Chapter 2

Methodology

Cecilya Laksmiwati Malik

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2.1 Model Framework

Energy modelling involves the forecast of final energy consumption and the corresponding primary energy requirements or supply. Final energy consumption forecasts cover the industry and transport sector, as well as 'the Others' sector, which comprises agriculture, residential, commercial, and other sectors.

The Lao PDR energy outlook model was developed using the Long-range Energy Alternatives Planning System (LEAP)[1] software, which is an accounting system used to develop projections of energy balance tables based on final energy consumption and energy input and/or output in the transformation sector. Final energy consumption was forecast using energy demand equations by the energy sector and future macroeconomic assumptions.

The energy demand equations are econometrically estimated using historical data, while future values are projected using the estimated energy demand equations under given explanatory variables. An econometric approach means that future demand will be heavily influenced by historical relations between socioeconomic activities and energy demand. However, the supply of energy and new technologies is treated exogenously.

Microfit,[2] a macroeconomic software was used in estimating the demand functions. Microfit offers an extensive choice of data analysis options. It is a versatile aid in evaluating and designing advanced univariate and multivariate time series models. It is an interactive, menu-driven programme with a host of facilities for estimating and testing equations, forecasting, data processing, file management, and graphic display.

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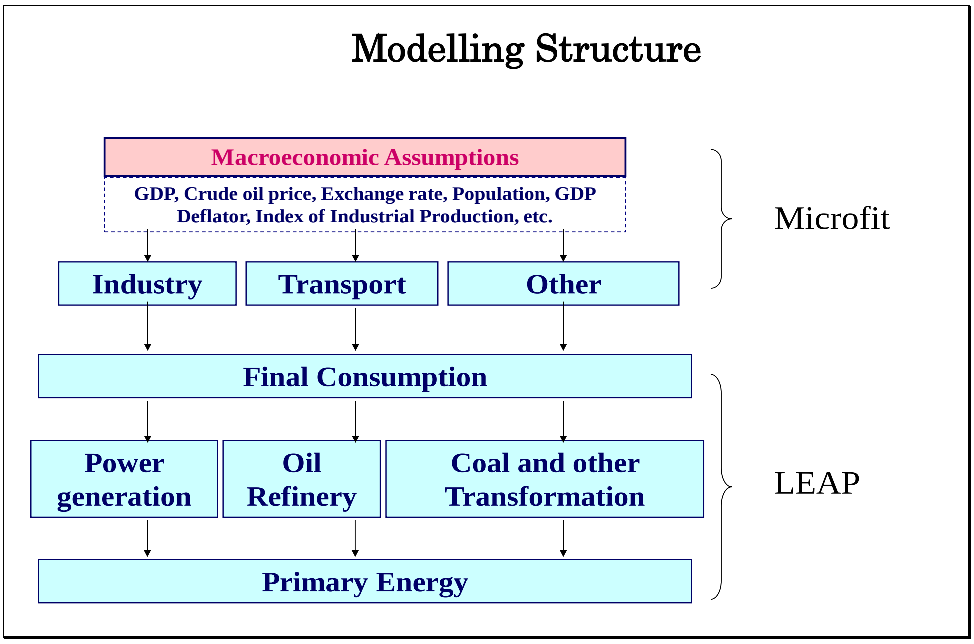
[1] LEAP or the Long-range Energy Alternatives Planning System is an energy policy analysis and climate change mitigation assessment software developed at the Stockholm Environment Institute. For more information see: http://www.energycommunity.org/default.asp?action=47

[2] For more information on Microfit, see http://www.econ.cam.ac.uk/people-files/emeritus/mhp1/Microfit/Microfit.html

Figure 2.1 showed the model structure from final energy demand projection and forecast of transformation inputs and/or outputs to arrive at the primary energy requirements including the computer software used in the modelling work.

Figure 2.1 Structure of the Lao PDR Energy Outlook Model

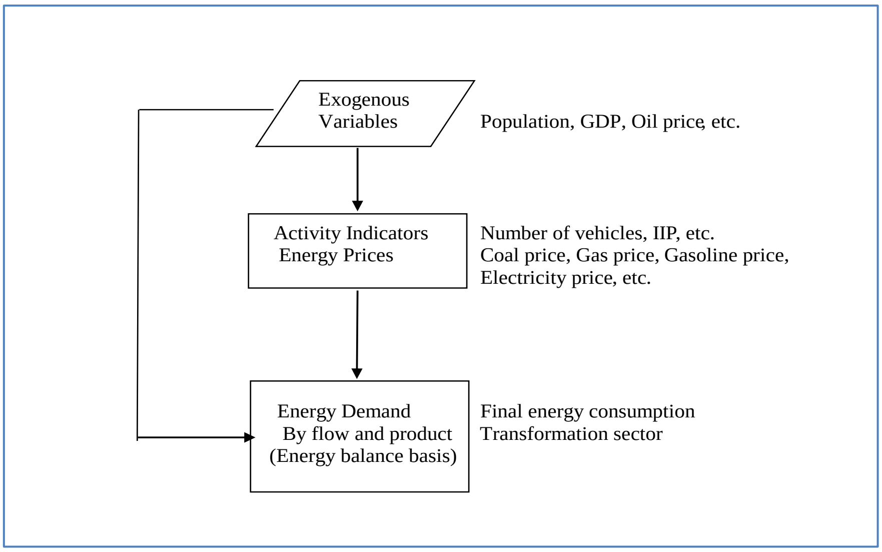


GDP = gross domestic product, LEAP = Long-range Energy Alternatives Planning System.
Source: Lao PDR modelling work.

2.2 Estimating Demand Equation

The future energy demand for various energy sources are forecast using assumed future values of the macroeconomic and activity indicators. The future values of these indicators were also derived using historical data when data are enough for such analysis. The overall concept of estimating the final energy demand equation is shown in Figure 2.2.

Figure 2.2 Process Flowchart of the Lao PDR Energy Outlook Model



GDP = gross domestic product, IIP = Index industrial production.
Source: Lao PDR modelling work.

In this process flowchart, energy demand is modelled as a function of activity such as income, industrial production, number of vehicles, number of households, number of appliances, and floor area of buildings. In the residential sector for example, the demand for electricity could be a function of number of households, disposable income, and penetration rate of electrical appliances. In the commercial sector, energy consumption could be driven by building floor area, private consumption, and other factors that encourage commercial activities.

Such relationships among variables were derived using linear regression. The basic formulation is:

$$Energy\ Demand\ (De) = f(Y,\ Pe/PGDP,\ De_{-1})$$

where,

Y: Income (GDP, etc.)

Pe: Energy price (Oil price, etc.)

PGDP: GDP` deflator (Overall price, CPI, etc.)

Pe/PGDP: Relative variable

De: Energy Demand (Coal, oil, gas, and electricity)

De_{-1}: Lag variable (show habit)

As mentioned earlier, the regression analysis for the Lao PDR energy outlook was derived using Microfit. The derived econometric equations were used in the LEAP model to estimate future energy demand based on growth assumptions of the activity (independent) variables such as the gross domestic product (GDP).

In cases where regression analysis is not applicable due to insufficient data or there is a failure to derive a statistically meaningful equation, appropriate growth assumptions were used to forecast future demand.

2.3 Forecasting Primary Energy Requirements

Having forecast the future final energy demand, the corresponding primary energy requirements need to be projected. Some of these primary energy requirements are the inputs to transformation to produce secondary fuels. Energy transformation involves electricity generation, oil refining, gas processing, charcoal making, and any other process that converts fuels from primary energy to secondary products.

For the Lao PDR, only the primary requirements for electricity generation were considered in the transformation sector. There is a plan to construct an oil refinery in the future. Since no firm capacity was provided, the oil refinery was not included in this first energy outlook.

Electricity in the Lao PDR is mainly produced from hydropower plants. The Lao PDR also has coal, solar, and biomass power plants. The electricity generation process in the model calculated the fuel requirement to produce electricity. The calculation of the primary energy requirements for electricity generation involves the following steps:

- *Forecasting the total electricity generation requirements*

  The total electricity generation requirement is greater than the final electricity demand to cover the electricity consumption in the power stations and the expected losses in the transmission and distribution systems. The additional requirement for the Lao PDR was above 10% of the total final demand.

- *Forecasting electricity generation capacity requirements*

  This involves two processes. The first process is forecasting the total capacity requirement, which is the capacity needed to meet the peak demand. The total capacity requirement is the peak demand plus the assumed reserve margin which is a percentage of the peak demand. The reserve margin is the preferred amount of available capacity above the peak demand to ensure that there is no disruption in the supply.

The second process is determining the power plants that should be added when the total capacity of the existing power plants cannot meet the peak demand. This is not the case for the Lao PDR due to its vast hydropower potential. The Lao PDR has been developing a sizeable amount of its hydropower resources for export to Thailand. Its coal resources have also been developed mainly for export to Thailand. Biomass and solar capacities will be further developed in the future with some possibility of also developing wind power plants.

- *Forecasting generation by each type of power plant*

  Generation by individual type of power plants in the Lao PDR's energy model used the dispatch rule that will meet both the annual demand for electricity as well as the instantaneous demand for power in time slices of the year. Each power plant will be run (if necessary) up to the limit of its maximum capacity factor in each dispatch period.

2.4 Estimating Fuel Inputs

Finally, the information of electricity generation together with conversion efficiency variables or the thermal efficiencies are used to calculate the input fuels required by power plants. This can be derived from the simple formula below:

$$Fuel\_Input_i = \frac{Electricity\_Generation_i}{Efficiency_i}$$

2.5 Case Studies and Scenarios

The Lao PDR outlook examined the Business-As-Usual (BAU) scenario reflecting the Lao PDR's current goals and action plans:

BAU. This scenario uses the historical correlations of final energy consumption and economic activity from 2000 to 2016. The GDP growth rate is appropriate. The GDP growth rate is used to estimate other drivers of energy demand like the GDP of the industrial sector, GDP per capita, number of vehicles, etc. In view of the use of the regression analysis, the trend of future consumption will be similar to the historical trends. The energy supply would be based on the current targets of the government as well.

In addition, the outlook examined the impact of the following cases:

1. Changes in the GDP. In this regard, the study examined the impact of increasing the GDP growth rates by 1% higher than that of the BAU scenario GDP growth rate. Next the study examined the impact if the GDP growth rate decreased 1% more than the BAU scenario for assessing energy demand sensitivity to the GDP.
2. High oil prices. Under this case, the crude oil price was assumed to reach $200 by 2030 and $250 by 2040, compared to $150 and $200 under the BAU scenario for assessing energy demand sensitivity to the energy price.
3. Additional energy efficiency (EE) promotion. This case examined the impact of implementing energy efficiency and conservation programmes that will reduce final energy consumption in the BAU scenario by 10% in 2040 (EE10) and by 20% in 2040 (EE20).
4. Renewable energy (RE) development. This case examined the impacts of implementing an RE development policy that will increase the share of RE (solar and wind) in the power generation mix to 10% by 2040 (RE10) and to 20% by 2040 (RE20).