Energy Demand Forecasting in Thailand

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1. Introduction

Estimates of future energy demand are a critical element of energy planning, at either the aggregate consumption level or the sectoral level. One of the most important reasons for making projections of future energy demand is the lead time required for supply projects. Since a typical baseload electric power plant takes between 5 and 10 years to build, investment decisions must also be made with a 5 to 10 year lead time. Similarly natural gas pipelines, LNG projects, and other capital intensive energy supply projects invariably are predicated upon some estimate of future demand. It is, therefore necessary to properly plan for meeting the future energy demand of the country, to avoid supply shortages in future. The goal of this study is to use historic evidence to make a quantitative of future energy demand in the country. In this study aggregate energy demand, commercial energy and renewable energy in the term of final energy were forecasted to the year 2010 by sectors using time-trend analysis, energy-GDP elasticity and econometric method.

The energy consumption in Thailand is usually disaggregated into 4 sectors, namely, industry; transportation; agriculture; and residential & commercial. In the past 10 years, the transportation sector has been the largest consumer of energy with a growth rate of 7.1 percent in the final energy consumption. The final energy consumption growth rates for the rest of the sectors : industry; residential & commercial; and agriculture sectors have been 7.2, 2.6 and 1.5 percent respectively.

2. Data

There are three types of data : consumption data, macroeconomic activity data and price data. The data collected are annual time series in each sectors of the country from 1984 through 1998. All the consumption data from the Thailand Energy Situation is published by the Department of Energy Development and Promotion, Ministry of Science, Technology and Environment[1]. Income figure of the country from the Office of the National Economic and Social Development Board[3]. All the price data are from the National Energy Policy Office.

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3. Methodology

The methodologies adopted for assessing the energy demand include time – trend analysis and energy – GDP elasticity. We also tried an alternate approach to the econometric model. All the approach, both total and sectoral energy demand have been considered which annual observation data from 1984 to 1998. In this study, aggregate energy demand including commercial energy and renewable energy were forecast to the year 2010.

3.1 Energy Demand Forecasting Using Trend Analysis

Based on the past fifteen years (1984 – 1998) data on the total energy consumption (TEC) in Thailand the following linear regression relationship of TEC with time (t) has been developed.

$$TEC(\text{in ktoe}) = 12892 + 2525.24\ t \quad ; R^2 = 96.7821 \qquad (1)$$

With t = 1 for 1984

Once again an attempt to undertake a time trend analysis of the sectoral energy consumption was made and the following regression relations were obtained.

$$TEC_{ind.} = 2625.74 + 975.132\ t \quad ; R^2 = 91.7439 \qquad (2)$$
$$TEC_{Tran.} = 3279.85 + 1177.61\ t \quad ; R^2 = 95.8885 \qquad (3)$$
$$TEC_{Agri.} = 1390.25 + 27.1357\ t \quad ; R^2 = 38.7848 \qquad (4)$$
$$TEC_{Res\&Com.} = 5595.9 + 345.379\ t \quad ; R^2 = 88.3236 \qquad (5)$$

The poor value of R^2 for agriculture sector is due to large fluctuation in annual values. Fig.1 shows the above regression relations graphically. It may be noted that the energy consumption in industry and transportation sectors of Thailand is increasing very rapidly. The energy consumption in residential & commercial sector is also showing moderate growth but the energy consumption in the agriculture sector is varying very little. Table 1 presents the sectoral energy consumption values as obtained using equation (2) – (5). The total energy consumption values obtained by summing up the sectoral values are compared with the total as obtained from equation (1).

Table 1. Projected Energy Consumption by Sectoral Using Trend Analysis. (ktoe)

Year	Industry (a)	Transportation (b)	Agriculture (C)	Res. & Com. (d)	Total	
					a+b+c+d	Eq.1
2000	19,203	23,299	1,851	11,467	55,820	55,821
2005	24,079	29,187	1,987	13,194	68,447	68,447
2010	28,954	35,075	2,123	14,921	81,073	81,073

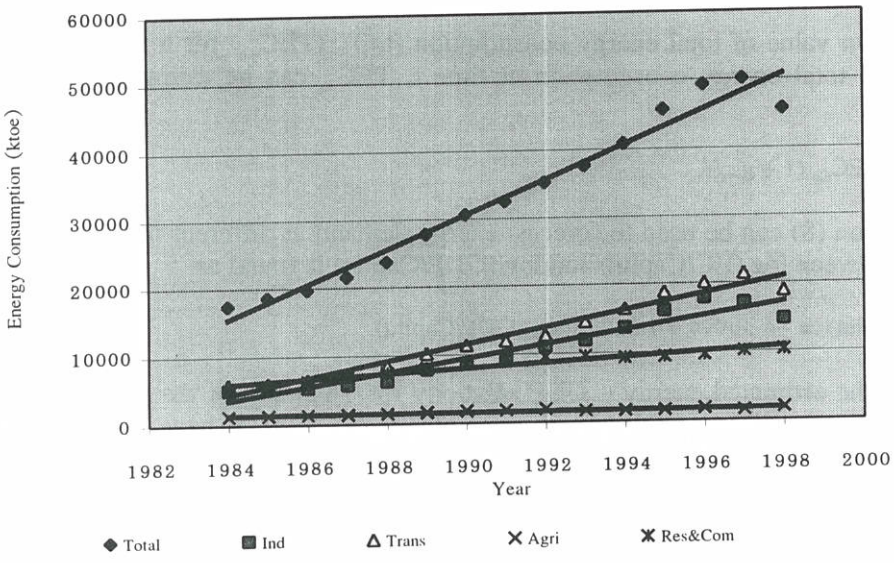

Fig. 1 Time Variation of Energy Consumption in Thailand.

3.2 Energy Demand Forecasting Based on Energy – GDP Elasticity.

The energy – GDP elasticity is defined as the ratio of the percentage change required in energy consumption to the percentage change in GDP. In other words the energy – GDP elasticity indicates the required percentage increase in energy consumption for a unit percentage increase in the GDP. For most of the developing countries with poor infrastructure the energy – GDP elasticity is greater than 1 in contrast with the developed countries where its value is usually less than 1. Thus, in most of the developing countries the growth rates of energy consumption have to be more than the desired growth rate in GDP. The energy planning exercise should accordingly be conducted. In the present work an attempt has been made to estimate the energy – GDP elasticity for the whole economy as well as for four different sectors. This was done by obtaining a log–log relationship between the total energy consumption (TEC) and GDP of the following form :

$$\log (TEC) = a + b \log (GDP) \qquad (6)$$

It can be shown that the coefficient in equation (6) is the energy – GDP elasticity. The energy – GDP elasticity can also be estimated for different sectors. The energy – GDP elasticity (EGE) can be used for energy demand forecasting. If the desired GDP growth rate is g_{GDP} then from the definition of energy – GDP elasticity, the growth rate in total energy consumption (g_{TEC}) can be estimated as

$$g_{TEC} = g_{GDP} * (\text{energy} - \text{GDP elasticity}) = g_{GDP} * EGE \quad (7)$$

For a known value of total energy consumption (t=0), ($TEC_{t=0}$) for a reference year the future value of total energy consumption at time t, $TEC_{t=t}$ can be estimated from the equation

$$TEC_{t=t} = TEC_{t=0} (1 + g_{TEC})^t \quad (8)$$

This equation (8) can be used to forecast energy demand at different times in future. The relationship between log (EC/Capita) and log (GDP/Capita) is found as

$$\log (EC/Capita) = -4.36494 + 1.01945 \log (GDP/Capita) \quad (9)$$

Therefore the estimated energy – GDP elasticity for Thailand for the period 1984 – 1998 is 1.01945. Three different GDP growth rates of 7%, 5% and 3% have been assumed for high, medium and low growth scenarios respectively. The energy – GDP elasticity (EGE) has been assumed to be the same as estimated above. Table 2. presents the energy demand projection for the three different growth rate scenarios. It may be noted that the projected energy consumption value 81,073 ktoe for the year 2010 as obtained by time trend analysis in Table 1. is very close to the value obtained for the medium growth rate scenario of Table 2.

Table 2. Estimated Energy Demand Based on Energy–GDP Elasticity Method (ktoe).

Year	High growth rate (7%)	Medium growth rate (5%)	Low growth rate (3%)
2000	52,427	50,453(55,821)	48,512
2005	74,004	64,699(68,447)	56,400
2010	104,460	82,968(81,073)	65,571

* In the parenthesis are the values obtained from time trend analysis (Eq.1)

3.2.1 Sectoral Energy – GDP Elasticity.

A similar attempt has also been made by determining sectoral energy – GDP elasticity. In this case, the energy – GDP elasticity for four different sectors of the economy has been estimated based on the sectoral energy consumption data and the contribution of the respective sectors to GDP.

$$\log (TEC_{Ind.}) = a + EGE_{Ind.} \log (GDP_{Ind.}) \quad (10)$$
$$\log (TEC_{Trans.}) = a + EGE_{Trans.} \log (GDP_{Trans.}) \quad (11)$$
$$\log (TEC_{Agri.}) = a + EGE_{Agri.} \log (GDP_{Agri.}) \quad (12)$$
$$\log (TEC_{R\&C.}) = a + EGE_{R\&C.} \log (GDP_{R\&C.}) \quad (13)$$

For certain values of assumed growth rates for the sectors and the values of respective energy – GDP elasticity obtained from equations (10) – (13), the future energy consumption of each sector can be estimated from the expression.

$$TEC_{Ind.,t=t} = TEC_{Ind.,t=0}(1 + g_{TEC,Ind.})^t \quad (14)$$
$$TEC_{Trans.,t=t} = TEC_{Trans.,t=0}(1 + g_{TEC,Trans.})^t \quad (15)$$
$$TEC_{Agri.,t=t} = TEC_{Agri.,t=0}(1 + g_{TEC,Agri.})^t \quad (16)$$
$$TEC_{R\ \&\ C.,t=t} = TEC_{R\ \&\ C.,t=0}(1 + g_{TEC,R\ \&\ C.})^t \quad (17)$$

Where

$$g_{TEC,Ind} = g_{GDP,Ind.} * EGE_{Ind.} \quad (18)$$
$$g_{TEC,Trans.} = g_{GDP,Trans.} * EGE_{Trans.} \quad (19)$$
$$g_{TEC,Agri.} = g_{GDP,Agri.} * EGE_{Agri.} \quad (20)$$
$$g_{TEC,R\ \&\ C.} = g_{GDP,R\ \&\ C.} * EGE_{R\ \&\ C.} \quad (21)$$

The average GDP growth rate (%) in different sectors for the last 5 year (1994 – 1998) are 4%, 5%, 1.5% and 4.5% for industry, transportation, agriculture and residential & commercial sector respectively. The GDP growth rates are used for estimation of energy demand in four different sectors using expressions (18) – (21). The energy – GDP elasticity for industry, transportation, agriculture and residential & commercial sectors are 0.958854, 1.07831, 0.570456 and 0.620061 respectively. Table 3 shows the projections of energy consumption in different sectors.

Table 3. Future Projections of Sectoral Energy Consumption Base on Energy-GDP Elasticity (ktoe).

Year	Industry	Transportation	Agriculture	Res. & Com.
2000	15,833	20,944	1,912	10,834
2005	19,111	27,232	1,996	12,432
2010	23,067	35,407	2,082	14,266

3.2 Econometric Method

In the econometric method the model developed determines the total demands for energy in the industry, transportation, agriculture and residential & commercial sectors. In the industry sector, the dependent variable is the total energy demand in industry sector. The independent variables are the GDP produce by industry sector, the average energy price, percent share of manufacturing sector, and demand lagged one year. The transportation sector, the total energy demand is a function of GDP in this sector, average energy price, GDP per capita and a lagged value of demand. Similarly to residential & commercial sector, the total energy demand is considered as a function of GDP from the sector, average energy price, number of population and a lagged value of demand. Except for the agriculture sector the model consists of two equation : an equation for petroleum product and electricity. Both of the equations are a function of GDP, average energy price, number of the areas for planting and a lagged value.

All the estimation has been made in the logarithmic form based on the observations in the past ten years (1989-1998) on final energy consumption in each sector. The estimation of the model is given in Table 4. All the equations are satisfactory in terms of their goodness-of-fit (adjusted R^2). The lower R^2 of the petroleum product is in the equation in

agriculture sector, relative to the large fluctuation in annual values of this sector. In this methodology the the foreast of total energy demand of the country is obtained by summing up the forecasting of each model. The Fig 2. hows the projection of the total energy demand as obtained by 3 different methods.

Table 4. Estimated Models in each sectors.

	Dependent variables				
	Log $EC_{Ind.}$	**log $EC_{Trans.}$**	**log $EC_{Res. \& Com.}$**	**log $PP_{Agri.}$**	**log $EE_{Agri.}$**
Constant	-27.493	-1.85173	14.7156	6.86516	28.2224
Lag dependent	-0.472124	-0.342851	0.172771	0.276161	-0.193393
log $GDP_{Ind.}$	1.64017				
log $Price_{Ind.}$	0.1753				
log SM	4.22673				
log $GDP_{Trans.}$		2.11493			
log$Price_{Trans.}$		0.100195			
logGDP/Cap.		-1.0505			
log $GDP_{Res\&Com.}$			0.172771		
log $Price_{Res\&Com.}$			0.235785		
LogPopulation			-13.5941		
log$GDP_{Agri.}$				0.17996	0.003856
Log$pricePP_{Agri.}$				0.375511	
Log$priceEE_{Agri.}$					2.14395
logArea.				-0.36467	-2.01982
R^2	**97.1534**	**98.8629**	**96.1576**	**51.1216**	**96.2516**

Table 5. Projected Energy Demand by Econometric Method. (ktoe).

Year	Industry	Transportation	Agriculture	Res. & Com.
2000	19,360	24,479	2,233	11,002
2005	24,394	31,267	2,304	12,389
2010	29,428	38,054	2,375	13,777

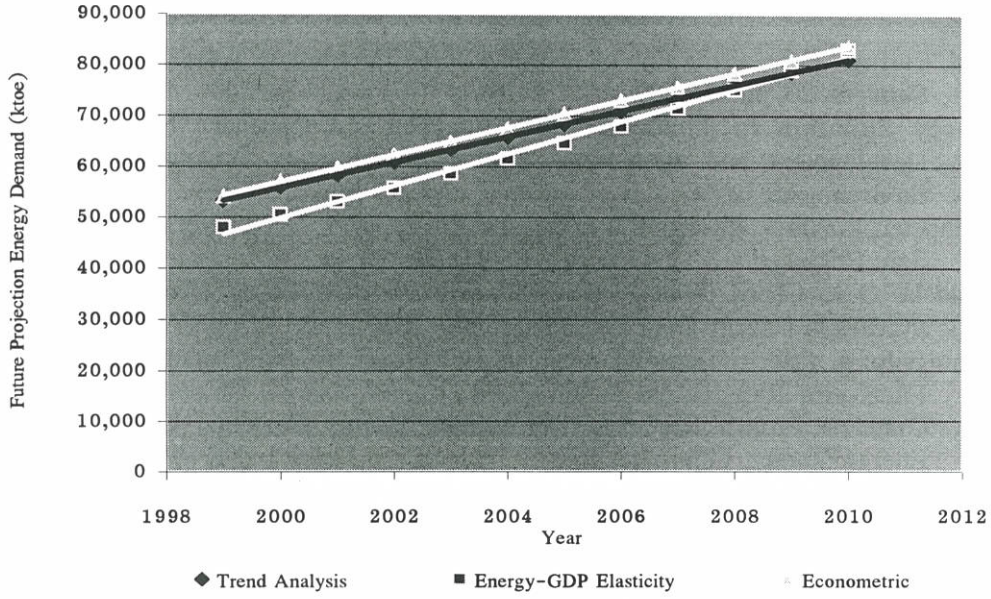

Fig 2. Total Energy Demand Projection by Different Method.

4. Conclusions and Recommendation

A preliminary attempt to forecast the final energy demand (total as well as sectoral) for Thailand has been made in the work, using different approaches. The time–trend analysis forecasts a final energy demand of 81,073 ktoe for the year 2010 which is equal to the summing up of results from sectoral forecasting. A similar figure for energy consumption for 2010 is arrived using energy – GDP elasticity method for a GDP growth rate of about 5 percent. In the econometric method, the result shows that by the same year, the total energy demand will reach 83,634 ktoe. Interestingly, the total projected sectoral energy consumption values base on individual time – trend analysis for each sector matches very closely with the projected aggregated energy consumption. Also, the total energy demand values obtained from three different approach are closely.

The present study is a modest attempt towards understanding some issues relating to the energy demand of the country. Future research could be directed at number of issues, in particular, to develop econometric models for the individual fuel including renewable energy. The other suggested research are development of detailed Reference Energy System (RES) for the country using data on energy extraction, transmission & distribution and utilization, to prepare various demand – supply balancing, strategies and analysis their investment implication and to analysis energy – economy – environment interaction. ❖❖

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