Economic Analysis of Gas Subsidy Reform and Fit Mechanism in the Malaysian Electricity Sector Based On the CGE Model

Fatemeh Chatri, Faculty of Economics and Management, National University of Malaysia, 43600 Bangi, Selangor Malaysia, Tel: +6017-278-5814, Email: f_chatri@yahoo.com.

Masoud Yahoo, Faculty of Economics and Management, National University of Malaysia, 43600 Bangi, Selangor Malaysia, Tel: +6017-278-5832, Email: yahoo.masoud@gmail.com.

Abstract

As a means to keep emissions low, the power sector in Malaysia benefits from the heavy subsidies provided for its gas inputs. However, such an intervention disrupts the price mechanism and causes inefficient resource allocation. However, removing the gas subsidy without provision for alternative clean energy will result in gas being substituted with cheaper energy inputs such as coal that will increase CO2 emissions. In addition, the government encourages the generation of electricity from renewable energy (RE) sources with the implementation of Fit-in-Tariff (FiT) policy in light of environment and climate change issues, and to strengthen energy security while diversifying energy supplies. However, financing FiT framework by passing the cost only to electricity users is not effective enough to develop RE sources in the electricity sector. Any subsidy reform inevitably has economic, social and environmental consequences. Hence comprehensive assessments of their potential implications are important. The lack of quantitative analysis on how fuel subsidy reforms would operate through the Malaysian economy has given rise to doubts and faces resistance from the general public. This study examines the impact of the removal of gas subsidies in the power sector on the Malaysian economy taking into account market inter-dependence in both the outputs and factors of production. The study also evaluates and compares several methods of levying funds and remunerating the existing FiT mechanism, which has been identified as the main policy instrument implemented by Malaysia for promoting electricity from RE sources.

Keywords: Electricity, Malaysia, Fuel subsidy reforms, CGE model, Renewable energy, Feed-in-tariff.

1 Introduction

As in most developing Asian countries energy in Malaysia is seen as a social good that is critical to poverty alleviation and economic development. Malaysia is blessed with both fossil and renewable-energy resources and has so far been able to meet the country's demand for energy. The country depends mainly on fossil fuels to supply its energy needs. Natural gas provides approximately 46 percent of the required fuel, while the remaining 54% of primary fuel supply comes from crude oil and petroleum products (32.5%) and coal and coke (18.9%). The contribution of renewable energy in Malaysia is small with only about 2.6% of the country's primary energy being derived from hydro sources (Energy Commission, 2012).

In the past decade, there has been a significant growth in the supply of primary energy in Malaysia. Based on data from APERC (2009) Malaysia's primary energy supply is projected to grow at 2.8% a year, from 65.9 Mtoe in 2005 to 130.5 Mtoe in 2030. The growth is driven mainly by the demand for coal and gas in the electricity generation sector and oil products in the transport sector. Electricity generation accounts for 91% of the total increase in primary coal consumption (APERC, 2009).

Of the final usage of total primary energy, the electricity sector's share was 22% in 2010 (Energy Commission, 2012). As Figure 1 shows, Malaysia's final energy demand is projected to grow at an average annual rate of 3.4% to reach 92.9 Mtoe in 2030 – more than double the 2005 level. In terms of types of energy, petroleum products will make up 56% of the total final energy demand in 2030, followed by electricity (23%), natural gas (15%), renewable energies (4%), and coal (2%).

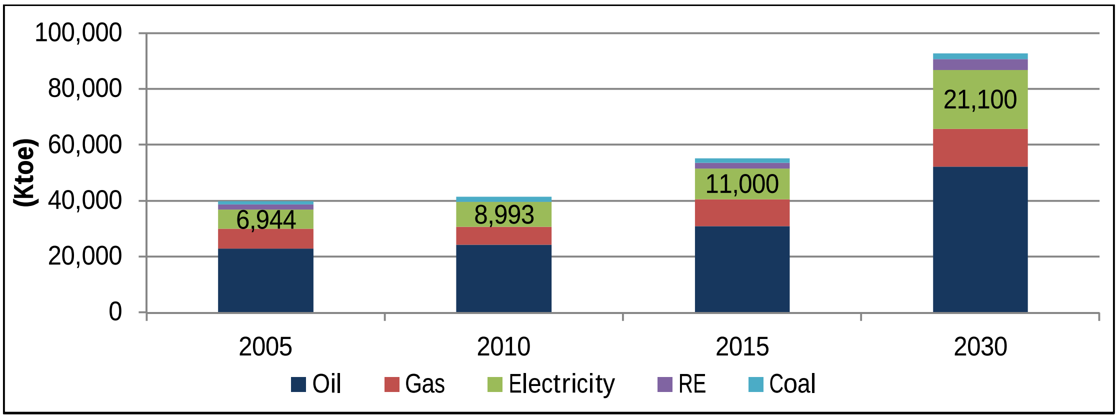

Figure 1 Final use of energy by type of fuels
Source: Based on APERC (2009); Energy Commission (2012)

From the final energy consumption perspective, electricity consumption has increased rapidly due to social development and impressive and economic growth (Chen, Kuo, & Chen, 2007; Tang & Tan, 2013). The consumption of electricity has risen from 19,932 GWh in 1990 to 80,705 GWh in 2005 with an annual growth rate of 9.8%. Based on data from 2012 National Energy Balance (NEB) electricity consumption and GDP have maintained a similar trend and have a positive relationship (Figure 2). The growth rate of GDP and electricity consumption was consistent until the mid 1990s when GDP growth rates declined although that of electricity consumption continued to increase. This trend is alarming for planners especially taking into account the country's dependence on fossil fuels.

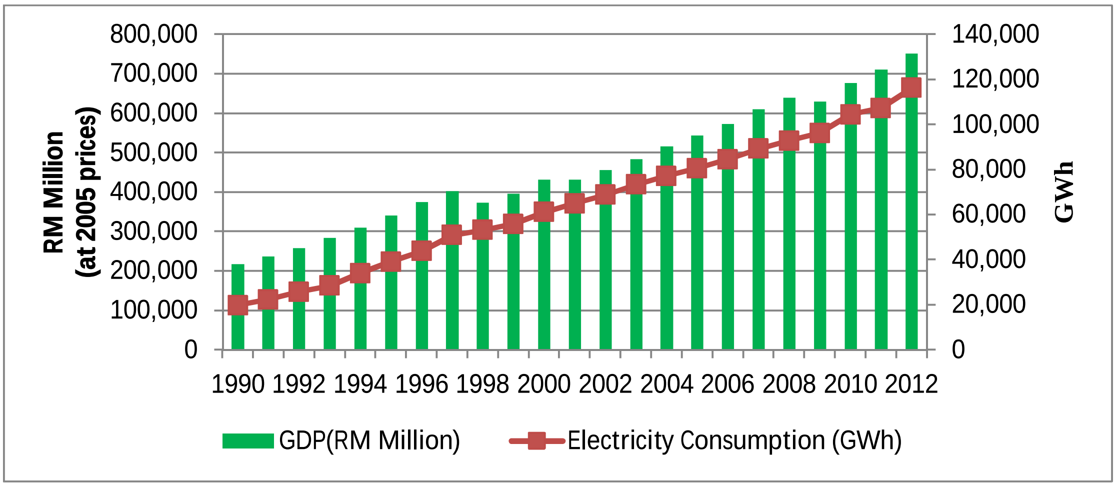

Figure 2 Trends of GDP and electricity consumption, 1990–2012
Source: Based on Energy Commission (2012)

As shown in Figure 3, Malaysia's electricity generation is primarily based on 5-types of resources namely, natural gas, coal, oil, hydro, and others (solar, biogas, and biomass). The total energy input in power stations increased slightly by 4.8% in 2012 to 29,252 ktoe while the portion of distillates and oils in the fuel-mix has drastically decreased from a significantly high 90% dependency in 1978 (M. Energy Commission, 2008) to less than 5% in 2012. To balance the ratio of the fuel-mix, and since Malaysia is blessed with abundant natural gas reserves, the trend for this fuel has shown an increase from less than 5% in 1978 to as much as 40% in 2012. Despite the fact that there are sufficient natural gas reserves in Malaysia, their depletion is inevitable. At current consumption rates, reserves are estimated to last another 32 years.[1] In addition, 90% of coal supplies into the country are imported from Indonesia, China, Australia, and South Africa (Mohamed & Lee, 2006). Consequently, a gradual shift towards coal (the most polluting fossil fuel) in the power sector over the past 17 years will lead to a significant rise in CO2 emissions.

[1]In 2010, Malaysia's natural gas reserves and production were 2.35 (Tscm) and 66.5 (Bscm) respectively.

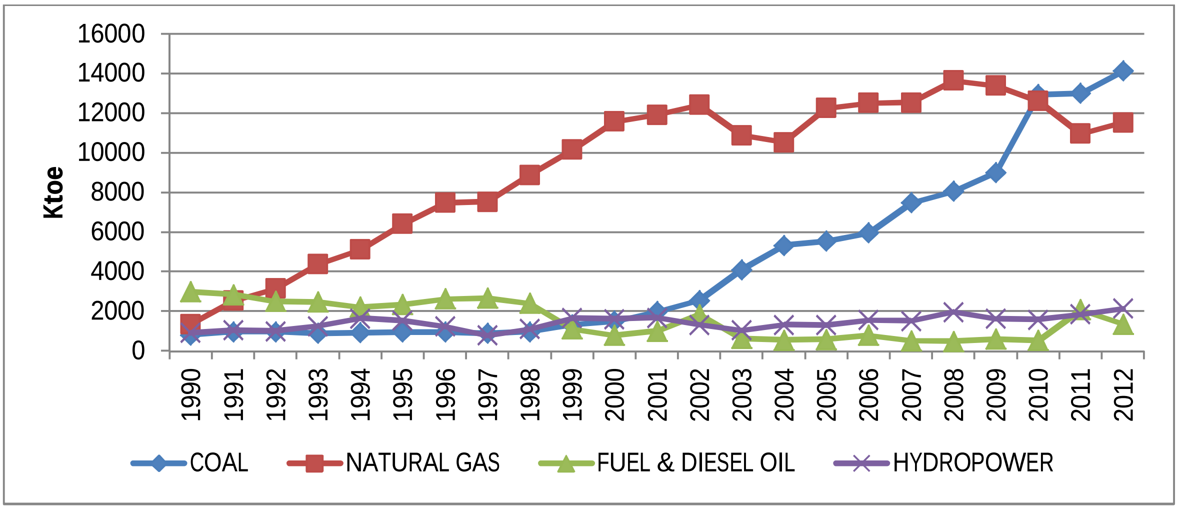

Figure 3 Malaysia's electricity generation fuel mix, 1990-2012
Source: Based on Energy Commission 2012

Indeed, following the 1973 oil crisis, the Malaysian government capped oil and gas production in line with the National Depletion Policy of 1980. This policy aimed to reduce dependence on oil for electricity generation (Mohamed & Lee, 2006). Later in 1981, the Four-Fuel Strategy introduced natural gas for electricity production (Jafar, Al-Amin, & Siwar, 2008). As such, the Malaysian government has been substantially subsidizing the use of natural gas inputs in the power sector since 1997.

The Malaysian national oil corporation, PETRONAS, subsidizes gas via the mechanism of importing 32% of gas demand from Indonesia, Thailand, and Vietnam and supplying the National Power Corporation (TNB) with a price which is roughly 25% of the imported cost (Hamid & Rashid, 2011). However, in recent years the amount of natural gas subsidy (in terms of revenue lost) has increased substantially as a result of the widening gap between international and domestic prices. In 2010, the gas price was capped at MYR10.70 (US$3) per million metric British thermal units (MMBtu) while the unsubsidized market price was MYR40.70/MMBtu.

As such, the power sector enjoys a price subsidy of about 73.7%. As shown in Figure 4, the total value of the gas subsidy reached about MYR20.1 billion in 2011 representing a dramatic increase of 171% since 2005. Of the total, 44% or MYR8.5 billion is for the non-power sector, which includes industries, and commercial and residential users, with the balance 56% or MYR11.6 billion applied for power generation.

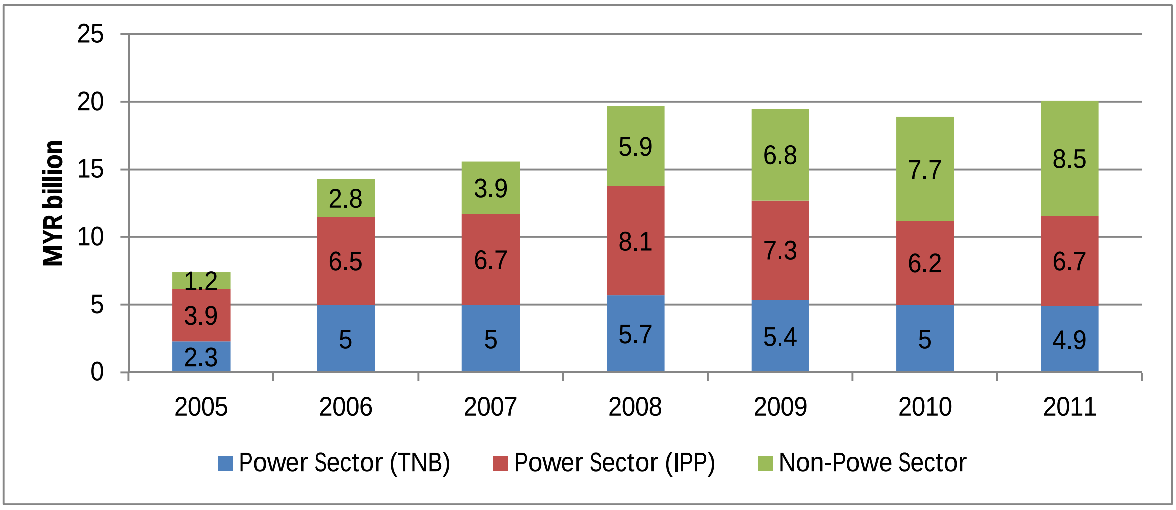

Figure 4 Gas subsidy allocation
Source: Ilias, Lankanathan, and Poh (2012)

Although, this can bring social benefits, from the economic viewpoint providing a lower price for natural gas for electricity production means that the supply of electricity by a cheap input and a lower output price will result in an increase in energy consumption as well as indirectly contribute to greater environmental pollution.

Analyzing Figure 2 and Figure 3 together illustrates two key issues: substantial increase in future demand for electricity and the dominance of fossil fuels over renewable ones. These two issues are sufficient to compel Malaysia to enrich it fuel-mix for electricity production. Accordingly, the Malaysian government introduced renewable resources under the Five-Fuel Diversification Strategy of 2000 (Chua & Oh, 2010). In spite of this policy, renewable capacity by 2011 was less than 1% of the total installed capacity (Muis, Hashim, Manan, & Douglas, 2011). Further, to increase renewable capacity the Malaysian government introduced a feed-in tariff (FiT) scheme. The implementation of the FiT sought to increase the RE contribution against its total electricity generation by 5.5% in 2015 (Economic Planing Unit, 2010) while the funds for the FiT are derived from an additional fee that heavy electricity consumers are obliged to pay. This scheme intends to stimulate investments by providing financial incentives to renewable power producers.

Nevertheless, for electricity generation, subsidies must be phased out as part of a strategic plan that promotes clean energy alternatives, in order to eliminate the incentive to replace the traditional dependence on natural gas with a new one on coal. Without such a plan there is the concern that gas will be substituted with coal once subsidies are removed, and CO2 emissions will increase as a result.

A number of studies have analyzed the effects of reducing or removing energy subsidies on the economy by applying a CGE model. Some study such as Liu and Li (2011), Lin and Li (2012), and Dartanto (2013), prove that any reform of fossil energy subsidies would exert a negative impact on the economy and a positive effect on emissions reduction. Further studies on energy subsidy reform confirm that reallocating a fuel subsidy back into the economy will have positive impacts (Hartono & Resosudarmo, 2006; Lin & Jiang, 2011). In addition, by employing the CGE approach, many studies found that subsidy reform leads to a loss in household welfare (ESMAP, 2004; Manzoor, Shahmoradi, & Haqiqi, 2009).

The next section introduces the model structure and explains the data and scenarios, Section 3 examines the simulation results, and the conclusions are in Section 4.

2 Method

By taking into account all economic factors, general equilibrium models constitute a comprehensive analysis of the effects of an energy policy on the economy as a whole or on a specific sector. They are able to trace the impacts of policy changes on the entire economy in the electricity sector. This paper applied a CGE model as an analytical tool to achieve the research objectives. The model used is an extension of the well-known Australian model developed by Horridge, Parmenter, and Pearson (2000).

A detailed single-country, multiple-sector, comparative statistic CGE model of the Malaysian economy is constructed which focuses on the electricity sector and its linkages with renewable energy development. The model incorporates two elements that distinguish it from existing general equilibrium models. Firstly, it captures the electricity sector which receives power from four energy types namely gas, coal, oil, and RE sources. Secondly, it contains a special extension module for the promotion of electricity produced from renewable energy source under a FiT financing mechanism.

The structure of general equilibrium is based on the Walrasian general equilibrium which was developed to prove the existence and stability of the equilibrium in the 1950s by Arrow and Debreu (1954). Demand and supply equations for economic agents are derived from solutions of optimization problems (cost minimization, utility maximization, etc.) which are assumed to underlie the behavior of the agents in conventional neoclassical microeconomics. The agents are assumed to be price-takers while producers are assumed to operate in competitive markets that exclude the earning of pure profits. The CGE model adopts the linear expenditure system (LES) demand function which is derived from the maximization of a Klein and Rubin (1947) utility function that distinguishes between necessary and luxury goods for household consumption. Also, household choices between domestic and imported commodities are modelled by CES function.

This modeling framework allows the evaluation of economy-energy interactions in an integrated and consistent way that has not been previously addressed in any existing studies in Malaysia. The model is used to quantify the economy-wide effects of gas-based electricity subsidy reform under with and without revenue offsetting scenarios. More specifically by utilizing a revenue recycling mechanism, the additional revenue from subsidy removals can be reallocated for the promotion of renewable energy within the power generation sector.

2.1 Production

The economy is classified into 129 production sectors producing 129 commodities. These sectors are derived from a grouping of commodity classes found in the 2010 input-output tables. The sectoral breakdown reflects the sub-sectors in the electricity sector and the other major sectors of the economy. The grouping is designed to study the interactions of the electricity, energy, and other sectors of this economy. This study distinguishes between electricity supply industries and all other industries.

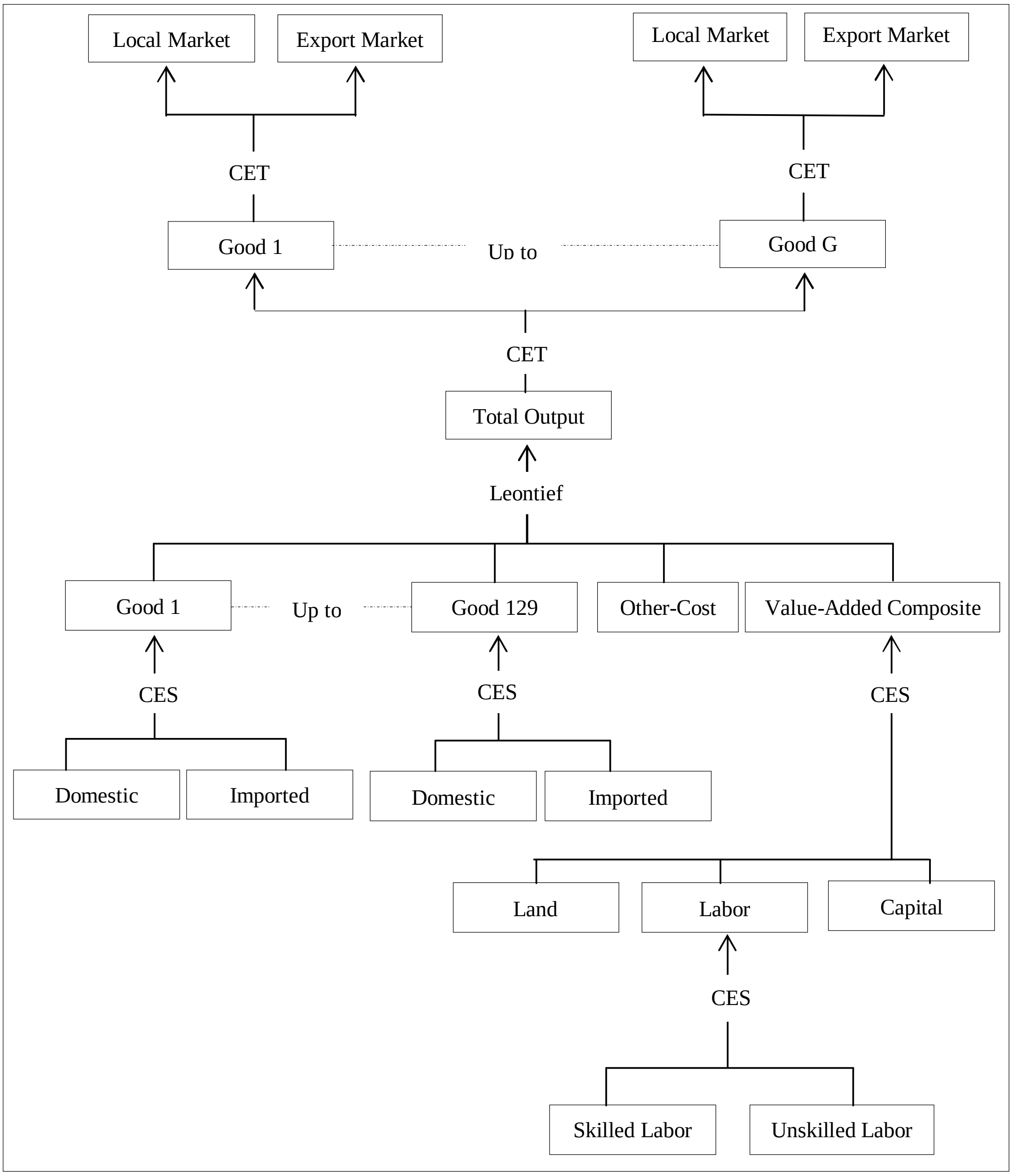

Figure 5 Production structure for non-electricity sector

Figure 5 describes the input structure of production for all non-electricity supply industries following Horridge et al. (2000). Each of these sectors recognizes two broad categories of inputs: intermediate inputs and primary factors. Industries are assumed to choose the mix of inputs which minimizes the costs of production for their level of output. They are constrained in their choice of inputs by a three-level nested production technology. At the first level, the intermediate-input and the primary-factor bundles are used in fixed proportions to output. These bundles are formed at the second level. Intermediate input bundles are constant-elasticity-of-substitution (CES) combinations of international imported goods and domestic goods. The primary-factor bundle is a CES combination of labor, capital, and land. At the third level, the labor input is formed as a CES combination of inputs from two different occupational categories.

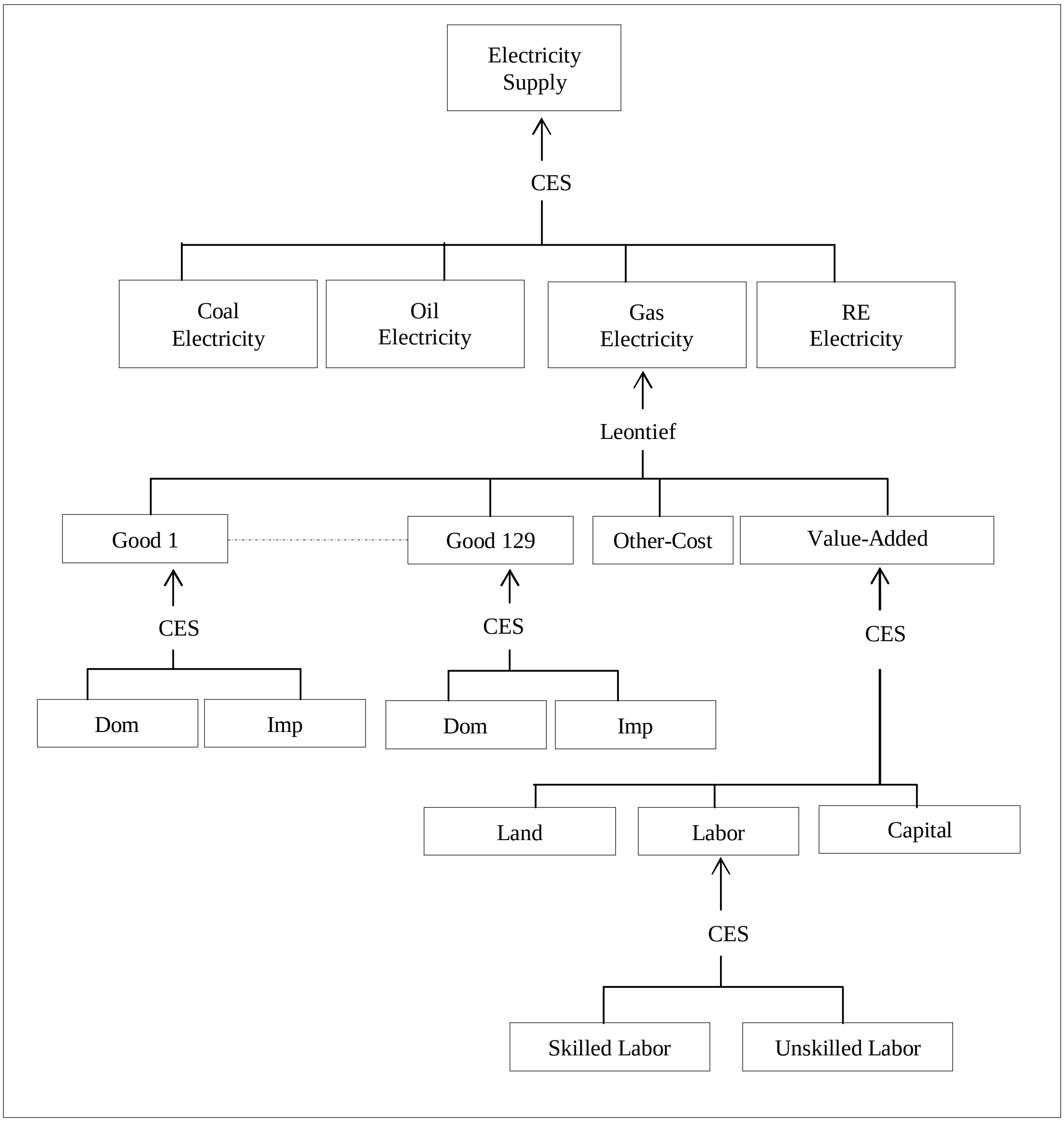

Figure 6 Structure of production for the electricity sector

In the case of the electricity sector, technological information is especially pertinent and is key to analyzing the effects of subsidy reduction due mainly to the existence of a wide range of generation technologies. Therefore this study modified the Horridge et al. (2000) model through extending a CES function for electricity generation composite to allow substitution possibilities among four types of electricity generation, instead of locating electricity commodity under Leontief functional form in the same level similar to other industries. More specifically, electricity generation is only used by the electricity sector and the electricity industry is disaggregated into five industries based on different generation technologies. Four of these relate to electricity generation while the fifth covers the electricity supply industry. The output of the different generation sectors is the input for the electricity supply industry which then transmits and distributes it to other industries and final users.

The electricity supply industry is a CES aggregation of four types of generation according to the energy input used, namely electricity generated from gas, coal, oil, and RE sources, as illustrated in Figure 6. Each generation is assumed to produce a particular type of product (coal-electricity, gas-electricity, etc.) using relatively fixed input proportions (Leontief function). In this approach, electricity generation is allowed to shift from highly subsidized gas generation to other generation technologies (e.g., coal and renewable energy). As such, the CES production function is employed to form the electricity output.

2.2 Data

The structure of the published data is often not in the required CGE database format, and a major task is to transform the official data into the format. Having constructed the database that conforms to the CGE structure, we proceeded to aggregate and disaggregate specified sectors namely the electricity and gas sectors to address the objective of this study. The main source of data is the 2010 Malaysia input-output (IO) table published by the Department of Statistics (Department of Statistics, 2014). The 2010 IO table distinguishes between 124 different commodities and 124 different industries. In addition, final demands include private households, government, exports, investment and stock purchases. In the 2010 I-O table and related tables (Supply and Use matrices) the data for electricity sector is not supplied in detail and does not even distinguish between different types of the electricity sector.

Of these the most important is that the data for electricity and gas are aggregated into a single row. Since natural gas is the main input in the production of electricity, explicit recognition of a natural gas sector in the database is a crucial step in the database construction process. A model to examine the impact of the reforms in the electricity market requires data at a higher level of disaggregation. Therefore, the next task was to disaggregate the data for the electricity sector into five new electricity industries (electricity-coal, electricity-oil, electricity-gas, electricity-RE, and electricity supply). The final product will be a 129 x 129 sector IO matrix for Malaysia comprising 124 non-electricity sectors that use commercial electricity as an important input in the production process and 5 electricity sectors. As the actual natural gas subsidy data is not considered in the published tables, the database construction needs to accurately include the amount of subsidy.

In the constructed IO there are two labor groups which are disaggregated based on the method used by Nagaraj and Goh (2006). For the simulation, parameters in the model are adopted from the literature. The value for Armington elasticities and the primary factor substitution elasticity except for capital are taken from Horridge et al. (2000). The four new elasticities between electricity generations are derived from McDougall (1993).

2.3 Closure

It is evident from the theoretical description of the CGE model that the model has more variables than equations. Closure rules of a CGE model establish which of the variables should be determined endogenously and exogenously within the model.

Therefore a standard short-run closure is applied following Horridge et al. (2000), but the characteristics of some exogenous and endogenous variables have been changed in this study to analyze the effect of the policy shocks on the Malaysian economy. Since in the short-run capital and land remain fixed, their prices will adjust in the face of any policy shocks. Employment, however, is allowed to change as firms can employ more labor, or more workers would be available, while the price of labor is fixed.

From the expenditure side of GDP it is assumed that in the short run, aggregate investment, government consumption, and inventories are exogenous, while consumption and the trade balance are endogenous. Real household consumption is endogenous as this allows us to have an insight into the effects of the suggested policies on Malaysia’s consumption and competitiveness. Apart from the above, all technical change and shift variables are exogenous as it is widely accepted that the former is a long-term phenomenon and should therefore be evaluated under constraints that reflect a long-term economic scenario. Since general equilibrium models determine only relative prices, it is necessary to define a numeraire price against which all other prices are measured. For this purpose, the nominal exchange rate is taken as the numeraire for the model. The GEMPACK software developed by Codsi and Pearson (1988) is used for solving the model

3 Simulation and Results

The aim of this study is to derive how the Malaysian economy, especially the electricity sector is affected by a gas subsidy reform and the recycling of savings from a subsidy to promote electricity from RE sources. The study simulations show the magnitude and direction of economic and sectoral impacts of a gas subsidy reform in the Malaysian power sector. To discuss the effect of the reforms more comprehensively, the simulations are performed under three scenarios. Scenario 1 models a Malaysian economy where all gas subsidies are completely removed (100% reduction), and no further recycling of these subsidy is considered. From January 2014, all electricity users consuming more than 300kWh (equivalent to RM 77) of electricity a month are required to contribute an additional 1.6% of their total electricity bill to the RE fund (Sustainable Energy Development Authority, 2011); as such, scenario 2 reflects a Malaysian FiT policy. The FiT mechanism is implemented in the model as an endogenous ad-valorem output subsidy to RE generation where the associated subsidy value is equal to government transfer from electricity users by imposing a 1.6% sales tax on the household sector. In scenario 3, we assume government removes the gas subsidy completely and the reallocation of all savings from RE electricity generation is complemented with a FiT policy.

3.1 Macroeconomic impacts

Table 1shows the short-run results from the simulated three scenarios on the Malaysian economy. Scenario 1 indicates that removing a gas subsidy from the electricity generation sector would raise the price of electricity by 0.6%. Since electricity is used as an intermediate input in most industries, a rise in its price will lead to higher costs of production and hence contract economic activity. This is reflected in a 0.02% and 0.04% decrease in real GDP and total employment respectively. Due to the increase in price of commodities, the consumer price index (CPI) rises and depletes household welfare, which ultimately decreases household (private) consumption.

The average price of exports in local currency terms increases due to the rise in domestic prices. As a result, the demand for Malaysian exports drops by 0.02% due to their decreases competitiveness in foreign markets. Since, import prices are fixed by the closure assumptions, the terms of trade increase by about 0.01 %. In the primary factor markets, because the capital and land supply are held fixed, the decrease in return to these factors reflects the decrease in prices for them arising from the reduction in demand. In the labor market, as wages are assumed to be sticky in the short run, the nominal wage rate is fully indexed to the consumer price index (CPI). A small rise in payments to labor indicates that the increase in the nominal wage rate outweighs the decline in employment.

Table 1: Macroeconomic Effects (Percentage change from base-run)

Variables	Scenario 1	Scenario 2	Scenario 3
Real GDP	-0.02	-0.01	-0.01
Real public consumption	-0.02	-0.01	-0.01
Aggregate employment	-0.04	-0.02	-0.02
Real export volume	-0.02	-0.01	-0.02
Real import volume	-0.01	-0.01	-0.01
Consumer price index (CPI)	0.02	0.01	0.02
Terms of trade	0.01	0.003	0.004
Aggregate payment to labor	-0.22	-0.005	0.000
Aggregate payment to capital	-0.05	0.04	0.08
Aggregate payment to land	-0.01	-0.01	-0.01

Source: simulation results

Scenario 2 shows that the GDP decreases slightly by 0.01%. The decline in household purchasing power induced by the subsidy payment through FiT has a negative effect on household consumption. The decrease in aggregate imports is mainly due to the decline in imports of fossil-fuel based electricity generation resulting from the contraction in such demand due to fuel switching within the electricity sector. In turn, the induced change in the price of primary factors namely labor, capital, and land (-0.005%, +0.04%, and -0.01%, respectively) is mainly driven by the modification in the production structure of the electricity sector, which becomes more capital-intensive.

As expected, when revenues are rechanneled into the economic system, the negative impacts on macroeconomic variables are mitigated. Comparing with the results in scenario 1, GDP and employment still contract albeit by a lesser extent (by 0.01% and 0.02% respectively). In the new electricity generation technology mix, where renewable technologies have a much higher share of total output, the relative weight of capital increases.

3.2 Sectoral impacts

Under the three scenarios, an increase in production costs arising from the rise in input prices results in a reduction in the output of most of the non-electricity sectors. As described in Table 2, under scenario 1 in the electricity sectors, the output of electricity-gas decreased as a result of higher costs of power generation by burning gas, which is the economic and normal response to the price change after a subsidy removal. Despite the contraction in the output of the gas generation sector, the ‘electricity-coal’ and ‘electricity-oil’ industries, as expected, show positive output change because of the substitution of coal and oil for natural gas for electricity generation. Switching to coal and oil for electricity generation will increase emissions; however, by producing electricity using renewable energy the emissions would be compensated, to some extent, depending on the contribution of such energy to total electricity production.

The results of scenario 2 show that the FiT policy modifies the production structure of the electricity sector with inter-fuel substitution. The implementation of the policy leads to a diversification of the energy mix with a large deployment of renewable energy sources. There is a shift from fossil-fuel power generation technologies, in particular coal, toward renewable technologies (-0.26% and +5.27% respectively). And since the production of RE electricity is fully supported by consumers, the production cost of electricity supply remains unchanged.

Table 2: Change in Industry Output and Commodity Prices

Sectors	**Scenario 1**		**Scenario 2**		**Scenario 3**	
	Output	**price**	**Output**	**price**	**Output**	**price**
ElecSupply	-0.23	0.60	0.25	0.44	0.20	0.54
ElecCoal	0.13	0.15	-0.26	-0.62	-0.25	-0.73
ElecOil	0.12	0.16	-0.24	-0.63	-0.23	-0.74
ElecGas	-0.27	0.35	-0.20	-0.65	-0.56	-0.58
ElecRE	0.08	0.17	5.27	-3.22	8.75	-4.85

Source: simulation results

The rise in RE electricity production subsidies (by financing from two sources) leads to a larger decrease in the price of RE electricity (4.85%). This will, in turn, encourage producers to generate more electricity from RE sources (which is resulted from an increase in demand), and, as expected, result in the output of renewable electricity growing dramatically by 8.75%. Applying the two scenarios simultaneously will result in a significant fall in fossil-fuel generation demand that could improve energy efficiency and emission reduction.

4 Conclusions

Impact assessments of policy instruments play a crucial role in making tough decisions relating to the electricity sector. This paper applied a CGE model to investigate the short-run effects of the gas-based electricity subsidy removal and FiT policy on the Malaysian economy as a whole and the electricity sector in particular.

Based on the research findings, several conclusions are summarized. First, relative to the percentage increases in RE electricity production, the negative macroeconomic impacts of the gas-based electricity subsidy removal and FiT policies would not be very large. Second, compared with a subsidy removal plus a reallocation into the RE electricity generation policy, Malaysia's FiT policy would be more effective in promoting the generation of electricity from renewable energy sources although it leads to higher macroeconomic costs. Third, a subsidy revenue recycling plan shows that reallocating the removed gas subsidy into the economy in the form of the RE electricity production subsidy helps mitigate the negative impacts on macroeconomic variables. The study also found that the FiT policy modifies the production structure of the electricity sector with inter-fuel substitution making it less dependent on energy imports. There is a shift from fossil-fuel power generation, in particular coal, toward renewable sources. Fourth, it can be concluded that the implemented FiT support scheme is not large enough for the RE technology to break even given its huge cost disadvantage compared to other fossil fuel technologies. As such, financing RE electricity production through any FiT support and accompanied by the provision of a gas subsidy will have a major impact in determining the contributions of the RE industry in electricity generation.

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