry led to the rapid expansion of electricity consumption. The share of oil consumption increased substantially over time. It represented about 18.5 percent of the total energy consumed by the sector in 1980, and amounted to about 34.7 and 38.9 percent in 1995 and 2003 respectively. The consumption of oil also increased, in absolute volume, over the time period, at an annual growth rate of about 8 percent.

Furthermore, the share of electricity increased slightly from about 2.4 percent of the total consumption in 1980 to about 2.5 and 3.3 percent in 1995 and 2003 respectively.

Natural gas has a special status in the industrial sector. It was mostly utilized in the electricity generation and water desalination plants, this represented about 46.1 percent of the industrial sector's natural gas consumption in 1995 and about 54.3 in 2003. Moreover, natural gas consumption grew steadily especially in the 1980s, however, its consumption dropped after the liberation of Kuwait due to the devastation of oil and gas installations caused by the Iraqi invasion and occupation. The production of natural gas, an associated gas, varies directly with crude oil production.

Natural gas is also re-injected in order to enhance crude oil recovery operations. The intensity of the re-injection of natural gas production has varied considerably over the years. Nevertheless, natural gas consumption in the industrial sector stood at about 43.1 mboe in 2003, a decline of about 7 percent from its peak of 46.43 mboe in 1989. Domestic utilization occurs primarily by the electricity generation industry, oil and gas extraction, the LPG plants, the refineries, and petrochemical plants. In 1980, electricity and water industry alone accounted for about 43 percent of total natural gas consumption in Kuwait, while the petroleum-based industries accounted for 57 percent. In 2003, however, electricity and water accounted for about 54.3 while the other industries accounted for 45.7 percent of total consumption of natural gas.

In terms of total energy consumption, the share of natural gas in the industrial sector has declined from 79 percent in 1980 to about 63 percent in 2003. However, the consumption of natural gas has increased modestly in absolute volume over the same time period, at an annual growth rate of about 2 percent.

3. The Model Estimation Results

The industrial sector mainly encompasses oil-based industries. These industries are directed toward exports and are the main sources for income generation in the country. They include oil and gas production, petroleum refining, petrochemicals, Liquefied Petroleum Gas (LPG) plant, and electricity and water. In view of their importance, the energy consumption behaviour of each of these industries has been modelled and estimated separately in this section. However, the approach is quite similar for each of them. Energy has been viewed as a factor of production within the context of the neo-classical "theory of the firm". The demand for energy has been treated as a function of industrial output of the corresponding industry along with some other variables that influence the production decisions.

Three important issues must be mentioned here. First, since oil-based industries are the backbone of the export revenues of the country and are totally owned and operated by the government, no domestic energy prices, in general, were used to explain the energy consumption behaviour of the oil-based industries. Furthermore, there have been no changes in energy prices for industrial use for decades, thus, real energy prices were actually declining over time. These oil based industries include; oil & gas extraction, oil refining, electricity & water, and LPG industries. Meanwhile, the petrochemical and non-oil industries are largely owned by private sector and are charged for their use of energy though at highly subsidized prices. Second, since disaggregated data are not available regarding the consumption of electricity by each sub-industry, an aggregated demand for electricity by the entire industrial sector has been estimated. Third, the conventional unit root tests and the Augmented Dick-fuller test for cointegration for all variables were conducted before proceeding to equations estimation. The empirical analysis starts with the examination of all the variables to determine if they are first-difference stationary. The resultant t-statistics on the first-lagged level obtained from employing the conventional DF test and its extended version, ADF for the 1975-2004 time period, gave evidence that the null hypothesis of non-stationarity has not been rejected for the undifferenced form of all the variables at the 5% level of significance. Moreover, these tests are reapplied after differencing all series. The resultant t-statistics on the lagged first-difference term indicate the rejection of the null hypothesis, suggesting that all the variables are first-difference stationary.

Electricity Consumption by the Industrial Sector

Oil and natural gas and other industries use electricity in their operations. However, data regarding electricity consumption is available for the industrial sector as a whole.

The following is the aggregate electricity demand model for the industrial sector. Total electricity utilised in the industrial sector (lnELCI) is modelled as a function of the real value added of the industrial sector (lnIGDP) where 2000 is the base year, the real price of electricity (lnPELCI), the nominal price of electricity divided by CPI, and lagged dependent variable ($\ln ELCI_{t-1}$). Furthermore, the observations for the 1990-1992 time period have been dropped from the estimation period because of the Iraqi invasion and occupation of Kuwait. The estimated equation is as follows:

$$lnELCI^{*} = -.961 + 0.2089\, lnIGDP - 0.6118\, lnPELCI + 0.4828\, lnELCI_{t-1} \quad (1)$$

$$(-1.97)\ (2.57) \qquad (-4.66) \qquad (4.55)$$

R^2 Adj. = 0.956   S.E.R = 0.09   D.W.= 1.5595

* T-statistics are in the parenthesis

The equation fits the data reasonably well. All the coefficients have the correct signs and are statistically significant. The consumption of electricity in the industrial sector is significantly determined by the income generated in the sector. It gives a short-run income elasticity of about 0.21 and a long-run of 0.404[1]. It shows that an increase in the level of industrial activity will have only a small impact in the short-run but in the long-run, if the prices of electricity and other factors which may also influence electricity consumption remain the same, the demand for electricity will substantially increase.

The results also indicate that electricity demand in the industrial sector is sensitive to the price of electricity. It gives a short-run price elasticity of about 0.61 and a long-run elasticity of about 1.183 which is more than perfectly elastic, indicating significant difference from the short-run elasticity. Both the short and long-run are significantly higher than earlier estimates by Eltony et al. (1997) and Eltony (1995), where the short-run industrial demand elasticity was only 0.05 and the long-run was 0.27, which indicates an improvement. Furthermore, this result is relatively higher than the earlier results obtained by Eltony and Mohammad (1995), where pooled cross-GCC countries data were utilized. The estimated short-run price elasticity was 0.14 and the long-run was about 0.20.

Furthermore, the lagged dependent variable was found to be significant but its size is reasonable. It should be mentioned here that since the regression equation contained lagged dependent variable, it may be argued that D.W. is not an appropriate test statistics, since the D.W. statistics is biased towards two or biased towards accepting the null hypothesis of no auto-correlation in such a situation. The Durbin-H statistics has been recommended to test for auto-correlation disturbances of the first degree. However, Inder (1984) showed that the D.W. test is generally more powerful than the Durbin-H in such cases. Inder (1986) also showed that the critical values of non-stochastic X matrix are valid in regression with lagged dependent variable. In the estimated model, both D.W. and Durbin-H were compared and were found to be in agreement with each other and hence only Durbin-Watson was reported.

A) Oil Industries

Oil and Gas Extraction Industry

Oil and natural gas extracting and processing industry is the most important primary energy supplier to the final demand sector in Kuwait. The energy demand in this industry is dominated by the consumption of natural gas. The industry also consumes a small proportion of oil products, which represents about 1 to 4 percent at the most of total consumption. Thus, total energy utilised by the industry (lnOGI) is modelled as a function of crude oil output (lnPRODO), which reflects the level of activity of the sector. In order to reflect the difficulties in instantaneous adjustments, a lagged dependent variable ($lnOGI_{t-1}$) has also been included. The observations for the 1990-1992 years have been dropped from the estimation period. The estimated equation is as follows:

$$lnOGI = -3.35 + 0.7042\, lnPRODO + 0.2935\, lnOGI_{t-1} \quad (2)$$

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[1] The formula used for calculating the long-run elasticity of a variable is : Bj / (1 – Bx) where Bj is the coefficient of the relevant variables and Bx is the coefficient of the lagged dependent variable.

(-1.79) (4.62) (5.53)

R^2 Adj. = 0.82 S.E.R = 0.17 D.W. = 0.96727

The equation fits the data reasonably well. All the coefficients have the correct signs and are statistically significant. The consumption of energy in the oil and gas operations is significantly determined by the production levels as shown by the results. It gives a short-run elasticity of about 0.70 and a long-run elasticity of about 0.998, which is near perfect elasticity. It may also be worth mentioning that an attempt was made to use crude oil prices in the international market as an explanatory variable, but was latter dropped since the results were not encouraging.

Petroleum Refining Industry

The refining industry uses oil and natural gas in its operations. The total energy demand (lnREFI) was specified as a function of refineries output (lnREFPROD). Kuwait's crude oil production level in any given time period is largely influenced by its production quota which is set by OPEC. As a rule, Kuwait has obligations under various contracts with foreign customers to supply them with certain quantities of crude oil. The availability of crude oil after fulfilling these obligations largely determines the amount of crude oil that goes through the refineries. Furthermore, a dummy variable for the war period (DUM1) was also included. The estimated results are as follows:

lnREF = -8.653 + 1.4317 lnREFPROD - 0.1811 DUM1 (3)

(-7.45) (15.90) (-1.48)

R^2 Adj. = 0.93 S.E.R = 0.23 D.W. = 2.2371

The equation fits the data reasonably well. All the coefficients have the correct signs and are statistically significant. The consumption of energy in this industry is heavily determined by the level of activity in the industry as reflected by the level of output (lnREFPROD). It gives a short-run elasticity to changes in the production level of about 1.43 which is quite high, indicating that the refining industry is rapidly changing with the level of its own output, constrained only by the refineries installed capacity.

Liquefied Petroleum Gas Industry

The LPG plants utilise only one type of fuel as their sole energy source, namely, natural gas. Total energy demand by this industry (lnLPGI) is modelled as a function of natural gas production level (lnGas PROD) lagged one time period, the lagged dependent variable, and the international prices of LPG for export to Japan (lnPLPG). This is mainly because Japan is traditionally the biggest market for LPG from Kuwait. The Japanese imports represented about 85 percent of Kuwait's total LPG exports since 1995. Moreover, the dummy variable for the war period, (DUM1), was included in the estimated equation. The estimated equation is as follows:

$lnLPGI = 6.811 + 0.4916\ lnLPGI_{t-1} - 0.4834\ lnGASPROD_{t-1}$

(4.42) (3.16) (-2.738)

- 0.3363 lnPLPG (4)

(-1.543)

R^2 Adj. = 0.71 S.E.R = 0.39 D.W. = 1.7349

The equation fits the data reasonably well. All the coefficients have the expected signs and are statistically significant. It shows that the consumption of energy in this industry is dependent on the production level of natural gas as well as the international prices of LPG. It gives a short-run elasticity to changes in the production level of natural gas equals to 0.48 and a long-run elasticity of 0.95, which is near perfect elasticity. It also gives a short-run elasticity of about 0.33 to changes in the international oil prices and a long-run elasticity of 0.65. The results indicate the existence of price inelasticity in both the short and long-run as the output of this industry is intended for export rather than for domestic use.

Petrochemicals Industry

This industry also uses one source of energy that is natural gas. It also uses natural gas as a feed-stock input into the production of urea and ammonia among other products. However, this latter use is included in the non-energy use sector. Total energy demand by the petrochemical industries (lnPICI) has been modelled as a function of natural gas production (lnGASPROD), which is largely determined by the production of fertilisers; urea and ammonia. Also, the price of natural gas (lnPNG) lagged one time period and a dummy variable for the occupation and war period (DUM1) was included. The results of the estimation are as follows:

$$\ln PICI = \underset{(1.061)}{0.9584} + \underset{(8.85)}{0.8339}\ \ln GASPROD - \underset{(-1.94)}{0.0791}\ \ln PNG_{t-1}$$

$$- \underset{(-1.62)}{0.0777}\ DUM1 \qquad (5)$$

R^2 Adj. = 0.93 S.E.R = 0.22 D.W. = 1.9136

The equation fits the data reasonably well. All the coefficients have the correct signs and are statistically significant. The consumption of energy in this industry is significantly dependent on the output level of natural gas. It gives a short-run elasticity to changes in output of natural gas of about 0.83, which is near perfect elasticity indicating that levels of natural gas production are crucial for the petrochemical industry. The price of natural gas has the correct sign and is also statistically significant but is inelastic in the short-run. Finally, the dummy variable is also significant and has a negative sign reflecting the stoppage of the production activities during the Iraqi occupation and the liberation war period.

However, there is another use of natural gas in the petrochemical industry that is called non-energy. This is mainly due to the fact that natural gas is not used as an energy source but as an input into the production process. That is to say, that natural gas is used in the petrochemical industry as both fuel and feedstock for the production process. This section is concerned with modelling the demand for natural gas as feedstock in the petrochemical industry (lnPEC). The demand is modelled as a function of the level of natural gas production (lnGASPROD), the domestic price of natural gas (lnPNG) lagged one time period, and a dummy variable (DUM1) for the war period.

$$Ln PEC = \underset{(6.13)}{5.9594} + \underset{(1.81)}{0.4747}\ \ln GASPROD - \underset{(-1.39)}{0.0374}\ \ln PNG_{t-1}$$

$$- \underset{(-1.16)}{0.1680}\ DUM1 \qquad (6)$$

R^2 Adj. = 0.64 S.E.R = 0.18 D.W. = 1.9071

The equation fits the data reasonably well and all the coefficients have the correct signs and statistically significant. The consumption of natural gas in the petrochemicals industry is largely determined by the natural gas production level as shown by the coefficient of natural gas output variable. It gives a short-run elasticity of about 0.47 for changes in the level of output, which is more than inelastic. It is also determined by the price of natural gas. It gives a short-run elasticity of about 0.04 for the changes in natural gas prices. Also, the dummy variables are negative, reflecting the negative impacts of the war on this industry.

Electricity and Water Industry

This industry is the largest user of primary energy in the entire industrial sector and in the Kuwaiti economy in general. It uses large quantities of natural gas and oil products, as well as crude, oil in the process of generating electricity and water desalination. Large volumes of oil and gas are used as the thermal efficiency in the conversion process is low. It is well known worldwide that the electricity generation by thermal technology is, generally, inefficient as only about 20 to 33 percent of oil and gas burned convert to usable electricity.

Total energy consumption (lnEWI) for electricity generation is modelled as a function of the maximum load of electricity production (lnMAX) which is used as a proxy for the level of output of the industry.

Since the residential sector is the biggest consumer of electricity, the level of activity in the residential sector is accounted for by including the variable number of households (lnHH). This variable proved to be significant while estimating the demand by the residential sector. It is worth noting here that we also tried the total number of dwellings as an explanatory variable, as it seemed like a more logical variable to represent the level of activity in the residential sector. However, its coefficient turned out to be insignificant, perhaps because of the dominance of larger dwellings, such as villas consumption of electricity compared to other structures. Therefore, it was dropped.

Since the sector uses natural gas and oil products, we also need to estimate their relative market shares in the total energy demand. However, there are only two types of fuel. Therefore, we need to estimate the consumption equation of only one of these two types, the consumption of the other type of fuel may be obtained as a reminder (residual). The consumption of natural gas (lnGEW) has been estimated. It has been modelled as a function of natural gas production (lnGASPROD) and a dummy variable (DUM1) for the war period. The estimated equations are as follows:

$$\ln EWI = 1.8084 + 0.8646 \ln MAX + 0.1274 \ln HH \quad (7)$$

(1.96) (11.91) (1.11)

R^2 Adj. = 0.98 S.E.R = 0.05 D.W. = 1.2053

$$\ln GEW = 6.253 + 0.9403 \ln GASPROD - 0.1423\, DUM1 \quad (8)$$

(17.09) (10.59) (-1.39)

R^2 Adj. = 0.85 S.E.R = 0.21 D.W. = 2.09297

The equations fit the data reasonably well. All the coefficients have the correct signs and are statistically significant. Equation 7 shows that the consumption of energy in the electricity and water industry is largely determined by the maximum load of production. It gives a short-run elasticity to changes in maximum load of production of about 0.86. The results for natural gas demand equation 8 indicate that the level of natural gas production is the most important determinant of the natural gas utilized in this industry. This is not surprising since all the natural gas produced in Kuwait is a by-product of the production of crude oil. Therefore, the availability of natural gas determines its utilization. The dummy variable gives a negative sign indicating the negative impact of the war period on the industry output and it capacity.

B) Non-oil Industries

This group of industries includes manufacturing of food, beverages and tobacco, textiles, wearing apparel and leather, wood products and furniture, paper and paper products, printing and publishing, non-metallic mineral products, metal industries and other manufacturing industries. In Kuwait, natural gas is made available only to the oil industries. Non-oil industries cannot use it. Therefore, they consume only electricity and some oil products. However, the consumption of electricity for the non-oil industries has already been included in the equation for electricity in the industrial sector (equation 1 above). Therefore, only the demand of non-oil industries for oil products is modelled here.

Total consumption of oil products in non-oil industries (lnNONI) is modelled as a function of the value added of non-oil industries (lnGDPNO). Contrary to oil industries which are totally owned and operated by state companies, the majority of non-oil industries are privately owned and operated. Thus, their activity level and hence their performance, is reflected in their net income (value added) as the main determinant of their demand for inputs, i.e. oil products among others. The average price of oil products used by these industries was also included as an explanatory variable (inPOIL). Also, a lagged dependent variable was included to reflect the stock adjustment energy using equipment and machines in the non-oil industries. The estimated results are as follows:

$$\ln NONI = \underset{(-1.5)}{-1.251} + \underset{(2.04)}{0.4144} \ln GDPNO - \underset{(-1.79)}{0.0597} \ln POIL_{t-1} + \underset{(11.35)}{0.8673} \ln NONI_{t-1} \qquad (9)$$

R^2 Adj. = 0.96   S.E.R = 0.17   D.W. = 2.1816

The equation fits the data reasonably well. All the coefficients have the correct signs and are statistically significant. The consumption of energy in the non-oil industries is dependent on the activities level as reflected by their value added. It gives a short-run elasticity to changes in value added of about 0.41 and a long-run elasticity of about 3.12, which is more than perfectly elastic. The price of oil products is inelastic in the short-run and long-run, it gives 0.05 and 0.38 respectively. The lagged dependent is also significant and gives a coefficient of about 0.87 which indicates a rapid level of stock adjustment.

4. Model Simulation and Forecasts

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 assumptions regarding policy variables, stochastic disturbance terms and values of the parameters (Intrilligator, 1978).

Assumptions of the future values of exogenous variables, together with estimated values of parameters; are used to calculate the values of the endogenous variables from the model's equations. Two main approaches to model simulation are historical and projection simulation.

Projection simulation forecasts values of endogenous variables beyond currently available sample data. Two variations of projection simulation are used: Ex post and Ex ante (Pindyck and Rubinfeld, 1990).

This paper is concerned with Ex ante projection simulation, which covers the period 2005-2015. One may argue that the forecast period of 12 years based on 23 observations (1980-2003) may be subject to large errors; however, given the good statistical results for all estimated equations, it is not the case. In fact, we feel that these errors are mainly contained and do not represent a significant problem in the forecasting process.

Ex ante Energy Consumption Forecasts (2005-2015):

The Baseline Scenario

The baseline scenario serves as a benchmark for the other scenarios and it projects current trends and directions. For the most part, the baseline scenario represents the situation when the current conditions (the status quo) continue. It also gives a long run projection of existing conditions regarding domestic energy consumption of oil products, natural gas, and electricity, but with slower economic rates of growth. A simple set of assumptions is utilised to measure the changes in the key exogenous variables with no changes in current domestic energy prices. The assumptions are:

1. An annual growth rate of 1.5% for the real Gross Domestic Production (2000=100) which is adapted by the Five-Year Economic Development Plan, Ministry of Planning. This growth rate is remarkably low when compared with the 1970s. However, it is not lower than historical levels that prevailed during the 1980s and 1990s.
2. All current domestic energy prices to remain constant throughout the forecast period. This assumption applies to refined products as well as the two-tier pricing policy maintained by Ministry of Electricity and Water for residential, commercial, and industrial users.
3. An annual inflation rate of about 2% in response to the expected slower growth rates for the economy as a whole.
4. All other exogenous variables are assumed to grow at their historical growth rates for the estimation period 1980-2003.

Moderate Scenario

The same set of assumptions that were used for the baseline scenario are essentially utilised here. One major exception is that all domestic nominal energy prices are assumed to increase by 100% fully in 2003 and then remain constant throughout the simulation period. However, the price of natural gas is directly linked to crude oil prices. The aim of this scenario is to reflect the current government intention with respect to increasing domestic energy prices in 2007 and to examine the consequences of such a price adjustment on the industrial sector.

Extreme Scenario

The same set of assumptions implemented by the baseline scenario is also applied to this scenario, with the exception that all domestic nominal energy prices are assumed to upsurge immediately by 200 % in 2003 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 and to learn about how the various energy consuming industries will cope with such a price shock. This will also be helpful in understanding how these industries will react in case of removing all types of energy price subsidies and to know about the directions of fuel switching. The results of these scenarios are reported in Table 1 and discussed in the empirical results section.

The Empirical Results

For the baseline scenario, the consumption of energy in the industrial sector is projected to grow at an annual growth rate of about 3.5% throughout the forecast period. It will increase from about 109.9 mboe in 2005 to about 137 mboe in 2015. This is primarily due to the rise in energy consumption by the electricity & water industry and the petroleum refining and petrochemical industries. The electricity & water industry alone is projected to grow at about 4.7% annually.

Moreover, the model forecasts a rise in the industrial sector's consumption of electricity by about 2.8% annually. It also projects that natural gas consumption by the industrial sector will increase from 49.6 mboe in 2005 to 55.6 mboe in 2015 at an annual growth rate of about

1.3%, which is lower than the historical level reflecting expected natural gas supply constraints.

Inter-fuel substitution occurs largely with the introduction of new technologies. The speed at which consumers adopt these new technologies varies from one sector to another. However, in the long-run, energy consumption could be quite sensitive to changes in the relative prices of various types of fuel. This seems to be the typical case for the industrial sector. The model forecast indicates that the consumption of oil products will increase substantially during the forecast period, from 58 mboe in 2005 to 78.5 mboe in 2015. This means an annual growth rate of about 6.3%, which is the highest growth rate recorded among all the energy resources.

In sum, if the current situation (Status quo) continues and the nominal prices of all energy resources remain the same, causing the real prices to decline, and despite the slower growth in GDP, aggregate energy consumption in the industrial sector will continue to grow for years to come. That is to say, under the assumption of the baseline scenario, there will be no real incentives for energy conservation and the aggregate industrial demand is expected to grow at 3.5% annually.

In the moderate scenario, the consumption of energy in the industrial sector is projected to grow by only 1.9% annually throughout the forecast period. This is primarily because of the increase in energy consumption in the oil and gas production, refining, electricity & water and petrochemical industries. The electricity & water industry alone is projected to grow at about 2.7% annually.

Furthermore, the model forecasts a decline in the industrial sector's consumption of electricity by about -2.5% annually for the entire forecast period. This result should not be surprising considering the fact that, due to the lack of detailed data, total electricity consumption by the industrial sector was modelled as a separate equation, which made the industrial sector appear to be more receptive to electricity price changes.

As for inter-fuel substitution, the model forecast indicates that due to the changes in the relative prices of various fuel types, the consumption of electricity will decline while the consumption of oil products will increase substantially from 41.4 mboe in 2005 to 52.8 mboe in 2015 at an annual growth rate of about 4.2%. Furthermore, natural gas by the industrial sector is projected to increase modestly from about 45.3 mboe in 2005 to about 47 mboe in 2015, at an annual growth rate of only 0.4%. This increase in natural gas consumption reflects mainly an expansion the in electricity & water and petrochemical industries.

In short, the forecast seems to suggest that raising the energy prices by 100 % will cause the consumption of electricity in the industrial sector to decline while the consumption of oil products to increase. That is to say, if the nominal prices of all types of energy rise immediately by 100%, the rate of growth in aggregate industrial energy demand will slow down significantly and the volume of energy use will be reduced by about 26% by the year 2015, when compared with the results of the baseline scenario. The results of the moderate scenario illustrate that, when energy prices move upwards, this will induce all industries to conserve on their consumption of all energy resources. The changes in the relative prices of the various fuel types will also spark the process of inter-fuel substitution.

When all the energy subsidies are removed as in the extreme scenario, the consumption of energy in the industrial sector is projected to grow by only 1.5% annually throughout the forecast period, which is yet lower than the growth rate for the moderate scenario, and less than half the rate of growth reported for the baseline scenario. The increase in the industrial sector energy consumption will primarily come from an increase in the energy consumption of oil and gas, refining, electricity & water, LPG, and petrochemical industries. The electricity & water industry alone is predicted to grow at about 2.2% annually. Furthermore, the model simulation predicts a decline in the industrial sector's consumption of electricity by about -5.4% annually.

Moreover, with respect to inter-fuel substitution, as in the pervious scenarios, the model forecast indicates that the consumption of electricity will decline while the consumption of oil products will increase from 39.9 mboe in 2005 to 48.7 mboe in 2015, which will amount to an annual growth rate of about 3.7%. Furthermore, natural gas by the industrial sector is projected to increase slightly from about 41.8 mboe in 2005 to 44.2 mboe in 2015, i.e., an annual growth rate of only 0.1%. In sum, the growth rate in total energy consumption will slow down dramatically due to a rise in energy prices by 200%. The results of the extreme scenario show that, under no energy price subsidies, the industrial sector's demand is projected to grow at much slower rates of only 1.5% annually.

5. Conclusions and Some Policy Implications

The purpose of building the industrial energy demand model was to assess the impact of possible policy options and forecast future energy demand under various assumptions including the impact of the possible removal of energy subsidies in accordance with the WTO agreement. This will help policy makers in setting effective economic policies. The current model takes advantage of recent advances in econometrics techniques and computing technology to make advanced capabilities for policy analysis and policy design. Moreover, the statistics of the estimated equations are quite reasonable, and the model is robust

The results of the model forecasts, based on the three scenarios, address several important issues. With nominal energy prices staying the same (status quo) and inflation and economic growth continuing to expand (baseline scenario), all industries are expected to have growing demand for energy, particularly the electricity & water and oil refining industries are likely to record the highest growth rates.

For the most part, the results indicate that short and long-run energy consumption and macroeconomic variables are interrelated. The model forecasts show that, for the industrial sector, energy consumption varies directly with economic growth and inflation rates. The simulation of the model under the three scenarios regarding energy prices has indicated that changing the price structure of energy resources should be done in a comprehensive manner. In other words, electricity prices should be adjusted upwards instantly with the adjustment of that of oil products, otherwise a massive inter-fuel substitution will occur within the various consuming industries. The end results of such massive inter-fuel substitution will not necessarily be desirable and they might actually become counterproductive to energy conservation efforts.

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 effectively reduce rates of growth in energy consumption in Kuwait's industrial sector. However, in the long-run, persistent lower economic growth will lead to a reduction in the rates of growth in energy consumption for all industries.

In view of the fact that the industrial sector in Kuwait is rather energy-intensive, the macroeconomic effects of using a deliberate energy price shock, as in the case of the extreme scenario, may substantially reduce real rates of economic growth in these industries without having marginally that large impact on total sector energy consumption. For example, a rise in energy prices by 100% (moderate scenario) will reduce energy consumption by about 26%, and a rise by 200% (extreme scenario) will result in a further reduction in energy consumption by only 6% (31% instead of 20%). In other words, the reason behind the non-linearity of the results of the moderate and extreme scenarios is mainly due to the technology utilized in key industries such as oil & gas extraction, oil refining, electricity generation, and petrochemicals & LPG where minimum capacity utilization have to be maintained.

The moderate scenario shows that a potential for energy conservation exists without too much adverse impact on the economic activities of the industrial sector. The model also reveals that there are definite long-run advantages of introducing an energy price adjustment upward. The greatest potential energy savings exist in the petrochemical, electricity & water, and the non-oil industries.

Given the natural gas supply constraint due to its association with crude oil production operations, on the one hand, and the rising domestic consumption, especially for the expanding petrochemical industry, on the other, the model simulations predicated inter-fuel substitution away from natural gas and electricity towards oil products, particularly in the oil & gas extraction, and Oil refining and LPG industries.

In general, the results of the moderate and extreme scenarios illustrated that there are no doubts increasing energy prices, i.e. reducing subsidies, will have a severe consequences on the entire industrial sector, however, an important note have to be mentioned here that about 95% of the industrial sector is run by state-owned companies that do not actually pay for their use of energy. As it has been pointed out earlier, no changes took place in the structure of energy prices for decades and the impact of price movements might, therefore, be underestimated in the model.

Finally, the results from the extreme case scenario showed that the total removal of energy price subsidies will have severe consequences on the entire industrial sector and will not substantially reduce the consumption of energy by the various industries. It will result in a further reduction in energy consumption by only 6% when compared with the moderate scenario. Thus, the recommendation is to reduce energy price subsidies gradually over a long period of time in order to allow various industries to mitigate the negative impacts of the new business conditions.

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Table 1: Industrial Sector Energy Consumption; Forecast Scenarios by energy type (MBOE)

Energy Type	1995	2000	2005	2010	2015	Growth rate*
Baseline						
Electricity	1.7	2.082	2.306	2.553	2.904	2.75%
Oil Product	23.8	39.559	58.004	59.64	78.486	6.32%
Natural Gas	43.1	47.168	49.615	52.209	55.576	1.29%
Total	68.6	88.809	109.93	114.4	136.97	3.47%
Moderate						
Electricity	1.7	2.082	1.25	1.163	1.018	-2.50%
Oil Product	23.8	39.559	41.413	43.836	52.822	4.16%
Natural Gas	43.1	47.168	45.264	45.976	46.965	0.43%
Total	68.6	88.809	87.927	90.974	100.81	1.90%
Extreme						
Electricity	1.7	2.082	0.863	0.734	0.534	-5.44%
Oil Product	23.8	39.559	39.97	41.075	48.695	3.71%
Natural Gas	43.1	47.168	41.824	43.921	44.206	0.13%
Total	68.6	88.809	82.657	85.73	93.435	1.50%