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ENERGY MARKET INTEGRATION IN EAST ASIA: THEORIES, ELECTRICITY SECTOR AND SUBSIDIES

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EXECUTIVE SUMMARY

1. Background and Objectives

Since the formation of the East Asian Summit (EAS) in 2005, Energy Market Integration (EMI) in East Asia has become one of the initiatives endorsed and actively promoted by EAS governments. Electricity market integration in East Asia is an important component of EMI. It is argued that an integrated East Asian electricity market would benefit all EAS members in several ways. These include potential access to competing suppliers within and beyond the borders, and hence better provision for peak electricity demand and supply security. Some progress has been made in this direction. These include the cross-border power trading within the Greater Sub-Mekong Region (GMS) and the scheduled construction of the ASEAN Power Grid (APG). However, electricity market integration within the EAS area remains a challenging task.

To gain a better understanding of the issues involved and follow two previous ERIA projects, this EMI project focuses on the electricity sector. It has several objectives. First, we want to explore some general issues associated with EMI particularly electricity market integration and hence contribute to the ongoing debates about regional market integration. Second, we select three countries for case studies, namely, Cambodia, China and New Zealand. These countries represent EAS members at different stages of development in their electricity sectors. The third objective of this project is to deal with the removal of subsidies in the energy sectors. We focus on three EAS members, namely Indonesia, Malaysia and Vietnam for detailed investigations. Specifically we consider various scenarios of reducing or removing subsidies and hence the possible consequences.

2. Key Findings

In total, nine reports are included in this volume. They can be broadly divided into three categories with three reports in each, namely: the general EMI issues, case studies, and energy sector subsidies. In terms of the general debate on EMI, it is shown in this report that industrialization may lead to an increase in energy consumption per capita as well as the income (expenditure) elasticity of energy. This tends to generate a surge in the overall demand for energy. In contrast, energy market integration may help reduce the pressure on energy demand as it smooths demand shock. The findings in this report also demonstrate that a more open power trade regime encourages the development of renewable sources such as hydro and wind for power generation and hence the total cost of meeting region-wide electricity demand will be reduced. Specifically under the scenarios of partial trade (20% and 50% capacity) the present value of cost savings would be USD 20.9 and USD 29.0 billion, respectively. Thus even with partial integration (cross-border power trading) substantial cost reduction could be realized. Finally our review of the trends of integration in the world's major electricity markets shows that the main initiatives in electricity market integration so far share some commonalities. First, interconnections mainly occur among neighbouring countries which have well-developed national markets. Second, bilateral electricity exchanges are often initiated first and then expanded to become sub-regional markets. Finally, market integration is accompanied with domestic reforms and international harmonization of regulation standards.

Our three case studies cover Cambodia, China and New Zealand. With a rate of electrification of about 25%, Cambodia is expected to expand electricity capacity and coverage. The country will need a large amount of capital for investment in the future. This demand is well beyond the capacity and resources of Cambodian economy. There are however major barriers to investment such as insufficient legal and institutional framework and high administrative costs. Thus the country's business environment must be enhanced in order to attract both foreign and local investment. Though China's electricity sector has been reformed, barriers to foreign participation in this sector still exist. Our case study shows that the electricity sector reform alone cannot deliver the expected benefits associated with the participation of the private sector. Changes in the broader institutional arrangement in the economy are needed in order to cope with issues such as regulatory system fragmentation, uncertain pricing mechanism, limited access to the transmission, disadvantage of accessing fuel and finance for private sector, and rampant expansion of state-owned sector. In New Zealand, market development and restructuring in the electricity sector seem to be very successful initially but produce problems later. Therefore, the Electricity Industry Act enacted in 2010 effectively allows the bundling of distribution and retailing and also raises the threshold for ownership separation among distribution, retail and generation. This new policy may also create vertically integrated electricity utilities, encompassing generation, distribution, and retailing. This practice is against the theoretical preference of competition and unbundling. Its impacts are yet to be assessed.

The last three reports deal with subsidies in the energy sector in Indonesia, Malaysia and Vietnam, respectively. In the Indonesian case it is found that the removal of fuel subsidies affects production output, employment and income in the country. In particular, the impact on labour income is higher than that on capital returns and the lowest income group will be affected the most. The latter is also observed in Vietnam where the average electricity tariff rate is far below the international rate. Our report shows that a one short increase in electricity tariffs (to match the international price) would lead to a substantial increase in the CPI (Customer Price Index) and hence would be socially unacceptable. Our findings support a gradual approach towards subsidy removal and separate implementation in each sector. Our last report investigates the effects of subsidy removal on the Malaysian economy. It is found that phasing out oil subsidy would initially increase the general prices but eventually bring about an increase in output due to the improvement in efficiency and a decrease in the cost of production. There are however significant variations across industries. In general, the less energy intensive industries and domestic resources-based industries are least affected by the removal of subsidies.

3. Implications and Policy Suggestions

The findings from these reports have important policy implications. Specifically, this project's findings imply i) Less developed countries should be prepared for faster growing energy demand when their industrialization process commences; ii) Countries can gain from sub-regional cooperation and electricity trading on the one hand and will benefit from a resilient, competitive and effective energy market on the other hand; iii) Full-scale power trade tends to lead to full utilization of hydro power, which produces the lowest cost option ; iv) Deregulation and unbundling may have unintended consequences; v) Market integration is often accompanied with domestic reforms and international harmonization of regulatory standards; and vi) The lower income group and the energy intensive industries will be disadvantaged by the removal of energy subsidies.

Finally, we make the following policy recommendations (R1-R6) for governments within the EAS member countries.

R1: To promote continuously a closely integrated energy market, which can lead to a less volatile, more flexible and resilient market through regional cooperation such as infrastructure connectivity, trade and investment arrangement, and the harmonization of regulatory and technological framework.

R2: To encourage free trade of electricity and more coordinated development of energy projects. This requires a fundamental review of energy security policies.

R3: To build continuously an open, competitive and effective domestic energy market. Equal access to energy infrastructure and finance for private investors is also important. In addition, it is necessary to enact necessary regulations, such as competition law, to protect both consumers and investors.

R4: To adopt a gradual and incremental approach of subsidy removal so as to minimize the interruptions in member economies concerned. While low income people should be compensated, reallocating the saved budget to targeted sectors, the so-called "sectoral approach", should be carefully designed.

R5: To boost electricity infrastructure. For EAS members with low electrification, the focus should be infrastructure development. For others, the policy priority is to achieve regional and nationwide interconnectivity.

R6: To harmonise regulations and technical standards gradually in the electricity and gas sector. Members could initially identify the best practice or whatever most suits the conditions within the region. Subsequently members can act together to catch up with the global best practice.

CHAPTER 1

The Electricity Sector Leads Energy Market Integration in East Asia: Introduction

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Electricity market integration in East Asia is an important component of the energy market integration (EMI) initiatives supported by the East Asian Summit (EAS) member countries. It is argued that an integrated East Asian electricity market would allow consumers to have access to competing suppliers within and beyond borders and enable electricity providers in member economies to deal with peak demand and supply security better. Electricity market integration within the EAS area has made some progress with the Greater Sub-Mekong Region (GMS) as the forefront of changes. The proposed ASEAN Power Grid (APG) has also been implemented gradually. However, electricity market integration within the EAS economies remains a challenging task. While physical infrastructure is often expensive and financially demanding, institutional development is more important and complicated since it is closely linked with market liberalization and regulation.

To gain a better understanding of the issues involved and follow two previous ERIA projects, this EMI project focuses on the electricity sector. In this introductory chapter, we first describe the objectives of this study in Section 1. The main findings in the core chapters are then summarized in Section 2. Some recommendations for policy makers are presented in Section 3.

1. Objectives

Although regional electricity market integration has been promoted by nations in the world, the actual progress in interconnection varies across continents and between countries within different country groups. In terms of interconnectivity and trade in the EAS electricity sector, there is still a long way to go. EAS lags behind Europe's electricity market integration efforts where physical cross-border exchanges have increased considerably. In terms of market development, most EAS members are yet to develop a national electricity market, let alone the pursuit of regional integration. Cross-border trading is still at the early stage of development. In general, the 16 EAS member countries can be broadly divided into several groups in accordance with their market and institutional development. Relatively mature and integrated national markets have emerged in several EAS countries, namely, Australia, New Zealand and Singapore. Some members are at various stages of developing a national electricity market (Brunei, China, Japan, Malaysia, the Philippines, South Korea, Thailand and Vietnam). Others are still trying to improve the level of electrification in their societies (India, Indonesia, Cambodia, Lao PDR and Myanmar). While governments in the EAS countries have moved in the right direction to promote market integration in the electricity sector, much more work is needed.

This project has several objectives. First, we want to explore some general issues associated with EMI particularly electricity market integration and hence contribute to the ongoing debates about regional market integration. These issues include the potential impacts of EMI on economic development, benefits of electricity trading, and domestic and regional policy responses in order to promote market integration. Second, we selected three countries for case studies, namely, Cambodia, China and New Zealand. Cambodia represents relatively less developed EAS members. While domestic electricity markets in those economies are yet to be developed, they could play a role in supporting regional market integration and contribute to institutional capacity building. As the largest market within the region, China is expected to play a significant role in regional market integration. We examine potential barriers to foreign and domestic private investment in the Chinese electricity sector. New Zealand is selected as a success story of introducing advanced unbundling, whose outcome, however, is still not clear-cut.

The third objective of this project is to deal with the removal of subsidies in the energy sectors within the EAS area. Energy subsidies are prevalent in EAS economies. The removal of those subsidies is a prerequisite for the EMI. In this study we present detailed investigations of energy subsidies in three EAS members, namely Indonesia, Malaysia and Vietnam. Specifically we consider various scenarios of reducing or removing subsidies and hence the possible consequences. In total, nine reports are included in this volume. They can broadly divided into three categories with three reports in each, namely: the general EMI issues, case studies (of Cambodia, China and New Zealand), and energy sector subsidies (in Indonesia, Malaysia and Vietnam). The main findings in those reports are summarized next.

2. Main Findings

Among the three papers addressing the general EMI issues, Sheng and Shi show that show that rapid economic growth due to industrialization and urbanization tends to increase the energy consumption per capita, which in turn may generate a surge in the overall demand for energy. The econometric results show that an increase in economic growth may increase 0.6 per cent of energy consumption per capita. Moreover, economic growth also leads to lower price and income elasticities (in absolute terms). However, energy market integration can help to reduce the energy demand pressure and to smooth the demand shock through decreasing the income elasticity and increasing the price elasticity in particular in the long run.

Chang and Li build a dynamic linear programming model and simulate optimal development paths of power generation capacities in ASEAN countries. They consider three scenarios (no trade, 20% trade and 50% trade in electricity) of developing optimal power generation capacity and their impacts on market integration in ASEAN (Table 1). Their findings show that a more open power trade regime encourages the development of renewable sources of power generation, and accrues more savings in the total cost of meeting the growing future power demand from 2010 to 2030. Chang and Li argue that with power trade more countries will utilize renewable-based power generation such as hydro and wind and hence the total cost of meeting region-wide electricity demand will be reduced. Because considering unlimited power trade may arouse energy security concern among the high import-dependency countries, the limited power trade in the region seems to be more realistic. Specifically under the scenarios of partial trade (20% and 50% capacity) the present value of cost savings would be USD 20.9 billion (3.0%) and USD 29.0 billion (3.9%), respectively. Thus even with partial integration (cross-border power trading) substantial cost reduction could be realized (Table 1).

Table 1: **Key Findings from Different Scenarios of Electricity Trade**

Scenario	Total Cost Savings	Development of Additional Capacity (Top Four in Turn)
No Trade	N.A.	Gas, Coal, Hydro and Geothermal
20% of demand met by trade	3.0% (USD 20.9 billion)	Gas, Hydro, Coal and Geothermal
50% of demand met by trade	3.9% (USD 29.0 billion)	Gas, Hydro, Coal and Geothermal

Sources: *Chang & Li (2012).*

Wu's report presents a review of the trends of integration in the world's major electricity markets and analyzes the experience and lessons in those markets. Wu shows that the main initiatives in electricity market integration so far share some commonalities. First, interconnections mainly occur among neighbouring countries which have well-developed national markets. Second, bilateral electricity exchanges are often initiated first and then expanded to sub-regional markets. Finally, market integration is accompanied with domestic reforms and international harmonization of regulations standards.

The three case studies cover Cambodia, China and New Zealand. Poch presents an overview of the Cambodian power sector. With a rate of electrification of about

25% in 2009, Cambodia is expected to expand electricity capacity and coverage and requires a large amount of capital for investment in the future. This demand is well beyond the capacity and resources of the Cambodian government. The electricity sector remains underinvested. Barriers to investment include huge capital requirement for large-scale projects, insufficient legal and institutional framework, and high administrative costs. Poch argues that the country's business environment must be enhanced to be conducive to both foreign and local investments.

In the report on China, Sun, Guo and Zheng discuss reform initiatives and barriers to foreign participation in China's electricity sector. They argue that the electricity sector reform alone cannot deliver the expected benefits associated with the participation of the private sector. The barriers to private participation are originated from not only the electricity sector regulation itself, but also the broader institutional arrangement in the economy, such as fragmented regulatory system, unpredictable pricing mechanism, limited access to the transmission, disadvantage of accessing fuel and finance for private sector, and rampant expansion of state-owned sector.

Shen and Yang examine the lessons learned from the New Zealand electricity reform. The Electricity Industry Reform Act 1998 (EIRA) prohibited common ownership of electricity distribution businesses and of either electricity retailing or electricity generation businesses (other than minor cross-ownerships). They argued that the forced ownership unbundling did lead to efficiency and quality improvements, high total factor productivity (TFP) growth, and reduction in retail prices, immediately after the unbundling. However, since 2003, retail prices have been rising, TFP has been falling, and service quality has been falling too. Furthermore, the unbundling does not seem to have facilitated greater competition in the electricity generation sector.

This has however been partly reversed since the enactment of Electricity Industry Act in 2010, which further reduces the extent of ownership separation among distribution, retail and generation by allowing distribution back into retailing and raising the threshold for ownership separation between distribution and generation. This new policy provides incentives for distribution businesses to invest in generation and retail. However, it may also create vertically integrated electricity utilities, encompassing generation, distribution, and retailing. This practice is against the theoretical preference of competition and unbundling, and its impacts are yet to be assessed. As a reference, the literature suggests that vertical integration is indeed associated with economy of scope; however, allowing competition in retail and wholesale markets tends to improve firm efficiency and service quality and leads to higher productivity and consequently lower prices. The net impacts tend to be positive but moderate.

The last three reports deal with subsidies in the energy sector (fuel, oil and electricity) in Indonesia, Malaysia and Vietnam. In the Indonesian case Widodo and his three colleagues consider several scenarios of the removal of fuel subsidies (Table 2). It is found that the removal of fuel subsidies has economy-wide effects on many factors such as output, employment and income in Indonesia. Specifically the removal of fuel subsidies of IDR1 billion would reduce production output, GDP, and labour income by approximately IDR0.164 billion, IDR0.088 billion and IDR0.112 billion, respectively.

Table 2: Multiplier Analysis of Social Accounting Matrix (SAM) on Output, GDP, and Income

Simulation		Output	GDP	Income
Baseline (A)		-2.5459	-1.6093	-2.0895
Scenario (B)		-2.7098	-1.6973	-2.2014
Impact (IDR billion)	(C = B – A)	-0.1639	-0.0880	-0.1119

Source: Widodo, *et al*. (2012).
Note: The negative sign (-) shows that the removal of subsidy will have negative impacts. The impact (C) corresponds to the impacts of the removal of the fuel subsidy by IDR1 billion.

At the sector level, it is found that the removal of fuel subsidy of IDR1 billion would reduce the output of chemical and cement industry and electricity, gas, and drinking water sector the most by approximately IDR 0.045 billion and IDR 0.026 billion, respectively. The simulation results also show that the impact on labour income is higher than that on capital returns. A more detailed analysis shows that the lowest income group will be affected most. Workers in administration, sales, and service sectors as well as production and unskilled workers would be affected the most. In contrast, high-income earners as well as workers in agriculture sector would be the least affected by the removal of the fuel subsidy.

With regards to income distribution of different types of households, firms, and the government, households in non-agriculture sector would be affected the most. Specifically, urban households, particularly managers, military personnel, professionals, and technicians, would experience the highest impact of the removal.

If this amount of subsidy is reallocated to four targeted sectors- i.e. Agriculture; Trade; Food, Beverage, and Tobacco Industry; and Education and Health, the gains would be smaller than the negative effect of fuel subsidy removal. While reallocation to Food, Beverage, and Tobacco industry provides the biggest impact on the economy, the impact is relatively lower than that of fuel subsidy removal shown in Table 2, which implies a total negative impact of subsidy removal. These findings are however subjected to qualifications. For example, their multiplier exercise is based on a fixed economic structure and does not take into account of the dynamics over time. It does not allow for substitution effect either as prices are fixed.

In the paper on Malaysia, Hamid and Rashid investigate the effects of subsidy removal on the Malaysian economy using the Malaysian input-output table supplemented by a static CGE model. Their findings imply that phasing out oil subsidy would initially increase the general prices that will especially affect the heavily oil-dependent sectors such as the petroleum refinery, wholesale and retail trade, and motor vehicles. The authors also argue that there are significant variations across industries since different proportions of energy inputs are employed in the production process. In general, the less energy intensive industries and domestic resources-based industries are less affected by the removal of subsidies. The authors' I-O table analysis illustrates that the removal of subsidy of a ringgit will increase the output by six cents and GDP by eight cents at the final demand. The most effect is on workers' income that experiences an increase of 34 cents due to the removal of subsidies. The authors further argue that delaying the removal of subsidies will primarily increase costs for the government and leave little room for policy space in case market prices are higher than expected.

In the last paper on subsidy Nguyen explores the impacts of an increase in the electricity tariff from 6.0 US cents/kWh (domestic price) to 9.5 US cents/kWh (international rate) (a rise of 58.3% in the electricity tariff) in Vietnam. He shows that prices in the five most affected sectors would in turn increase by 11.15% (water), 7.36% (gas), 4.82% (paper & paper products), 4.73% (chemicals and chemical products) and 4.30% (sports and entertainment). The price increase in all other sectors would be less than 4%. These increases in prices would lead to an increase in the CPI (Consumer Price Index) of 4.2%. Lower income earners suffer more from an electricity tariff increase because their payment for electricity represents a bigger share in their annual expenditure than the rich's. Nguyen argues that though the impacts of subsidy removal on the economy are not very large, a one-shot increase in electricity tariffs would be socially unacceptable. He thus proposes a gradual approach towards subsidy removal and separate implementation in each sector. Nguyen further argues that an improvement in efficiency in the power sector would help reduce the repercussions of subsidy removal.

3. Implications and Policy Recommendations

Major policy implications are summarized as follows:

- ✓ Less developed countries should be prepared for faster growing energy demand when their industrialization process commences.
- ✓ Countries can gain from sub-regional cooperation, investment and electricity trading on the one hand and will benefit from a resilient, competitive and effective energy market on the other hand.
- ✓ Full-scale power trade tends to lead to full utilization of hydro power, which produces the lowest cost option of power mix to meet the electricity demand.
- ✓ Deregulation and unbundling, prevalent measures in electricity market reform, may have unintended consequences, such as a rise of tariff and a deterioration of service quality, without proper designing of policy package.
- ✓ Market integration is often accompanied with domestic reforms and international harmonization of regulations standards.
- ✓ The lower income group and the energy intensive industries would be disadvantaged by subsidy removal unless proper backups.

Given these findings and implications, the following policy options may be considered by the EAS member countries:

1. Continuously work toward a closer integrated energy market, which can lead to a less volatile, more flexible and resilient market (against price shocks) through regional cooperation such as infrastructure connectivity, trade and investment arrangement, and the harmonization of regulatory and technological framework. The current development of the GMS power market and construction of APG are the right directions to go. Immediately, initiatives could include the establishment of small-scaled power exchanges in border areas, and cross-border grids with synchronized operations to exploit peak loads in different time.

2. Move toward a freer trade of electricity and more coordinated development of energy projects. This requires a fundamental review of energy security policies. The energy security policies should shift their weights from the national level to the regional level since EMI takes care of energy demand in an open regional market, which requires overcoming concerns over regional energy security. When it is technically advantageous, it is certainly appropriate to electrify rural communities with electricity imports rather than own grid extension. Domestic projects near border areas could be developed for the purpose of meeting both domestic demand and cross-border trading.

3. Continue efforts to build open, competitive and effective domestic energy markets. Paths towards such a competitive market, however, may be different across countries since costs and benefits for vertical integration and unbundling may vary. Equal access to energy infrastructure and finance for private investors is also important. In addition, it is necessary to enact necessary regulations, such as competition law, to protect both consumers and investors.

4. Gradually remove subsidies with necessary compensation directed to lower income groups. A gradual and incremental approach of subsidy removal should be adopted to minimize interruptions in member economies concerned, such as economic, social and political instability. While low income people should be compensated, reallocating this saved budget to targeted sectors, the so-called

"sectoral approach", should be carefully designed. The subsidy removal may also need to be implemented sector by sector to reduce shocks.

5. Infrastructure should be at the core of EMI. EAS Members with low electrification should focus on infrastructure development and hence ensure equity in electricity access. To tackle the issue of investment shortage, more transparent governance can be helpful in attracting investment. For other EAS members with almost universal access, and the region at a whole, their policy priority is to achieve regional and nationwide interconnectivity, which will also help to generate economics of scale and reduce electricity costs.

6. Gradually harmonize regulations and technical standards in the electricity sector. An integrated regional electricity market needs harmonized regulations and standards associated with consumer protection and safety standards; legal and tax issues; contract forms; tariff-setting mechanism; and trading systems. Members could initially identify the best practice or whatever most suits the conditions within the region. Subsequently members can act together to catch up with the global best practice.

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CHAPTER 2

Economic Development, Energy Market Integration and Energy Demand: Implications for East Asia

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This paper uses the General Method of Moment (GMM) regression technique to estimate an cross-country energy demand function with a data set covering 71 countries over the period of 1965-2010. The estimated results show that rapid economic growth due to industrialization and urbanization tends to increase the energy consumption per capita, which in turn may generate a surge in the overall demand for energy. As is shown in the econometric results, an increase in economic growth (i.e. the dummy of GDP level) may increase 0.6 per cent of energy consumption per capita. Moreover, economic growth also leads to lower price and income elasticities (in absolute terms). However, energy market integration can help to reduce the energy demand pressure and to smooth the demand shock through decreasing the income elasticity and increasing the price elasticity in particular in the long run. This finding can be used to explain how cross-country institutional arrangement related to energy market may affect regional energy consumption patterns over the period of rapid economic growth and offer policy implications for East Asia, which is diversified in terms of development level.

1. Introduction

Price and income are two primary factors shaping energy demand, and thus the elasticities to price and income are leading factors for understanding energy demand. It is widely believed that the income and own-price elasticities of energy products found in previous studies (Dahl & Sterner, 1991, Ferguson, *et al*., 2000, Bohi & Zimmerman, 1984, Taylor, 1975, Brenton, 1997) are two important indicators for measuring the response of a country's energy consumption to national income and international market price. However, there appears to be lack of a general agreement on representative values for these energy consumption elasticities, and in particular on why the magnitude of the elasticities may differ across countries with disparate development level and institutional arrangements.

For example, in a comprehensive survey of quantitative studies on country-specific energy consumption, Dahl (1992) showed that the demand for energy was price inelastic and slightly income elastic at the aggregate level but there were no clear cut evidence that the developing world's energy demand is less price elastic or more income elastic than for the industrial world, while Brenton (1997) and Ferguson, *et al*. (2000) used some cross-country energy consumption data to estimate different energy demand equations respectively and found that the own-price elasticity for energy is higher in the poor than in the rich countries and income elasticity for energy declines with the rising of income.

To explain the above phenomenon, many studies including Maddala, *et al.* (1997), Garcia-Cerrutti (2000), Lowe (2003), Bernstein & Griffin (2005), and Yoo (2006) attempted to incorporate some regional specific characteristics, such as different consumption preferences and different energy-usage techniques in production across countries, into the estimation of the cross-country energy consumption function. Those studies provided some interesting results with respect to the relationship between economic growth, policy making and energy consumption through improving the accuracy of estimating the income and price elasticities of energy products. However, they could not explain two important phenomena (Bernstein & Griffin, 2005): (1) estimated energy consumptions in cross-country studies generally lack price elasticity, which is significantly different from those in country-specific studies; (2) estimated energy consumptions in country-specific studies usually show different trends over different time periods, which is probably due to the differences in country-specific characteristics.

The above two phenomena raise an interesting question as to whether "Economic Development and Institutional Arrangements associated with Energy Market" — the two most important features specific to countries at different phases of development and income levels — can be identified as affecting the income- or own-price- energy consumption relationship and changing the related elasticity estimation across countries over time.

The attempt to link economic development and institutional arrangements associated with energy market to energy demand is of interest to academics and policy makers. On one hand, the contradictive findings from the previous literature ask for further studies from the academic perspective to fuel the debate in public. On the other hand, policy makers need to know energy demand in the future and its resistance to price volatility in the energy market in order to assist decision making. In practice, an accurate projection on energy demand is important for policy makers to secure energy supply, while understanding the response of energy demand to price is essential for reducing market uncertainty.

This study attempts to measure the income and price elasticities of energy consumption and link them to a country's economic development and institutional arrangements related to Energy Market Integration (EMI), aiming to inform policy makers on the different roles EMI may play in changing a country's energy demand when the country stays at different economic development stages. Implications from this study can be shed light on two policy issues in the East Asian Summit (EAS) region. The first policy issue is that many EAS countries are less developed and will industrialize in the future, thus the projection on the relationship between energy-demand and industrialization is critical to inform the potential energy supply challenge. The second policy issue is about how to value the impact of EMI. An incentive for EAS countries to participate in EMI is that regional integration may help to secure the energy supply for sustainable economic growth and to reduce income disparity in the region. However, to what extent this goal can be achieved and how much benefit each country can obtain from regional integration depend on the impact of regional integration on the income and own-price elasticities of energy products.

The paper is organized as follows. Section 2 summarizes the structural change in energy demand of some major countries. The experience of development shows that there are often significant structural changes in energy demand when a country moves from the lower economic-growth stage to the higher one, and different institutional arrangements associated with energy market may impose different impacts on such structural changes. Section 3 develops a dynamic panel data model, which incorporates the impact of different economic-growth stages and different institutional arrangements associated with energy market into the estimation of energy demand function. Section 4 presents the estimated results which show that countries in different stages of economic development, and with different involvement in energy market integration, would demonstrate different levels of demand for energy consumption in response to changes in price and income. Section 5 applies the empirical results for analysing the economic development, changes in institutional arrangements and energy demand in the EAS region. Some policy implications are drawn concerning energy market integration and its impact on the future demand and international trade in the world energy market. Section 6 concludes.

2. Changing World Energy Demand and Its Determinants

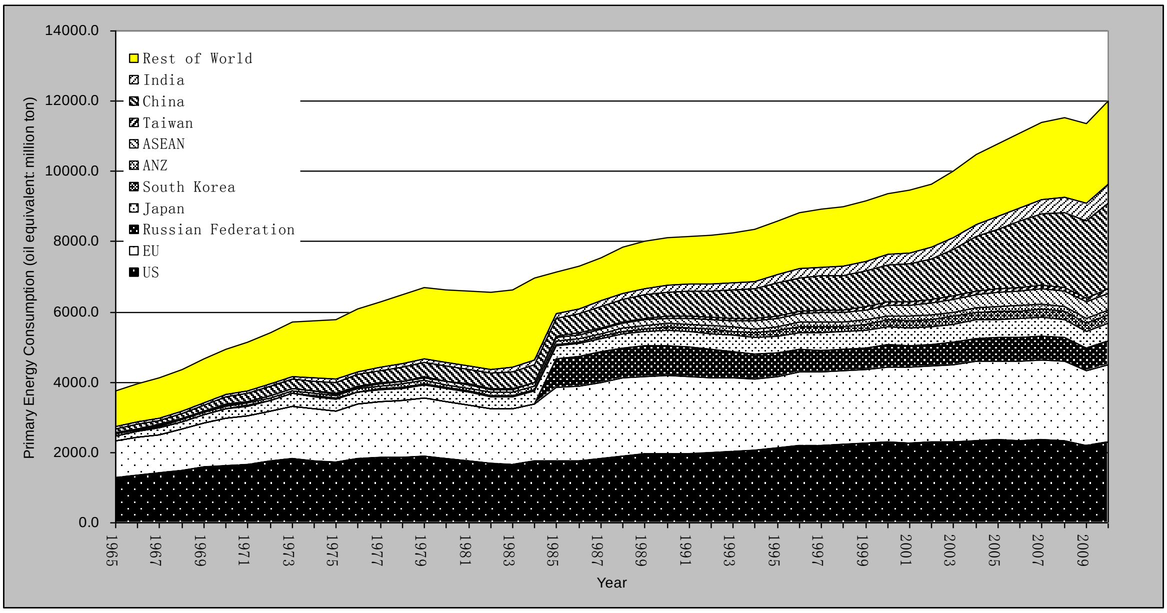
The world primary energy demand has experienced rapid growth over the past five decades, despite a slight drop due to the supply shock in the late 1970s. Up to 2010, the total world primary energy demand had reached 12.0 billion ton of oil equivalent which is 3.2 times of that (3.8 billion ton of oil equivalent) in 1965. Behind the steady increasing trend of world primary energy demand, countries with different levels of development have demonstrated different energy demand patterns. Three characteristics of cross-country primary energy consumption trends in the world can be summarized as follows (IEA, 2011). First, the primary energy demand in developed countries is still dominant in the total world primary energy consumption, though they increased slowly. Second, the primary energy demand in developing countries, in particular the new industrialized economies (NIEs) in East Asia, increased rapidly and became a new engine of the total world energy consumption growth. Third, the newly increased part of the world primary energy demand came in a wave by wave pattern and has been dominated by different countries with different stages of development over time.

Figure 1 shows the world primary energy consumption and the components of its growth across countries and economies during the period 1965-2010. As shown in Figure 1 (a), from 1965 to 2010, the annual growth rate of primary energy demand from the United States, the European Union and Japan is on average 1.5 per cent which is far lower than that from developing economies in East Asia, such as South Korea, Taiwan, ASEAN, China and India, which is around 5.8 per cent on average. As a consequence, the share of the primary energy demand from the US, EU and Japan over the total demand of the world, declined from 79.3 per cent to 53.1 per cent (but is still dominant in world primary energy consumption) while that from South Korea, Taiwan, ASEAN, China and India increased from 6.9 per cent to 24.7 per cent over this period. This implies that developing economies are increasingly becoming a major driving force of the primary energy demand in the world.

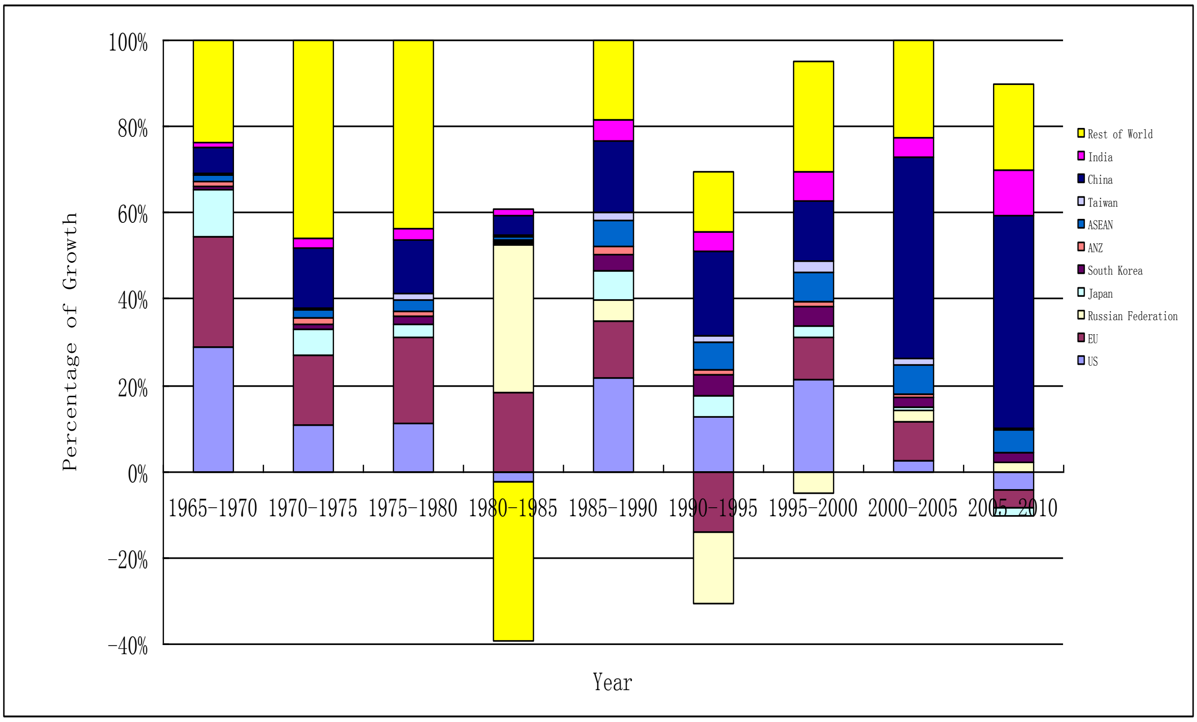
Moreover, as shown in Figure 1 (b), the driving force for the primary energy demand seemed to come from different counties/economies over different time periods. The newly increased primary energy demand mainly came from the EU and Japan during the period of 1965-1970, the major driving force for the primary energy demand came from the new industrialized economies, such as South Korea, Taiwan and ASEAN, during the period of 1980-1990, and the major driving force for the primary energy demand came from China, followed by India, after 1990-2010. This implies that the newly increased world primary energy demands have been waved up and increased as more and more countries/economies have entered the process of industrialization.

Figure 1: World Primary Energy Consumption and Its Structural Distribution by Countries

(a) World primary energy consumption by countries (oil equivalent: million ton): 1965-2010



(b) Share of world primary energy consumption growth by countries: 1965-2010

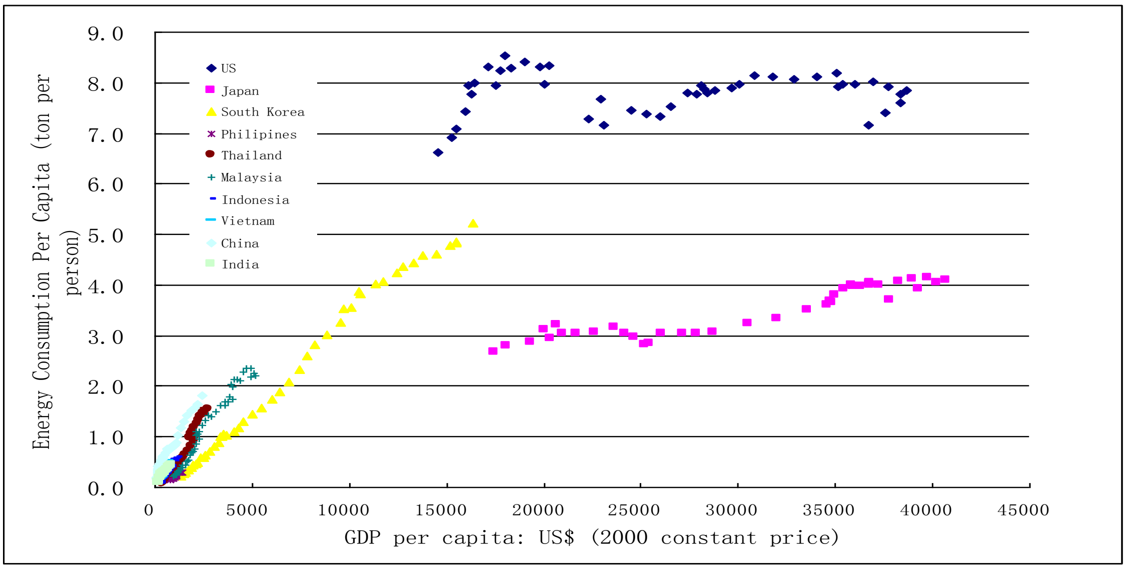


Source: BP Statistical Review of World Energy (BP, 2011).

The above phenomena raised a number of questions: why could East Asia, rather than any other parts of the world, has become the new engine of world primary energy demand? What are the underlying factors which can be used to explain the changing trend in the world primary energy demand? How has the changing world income and price of energy price affected world energy consumption? To answer those questions, a number of previous studies, such as IEA (2011), Karki, *et al.* (2005) and Yoo (2006) argued that the rapid increased world income and the vibrating oil price in the international market changed the demand pattern of world energy consumption, and the adjustment of institutional arrangements associated with energy market had played an important role in affecting the energy income and price elasticities.

Figure 2 shows the relationship between energy consumption per capita and GDP per capita in major Asia-Pacific countries during the period 1965-2010. As it is shown, there are significant increases in primary energy consumption in most countries when they experience rapid economic growth. This suggests that it was GDP per capita range rather than GDP per capita level seemed to play a more important role in affecting the primary energy demand both across different countries and over different periods of time. This observation provided us with a perspective for carrying out our empirical work.

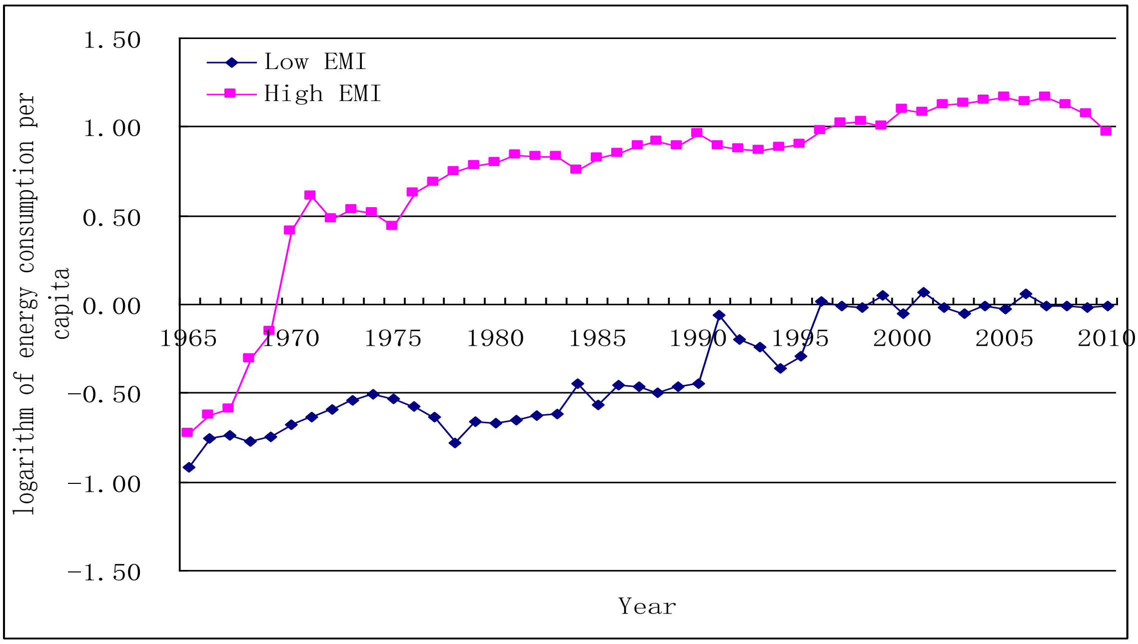
Figure 2: Relationship between Energy Consumption per Capita and GDP per Capita: 1965-2010



Source: Authors' calculation with the data from World Development Indicator (World Bank, 2012).

Moreover, as countries are re-categorized into two groups according to the level of their involvement into the energy market integration, it is easily to find that countries with different energy market integration level may have different energy consumption per capita. For the measurement of institutional arrangement, the paper follows Sheng & Shi (2011) to construct an energy market integration index by using bilateral trade of fossil fuel products, geographical distance between each trading partners and each country's population. As shown in Figure 3, countries with relatively higher energy market integration level have, on average, a higher energy consumption per capita compared with countries with relatively lower energy market integration level. This implies that EMI (or its representing institutional arrangement) is an important factor affecting the relationship between energy consumption and income and price.

Figure 3: Energy Consumption per Capita by EMI level: 1965-2010



Source: Authors' calculation with the data from World Development Indicator (World Bank, 2012)

3. Theory, Methodology and Data

Following the classical development theory (i.e. Chenery, *et al*. (1986)), the economic development of a country usually consists of four stages: agricultural economic stage, industrialization economic stage, commercialization economic stage and advanced economic stage. Each stage of economic development has its own significant features. More specifically, the agricultural economic stage is the initial development stage of an economy, which is characterized by the relatively large proportion of agricultural population and the relatively low level of industrialization. In this stage, the core of the economic development is to overcome the "dual economy". When economic growth moves on and the national income increases to some extent, the economy may enter into the second and the third development stages sequentially — that is, the industrialization and the commercialization economic stages. At these stages of development, the core of economic development is industrialization and urbanization and as a consequence, the economy will experience dramatic changes in industrial structure. Finally, after both secondary and tertiary industries are mature and primary industry declines below 10 % of total output, the economy can achieve the integration and step into the advanced economic stage. From then on, the economy growth will be mainly driven by technological progress and population growth. In each of the economic development stage, the disparity in institutional arrangements across countries may significantly promote or hamper the structure adjustment and its related resource consumption.

Applying the structural economic development theory with the changing pattern of energy consumption associated with economic development, one can easily find that: since different economic development stages are corresponding to different industrial structures and institutional arrangements associated with energy market, the relationship between economic growth of a country and her primary energy demand would vary along the economic development path. Thus, it is necessary to incorporate the economic development stages and institutional arrangements into the estimation of energy consumption function so that the impact of economic structural change on the fall and rise of energy consumption along the economic growth path can be examined.

Based on the standard consumption function with utility maximization theory, we assume that the demand for energy products is determined not only by changes in income and price but also varies with different economic development stages and institutional arrangements with which a particular country is associated. Thus, the demand function for energy products in double-log form for panel data regression can be written as:

$$\ln C_{it} = \beta_0 + \beta_1 \ln P_{it} + \beta_2 \ln Y_{it} + \gamma S_{it} + u_i + \varepsilon_{it} \qquad (1)$$

where C_{it} is the aggregated demand for all energy products in country i at time t which is measured with tons of oil equivalent and Y_{it} is the national income of country which is measured with US dollar at the 2000 current price and adjusted by purchasing power parity across countries. Both of those variables are measured on a per capita basis so as to control for any variation in population growth. Data for the price variable P_{it} is the real price of crude oil in the world market adjusted with country-specific factors (such as transportation costs and individual country's market condition), which is calculated using the spot price in the international market adjusted by the consumer price index in each country.[1] S_{it} is a group of variables representing structural change. In addition, u_i is defined as the country specific effect which does not change over time, and ε_{it} is defined as the random effect.

A key assumption of Equation (1) is that the income and price elasticities of each country for energy products are independent of their development stages or stable over time and thus all the effects associated with economic development can be squeezed into the coefficients of S_{it}. Moreover, as Equation (1) can be regressed with sample countries involving into different levels of institutional arrangements, the comparison of these regression results can also be used to examine the potential impact of institutional arrangements associated with energy market on various energy consumption elasticity and its relationship with economic development.

[1] Based on the BP Statistical Review of World Energy (2006), the spot price of crude oil before 1984 is set as the price of Arabian Light posted at Ras Tanura and that after 1984 is set as Brent dated price.

The appropriate measure of different economic development stages of a country has been a controversial topic in the literature on economic development. Many authors prefer to the use of trend proxies, such as the industrialization rate (or the share of secondary and tertiary industrial output over the total GDP), the urbanization rate (the share of the number of urban population over that of the total) and the industrial structural index of workforce, for this variable. Although those proxies reflect some characteristics of different stages of economic development, they may be generally biased when being incorporated into the estimation of energy consumption function since energy consumption is usually related to changes of the whole economy. For this reason, we use different ranges of GDP per capita (measured with 1984 constant price and adjusted with the purchasing power parity across countries) to generate a dummy variable (d_dgp) designed to capture the characteristics associated with industrialization along with economic development (with GDP per capita more than USD 5000 and less than USD 10,000 at the 1984 price taking the value of 1, otherwise 0) and its interaction term with price and income variables are included into the regression. Such design is consistent with Chenery, *et al*. (1986).

$$\gamma S_{it} = \gamma_1 \times d\_gdp + \gamma_2 \times d\_gdp \times P_{it} + \gamma_3 \times d\_gdp \times Y_{it} \qquad (2)$$

Where γ is a vector of coefficients and the interaction terms between the dummy for economic development (d_gdp) and income and energy price are included.

The EMI index (as is shown in Equation (3)) is defined as the relative import of fossil fuel products, which is equal to the average import of a country's fossil fuel products from its trading partner over its population (Sheng & Shi, 2011). To account for the impact of geographical vicinity and country-specific scale effects, the average import of a country's fossil fuel products is defined as the weighted average of the i country's import of fossil fuel products ($energy\_trade_{ijt}$) from each if its n trading partner (j) with the weights being geographical distance between the two countries ($distance_{ij}$) (obtained from Subramanian & Wei (2007)) and their population. Since the index generally increases as the country imports more fossil fuel from the neighborhood countries and deceases as domestic consumption) of fossil fuel products increase (or decrease), it can be used to reflect the extent to which the country is involved in neighborhood energy market integration.

$$EMI\_TRADE_{it} = \frac{1}{n}\sum_{n}(energy\_trade_{ijt} / distance_{ij}) \times 1 / Population_{it} \quad (3)$$

Estimation of our general model would seem to be quite simple using the standard ordinary least squares (OLS) method. However, this would be misleading with respect to its estimation due to the fact that most economic variables are non-stationary in their level form and this high auto-correlation may generate in-consistent estimators and inaccurate hypothesis tests (Granger & Newbold, 1974). To deal with this econometric problem, we use the dynamic panel data (DPD) regression technique developed by Arellano & Band (1991), Arellano & Bover (1995) and Blundell & Bond (1998) in this study. The advantage of the method is that it can make full use of the combinations of different variables to eliminate the endogeneity between independent variables and the residuals (or the co-integration of the non-stationary series) and as a result, both the long-term and short-term elasticities of energy consumption can be specified.

For a group of non-stationary series, Equation (1) can be re-arranged in a structural form to detail the long-run and short-run dynamics of a group of integrated variables:

$$\Delta Z_{it} = \eta + \sum_{j=1}^{n}\Gamma_j \Delta Z_{jt-ji} + \pi Z_{it-1} + \gamma S_{it} + u_i + \varepsilon_{it} \quad (4)$$

where Z_{it} is a vector of $I(d)$ variables, ε_{it} is a vector of white noise residuals, and η is a constant vector (representing the time trend). The adjustments to disequilibrium are captured over n lagged periods in the coefficient matrix Γ_j.

Following Roodman (2006), we can specify suitable instrumental variables from the lagged or differentiated dependent and independent variables and use the difference and system GMM methods to investigate the relationship between integrated series with dynamic panel data.[2] Obviously, for a long-run relationship to

[2] The Johansen (1991) test orders linear combinations of the different variables using eigen values, and then sequentially tests whether the columns of the α matrix are jointly zeros.

exist, at least the first column must contain non-zero elements. Thus, this co-integrating relationship specified in Equation (4) represents the foundation of a complete dynamic panel model and the regression which allows us to compare the immediate and overall average elasticities of energy demand across countries.

Finally, the data used in the above regression covered 71 countries and regions for the period 1965-2010. The data for energy consumption in each country and that for the real price of crude oil come from BP Statistical Review of World Energy (BP, 2011). The data for population and GDP (calculated with the constant price and adjusted for purchasing power parity) come from the World Development Indicators (World Bank, 2012).

4. Empirical Results

4.1. Model Selection and Benchmark Results

Before estimating any relationship between energy consumption and its explanatory variables, one may need some identification strategy either from economic or statistical perspectives. Specifically, it is assumed that all lagged independent variables on the RHS of Equation (4) are exogenous so that their further lagged or differentiated items can be used as the instrument variables for GMM estimation.[3] Based on Roodman (2006), we first differentiate the regression function (say, Equation (4)) to remove country specific effect (u_i) and thereafter produce an equation that is estimable by instrumental variables and use a Generalised Method of Moments estimator for coefficients using lagged levels of the dependent variable and the predetermined variables and differences of the strictly exogenous variables. The results from both a difference GMM and system-GMM estimation are compared to examine the autocorrelation of the logged energy consumption (with Equation (5)).

$$\ln C_{it} = \theta \ln C_{it-1} + \sum_{t=1}^{T} D_{it} + u_i + \varepsilon_{it} \tag{5}$$

---

[3] This assumption is only made for simplicity, and the results from the endogenous independent variables are shown in Appendix A.

where D_{it} is a group of lagged independent variables. The results show that the coefficient of $\ln(C_{t-1})$ is 0.95 and the significance level is ($Z = 58.45$) close to 1 per cent ($m_1 = 0.002$, $m_2 = 0.026$, Sargan-Hassen test=1). According to Blundell & Bond (1998), this suggests that a system GMM estimate will be more suitable than the difference GMM estimation. Furthermore, we use the Arellano-Bond test for AR(1) and AR(2) in first differences to choose the suitable lagged periods for dependent and independent variables and the Sargan-Hassen test to specify the combination of instrumental variables for the system GMM estimation. Finally, we eliminate the insignificant independent variables from the regressions with no dummy for economic development, with only intercept for economic development and with intercept and interaction terms, and the results are shown in Table 1. A further split of the sample into countries with high and low EMI indexes are also used to examine the impact of different institutional arrangements associated with energy market on the estimated energy income and price elasticities, and results are shown in Table 2. There are two interesting findings shown below.

4.2. Impact of Economic Development on Energy Consumption

First, there exist some significant income and price elasticities for energy demand with the cross-country data over time and in particular there are significant time structures for these income and price elasticities for energy demand which is different from the results obtained from the previous studies on cross-country studies (Dahl, 1992). From column 1 of Table 1, we have the estimated energy demand function as below:

$$d\ln C_t = -0.241 + 0.555 d\ln Y_t - d\ln P_t - 0.081[\ln C_{t-1} - 0.407\ln\ln Y_{t-1} + 0.012\ln P_{t-1}] \quad (6)$$

from which both the short-run and long-run income and price elasticities can be calculated.

Table 1: The GMM Estimations of Price and Income Elasticity of Energy

	No Dummy	With Dummy	With Interaction
Dependent variable: lnenergy_consumption_per capita			
lnenergy_consumption_per capita (t-1)	0.919***	0.918***	0.908***
	(0.007)	(0.007)	(0.007)
lnprice (t)	-0.008***	-0.008***	-0.007***
	(0.003)	(0.003)	(0.000)
lnprice (t-1)	0.007***	0.007***	0.006***
	(0.003)	(0.003)	(0.002)
d_gdpXlnprice(t)	-	-	0.006***
	-	-	(0.006)
d_gdpXlnprice(t-1)	-	-	-0.008*
	-	-	(0.006)
lngdp_percapia (t)	0.555***	0.555***	0.582***
	(0.027)	(0.027)	(0.032)
lngdp_percapita (t-1)	-0.522***	-0.523***	-0.538***
	(0.027)	(0.027)	(0.033)
d_gdpXlngdp_percapita(t)	-	-	0.257***
	-	-	(0.065)
d_gdpXlngdp_percapita(t-1)	-	-	-0.235***
	-	-	(0.064)
d_gdp	-	0.006***	0.283***
	-	(0.001)	(0.096)
Constant	-0.241***	-0.237***	-0.332***
	(0.056)	(0.056)	(0.068)
Number of observations	2,272	2,272	2,272
Wald Test	50,539	50,546	50,790

Note: the numbers in brackets are the standard errors. "*", "**" and "***" represent the coefficients are significant at 10 per cent, 5 per cent and 1 per cent level respectively. Source: Authors' own estimations. Year dummies have been included to control for the year-specific effects.

The short-run and the long-run price elasticities are -0.008 and -0.012 respectively. The finding that elasticities are less than one is expected since energy is a necessity. The finding that the absolute value of the short-run own price elasticity is lower than the long-run one is also expected. A feasible explanation is that energy products lack substitutes especially in the short run but in the long run exploration of new technology and energy products may reduce the energy demand. For example, when there is a hike of oil prices, customers can reduce their vehicle use immediately and later, in the long run, they can also use more energy efficient vehicles.

Equation (6) also shows that the short-run and the long-run income elasticities are 0.555 and 0.407 respectively. That is, the absolute value of the short-run income elasticity is higher than the long-run elasticity. The relatively low income elasticity in the long run could be explained that as time goes on, there is a shift away from traditional energy consumption technology towards new energy consumption technology; and improved energy usage efficiency. In addition, income growth leads to exploration of new substitute for energy products in production and consumption (Jones, 1991), and thus the income elasticity will be lower in the short run as compared to the long run.

The above finding of different long-term vs. short-term price and income elasticity also helps to explain the inconsistency between the cross-country and country specific estimates on energy demand. Unlike this present study, previous studies on cross countries samples show no significant price elasticity, which is inconsistent with the impact of international oil price on demand, see IEA (2011). The reason is likely that the analytical approach adopted in the previous study only allows them to show the short-run effects. As there is no substitute for energy products in production and consumption for the short term, it is of no surprise that there is no significant price elasticity.

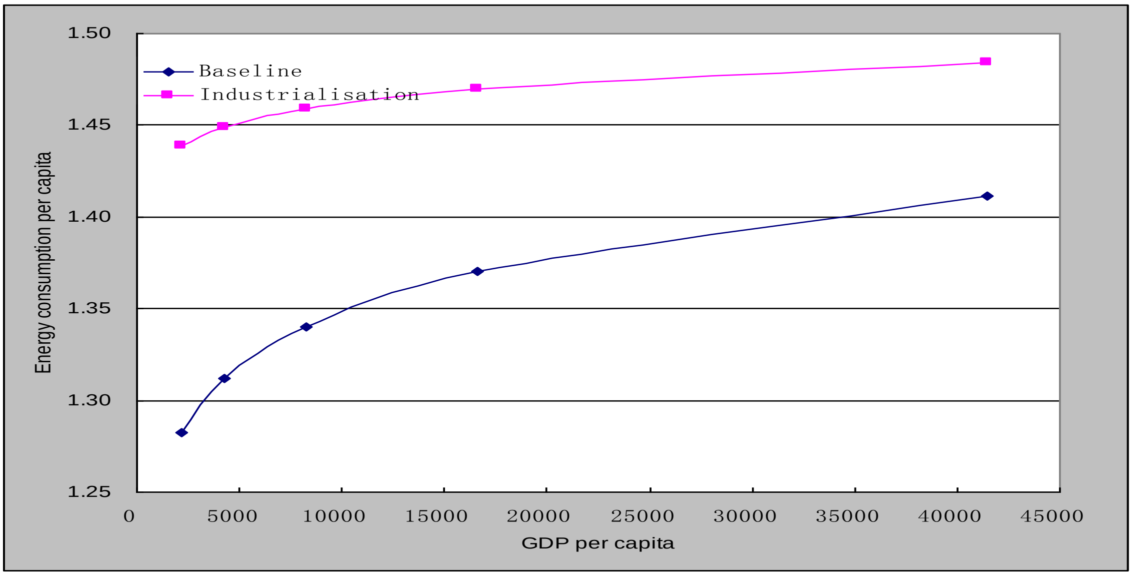
Second, the different stages of economic development play an important role in affecting the energy demand in addition to the income and price effects. To illustrate this point, we make use of the dummy for economic development level (as shown in column 2) and their interaction terms with price and income (as shown in column 3) and the related lags to estimate the income elasticity of energy consumption for different stages of a country's development.

The estimated results obtained from the regression incorporating the interaction terms between dummy for economic development level and price and income variables and its lags show that countries at different economic development stages may have different price and income elasticities. Compared to other countries, countries when coming to the stage of industrialization and urbanization process may tend to have relatively lower price and income elasticities in both the short and long run. Estimated price and income elasticities for countries expiring rapid economic growth is around -0.016 and 0.475, which are lower than the coefficients for countries at lower development stage, say -0.042 and 0.712. This suggests that as economies are experiencing industrialization and urbanization processes, their energy consumption is less likely to respond to the price and income level. Observation that fast growing regions have lower price elasticity is demonstrated at least in the case of oil (Dargaya & Gately, 2010).

Moreover, in both cases, the estimated coefficients of the dummy for economic development level are positive and significant at 1% level. This suggests that an economy when coming to the stage of industrialization and urbanization process may consume more primary energy products than countries in other economic development stages. In other words, as GDP per capita increased from USD 5,000 to USD 10,000 (1984 constant US dollars) (or at the industrialization stage), there will be a significant increase in energy demand in addition to the income effects. An explanation for this phenomenon is that: when an economy undergoes transformation from an agricultural society to an industrialized society the more capital- and energy-intensive sectors will substitute the labor-intensive sectors in dominating the production (Humphrey & Stanislaw, 1979). This could also be the case in the advanced development stage where services, while not high energy-intensive industrial goods, are the driver of economic growth. Another explanation is that associated urbanization will drive more energy demand than the agricultural society through food delivery, infrastructure development and maintenance, changing domestic activity (Jones, 1991). In other words, the relationship between economic growth and energy demand will be changed when a country starts and finishes industrialization. Therefore, those energy outlooks that did not take consideration of such structural changes would be questionable.

Combining the above two points, Figure 4 provides the simulated relationship between energy consumption per capita and stages of economic development, which shows that the marginal contribution of industrialization towards percentage changes in energy consumption won’t reach the peak until the per capita income level reaches USD 10,000. These findings can be used to explain the pattern of wave-by-wave increases in energy demand from East Asia following the development process of different countries in this region during the past four decades, even if the price elasticity is assumed to be constant across countries. This also helps us to identify the future trend of changing world energy demand as some new industrialized countries such as China and India move along the path characterized with the "continuous change and breaking-points". This also means that we should expect more energy demand from China and India in the past decade when industrialization and urbanization is at a historic high speed.

Figure 4: Simulated Relationship between Energy Consumption and Changes in Income



Source: Authors' own calculation.

4.3. Role of Energy Market Integration in Affecting Energy Consumption

How do different institutional arrangements associated with energy market may affect energy demand of countries at different economic development stages? To answer this question, we adopt a regression (similar as that for economic development) to re-estimating the price and income elasticity of energy consumption with the control of the dummy for energy market integration and its interaction with price and income included separately. The dummy for EMI is evaluated against the average EMI index: countries with high EMI indexes taking 1 and countries with low EMI indexes taking 0. The regressions have been made for all samples and countries with high economic growth as a robustness check. For simplicity, there is no distinction between the long-term and short-term effects in this exercise, and the estimation results are shown in Table 2.

Table 2: Impact of EMI on Energy Consumption Elasticities

	All Sample		High Growth/Industrialization Countries	
	With Development Dummy	With Interaction Term	With Development Dummy	With Interaction Term
Dependent variable: lnenergy_consumption_per capita				
lnenergy_consumption_percapita (t-1)	0.966***	0.958***	0.897***	0.900***
	(0.007)	(0.008)	(0.013)	(0.014)
lnprice (t)	-0.008***	-0.010***	-0.009**	-0.027***
	(0.003)	(0.003)	(0.004)	(0.010)
lnprice (t-1)	0.007***	0.010***	-0.002	0.012
	(0.003)	(0.003)	(0.004)	(0.009)
EMI_DummyXlnprice(t)		0.002		0.021**
		(0.004)		(0.010)
EMI_DummyXlnprice(t-1)		-0.006*		-0.016*
		(0.004)		(0.009)
lngdp_percapia (t)	0.523***	0.521***	0.386***	0.421***
	(0.028)	(0.028)	(0.046)	(0.051)
lngdp_percapita (t-1)	-0.516***	-0.516***	-0.360***	-0.368***
	(0.028)	(0.028)	(0.045)	(0.046)
EMI_DummyXlngdp_percapita(t)		0.010**		-0.032*
		(0.005)		(0.019)
EMI_DummyXlngdp_percapita(t-1)		0.001		0.005
		(0.002)		(0.004)
EMI_Dummy	0.012***	-0.070*	0.043***	0.276
	(0.006)	(0.037)	(0.008)	(0.179)
Constant	-0.037***	-0.028	-0.103	-0.337*
	(0.058)	(0.063)	(0.068)	(0.189)
Number of observations	2,272	2,272	955	955
Wald Test	48,177	48,533	15,035	14,902

Source: Authors' own estimation.

Given the same condition, energy consumption per capita in countries with higher level of involvement in energy market integration are significantly higher when the price and income elasticities are assumed to be same. The estimated coefficients in front of the dummy for energy market integration from both regressions are positive and significant at 1% level (shown in columns (1) and (3) of Table 2). However, when the interaction terms between the dummy for energy market integration and price and income variables (as a substitute for the dummy for energy market integration itself) are added into the regression, the estimation result shows that the coefficients in front of the dummy variable of energy market integration become less significant. This suggests that the difference in energy demand among countries with different levels of involvement energy market integration comes from their different price and income elasticities.

Furthermore, to understand the impact of EMI on the energy consumption behaviors of countries at different economic development stages, we convert the estimated coefficients obtained from the regression into the corresponding price and income elasticities shown in Table 3.

On average, the countries with a higher level of involvement in energy market integration tend to have no significant difference in energy consumption level but do have a relatively lower income elasticity and higher own-price elasticity. In other words, policy towards energy market integration tends to improve the flexibility of a country in meeting its energy demand through the international market.

Table 3: The Impact of EMI on the Price and Income Elasticities

	All samples		High income country	
	emi	base	emi	base
Price Elasticity: long term	-0.15	0.00	-0.22	-0.15
Price Elasticity: short term	-0.01	-0.01	-0.01	-0.03
Income Elasticity: long term	0.35	0.32	0.20	0.52
Income Elasticity: short term	0.53	0.52	0.39	0.42

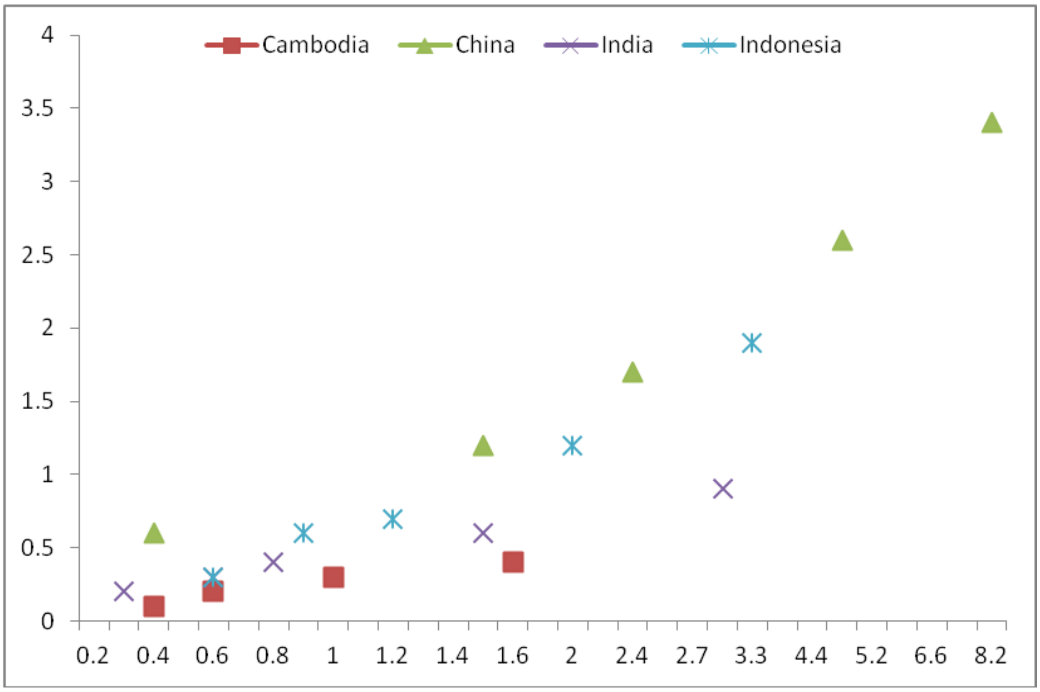
Source: authors' own estimation.

5. Policy Implications

As argued in the previous section, the results show that EMI does help to strengthen the energy supply to the region as a whole so as to increase the income elasticity of energy consumption of countries with rapid economic growth driven by factors such as industrialization and urbanization, whose further economic development may be restricted by high energy price and low-linkage between energy consumption and income. In addition, we also show that the future energy demand of the whole region can be better projected when accounting for country-specific characteristics related to economic growth and institutional arrangements.

The study may also offer policy makers a chance to understand countries' future paths of energy demand. Current energy outlooks, such as Kimura (2011), often assume liner relationship between economic growth and energy demand and reply on history trend. This will create at least two problems: countries with low/high history data will stay low/high, which are unrealistic. For example, the path of Cambodia and China in Figure 5. The likely difference for the forecasting between China and Cambodia is that Cambodia is on a long energy intensity path due to agriculture dominated economy which China is on a rapid growing energy intensity path due to industrialization and urbanization.

Figure 5: Economic Development and Energy Demand in Selected Countries, 1990-2005



Source: Kimura (2011).

However, if we consider the structure change in the relationship between economic growth and energy demand, the future scenarios would be different. As has been shown in Figure 4, in the advanced stage of development, the growth of energy demand would slow down. The change of relationship will change the regional energy outlooks significantly. Earlier developing countries, like China may demand less energy in the future while later developing countries, like Cambodia, may demand more. The changes in policy implications could be: the region could be relatively easy about the demand from China; instead, it needs to pay more attention to later developing countries; the later developing countries need to prepare for their booming demand of energy and consequent environmental impact. Improvement of supply capacity in those later developing countries thus should be a policy priority; In contrast, earlier developing countries should switch focus from the supply side to the demand side, such as energy saving and energy productivity.

Clearer understanding of energy trend, in particular, structure change, also helps energy modelers to improve their forecasting. Structural changes were deliberately omitted by energy modelers in predicting long run energy outlooks, which, however, play an important role in shaping future energy policy, and technical development. However, there is a general trend that the outlook of energy demand tends to extend recent trend to the future, whilst avoiding structure change. One of the reasons for this trend is that modelers themselves are not sure about the structure changes and thus tend to minimize their risks of predictions by not proposing scenarios that will significantly increase the level of acceptance of their outlooks (Matsui, 2011). Considering the fact that EMI has been implementing in many regions, EMI structural change would be popular and have impacts on a large scale. Therefore, a deep understanding of its impacts on energy trend is beneficial and necessary for future policy making.

Another policy implication is that EMI can smooth the fluctuation of energy demand, which will improve energy security and thus should be firmly promoted. In particular, economies that are undergoing industrialization and commercialization should adopt EMI, which can increase price elasticity of energy demand. With increased elasticity, the economy will be more resilient to price volatility.

6. Conclusion

This study uses a dynamic panel regression technique to estimate a cross-country demand equation for energy products with 71-country and 45-year long data and examines the cross-country income and price elasticities of energy consumption during the period of 1965-2010.

The results show that countries in different stages of economic development and institutional arrangement associated with energy market would demonstrate different levels of demand for energy consumption and thus the energy consumption related to price and income elasticities. In particular, we found that countries at specific economic development stages may have relatively higher income elasticity or relatively lower price elasticities due to economic structural changes, which in turn may impose additional pressure on the demand side of the international energy market.

Energy market integration can help to reduce such a pressure by improving the domestic energy supply and thus reduce the price elasticity. This finding can be used to shed light on explaining the recent boom in China's and India's ever increasing demand for energy products in the East Asian Submit region, which has important policy implication for assessing the role of EMI in the region to maintain sustainable regional economic development.

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CHAPTER 3

Power Generation and Cross-border Grid Planning for the Integrated ASEAN Electricity Market: A Dynamic Linear Programming Model

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The central question raised in this study is how to meet the growing power demand in ASEAN countries in the next two decades. Uneven distribution of energy resources and uneven paces of economic development among ASEAN countries complicate the question. The ASEAN Power Grid (APG) that interconnects all ASEAN countries and enables cross-border power trade could potentially provide cost-saving solutions. This study builds a dynamic linear programming model and simulates optimal development paths of power generation capacities in ASEAN countries. Scenarios are built around the assumptions about the power trade policy regimes. It is found that more open power trade regime encourages more development of renewable sources of power generation, and accrues more savings in the total cost of meeting the growing future power demand from 2010 to 2030.

1. Introduction

Electricity demand in the ASEAN region is projected to grow 6.1%-7.2% per annum. At such speeds, it would arrive at 3-4 times of current level by 2030 (Institute of Energy Economics, Japan *et al*., 2009). Comparing to the Asia Pacific region as a whole for which the electricity demand grows at 3.4% per annum (ADB, 2009), ASEAN's demand for electricity is growing especially fast, thanks to the exceptionally high economic growth prospect of the region.

Meeting such high growing demand will be extremely challenging although ASEAN countries are considered rich in energy resources. It is estimated that the ten member countries of ASEAN have 22 billion barrels of oil reserve, 227 trillion cubic feet of natural gas reserve, 46 billion tons of coal reserve, 234 gigawatts of hydropower potential and 20 gigawatts of geothermal capacity (ASEAN Ministers on Energy Meeting, 2004). However, the distribution of the resources is unbalanced. Most of the hydropower resource is located within the Greater Mekong Subregion that includes Cambodia, Lao PDR, Myanmar, and Viet Nam, as well as Yunnan and Guangxi Provinces in southern China. Coal resource concentrates in Indonesia and Malaysia. Most of the gas and oil reserves are in Malaysia and Indonesia. Apart from uneven energy resource endowment, the unbalanced level of economic development among the ASEAN countries adds to the difficulty in utilizing these resources to meet the fast-growing electricity demand (Atchatavivan, 2006).

In vision of the above situation, an ASEAN power grid that links the energy resource-rich and the energy resource-poor countries could potentially play an important role in reducing the overall cost to the region to meet its growing electricity demand. The ASEAN 2020 Vision adopted in 1997 by the heads of state at the 2nd ASEAN Informal Summit held in Kuala Lumpur envisioned an energy-interconnected Southeast Asia through the ASEAN Power Grid and the Trans-ASEAN Gas Pipeline Projects. A working group was established in 2000 to undertake an ASEAN Interconnection Master Plan Study (AIMS), completed in 2003. Based upon an optimization study, eleven potential power grid interconnection projects were selected for potential implementation through 2020. The Heads of ASEAN Power Utilities/Authorities (HAPUA), a specialist organization under the ASEAN Center for Energy (ACE), monitors the implementation of the Power Grid (Atchatavivan, 2006).

The quantitative analysis of regional power market integration in ASEAN has not been studied extensively, and a few existing studies have focused on the institutional and policy aspects of regional development in relation with energy cooperation. Yu (2003) discussed the policy and institutional barriers to the formation of the Greater Mekong Sub-region (GMS) energy cooperation. Economic Consulting Associates (2010) provides an update on the progress of GMS power market integration. Adopting the Purdue Electricity Trade Model – a cost minimization model for energy resource planning, Yu, *et al*. (2005) assess the potential of hydropower development and free power trade between China and ASEAN countries. Watcharejyothin & Shrestha (2009) develop a simulation model to analyze the power development planning of Lao PDR and Thailand and explore the power trade opportunities between the two countries, focusing on hydropower. In sum, a systematic analysis on the planning of power development and the economic benefits with an integrated ASEAN power market has not been conducted.

This study serves to quantify the economic benefits of the ASEAN power grid, as well as to propose an optimized development plan of power generation capacity in the region, based on the ASEAN Power Grid (APG). Accordingly the purposes of this study are on the one hand to justify the investments on the ASEAN Power Grid, and on the other hand to identify the priorities in developing new power generation capacity and transmission lines to meet the growing demand over time. For these purposes, a dynamic linear programming model is built to simulate the demand and supply of electricity in the ASEAN region in the next few decades. The following section presents more details about our methodology.

2. Methodology

Answering how to prioritize increasing generation capacity and expanding grid networks, this study applies a well-established dynamic linear programming model to the power planning of the ASEAN countries for the next few decades, assuming that the corresponding ASEAN Power Grid infrastructure would be in place. In this way, this study delivers implications on the optimal timing of investment in both the power generation capacity and the cross-border power grid infrastructure. In our framework, being optimal would imply the least cost of power generation while catering to meet the growing electricity demand.

This study intensively scans and collects data about exploitable energy resources in each member country of ASEAN as well as the operation cost and capital cost of monetizing the resources for power generation using different technologies. Our dynamic linear programming algorithm suggests the optimal timing of investing and monetizing each type of energy resource of the ASEAN countries.

A few scenarios are constructed to reflect different assumptions about power trade policies: no power trade, 20% of demand allowed to be met by power trade, and 50% of demand allowed to be met by power trade.

The study adopts a dynamic linear programming framework in power generation first developed by Turvey & Anderson (1977) and later adapted by Chang & Tay (2006). In this study, significant extensions of the original models are made. A new country dimension is added to allow an international framework with cross-border electricity trade. The new model also adds the cost of cross-border power transmission as well as transmission loss into account. Last but not least, the model covers the issue of carbon emissions from power generation as well as the carbon cost of power generation. The model is solved using General Algebraic Modelling System (GAMS).

The study serves two important purposes, one of which is to examine the least-cost development of different types of energy resources using dynamic optimization and the other is to comprehensively scan alternative combinations of energy resources needed for power generation in each time period.

In such a model, taking a long-time horizon, the planner's objective is to choose plant capacities and outputs so as to minimize the present value of total costs.[1] The levelized cost of generating electricity is therefore embedded in this model. The sets of constraints to be satisfied are as follows. First, available installed capacity needs to be sufficient to meet the expected peak demand plus an allowance for demand above expected levels. Second, the total plant output must be sufficient to meet the

[1] The model is one with cost-minimization of power development planning over long-time horizon. Unlike a dynamic CGE model, it does need to assume a steady state solution.

instantaneous power demand levels. Third, the output from each plant cannot exceed its available capacity.

Adapting and modifying the dynamic linear programming framework, this study quantifies external economic, technological, and institutional shocks in different scenarios and develops power planning strategies accordingly.

3. Model Description

CAPEX

The following models the capital expenditure (CAPEX) of a certain type of power generation capacity at a certain point of time. Let x_{miv} be the capacity of plant type *m*, vintage *v*,[2] in country *i* and c_{miv} be the corresponding capital cost per unit of capacity of the power plant. So the total capital cost during the period of this study would be $\sum_{i=1}^{I}\sum_{v=1}^{T}\sum_{m=1}^{M} c_{miv} * x_{miv}$ (In GAMS code, for consistency in presentation with the other cost terms, we add a time dimension to the equation besides the vintage dimension. By doing that, we amortize capital cost using a capital recovery factor).

OPEX

The following models the operational expenditure (OPEX) of a certain type of power generation capacity at a certain point of time. Let u_{mijtvp} be power output of plant *m*, vintage *v*, in year *t*, country *i*, block *p* on the load, and exported to country *j*. Let F_{mitv} be the corresponding operating cost which varies with *v*, and θ_{jp} be the time interval of load block *p* within each year in the destination country. *Opex*(*t*) in year t is expressed as $\sum_{i=1}^{I}\sum_{j}^{J}\sum_{v=-V}^{t}\sum_{p=1}^{P}\sum_{m=1}^{M} F_{mitv} * u_{mijtvp} * \theta_{jp}$. .

Carbon Emissions

The model considers carbon emissions of different types/technologies of power generation capacity and takes the cost of carbon emissions into consideration. Let ce_m

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[2] Vintage indicates the time a certain type of capacity is built and put into use.

be the carbon emissions per unit of power plant capacity of type j plant, and cp_t be the carbon price per unit of carbon emissions in year t. The amount of carbon emissions produced are expressed as $\sum_{m=1}^{M}\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{v=-V}^{T} u_{mijtvp} * \theta_{jp} * ce_m$, and carbon cost in year t is $CC(t) = cp_t * (\sum_{m=1}^{M}\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{v=-V}^{T} u_{mijtvp} * \theta_{jp} * ce_m)$.

Cross-border Transmission Cost

The costs of cross-border transmission come in two forms. One is the tariff paid to recover the capital investment and operational cost of the grid line. The other is the transmission loss, which could be significant if the distance of transmission is long. To model the tariff of transmission, let $tp_{i,j}$ be the unit MWh transmission cost of power output from country i to country j. Let $TC(t)$ be the total cost of cross-border power transmission in year t, we have $TC(t) = \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{v=-V}^{T}\sum_{p=1}^{P} u_{mijtvp} * \theta_{jp} * tp_{i,j}$.

Objective function

As discussed earlier in the methodology section, our objective is to minimize the total cost of electricity during the period of this study. The objective function is written as:

$$obj = \sum_{i=1}^{I}\sum_{v=1}^{T}\sum_{m=1}^{M} c_{miv} * x_{miv} + \sum_{t=1}^{T}\{Opex(t) + CC(t) + TC(t)\} \quad (1)$$

Constraint conditions

Optimizing the above objective function is subject to the following constraints. Equation (2) shows a first set of constraints, which require total power capacity to meet total power demand in the region. Let Q_{itp} be the power demand of country i in year t for load block p.

$$\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{m=1}^{M}\sum_{v=-V}^{t} u_{mijtvp} \geq \sum_{i=1}^{I} Q_{itp} \quad (2)$$

The second one, shown in equation (3), states the constraint of load factor lf_{mi} of each installed capacity of power generation. Let kit_{mi} be the initial vintage capacity of type m power plant in country i.

$$u_{mijtvp} \leq lf_{mi} * (kit_{mi} + x_{miv}) \quad (3)$$

The third constraint, shown in equation (4), says that power supply of all countries to a certain country must be greater than the country's power demand. Let $tl_{i,j}$ be the ratio of transmission loss in cross-border electricity trade between country *i* and country j.

$$\sum_{j=1}^{J}\sum_{m=1}^{M}\sum_{v=-V}^{t} u_{mijtvp} \cdot tl_{ij} \geq Q_{itp} \tag{4}$$

Equation (5) states that total supply of power of one country to all countries (including itself) must be smaller than the summation of the country's available power capacity at the time.

$$\sum_{j=1}^{J} u_{mijtvp} \leq \sum_{m=1}^{M}\sum_{v=-V}^{t} lf_{mi} * (kit_{mi} + x_{miv}) \tag{5}$$

The fifth constraint, shown in equation (6), is capacity reserve constraint. Let pr be the rate of reserve capacity as required by regulation. And let $p = 1$ represent the peak load block.

$$\sum_{i}^{I}\sum_{m=1}^{M}\sum_{v=-V}^{t} lf_{mi} * (kit_{mi} + x_{miv}) \geq (1 + pr) * \sum_{i}^{I} Q_{it,p=1} \tag{6}$$

Specifically, hydro-facilities have the so-called energy factor constraint as shown in equation (7). Let ef_{mi} be the energy factor of plant type *m* in country *i*. Other facilities will have *ef*=1.

$$\sum_{p=1}^{P}\sum_{j=1}^{J} u_{mijtvp} \leq ef_{mi} * (kit_{mi} + x_{miv}) \tag{7}$$

Lastly, development of power generation capacity faces resource availability constraint, which is shown in equation (8). Let $XMAX_{mi}$ be the type of resource constraint of plant type *m* in country *i*.

$$\sum_{v=1}^{T} x_{miv} \leq XMAX_{mi} \tag{8}$$

4. Data Description

<u>Range</u>

This study covers the ten member countries of ASEAN, which are Brunei, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Viet Nam.[3] Technologies or means of power generation covered in this study include coal, diesel, natural gas, hydro, geothermal, wind, solar PV, and biomass.[4]

Data Inputs

The main items of data required for this study include existing capacities of the mentioned types of power generation, the CAPEX and OPEX of these types of power generation, the load factor and life expectancy of each vintage of each type of power generation, the energy resources available for power generation in each country, the peak and non-peak power demand and duration of power demand of each country, projected growth rate of power demand, and transmission cost and transmission losses of cross-border power trade.

Data are collected from the Energy Information Administration (EIA), the International Energy Agency (IEA), the Heads of ASEAN Power Utilities/Authorities (HAPUA), the ASEAN Center for Energy (ACE), the World Energy Council (WEC), the Solar and Wind Energy Resource Assessment project, and other country-specific sources. Detailed data and sources of data are presented in Appendix A from Table A1 to Table A5.

Scenario Parameters

Growth in power demand is derived from the Third ASEAN Energy Outlook. Different countries grow at their own paces, from 2010 to 2030, as shown in Table 1.[5]

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[3] It is understood by the authors that Yunnan province of China has been conducting cross-border power trade with Viet Nam and Lao PDR. However, the maximum of the power trade between Yunnan and Viet Nam is 800MW, and in the case of Lao PDR it is much smaller. We therefore think these cross-border power trade activities are not going to bring major impacts to the pattern of cross-border power trade within ASEAN, as estimated by our model.

[4] Nuclear is not covered in the scope of this study for two reasons. First, after the Fukushima nuclear power station accident, the attitude of the world has changed drastically against nuclear power generation. Second, the risks embedded with nuclear power generation are hard to estimate and therefore not reflected in the data about its costs reported publically.

[5] If legitimate forecasts on the growth of power demand are available, a kind of sensitivity analysis such as lower growth or higher growth cases could be done. As the focus of this research, however, is to examine the impact of regional power trade policy regime and corresponding power development planning, it does not consider alternative growth rates of power demand.

Table 1: Growth Rate of Power Demand in ASEAN Countries

	Growth Rate (%)
Brunei	1.2
Cambodia	9.9
Indonesia	3.9
Lao PDR	7.7
Malaysia	4.5
Myanmar	9.0
Philippines	4.5
Singapore	4.2
Thailand	4.9
Viet Nam	6.7

Sources: The Third ASEAN Energy Outlook

Projections of future economic activity are always built on assumptions of different scenarios. In this model, the parameters to reflect different visions about future technology evolutions and social and economic trends include the growth rate of OPEX, the growth rate of CAPEX, the growth rate of carbon emissions costs, and the growth rate of power demand in each country.

Our assumptions on the rate of changes of OPEX and CAPEX are assumed as in Table 2. The growing costs of power generation from coal, diesel, and gas reflect the common understanding that the prices of fossil fuel will keep increasing in the future. The declining costs of power generation from hydropower, geothermal, wind, and Solar PV reflect the common expectation that renewable energy technologies will keep improving and therefore bring down costs in the future.

Table 2: Rate of Changes of OPEX and CAPEX

	Rate of Changes (%)
Coal	2.1
Diesel	1.26
Natural Gas	1.36
Hydro	-0.5
Geothermal	-0.5
Wind	-1.4
Solar PV	-4.6
Biomass	0.3

Sources: EU SEC (2008)

Other parameters include carbon cost, preservation rate, and discount rate. Carbon cost is set to start from current European market price at USD 8/ton of CO_2 emissions and is assumed to increase at an annual rate of 10%. Preservation rate, as referred to in equation (6), is assumed to be 20%. And discount rate, which is important in determining the estimated LCOE, is set at 5%. Carbon emissions parameter for each type of power generation is taken from Varun, *et al*. (2009).

The percentage of demand to be met by power trade is the key parameter in distinguishing the three scenarios we estimate. The first one is a scenario without any power trade, and the percentage is set to be equal to zero. The second one is a scenario with 20% of demand allowed to be met by power trade. And the third one is a scenario with 50% of demand allowed to be met by power trade.[6]

5. Simulation Results and Findings

Our simulation results indicate that with the Business As Usual (BAU) projection of power demand from 2010 to 2030, the ASEAN power grid enables active cross-border power trade between countries rich in resources and countries with high demand. The total cost to meet the growing electricity demand during 2010-2030 is reduced by around 3.9% with cross-border power trade enabled by the ASEAN power grid in the 50 % power trade scenario, as compared to the no power trade scenario in which each country struggles to build high cost power generation capacity to meet its own demand. In absolute terms, this savings is equivalent to USD 29 billion.

In addition to the quantified benefits of the ASEAN power grid in terms of cost savings, the results are also expected to imply which type of power generation capacities should be prioritized and built over time, as the following three figures show. Each of the three figures shows the optimal path of development of new power generation capacities under the corresponding scenario, which assumes different policy

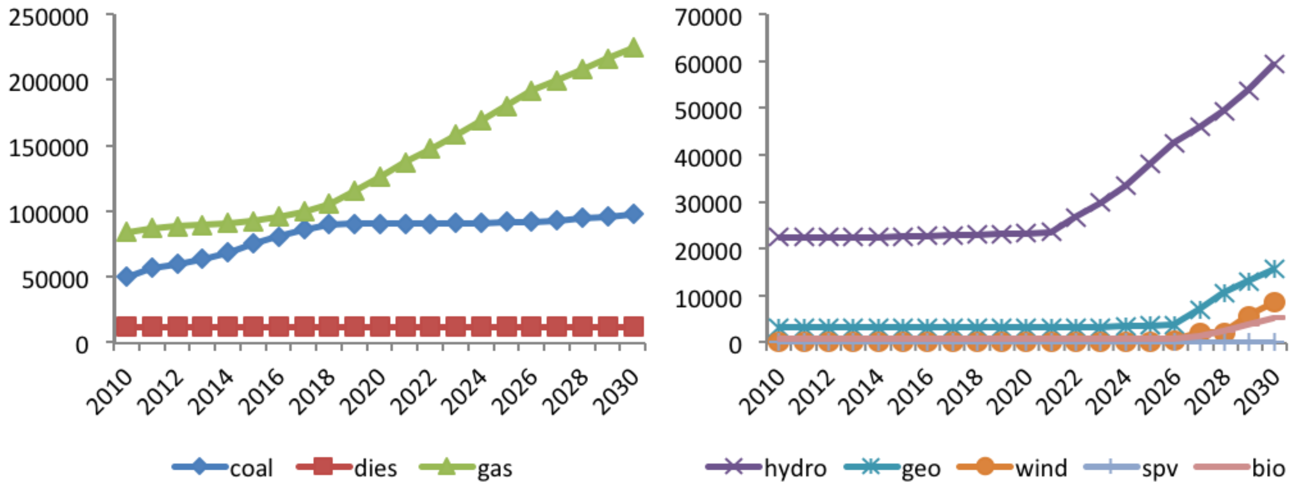
[6] A free power trade scenario was considered but is not reported here as it is too hypothetical and its results could be distorted by the concern of so called "home preference bias" in power supply and energy security.

regimes on cross-border power trade within the ASEAN region.

In this way, the results of this study not only quantify the direct economic benefits of the ASEAN power grid but also indicate the practical path of power generation capacity development to make best use of the ASEAN power grid infrastructure.

Figure 1: Accumulated Power Generation Capacities of All ASEAN Countries in the No Power Trade Scenario (Unit: MW)*

(a) Thermal Power Generation (b) Renewable Energy for Power Generation



Note: * "Coal" stands from coal-fired power plants; "Dies" stands for diesel-fired power plants; "Gas" stands for natural gas-fired power plants; "Hydro" stands for hydropower; "Geo" stands for geothermal power plants; "Wind" stands for wind power; "spv" stands for solar PV power generation; and "bio" stands for biomass-fired power plants.

Figure 1 presents which type of power generation capacity should be developed at what time and with what amount, when no power trade is allowed. The left panel presents the development of fossil fuel-based power generation while the right panel presents the development of renewable energy for power generation. It is observed that future power generation in the ASEAN region will be dominated by natural gas and coal in the next two decades. New hydropower capacity is not being developed until 2022, and total new hydropower capacity is about 37 GW by 2030. Other renewable energy such as wind, geothermal, and biomass will be developed, but at much smaller scale. Solar PV sees no new development at all.

The exceptionally high growth in natural gas-fired and coal-fired power generation capacities is partially driven by high growth in power demand in the ASEAN countries.

While demand is growing fast, the fact that, in this scenario, countries that lack in renewable energy sources are not able to access other cheap renewable energy sources from other resource-rich countries such as hydropower, geothermal and wind power is the other important reason. They are forced to build more natural gas-fired and coal-fired power generation capacities to meet growing domestic demand.

Figure 2: Accumulated Power Generation Capacities of All ASEAN Countries in the 20% Power Trade Scenario (Unit: MW)

(a) Thermal Power Generation (b) Renewable Energy for Power Generation

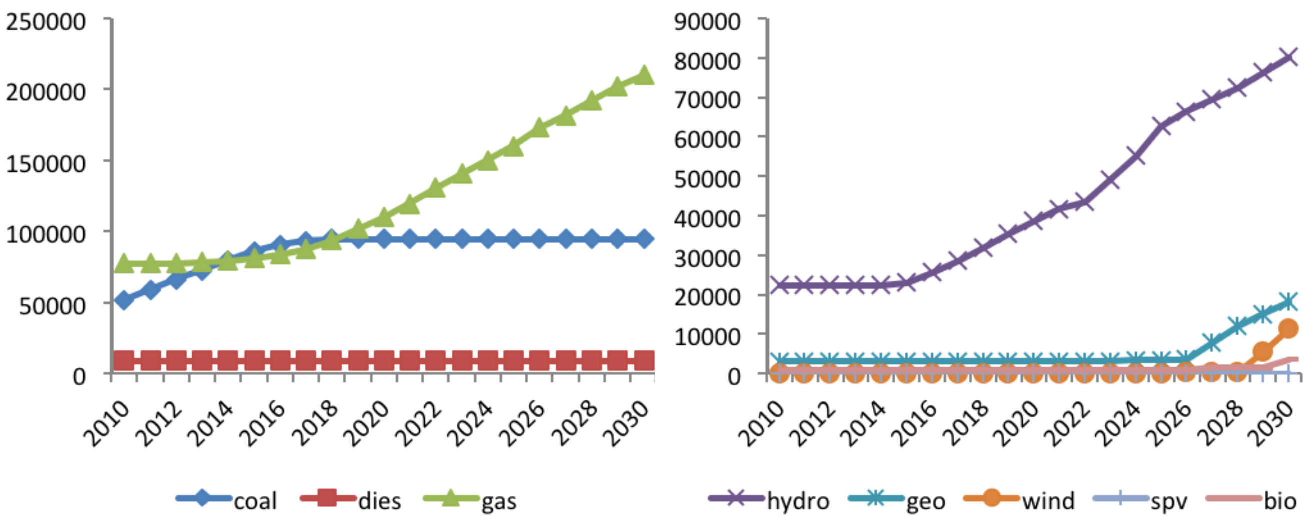


Figure 2 presents the type of power generation capacity to be developed over time in the scenario where 20% of each country's power demand is allowed to be met by power trade. It is observed that new hydropower is being developed as early as 2016, and total new capacity reaches about 58 GW by 2030. Total new coal-fired and natural gas-fired capacities are slightly reduced, as they are substituted mainly by hydropower.[7] The implication is that by opening power trade within the region, countries are able to draw cheaper hydropower from the countries in the Greater Mekong Subregion such as Lao PDR and Cambodia. Although the growth in demand remains unchanged in the ASEAN countries in this scenario, resource-rich countries could build more hydropower,

[7] Later we show that other renewables including geothermal and wind power generation also contribute to the substitution of fossil fuel-fired power generation capacities.

geothermal, and wind capacities and export power to resource-poor countries. The imported power thus substitutes a significant amount of new fossil fuel-fired power generation capacities otherwise to be built in the resource-poor ASEAN countries.

The second scenario reduces the total cost to meet the growing electricity demand during 2010-2030 by 3%, as compared to the total cost incurred in the first scenario without any power trade. In absolute terms, the savings amount to USD $20.9 billion.

Figure 3: Accumulated Power Generation Capacities of All ASEAN Countries in the 50% Power Trade Scenario (Unit: MW)

(a) Thermal Power Generation (b) Renewable Energy for Power Generation

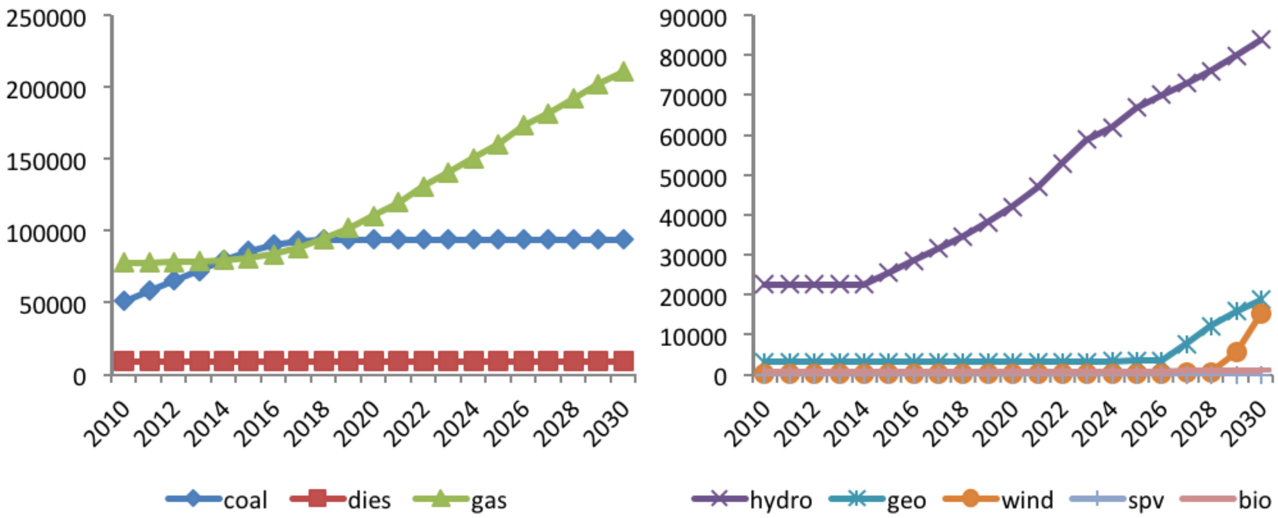


Figure 3 presents the type of power generation capacity to be developed over time in the scenario where 50% of each country's power demand is allowed to be met by power trade. It is observed that the large-scale development of new natural gas-fired power plants is delayed to 2015. The development of new hydropower is brought forward to 2015, one year earlier as compared to the previous scenario. Total new hydropower capacity would reach over 61 GW by 2030. The implication is that more open power trade in the region would allow countries to draw more and cheaper hydropower from the Greater Mekong Subregion as well as from Malaysia.

Table 3 gives more details about the additional power generation capacities to be built over the period of 2010 to 2030, in the three simulated scenarios.

Table 3: Development of Additional Capacities in the Three Simulated Scenarios

	No Trade		20% Power Trade		50% Power Trade	
	Number of Countries	Additional Capacity (MW)	Number of Countries	Additional Capacity (MW)	Number of Countries	Additional Capacity (MW)
Coal	4	57,498	4	53,625	4	57,244
Diesel	1	2,825	0	0	0	0
Gas	9	149,435	9	135,432	9	130,490
Hydro	5	36,887	5	57,844	5	61,434
Geo	6	12,476	6	15,046	6	15,651
Wind	4	8,504	5	11,509	8	15,156
Solar	0	0	0	0	0	0
Bio	3	4,569	3	2,659	2	450
Total		272,193		276,114		280,425

In Table 3, for each scenario, the first column indicates the number of countries which should develop the corresponding type of power generation capacity. The second column indicates the total amounts of capacities developed for the type of power generation capacity.

In the three scenarios, the policy regime of power trade in the region gradually relaxes, from no power trade allowed, to allowing 20% of demand to be met by power trade, and then to 50% of demand to be met by power trade. Table 3 presents how power generation capacities are developed differently in response to changes in power trade policy.

Certain trends and stylized facts could be observed from Table 3, as policy regime shifts in this order. First, the required amount of new natural gas power plants is reduced significantly over the increased possibility of power trade. Second, the amounts of renewable energy such as hydro, geothermal, and wind developed for power generation increase significantly over the increased possibility of power trade. Third, biomass power generation, which uses domestic biomass resources, is less needed as power trade allows the country to draw from cheaper sources in other countries. Fourth, solar PV power generation is not developed in any of the three scenarios, indicating that either the costs or the efficiency of the technology needs to be further improved. The current assumption that the costs of solar PV decrease 4.6% annually is insufficient to render the technology matured for the ASEAN region.

There are a few reasons why natural gas appears to be the dominant energy source for power generation in future in the region. First, power generation using natural gas is far more competitive in terms of capital cost than other means such as coal or hydropower. Second, the power generation technology of natural gas is more efficient with lower carbon emissions than other thermal power generation technologies. Since the model considers the cost of carbon emissions, the relatively low amount of carbon emissions by natural gas makes the levelized cost of natural gas power generation even more competitive. Third, natural gas power generation also has higher load factor than hydropower, which contributes to a lower levelized cost of natural gas power generation (See Table A2 for reference). The above three reasons render natural gas more competitive against its two main competitors - coal and hydropower. In addition, since natural gas is a globally traded energy commodity like crude oil, the theoretical potential capacity of natural gas power generation is not bounded by local energy resources.

Changes in the power trade policy regime also impact the pattern of power trade in the region. Table 4 lists the three most important exporting countries in the two scenarios that allow power trade. The third column of the table summarizes the types of additional power generation capacity developed in the exporting country. And the fourth column lists the main trading partner of the exporting countries. The development of cross-border power grid in the region should therefore prioritize the linkage among the listed exporting countries and importing countries.

Table 4: Summary of Power Trade in the Region

Scenario	**Main Exporting Country**	**Types of Additional Capacity**	**Main Importing Countries**
20% Power Trade	Lao PDR	Hydro	Viet Nam, Thailand, Malaysia, Singapore
	Malaysia	Coal, Natural Gas, Hydro, Geothermal, Wind	Singapore, Philippines, Indonesia
	Cambodia	Natural Gas, Hydro	Viet Nam, Thailand, Malaysia, Indonesia
50% Power Trade	Lao PDR	Natural Gas, Hydro, Wind	Viet Nam, Thailand
	Malaysia	Coal, Natural Gas, Hydro, Geothermal, Wind	Singapore, Philippines, Indonesia, Thailand
	Thailand	Coal, Natural Gas, Geothermal, Wind	Viet Nam, Myanmar

According to the summarization in Table 4, a few observations could be made. In the 20% power trade scenario, the three countries which are rich in hydropower resource dominate the power export market in the region. In the 50% power trade scenario, it is of interest that Thailand has replaced Cambodia as the third most important exporter. One of the reasons this situation arises might be explained by the geographical position of Thailand – it links northern ASEAN countries to the southeastern ASEAN countries through the Malaysia peninsular. If one looks at the third column of main importing countries, Thailand is found to be a major importer of the power from Lao PDR and Malaysia and re-exports the power together with power from its own power generation capacities. This implies the potential of Thailand to play as a power trading hub in the region in future.

These observations about Thailand thus lead us to the important proposition that follows. The problem of where to build power generation capacities and to export power does not only depend on the costs of power generation in the country, but also on the geographical location of the country which best saves transmission costs and transmission losses.

More importantly, our simulation results lead us to the observation that opening power trade in the ASEAN countries would encourage the development of power generation from renewable sources, especially hydro, geothermal, and wind. In terms of time sequence of development, hydro should be developed first, and followed by geothermal and then wind.

6. Conclusions

The central question raised in this study is how to meet the growing power demand in ASEAN countries in the next two decades. The region is known to be rich in energy resources on the one hand, and experiencing fast economic growth which drives power demand on the other. Uneven distribution of energy resources and uneven pace of economic development among ASEAN countries complicates the question.

This study applies a dynamic linear programming model to simulate the optimal development paths of power generation capacities in the ASEAN region, assuming that the ASEAN Power Grid (APG) is in place. The model is based on Turvey & Anderson (1977) and Chang & Tay (2006) with the further development of many innovations. First, the model is extended from a single country model into a model of multiple countries with cross-border power trade. Second, the model incorporates the costs and losses of power transmission between countries. Third, the cost of carbon emissions from power generation activities is also taken into consideration in this model. Therefore, this model is based on the concept of levelized social cost of electricity.

Three scenarios are simulated to examine the impact of power trade policy regimes in the region. The first scenario assumes that no power trade is allowed. The second scenario assumes that 20% of a country's power demand could be met by power trade. And the third scenario assumes that 50% of a country's power demand could be met by power trade. The simulation results lead us to several interesting observations.

First, in the scenarios that open power trade, the ASEAN power grid enables active cross-border power trade between countries rich in resources and countries with high demand.

Second, with 50% power trade, the total cost to meet the growing electricity demand during 2010-2030 is reduced by around 3.9% as compared to the no power trade scenario. In absolute terms, this saving is equivalent to USD 29 billion. With 20% of demand allowed to be met by power trade, the total cost to meet the growing electricity demand during 2010-2030 decreases by 3% as compared to the no power trade scenario. In absolute terms, the savings amount to USD 20.9 billion. The savings are net gains after all costs related to the ASEAN power grid have been paid off.

Third, in the 20% power trade scenario, the three countries which are rich in hydropower resource dominate the power export market in the region. In the 50% power trade scenario, Thailand notably replaces Cambodia as the third most important exporter. This is because of the geographical position of Thailand, which links northern ASEAN countries to the southeastern ASEAN countries through the Malaysia peninsular. The problem of where to build power generation capacity and to export power does not only depend on the costs of power generation in the country, but also on the geographical location of the country which best saves transmission costs and transmission losses.

Fourth, opening power trade in the ASEAN countries would encourage the development of power generation from renewable sources, especially hydro, geothermal, and wind.

Based on the above, the following policy implications could be drawn.

- Hydropower appears to be fully utilized when full-scale power trade across the region is allowed and produce the lowest cost option of power mix to meet the electricity demand in the region. This strengthens the necessity of integration of power infrastructure in the region such as the development of APG.
- Renewable energy for power generation appears to be utilized more under the scenarios with open power trade. Power trade policy regime is therefore important in this respect.
- Considering the energy security concern among the high import-dependency countries, the 50% power trade scenario seems to be more realistic in the region. And this power trade policy regime better supports the development of indigenous renewable energy in the region.
- The simulation results also provide references to the time sequence of power generation capacity development and cross-border power grid development in the region.

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Appendix A. Input Data of the Model and Sources of Data

Table A1: Existing Power Generation Capacity of ASEAN Countries (Base year 2009, Unit: MW)

	Brunei	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam
Coal	0	0	12203	0	9068.4	0	5584.4	0	10719.2	3301.7
Diesel	5.8	372	3328	50	685.4	279.08	1330.4	2511.2	269.3	580.5
Natural Gas	753	0	10929	0	13380.2	980.92	3387.2	7934.8	32088.6	5795.9
Hydro	0	13	4872	1805	2107	1460	3291	0	3488	5500
Geothermal	0	0	1189	0	0	0	1953	0	0.3	0
Wind	0	0	1	0	0	0	33	0	0.4	8
Solar PV	0	0	0	0	0	0	1	0	10	0
Biomass	0	5.78	0	0	0	0	0	20	800	0

Sources: EIA website and IEA website

Table A2: CAPEX, OPEX, Life, and Availability of Power Generation Assets

	Coal*	Diesel	Natural Gas	Hydro**	Geothermal	Wind	Solar PV	Biomass
CAPEX (Million USD/MW)	2.079	1.139	1.054	4.933	6.18	2.187	5.013	4.027
OPEX (USD/MWh)	31.86	229.75	43	4.32	14.23	20.58	19.52	28.87
Life (Years)	40	30	30	80	30	25	25	25
Load Factor (Percentage of A Year)	0.85	0.85	0.85	0.23-0.64	0.95	0.3	0.11	0.85
Carbon Emissions (ton/MWh)	1.0	0.8	0.5	0.001	0.05	0.01	0.05	0.05

Note: * Due to the consideration of abundance in coal resources, countries including Indonesia, Malaysia, Thailand, and Viet Nam are assumed to have 30% lower CAPEX and OPEX in coal-fired power generation.

** Due to the consideration of abundance in hydropower resources, countries including Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, and Philippines are assumed to have 30% lower CAPEX and OPEX in hydropower generation.

Sources: IEA (2010) and EU SEC (2008)

Table A3: Energy Resources for Power Generation in ASEAN Countries (Unit: MW)

	Brunei	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam
Coal	15000	15000	50000	15000	50000	30000	30000	15000	50000	50000
Diesel	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Natural Gas	15000	15000	50000	15000	50000	30000	30000	30000	50000	50000
Hydro	0	10300	75459	18000	29000	0	13097	0	700	2170
Geothermal	0	0	27000	0	67	930	2379	0	5.3	270
Wind	0	452	7404	1600	452	1600	7404	0	1600	452
Solar PV	115	3771	37800	4538	6192	12967	6336	130.7	300	10321
Biomass	0	700	49810	0	29000	4098	200	50	7000	400

Sources: Lidula, *et al.* (2007) and WEC Survey of Energy Resources 2010

Table A4: Power Demand and Duration of the Demand in ASEAN Countries

	Brunei	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam
Peak Demand (MW)	454.7	291	23438	350	12990	1140	8766	5711	22586	11605
Peak Duration (Hours)	4681.7	4925.2	4681.7	4745	4681.7	2428	4015	5840	4015	2428
Non-peak Demand (MW)	257	85	5338	60	8388	162	3394	1324	8692	6862
Non-Peak Duration (Hours)	4078.3	3834.8	4078.3	4015	4078.3	6332	4745	2920	4745	6332

Sources: HAPUA website; Indonesia Energy Handbook 2011; Electricite du Laos Annual Report 2010; and Zhai (2008, 2009)

Table A5: Transmission Loss and Cost among ASEAN Countries

		Transmission Loss (%)	Transmission Cost ($/MWh)
Distance*	0-1600 km	0.01	3
	>1600 km	0.087	5
	>3200 km	0.174	7.5

Note:* Distance is estimated as the distance between Capital cities of countries.

Sources: Claverton Energy Research Group http://www.claverton-energy.com/

CHAPTER 4

Electricity Market Integration: Global Trends and Implications for the EAS Region

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Electricity market reform has been implemented in many countries andregions in the world. There is no doubt that electricity consumption continues to increase in East Asia. Electricity market integration in East Asia is thus an important component of the Energy Market Integration (EMI) initiatives supported by the East Asian Summit (EAS) group. It is argued that an integrated East Asian electricity market would allow consumers to have access to competing suppliers within or beyond the borders and enable electricity providers in member economies to better deal with peak demand and supply security. The objectives of this study are twofold, namely, a) to present a review of the trends in regional electricity market integration and b) to draw implications for electricity market development in the EAS area. Specifically, this project will review the trends of integration in the world's major electricity markets and analyze the experience and lessons in those markets. It will provide an examination of the electricity sectors in East Asia in terms of market development and connectivity. It will provide policy recommendations for the promotion of electricity market integration.

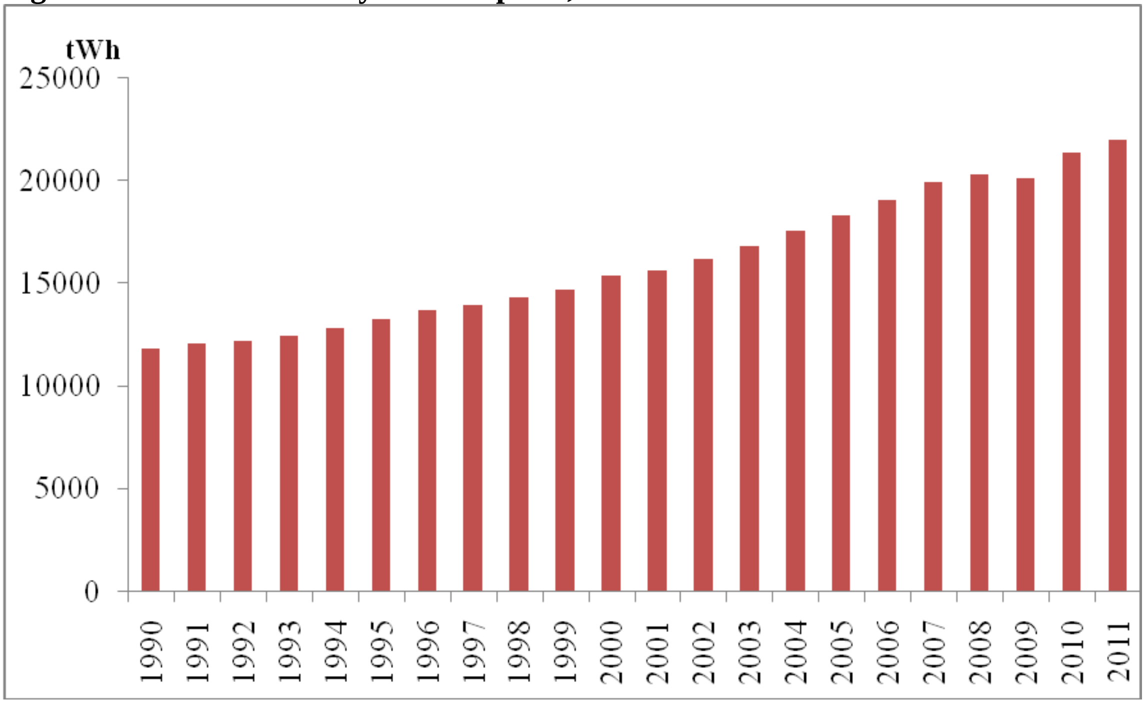
1. Introduction

In the coming decades world demand for electricity is projected to have an average annual rate of growth of 2.3% which exceeds the growth rate (1.6%) of total energy use globally (EIA 2011a). Thus the electricity sector plays an important role in promoting Energy Market Integration (EMI) in the East Asian Summit (EAS) region. This report aims to present a brief review of the world's major electricity markets and global trends towards market integration. The findings are employed to draw implications for electricity market integration in the EAS area. The rest of the report begins with an overview of electricity demand in the world in Section 2. This is followed by discussions about the trends of electricity sector reforms and hence market integration initiatives in Section 3. Subsequently electricity markets in the EAS region are examined in Section 4. Policy recommendations are presented in Section 5 with the final section presenting concluding remarks (Section 6).

2. Global Electricity Demand

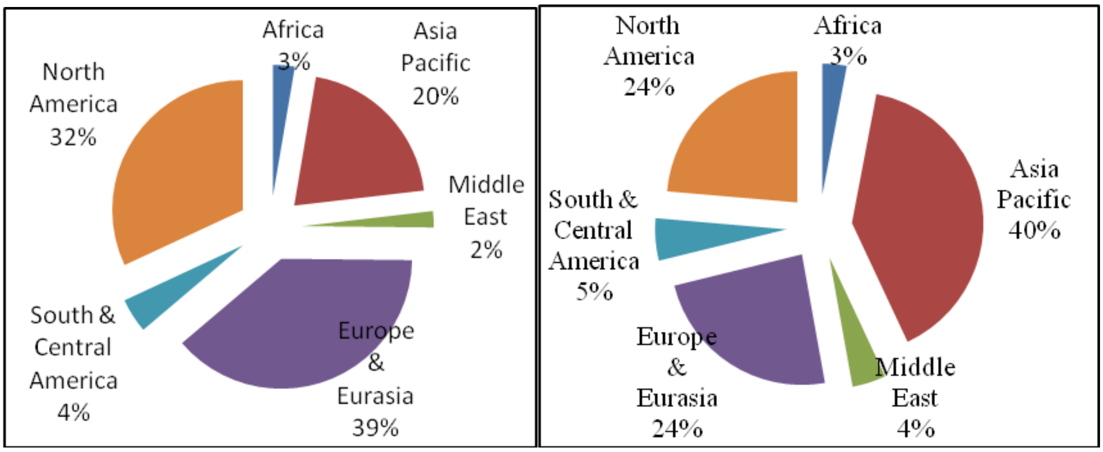
Electricity consumption in the world has maintained a steady growth trend in recent decades (Figure 1). Total consumption almost doubled between 1990 and 2011. During the same period, the Asia Pacific region has overtaken Europe and North America to become the largest electricity consumer (Figure 2). In 2010 the United States was still the largest single consumer with a share of 20.3% over the world total while China was just behind the US with a share of 19.7%. By 2011 China overtook the US to become the world's largest electricity user as well as producer with a share of 21.3% while the US share continuously declined to 19.6%. Japan is the third largest consumer with a share of about 5% followed by Russia (4^{th}) and India (5^{th}).

Figure 1: World Electricity Consumption, 1990-2011



Notes: The unit is terawatt hours (tWh). The raw data are drawn from BP (2012).

Figure 2: Electricity Consumption Shares by Regions, 1990 and 2011



1990 **2011**

Notes: The raw data are drawn from BP (2012).

At the sector level, the industrial sector is still the largest electricity consumer in the world with a share of 40.2% in 2009 (IEA 2011). This figure, however, varies considerably across the countries ranging from 26% in the US to 39% in India and 74% in China (Table 1). The general trend is that electricity consumption shares have declined in major developed economies due to the delocalization of manufacturing activities, the growth of commercial and public service sectorsand increasing ownership of appliances and electronic equipment in households. For example, among IEA member economies, the share of industrial electricity consumption declined from 49% in 1974 to 33% in 2007, with the US having the smallest industrial share among the members (IEA 2009a). Residential consumption sharesvary from39% in the US to24%in India and 12% in China (Table 1). Agriculture and transportationare included in the “others” category in Table 1. These two sectors generally account for small shares in electricity consumption in major economies. There are however exceptions. For example, agricultural consumption of electricity reported in Table 1 has a share of 19% in India (CSO 2012).

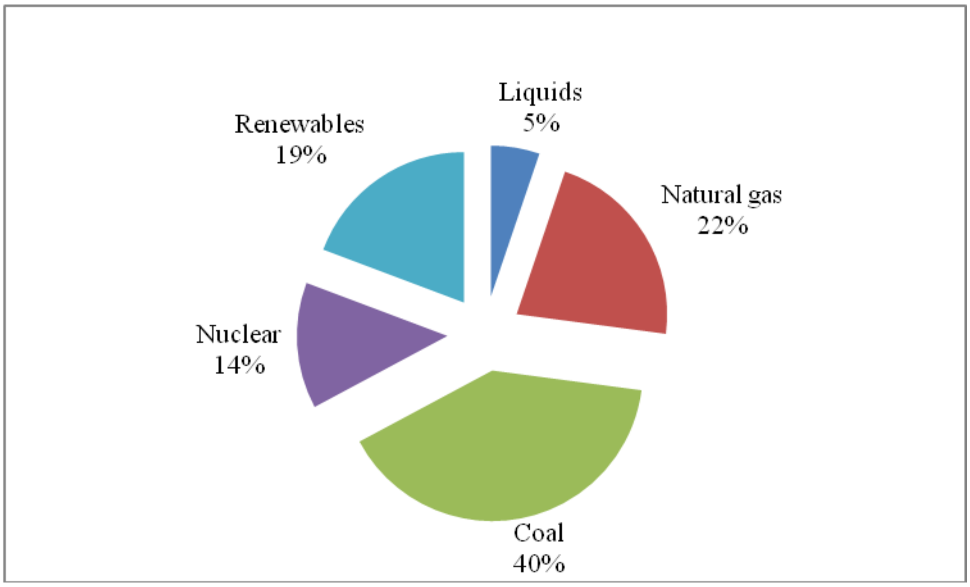
Table 1: Electricity Consumption Shares (%) by Sector in Selected Economies

Sectors	IEA	China	India	US
	(2007)	(2010)	(2010)	(2010)
Industrial	33	74	39	26
Residential	31	12	24	39
Commercial	31	6	10	35
Others	5	8	27	0

Notes: Indian data cover the 2010/2011 financial year. Data are drawn from NSBC (2012), CSO (2012), EIA (2012) and IEA (2009a).

Electricity generation is still dominated by coal (40%) followed in turn by natural gas, renewables, nuclear and liquids (Figure 3). This pattern will probably remain for a long time. According to EIA (2011a), by 2030, the share of coal in electricity generation will decline slightly (36%) and the winners will be renewables (24%) and natural gas (24%) with nuclear power remaining the same (14%) and the share of liquids shrinking to about 2%.

Figure 3: Sources of Electricity Generation in the World, 2008



Source: EIA (2011a).

3. Trends in Market Integration

It has been argued that an integrated electricity market can improve efficiency in electricity supply, reduce costs of production and hence electricity prices, and raise standards of services due to increased competition. As global concerns for climate change increase, regional power integration could be an effective way to reduce carbon emissions (Zhai, 2010). Following these arguments, various policy measures have been implemented in order to promote national and regional electricity market integration. The progress of changes varies among the major markets. The large markets include the European Union (EU) and the United States (US). The relatively successful examples of small economies include Chile, New Zealand andSingapore. The reforms have led to the formation of national electricity markets in some countries such as Australia, Norway and the UK. In some regions cross-border trade has emerged through different kinds of cross-border access arrangements such as the France-Belgium-Netherlands connection and the Nordic market (Norway, Sweden, Finland and

Denmark). Though electricity market integration has been challenged due to events such as the California electricity crises during 2000-01 and the 2003 New York black out, reforms are still debated and implemented in different forms (Kwoka, 2006).

Chile was the world's first countryintroducing reforms in the electricity sector in 1982 (Nagayama, 2011). Chile's reformhas been hailed as a successful example (IEA 2009b). The main law that governs the electricity sectorin Chile is the General Electric Services Law of 1982, which was amendedin 2004 and 2005, respectively. Enactment of the law in 1982 led to the vertical and horizontal unbundling of the electricity sector. The process of privatization of state-owned utilities began in 1986 and was completed in 1998. Together with privatization was the establishment of a spot marketfor electricity and a contract market in which generators and large industrial users could trade freely. The electricity market in Chile is now characterized with free competition in generation and distribution while transmission is still regulated. Reforms have led to growth in Chile's electricity sector for about two decades. But major blackouts and some other problems did occur. Therefore, Chile's electricity sector is still facing some challenges and possibly further reforms. For example, Pollitt (2005) pointed out the need to improve the transparency of the regulation and oversight of the industry and the inflexibility in regulations governing the power sector due to overly detailed specifications.

The UK was one of the first European countries to embark upon reforms of the electricity sectors. In 1989 the Electricity Act was enacted to introduce competition in power generationand electricity wholesale in the UK. By the implementation of the Electricity Act 2000, a highly competitive electricity market was to emerge. In March 2001 NETA (the new electricity trading arrangements) was introduced for wholesale trading. There were about 40 power producers competing in the markets compared to seven in 1990 (EA, 2002). The three regions in the UK used to be covered by three markets which were separated up until 2005 (Pond, 2006). In April 2005 NETA was replaced by BETTA (British electricity transmission and trading arrangements) to accommodate the interconnection with the power grid of Scotland (Giulietti,*et al*. 2010). Deregulation progress in the UK electricity market is now well ahead of the rest of Europe. Since deregulation the market has performed well. The generation sector has maintained an adequate margin of spare capacity and electricity prices have been comparatively low and fairly responsive to the movements in fuel prices (DECC, 2010). Sweeting (2007) constructed the Herfindahl-Hirschman index to show that competition in generation is indeed enhanced.

Before 1978 the US electricity market was dominated by large, vertically integrated utilities. To create an integrated electricity market, deregulation began with the issue of the Public Utility Regulatory Policies Act (PURPA) in 1978. The initial reform targeted at the wholesale sector and aimed to promote the wholesale power transactions between utilities. By the 1990s, further reforms were introduced and a deregulated industry took shape. For example, non-discriminatory open access was protected through the promulgation of the Energy Policy Act 1992 and later the FERC Orders 1996.[1] The system was further improved through the introduction ofregional transmission organizations (RTOs) under FERC Order 2000. RTOs are empowered to operate the transmission lines on behalf of all market participants. By 2000 more than half the states either had restructured their electricity sectors or were planning to do so though changes varied across the states. An important factor that influences tariff levels in the US is the mix of energy sources used in power generation. For example, access to cheap federal power from hydropower plants contributes to low electricity tariffs in some states. In the aftermath of the California blackout, the pace of reform has slowed.

Chile, the UK and US are good examples of successfully developing a nationally integrated electricity market through several phases. In recent years a lot of efforts have also been made to develop sub-regional electricity markets through cross-border connections and trading. One of the earlier initiatives was the establishment of the Nord Pool which interconnects the national grids of Norway, Sweden, Finland and Denmark. Since its launch in the 1990s the Nord Pool has evolved into a well-integrated and efficient wholesale market though retail markets still remain national markets in these countries. In 2006 France, Belgium and the Netherlands also launched the TLC market. Germany and Luxemburg later joined this interconnected market. A late comer was the interconnection between Spain and Portugal launched in 2007. In other continents, the six states of the Gulf Cooperation Council (GCC) formed their interconnection authority in 2001. The final interconnection work is supposed to be completed by 2013.

[1]FERC is short for the Federal Energy Regulatory Commission.

Regional electricity market integration has been promoted by nations in the world, including countries in the EAS area. The actual progress in interconnection varies across the continents. The major initiatives so far share some commonalities. First, interconnections mainly occur among neighboring countries which have well-developed national markets. Second, sub-regional markets are outgrowth of bilateral electricity exchanges. Finally, market integration is accompanied with domestic reforms and international harmonization of regulationsstandards. These observations have important implications for the development of integrated electricity market in the EAS region.

4. Electricity Markets in the EAS Region

The EAS economies as a group amounted to about 19% of the world's total electricity consumption in 1990 (Table 2). This share almost doubled by 2010 (36%) and will maintain a modest growth in the coming decades according to predictions (ADB, 2009). In terms of market integration, most EAS members are yet to develop a national electricity market. Cross-border trading is still at the early stage of development. In general the 16 member countries can be broadly divided into several groups in accordance with their market and institutional development.

Due to different stages of economic development, EAS members have made different progress in electricity market development. Relatively mature and integrated national markets have emerged in several EAS countries, namely, Australia, New Zealand and Singapore. Some members are at various stages of developing a national electricity market (Brunei, China, Japan, Malaysia, Philippines, South Korea, Thailand and Viet Nam). Others are still trying to improve the level of electrification in their societies (India, Indonesia, Cambodia, Laos and Myanmar). In terms of the integration and unbundling of business activities, namely, generation (G), transmission (T), distribution (D) and retailing (R), the sixteen EAS members are broadly divided into four groups (Figure 4). Each of them is discussed in the following text.

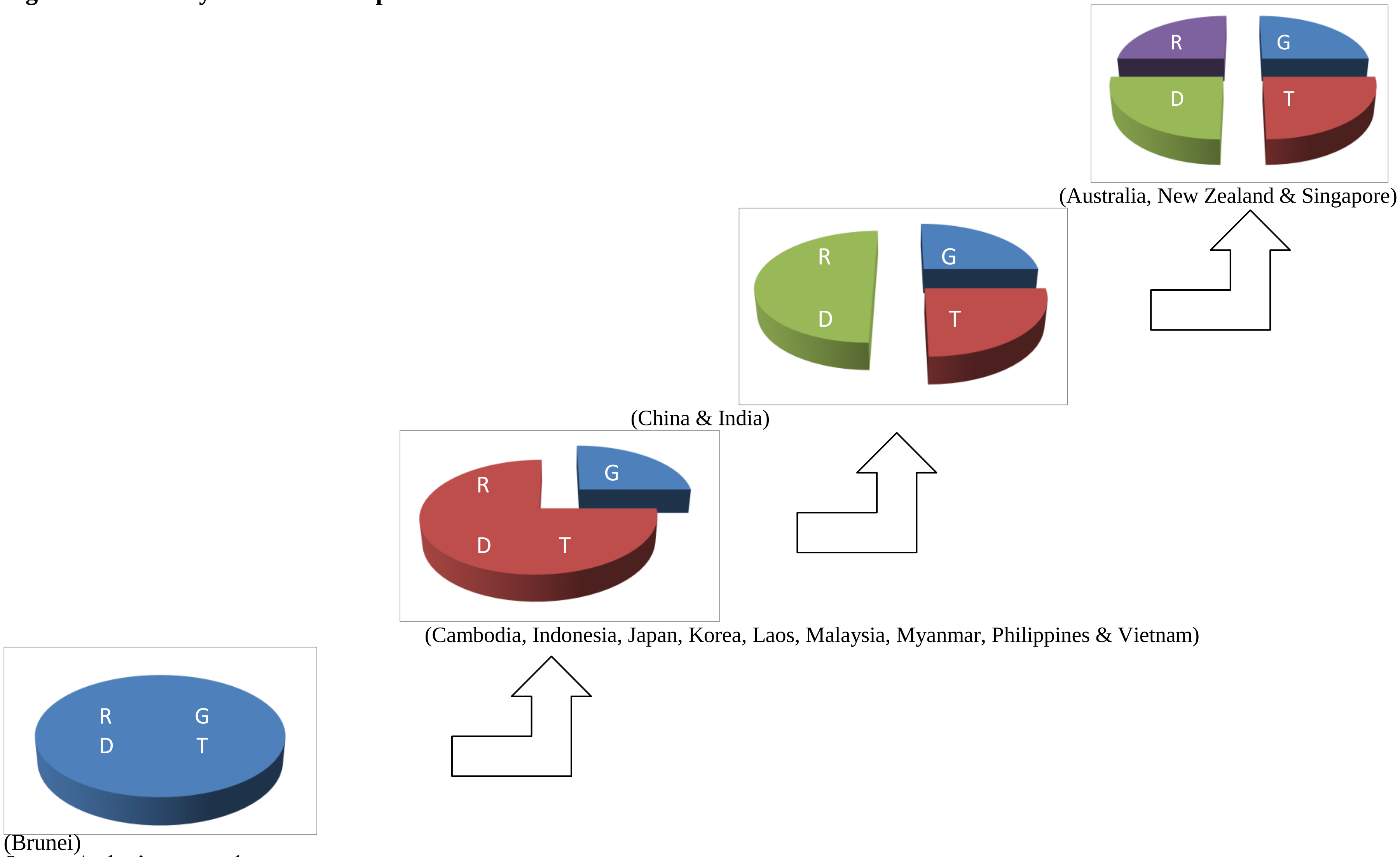
Table 2: Electricity Demand in EAS Economies

Countries	1990	2011	2030
Australia	156	264	367
Brunei	1	3	4
Cambodia	1	2	13
China	621	4700	6374
India	284	1006	2414
Indonesia	33	182	318
Japan	841	1104	1324
Lao PDR	1	7	60
Malaysia	25	119	265
Myanmar	2	9	56
New Zealand	32	43	64
Philippines	26	69	165
Singapore	16	46	105
South Korea	118	520	624
Thailand	44	152	400
Vietnam	9	111	235
EAS	2211	8338	12783
World	11861	22018	31779
EAS/World(%)	19	38	40

Notes: Demand is expressed in terawatt hours (tWh). The raw data are drawn from BP (2012) for 1990 and 2011 and ADB (2009) for 2030.Data for Brunei, Cambodia, Lao PDR and Myanmar areauthor's own estimates.

The Singapore public utilities board (PUB) has been the sole provider of electricity until 1995 when the regulatory roles were separated from businesses by corporatizing electricity supplies under Singapore Power. In 2001 Energy market authority (EMA) was established to become the industry regulator. Since then competition has been introduced into generation and wholesale and retailing to large electricity users though transmission is regulated. Further reform is to deregulate the retail market of small users. According to Tan (2008), deregulation has provided power companies the incentives to reduce costs by using cheap fuels, adopting cost competitive technologies and hedging against volatility in fuel prices. Tan also observed that the rise in electricity tariffs has been significantly smaller than oil price increases since deregulation. However Chang (2007) argued that the deregulated electricity sector in Singapore is only marginally competitive.

Figure 4:Electricity Market Development Status of EAS Members



Source: Author’s own work.

The Australian electricity sector used to be dominated by vertically integrated businesses operating in each state. These businesses were government owned and operated monopolies and interconnection between the statesvirtually did not exist. The restructuring reform began with the separation of the contestable generation and retail services from the non-contestable transmission and distribution services in the early 1990s. The National Electricity Market (NEM) was formally established and commenced operation in December 1998 under the rules of the National Electricity Code.Further reforms led to the issue of the National Electricity Rules authorized by the National Electricity Law in July 2005. Electricity sector reform in Western Australia began with the disaggregation of Western Power (the State monopoly) into four state-owned companies in April 2006. Subsequently, the Wholesale Electricity Market (WEM) was established in September 2006. Since then, the WEM has facilitated competition and promoted private investment in the generation and retail sectors of the electricity industry in Western Australia. The electricity market in Australia is now divided geographically into two deregulated markets, namely, the NEM and WEM. The NEM covers the Southern and Eastern Australia and has a market share of 89% while the WEM has a market share of 10% (Davidson 2010). In the NEM areas, generators compete for the right to supply electricity; there is open access to the grid for new generation; andcustomers are free to choose who supplies their electricity. In the small WEM, competition exists mainly in the generation sector.

The electricity industry in New Zealand was one of the pioneers undertaking deregulation and reforms. In April 1987, the state-owned Electricity Corporation of New Zealand Ltd (ECNZ) was established (Shen & Yang 2012). In May 1993, ECNZ’s transmission businesses were set up as a separate transmission company, Transpower. Five years later, the Electricity Industry Reform Act 1998 was enacted to introduce competition in generation and retailing. Under this Act, joint ownership of the electricity distribution businesses and energy businesses (generation and retailing) is prohibited. The Act also guided the split of ECNZ into three state owned generators in 1998. Due to public complaints about high wholesale and retail electricity prices, a review of the electricity sector was conducted in 2009. This review and its recommendations led to the enactment of Electricity Industry Reform Act 2010. One of the major changes was to allow joint ownership of generation and retailing businesses (or gentailors). Currently, the New Zealand electricity market has five large gentailors (Shen & Yang 2012).

IPPs were first introduced into China's electricity sector in 1985. By the end of the 1990s over a half of the electricity supply was generated by non-state owned units (Du, *et al.* 2009). Genuine competition in generation was limited until the corporatization of state generation and transmission assets in 2002 and the formation of the regulatory body, the State Electricity Regulatory Commission (SERC) in the same year (Gao& Van Biesebroeck, 2011). Further reforms were implemented to split the former State Power Company (SPC) into two transmission companies and five generation corporations. There is now some competition in generation and free bidding for transmission access has been pilot-tested (Shi, 2012). However distribution and retailing are still regulated. The process of reforms has been slowed down, especially since the power crises in the US. Further moves are still being debated.

India's electricity sector has traditionally been segmented across the states and hence controlled by the State Electricity Boards (SEBs). The government-owned Power Grid Corporation of India Limited (PGCIL) is now working to integrate the regional grids into a national one (Kumar, 2010). Reforms of the vertically integrated SEBs began after the 1991 balance of payment crisis in India. Private participation in the power sector has been encouraged since then. Steps have also been taken to corporatize and unbundle the SEBs. These include the establishment of the independent Electricity Regulatory Commissions in 1998 and the enactment of Electricity Act 2003. However, implementation of reforms has been very slow. By June 2012 the private sector only had a capacity share of 27.75% (Ministry of Power, 2012). SEBs used to be the sole purchasers of power. Since January 2009, open access has become possible for all users. Several options of power trading are now available, namely, bilateral trading, unscheduled interchange, national level power exchange and third party sales (PWC, 2009). Bilateral trading still dominates with a share of 48%.

For decades Japan's electricity sector has been monopolized by ten regional electric power companies responsible for regional generation, transmission, distribution and retailing and for coordinating national interconnection (FEPCJ, 2011). The government amended the Electricity Utilities Industry Law (EUIL) in 1995. Subsequently the IPPs entered the market. In 1999 the EUIL was amended again to allow for partial deregulation of retail power supply for extra high voltage users (2 megawatts) starting in March 2000 (Goto & Sueyoshi 2009). In June 2003 the EUIL was further amended to accommodate the extension of reforms in the following years. For example the partial liberalization in 2000 has been extended to medium-sized users (50 kilowatts) since April 2005. However further reforms were halted in 2008 after an industry policy review and will not be reconsidered until the next review in approximately five years (in 2013). In the aftermath of the 2011 Fukushima tragedy, urgent changes in the Japanese electricity sector have been voiced and new reforms may be introduced sooner (Nagayama, 2011).

South Korea's electricity sector has been monopolized by the state-owned Korea Electric Power Corporation (KEPCO). In the aftermath of the 1997 Asian financial crisis, KEPCO's generation business was split into six separate power companies in 2001. In the same year IPPs were allowed to enter the sector and the Korea Electric Power Exchange (KPX) was established. The original plan of reforms is to privatize the six generation companies and to introduce completion in both generation and distribution. However, further reforms have been delayed. By 2008 KEPCO's subsidiary companies still had a generation share of 82% (EIA 2011b). KEPCO still controls the country's electricity transmission, distribution and retailing (Kim & Kim 2008). Thus competition is very limited in the entire electricity sector in South Korea.

In 1992 the Thai government for the first time legalized the participation of the independent power producers (IPPs) in the electricity sector. Since then several attempts under various governments have been made to deregulate the electricity sector. They were all unsuccessful (Nikomborirak & Manachotphong, 2007). Recent reform initiatives include the release of the Energy Industry Act in December 2007 and subsequently the establishment of the energy regulatory commission (ERC). There are, however, some major difficulties in introducing competition into the electricity sector (Wisuttisak, 2012). The electricity sector in Thailand is still dominated by the state-owned Electricity Generating Authority of Thailand (EGAT). By 2011 EGAT had a market share of 47% followed by the IPPs (39%), small power producers (SPPs) (7%) and imports (7%). Under the government regulations, EGAT as the largest generator also has the sole right to purchase power from other private producers including neighbouring countries. The EGAT is also the only firm permitted to supply electricity to the distributors and retailers. Thus, there is no competition in the wholesale electricity market in Thailand. For the distribution and retail sectors, the markets are also under the monopoly of Provincial Electricity Authority of Thailand (PEA) and Metropolitan Electricity Authority of Thailand (MEA).

The Indonesian power sector is dominated by the state-owned *Perusahaan Listrik Negara* (PLN). In 1992 the first IPP was approved after the passing of the 1985 Electricity Law in Indonesia. But reforms in the electricity sector have been interrupted by the 1997 Asian financial crisis and subsequently, political instability. By 2009 the IPPs had a market share of about one-sixth (Purra, 2010). Over time the Electricity Law has been revised several times (1999 and 2002). More recently the passing of the 2009 Electricity Law offers some degree of freedom to local governments in dealing with IPPs and setting tariff rates. In terms of regulatory reforms, Purra (2010) argued that the 2009 Law offers very little.

The Philippines was one of the first Southeast Asian countries to allow IPPs with the first IPP contract signed in 1989. In 2001, about 41% of electricity is produced by the IPPs and the rest by the National Power Corporation (NAPOCOR) in the Philippines (Nikomborirak & Manachotphong, 2007). There is very little competition in the wholesale market. In 2001, a full privatization agenda covering unbundling generation, transmission, distribution, and retail services was approved by the government through the Electricity Power Industry Reform Act (EPIRA). By 2007, the National Transmission Company (TRANSCO) was separated from NAPOCOR. Both TRANSCO and NAPOCOR are supposed to be privatized, but the implementation has been delayed.

Malaysian electricity sector used to be controlled by a vertically integrated system. Reform in this sector has been implemented since the passing of the Electricity Supply Act 1990 and corporatization of the national electricity board in the same year (Fong 2007). IPPs entered the generation businesses in 1993. However deregulation has been interrupted due to power crisis in the 1990s. There is still monopoly in power purchase, transmission and distribution in the Malaysian electricity sector (See, 2011).

The electricity sector of Brunei Darussalam is guided by the Electricity Act 1973 and recently by the Electricity Act (amendment) Order 2002. The business activities are controlled by two state agencies, namely, the Department of Electrical Services (www.des.gov.bn) and Berakas Power Company (BPC). Electricity is generated through seven power stations maintained by the two agencies (ED, 2007).

Vietnam, as a relatively low income EAS member, has enjoyed the fastest growth in the rate of electrification in recent years. In March 2004 the first IPP started production in Vietnam (Lovells, 2009). The country's generation capacity however cannot meet the burgeoning demand. As a result an ambitious electricity reform program has been initiated. The purpose of the reform is to achieve full power market liberalization through a gradual three-stage transition. The starting point was the passing of the country's Electricity Law in 2005. Due to this legislation, competition was initially introduced into power generation in 2007 and hence Gencos are allowed to sell to a single buyer (stage I). Further deregulation in the wholesale sector is expected to commence in 2014 (stage II) and a fully deregulated power sector including retailing competitionmay be realized in 2024 (stage III).

Several EAS members with relatively low income, namely Cambodia, Lao PDR and Myanmar, are still in the process of expanding electrification in their economies. In general, the rate of electrification is still low in those economies but is growing. For example, it expanded from 16% in 1995 to about 63% in 2009 in Lao PDR (Bambawale, *et al*. 2011). According to the World Bank (2012), the rate of electrification in 2009 was only 13% in Myanmar and 24% in Cambodia. The immediate task for governments in these countries is to expand electricity access and hence eventually develop a national grid. The private sector is already participating in these fledgling electricity markets. Poch & Tuy (2012) reported that about 91% of electricity supply in Phnom Penh, Cambodia, was generated by IPPs in 2010. Cambodia, Laos and Myanmar are also engaged in cross-border trade in electricity with neighboring countries.

5. Towards an Integrated Electricity Market in the EAS Area

In order to promote an integrated electricity market within the EAS area, the first step is to achieve cross-border interconnectivity. Over the years, two initiatives have emerged. That is, the development of the ASEAN Power Grid (APG) and Greater

Mekong Sub-regional (GMS) connectivity. APG was proposed as part of the plan to establish an ASEAN Economic Community (AEC) by 2015. Through the coordination of the heads of ASEAN power utilities or authorities (HAPUA), some cross-border connectivity has been achieved since the implementation of AIM I (ASEAN interconnection master plan study 2003). Under AIM II (ASEAN interconnection master plan study 2010), nineprojects are expected to be completed by 2015 and six more after 2015 (Table 3).

Table 3:ASEAN Power Grid Interconnections

Connections	No. of Projects	Capacity (MW)
Thailand-Malaysia	2	380
Thailand-Lao PDR	4	1853
Singapore-Malaysia	2	400
Cambodia-Vietnam	1	135
Thailand-Cambodia	1	80

Source: Hermawanto (2011).

In 2002 countries in the greater Mekong sub-region (GMS) also signed an inter-governmental agreement on regional power trade (IGA). In the following year (2003) a regional power trade coordination committee (RPTCC) was formed. One of the tasks of RPTCC is to investigate options for a future GMS power market. By 2012 a formal market is yet to emerge.Some analysts have called for the development of a new GMS strategy (2012-2022) (Baardesen, 2012). Though the process is slow, some connectivity is already achieved among the GMS economies (including Cambodia, China's Yunnan province, Lao PDR, Myanmar, Thailand and Vietnam). For example, China started exporting electricity to Vietnam in 2004. Total exports through seven lines reached 5.5 billion kWh in 2010 (Xinhua, 2011). According to the same source, it was reported that China also started importing electricity from Myanmar in 2008 and a total of 1.7 billion kWh was imported in 2010. China's exports to Lao PDR started in 2009. Apart from the connectivity identified in Table 3, there are also interconnections between Cambodia and Laos (155 kV grid) and between Vietnam and Lao PDR. In the lower Mekong region, both Vietnam and Thailand are net importers of electricity while Lao PDR is a net exporter. In 2007 electricity exports from the Lao PDR amounted to 11.6% of the country's export revenues (ICEM, 2010). Cambodian electricity imports amount to 385 million kWhfrom Thailand and 1162 million kWh from Vietnam in 2010 (Poch & Tuy, 2012). These two sources combined account for about 60% of total electricity consumption in Cambodia.

In general there is still a long way to go in terms of interconnectivity and trade in the EAS electricity sector. EAS is also lagging behind Europe where physical cross-border exchanges have increased from 7.6% of electricity consumption in 1998 to 10.3% in 2005 (Meeus & Belmans, 2008). The development of regional markets such as the GMS market and APG is a necessary interim stage of market integration. In the EAS area, other regional interconnections have also been proposed. These include potential interconnections between Japan and South Korea to deal with emergence (Tanaka 2012) and trade with Russia (von Hippel, *et al*. 2011) and between India and Myanmar (World Bank, 2007).

While governments in the EAS countries have moved in the right direction to promote market integration in the electricity sector, much more work is needed. Especially, government policies should focus on the development of national electricity markets, the promotion of sub-regional connectivity and power market, harmonization of regulations and standards and coordination in power sector investment and planning. Each of these is discussed next.

National market development

The rate of electrification in several EAS members is still very low. Apart from the very low electrification rates in Myanmar and Cambodia (under 30%), access to electricity in India, Indonesia and Lao PDR is also limited (under 70%). Therefore, the policy priority in these countries is to invest in infrastructure and hence ensure equity in electricity access. For other EAS members with almost universal access, their policy priority is to develop a national grid and hence to achieve nationwide interconnectivity. The formation of national markets is a prerequisite for sub-regional and regional electricity market integration. With the realization of a national market, many countries have initiatedreforms of their electricity sectors. Though reform progress varies, the purposes of reforms are the same, namely the introduction of competition into the traditionally state-controlled sector, the improvement in the security and sufficiency of electricity supply, and the encouragement of private sector participation in the electricity businesses. Members who have implemented reforms should continue the course and those without reforms should identify the appropriate policy options. The selection of the reform approach and pace is important for a country to truly realize the benefits of changes as there are many examples of failures and successes in the world (Bacon & Besan-Jones 2001, Zhang, *et al.* 2008 and Erdogdu, 2012).

Sub-regional Connectivity and Power Market

Bilateral or sub-regional interconnection becomes possible even if individual members' national markets are not fully developed yet. Member countries can gain and learn from sub-regional cooperation and electricity trading. The experience could be valuable for eventual market integration within the region. For example, it is argued that the long-term goal of buyers and sellers competing across national borders and without constraints (like cross-border commodity trade) has been elusive (Bannister, *et al.* 2008). However such a goal may be achievable if only two or a small number of countries are engaged. It has been suggested that bilateral trade could be pilot-tested (Antikainen, *et al.* 2011). In the future the gained experience can be adopted by other groups. The current discussion and development of the GMS power market and APG are the right things to do. Other initiatives could include the establishment of small-scaled power exchanges near border areas and cross-border grids with synchronized operation to exploit peak loads in different time (Baardsen, 2012). A sub-regional approach can also make the best use of different energy resources in a region and contribute to the sustainable management of resources. This is particularly so for hydropower which may use water from the same river system such as the Mekong river. A sub-regional approach can also accommodate the diversity of member economies in terms of economic, regulatory and power sector development.

Harmonization of regulations and standards

To achieve the goal of an integrated electricity marketin the EAS area, members should work together to harmonize regulations and technical standards. The eventual goal is to identify regional best practice and catch up with the global one. Specifically, an integrated regional electricity market needs harmonized regulations and standards associated with

- consumer protection and safety standards
- legal and tax issues
- standardized contract forms
- tariff-setting mechanism
- trading systems

Coordination in electricity policies and planning

The strategy of establishing a regional integrated electricity market should be reflected in individual members' domestic policies and planning in power sector investment and development. Thus members should coordinate to utilize the existing resources efficiently and develop new infrastructures strategically in the future. For example, domestic projects near the border areas could be developed for both domestic and cross-border trading. Other areas for coordination include:

- cross-border investment in the electricity sector
- cross-border licensing
- distribution of generators near border areas
- information exchanges
- management of shared river resources

6. Conclusion

Growth in electricity demand in the world will outpace the growth of world energy consumption in the coming decades. The EAS economies currently account for about one third of the world's total electricity consumption. This share is to grow modestly in the future. Thus electricity market integration has become an important part of the overall goal of developing an integrated energy market in the EAS area. Though major initiatives have been made to promote cross-border electricity trade and hence regional market integration, an integrated EAS electricity market is still a long way to go. Member economies have made various levels of progress towards market development, deregulation and interconnections. Much more work is however needed. Specifically many EAS members should focus on the development of national electricity markets and hence achieve the goal of internal market integration. Relatively more developed members could explore the possibility of sub-regional interconnection and development of cross-border power markets (such as the greater Mekong sub-regional connectivity and ASEAN power grid). In order to prepare for eventual regional integration, members should work together to harmonize regulatory standards and rules. Finally members should coordinate in national policy making and development planningin the electricity sector so as to achieve efficient allocation of resources and investment at the national level as well as within the EAS area.

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CHAPTER 5

Market Entry Barriers for FDI and Private Investors: Lessons from China's Electricity Market

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EMI is one of the priorities of regional cooperation identified by leaders from the EAS region. The countries in the region have made great efforts to push for the electricity sector reform so as to boost the participation of private investment. However, a review of these reform experiences suggests that there is significant disparity between the expected and actual outcomes of reform. China has implemented its reform program since the 1990s, and a major reform was introduced in 2002, with the corporatization and unbundling of electricity being achieved. But, a competitive market has not yet been established due to both political and technical difficulties. Motivated by the Power Purchase Agreement (PPA), the participation of private investment in China was expanded in the 1990s. Paradoxically, after the introduction of a major reform in 2002 which created more favorable conditions for the private sector, foreign investors retreated from China. Among other things, the authors identified the fragmented regulatory system, unpredictable pricing mechanism, limited access to transmissions, fuel and financing, and unchecked expansion of the state-owned sector as major barriers that impeded the participation of the private sector. The policy responses and implications of China's experience for the region are also discussed.

1. Introduction

In the fifth EAS, leaders cross the region emphasized the need for greater regional cooperation on energy and welcomed the efforts to address market barriers and promoted more transparent energy trade and investments (Shi & Kimura, 2010). Clearly, market liberalization is an important part of EMI in the East Asia Summit region. However, for the electricity sector, once dominated by publicly owned monopolies over the full range of sector activities from production to distribution, market liberalization is a hard nut to crack. Since the 1980s, electricity sector reform has been implemented across the region in hope to break the monopoly and in turn to attract private investment. A review of these reform experiences suggests a significant disparity between the expected and actual outcomes of reform (Sharma, 2005). The World Bank attributed the disparity to the political nature of electricity tariff setting and the huge stake of investments and assets involved (Manibog, *et al.* 2003). To better understand the barriers of private participation specific to the region, this study will examine China's experience in electricity sector reform and private participation in the electricity sector. Since the introduction of economic reform in 1978, China has implemented a profound reform in the electricity sector, paving the path for private and foreign investor entry. Paradoxically, after a major liberalization reform in 2002, private and foreign investment in the electricity sector receded, revealing that breaking the entry barrier is much more than a one-strike effort. The study is aimed to systematically examine the barriers that hinder the participation of private and foreign investors in China's electricity sector and shed light on policy measures to address this problem.

2. Chinese Electricity Market Reform

Before the reform, the Chinese electricity sector was a typical state-owned and vertically integrated industry run directly by the power ministry. As a major measure to break the bottlenecks of power shortage, China begun its electricity sector reform in the 1990s. The reform initiatives are discussed as follows.

2.1. The Unbundling of the Electricity Industry

The first step of the reform was the corporatization of the electricity businesses once run directly by the government. In 1997, the state electricity company was created to take over the management of the electricity industry and the power ministry was scrapped in the following year. In 2002, the State Council officially adopted the electricity system reform program, which asked for the separation of power grid and plant and claimed that the goal of the reform was being implemented to establish a competitive electricity market. The unbundling went smoothly. The state grid and its junior counterpart, South Grid, were established. Both are responsible for electricity transmission and distribution. On the power plant side, five power generation companies were also put into operation. However, the establishment of a competitive electricity market has never been within reach because of political and technical difficulties.

2.2. Electricity Pricing Mechanism

In China, electricity prices are subject to government regulations. The National Development and Reform Commission sets both the on-grid price and retail price. The rule of price regulation has been changed several times. At the beginning of policy implementation, in order to promote investment in the electricity sector, the on-grid price was set based on the cost and allowed return of individual projects. Later, for improving the efficiency of investment, a yardstick pricing mechanism was introduced. Under this rule, the same on-grid tariff is applied to all power plants of the same type located in the same region no matter what the individual cost was. To tackle the impact of the fluctuation of fuel price on power plants, a mechanism to link the on-grid price to coal price was also established. However, this mechanism has not been strictly followed; coal prices have skyrocketed and general inflation has risen driving power plants into difficult financial situations in recent years. The retail price of electricity, on the other hand, has been set more discretionally as the independent transmission and distribution price is not yet determined. China has adopted the rate of return method for setting transmission and distribution prices. However, the rule for accounting regulatory assets and allowed costs has not been established.

2.3. Market Entry Regulation

The liberalization of the power generation sector entry was done well before the major reform in 2002 with the aim of alleviating the serious shortage of electricity supply caused by the take-off of the Chinese economy. As a result, foreign investors were encouraged to build Independent Power Plants (IPP) in China at very favorable terms. The long term Power Purchase Agreement (PPA) usually offered the foreign investors three guarantees, i.e. guarantee of the sale of electricity, guarantee of the electricity price, and guarantee of the investment return. The committed return could be as high as 15% to 20% annually. This super-national treatment ceased by reform in 2002 basically putting all agents of the electricity sector, both domestic and foreign, into the same regulatory framework. In 2010, a new package to encourage private investment was announced by state council. Renewable energy such as wind, solar, geothermal, and biomass were identified as sectors that generally welcomed the involvement of the private sector. The private sector is also permitted a controlling stake of, or sole ownership of, conventional power plants. The participation of the private sector in nuclear power plants is also allowed in the form of joint venture. The electricity transmission and distribution business, dominated by State Grid, South Grid and a small number of local grids, is still de facto, closed to foreign or private investment, even without explicit embargo.

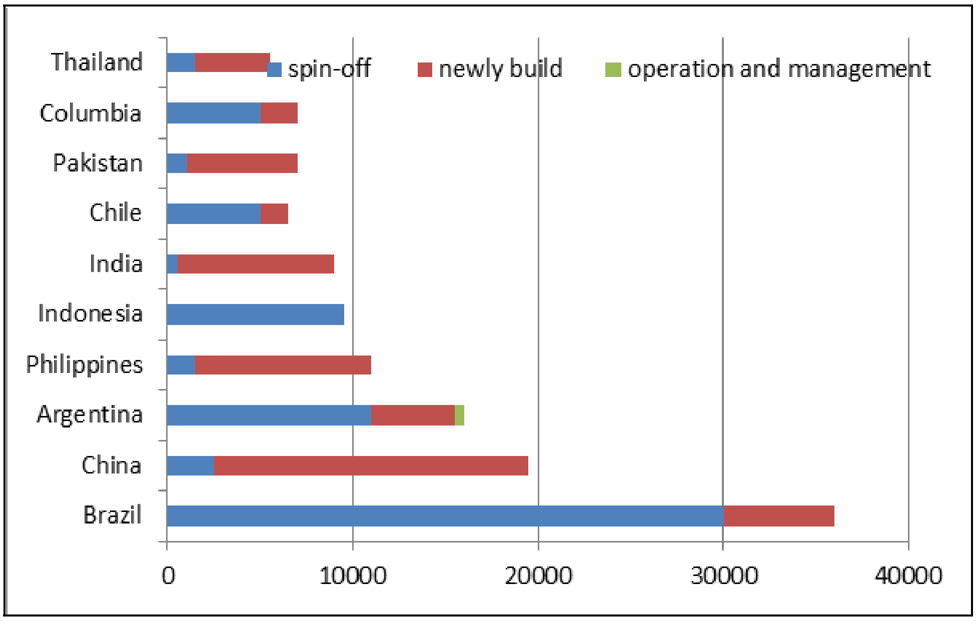
3. The Evolving Role of Foreign and Private Investment in China's Electricity Industry

Corresponding to the change in policy regime and market conditions is a change in the role of foreign and private investment in China's electricity sector. Supported by preferential treatment, foreign and private investment experienced a booming in the 1990s. The major reform introduced in 2002, which provided a more secure legal framework for market opening, also terminated the super-national treatment to foreign investment together with other factors (for example, the Asian financial crisis of 1997 led to a large scale exodus of foreign investors). As a result, foreign and private investment that had accounted for a considerable share of power generation capacity now plays a relatively insignificant role in China's electricity sector.

3.1. The Prime Time for Foreign and Private Investors in the 1990's

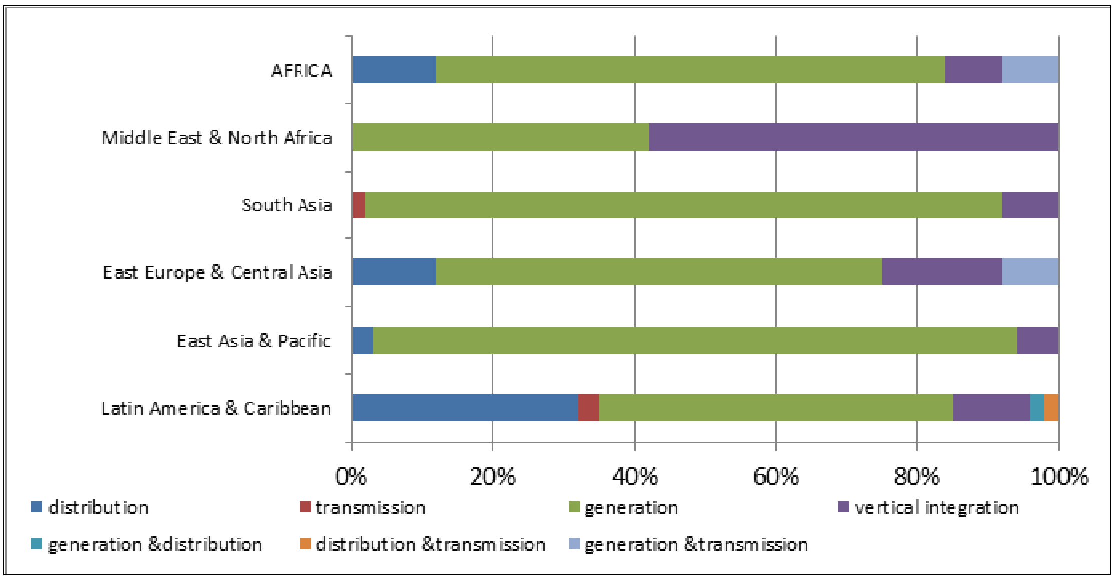
As the Chinese economy took off after the reform in 1978, electricity supply increasingly became a bottleneck to further development. To close the gap of electricity demand and supply, the Chinese government worked out a policy to encourage investment from all sources to this sector. Among other things, PPA was widely used during this time to attract the foreign investment. As the result, Independent Power Plants (IPP) mushroomed; and their numbers rivaled central government owned power plants. Local governments were owners or co-owners of most IPPs while a considerable number of foreign and private players also participated. The World Bank data revealed that from 1990 to 1999 China attracted USD 19 billion FDI to invest in the electricity sector; second only to Brazil (see Figure 1). Most FDI to China was greenfield investment rather than divesture, making China an outstanding target of investment as compared to other developing countries. Power plants were the main field of investment, roughly accounting for 90% of total electricity-related investment. This pattern is generally in line with other East Asian and Pacific countries (Joscow，2010)(see Figure 2).

Figure 1: The Type of FDI in Electricity Sector: China and Other Developing Countries



Source: World Bank, IPP Database.

Figure 2: The Type of FDI by Region



Source: World Bank, IPP Database.

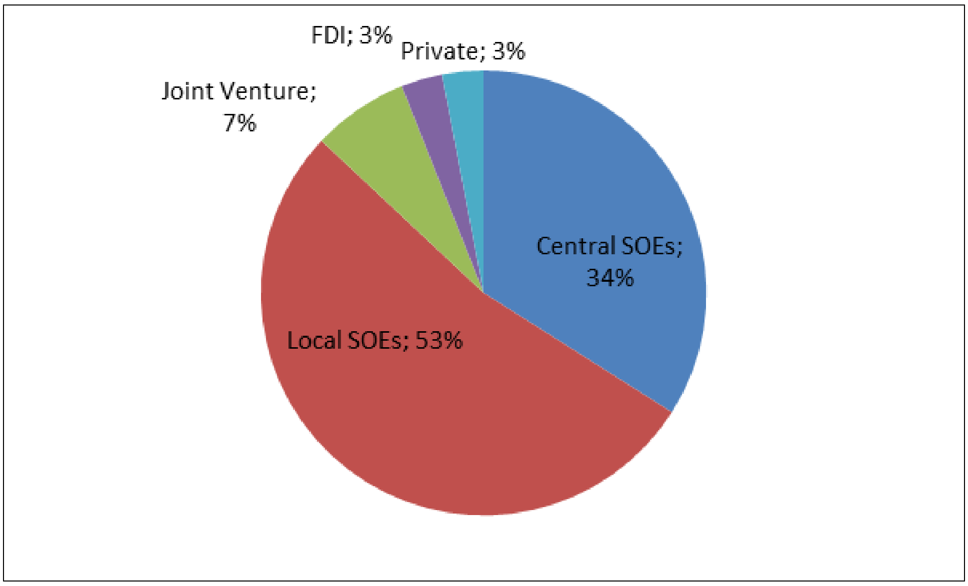
3.2. The Large Retreat of Foreign Investors around the Electricity Reform in 2002

Supported by the PPA introduced at the beginning of the reform, foreign and private investors flooded into electricity sector. In 1990, the foreign and private sector accounted for 12.2% of total generation capacity. This share peaked at 14.5% in 1997. Afterwards, the share went down. The share in 2004 was only about half of that in 1997. The decline of the share was not only the result of slower growth of foreign and private investment relatively to the state-owned sector, but also represented an absolute decline of the installed capacity of the non-state sector. There was an exodus of foreign investors around the time when the major reform was introduced in 2002. The American company Mirant, listed in Fortune 500, sold all of its stake in Shandong Guodian, and Shajiao power plant in Guangdong, and closed its office in China in 2002. The American energy company, Celgard, sold its shares in Zhejiang, Guangdong, Hebei and Hubei in 2003. The power plant in Zhejiang province that Celgard had withdrawn from had been the first joint venture power plant in that province. Alstom, a French energy company, walked away from Laibing power plant, a textbook case of the first BOT project in China. Simens, HAW, Vattenfall, and Peak Pacific, all followed the suit and withdrew their investment in China (Yang, 2005). The exodus of foreign investors does not seem to be over. In 2011, AES, one of the largest IPPs in the world, planned to sell all or a large part of its assets in China. The transaction is estimated to be worth several hundred million dollars (Zhang, 2012).

3.3. The Current Situation of Participation of Foreign and Private Investment in China's Electricity Sector

Due to the lack of national level data, we take the Guangdong and Shandong provinces as examples to demonstrate the current situation of participation of foreign and private investment in China's electricity sector. Both provinces are major economic power houses in China and have experienced very rapid growth in power generation capacity. Guangdong is a province that enjoys a relatively high degree of participation of foreign and private investment but the share of foreign and private owned capacity is relatively small. In 2010, foreign and private investment accounted for 13% of total thermal power plant capacity. Most investments took the form of joint venture, which accounted for 7% of total capacity, while solely foreign- and private- owned each accounted for 3%. Local state-owned plants took a relatively larger share of total capacity, at 53%. The central government's SOE accounted for one third of the total (see Figure 3), foreign and private investors usually running small power plants. Among twelve power plants with more than 1.2 million KW in Guangdong province, seven are local SOEs, three are central SOEs, and only two are Sino-foreign joint ventures. Most private power plants are captive, supplying few or no electricity to the grid. In recent years, private investors have also entered the business of renewable energy, building wind farms and rubbish fired plants.

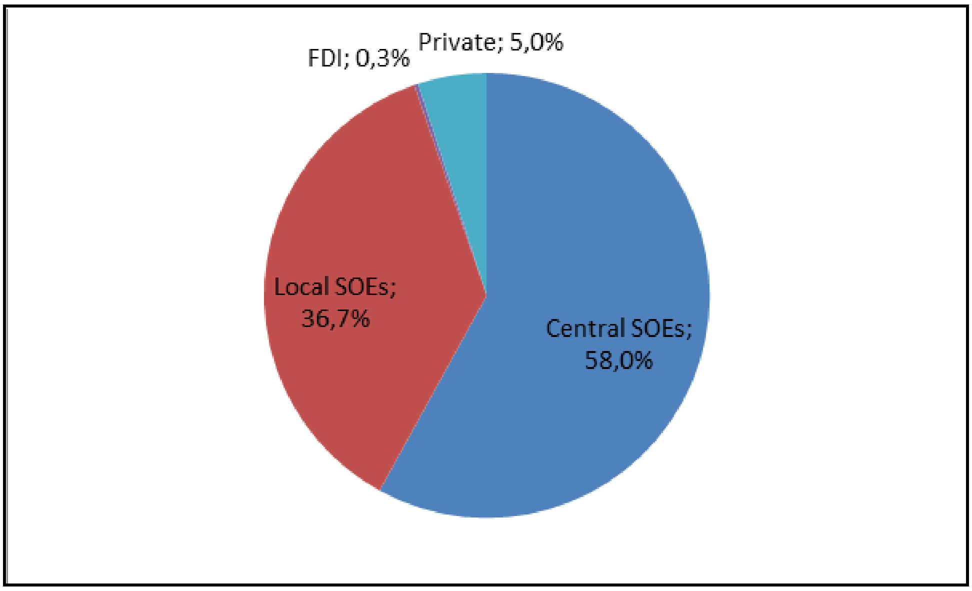
Figure 3: The Ownership Structure of Thermal Power Generation in Guangdong Province



Source: author's calculation.

The Shandong province represents a more typical pattern of ownership structure of generation capacity that is dominated by the central SOEs. Huaneng, Huadian, Guodian, Datang and other central government owned SOEs represent almost 60% of total generation capacity. The electricity produced by these central SOEs are transmitted on the backbone grid while the plant of local SOEs and non-state sectors are mainly stand-alone power sources or transmitted on the local grid. The size of foreign and private owned power plants in Shandong is even smaller than its counterpart in Guangdong. There is only one private power plant with a capacity more than 1 million KW, ranking 14th in Shandong. The foreign-owned plants are even smaller than the private ones, usually producing below 60 KW, a result of the withdrawal of big foreign players from the market.

Figure 4: The Ownership Structure of Power Generation of Shandong Province



3.4. The Performance of Foreign and Private Power Plants

The performance of power plants can be measured by financial and technical efficiency. Because of a lack of financial indicators, we compare one of the most important technical indicators - the coal consumption per kWh. The results show that foreign funded power plants are basically on par with the state power plant while private power plants are inferior to other players in terms of technical efficiency. Data from both Guangdong and Shandong present a similar picture (see Tables 1 and 2). However, the difference in technical efficiency could be the result of the difference in the scale of power generator and the age of equipment, rather than the difference in management skill. The private power plants are mainly installed with smaller and older generators. Therefore, the low technical efficiency of the private sector does not necessarily suggest a low economic efficiency. There are some anecdotal evidences that show that for newly-built power plants, if it is done by private investment, the cost per kWh could be 20% lower than average.

Table 1: The Technical Efficiency of Power Plants by Ownership in Guangdong Province

Type	No.	Electricity Billion KWH	Coal consumption gram/KWH
Central SOE	15	79	315
Local SOE	44	131	311
Local Captive	23	5.4	454
Foreign-funded	17	27.4	341
Private	9	8.5	485

Source: authors' own calculation.

Table 2: The Technical Efficiency of Power Plants by Ownership in Shandong Province

Type	No.	Electricity Billion KWH	Coal consumption gram/KWH
Central SOE	38	216	328
Local SOE	13	16	349
Local SOE(local grid)	140	13.4	375
Local captive SOE	113	33.9	391
Foreign-funded(local grid)	5	0.6	351
Foreign-funded captive	3	0.2	313
Private(local grid)	13	0.6	396
Private captive	22	7.8	393

Source: authors' own calculation.

4. Identifying Barriers to the Participation of Foreign and Private Investors in China's Electricity Sector

The last round of reform basically lay down a legal framework allowing the foreign and private sectors to invest more freely in China's electricity industry. But, paradoxically, as demonstrated earlier, foreign and private sectors have been leaving rather than arriving in this sector after the reform. Although the change in market conditions, the great improvement of electricity supply in China, and the emergence of electricity shortages in host countries like the US, can explain somewhat this reversing flow, a deeper analysis reveals that domestic barriers are more to be blamed. Barriers are not only originating from electricity sector regulation, but also from wider institutional arrangements.

4.1. Inadequate Electricity Regulatory System

The electricity regulatory system in China is very fragmented. China's Electricity Regulatory Commission, created in 2004's reform, has only limited functions, for example, responsibility for licensing. Other important regulatory functions are controlled by line ministries. The Pricing Department of NDRC and its provincial offices determine the electricity tariff rates, and the Energy Bureau of NDRC and its provincial offices issue investment permits. The range of business activities is subject to the approval of the General Bureau of Industry and Commerce. The Finance Ministry sets the rule for cost and accounting standards. The State-owned Asset Supervision and Administration Commission is responsible for the reorganization of the state-owned electricity company, which still dominates this sector. The fragmentation of the regulatory system is not only burdensome, but also more often than not, uncoordinated, resulting in very high levels of compliance costs for investors. To make things worse, the regulatory system is not rule-based, which gives too much discretion to the regulators. This creates lots of uncertainties for investors as they have to face unpredictable policy changes. For example, the central government issued a three year embargo on all coal-fired power plant projects in 1998 and stopped 9 million kW in ongoing projects in 2004. Regulatory capture is another problem. In China, most investment permits in the electricity sector are issued by local governments who also serve as conduits for the submission of application of projects which are subjected to central government approval, creating opportunities for rent-seeking. Lack of local connection and the intimacy of local governments with local SOEs in China may explain to some extent the decline in foreign investment in the electricity sector.

Pricing regulation is another important factor impeding the entry of foreign and private investment. The 2002 reform set the goal to build a competitive electricity market which would determine the electricity price. However, reform stopped at separating power generation and transmission due to political and technical difficulties in establishing a competitive market, leaving the price still in the control of the government. The government basically uses the cost markup to set the price, to allow investors to recover their investment. However, due to a lack of reliable cost information and supervision, the price is more the result of negotiation and needs to be renewed every year, creating uncertainty (Liu, 2011). Complicating pricing decisions, the Development and Reform Commission (DRC) at each level also assumes the role of maintaining stability of general price levels. In an environment of high inflation, the DRC may be reluctant to factor in the cost of rising electricity prices. An example of this has been the government's suspension of the linkage mechanism between the coal price and electricity price in 2008 in fear that the mechanism may have fueled inflation further. This resulted in a record loss in the power generation sector in recent years. The unpredictability of China's electricity price greatly discourages investors, especially foreign and private, who are more sensitive to risks with uncertainty affecting the financial result of their investment.

4.2. Less Favorable Access to the Fuel, Grid and Financing by Foreign and Private Sectors

The opening of the market is only the first step in the liberalization of the electricity market. The operational environment is equally important, if not more important, in impacting entry decisions of investors. In this regard, we find that foreign and private operators are still in a less favorable position compared to the state-owned competitors. This is especially true in foreign private operators' ability to access fuel, grid and financing, the key resources required for power producers to grow.

4.2.1. Less Secure Coal Supply for the Non-State Sector.

Eighty two percent (82%) of Chinese electricity comes from coal-fired power plants, and 40-50% of railway and ferry transportation is used for moving the coal from north to south. The importance of access to coal for a power operator cannot be overstated. The Chinese coal market has largely been liberalized since 2005, the price being decided by the market. Responding to rising demand and crude oil prices, the coal price has rapidly increased since 2005. In some cases power plants have had to cease operation due to shortages in the supply of coal. To deal with this situation, the government has encouraged power plants and coal enterprises to sign an annual contract to secure the supply of the coal and to smooth the coal price. Because many large coal producers are also state-owned and state-owned power plants are larger buyers, it is easier for state-owned power plants to secure a supply contract to secure better terms. State-owned power plants also enjoy privileged access to the state-owned railway system which is increasingly causing bottlenecks in the coal supply chain. Furthermore, the state-owned power company can secure the supply of the coal by vertical integration. The Big Five state-owned power groups have quickly moved into the upstream industry, investing heavily in coal mines. By 2009, the coal production of the Big Five groups reached 128 million tons, accounting for 9.16% of total coal used for electricity generation. Huaneng, one of the Big Five companies, began its own coal mine projects in Inner Mongolia, Shanxi, Gansu and Xinjiang concurrently. Now the Huaneng company controls 40 billion ton of reserve, and annual production of coal is as high as 44.1 million tons (Zunfa, 2010). Moving to upstream industry not only helps secure the supply of the fuel but also cushions the shock brought by rising coal prices. The state-owned plants did lose money from state power generation business, but some of that loss has been recovered from profitable coal business. The foreign and private investors, on the other hand, are constrained in achieving similar vertical integration, partly due to their small size and political barriers, leaving them more vulnerable to shortages of coal supply and rising coal prices. This situation gives state-owned power plants an advantage over foreign and private investors.

4.2.2. Less Access to Transmission

Access to transmission is another key development factor for the power generation subsector. China has not yet established a competitive electricity market. Without a competitive market, and a relatively balanced supply and demand of electricity, power plants are placed at the mercy of the grid controllers in regard to how much electricity can be transmitted, and then produced. Due to the importance of big state-owned power plants, it is of no surprise that the state-owned plants have easy access to transmissions. Where transmission capacity is not sufficient or limited by technical reasons, for instance wind farms, ability to access the grid could be the single most important factor deciding the viability of a project. This is why, in the renewable sector, the non-state sector finds itself increasingly in a difficult position to compete with the state-owned sector.

4.2.3. Less Access to Financing by the Private Sector.

Power generation is a capital intensive sector. Adequate access to financing is very important to the development of business. Private investors in the electricity sector suffer from dual disadvantages in this front arising from ownership and size. China’s financial system is largely dominated by state-owned big banks. Although the government no longer directs banks to issue loans, banks are still more comfortable making deals with state owned companies, which are politically safe and economically cost-efficient. The chance of direct financing, such as raising funds in the stock and bond market, is also largely reserved for the state-owned sector, evidenced by that fact that most listed companies have a stake in state ownership. This situation makes it difficult for the private sector to compete with incumbent state giants.

4.3. Unlimited Expansion of Big State-Owned Groups Suffocate the Foreign and Private Players

One important strategy of Chinese SOE reform is the reorganization of the state owned sector to make it more efficient. State council’s State Asset Supervision and Administration Commission (SASAC) orchestrates the reorganization by letting small and slow-growing companies be taken over by bigger and faster growing companies. So the number of companies under its administration constantly declines, for example, from 200 companies several years ago to 120 companies presently. This policy has created a strong incentive for big group to grow bigger and faster;

otherwise they would be a prey of others. In recent years, the electricity sector witnessed a frenzy expansion of state-owned big groups. The Big Five have gained the franchise of the development of all Chinese major rivers, leaving almost no room for the foreign and private sector to build big scale hydraulic power stations. The expansion of the Big Five in the renewable sector is also astonishing. According to SERC (2011), central and local SOEs are the main investors of wind farms. The top ten accounted for more than three quarters of total capacity. The leading players are Guodian, Huaneng and Datang. China adopted a tendering system to award the project to the bidder who offered the lowest electricity price in the renewable energy sector. State-owned sector undercuts their private rivals by a very low bid price. One reason for the state-owned sector doing this is because of the quota system for renewable energy. China's national, middle, and long term renewable development plans imposes 8% of renewable electricity quotas for power generation companies with an installed capacity of more than 5 million KW. If that requirement is not met, no new thermal plant could be allowed. The rapid expansion is mainly supported by debt increase. In the past seven years, the debt ratio has increased by 20 percentage points. By the end of 2009, the asset-debt ratio of the Big Five reached 85.94%, above the upper limit set by SASAC and highest amongst all SASAC administrated big groups.

5. Overcome Market Entry Barriers: Policy Option for Further Reform

As the barriers do not arise from one single cause and extend far beyond the electricity sector, it is necessary to take an holistic approach to deal with this issue.

5.1. Build a Competitive Electricity Market

A competitive electricity market is essential to permitting the participation of the private player in the market to grow. In this market, the electricity producer and user can directly negotiate deals. The grid will no longer be the arbitrator of the deal, but should become a more independent system operator. This impartial role of the grid will eliminate the ground for favoritism towards state power plants and create a level playing field in which the private sector will be encouraged to compete. The establishment of a competitive electricity market will also result in less regulation by the government of the on-grid electricity price, reducing uncertainty caused by policy change at the discretion of government.

5.2. Reform the Electricity Pricing Regulation

Correct price is the most important incentive guiding the investment of the foreign and private sector. Electricity price regulation in China is inadequate in imposing controls on prices in a competitive power generation sector while there is no regulation in the monopolistic transmission and distribution sector (Liu, 2011). The mispricing has clearly discouraged the entry of private investors. China needs to move quickly to establish a pricing mechanism for the transmission and distribution business in order to allow the competitive market to operate by permitting the market to determine the electricity price. China also needs to allow electricity price regulation to operate independently from the mandate of maintaining general price stability. The general price stability should be achieved by macroeconomic policy, rather than via the distorted stated mechanism, a practice that will weaken the rule-based system and shake the confidence of investors.

5.3. Set Right Incentive for State-Owned Sector

It is a progress that State-owned power generators actively pursue growth. However, pursuing expansion at any cost will be a problem. This practice will not only suffocate private investors but will also lead to over investment and inefficient investment that in turn, in the middle and long terms, will endanger the financial sustainability of the sector and will draw the bank and other creditors into trouble. So, the SACACS needs to set correct incentives for the state-owned sector and act more reasonably, not only by watching size but also watching balance sheets more carefully to deter risk accumulation. For the sake of readjusting the whole state-owned sector, the SAACS also need to consider the right size of state-asset in this highly competitive sector. To withdraw state-assets from this sector will not only create room for private actors to develop, but will also strengthen the role of government in the fields in which government should assume more responsibilities, such as social security, innovation and education.

5.4. Transparent and Modern Regulatory System

The Chinese electricity regulatory system is fragmented and uncoordinated, creating excessive high compliance costs for the private sector. China needs to reorganize the regulatory structure in order to empower the independent regulator with major regulation functionality so as to improve the efficiency of regulation. The regulatory system needs also to be more rule-based and more transparent, to reduce the discretion and rent-seeking of regulators.

5.5. Improve Access of Private Sector to Financing and Transportation

Equal access to financing is essential to permitting the private sector to compete with the state-owned sector at an equal footing. China's state-owned big bank dominated financial system needs to be reformed to allow small and private financial institutions to play a greater role, in order to improve the financial service to the private sector. It also needs to be more open to direct financing chances from the private sector in the transformation from indirect financing to direct financing.

Access to transportation, other infrastructure, and public service is also very important for the private sector. The effort should coincide with reforms in other sectors, for example, railway reform. Market orientation reform will better serve equal access to public services. To this end, China needs to speed up its market reform on all fronts. Such reform will not only benefit the private investor in the electricity sector but will also provide benefits economy-wide.

6. China's Lesson and Policy Implications for EMI

China's situation, unfinished reform and the lack of a comprehensive package to foster private investment in the electricity sector, is not unique in the region. For example, in most ASEAN countries, such as Singapore, Thailand, Indonesia, Philippines, Malaysia and Cambodia, regulatory and structural reforms are delayed due to problems associated with the various crises post 1997 (Porter, *et al*. 2005). With this similarity, the countries in the region can draw several lessons from China's experience. First, the PPA based-super-national treatment only motivated private sector temporarily in the context of supply shortage. The inevitable transformation to the rule-based regulatory system, as a result of electricity sector reform and conformity to the WTO rule, undid much of what had been achieved, and this has had long-lasting negative effects on willingness of participation of the private sector. In a market condition with relatively balanced demand and supply, the commitment for investment return and sale volume of electricity, usually a key component of PPA, is hard to honor. Second, the unfinished reform discourages the participation of the private sector by failing to provide a predictable regulatory framework and leaves the electricity price in the control of the government. Third, electricity sector reform alone could not deliver the expected benefits on motivating the private sector. China's experience demonstrated that the private sector is crippled by the limited access to transmission, fuel and financing. Therefore, until these problems are adequately addressed, the participation of the private sector can not be realized. Fourth, unchecked growth of incumbents, who usually enjoy many advantages due to their connection to the regulatory authority or purely due to big size, will also stifle competition by suffocating private players. Where the policy responses are concerned, we believe that the policies proposed for China in this paper are also relevant for other countries in the region. The adoption of these policies in the region would contribute to the better preparation of EMI. The implementation of the policy will help push for the establishment of a competitive market, harmonization of the regulatory system, and improve access to the key resources for business development. However, it is also needed to bear in mind that each country has its own challenges. SOE reform in the electricity sector is extremely important but difficult in China.

7. Conclusion

There has been big fluctuation of private and foreign investment in China's electricity sector. The initial boom of private investment, especially foreign investment was induced by government incentive schemes. The major reform introduced in 2002 set the legal framework for private participation and made competition possible by unbundling the vertically integrated state power companies. However, on the other hand, the reform scrapped PPA that gave the super-national treatment to the foreign investors. The reform therefore remains unfinished due to technical and political difficulties, leaving the private investor uncertain. The private sector is also troubled by electric tariff regulation that is not only unpredictable but also often succumbs to other government policy objectives. The limited access of private sector to fuel, transmission and financing, and the key resources required to permit power producers to grow constitute further barriers to entry. Last, but not least, the unlimited expansion of big SOEs has suffocated the private sector. As the barriers multiply and extend far beyond the electricity sector, it is necessary to take a holistic approach to deal with this issue. Electricity reform needs to be continued so that a competitive electricity market can take over price-setting from the government. Electricity sector reform should be accompanied by the further reforms of SOEs, the financial system, energy markets and infrastructural service. These reforms would encourage the private sector to play a role in the electricity sector.

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CHAPTER 6

Lessons from Electricity Market Regulation Reform in New Zealand: Vertical Integration and Separation

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All around the world, electricity market reforms involve various forms of unbundling previously vertically integrated state-owned or privately owned electricity monopolies. New Zealand is the only country in the developed world that has implemented forced ownership unbundling of electricity distribution and transmission activities from the rest of the electricity network. The Electricity Industry Reform Act 1998 (EIRA) strictly prohibited distribution businesses from being involved in either generation or retailing activities. However, the strict ownership separation between distribution and generation was relaxed not long after the enactment of this legislation. In 2010, the New Zealand government enacted the Electricity Industry Act 2010 (EIA), which revised the strict ownership separation between distribution and retail by allowing distribution back into retailing, and relaxed further the separation between distribution and generation by raising the threshold further for ownership separation between distribution and generation. This study will review the New Zealand reform experience, examine the market structures resulting from ownership unbundling, and evaluate the impacts of ownership unbundling on the performance of the electricity sector. It will also explore the rationale underlying recent reforms that allow re-integration, and to gauge the impact of the recent reforms.

* The assistance of Sarah Spring is gratefully acknowledged.

1. Introduction

All around the world, there has been market reform in the electricity sector. Common practices include the unbundling of previously vertically integrated monopolies, the introduction of wholesale and retail competition, the privatisation of former state-owned utilities, the regulation of the natural monopolies of transmission and distribution networks, and freedom of choice for electricity consumers.

The objectives of the reforms in the electricity sector have been to introduce competition to operations, such as electricity generation and electricity retailing; to regulate only the natural monopoly components, transmission and distribution, of the electricity network; to improve the efficiency of electricity utilities; to ensure the security and sustainability of electricity supply; and to encourage investment and innovation.

There are various forms (and degrees) of unbundling a previously vertically integrated electricity network. The four most common forms of unbundling are management unbundling, accounting unbundling, legal unbundling, and ownership unbundling. Among them, ownership separation is the strictest form of separation, while management the lightest form of separation.

New Zealand is the only country in the developed world that has implemented forced ownership unbundling of electricity distribution and transmission from the rest of the electricity network. The Electricity Industry Reform Act 1998 (EIRA) legislated unbundling, and there were several amendments to relax the strict ownership separation between distribution and generation. The enactment of the Electricity Industry Act 2010 (EIA) further reduced the extent of ownership separation between distribution and retail and generation by allowing distribution back into retailing and raising the threshold for ownership separation between distribution and generation.

This study will review the New Zealand reform experience and the impact unbundling had on our vertically integrated electricity network and the subsequent reforms allowing re-integration, to provide some learning experience for East Asia Summit countries.

This paper is organised as follows. Section 2 reviews the literature on vertical integration in electricity markets. Section 3 provides a snapshot of developments in the New Zealand electricity market since the 1990s. The main discussion is on the evolution of regulatory change in New Zealand. Section 4 describes the current electricity market in New Zealand while section 5 discusses the reforms since 2010 and section 6 provides our conclusion.

2. Vertical Integration

2.1. Literature Review

Perry (1989) defines "vertical integration" in two ways:

"*The entire output of the upstream process is employed as part or all of the quantity of one intermediate input into the "downstream" process, or Intermediate input into the "upstream" process*."[2]

Electricity sectors all around the world evolved into vertically integrated monopolies, which were either state-owned or privately owned subject to state regulation. Under this vertically integrated monopoly, the four components of electricity supply --- generation, transmission, distribution, and retail supply --- were integrated within a single electricity utility. Vertical integration can better harmonise these sometimes conflicting activities, facilitate efficient investment in the electricity network, and better adapt to changing supply and demand conditions over time (Joskow, 2006a; Williamson, 1985).

While the transmission and distribution activities are naturally monopolistic, generation and retail are potentially competitive. Electricity businesses with vertically integrated monopolistic transmission and distribution activities with potentially competitive generation and retail activities tend to have incentives to restrict the access of transmission and distribution facilities by non-vertically integrated generators and retailers, and lead to the foreclosure of the competitive activities and monopolisation in electricity generation and retail.

[2] Page 183, (Perry, 1989).

Unbundling can reduce the disadvantages that would otherwise exist for firms without ownership of transmission and distribution facilities. There are various forms (and degrees) of unbundling a previously vertically integrated electricity network. The four most common forms of unbundling are management unbundling, accounting unbundling, legal unbundling, and ownership unbundling. Among them, ownership separation is the strictest form of separation, while management the lightest form of separation.

Broadly speaking, ownership separation can stimulate innovation and efficiency in distribution and retail sectors, eliminate cross subsidisation, and limit the need for certain regulations that are difficult, costly and only partially effective, such as access regulation. On the other hand, ownership separation may: result in the loss of economies of scope from integration; increase the transaction costs between activities at different levels of operation; and reduce the adequacy of investment. It may also lead to some unexpected outcomes. Furthermore, implementing ownership separation involves significant cost and is difficult to reverse. Therefore, for policy makers considering ownership separation, the benefits and costs of ownership separation need to be balanced.

One unintended output of the electricity market restructuring is the re-integration of generation and retailing activities after the initial unbundling. This seems to make commercial sense as the supply risks inherent in the generation activities, and the consequent volatility in the wholesale price faced by both generators and retailers can be insured against by integrating generation and retailing. Standalone generation and retail businesses, especially smaller ones, are the most susceptible to volatile wholesale prices. It would be difficult to maintain profits without integration with each other. Thus, vertical integration allows both the retailer and the generator to manage risk in terms of commercial interest, and helps to avoid the double marginalisation problem as well. Of course, the cost of vertical integration between generation and retailing is also associated with costs, such as restricting the entry of new generators or retailers.

2.2. International Practice in Vertical Integration

Over the past two decades, countries around the world have been trying to liberalise their vertically integrated electricity sector and to introduce competition where possible.

Reforms typically started from either of the following two market structures:

- **Single fully vertically integrated monopoly**

A country's electricity supply comes from one state-owned vertically integrated electricity utility, operating in generation, transmission, distribution and retailing. This was the typical structure in most countries before their electricity market reform. For example, Electricite de France (EdF), a publicly owned monopoly in France; state-owned Enel in Italy, etc., operated at all stages from generation to transmission, distribution, and sales before market restructuring. EdF in France is still a vertically integrated public monopoly, even after the introduction of a series of reforms including the establishment of a wholesale market, allowing competition in retail, and the introduction of sector specific regulation.

- **Multiple vertically integrated regional monopolies**

There are two forms of regional vertically integrated regional monopolies. The first is that each region is supplied by one fully integrated firm. Each region is connected to one another. For example, operating at all stages of supplying electricity, there were nine vertically integrated private regional companies in Germany prior to the reform, and ten vertically integrated investor owned companies in Japan, each serving an exclusive area. Australia had the same structure; each state was served by a vertically integrated state owned electricity utility enterprise.

The other form involves some degree of vertical separation along the supply chain of electricity. For example, in England and Wales before restructuring, generation and transmission services were provided by a vertically integrated state-owned Central Electricity Generating Board (CEGB), while distribution and retail services were provided by 12 area electricity boards (AEBs). New Zealand had a similar structure before reform. Electricity Corporation New Zealand (ECNZ), and its predecessor Ministry of Energy, was responsible for generation and transmission, while 61 local electricity supply authorities (ESAs) were responsible for distribution and retail for exclusive areas. This structure has also been adopted as an intermediate structure at the initial stage of an electricity market restructure, for example, in Turkey and Romania.

The main purposes of these reforms are: to introduce competition to a component of the industry where competition is possible; increase the sustainability of the market; and to secure electricity supply. The most common reforms include: the break-up of monopolies; privatising state-owned utilities; introducing a wholesale market; increasing the transparency of industry information; encouraging consumer switching; and regulatory incentives for transmission and distribution investment.

Because of the differences in starting points, restructuring strategy and restructuring progress, a number of electricity models coexist even for countries with highly developed reforms, and they are different from one another in terms of the degree of vertical integration and degree of openness to competition. On one hand, for example, in France, a vertically integrated public monopoly is still operating at all stages from generation to transmission, distribution, and retail. While in New Zealand, the previously vertically integrated state monopoly was completely unbundled with strict ownership separation between energy businesses (generation and retail) and line businesses (distribution and transmission). Several European Union countries, such as the United Kingdom, have adopted a similar form of market structure too.

However, up to until now, New Zealand has been the only country around the world that has had strict ownership separation between the energy businesses (generation, retailing) and line businesses (distribution and transmission). The Netherlands had ownership separation from January 1, 2011. Many European countries have other types of separation, such as management separation, legal separation and operational separation (see Table 1 for a summary of the different types of separation).

2.3. Empirical Evidence

A number of empirical research studies have investigated the impact of vertical integration, unbundling and market reform in general on the performance of the electricity market. The findings of these studies suggest that vertical integration is indeed associated with economy of scope; however, allowing competition in retail and wholesale markets tends to improve firm efficiency and service quality and lead to higher productivity and consequently lower prices. The net impacts tend to be positive but moderate.

Table 1: Different Types of Unbundling across European Countries

Country	**Type of Unbundling**	**No. of distribution businesses**	**Distribution businesses with less than 100,000 connections**
Austria	Legal	138	n.a.
Belgium	Legal	30	20
Denmark	Legal	120	112
Finland	Operation	94	88
France	Management	166	160
Germany	Legal	950	900
Greece	Legal	1	0
Ireland	Management	1	0
Italy	Legal	170	n.a.
Luxembourg	Management	10	9
Netherlands	Legal	20	0
Portugal	Operation	11	10
Spain	Legal	308	300
Sweden	Legal	184	179
UK	Legal	18	3

Source: Skytte & Ropenus, 2005

Economies of Scope

Empirical evidence has generally found economies of scope for vertically integrated electricity utilities. Several empirical studies have considered the economies of scope that can exist for a vertically integrated electricity generation and ‘distribution’ business. The studies undertaken by Kaserman & Mayo (1991), Kwoka (2002), Piacenza & Vannoni (2004), Nemoto & Goto (2004), Meyer (2012), and Fetz & Filippini (2010) examined whether there were cost savings for an integrated generation and transmission and distribution (line) business versus a line business with no generation assets. All of them identified that there were cost savings for an integrated firm compared with a line business with no generation assets. These cost savings could arise from reduced transaction costs and better coordination.

However, these studies do not take into account the benefits associated with market liberalisation and increased competition. Douglas (2006) found cost savings at coal fired power plants in the eastern United States of 2-3% following the opening of transmission systems to wholesale power market competition in 1996 in regions with independent system operators. Steiner (2001) using data from 19 OECD countries has also found that the separation of generation and transmission is associated with higher capacity utilisation rates, although not associated with lower prices.

Price

In looking at the impact of unbundling on retail price, Bushnell, *et al*. (2008) found that had PJM[3] and New England markets been forced to fully unbundle (as happened in California), retail prices in those areas would have been significantly higher due to production inefficiencies. Hogan & Meade (2007) also found that generators tend to overstate their wholesale prices when there is unbundling, resulting in higher retail prices.

On the other hand, Florio, *et al.* (2008) examining the impact of reform on household electricity prices in 15 EU countries over the period 1978 and 2005, found that less vertical integration is associated with lower prices. Joskow (2006b) used time series econometrics to find that competitive wholesale and retail markets reduced prices (relative to their absence) by 5-10% for residential customers and 5% for industrial customers.

Quality

Nagayama (2010) analyses original panel data from 86 countries between 1985 and 2006 to identify the effects of different policy devices of power sector reforms on service quality performance indicators (installed capacity per capita, transmission and distribution loss). The research findings suggest that reform variables such as the entry of independent power producers (IPPs), unbundling of generation and transmission, establishment of regulatory agencies, and the introduction of a wholesale spot market are the driving forces of increasing generation capacity, as

[3] Pennsylvania, New Jersey, and Maryland in USA.

well as reducing transmission and distribution loss in the respective regions. Yu & Pollitt (2009) discuss the impact of electricity liberalisation on service quality by looking at the incidence of newspaper reported blackouts in Europe. They find that for the period 1998-2007, there is no evidence of a statistically significant increase in the number of newspaper reported blackouts correlated with the degree of liberalisation.

Market Power

Joskow & Tirole (2000) analyse the relationship between transmission rights ownership and market power and show that the ownership of physical transmission rights (such would be the case under vertical integration) increases the ability of generators to exercise market power through withholding transmission capacity. Davies and Price (2007), examining the impact of ownership unbundling in the United Kingdom energy market, found that the market share of vertically integrated utilities, in any one year, tend to be 8% higher than their non-integrated counterparts all else being equal. This indicates to some extent that vertically integrated utilities have advantages over non-integrated utilities.

Mansur (2007) in analysing firm behaviours within the PJM electricity market found two large net wholesalers increased anti-competitive behaviour through wealth transfer. However, he also found that vertical integration mitigates market power and limits distributional impacts.

Overall Performance

Pollitt (2009a) reviewed the electricity market reform in the European Union (EU) from the perspectives of sector performance and firm level performance. He concluded that the liberalisation has seen some notable market impacts, including increased EU cross-border trade, improvement in regulation, impressive labour productivity gains, and some price falls. However, the market reform is still incomplete, and the European Commission has significant competition concerns, including rising prices and the exercise of market power by incumbents. Furthermore, the social return to the reform is difficult to call but could be moderately positive.

In reviewing the electricity market reform in the United States, Joskow (2006a) concluded that there has been significant progress on the wholesale competition front but major challenges must still be confronted. The framework for supporting retail competition has been less successful, especially for small customers. Empirical evidence suggests that well-designed competitive market reforms have led to performance improvements in a number of dimensions and benefited customers through lower retail prices.

Several papers have looked at the impact of electricity market reform in developing countries. For example, Galal, *et al*. (1994) on Chile, Toba (2007) on the Philippines, Mota (2003) on Brazil, Anaya (2010) on Peru, Gao and Van Biesebroeck (2011) on China. These studies have all found moderately positive impacts.

3. New Zealand Electricity Market Reform before 2010

Starting from a classical publicly owned monopoly that undertook generation, transmission, distribution, and retailing activities in New Zealand, the electricity sector has been increasingly pushed to become more liberalised since the mid-1980s (Bertram, 2006). The restructuring started from the corporatisation, and privatisation in some cases, of state trading departments, the removal of statutory monopoly rights, and vertically unbundling transmission and distribution from the more contestable generation and retail components of the industry.

In April 1987, as part of wider economic liberalisation policies, the New Zealand government corporatized the New Zealand Electricity Department, which was a government department that controlled and operated almost all New Zealand electricity generation and operated the electricity transmission grid, and formed the state-owned New Zealand Electricity Corporation (ECNZ). Table 2 below gives a time line of the ECNZ from its establishment to its split.

Table 2: Split of ECNZ

Year	Changes
Apr-87	ECNZ was set up as a company under the State-Owned Enterprises (SOE) Act 1986
May-93	Transmission activity moves from ECNZ to “Transpower”. Transpower was set up to run transmission in New Zealand.
Feb-96	Contact Energy commenced by acquiring some of ECNZ’s generators
Jul-98	Electricity Industry Reform Act 1998 split ECNZ further into three state-owned generators: Genesis Power Ltd, Meridian Energy Ltd and Mighty River Power Ltd

Source: Author’s own based on information in the text.

Prior to 1993, wholesale and transmission activities were controlled by ECNZ, while retail and distribution were controlled by 61 publicly owned holders of exclusive franchises. In 1992, the Electricity Act 1992 removed statutory exclusive retailing franchise areas. In May 1993, the government decided to separate transmission from ECNZ and set up a stand-alone transmission company, Transpower, to undertake transmission activities in New Zealand. In order to improve market competition in electricity generation in 1995, Contact Energy was set up as a state-owned enterprise, and started operation by acquiring generation assets from ECNZ since February 1996. Later on, in 1999, Contact Energy was sold by a public offering of shares.

During this period, the industry was subject to regulation under the Commerce Act 1986, together with the so-called “lighted-handed regulation” implemented since 1992, including the compulsory information disclosure and the threat of regulation. However, it soon became clear that greater transparency alone was not a sufficient check on monopoly power. The government became concerned that local electricity companies, vertically integrated at distribution and retail levels, had the incentives and the ability to use their market power in distribution to restrict competition in retail. The government was also concerned that the gains from lower wholesale prices would be captured by distributors rather than passed through to consumers.

To mitigate those concerns, the Electricity Industry Reform Act 1998 (EIRA) was enacted with the objectives of improving efficiency and consumer welfare through increased competition in generation and retail markets and preventing cross subsidisation of generation and retailing from lines businesses. EIRA prohibited common ownership of electricity distribution and either electricity retailing or electricity generation businesses (other than minor cross-ownerships). Under EIRA, ECNZ was split into three competing state-owned generators (Genesis Power, Meridian Energy and Mighty River Power), and the vertically integrated distribution and retail businesses were required to achieve full ownership separation no later than 31 December 2003. However, not long after the implementation of EIRA, rules around ownership separation were relaxed and distribution businesses were allowed to own small distributors of renewable generation. Table 3 shows the changes in the generation market.

Table 3: Generation Market Structure Changes

	Mar-98		Jun-99
	Capacity Share		Capacity Share
Contact Energy	26%	Contact Energy	25.10%
ECNZ	63%	Mighty River (SOE)	14.30%
		Meridian (SOE)	30.00%
		Genesis (SOE)	19.20%
Other Generators	4%	Other Generators	5.80%

Source: Ministry of Economic Development, 1998; 1999.

The benefits expected from ownership separation were as follows:

- It could help to better expose the monopoly lines businesses to closer scrutiny by users and other market participants."
- The lines businesses would become stand-alone entities, with their operations becoming more open to the consumer - in the same way that Transpower has become more transparent since it was separated from ECNZ in 1994.
- It would encourage the amalgamation of retail businesses, which would achieve greater efficiencies and offer stronger competitive choices to consumers.
- It would encourage the amalgamation of lines businesses to achieve lower costs and provide better services to users.

However, some cost consideration of the distribution and supply ownership separation should be taken into account as well, such as one-off transaction costs, loss of economies of scale and the risk of less investment in generation.

The reform promoted a wave of mergers between generators and retailers. This kind of vertical integration is known as a “gentailer” in New Zealand. Between 1998 and 1999, the majority of integrated electricity businesses[4] retained their distribution business and sold their retail business, while generators saw the business opportunities and expanded into the retailing business. A list of approximate activities are presented in Table 4.

Table 4: 36 Integrated Electricity Businesses’ Separation Activities during July 1998 to April 1999

	Electricity Retail	Distribution	Generation
Trust power	✓	✗	
Trans Alta	✓	✗	
Central Electric	✓	✗	
Wairoa Power		✗	✗
King Country Energy	✓		
Waitomo Energy Services		✓	
Another 30 integrated business	✗	✓	✗

Notes: (1) “✓” means integrated business retained this part of business
(2) “✗” means integrated business divested this part of business
(3) King Country and Waitomo Energy Services swapped their assets

After the separation of contestable retail and generation businesses from natural monopolistic transmission and distribution businesses, the remaining issue was how to regulate prices charged by transmission and distribution businesses. Following a Ministerial inquiry into the electricity industry, the Commerce Act 1986 was amended in August 2001 to provide a targeted control regime for electricity lines businesses.

Under the regime, businesses were only subject to control if they crossed either of the two thresholds of performance. The two thresholds are a specified CPI-X price path and a specified reliability and consumer engagement criteria. The X factor was set differently for different businesses based on a benchmarking analysis of relative business productivity and profitability.

[4] Integrated electricity: electricity distribution business also has either generation business or retail business or both.

The aim of this amendment was to improve the performance of the electricity distribution networks; improve the effectiveness of competition; and provide for more efficient regulation. This regime applied to lines businesses until 2008 when it was replaced by the current more heavy-handed Default/customised price path regulation in 2008, which is based on a bottom up building block analysis.

4. Current Electricity Market in New Zealand

As the result of the restructuring in the late 1990s, the current New Zealand electricity market is split into the following areas: administration and market clearing, regulation, generation, transmission, distribution and retailing.

4.1. Electricity Generation

Electricity in New Zealand is largely generated from hydro, gas, coal, and geothermal resources, of which hydro accounts for more than 50% of the electricity generated. Electricity is produced at generation stations and supplied at high voltage to the national grid at grid injection points (GIPs). There are around 40 major electricity generation stations connected to the grid.

In New Zealand, there are currently five major generation companies: Contact Energy, Genesis, Meridian, Mighty River Power and Trust Power. These five companies generate over 93% of New Zealand's electricity; the biggest three supplied 74% of New Zealand's electricity. There are also some smaller generators - mostly 'cogeneration' associated with major industrial processes, accounting for 7% of New Zealand's electricity. Four of the five major generators were the "babies" of ECNZ, products of the split of ECNZ by the government in the late 1990s.

The split of ECNZ into competing electricity suppliers increased competition in the electricity generation sector. As an indicator of market concentration, the HHI index in the generation sector has decreased from more than 8,528 in 1996 before Contact Energy was split from ECNZ to less than 2,200 now.

However, in the 15 years since 1996 there have been no major new generation entrants into the generation market apart from the ECNZ "babies", which itself is an indicator of the existence of high entry barriers in generation. Consequently, the five major generators may have significant market power. In fact, since early 2000, there have been constant complaints of generators abusing their market power or engaging in anti-competitive activities, which has led to the investigation of wholesale electricity market by the New Zealand Commerce Commission, New Zealand's competition and regulation authority.

4.2. The Wholesale Market

The New Zealand electricity wholesale market is a place where the electricity supplied by generators meets the demand from retailers. Formed in 1996, it was initially a voluntary market, and the market rules were developed by the market participants rather than by a regulatory body or government. Since 2003, the government began to formally update the market rules and the market switched from being a voluntary market to a mandatory one.

All electricity generated is traded through the central pool, with the exception of small generating stations of less than 10MW. Bilateral and other hedge arrangements are possible, but function as separate financial contracts.

Electricity is traded at a wholesale level in a spot market. Service providers manage the market's operation under agreements with the Electricity Authority. Transpower, in its role as System Operator, manages the physical operation of the market.

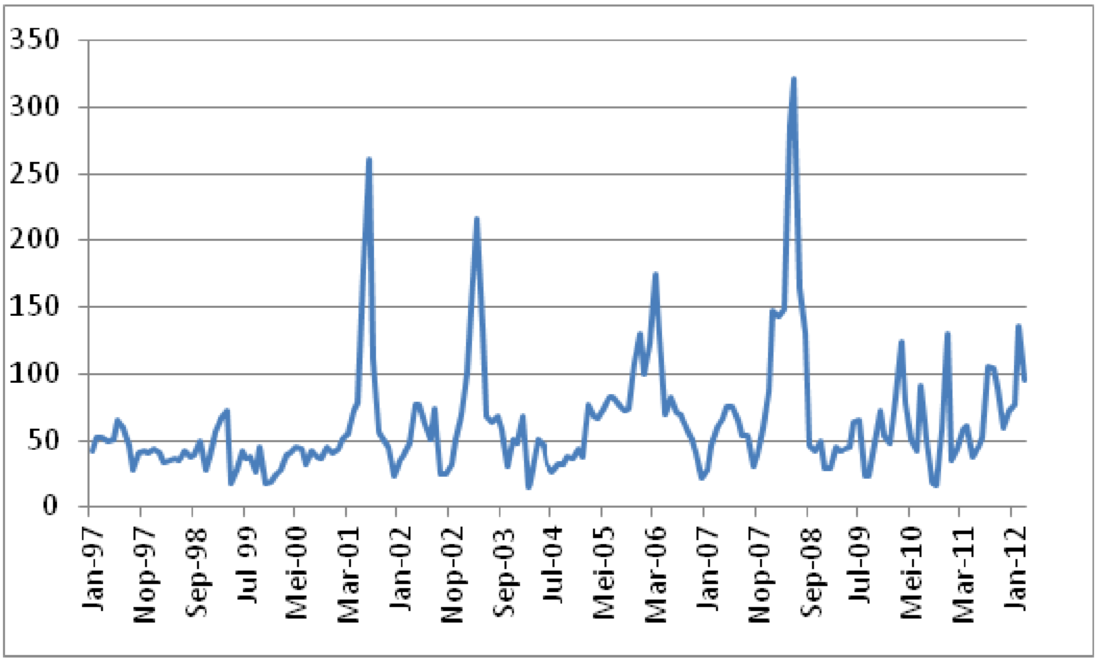
The wholesale market operates every day on a continuous basis in 30-minute trading periods; there are 48 trading periods per day. Generators submit generation offers to the system operator, indicating for each period how much electricity the generator is willing to supply, and at what price. Likewise, electricity purchasers must submit bids to the system operator, indicating the amount of electricity they intend to purchase.

Once all offers and bids have been received and finalised for a particular trading period, the system operator issues actual dispatch instructions to each generator on how much electricity it is required to generate and/or other required actions.

For each trading period, the pricing manager determines the single price to be paid to the generators for all electricity supplied. This price is determined by the price of the marginal generator required to meet demand for a given trading period.

Electricity spot prices can vary significantly across trading periods, reflecting factors such as changing demand (e.g. lower prices in summer when demand is subdued) and supply (e.g. higher prices when hydro lakes and inflows are below average). In July 2001, April 2003, and June 2008, the consumption weighted average wholesale price went over NZD 200/MWH, more than four times as that in normal times. Figure 1 below shows the monthly consumption weighted average wholesale price.

Figure 1: Consumption Weighted Average Wholesale Price ($/MWH), Jan 1997-Mar 2012



Source: Electricity Authority, 2012a.

Spot prices can also vary significantly across locations, reflecting electricity losses and constraints on the transmission system (e.g. higher prices in locations further from generating stations).

It is worth noting that pricing in the wholesale market is essentially short term marginal pricing, which may not provide sufficient incentives for the security of energy supply. In fact, the extreme level of wholesale prices in June 2008 indeed sparked concern about energy security.

4.3. Transmission

The electricity transmission system connects generators to the local distribution networks, who transmit high voltage electricity from GIPs at generation stations to GXPs (Grid Exit Points). At GXPs, transformer substations reduce the electricity voltage for distribution through local distribution networks to end-users.

The New Zealand transmission network consists of two subsystems, one in the North Island and one in the South Island. The two subsystems are connected by a High Voltage Direct Current link. This makes possible the export of electricity from the South Island, where 60% of the electricity is generated, to the North Island, where the demands for electricity are predominantly located.

Transpower, a State-Owned Enterprise (SOE), owns, operates and maintains the transmission network. As owner it provides the infrastructure of electric power transmission that allows consumers to have access to generation from a wide range of sources, and enables competition in the wholesale electricity market. As System Operator, under contract with Electricity Authority, it manages the real-time operation of the network and the physical operation of the New Zealand Electricity Market.

Like the electricity distribution network, transmission is also subject to regulation under the Commerce Act 1986. This moved from the price and quality threshold regime under Part 4A of the Commerce Act 1986 before 2008, to the current Default/Customised price – quality path regime.

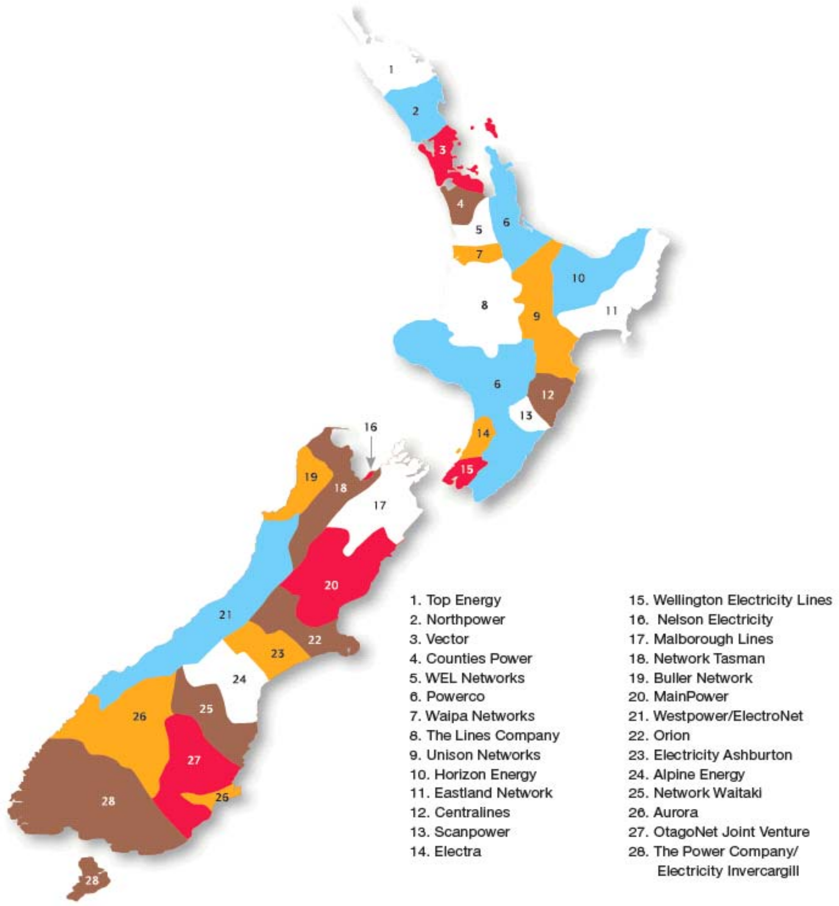
4.4. Distribution

There are 28 “large electricity lines businesses” in New Zealand. They range in size from around 5,000 electrical connections to nearly 500,000 connections. Other entities also provide electricity distribution services as part of their normal activities. Included among these are airports, ports, and large shopping mall operators.

Figure 2 shows a map of the 28 Electricity Distribution Businesses (EDBs). While most EDBS are located only in one region, PowerCo’s distribution businesses are located in two regions (see number 6 in the map). Between 2003 and 2008, Vector’s distribution businesses also operated in two regions, Auckland (number 3) and Wellington (number 15). In 2008, Vector sold its distribution business in

Wellington, which they acquired from United Networks in 2003, to Hong Kong-based Cheung Kong Infrastructure (CKI), which formed Wellington Electricity.

Figure 2: Map of Electricity Distribution Businesses in New Zealand



Source: Electricity Networks Association, 2012.

4.4.1. Structure

These EDBS were created in 1998 following the corporatisation of the 61 local electricity supply authorities (ESAs) under the Energy Company Act 1992, the consolidation by merger and acquisition thereafter, and the forced ownership separation of retailing businesses from the operation of distribution networks under the Electricity Industry Reform Act 1998. The Electricity Industry Act 2010 revoked the forced ownership separation to some extent.

The ownership of distribution companies is a mix of publicly listed companies, shareholder trusts, community trusts and local body ownership. Each company tends to have defined geographic areas of activity. Through acquisitions of other distribution companies, several now operate in a number of discrete areas. Distribution companies do not have exclusive legal territorial franchises.

The normal Commerce Act provisions apply to the mergers of distribution companies. The test is whether the merger will lead to a "significant lessening of competition". It is hard to argue that the merger of two geographically distinct monopoly distribution companies would lessen competition, as there is none; therefore, there is little if any constraint on mergers in the sector. As there are economies of scale in the provision of distribution services, the non-commercial nature of much of the ownership probably explains why there have not been more mergers.

4.4.2. Regulation

EDBs are subject to regulation under the Commerce Act 1986, which has gone from:

- the light-handed regulation (mandatory information disclosure combined with the threat of price control since 1992), to
- CPI-X style price and quality threshold regime under the Part 4A of the Commerce Act 1986 since 2001, which is in fact a screening mechanism to identify EDBs whose performance may warrant further examination through a post-breach inquiry and, if required, control by the Commerce Commission, to
- the current more heavy-handed Default Price-quality Path (DPP) and Customised Price-quality Path (CPP) under Part 4 of the Commerce Act 1986. EDBs that meet the 'consumer owned' criteria set out in the Commerce Act 1986 are exempted from this type of regulation.

4.4.3. Performance

There are a few studies examining the performance of EDBs' and the impacts of regulation on EDB's performance in New Zealand. However, the results are not conclusive.

Bertram and Twaddle (2005) analysed the trends in the price-cost margins of the EDBs between 1991 and 2002. They found that price-cost margins had increased during the period of "light-handed regulation". As a result, the allowed profit under light-handed regulation had exceeded that allowed under rate-of-return regulation by

$200 million. They concluded that New Zealand's experiment with light-handed regulation was not successful.

However, Bertram and Twaddle's (2005) estimation of allowed revenue under rate-of-return regulation would have been much higher without the light-handed regulation. Because they implicitly assumed the costs under rate of return regulation were the same as the costs under light-handed regulation. In fact, the costs under light-handed regulation would be lower due to its stronger cost reduction incentives. Therefore, at best, the conclusion from this paper is that light-handed regulation was not so effective as to allow consumers to share the benefits of efficiency gains.

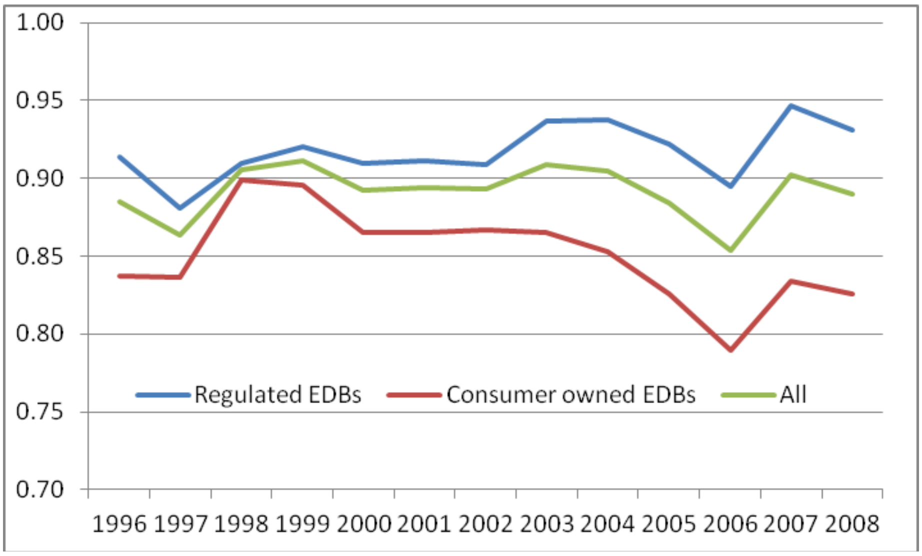
Nillesen and Pollitt (2008), studying the effect of ownership unbundling in electricity distribution in New Zealand, suggested that there was a sharp reduction in unit operational costs between 1998 and 2001, but that these seemed to be increasing since 2003. Economic Insights (2009) has also found that Total Factor Productivity (TFP) in EDBs had increased from 1996 to 2003, but had fallen in each of the years after 2003, which coincided with the implementation of the threshold regime.

We have examined directly the efficiency of EDBs by a benchmarking exercise using Data Envelopment Analysis (DEA) method. The data we used for this exercise covered the period between 1996 and 2008. In this study, we use electricity throughput, customers and the network length as outputs, and OPEX and fixed assets valued using Optimised Deprival Valuation (ODV) methodology as inputs. However, we do not have service quality information.

We estimated the technical efficiency scores of individual EDBs for the period 1996 and 2008. The results are in Figure 3.

This suggests that over time the EDBs' average efficiency remained constant. However, there is a divergence of efficiency between EDBs that are regulated under the current Commerce Act, regulated EDBs, and the EDBs that are mainly consumer owned and are exempted from regulation. While the regulated EDBs have improved their efficiency, consumer-owned EDBs have lagged behind. This may suggest that ownership changes have played a part too.

Figure 3: Efficiency Scores (Constant Return to Scale), 1996-2008



Source: New Zealand Commerce Commission, 2012a.

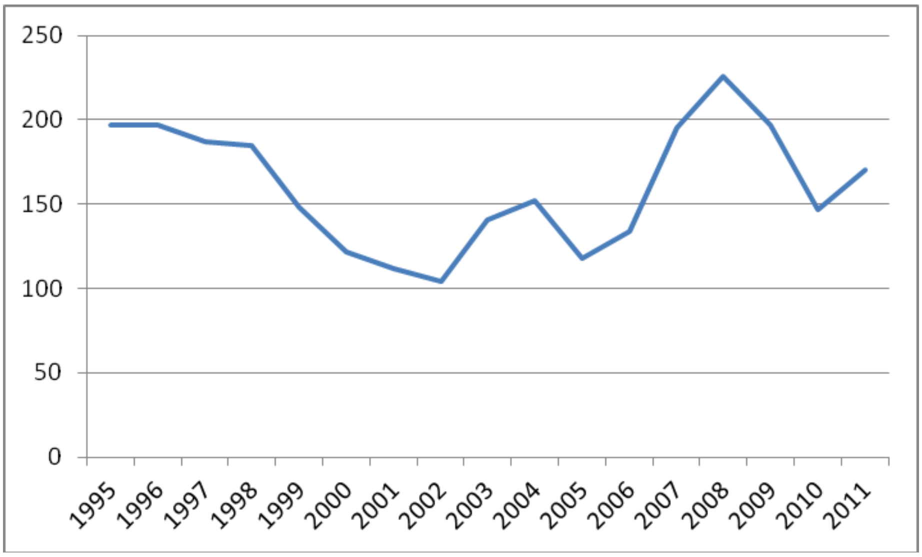
Improving and maintaining the quality of electricity distribution services is another objective of regulation. The most common quality measures for electricity networks are outages. There are three outage indicators, which are monitored under regulation: SAIDI (System Average Interruption Duration Index – minutes per connected customer), SAIFI (System Average Interruption Frequency Index – interruptions per connected customer), and CAIDI (Customer Average Interruption Duration Index – minutes per customer interrupted). Figure 4 to Figure 6 show the development of SAIDI, SAIFI, and CAIDI over the period between 1995 and 2011.

Following the unbundling, both SAIDI and SAIFI experienced sharp decreases up until to 2002. However, since 2003, SAIDI has demonstrated sharp increases especially in 2007 and 2008. At the same time, SAIFI has been increasing gradually. While remaining stable before and after the unbundling, CAIDI increased sharply in 2007 and 2008. Although it has decreased since 2009, it has not decreased to the level it was before 2007.

4.5. Electricity retail market

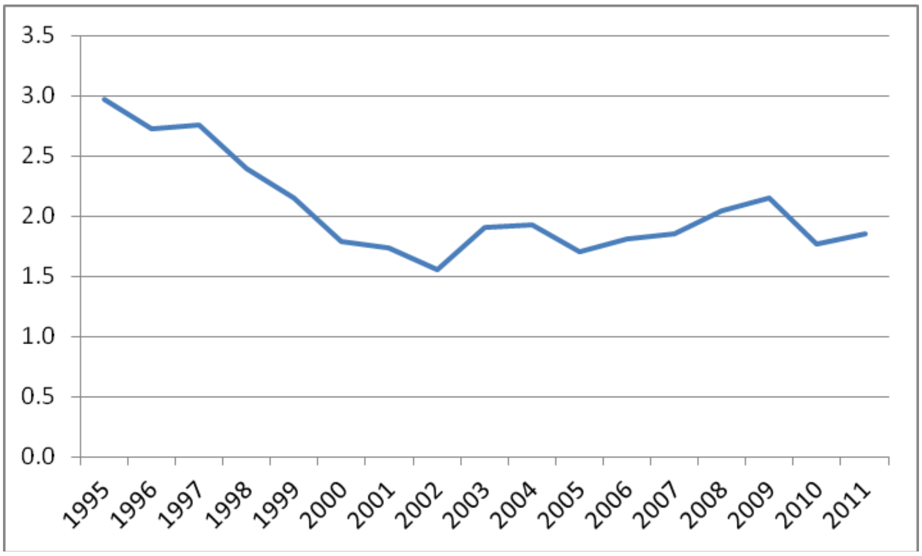
Electricity retailing involves the supply of electricity to residential and small commercial and industrial customers. Electricity is purchased from the wholesale market. The electricity purchased may come from its own generation arm of a vertically integrated gentailer or another generator that has supplied into the wholesale market. Retailers pay distribution companies for distribution and transmission services.

Figure 4: kWh-transmitted Weighted Average SAIDI, 1995-2011



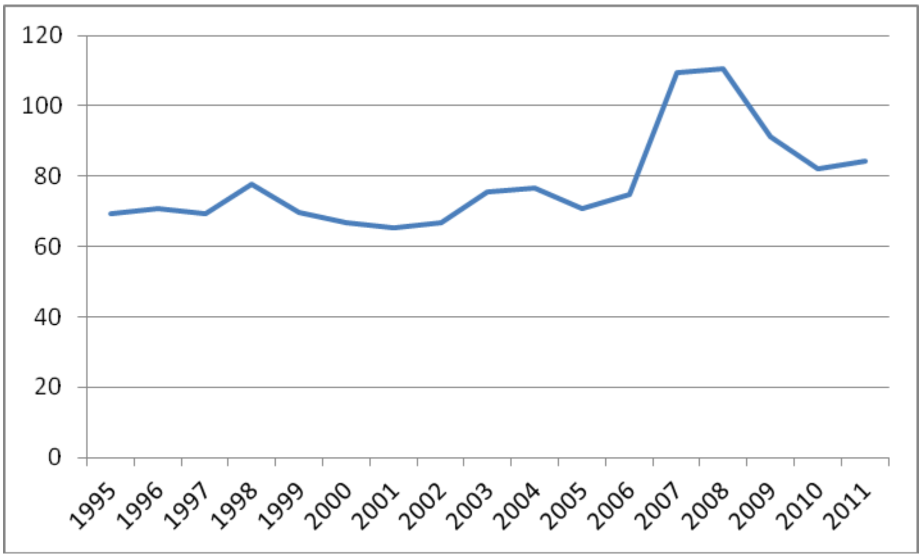
Source: New Zealand Commerce Commission, 2012b.

Figure 5: kWh-transmitted Weighted Average SAIFI, 1995-2011



Source: New Zealand Commerce Commission, 2012b.

Figure 6: kWh-transmitted Weighted Average CAIDI, 1995-2011



Source: New Zealand Commerce Commission, 2012b.

4.5.1. Retail Market Structure

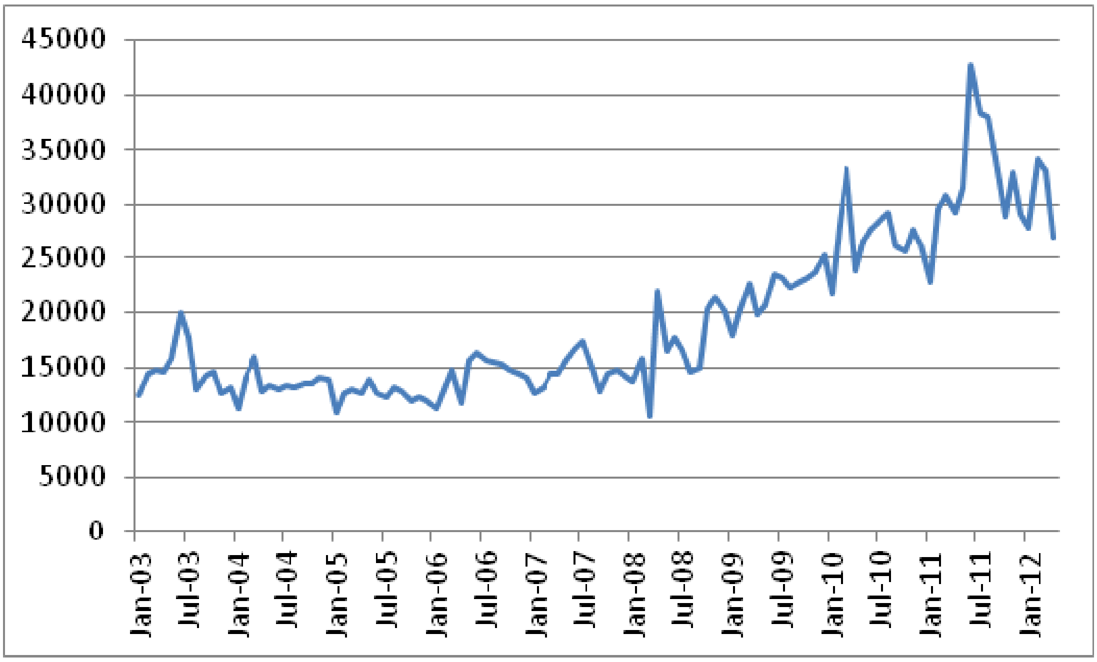
Currently, there are five major retailers. All of them are vertically integrated gentailers, and they are all major generators too. These five companies account for 96% of the electricity purchased from the wholesale market, while the remaining 4% is purchased by a number of small retailers.

Under the forced ownership separation between distribution and other electricity businesses in 1998, most of the distributors chose to retain their distribution businesses and divest their retail businesses. The five major generators, realising the benefits of having retail businesses, quickly snapped up these retail businesses, together with their customer bases, and formed the vertically integrated gentailers.

As a result of this wave of divestment and acquisition, the number of retailers decreased from 36 in 1998 to 11 in 1999/2000. The number of retailers further reduced to 10 and 9 in 2001 and 2003 respectively. At the same time, the HHI index in the retail has increased from around 700 in 1998 to more than 2,200 in 2010. Electricity retailing has been gradually concentrated to big retailers, with the top three firms capturing more than 70% of the retail market.

Thus said, there are indicators showing greater competition between retailers, which leads to better deals for customers, especially since 2008. One such indicator is the number of customers switching. Figure 7 shows the monthly number of consumer switch for the period between January 2003 and April 2012. Before 2008, the number of consumers switching stabilised at around 14,000 per month; since 2008, this number has increased to more than 25,000 per month by April 2012.

Figure 7: Customer Switching, Jan 2003- Apr 2012

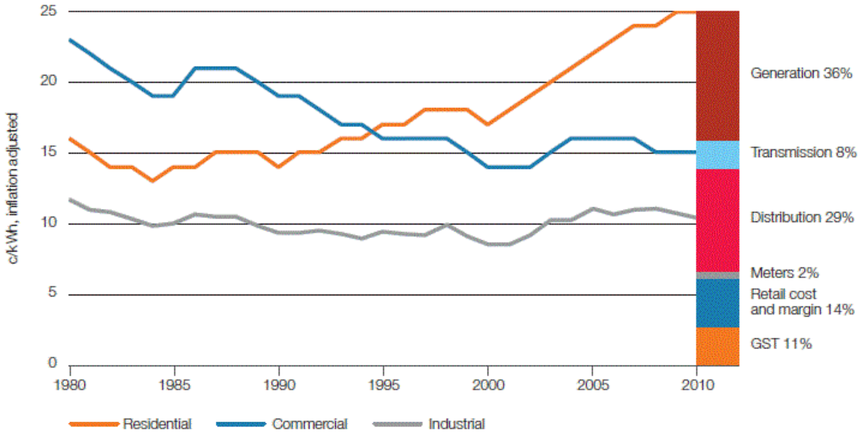


Source: Electricity Authority,2012b.

4.5.2. Electricity Prices

Figure 8 shows the retail electricity prices for the period between 1990 and 2009. For the first 2-3 years after ownership unbundling in 1998, retail prices fell in all three sectors, with the commercial sector experiencing the biggest reduction. However, since the early 2000s, all three sectors have experienced retail price increases, with the biggest price increase in the residential sector. Compared to the residential retail price in 2000, the residential price in 2009 has nearly increased by 50%. After an initial increase between 2001 and 2003, the commercial retail price has been relatively constant.

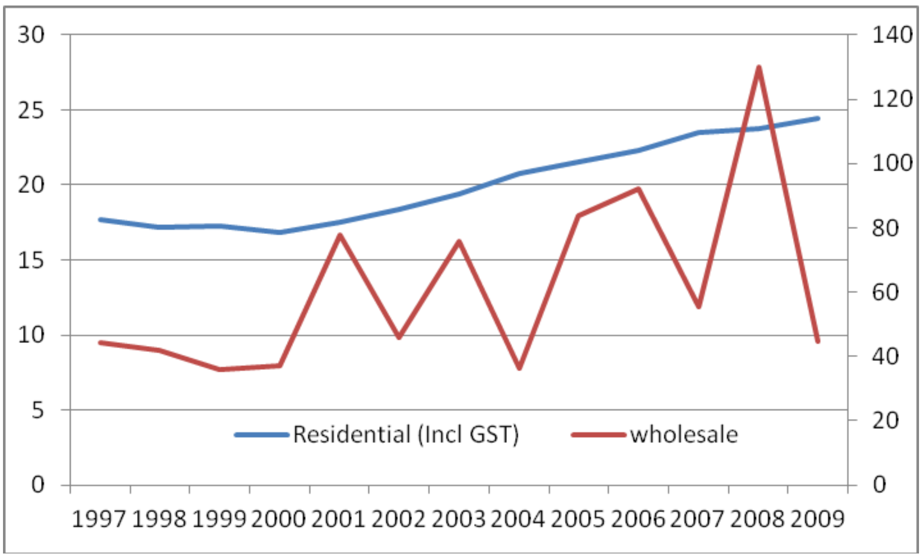
Figure 8: Retail Electricity Prices (Cents/kWh at 2009 price), 1990-2010



Source: New Zealand Ministry of Economic Development, 2012.

However, the increase in retail prices may be due to increases in wholesale prices, which is the most important component of retail prices. See Figure 8 for the composition of the retail price. Figure 9 shows a comparison of retail residential price vs. a consumption weighted average wholesale price. We can see that increases in the wholesale price are almost completely passed through to the retail price.

Figure 9: Retail Residential Price (c/kWH) and Consumption Weighted Average Wholesale Price ($/MWH), 1997-2010



Sources: New Zealand Ministry of Economic Development, 2012; and Electricity Authority, 2012c.

In 2010, New Zealand enacted a new electricity industry act, the Electricity Industry Act 2010 (EIA), in response to the concerns raised and recommendations proposed in a series of electricity industry investigations and inquiries. This has started another round of reform in electricity sector.

4.6. Electricity Market Investigations and Inquiries

Since the mid-2000s, there have been several investigations and inquiries to investigate the different aspects of performance of the electricity market, which eventually lead to the reform in 2010.

4.6.1. Commerce Commission Investigation

In August 2005, the Commerce Commission after receiving an allegation of market power and complaints about high wholesale and retail prices, and noting the low number of competitive activities in the wholesale and retail markets, decided to investigate whether there was collusion or anti-competitive behaviour in the electricity wholesale market that contravened the Commerce Act 1986.

Professor Wolak from the University of Stanford led the investigation and it was completed in 2009. The investigation concluded that the four main generators have substantial market power in the wholesale market, and have exercised this market power to earn market rents estimated conservatively to be $4.3 billion over the period January 2001 to July 2007, which were gradually passed through in higher prices to end customers.

The usual suspect for the cause of high prices, transmission constraints, was found not to be the predominant factor in explaining the high prices. The investigation also suggested that the current wholesale market mechanism may provide insufficient incentives to address the issue of supply adequacy.

4.6.2. Electricity Commission Market Design Review, and Other Reviews

In 2007, The Electricity Commission (EC) initiated the Market Design Review to identify what changes could be made to the electricity market to improve its performance. The Review identified five areas of concern:

- pricing and competition (especially in the retail market)

- energy affordability issues
- the effectiveness of the energy-only spot market design
- demand-side participation
- availability of market information.

In July 2008, the EC released an Options Paper for consultation, which presented possible options for addressing concerns identified in the Issues Paper, and proposed future actions.

In 2008, in response to the high profile outages and extremely high wholesale market prices experienced during the dry season, the EC initiated another review to assess the experience of dry year risk management with respect to the winter of 2008 and to identify options to improve the energy security policy framework. The Review highlighted issues with the security of electricity supply.

In 2009, Business New Zealand, an industry lobby organisation, commissioned LECG to look into regulatory and governance issues. This report also made recommendations on how to improve the regulatory and governance structure of the electricity market.

4.6.3. Ministerial Review of the Electricity Market

While there are issues common to the above-mentioned investigations and reviews, each review had its own focus and made different recommendations about the same issue. In order to have systematic review of the electricity sector, the New Zealand Cabinet decided on 30 March 2009, to conduct a Ministerial Review of the electricity market to examine electricity market design, regulation, and governance issues.

The Review was conducted by the Ministry of Economic Development together with a panel of independent experts (ETAG)[5] appointed by the Minister of Energy and Resources. The Review identified issues and made recommendations on five aspects of the electricity sector:

- wholesale and retail, and competition in the wholesale and retail markets
- security of electricity supply
- costs of electricity supply
- governance and regulation of the electricity sector

[5] Electricity Technical Advisory Group.

- implementation of proposals.

In summary, the ETAG report contained a range of findings about the New Zealand electricity market:

- New Zealand has sufficient generation capacity, but the current market structure does not allow that capacity to be managed efficiently in dry winters
- in particular, some market participants may not manage dry winter risks, because they can shift costs to consumers through public conservation campaigns at no cost to themselves
- the electricity retail market lacks competition, particularly outside the main centres
- the transmission system is still vulnerable due to lack of investment
- electricity governance arrangements are unsatisfactory.

The Review made 29 recommendations to address these issues. In relation to wholesale and retail prices and competition in the wholesale and retail markets, which are of particular interest to the current paper, the Review identified that transmission constraints, the absence of a liquid energy hedge market and the vertical integration of generators and retailers all act as barriers that deter the entry of new retailers, especially independent retailers, to the electricity market.

The Review recommended allowing lines businesses back into retailing, along with some restrictions.

The main argument for allowing distribution back into retailing is that it would encourage more retail competition, especially in smaller and remote areas where there is only weak retail competition. In these areas, lines businesses, which are generally trust-owned, may be 'natural' new entrant retailers because they have existing relationships with customers, familiarity with the energy sector, local presence, and brand recognition. Although many distributors may not be interested in getting back into retailing, the sheer prospect of new entrants may improve the performance of incumbents. This recommendation has further reduced the extent of the strict ownership separation between lines businesses and energy supply businesses enforced under the EIRA 1998.

However, there are some risks associated with allowing distributors back into retailing, including:

- the possibility of a vertical integrated regional monopoly, encompassing generation, distribution, and retailing

- distribution businesses may discriminate against their retail competitors accessing its distribution network
- independent retailers may be reluctant to enter the market as they have to deal with the distribution business, which is also their retail competitor.

The Review proposed allowing distribution back into retailing, subject to:

- retaining the existing provisions, the thresholds for ownership separation, and corporate separation and arm's length rules, specified in the Electricity Industry Reform Act 1998
- prohibiting a retail business, owned by a lines business, from buying the customer base of an existing retailer.

4.7. Electricity Industry Act 2010 and its Potential Impacts

In 2010, as a result the Review's recommendations, the Electricity Industry Act 2010 (EIA) was enacted. The EIA not only allows distribution businesses back into retailing but also increases the thresholds for ownership separation, and for corporate separation and the application of arm's length rules. By increasing the thresholds for ownership and corporate separation, the EIA provides further incentives for distributors to invest in generation to ensure security of supply; this reflects the idea that lines companies may be better placed to invest in generation than other investors.

The EIA came into effect on November 1, 2010. As the EIA has only been in effect for a year and half, it is still too early to examine its impact. We will only discuss the possible market structures under the EIA here. When discussing these, we will keep in mind that the purpose of the EIA is to enhance electricity market competition in far and remote areas, and to resolve energy security problems arising from transmission constraints. The Electricity Industry Act 2010 may potentially lead to diverse and complicated forms of vertical integration, as described below:

Full vertical integration between generators, distributors and retailing with some restrictions

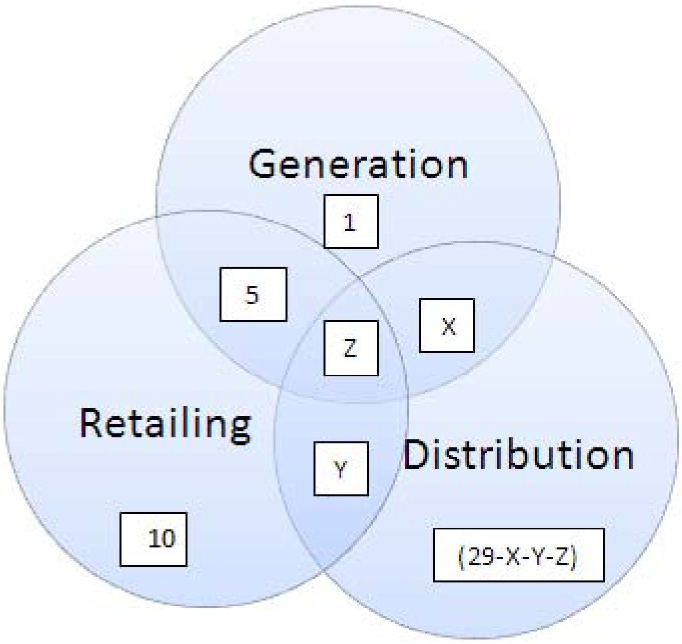
According to the EIA Act 2010, this can only happen when EDBs own a generator with a capacity less than 50 MW and it is not connected to the national grid, and operates a retailer that only sells 74 MW electricity annually. We assume the market is going to have **Z** numbers of such full integration (see Figure 10).

Vertical integration where an electricity corporation is involved in generation and distribution

The generator can be distributor generators and have a capacity less than 50MW. An EDB can also own a generator with a capacity up to 250 MW regardless of whether it connects to the national grid or not. However, under this scenario, it requires corporation separation. We assume the market is going to have **X** numbers of such partial integration (see Figure 10).

Vertical integration can occur where an electricity corporation is involved in retailing and distribution, and/or where a retailer that retails less than 75 GWH annually is connected to the distributor's local network. We assume the market is going to have **Y** numbers of such partial integration (see Figure 10).

Figure 10: Potential Vertical Integration in New Zealand



According to the above analysis and from the perspective of the current regulatory change for EDBs, the potential market structure for New Zealand could possibly turn out to be like that shown in Figure 10. As transmission remains operating as a state-owned monopoly, vertical integration will only happen between generation, distribution and retailing. It is possible to have **X** number of vertically integrated corporations between generation and distribution, **Y** number of vertical integrated corporations between retailing and distribution, and **Z** number of full vertical integration. This stand-alone distribution would be '29-X-Y-Z'.

Considering our discussion above and compared to ETAG's proposal, the capacity restrictions are tougher in the EIA. The Act may create a market structure with some large players along with a number of smaller players. In this way, the large-scale energy suppliers can provide services nationally, and smaller scale energy suppliers can serve the regional markets cost effectively. Both scenarios are in a relationship of competition and compensation. All in all this might lead to a cost-efficient system.

5. Conclusion and Policy Implications for East Asian Countries

In this paper, we have discussed the reform experience in New Zealand's electricity sector and have summarised the objectives, the reform methods, and the outcomes of the two reforms in the Table 5.

The experience of reform in New Zealand suggests:

First, the reform process is long term and on-going. New Zealand started its market reform of the electricity sector in the mid-1980s by corporatising the activities formally administered by a government department, then in 1998 introduced complete ownership unbundling of the formally vertically integrated electricity utilities and established a wholesale market; and for the past 15 years has been fine tuning the structure.

Second, there are both costs and benefits associated with vertical integration and unbundling. Market restructure designs need to balance the costs and benefits associated with it. Empirical studies suggested that the forced ownership unbundling did lead to efficiency and quality improvements, high TFP growth, and reduction in retail prices, immediately after the unbundling. However, the impact of unbundling on competition may have been limited and temporary especially after 2003. Since

2003, retail prices have been rising, TFP has been falling, and service quality has been falling too.

Table 5: Electricity Reforms in New Zealand

	1998 reform (EIRA 1998)	2010 reform (EIA)
Reform objectives	• encourage competition in generation and retail • improve efficiency of the network components (transmission and distribution) • prevent cross-subsidisation of generation and retailing from EDBs	• increase retail competition, especially for remote areas • encourage competition in the wholesale market • improve security of supply • encourage investment in generation
Methods	• ownership separation of distribution from retail and generation • regulation of distribution and transmission businesses • wholesale spot market	• allowing distribution get back into retail • privatising state-owned generators • relaxing the restraints on distributors investing in generation
Market structure and performance	Structure: • 5 vertically integrated gentailers • 28 EDBs and 1 Transmission under regulation Performance: • the impacts of unbundling may be limited, especially after 2003: • lack of competition in retail • high retail price for residential customers • gentailers have exercised their market power • energy security However: • quality improved	• will depend on the investment incentives • may create vertical integration of generation, distribution, and retail • may create regional monopoly in generation and retail, as well as in distribution

Source: Authors' own preparation according to account in the text.

Furthermore, the unbundling does not seem to have facilitated greater competition in electricity generation sector, which has been the subject of several anti-competitive complaints since 2003. In the retail sector, the creation of vertically integrated gentailers probably didn't improve the competition situation in retail. After the initial decrease, the retail price, especially for residential customers, increased sharply. The five dominant gentailers had significant market power, and this led to higher wholesale prices especially in the dry season. Re-bundling may provide a solution to the problems resulting from unbundling. It may increase economies of scope, increase the incentives for investing in distributed generation, reduce transaction costs, encourage retail competition, and provide choices for retail customers. However, there are risks associated with it that need to be taken seriously, such as the possible creation of a regional monopoly, which may deter the entry of new retailers and discourage retail competition, an objective the newly enacted EIA meant to promote.

Third, well intended market reform may lead to unintended outputs. One unintended result from the ownership unbundling is the integration between generation businesses and retail businesses, may have given generation businesses market power in generation that advantaged their retail businesses.

Finally, in response to the concerns of inadequate competition in retail and generation markets and the concerns of security of electricity supply, New Zealand government enacted the Electricity Industry Act 2010. This new act relaxes the restrictions on ownership separation between distribution and retail and generation by allowing distribution back into retailing and raising the threshold for ownership separation between distribution and generation. This new policy provides incentives for the distribution businesses to invest in generation and retail. However, it may also create vertically integrated electricity utilities, encompassing generation, distribution, and retailing. This impact of this reform is still too early to assess.

Currently, electricity market reforms in East Asian countries are at different stage. The experience and the impacts of the ownership unbundling and the recent reversal to allowing bundling may provide useful lessons for East Asian countries. The New Zealand experience indicates the potential benefits of ownership unbundling but also the dangers of unintended consequences. Policy makers should take care in using ownership unbundling to achieve the objectives of market reform in the electricity sector.

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CHAPTER 7

Cambodia's Electricity Sector in the Context of Regional Electricity Market Integration

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Cambodia's integration into the regional electricity market is a policy priority. With a constrained supply-side, the increasing demand posts a critical challenge for electricity sector development. Against this backdrop, this paper provides an overview of the current situation of Cambodia's electricity sector and explores other critical issues in the sector. Diesel and heavy fuel oil is the major source of power generation as hydropower will be the successor source in the future. Tariffs range from US¢9-25/kWh for EDC grid and US¢40-80/kWh for rural areas. Electrification rate through grid expansion is about 24.72 per cent in 2009. Cambodia's electricity tariff remains one of the highest in the region and the world. With a consolidate license, EDC, the state-owned utility, is the dominant key player in the electricity market. Two main institutions playing important roles in governing the electricity sector include MIME and EAC. The electricity sector remains underinvested. Only large scale investment projects are preferred in the market. High-voltage transmission connections, large-scale hydropower dams, and coal-fired plants have been the focused priority for power development thus far. Barriers to investments include huge capital requirement for large-scale projects, insufficient legal and institutional framework, and high administrative costs. Therefore, it is essential that national grid development is accelerated and more investment is encouraged in order to reduce current high tariffs. Investment climate must be enhanced to be conducive to foreign and local investment.

1. Introduction

Energy cooperation is one of the focused priorities in the East Asia Summit (EAS) region. To advance this cooperation, energy market integration is, among other things, laid out by the member countries to address barriers of trade and investments in the energy sector across the region. Being a member of the sixteen-countries-EAS region, Cambodia, one of the poorest countries in the region, needs to take steps to accelerate this envisaged integration and to fulfill its increasing demand for electricity for continued economic development.

Cambodia has achieved strikingly high rates of economic growth over the past ten years; the real gross domestic product (GDP) grew on average 8.0 % per annum. This robust growth has stimulated substantially-increasing demands for electricity. With a constrained supply-side, Cambodia faces critical challenges in satisfying this greater demand. In this regard, regional electricity market integration serves as a useful tool for Cambodia to optimize benefits enhancing the domestic electricity sector and to further regional energy cooperation.

Despite remarkable improvement in the energy sector, the electrification rate in Cambodia remains low. The majority of the population is not connected to electric power networks. Moreover, electricity cost remains one of the highest in the region and the world. Investment in the electricity sector represents a small proportion of the total investment needed for electricity sector development.

Although electricity imports from neighboring countries have been on the rise, the supply of electricity still suffers shortage and reliability. Electricity market players are diverse, ranging from small Rural Electricity Enterprises (REEs) and Independent Power Producers (IPPs) to the state-owned utilities while a national power grid has not yet materialized. In terms of regional cooperation, the government's current policies and strategies have significant effects and implications for electricity supply and coverage in Cambodia.

Against this background Cambodia's electricity sector has steadily developed in the past decade, although its development has not been at parity with the pace of economic development. Therefore, to better understand the current situation of the Cambodia's electricity sector, this paper considers the overall situation and progress of the sector in the context of regional integration. It is crucially important to shed light on furthering development of the electricity sector in Cambodia and integrating Cambodia's electricity market into the region.

With the main purpose of providing a general background of the electricity sector in Cambodia, the study has five objectives as follows:

1) To lay out an overview of Cambodia's electricity sector covering issues such as supply, demand, transmission, tariffs, investment, access, electrification, and government strategies and policies;
2) To summarize present strategies and policies of the Cambodian government in regards to the ASEAN Power Grid (APG);
3) To understand the current situation of investment in the electricity sector covering issues such as key market players, main investment barriers, and the attraction of foreign investment in the sector;
4) To illustrate a case study of Cambodian electricity imports from Vietnam; and
5) To explore other issues which are significant and relevant to electricity sector.

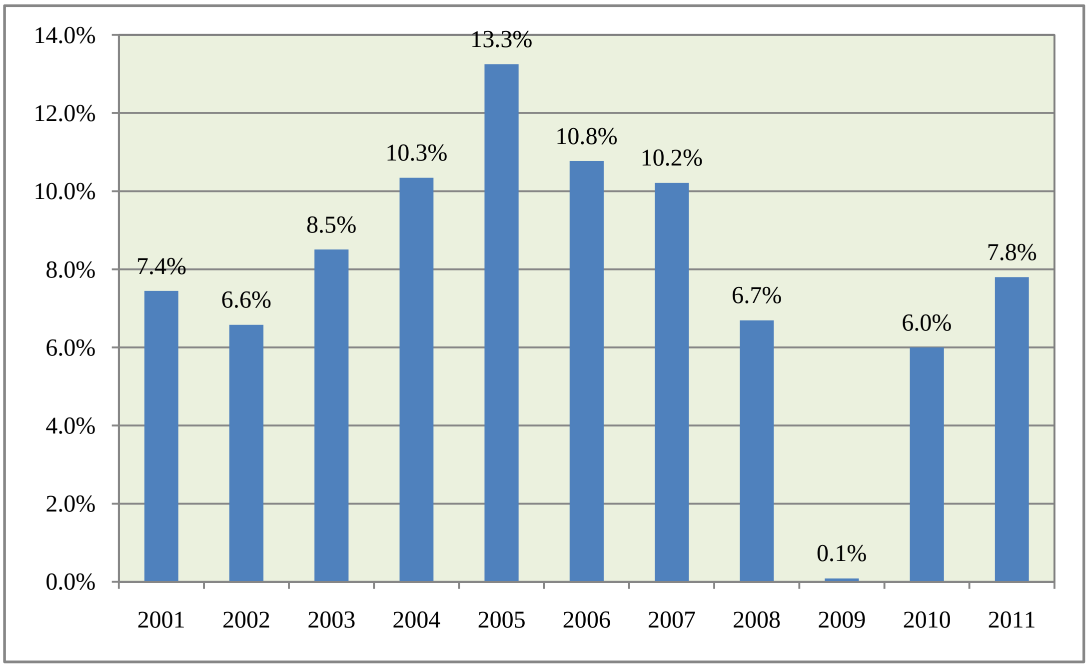
2. Overview of the Cambodian Economy

Cambodia, officially known as the Kingdom of Cambodia, is a member of the Association of the Southeast Asian Nations (ASEAN) and Greater Mekong Subregion (GMS). Situated at the heart of the GMS, Cambodia is a land of rice and forest covered by the Mekong River and Tonle Sap Lake (ESMAP, 2005). It is bordered with Thailand and the gulf of Thailand in the West and South respectively, Vietnam in the East, and Lao PDR in the North. With a total area of 181,035 Km^2, Cambodia has a total population of about 15 million, of which approximately 80 % live in rural areas.

Cambodia had gone through several civil wars over three decades since the military coup d'état in 1970. In particular, the Cambodian economy had been gravely destroyed during the genocidal Democratic Kampuchea regime during 1975-1979. As a result, the economy plunged into almost zero levels of growth because either physical or non-physical infrastructure had been demolished. The economy began to develop from this level as a socialist economy before it embarked upon free-market economy in 1989 (MoE, 2002). The country had its first national election in 1993, and the economy developed gradually and steadily to be a post-conflict economy in 1999 when reconciliation among all political tendencies was successfully accomplished.

In the last decade, Cambodia enjoyed exceptionally high rates of economic growth. The economy grew 8.0% per annum on average during 2001-2010.[1] The economy experienced the highest growth rate at 13.3 percent in 2005. Later, it declined from 6.7% in 2008 to 0.1% in 2009 due to global economic downturn in 2008/2009 because Cambodia’s major economic sectors such as garment, tourism, and construction dramatically contracted. Real GDP growth started to edge up again to around 6.0% in 2010 and was estimated to realize a rate of 7.8% in 2011 (Khin, *et al*. 2012). In the meantime, Cambodia needs to achieve at least an average growth rate of 6-7% per annum to achieve sustainable poverty alleviation in accordance with government policy ambitions. In this regard, development of the electric power sector needs to be hastened to support sustainable growth and economic development.

Figure 1: Cambodia's Real GDP Growth Rate over 2001-2011



Source: Data compiled from NIS and EIC estimate (2011).

[1] Data compiled from the National Institute of Statistics (NIS).

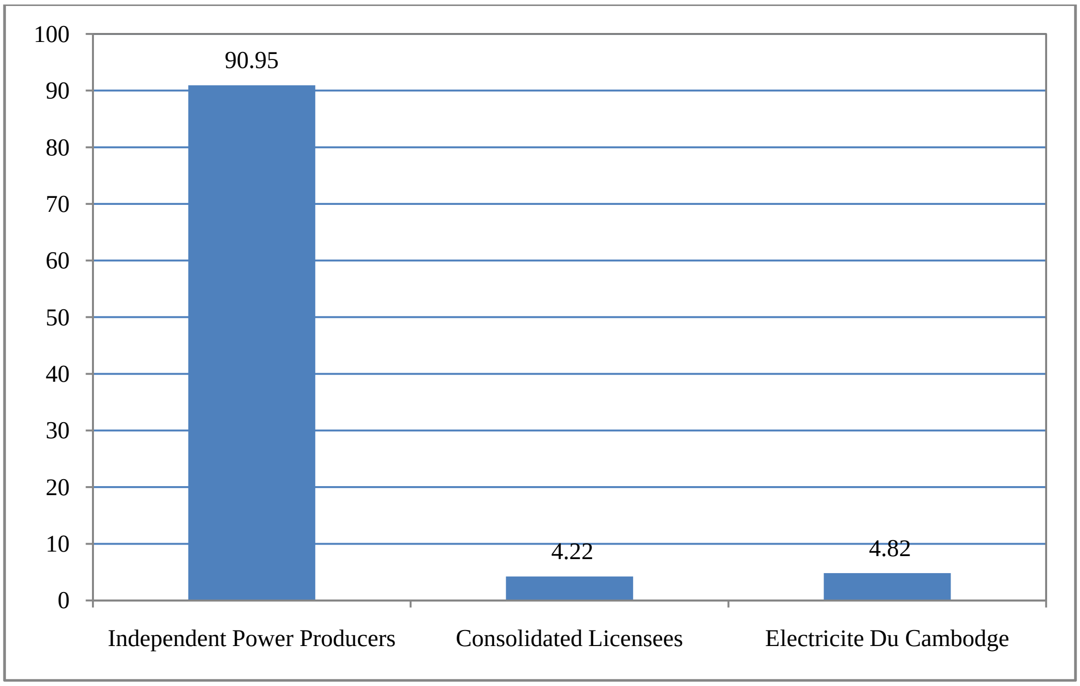
3. Electricity in the Energy Sector

3.1. Overall Situation

The power sector in Cambodia is supplied by different sources such as heavy fuel oil (HFO), diesel, gasoline, gas, wood, coal, hydropower, wind and solar energy, biomass, and biogas (World Bank, 2006). The major source of power generation is diesel and HFO. Cambodia actively seeks other alternative sources which have high possibility for power generation. Noticeably, hydropower, which holds considerable potentials for power production in Cambodia, will become the major source in the long term (World Bank, 2006).

Electric power supplied throughout the country is sourced from three different types of licensees including the state-owned Electricite du Cambodge (EDC), IPPs, and consolidated licensees including REEs. However, REEs supply electricity typically in the rural areas. As shown in the following Figure 2, the capacity of electricity sent out by IPPs accounts for approximately 90.95% of electricity supply in Phnom Penh, followed by 4.82% by EDC and 4.22% by consolidated licensees.

Figure 2: Proportion of Energy Sent Out by Licensee in 2010 in Phnom Penh (%)

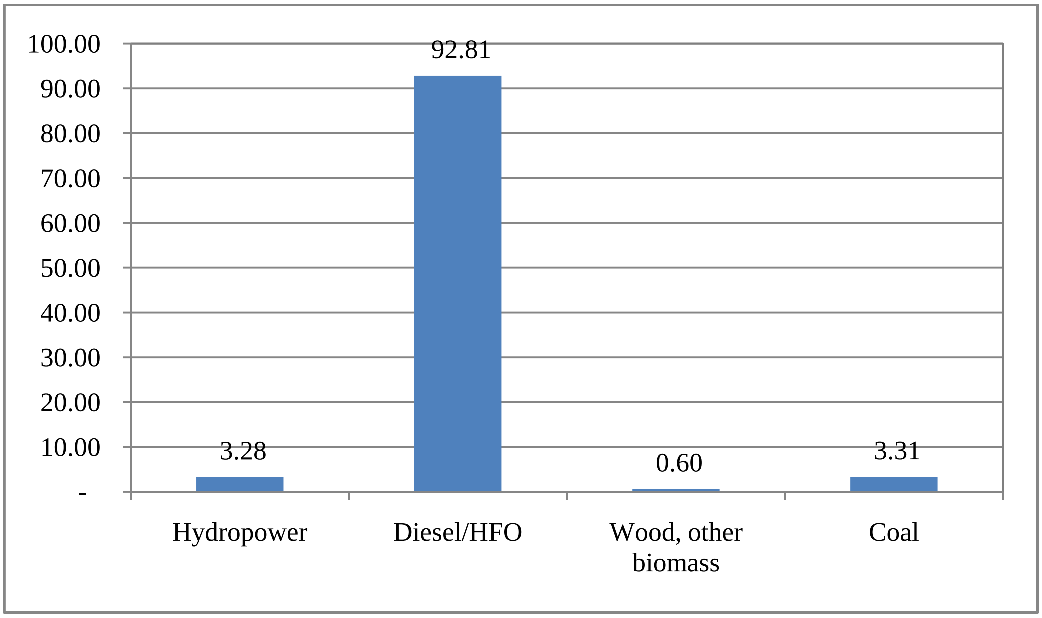


Source: EAC Annual Report 2010.

Although the Electricity Authority of Cambodia (EAC) reports the usage of different sources of power, the main source of power in which licensees across the country are utilizing is diesel which is imported from abroad making the electricity tariff very volatile. In 2010, diesel accounted for almost 93% of the total power sources used to generate electricity (Figure 3).

This indicates that the price of electricity is rather unstable because it is attached to the cost of diesel. Given the fact that Cambodia is an oil-importing country, the cost of diesel is quite sensitive to global market movements; thus, the price of electricity moves generally along with the fluctuation of the cost of diesel. It is worthwhile noting that the volatility of the electricity price significantly affects the ability of consumers to pay electricity bills and impacts investors' sentiments.

Figure 3: Proportion of Energy Sent Out by Sources in 2010 (%)



Source: EAC Annual Report 2010.

According to the EAC, consumers' demand for electricity increases every year; hence, the demand for electricity-producing capacity installed must also be increased. In 2002, the number of consumers was only 182,930 (Table 1). Consumer numbers increased about 268% to reach 672,709 in 2010. In the meantime, installed capacity edged up around 310% from 614.03 million kilowatt-hour (kWh) in 2002 to 2,515.67 million kWh in 2010. Within the next 15 years, the demand of power in the country is expected to increase by as much 500% reaching about 3,000 Megawatts (MW) in 2025 (Phnom Penh Post (PPP), 2012).

Table 1: Number of Energy Consumers by Year

Items	2002	2003	2004	2005	2006	2007	2008	2009	2010
Number of consumers	182,930	231,964	272,668	306,176	358,270	415,141	487,426	552,521	672,709
% increase over previous year		26.80	17.55	12.29	17.01	15.87	17.41	13.35	21.75
Energy available in million kWh	614.03	692.66	814.13	977.26	1,203.20	1,516.73	1,858.36	2,076.99	2,515.67
%increase over previous year		12.81	17.54	20.04	23.12	26.06	22.52	11.76	21.12
Energy sold in million kWh	525.69	599.04	702.31	858.36	1,057.16	1,349.12	1,664.40	1,853.50	2,254.04
%increase over previous year		13.95	17.24	22.22	23.16	27.62	23.37	11.36	21.61

Source: EAC Annual Report 2010.

With current supply capacity, reliability remains a concern for consumers. Blackouts have been routinely reported, especially in Phnom Penh municipality as the supply capacity reaching peak level, particularly in the dry season, is still below the demand. Phnom Penh is currently requires electricity up to 400 MW per day, but the current supply available is only 290 MW of which half is imported from Vietnam (PPP, 2012). Therefore, there is a huge need for investment in electricity to fulfill demand which is steadily increasing over time. An overview of electricity supply is shown in the following Table 2.

Table 2: Electricity Sector in Cambodia at a Glance

Description	Unit	2009	2010	% Change
Electricity generated	million kWh	1,234.59	968.36	(21.56)
Electricity imported from Thailand	million kWh	324.25	385.28	18.82
Electricity imported from Vietnam	million kWh	518.15	1,162.03	124.27
Total electricity import	million kWh	842.40	1,547.31	83.68
Total electricity available	million kWh	2,076.99	2,515.67	21.12
Generation Capacity	kW	372,129	360,078	(3.24)
Number of consumers	#	552,521	672,709	21.75
Electricity sold to consumers	million kWh	1,853.50	2,254.04	21.61
Overall loss	%	10.76	10.40	

Source: EAC Annual Report 2010.

According to the Asian Development Bank (ADB), the number of households supplied with electricity from the main electricity grid was 633,123 in 2008 (ADB, 2011). As set out in the development plan, this number is expected to increase to 1,131,190 by 2013. Electrification rate through grid expansion in Cambodia is about 24.72% in 2009, but it is expected to move up to 35.17% by 2013 (ADB, 2011).

Cambodia is on track to achieve a target of increasing the length of high-voltage transmission network by 100 Km from 2005 to 2010 and increasing per capita use of electricity from 54 kWh in 2005 to 89 kWh in 2010 in terms of improving access to a reliable and affordable power supply (ADB, 2007a). Nonetheless, challenges remain in meeting the rising demand of the growing economy, improving access to electricity, and reducing its costs in rural areas.

3.2. Electricity Tariffs

Electricity service providers (ESPs) set prices for their electric power services supplied to consumers; however, the set prices require approval from the EAC. As stipulated in the electricity law, the approval is required to ensure that prices are reasonably affordable by consumers and businesses of ESPs are carried out efficiently, qualitatively, sustainably and transparently (EAC, 2008). The EAC determines and reviews the tariff rates, charges, and service terms and conditions for the electricity service provided by licensees (ESPs). Within ninety days from the receiving date of any application by licensees requesting the EAC to determine or revise their tariff, the EAC either approves, revises, or disapproves requests (Royal Government of Cambodia (RGC), 2001).

Cost of electricity generation is the single largest component of the price of electricity supplied by licensees to consumers. In this regard, unlike other commodities in the market, the electricity price is not determined by demand and supply interaction. It is very much dependent on input factors of the supply side. Specifically, it hinges on the cost of producing electricity per kilowatt-hour. Moreover, electricity is a natural monopoly service in Cambodia; ESPs have significant power in setting the electricity tariff and manipulating the electricity market.

On the one hand, electricity tariff rates in Cambodia vary considerably depending on the source of electric power generation. Almost 95% of the cost of electricity supply is related to the cost of fuel. Licensees generating electricity from diesel or HFO or purchasing electricity from IPPs, with costs of electricity purchase linked to the cost of fuel, the price of electricity supply is extremely high. Moreover, it varies critically according to the fuel cost.

The cost of electricity supplied by hydropower plant or purchase from neighboring countries fluctuates little. As a result, the tariff of electricity provided to consumers by licensees getting electric power from such sources does not change frequently.

On the other hand, different types of tariffs have been applied by different types of ESPs to different categories of customers. IPPs importing electric power supply from neighboring countries apparently have the tariff rates lower than IPPs that generate electric power using diesel or HFO (EAC, 2007).

Given the fact that tariffs are set by each ESP based on full-cost recovery principle, the tariff levels, vary from area to area; and, there is a huge discrepancy between urban and rural customers. Rural customers generally pay higher tariffs than their urban counterparts (CRCD, 2006b). As Phnom Penh residents pay the electricity bill at a tariff rate of around 18.00 US¢ /kWh, some rural residents pay the tariffs rate as high as USD 1.00/kWh. This large gap is due to various factors such as differences in supply capacity of ESPs, economy of scale, load factor, fuel transportation cost, cost of capital and financing, power supply losses, and risk premium for rural customer’s low capacity to pay the bill. The following Table 3 and 4 present the fundamental tariffs charged by EDC by categories of consumers and distribution areas, respectively.

Table 3: Tariff of EDC in 2010 in Phnom Penh, Kandal and Kampong Speu Province

Categories of Consumers	Tariffs (US₵ /kWh)	Condition
Domestic in Phnom Penh and Takhmao Town of Kandal Province	15.25	All kWh if monthly consumption does not exceed 50 kWh
	18.00	All kWh if monthly consumption exceeds 50 kWh
Domestic in Kampong Speu province	18.00	All domestic consumers
Embassy, NGO and foreign residents and institutions	20.5	
Customers paid by government budget, Commercial and industrial customers	Tariff rate= average cost of total electricity purchased in previous month + 3.6 US ¢ /kWh	For small commercial and Industrial customers
	Tariff rate= average cost of total electricity purchased in previous month + 2.8 US ¢ /kWh	For medium commercial and Industrial customers
	Tariff rate= average cost of total electricity purchased in previous month + 2.4 US ¢ /kWh	For big commercial and Industrial customers
	Tariff rate= average cost of total electricity purchased in previous month+2.0 US Cents/kWh	For commercial and Industrial customers who are connected directly to MV

Source: EAC Annual Report 2010.

Table 4: Electricity Tariff of EDC at Other Provinces in 2010

Distribution Areas of EDC	Tariffs (US Cents/ kWh)	Condition
Provincial Town of StuengTreng	30.5	All consumers
Provincial Town of Ratanakiri	16.75	All consumers
Provincial Town of Kampot	27.5	All consumers
Provincial Town of Prey Veng	30.5	All consumers
Memot	12.5	Bun Rany Hun Sen Primary and High School
	16.25	Small consumers
	12.5	Medium consumers
	11.5	Medium Voltage
	16.25	Small consumers
Ponhea Kraek and Bavet	12.5	Medium Voltage
	11.5	Medium Voltage
Kampong Trach	16.25	Small and medium
	11.5	Big consumers
Svay Rieng, Kampong Row, SvayTeap	16.25	All consumers

Source: EAC Annual Report 2010.

Cambodia's electricity tariff is one of the most expensive in the Southeast Asian region. Tariff rates range from US¢9-25 per kWh for EDC grid and US¢40-80/kWh for rural areas (Lieng, 2010). As shown in Table 5 below, the average electricity prices for industrial consumers range from US¢11.71 to US¢14.63 which is the highest among the ASEAN economies.

Table 5: Electricity Tariff in ASEAN Nations (US¢ /kWh)

Country	Residential	Commercial	Industrial
Brunei	3.82-19.11	3.82-15.29	3.82
Cambodia	8.54-15.85	11.71-15.85	11.71-14.63
Indonesia	4.60-14.74	5.93-12.19	5.38-10.14
Lao PDR	3.34-9.59	8.80-10.36	6.23-7.34
Malaysia	7.26-11.46	9.67-11.10	7.83-10.88
Myanmar	3.09	6.17	6.17
Philippines	6.65-10.52	--	--
Singapore	19.76	10.95-18.05	10.95-18.05
Thailand	5.98-9.90	5.55-5.75	8.67-9.43
Vietnam	2.91-9.17	4.38-15.49	2.30-8.32

Source: ASEAN Center for Energy (2011).

Table 6 demonstrates monthly electricity prices of EDC by consumer categories in Phnom Penh, Kandal province and Kampong Speu provincial town in 2010. The prices on average are quite high across consumer categories. They are in the range of US¢18-23 per kWh.

Table 6: Monthly Electricity Tariffs of EDC for Phnom Penh, Kandal Province and Kampong Speu Provincial Town in 2010 (US Cents/kWh)

Categories of Consumers	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Small	22.99	20.26	20.05	19.9	20.21	19.92	19.57	19.21	19.32	19.25	19.5	19.68
Medium	22.19	19.46	19.25	19.1	19.41	19.12	18.77	18.41	18.52	18.45	18.7	18.88
Big	21.79	19.06	18.85	18.7	19.01	18.72	18.37	18.01	18.12	18.05	18.3	18.48
Medium Voltage	21.39	18.66	18.45	18.3	18.61	18.32	17.97	17.61	17.72	17.65	17.9	18.08

Source: EAC Annual Report 2010.

There are three important reasons behind the skyrocketing prices in the country. First, although Cambodia is endowed with an abundance of hydropower resources, it depends heavily on costly fuel-based engines or generators to produce electricity. Furthermore, accessibility to sources of electric power is quite limited. While coal power plants have been constructed to provide more electric power to consumers, only several hydropower plants are being operated to extract electricity.

Second, with isolated electricity generation systems across the country, the electricity infrastructure stays vastly fragmented although considerable progress has been made. According to Breeze (2010), Cambodia's electricity infrastructure was almost completely destroyed by war as were facilities of electricity supply (EAC, 2008). Presently, the national grid is being constructed to bring electricity supply to provinces throughout the country (EAC, 2011).

Third, high tariff is caused by significant electric power loss. Inefficient electric power facilities, small fragmented diesel-based generation systems, and lack of interconnection within the system can explain this electric power loss very well (EAC, 2008). Overall power loss for the country is on average 11.05 %; however, the power loss for rural areas stays around an extremely high rate of 25.34 % (EAC, 2008).

The following Table 7 presents the energy situation in Cambodia with power loss in 2010 which is supplied by EDC only.

Table 7: Energy Situation Supplied by EDC in 2010

Area of Supply	Installed Capacity (kW)	Energy Purchased (kWh)	Energy Sent Out by Generation (kWh)	Energy Transferred from/to other Branches (kWh)	Energy Sold to Other Licensees (kWh)	Number of Consumers	Energy Sold to Consumers (kWh)	Loss in %
Phnom Penh Grid System	45,560	1,676,055,488	31,702,495		60,412,598	246,973	1,488,183,010	9.32
Banteay Meanchey Grid System	15,580	272,123,600	1,287,558		6,899,043	66,300	231,476,332	12.81
Kampot	3,080	3,951,740	665,179	15,841,180	546,046	7,168	14,559,593	26.16
Sihanoukville	5,600	51,522,280	8,655,407		721,770	10,632	57,086,359	3.94
Kampong Cham		34,951,440			12,499,998	10,474	18,683,236	10.78
Prov.Town of Prey Veng	1,640	4,032,974	631,732		418,520	4,445	3,695,679	11.80
Prov. Town of Steung Treng	1,640	5,748,768	50,784			2,634	4,768,664	17.78
Pro. Town of Ratanakiri	960	6,359,699	1,766,000			2,904	7,448,230	8.34
Prov. Town of Svay Rieng	1,000	18,039,900	108,640		173,730	10,789	16,280,618	9.34
Khum Bavit		60,861,000				2,494	57,564,164	5.42
Memot District		10,403,000				4,015	9,759,063	6.19
Ponhea Krek District		25,977,000			14,099,259	2,385	10,550,045	5.11
Kampong Trach District		28,585,992		(15,841,180)	4,060,892	2,513	8,188,704	1.73
Mondulkiri	670		1,821,545			1,328	1,571,300	13.74
Keoseyma District		764,700				861	589,694	22.89
Total	**75,730**	**2,199,377,581**	**46,689,340**		**99,831,856**	**375,915**	**1,930,404,691**	**9.61**

Source: EAC Annual Report 2010.

4. Governance of the Electricity Sector

4.1. Policy and Regulatory Framework

According to the Royal Government of Cambodia (RGC), there are four main objectives of energy sector development policy detailed out as follows:

1) Providing an adequate supply of electricity throughout the country at reasonable and affordable price;
2) Ensuring reliable and secure electricity supply which facilitate investment in Cambodia and development of the national economy;
3) Encouraging exploration of environmentally and socially acceptable energy resources needed to supply all sectors of the Cambodian economy; and
4) Encouraging efficient use of energy to minimize environmental effects resulting from energy supply and use.

To prepare a governing framework for the electric power supply and services throughout the country, the "**Law on Electricity**" was adopted by the National Assembly on November 6, 2000 and then promulgated by the Royal Degree on February 2, 2001. This law covers all activities related to the supply, provision of services and use of electricity, and other associated activities of power sector. It helps reform the current electricity sector, and is endorsed to boost private investors in the power sector in a fair, just, and efficient manner for the benefit of the Cambodian society.

Overall, this law has key components including:

1) Establishing the principles for operation of the sectors;
2) Establishing favorable conditions for competition, private investment, private ownership and commercial operation of the electric power industry; and
3) Establishing and defining the functions of the EAC and the Ministry of Industry, Mine and Energy (MIME).

In this regard, there are three main players who have considerable power in the electricity sector in Cambodia: the MIME, EAC and EDC. The EDC is the most influential of the three in the electricity market. Other players in the market include

IPPs, REEs, and other licensees that import electricity from neighboring countries or own stand-alone diesel generators.

In addition to the Law on Electricity, RGC also specifies the development of the energy sector in the National Strategic Development Plan (NSDP) with the prioritized aims of increasing electricity supply capacity and reducing tariff rates to an appropriate level while strengthening institutional mechanism and management capacity. To achieve the desired goals, the development of the electricity sector is set out in the Rectangular Strategy Phase II of the fourth-mandate RGC.

To ensure sustainable development of the electric power sector, an electrification master plan was worked out for: (1) electricity generation development including hydropower resources development and development of coal or gas power plant, (2) electricity import to coordinate the development of the border zones of the kingdom and (3) the development of transmission grid throughout the country in order to establish the electricity transmission system of Cambodia (EAC, 2009). Furthermore, RGC will encourage the construction of low cost electricity generating plants by using local energy sources such as hydro-power, natural gas, and coal.

As the electricity sector in Cambodia is fundamentally governed by the Law on Electricity, sub-degrees and other regulations have subsequently been issued by the EAC. Table 8 presents a list of noticed electricity legal documents.

Table 8: Important Legal Documents in Electricity Sector

No.	Name of Standard Documents	Promulgated by	Date Promulgated
1	Electricity Law of the Kingdom of Cambodia	The King	February 2, 2001
2	Sub-Degree on the Rate of the Maximum License Fees applicable to Electric Power Service Providers in the Kingdom of Cambodia	RGC	December 27, 2001
3	Procedures for Issuing, Revising, Suspending, Revoking, or Denying Licenses Revision 1 Revision 2	EAC	September 14, 2001 December 12, 2002
4	Regulations on General Conditions of supply of Electricity in the Kingdom of Cambodia Revision 1	EAC	January 17, 2003 December 17, 2004
5	Regulatory Treatment of Extension of Transmission and Distribution Grid in the Kingdom of Cambodia	EAC	October 28, 2003
6	Regulations on Overall Performance Standards for Electricity Suppliers in the Kingdom of Cambodia	EAC	April 2, 2004
7	Procedure for Filing Complaint to EAC and for Resolution of Complaint by EAC	EAC	April 2, 2004

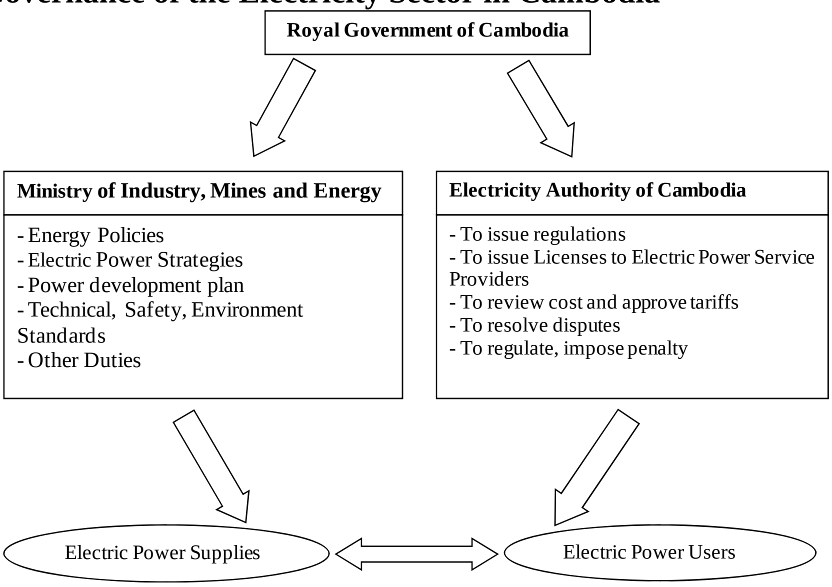
No.	Name of Standard Documents	Promulgated by	Date Promulgated
8	General Requirements of Electric Power Technical Standards of the Kingdom of Cambodia	MIME	July 16, 2004
	First Amendment		August 9, 2007
9	Sub-Degree on Creation of Rural Electricity Fund of the Kingdom of Cambodia	RGC	December 4, 2004
10	Sub-Degree on Principles for Determining the Reasonable Cost in Electricity Business	RGC	April 8, 2005
11	Prakas on Principles and Conditions for issuing Special Purpose Transmission License in the Kingdom of Cambodia	MIME	July 21, 2006
12	Specific Requirements of Electric Power Technical Standards of the Kingdom of Cambodia	MIME	July 17, 2007
13	Regulations on General Principles for Regulating Electricity Tariffs in the Kingdom of Cambodia	EAC	October 26, 2007
14	Procedures for Data Monitoring, Application, Review and Determination of Electricity Tariff	EAC	October 26, 2007
15	Grid Code	EAC	May 22, 2009

Source: EAC Annual Report 2010.

4.2. Institutions

Under the electricity law, there are two main institutions playing important roles in governing the electric power sector in Cambodia, namely MIME and EAC. Whilst MIME is mainly responsible for the formulation of policies and strategies, EAC is a legal public entity being granted the right from RGC to be an autonomous agency to regulate the electricity services and to govern the relation between the delivery, receiving, and use of electricity. Roles of these two government agencies are illustrated in the following Figure 4.

Figure 4: Governance of the Electricity Sector in Cambodia



Source: EAC Annual Report 2010.

4.2.1. Ministry of Industry, Mines and Energy

As set out in the Law on Electricity, the MIME has the following roles:

- Responsible for setting and administrating the government policies, strategies and planning in the energy sector.
- Providing the EAC information on policies, strategies, planning of energy sector and its decision on:
  - ➢ Investments in the rehabilitation and development of the energy sector in the short, medium and long term;
  - ➢ Restructuring, private sector participation and privatization of public utilities;
  - ➢ Promotion of the use of indigenous energy resources in the generation of electricity;
  - ➢ Planning and agreements on the export and import of electricity;
  - ➢ Subsidies to specific classes of customers and priorities regarding consumers of electricity;
  - ➢ Promotion of efficiency in generation, transmission, distribution and consumption of electricity and action taken to create a comprehensive electricity conservation program for Cambodia; and
  - ➢ Electricity sector emergency and energy security strategies.

4.2.2. Electricity Authority of Cambodia

The EAC is a legal public entity, being granted the right from the RGC to be an autonomous agency to regulate electricity services and to govern the relation between the delivery, receiving and use of electricity.

The Law on Electricity regulates the roles of the EAC as follows:

- To issue, revise, suspend, revoke or deny the licenses for the supply of electricity services;
- To approve tariff rates and charges and terms and conditions of electric power services of licensees, except where the authority (EAC) consider those rates or charges and terms and conditions are established pursuant to a competitive, market-based process;
- To order to implement guidance procedures and standards for investment programs by licensees;
- To review the financial activities and corporate organization structure of licensees to the extent that these activities and organization directly affect the operation of the power sector and the efficiency of electricity supply;
- To approve and enforce the performance standards for licensees;

- To evaluate and resolve consumer complaints and contract disputes involving licensees, to the extent that the complaints and disputes relate to the violation of the condition of licenses;
- To approve and enforce a uniform system of accounts for all licensees;
- To prescribe fees applicable to licensees;
- To determine the procedures for informing the public about affairs within its duties, in order to ensure that the EAC comply with the principle of transparency;
- To issue rules and regulations and to make appropriate orders, and to issue temporary and permanent injunction for electric power service;
- To impose monetary penalty, disconnect power supply, suspend or revoke the license for the violations of this Law, standards and regulations of EAC; and
- To require the electric power services and the customers to obey the rules relating to the national energy security, economic, environment and other government policies.

4.2.3. Electricite Du Cambodge

According to the EDC Annual Report 2007, the EDC, the state-owned public utilities entity, has the following functions and responsibilities:

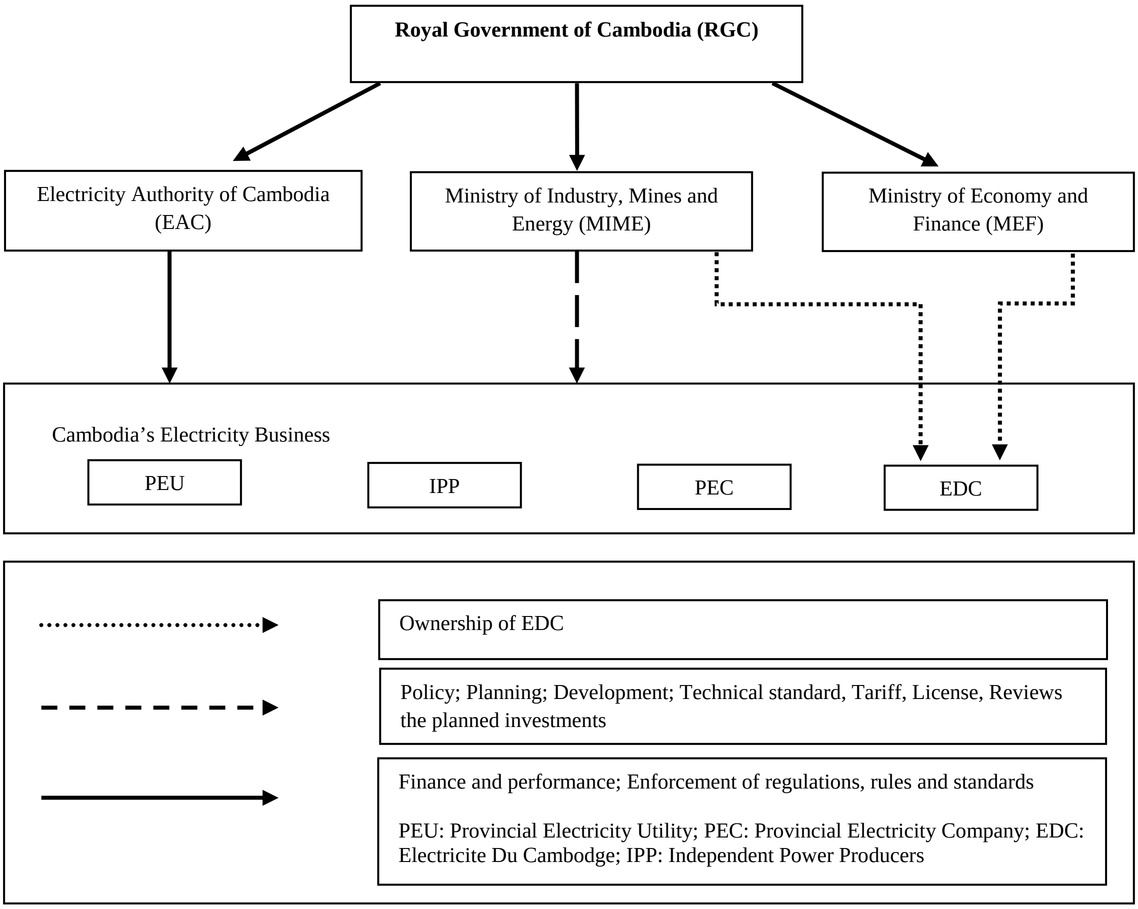
- To develop, generate, transmit and distribute electric power throughout Cambodia;
- To operate as a commercial entity, independently organize production and operation in accordance with market demand and seek to earn a profit, increase the value of its assets, create economic, benefits and raise labor productivity;
- To prepare, build, own, finance, lease and operate power generation and sub-stations, transmission lines, distribution networks and other infrastructure necessary;
- Eliminate inefficiencies from operation, reduce unnecessary costs;
- Maximize the output and reliability of the assets, customer satisfaction with higher quality and better services; and
- To be polite, receptive, act promptly with customers' concerns.

Co-owners of the EDC are the MIME and the Ministry of Economy and Finance (MEF). Based on the EAC Annual Report 2010, the EDC is currently holding a consolidate license that has the following components:

1. Generation license: giving the right to EDC to generate electricity for the purpose of supply to its transmission and distribution system.

2. National Transmission License: giving the right to EDC to transmit electricity for the purpose of supply to any distribution system and bulk power consumers throughout Cambodia.
3. Distribution license: giving the right to EDC to distribute and supply electricity to any premises in the authorization distribution areas.

Figure 5: Structure of the Electricity Sector



Source: Adapted from MIME (2009).

4.3. Electricity Service Providers

There are different types of licensees providing electric power services throughout the country. They are the state-owned EDC, private entities including IPPs in provincial towns, provincial department of MIME electricity operators, licensees in small towns, and REEs (World Bank, 2006).

The EDC, a national utility enterprise co-owned by MIME and MEF, was granted a consolidate license from the EAC to generate, distribute and transmit electricity throughout Cambodia. It currently supplies electricity in the areas of Phnom Penh/Kandal, eight provincial towns, and four small isolated systems near the Vietnamese border. As a consolidate licensee, the EDC can also generate power up to 95 MW and purchase from IPPs around 86.4 Megawatts in 2004 (CRCD, 2006a).

Licensed ESPs have been dramatically increased during the past seven years. This increase has edged up from 104 valid licensees in 2004 to 278 in 2010, an increase of 167 percent. However the supply of electricity is still in shortage, especially in Phnom Penh capital city, and is accompanied by high tariffs. REEs operate small diesel generators and produce electricity for their own use and for neighboring customers. Their supply operation ranges from twenty to a few hundred customers. The number of REEs in the country overall was estimated at around 500 (CRCD, 2006a).

Table 9: Types of ESPs with Installed Capacity (MW) in 2001

Supplier	Areas Supplied	Installed Capacity
Electricite du Cambodge (EDC)	6 Major towns, including Phnom Penh (MIME 2002)	32
Independent Power Producers selling to EDC	Phnom Penh and Kompong Cham	127
Provincial Electricity Operators (provincial departments of MIME)	10 Provincial towns	14
Rural Electricity Enterprises (REE) operating mini-grids	4 Provincial towns and hundreds of smaller towns and villages (estimated 600 REEs)	60
Battery Charging Services (REEs which do not also operate a mini-grid)	1500 battery charging services (REEs) in hundreds of towns	38
Imported Power from Thailand and Vietnam (22kV lines)	7 Borders towns	15
Private stand-by diesel generation (large scale only)	All areas, bug mainly Phnom Penh and Siem Reap	116
Total		**402**

Source: CRCD 2004.

5. Regional Cooperation and Trade

5.1. ASEAN Power Grid

Shared concerns among the ASEAN nations over energy security and sustainability are the key drivers for the opening up of energy markets within the region. To accentuate energy cooperation, the Heads of ASEAN Power Utilities Authorities (HAPUA) was established in 1981. However, little progress had been achieved until 1999 when the ASEAN Plan of Action for Energy Cooperation 1999-2004 (APAEC), a five-year plan covering energy cooperation which is a component of the ASEAN Vision 2020, was adopted. This was followed by the second five-year APAEC 2004-2009 which was endorsed by ASEAN energy ministers in 2004; Both APAECs consists of six programs including ASEAN Power Grid (APG), Trans-ASEAN Gas Pipeline (TAGP), coal utilization, energy efficiency and conservation, renewable energy utilization, and regional energy policy and planning.

APAEC 2010-2015 is the third action plan for the implementation of energy cooperation, which continues from the previous two series of APAEC. This third APAEC enacted in 2009 composes of seven programs including: (1) APG, (2) trans-ASEAN gas pipeline, (3) coal and clean coal technology, (4) renewable energy, (5) energy efficiency and conservation, (6) regional energy policy and planning, and (7) civilian nuclear energy.

In this regard, APG remains one of the key thrusts in energy cooperation; the implementation of APG is under the supervision and coordination of HAPUA. The implementation of APG so far is in the form of bilateral arrangements among member countries (APAEC, 2009). As of June 2011, the implementation plan laid out 16 projects proposed cross-border interconnection bilaterally; the plan then proposes gradually enlarging to a sub-regional basis aiming to form a totally integrated region. Of the 16 interconnection projects, 4 are in operation, 3 are under construction, and 9 are under preparation (e.g. study or negotiation) (Table 10).

Enhancement of bilateral political relations between member countries and closer regional energy cooperation were recorded as the benefits of the operation of the four completed interconnection projects (Nicolas, 2009).

Figure 6: Interconnection of Power Grid in ASEAN

Source: Power Engineering International

Table 10: Status of Implementation of Interconnection Projects under APG

No.	Project	Status
1	P. Malaysia – Singapore	Operation
2	Thailand - P. Malaysia	Operation
3	Sarawak - P. Malaysia	Preparation
4	P. Malaysia – Sumatra	Preparation
5	Batam – Singapore	Preparation
6	Sarawak - West Kalimantan	Preparation
7	Philippines – Sabah	Preparation
8	Sarawak - Sabah – Brunei	Preparation
9	Thailand - Lao PDR	Construction
10	Lao PDR – Vietnam	Construction
11	Thailand – Myanmar	Preparation
12	Vietnam – Cambodia	Operation
13	Lao PDR – Cambodia	Construction
14	Thailand – Cambodia	Operation
15	East Sabah - East Kalimantan	Preparation
16	Singapore – Sumatra	Preparation

Source: Compiled from Hermawanto (2011).

Cambodia joined ASEAN as the 10th member country in 1999. Being a signatory party of the Memorandum of Understanding on ASEAN Power Grid (APG-MoU) endorsed in 2007, Cambodia has duties to fulfill the objective of the MoU that states that "*member countries agree to strengthen and promote a broad framework for the Member Countries to cooperate towards the development of a common ASEAN policy on power interconnection and trade, and ultimately towards the realisation of the ASEAN Power Grid to help ensure greater regional energy security and sustainability on the basis of mutual benefit.*"

Against this backdrop, Cambodia has actively implemented the agreed plan of actions. Cambodia has completed the construction and put into operation the two projects under the APG framework. They are Project No. 12 and 14, which is the bilateral arrangement between Cambodia and Vietnam, and Cambodia and Thailand, respectively. However, it is noteworthy that under Project No. 12 and No. 14, as well as Project No. 1 and No. 2 which are presently under operation, new sub projects have been proposed to promote further interconnection in the region.

There is no specific policy document to carry out the APG in Cambodia. Given the proposed projects in the APG framework are bilateral agreements among member countries in characteristics, Cambodia has incorporated those agreed projects into its overall national power development plan. In this regard, the Power Sector Development Plan (PSDP) was prepared by MIME in 2007 (EDC, 2010).

A rural Electrification Mater Plan focusing on the use of renewable energy has also been prepared and implemented. To implement the Rural Electrification Policy, the government has established a Rural Electrification Funds (REF) to promote equity in access to electricity supply services and encourage private sector to participate in investments in rural power supply services in a sustainable manner, in particular to encourage the use of new technologies and renewable energy. These efforts have been undertaken not only to advance the domestic electricity sector but also to facilitate regional cooperation under the frameworks of GMS, ASEAN, and EAS, and other sub-regional cooperation.

Moreover, the RGC will encourage construction of electricity transmission lines covering all parts of the country to enable the supply of quality and low cost energy from all sources to meet the demand in cities, provinces, urban and rural areas. The government has indicated that it intends to gradually integrate Cambodia's electric power system into the networks of the GMS and ASEAN countries (Ministry of Planning (MoP), 2009).

5.2. Greater Mekong Subregion

As initiated by the ADB, the Greater Mekong Subregion Economic Cooperation Program (GMSECP) was launched by six member countries around the Mekong River including Cambodia, China, Lao PDR, Myanmar, Thailand, and Vietnam. The energy sector is one of the focal priorities of this sub-regional cooperation. According to IRM-AG (2008), most of the tasks of the energy sector are included in the overall work plan for the development of power trade in the region agreed to in April 2005 by all GMS countries and their development partners through the Regional Power Trade Coordination Committee (RPTCC).

In this spirit, Cambodia has signed various power sector cooperation agreements with its neighboring countries. These agreements are in line with energy cooperation and eventual regional integration of the Greater Mekong Subregion. A power cooperation agreement between Cambodia and Vietnam was signed on June 10, 1999. With this agreement, power supply to border areas by medium voltage connections and interconnection between high voltage lines are promoted (EDC, 2010). Likewise, Cambodia and Lao PDR entered into a power sector cooperation agreement on October 21, 1999.

MoU on power cooperation between Cambodia and Thailand was signed on February 3, 2000. EDC (2010) stated that "this MoU provided a framework for the power trade and technical assistance between these two countries and opened power access to the third countries." ADB (2007b) stated that the power sector cooperation agreement between Cambodia and Thailand set up a framework for power trade and technical assistance between the two economies.

The national power master plan was updated in 2004 for the purpose to promote electric power development to be in line with the GMS regional master plan (ADB, 2009). At the present, PSDP 2007 provided an overall plan of action for the implementation of electric power development plan. Generation and transmission master plan is presented in the following Tables 11 and 12.

Table 11: Generation Master Plan 2008-2021

No.	Year	Power Station	Type	MW	Remark
1	2008	SR-BTB-BMC - Thailand	Import	80	Completed in 2007
2		Kampong Cham - Vietnam	Import	25	By 22 kV
3	2009	Phnom Penh - Vietnam	Import	200	Completed
4	2010	Stung Treng - Lao PDR	Import	10	By 22 kV
5		Kamchay	Hydro	193	Postpone to 2011
6		Kampong Cham - Vietnam	Import	10	Cancel
7	2011	Kirirom III	Hydro	18	
8		Coal SHV	Coal	100	
9	2012	Stung Atay	Hydro	120	
10		Coal SHV	Coal	100	
11	2013	Retirement - C3 (GM)	DO	3	
12		Coal SHV	Coal	100	
13		Lower Russei Chrum	Hydro	338	
14		Upper Russei Chrum	Hydro		
15	2014	Coal SHV	Coal	100	
16	2015	Stung Tatay	Hydro	246	
17		Coal SHV	Coal	100	
18		Stung Treng - Lao PDR	Import	20	
19		Kampong Cham - Vietnam	Import	22	
20	2016	Lower Se San II	Hydro	420	
21		Lower Sre Pok II	Hydro		
22	2017	Stung Chay Areng	Hydro	240	
23	2018	Coal SHV	Coal	300	
24	2019	Sambo	Hydro	450	
25	2020	Kampong Cham - Vietnam	Import	31	
26	2021	Coal/Gas SHV	Coal/Gas	450	

Source: EDC Annual Report 2010.

Table 12: Transmission Master Plan 2008-2021

No.	Year	Project	High Case			Remark
			Line Type	Section (mm2)	Line Length (Km)	
1	2008	230kV VN-PP S/S Connection	D-C	630	111	Completed in 2009
2	2010	230kV Takeo-Kampot	D-C	400	100	Postpone to 2011
3	2010	115kV Lao PDR-Stung Treng	D-C	240	56	Postpone to 2014
4	2010	230kV Kampot-SHV	D-C	630	82	Postpone to 2013
5	2011	115kV Kampong Cham-Kratie	D-C	630	87	Postpone to 2015
6	2011	230kV Kampot-Kamchay Hydro Connection	D-C	630	20	
7	2011	115kV Stung Treng-Kratie	D-C	400	130	
8	2012	230kV WPP-Kampong Chhnang-Pursat-Battambang	D-C	630*2B	310	
9	2012	230kV Pursat-O Soam	D-C	630	80	
10	2012	115kV O Soam - Atay include S/S	D-C	630	30	
11	2012	115kV GS1-SWS-NPP	D-C	250*2B	28	
12	2012	115kV GS2-SPP	D-C	250*2B	25	
13	2012	115/230kV NPP-Kampong Cham	D-C	400*2B	120	
14	2013	230kV Lower & Upper Russei Chrum - O Soam	D-C	630	30	
15	2013	230kV WPP-SHV include Veal Rinh S/S	D-C	630	220	
16	2014	115kV SPP-EPP-NPP	D-C	250	20	
17	2014	115kV EPP-Neak Loeung-Svay Rieng S/S connection	D-C	250*2B	122	
18	2017	230kV Kratie-Lower Se San 2 - Vietnam	D-C	630	90	
19	2017	230kV WPP-NPP	D-C	630	25	
20	2017	230kV NPP-Kampong Cham-Kratie-Se San 2 - VN	D-C	630	300	
21	2018	230kV Sre Ambil-Koh Kong-O Soam	D-C	400	200	
22	2019	230kV Sambor-Kratie	D-C	630	30	
23	2021	230kV Kampong Cham-Kampong Thom-Siem Reap-Battambang-Thailand	D-C	630	350	

Source: EDC Annual Report 2010.

5.3. Electricity Import from Vietnam

As outlined in the MoU on APG and GMSECP, electricity is one of major energy commodities identified for cooperation in terms of assistance, trade and investment. With limited capacity to produce electricity domestically, Cambodia needs to cooperate with neighboring countries to fill the energy gap. Currently, Cambodia imports electricity from all neighboring countries, including Lao PDR, Thailand, and Vietnam.

Cambodia's import of electricity from Lao PDR is currently at 22 kilovolts (kV) to areas in Steung Treng province. The import from Thailand is currently at 22 kV via various connections and currently at 115 kV through the Thailand-Banteay Meanchey-Battambang and Siem Reap lines. Likewise, the import from Vietnam is at present at 22 kV via a number of connections and at 230 kV through the Vietnam-Takeo-Phnom Penh 230 kV line (EAC, 2010).

In regard to Vietnam, there is an Electricity Trade Agreement between the MIME of Cambodia and the Ministry of Industry of Vietnam. Governmental agencies, such as the EDC and Electricity of Kratie of Cambodia, have signed Power Purchase Agreements (PPAs) with Vietnam Power No.2 for the electricity import at a number of points for supply of electricity to areas located near the Cambodia-Vietnam border either by themselves or through other licensees.

According to the report released by EAC, Cambodia’s import of electricity from Vietnam totaled 518.1 million kWh in 2009 (EAC, 2010). It jumped about five times the level of the previous year which was 100.1 kWh. This substantial import was about 40.0 percent of the total electricity produced domestically; the total electricity generated in 2009 was 1,234.6 million kWh according to data released by EAC in 2010.

EAC (2010) also stated that with grid substations (GS) at Takeo province and GS4 at Phnom Penh in Cambodia, the double circuit 230 kV line from Vietnam to Phnom Penh was commissioned in 2009. Hence, given stable electricity import from Vietnam, EDC could terminate PPA with SHC (Cambodia) International Pte Ltd for the high-cost diesel generation at Phnom Penh.

It is noteworthy that import of electricity from Vietnam has not only reduced the burden of demand for electricity but also the price. EAC (2010) revealed that based on the PPA, which was signed between Vietnam Power No. 2 and the EDC and other state-owned utilities in Cambodia, the Vietnam Power No. 2 charges a fixed tariff rate at 6.9 US¢ per kWh for supply to Cambodia at medium voltage lines (22 kV or 15 kV).

Meanwhile, investments from Vietnam in the electricity sector are significant. Recently, an electrical Vietnamese company has invested USD 3 million in its Cambodian factory, and is hoping to inaugurate its operation in mid-2012 and employ between 100-120 people (PPP, 2011).

Increased trade and investment in the electricity sector between Cambodia and Vietnam are rather substantive, but their challenges, obstacles, and opportunities have not been widely studied. More importantly, the economic impact of this electricity market integration has been barely noticed. Therefore, a study to review this integrated electricity market and its impact should be conducted to shed light on the possibilities arising from further integration.

6. Investments in the Electricity Sectors

6.1. Current Situation

In line with the policy of the RGC in increasing electricity coverage, investments in the electricity sector have continued to increase over the past decade. With sole responsibilities of EAC in granting licenses to ESPs, the number of licenses issued is on the rise. According to data released by the latest report of EAC, the total licenses issued by EAC increased from 21 in 2002 to 278 in 2010.

Out of the total 278 licenses issued in 2010, the number of consolidate licenses is 221 which takes the biggest share. The second biggest share is the distribution license which reached 27 followed by the generation license which is at 19 licenses. The break-down of licenses by category is illustrated in the following Table 13.

Table 13: Number of Licenses Issued by Category during 2002-2010

Type of License	2002	2003	2004	2005	2006	2007	2008	2009	2010
EDC	1	1	1	1	1	1	1	1	1
Generation	6	7	8	11	14	14	20	19	19
Distribution	4	7	8	9	13	16	21	25	27
Consolidate (Generation + Distribution)	10	69	87	98	114	147	172	197	221
Retail					1	1	1	1	1
Special Purpose Transmission						1	1	3	3
Consolidate (SPT + Distribution)							2	3	6
Total	21	84	104	119	143	180	218	249	278

Source: EAC Annual Report 2010.

Regarding big energy investment (over USD 1 million), four investment projects were approved by the Council for the Development of Cambodia (CDC) in 2010. Total registered capital for those four projects was USD 20 million. It recorded an increase of around 41% from USD 14.2 million in 2009.[2] Though there was no investment project in the energy sector approved in 2011.

6.2. Investment Shortage in Electricity

Expansion of electricity capacity and coverage requires enormous capital investments. Yet, the government is unlikely to be able to allocate its limited budget for this huge financial requisite of investments. As a result, private sector participation is of crucial importance to accelerate power sector development.

Low cost of electricity is one of the RGC's priorities to attract both foreign and domestic investments and to eradicate poverty as clearly stated in the NSDP Update 2009-2013, an overarching national development policy paper (MoP, 2009). This policy paper encourages participation of the private sector in electricity investment in various areas such as electricity generation and distribution, expansion of national transmission grid that facilitates power imports from neighboring countries, and the hydropower development projects (Ryder, 2009).

A national power grid is a crystal-clear goal of RGC to distribute electric power service to all villages across the countries (EAC, 2011). It is also to connect with transmission lines of neighboring countries, as regional integration is the defined target. Hence, high-voltage transmission connections, large-scale hydropower dams, and coal-fired plants have been the focused priority for Cambodia's power development plan (Ryder, 2009).

Private electric power producers are, thus, unlikely to sustain their businesses in the long term. Ryder (2009) found that "Cambodia's private electricity companies provide essential service yet the EAC describes them as an 'interim solution' until the state utility, EDC, can bring its preferred IPP projects online."

According to Purka & Litwin (2003) and Ryder (2009), REEs, small-scale electric power service providers delivering electricity to rural households, are operating in a stiff

[2] Data compiled from the CDC.

business environment. Access to affordable capital is a common obstacle for most of REEs if not all, and requesting long-term permit from the regulatory agency to operate their businesses is very difficult. They also operate under high levels of uncertainty due to unclear rules for stand-alone operations, mini-grid operations, and future larger grid connections (Ryder, 2009).

Hence, private small-scale investments in the electricity sector seem unable to be sustained in the long term, and only large-scale investments appear to be viable. Break through investments in the electricity sector require a huge amount of capital, and risk is quite high in terms of investment payback. Therefore, capital requirement is very likely an investment barrier causing the current investment shortage in this sector. A lack of legal and regulatory framework in the sector is also a determinant of the investment shortage.

6.3. Policy Options

As electricity imports represent a large proportion of total electricity supply and electricity shortage remains persistent, developing further electricity production in the country is a necessity. Moreover, Cambodia is endowed with an abundance of hydro resources which should be utilized to increase electricity generation.

The power grid is, on the other hand, quite integrated with neighboring countries in the GMS region, but is noticeably limited within the country. Specifically, the electric power networks are well connected to neighboring countries such as Thailand, Lao PDR, and Vietnam, but have not yet been sufficiently developed to provide electricity across the country. Hence, more investment is required to hasten development of the national power grid.

With these critical challenges, there are a few policy options readily available to the government. First, enhancing the investment environment with a clear-cut policy direction for this sector is of fundamental importance in order to attract foreign and local investment. Second, public-private partnership for hydropower development and grid expansion appears as a preferable solution as long as it is accompanied with good environmental policy. Third, joint development of hydropower resources with countries in the ASEAN or GMS region is one of the viable options to electricity sector development in the country.

7. Concluding Remarks

Sources in the energy sector in Cambodia are mixed. However, the main source consists mainly of diesel and HFO. As a result, the electricity price is significantly volatile given the cost of diesel and HFO in the market. More importantly, the electricity price is the highest in the Southeast Asia region as electricity is extracted from these costly energy sources. A great discrepancy of electricity price is also found between urban and rural areas due to difference in supply capacity, economies of scale, load factor, power supply loss and risk premium between urban and rural ESPs. However, demand for electricity keeps increasing dramatically in urban and rural areas.

MIME and EAC are the regulatory entities in the electricity sector. As set out in the Law on Electricity, these two institutions have different functions and responsibilities. Meanwhile, key players in the electricity market include the EDC, IPPs, and REEs. Nonetheless, the EDC is the most influential, forming almost a monopolistic public utility providing electricity to Phnom Penh capital and other provincial towns.

Cambodia seems to be on track in implementing the APG action plan, completing two connection projects with Thailand and Vietnam. MoUs with three neighboring countries have already been signed to implement the electricity market integration as set out in the GMS cooperation framework. This has reduced the burden for electricity demand as well as tariffs to some extent.

Investment in the electricity sector has increased steadily during the past decade. However, this sector still remains under invested given rising demand. Big investment projects seem to be preferred in the energy sector development plan of the government. Thus, capital is very likely the most challenging constraint in addition to the lack of legal and regulatory framework, and high risk of investment paybacks.

Therefore, an improved investment environment is the pre-requisite to attract more investment in the sector to serve increasing demand for electricity as the economy grows steadily.

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CHAPTER 8

Impact of Fuel Subsidy Removal on the Indonesian Economy

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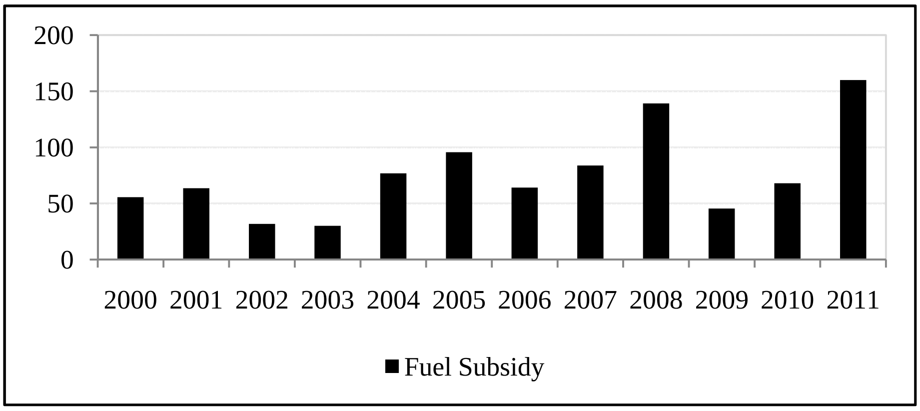
This research aims to analyze the impacts of fuel subsidy removal on Indonesian economy. Social Accounting Matrix (SAM) is applied to simulate the impact. The simulation shows that removal of fuel subsidy affected income distribution of households, firms, and governments. The impact of reallocation of subsidy to four targeted sectors- i.e. Agriculture; Trade; Food, Beverage, and Tobacco Industry; and Education and Health- would be relatively smaller than that of fuel subsidy removal. Some policy implications can be withdrawn. First, for the reasons of long-term efficiency, competitive advantage and manageable economic, social and political instability, the Goverment of Indonesia (GoI) should have clear, long-term, "sceduled" and "gradual" program of fuel subsidy reduction, not the "big-bang" total removal of the fuel subsidy. Second, the GoI could consider the certain amount of subsidy which is adjusted with the increase of goverment fiscal capacity, and let the domestic fuel price fluctuated as the ICP fluctuated. Societies (both domestic consumers and producers) will learn rationally and adjust logicly with the fluctuation of domestic fuel price. Third, the GoI should not consider the "sectoral approach" to reallocate the fuel subsidy. The GoI should consider programs such as "targeted fuel subsidy" to correct the misallocation the fuel subsidy ("subsidy is for the poor").

1. Introduction

This research starts with evidence that fuel subsidy has been a poor policy tool for the Government of Indonesia (henceforth, GoI). *First*, the fuel subsidy scheme enacted since 1967 is implemented to particular goods, i.e. fuels, as opposed to subsidy transferred to targeted households or industries (Pradiptyo & Sahadewo, 2012a). *Second*, there has been no restriction on the purchase of subsidized fuel in retail outlets. Every household, both poor and rich, has equal chance to buy subsidized fuel (IEA, 2008).

Figure 1: Fuel Subsidy in Indonesia, 2000-2011 (IDR trillion).

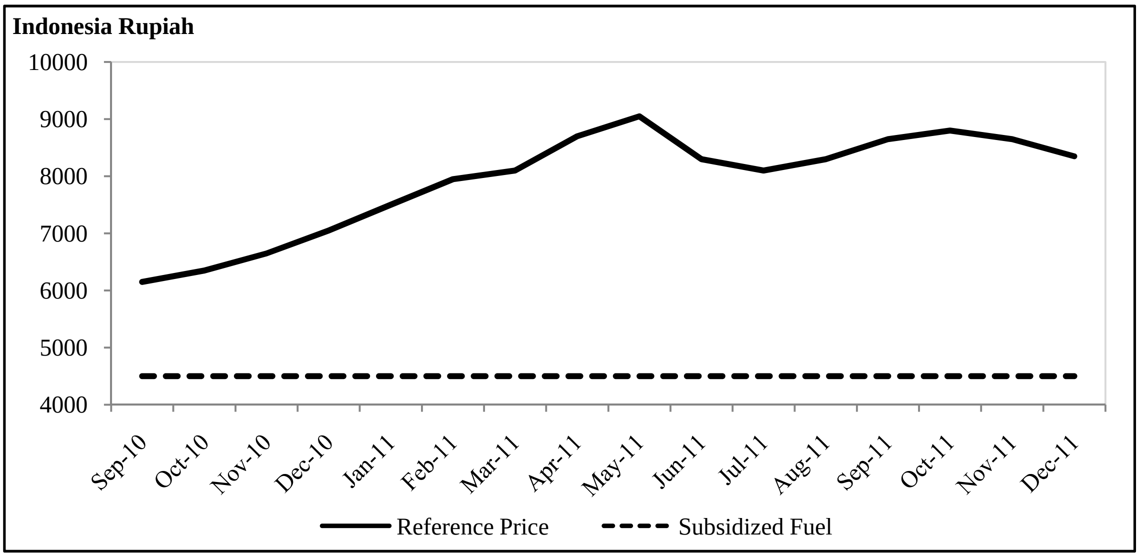


Source: Calculated from Ministry of Energy and Mineral Resources (2010) and APBN-P 2011.

The consequence of this policy, in terms of efficiency in resource allocation, has been unequal distributive effects. The Coordinating Ministry for Economic Affairs of Indonesia (2008) and the World Bank (2009, 2011a, 2011b) showed that the subsidy has been a crowd pleaser for particular socio-economic groups; the distribution of fuel subsidy is skewed to wealthy households.

Fuel subsidy has also imposed persistent pressure on GoI fiscal aspects (Pradiptyo & Sahadewo, 2012a). The Ministry of Energy and Mineral Resources (2010) recorded increasing trends in gasoline subsidy expenditure in the last decade (Figure 1 and 2). The revised expenditures for subsidy in 2011 accounted for 129.7 Indonesian rupiah (henceforth, IDR) trillion, higher than the planned IDR 95.9 trillion. The realization of fuel subsidy expenditure at the end of 2011, however, amounted to an estimated IDR160 trillion.

Figure 2: The Price of Subsidized and Non-subsidized Fuel, 2010-11.



Source: Calculated from Pertamina (2012) and Ministry of Energy and Mineral Resources (2010). *Notes*: Reference price refers to Pertamax recorded every month in the 15th day

Fuel subsidy also hinders the ability of ministries to expand their expenditure function to some extent. Tables 1 and 2 show that fuel subsidy expenditure is 8.5 times (or 850% higher than) food subsidy expenditure in 2011. The ratios are even starker in comparison with other types of subsidy including agriculture related subsides, Public Service Obligations (PSO), and Credit Assistance for micro and small enterprises Which are proactive in improving the conditions of poor and low-income households.

Fuel subsidy also imposes adverse effects on energy allocation and investment. Fuel subsidy drives excessive consumption and inefficient use of energy. Price difference between subsidized and non-subsidized fuel creates opportunities for smuggling. BPH Migas reported that 10 to 15 percent of subsidized fuels are redistributed illegally to industry particularly in industrial zones and mining area (GSI, 2011). These phenomena lead to distortion in the efficient allocation of energy and resources. The low prices of fuel due to the subsidy create disincentives for investment in energy diversification. Mourougane (2010) suggested that subsidy hinders investment in infrastructure for energy infrastructure.

Table 1: Subsidy Expenditure in Indonesia, 2005-2012.

Subsidy Expenditure	2005	2006	2007	2008	2009	2010	2011 APBN-P	2012 APBN
Energy								
Fuel subsidy (A)	95.6	64.2	83.8	139.1	45	82.4	129.7	123.6
Electricity	8.9	30.4	33.1	83.9	49.5	57.6	65.6	45
Total Energy (1)	**104.5**	**94.6**	**116.9**	**223**	**94.5**	**140**	**195.3**	**168.6**
Non-energy								
Food	6.4	5.3	6.6	12.1	13	15.2	15.3	15.6
Fertilizer	2.5	3.2	6.3	15.2	18.3	18.4	18.8	16.9
Plant seed	0.1	0.1	0.5	1	1.6	2.2	0.1	0.3
Public Service Obligation	0.9	1.8	1	1.7	1.3	1.4	1.8	2
Credit assistance	0.1	0.3	0.3	0.9	1.1	0.8	1.9	1.2
Tax subsidy	6.2	1.9	17.1	21	8.2	14.8	4	4.2
Other subsidy	0	0.3	1.5	0.3	0	0	0	0
Total Non-Energy (2)	**16.2**	**12.9**	**33.3**	**52.2**	**43.5**	**52.8**	**41.9**	**40.2**
Total Subsidy Expenditure (3=1+2)	**120.7**	**107.5**	**150.2**	**275.2**	**138**	**192.8**	**237.2**	**208.8**
Ratio (%) Fuel Subsidy/Total Subsidy (=A/3)	**79.2**	**59.7**	**55.8**	**50.5**	**32.6**	**42.7**	**54.7**	**59.2**

Source: Calculated from Coordinating Ministry of the Economy and Bank Indonesia, 2011.
Note: Subsidy expenditures from 2005 to 2010 are obtained from LKPP (Central Government Financial Report) where subsidy expenditure in 2011 is obtained from Revised APBN (National Revenue and Expenditure Budget).

It is envisaged that the government will eliminate fuel subsidy due to increasing fiscal pressure in coming years. This reform will certainly bring structural changes in the economy both for the government and for households. These structural changes should be evaluated to determine the extent of the impact on the economy.

Short-run impact of fuel subsidy removal to the economy is quite complex. Price levels will increase as prices of goods and services adjust. Output will also adjust given certain groups of households will reallocate their spending to compensate extra spending on fuel. Firms will keep their output level and prices will remain unchanged but firms will receive fewer margins per output produced.[1]

Fuel subsidy removal will certainly improve government budget. Expenditure-wise, the government will have more room for various fiscal policies from subsidy removal. The government should reallocate this extra budget to each sector accordingly.

[1] Assuming monopolistic competition in standard microeconomic foundation for macroeconomics.

The government, however, must simulate the effect on the economy of subsidy removal. Evidence obtained from impact simulation will be essential in providing guidelines regarding reallocation scheme. Unfortunately, there has been little research undertaken on the effect of the fuel subsidy removal to inform policy consideration. Specifically, there has been a paucity of consideration regarding the counterfactuals of phasing or removal of the fuel subsidy.

Table 2: Ratio of Fuel Subsidy to Other Subsidies, 2005-2012.

Ratio of Fuel Subsidy to Other Subsidy	2005	2006	2007	2008	2009	2010	2011 APBN-P	2012 APBN
Food	14.9	12.1	12.7	11.5	3.5	5.4	8.5	7.9
Fertilizer	38.2	20.1	13.3	9.2	2.5	4.5	6.9	7.3
Plant seed	956.0	642.0	167.6	139.1	28.1	37.5	1297.0	412.0
Public Service Obligation	106.2	35.7	83.8	81.8	34.6	58.9	72.1	61.8
Credit assistance	956.0	214.0	279.3	154.6	40.9	103.0	68.3	103.0
Tax subsidy	15.4	33.8	4.9	6.6	5.5	5.6	32.4	29.4

Source: Calculated from Coordinating Ministry of the Economy and Bank Indonesia, 2011.
Note: Subsidy expenditures from 2005 to 2010 are obtained from LKPP (Central Government Financial Report) where subsidy expenditure in 2011 is obtained from Revised APBN (National Revenue and Expenditure Budget).

The objective of this research is to construct general equilibrium analysis based on Indonesian Social Accounting Matrix (SAM). This analysis will be utilized to simulate the impacts of existing fuel subsidy scheme on the distributional broad-spectrum macroeconomic and microeconomic variables (Defourny & Thorbecke, 1984)—such as output, national income sectoral multiplier, employment, and household income in both agricultural and non-agricultural sector Output, Gross Domestic Product (GDP) and Income. Further, the analysis will also be utilized to simulate the impact of fuel subsidy removal on the distributional aspect of macro- and microeconomic variables.

The report is organized in five sections. The second section reviews relevant literatures subsequent to the introduction in the first section. The third section discusses data and methodology of constructing Social Accounting Matrix. The fourth section considers the results of the analysis. The fifth section is dedicated for discussions regarding the results of the analysis.

2. Literature Review

2.1. Fuel subsidy in Indonesia

Subsidy for consumption of energy is a common feature in developing countries. Such subsidy is defined as "any government action that lowers the cost of energy production, raises the revenue of energy producers, or lowers the price paid by energy consumers" (IEA, OECD, and World Bank, 2010, cited in GSI, 2011). In the case of Indonesia, energy subsidy is defined as government action that lowers the price paid by consumers thus referred to as consumer subsidies.

Energy subsidies would be theoretically justified if the subsidies improved social welfare (Elis, 2010). The GoI first implemented the fuel subsidy scheme owing to high revenue generation from the oil sector. The GoI felt that the people should receive benefit from the common resources by implementing the fuel subsidy (Pradiptyo & Sahadewo, 2012b). The scheme was also implemented to promote economic growth.

Fuel subsidy scheme in Indonesia, at least in the last eight years, is no longer sustainable. First, since 2004 Indonesia was no longer a net oil-exporting country. Thus, an increase in international crude price (ICP) would create oil trade deficit. The fuel subsidy scheme also distorts the efficient allocation of resources (GSI, 2011; Pradiptyo & Sahadewo, 2012a). GSI (2011), in particular, emphasized that the fuel subsidy encourages overconsumption and inefficient use of fuel.

The cost of the fuel subsidy scheme to the economy is tremendous particularly considering the increase of risk in the GoI's fiscal condition. *First*, the accounting cost of the subsidy to the GoI budget, as shown in Table 1, had increased tremendously as Indonesia has become a net fuel importer. The subsidy schemes impose budgetary pressures owing to vulnerability in ICP, and political difficulties and economic constraints in increasing the price of subsidized fuel. *Secondly*, the subsidy schemes impose opportunity cost to strategic poverty alleviation programs and infrastructure developments, as well as investment in renewable fuel alternatives.

The GoI pursues fuel subsidy reform in order to minimize the distortions and budgetary pressures. The reform, particularly removal of fuel subsidy, would be difficult as fuel prices are embedded in households and firms' optimization problem.

Removal of subsidy would impose negative impacts particularly to poor and medium-income households.

2.2. Previous Attempts to Phase Out or Eliminate Fuel Subsidy in Indonesia

Since its independence in 1945, subsidies have been a common feature in Indonesia‘s economy (Beaton & Lontoh, 2010). Beaton & Lontoh (2010) note that since the first presidential reign of Soekarno, the GoI has always attempted to stimulate economic development by prompting the private sector—using public sector spending. Other spending, which include transfer payment such as subsidies (typically on energy and rice), were used as a way to protect people from the effects of inflation. The amount of subsidy, especially fuel subsidy, had always been large. Beaton & Lontoh (2010) state that, in 1965, fuel subsidies represented approximately 20% of the country’s total spending.

In 1966, the rise of the New Order, led by Suharto, did not herald an end to the heavy subsidizing regime (Beaton & Lontoh, 2010). The new reign continued to oversee prices for fuel, electricity, urban transport and drinking water. Beaton & Lontoh (2010) reported, that as goods’ price increases did not match rises in costs, government had to bear a high fiscal pressure. Having to stimulate growth even more, Beaton & Lontoh state that government then started to solicit foreign aid and loans, and liberalize capital flow by offering investors generous incentives on investment packages in the Foreign Investment Act in 1967.

Following the Asian crisis in 1998, Soeharto was forced to sign up to an agreement with the IMF in order to qualify for an emergency loan. Beaton & Lontoh (2010) note that the agreement included dismantling of state and private monopolies and the reduction of subsidies to basic commodities. At the beginning of May 1998, the GoI announced large price increases for fuel and electricity. However, even after the New Order regime collapsed, subsidy was not easily phased out. There are several constraints restricting the GoI efforts to phase out subsidies: economic (e.g., inflation and hoarding), political, social, and behavioral.

2.2.1. Constraints in implementing policy to phase out fuel subsidy

There has been wide and prolonged debate on whether governments should reduce or remove fuel price subsidies. Removing fuel price subsidies, according to Burniaux &

Chateau (2011) would bring both economic and environmental benefit. In their study, Burniaux & Chateau (2011) suggested that if non-OECD countries were removing fuel price subsidy, most countries or regions exemplify welfare gains ranging from 0.3%, while the oil-exporting countries gains more than 4% by 2050. They added that the welfare gains associated with subsidy removal are accompanied, in most cases, by a more efficient allocation of resources across sectors. Bacon & Kojima (2006) conveyed that, while subsidy on fuel prices helps the poor, it is at a large cost to government and society. They also suggested that it is crucial for government to search for policies to move away from fuel price subsidies as rapidly as possible and switch to policies targeting assistance to the poor.

The four main constraints in removing fuel price subsidy such are prices hike, hampered growth, speculation and hoarding, and political turmoil. In Indonesia, the GoI has constantly encountered these problems. When deciding to reduce fuel subsidy in October 2005, Bacon & Kojima (2006) report that it resulted in extra purchasing and hoarding—with a significant drop in purchasing immediately after the price rise took effect. Because the October 2005 price increase was signaled beforehand, the extra purchasing and hoarding perniciously affected prices even before the policy was being implemented. Regarding speculation and hoarding, Bacon & Kojima (2006) also mentioned that, while short-term price elasticity of fuel demand is low, fuel hoarding and smuggling responds instantly to price changes.

Bacon & Kojima (2006) suggest that large fuel price increases exacerbate the gap between non-subsidized prices and subsidized prices, and when the gap is sufficiently large, causes localized shortages and black market pricing of subsidized fuels. Furthermore, because petroleum products are easy to store and transport, another problem arises where a neighboring country charges lower prices; phasing out fuel subsidy creates strong incentive to smuggle in the subsidized fuel from abroad for resale at domestic higher prices.

Apart from inflation, phasing out subsidy has always been a dilemmatic, as growth may be hampered. Because growth is necessary, governments understand that fuel and other energy must be affordable. In other words, they have to be cheap because fuel is critical to modern economies. Fuel is an essential component of a modern functioning economy. In Indonesia, this view seems to be plausible as subsidy removal reduces real output by 2% in the short-term (Clement, *et al.*, 2007). However, these research findings are contradictory to research conducted by Hope & Singh (1995) which indicates that a reduction of fuel subsidy stimulates higher growth. Other research conducted by IEA (1999 cited in Mourougane, 2010) suggests that Indonesia would actually gain a 0.24% increase in GDP if fuel subsidy were removed.

As inflation, hoarding, and slower growth might hurt the economy in a direct fashion, fuel price increases have also, historically, sparked large and sometimes violent social and political turmoil. The public has always responded negatively to plans regarding subsidy removal. Rampant protests are not common during the policy initiation. Analysts described fuel demonstrations as being symbolic of a wider public dissatisfaction with the GoI, particularly with regard to corruption and inefficiency perceived to permeate political and bureaucratic life in Indonesia (Bacon & Kojima, 2006). Bacon & Kojima (2006) suggest that society views and judges subsidy reductions against the background of other government decisions, which appeared to favor powerful interests and thus become difficult to administer.

2.2.2. Benefit of subsidy removal

Bacon & Kojima (2006) argue that six months after the fuel price increase in October 2005 the fuel consumption declined. They add that the higher price of fuel and dramatic fall in the vehicle sales is certain to have an effect on the growth of fuel consumption. The reduction in fuel consumption and subsidy eased fiscal pressure endured by government. However, Burniaux & Chateau (2011) note that for countries to achieve gains originating from an increase of consumer welfare, they should use more efficient resource reallocation policies. Similarly, Bacon & Kojima (2006) argue that government should develop policies which target poor households.

Further, not only reducing fuel consumption inefficiencies, phasing out fuel subsidies also have profound environmental benefits. The environmental benefit of reducing or removing fuel price subsidies can be seen from two aspects. *First*, phasing out fossil fuel subsidies would cut emissions—which would be beneficial for air quality and thus human health. At the G20 Leaders Summit in September 2009, summit leaders proclaimed that they would commit to "rationalize and phase out over the medium term inefficient fossil fuel subsidies that encourage wasteful consumption" (Burniaux &

Chateau, 2011). Burniaux and Chateau (2011) added that this commitment was conveyed after joint research by OECD and IEA, which had reached conclusions that the phasing out fossil-fuel subsidies[2] in some non-OECD countries would reduce world Greenhouse Gas (GHG) emissions by 10 percent in 2050.

Second, phasing out fuel subsidy would level the playing field of renewable energy. As stated in several articles, a large discrepancy between fossil fuel and renewable energy price creates disincentives on renewable energy. Reducing or removing fuel price subsidy would then allow for rapid transition from fossil fuel to renewable energy (Guerrerio, 2010). Guerrerio (2010) added that funds arising from fuel subsidy could be redirected to clean energy subsidy and other environmental programs designed to mitigate environmental degradation.

2.3. The Economics Modeling Approaches

Elis (2010) suggests two economic modeling approaches to study the impact of subsidy reform: partial- and general-equilibrium modelling. Von Moltke, *et al.* (2004) suggest that partial-equilibrium model considers the changes in energy markets, such as changes in price, demand, and production, because of subsidy reform. Such a model is not suitable for the case of Indonesia since the price of fuel is pegged at certain level and, therefore, not enough variation in price for the model to capture any correlation with demand and production.

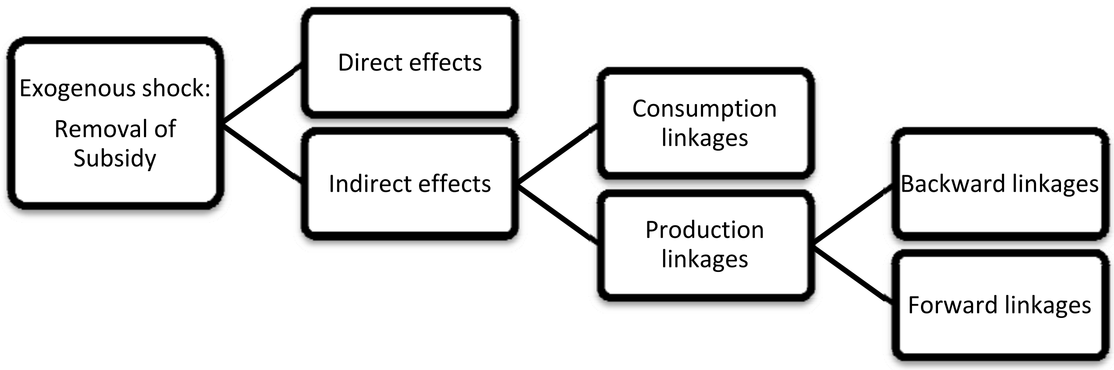
General-equilibrium modeling would be a more accurate approach to observe the changes in market for inputs and goods across sectors. An example of a general-equilibrium model is the Social Accounting Matrix, which can be extended to Computable General Equilibrium (CGE). Although CGE is a more powerful tool to simulate any shock, the accuracy of the result is heavily dependent on the quality and accuracy of the assumptions and data (Elis, 2010).

The strategy to phase out or remove fuel subsidy would certainly impose economic effects on the economy, specifically on output, national income, employment, as well as sectoral multiplier. Breisinger, *et al.* (2010) suggested that any exogenous shock would impose direct and indirect effects. Direct effects explain the effects to the sectors,

[2] Amounted USD 557 billions in 37 non-OECD countries and almost five times the yearly bilateral aid flows to developing countries in the form of Official Development Assistance (ODA).

directly affected by the shock. Hypothetically, removal of fuel subsidy would have direct impact on the land transportation sector. Indirect effects of the removal would be the correlation between transportation sectors with other sectors in the economy. Breisinger, *et al.* (2010) showed that the measure of the removal multiplier effect is the sum of direct and indirect linkages. (Figure 3)

Figure 3: Direct and Indirect Effects of an Exogenous Shock.



Source: Modification from Breisinger, *et al.* (2010).

The production linkages in the analysis of SAM include backward and forward linkages (Breisinger, *et al.* 2010). Backward linkages explain the decrease in demand of inputs as producers supply less goods and services owing to removal of fuel subsidy. Forward linkages on the other hand record the decrease in supply of inputs to upstream industries as the GoI removes the fuel subsidy. The stronger the forward and backward linkages, the larger are the multipliers. Unlike multipliers provided by input-output analysis, SAM multipliers capture both production and consumption linkages (Breisinger, *et al.* 2010).

Increase in the price of fuel owing to removal of the fuel subsidy, leads to first-, second-, and subsequent round linkage effects. The first-round linkage effect explains that decreases in production in the transportation sector leads to production disincentives in the transportation equipment industry. The subsequent second-round linkage effect explains that decrease in production of transportation equipment industry would affect other sectors. The multiplier effects in SAM analysis record the total effects of economic linkages over a period of time (Breisinger, *et al.* 2010).

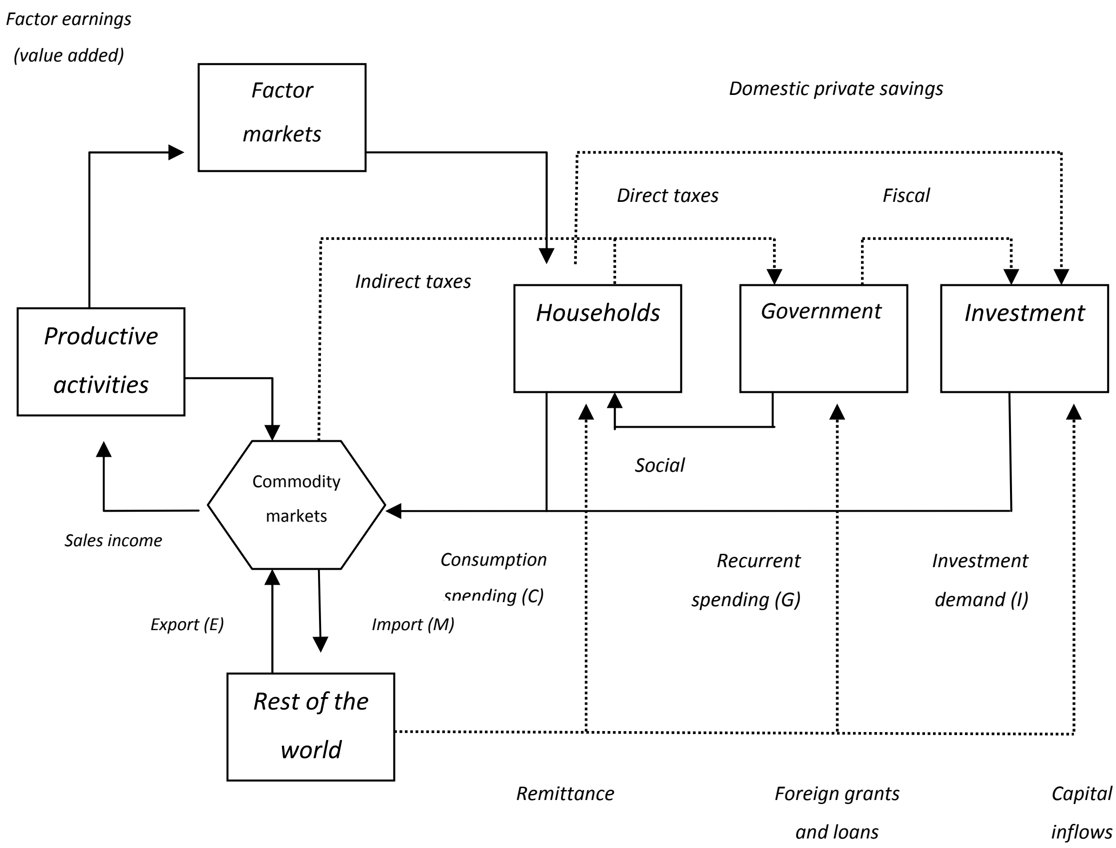
SAM analysis is widely used for economic-wide analysis in developing countries. Iqbal & Siddiqui (1999) studied the impact of fiscal adjustment on Pakistani income distribution. The fiscal adjustment studied was reduction in government expenditure including reduction in subsidy and public expenditure. Nganou, *et al.* (2009) analyzed the impact of oil price shocks on poverty and households' income distribution.

3. Data and Methodology

This study utilizes Indonesian SAM, published by the Central Bureau of Statistic (BPS), to construct the applied general equilibrium model. SAM is a skeletal system data presented in matrix form, which gives a broad overview of the economic and social conditions of society and the interrelationship between the two in a comprehensive, consistent and integrated form (Thorbecke, 2003). BPS (2010) explains that as a system framework of comprehensive and integrated data, SAM covers a wide range of economic and social data. This data is consistent because it ensures that the balance of transactions in each balance sheet is contained in it (Figure 4).

SAM is essentially a square matrix that describes monetary flows from a variety of economic transactions. The columns on the SAM represent spending (expenditures) while the rows describe the recipients (Table 3). Daryanto & Hafizrianda (2010) explained that one of the fundamental characteristics of SAM is its ability to present comprehensive and consistent information about the economic relations at the level of production and factors, as well as the government, households and firms (private sector). Specifically, analysis of SAM decomposes multiplier effects within and between domestic sectors in the process of economy-wide income generation (Trap, *et al.* 2002). Analysis of SAM also permits the examination of policy or external shocks impact on households' income distribution in rural and urban area (Iqbal & Siddiqui, 1999).

Figure 4: Flow Diagram of Circulation Economy.



Source: Breisinger, *et al.* (2010)

The basic framework SAM Indonesia includes 4 main balance sheets, namely (Civardi, *et al.* 2010):

1. The balance sheet of factors of production;
2. The balance sheet of the institution;
3. The balance sheet of the production sector, and
4. The balance sheet consisting of exogenous capital account and the rest of the world (ROW).

Each sheet is occupied rows and columns. The intersection between balance sheets with other balance sheet gives a special meaning (Table 3).

Table 3: Social Accounting Matrix Framework

Recipients	Spending				
	Production Factor	**Institution**	**Production Sector**	**Other Sheet**	**Total**
Production Factor			Allocation of added value to production factors	Income of production factors from abroad	Income distribution by production factors
Institution	Income allocation from production factor to institution	Transfer among institutions		Transfer from abroad	Institutional income distribution
Production Sector		Final demand	Intermediate demand	Export and investment	Total Output
Other Sheet	Income allocation from production factor to abroad	Saving	Import, indirect tax	Transfer and other balances	Total receipt
Total	Spending distribution of production factor	Institutional spending distribution	Total input	Total other spending	

Source: BPS (2010)

The Balance sheet of institutions includes households, enterprises, and governments. Households are classified into groups of mutually distinct socioeconomic levels. In Indonesian SAM 2008 data, the households were divided into eight groups. The households income is derived from the factors of production transfer both inter-household transfers, transfers from government and from companies and from abroad. Household expenditures are devoted to the consumption of goods and income taxes as well as some incorporated to saving in the capital account. Institutional income of the company comes from the profits and a portion of the transfer. Government expenditure in the form of consumption of goods and services, transfers to households and firms as well as some form of saving.

Fuel subsidy is assumed to be an exogenous account in the Indonesian Social Accounting Matrix. It is then injected into the Indonesian Social Accounting Matrix to observe its effects on other endogenous variables. The fuel subsidy in this study includes: Premium (with RON92) and Solar (automotive diesel oil or ADO). We assume that reduction in fuel subsidy is implemented uniformly to these two types of subsidized fuel. This assumption is sensible since fuel subsidy reductions in 2005 and 2008 were implemented uniformly.

4. Results

4.1. Impacts of Fuel Subsidy Removal

The analysis regarding impacts of fuel subsidy removal, which is the exogenous shock, starts with two basic scenarios. The impact of the removal, derived from these scenarios, would be defined as the change of multiplier before and after the exogenous shock. The scenarios include: 1) baseline multiplier analysis of Indonesia SAM and; 2) multiplier analysis of Indonesia SAM with IDR1 billion fuel subsidy reductions in the total subsidy. The output of this analysis is the multiplier impact of the shock in economy-wide variables including output, GDP, and production factors' income. The outputs of the analysis also include distribution of impact across production sectors, commodities, as well as households' distribution.

Table 4 shows that the fuel subsidy removal induces decreases in the values of the economy such as output, GDP, and production factors' income. The simulation shows that removal of the fuel subsidy by IDR 1 billion decreases the output, GDP, and income by approximately IDR 0.1639 billion, IDR 0.088 billion, and IDR 0.1119 billion respectively. A relatively higher change in output shows that removal of the fuel subsidy affects production sectors in Indonesia.

Table 4: Multiplier Analysis of SAM on Output, GDP, and Income.

Simulation	Output	GDP	Income
Baseline (A)	-2.5459	-1.6093	-2.0895
Scenario (B)	-2.7098	-1.6973	-2.2014
Impact in billion rupiah (C = B – A)	-0.1639	-0.088	-0.1119

Source: calculated from SNSE (2008)

Note: Sign (-) shows that the removal of fuel subsidy will have negative impacts on Output, GDP and Income. The impact (C) corresponds to removal of the fuel subsidy by IDR1 billion

Changes in the output multipliers in each production sector owing to fuel subsidy removal are specifically shown in Table 5.

Table 5: Multiplier Analysis of SAM on Production Sectors and Domestic Commodities.

Production Sector	Impacts in billion IDR	
	Impacts on Production Sectors	**Impacts on Domestic Commodities**
Chemical and cement industry	-0.0449	-0.0160
Electricity, gas, and drinking water	-0.0264	-0.0032
Food, beverage, and tobacco industry	-0.0117	-0.0148
Trade	-0.0115	-0.0119
Coal, metal, and oil mining	-0.0107	-0.0112
Paper, printing, transportation tools, metal products, and other industries	-0.0081	-0.0097
Crop farming	-0.0068	-0.0080
Government, defense, education, health, film, and other social services	-0.0067	-0.0067
Restaurant	-0.0039	-0.0038
Air Transportation and Communication	-0.0039	-0.0041
Livestock and Livestock products	-0.0038	-0.0051
Bank and insurance	-0.0036	-0.0037
Individual, households, and other services	-0.0036	-0.0036
Land transportation	-0.0035	-0.0034
Other crop farming	-0.0034	-0.0037
Real estate and service firms	-0.0034	-0.0035
Fishery	-0.0026	-0.0035
Garment, textile, clothes, and leather industry	-0.0021	-0.0024
Construction	-0.0013	-0.0013
Wood and wood products industry	-0.0008	-0.0010
Transportation supporting services and warehousing	-0.0005	-0.0005
Other mining industry	-0.0003	-0.0004
Forestry	-0.0002	-0.0003
Hotels	-0.0002	-0.0002

Source: calculated from SNSE (2008)
Note: Sign (-) shows that the removal of fuel subsidy will have negative impacts.

Each sector, in general, responded uniquely as shown by the difference in multipliers for each sector. The range of impact of IDR1 billion removal of subsidy is between IDR 2 million to IDR 0.0449 billion. The chemical and cement industry as well as electricity, gas, and drinking water sectors would experience the highest impact of fuel subsidy removal. The multiplier analysis of SAM shows that a IDR 1 billion removal of fuel subsidy will decrease the output of chemical and cement industry and electricity, gas, and drinking water sector by approximately IDR 0.0449 billion and IDR 0.0264 billion, respectively.

In practical terms, these sectors would be hit hardest as the industry utilizes a relatively high amount of subsidized fuel in their respective production processes. A relatively high decrease in output would also be evident in food, beverage, and tobacco industry, trade, as well as coal, metal, and oil mining. It is interesting to note that the magnitude of the impact on land transportation is not relatively high. An IDR 1 billion removal of subsidy would decrease production by only IDR 35 million.

This presents an avenue to conduct further study to follow up the result regarding the magnitude of the impact on land transportation. Sensible explanation for this result is that there are not many alternatives to land transportation for people particularly in urban areas. There would be time lag until the government establishes necessary public transportation. People, therefore, would still be using existing land transportation.

The multiplier analysis of SAM on domestic commodities shows relatively similar results to that on production sectors (Table 5). Removal of the fuel subsidy would affect domestic commodities produced by the chemical and cement industry and electricity, gas, and water sectors the most. Results in Table 5 also suggest that the GoI should address concerns to the trade sector. The trade sector and domestic trade commodity are also highly affected by the removal of fuel subsidies.

Table 6 shows the changes in multiplier on income of factors of production, which include labor and capital, owing to removal of fuel subsidy. The results of the simulation show that the impact on the labor multiplier is higher than that on capital. Specifically, an IDR 1 billion removal of subsidy would decrease labor income by IDR 0.0882 billion, about IDR 0.0374 billion higher than capital income. A more detailed analysis shows that labor in administration, sales, and services sector as well as production and unskilled labor would be affected the most. On the other hand, high-income labors as well as labor in the agriculture sector would, relatively, be the least affected by removal of the fuel subsidy.

Table 6: Multiplier Analysis of SAM on Income of Factors of Production.

			Baseline (A)	Scenario (B)	Impacts in billion rupiah (C = B– A)
Factors of Production	Labor	Agriculture	-0.1309	-0.1396	-0.0087
		Production, operators of transportation means, unskilled labors.	-0.1555	-0.1671	-0.0116
		Administration, sales, and services	-0.1955	-0.2079	-0,0124
		Leaders, military, professional, and technicians	-0.0787	-0.0834	-0,0047
	Non-labor (Capital)		-1.0487	-1.0995	-0.0508

Source: calculated from SNSE (2008)
Note: Sign (-) shows that the removal of fuel subsidy will have negative impacts.

Table 7 summarizes the multiplier analysis of SAM on income distribution of different types of household, firms, and the government.

Table 7: Multiplier Analysis of SAM on Income Distribution.

				Baseline (A)	Scenario (B)	Impacts (C = B– A)
HOUSEHOLDS	Agri-culture	Labor		-0.0425	-0.045	-0.0025
		Enterpreneurs		-0.1837	-0.1947	-0.0110
	Non-Agriculture	Rural	Low-income enterpreneurs, administration officer, unskilled labor, and individual services	-0.1163	-0.1232	-0.0069
			Non labor force	-0.0421	-0.0447	-0.0026
			High-income enterpreneurs, non-agricultural enterpreneurs, managers, military, professional, and technicians.	-0.1284	-0.1359	-0.0075
		Urban	Low-income entrepreneurs, administration officer, unskilled labor, and individual services	-0.1729	-0.1834	-0.0105
			Non labor force	-0.0644	-0.0682	-0.0037
			High-income entrepreneurs, non-agricultural entrepreneurs, managers, military, professional, and technicians.	-0.225	-0.2379	-0.0129
FIRMS				-0.7799	-0.8177	-0.0379
GOVERNMENTS				-0.3343	-0.3508	-0.0165

Source: calculated from SNSE (2008)
Note: Sign (-) shows that the removal of fuel subsidy will have negative impacts.

An IDR 1 billion decrease in the fuel subsidy would decrease the households' income by IDR 0.576 billion. The results shows that households in non-agriculture sector would be affected the most by removal of the subsidy. Specifically, urban households, particularly managers, military, professionals, and technicians, would experience the highest impact of the removal. This type of household would also experience the highest impact in the rural area. Households in agriculture sector are also relatively affected by removal of the subsidy particularly entrepreneurs. These results are sensible since these types of household are most likely to own a car(s) thus they consume a relatively high amount of subsidized fuel.

Removal of the fuel subsidy also imposes pressure on firms' income. The impact of an IDR 1 billion removal of the fuel subsidy would decrease firms' income by IDR 0.379 billion. Firms' income decreases as their supply of goods and services decline owing to decrease in the final demand. The decrease in firms' income would trickle down to sectors through economic linkages. The government would also experience decrease in income owing to the removal of the fuel subsidy. Although the government's subsidy expenditure decreases, the magnitude of decrease in tax revenue is relatively greater. The removal of the fuel subsidy would therefore reduce government income.

4.2. The Impact of Fuel Subsidy Reallocation to the Economy

The main benefit of fuel subsidy removal is the availability of government's endowment to be reallocated to other sectors. This endowment should be reallocated to strategic programs that would create multiplier effect both in the short- and long-run. For example, the endowment could be reallocated to enhance the existing poverty alleviation programs such as Rice for the Poor (*Raskin*) and Community Empowerment Based Poverty Reduction Program (*PNPM*). The endowment could also be reallocated to strategic programs intended for development of human quality such as Health Insurance for the Poor (*Askeskin*) and School Operating Grants (*BOS*). Further impact evaluation studies should be conducted to observe the optimum programs for these.

This study will provide the impact of reallocation to output, GDP, and income distribution using the analysis of SAM. The sectors are chosen based on several parameters available in Indonesia SAM. These parameters include consumption expenditure, number of workers, and average labor's wage. Consumption expenditure parameters include those in agriculture as well as rural and urban non-agriculture sector. Table 8 shows the priority sectors chosen based on the highest value for each parameter.

Table 8: Priority Sectors for Reallocation.

Parameter	Sector
Consumption expenditure in agriculture sector	Food, Beverage, and Tobacco Industry
Consumption expenditure in non-agriculture sector	
Rural	Food, Beverage, and Tobacco Industry
Urban	Food, Beverage, and Tobacco Industry
Average labor's wage	Trade
Number of workers	Agriculture

Source: calculated from SNSE (2008)

Table 9 shows the impact of IDR 1 billion reallocation of fuel subsidy to output, GDP, and multiplier through four different sectors. The simulation shows that the results of reallocation through different sectors vary. Reallocation to food, beverage, and tobacco industry provide the biggest impact to the economy. The impact is relatively lower than that of fuel subsidy removal shown in Table 4. The results suggest that fuel subsidy has greater backward and forward linkages relative to these sectors thus implying a higher multiplier.

Table 9: Impact of Reallocation to National Output, GDP, and Income Multiplier.

Simulation: Impact of Reallocation to a Sector	Output	GDP	Income
Agriculture	0.1141	0.0613	0.0779
Trade	0.1179	0.0633	0.0805
Food, Beverage, and Tobacco Industry	0.1205	0.0647	0.0823
Education and Health	0.1186	0.0637	0.0810

Source: calculated from SNSE (2008).

We can observe that the overall benefit of fuel subsidy removal is negative, calculated from results shown in Table 4 and Table 9. There are two possible explanations for our result. First, the reliance of sectors to fuel subsidy is very high thus multiplier effects of removal is higher than that of any direct reallocation scheme. Second, this result does not take into account the reduction in inefficiencies, such as traffic congestion, excessive use of personal vehicle, and unequal distribution of subsidized fuel among sectors, created by fuel subsidy scheme. This assumption may understate the effect of fuel subsidy removal and/or reallocation to other sectors.

The impacts of reallocation to output multipliers in each production sector are specifically shown in Table 10.

Table 10: Sectoral Reallocation Impact to Multiplier on Production Sectors.

		Impacts in billion IDR			
		Agriculture	**Trade**	**Food Beverage and Tobacco Industry**	**Education and Health**
PRODUCTION SECTORS	Chemical and cement industry	0.0313	0.0323	0.033	0.0325
	Electricity, gas, and drinking water	0.0184	0.019	0.0194	0.0191
	Food, beverage, and tobacco industry	0.0081	0.0084	0.0086	0.0085
	Trade	0.008	0.0082	0.0084	0.0083
	Coal, metal, and oil mining	0.0075	0.0077	0.0079	0.0077
	Paper, printing, transportation tools, metal products, and other industries	0.0056	0.0058	0.006	0.0059
	Crop farming	0.0047	0.0049	0.005	0.0049
	Government, defense, education, health, film, and other social services	0.0047	0.0048	0.0049	0.0048
	Livestock and livestock product	0.0027	0.0028	0.0028	0.0028
	Restaurant	0.0027	0.0028	0.0029	0.0028
	Air and water transportation and communication	0.0027	0.0028	0.0029	0.0029
	Bank and insurance	0.0025	0.0026	0.0026	0.0026
	Individual, households, and other services	0.0025	0.0026	0.0026	0.0026
	Other crop farming	0.0024	0.0024	0.0025	0.0024
	Land transportation	0.0024	0.0025	0.0026	0.0025
	Real estate and service firms	0.0024	0.0025	0.0025	0.0025
	Fishery	0.0018	0.0019	0.0019	0.0019
	Garment, textile, clothes, and leather industry	0.0014	0.0015	0.0015	0.0015
	Construction	0.0009	0.0009	0.001	0.001
	Wood and wood products industry	0.0005	0.0006	0.0006	0.0006
	Transportation supporting services and warehousing	0.0004	0.0004	0.0004	0.0004
	Forestry	0.0002	0.0002	0.0002	0.0002
	Other mining industry	0.0002	0.0002	0.0002	0.0002
	Hotel	0.0001	0.0001	0.0001	0.0001

Source: calculated from SNSE (2008)

Each sector, in general, responded uniquely to reallocation of fuel subsidy through different sectors. The sectoral distribution of the impact of reallocation is relatively different from that of fuel subsidy removal. The sectors that pertained the highest impact are: 1) chemical and cement industry; 2) electricity, gas, and drinking water; 3) food, beverage, and tobacco industry; 4) and trade. The impact of reallocation is also relatively lower than that of fuel subsidy removal shown in Table 5.

The impacts of reallocation of fuel subsidy to the distribution of income vary across households. The impact mostly benefits urban households in the non-agricultural sector particularly high-income entrepreneurs, managers, military, professional, and technicians. Urban households would experience the highest impact of reallocation owing to greater backward and forward linkages of economic activities in urban areas. Entrepreneurs in the agriculture sector would also experience a great multiplier impact owing to production and consumption linkages to other sectors (Table 11).

Table 11: Impact of Reallocation on Income Distribution Multiplier

				Agriculture	Trade	Food Beverage and Tobacco Industry	Education and Health
HOUSEHOLDS	Agri-culture		Labor	0.0017	0.0018	0.0018	0.0018
			Entrepreneurs	0.0077	0.0079	0.0081	0.0080
	Non-Agriculture	Rural	Low-income entrepreneurs, administration officer, unskilled labor, and individual services	0.0048	0.0049	0.0051	0.0050
			Non labor force	0.0018	0.0018	0.0019	0.0019
			High-income entrepreneurs, non-agricultural entrepreneurs, managers, military, professional, and technicians.	0.0052	0.0054	0.0055	0.0054
		Urban	Low-income entrepreneurs, administration officer, unskilled labor, and individual services	0.0073	0.0075	0.0077	0.0076
			Non labor force	0.0026	0.0027	0.0028	0.0027
			High-income entrepreneurs, non-agricultural entrepreneurs, managers, military, professional, and technicians.	0.0090	0.0093	0.0095	0.0093

Source: calculated from SNSE (2008)

4.3. Distributional Effect of the Reallocation: Structural Path Analysis (SPA)

This research applies Structural Path Analysis (SPA) to trace the sectoral interactions in the Indonesian economy. The SPA provides information on how the impacts of fuel subsidy removal and subsidy reallocation are transmitted from one sector to the others. By using SPA, elements of multipliers can be decomposed into three impacts: direct influence (DE), total influence (TE) and global influence (GE).

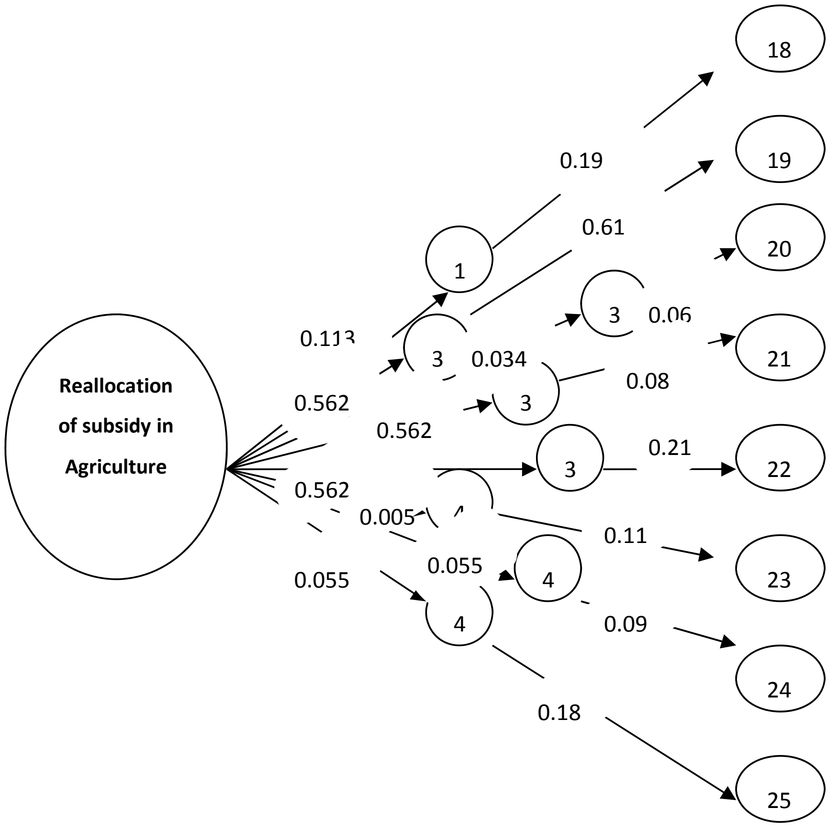
Direct influence (DE) of sector *i* on sector *j* represents the changes in sector *j*'s income or production due to the 1 unit output change in sector *i* (holding the other income and production constant). Total influence (TE) of sector *i* on sector *j* shows the changes in sector *j*'s income or production due to the output change in sector *i* through both elementary and circuit paths. Global influence (GE) of sector *i* on sector *j* represents the overall changes in sector *j*'s income or production due to the 1 unit output change of *i*.

Figure 5 shows the distributional impacts of the fuel subsidy removal and Figures 6 to 9 shows subsidy reallocation on agriculture; trade; food, beverage, and tobacco; and health and education sector, respectively. Figure 5 shows that the distributional effect of reallocation will affect the urban class most, followed by the rural class. The urban and rural classes include upper class entrepreneurs, nonagricultural entrepreneurs, managers, military, professionals, technicians, teachers, workers and sales, administrative staff. This result is sensible since the numbers of households in urban areas are relatively higher than those in rural areas.

Figure 6 shows the distributional effect of subsidy reallocation on the agriculture sector. Households in rural areas will be benefited most from the reallocation owing to their dependence on agricultural activities. Distributional effects of reallocation on trade sector, on the other hand, benefit the urban class most (Figure 7). These results also show that the urban class depends mostly on trade while the rural class depends mostly on the agriculture sector.

Figure 8 and 9 shows the effect of reallocation on food, beverage, and tobacco and education and health sectors respectively. Household groups who will be benefited the most from reallocation to food, beverage, and tobacco sector are those who work in urban areas as low-class employers, administrative staff, mobile vendors, transportation sector workers. On the other hand, urban households working as upper class entrepreneurs, nonagricultural entrepreneurs, managers, military, professionals, technicians, teachers, and sales administrative, will be benefited the most by reallocation to education and health sector.

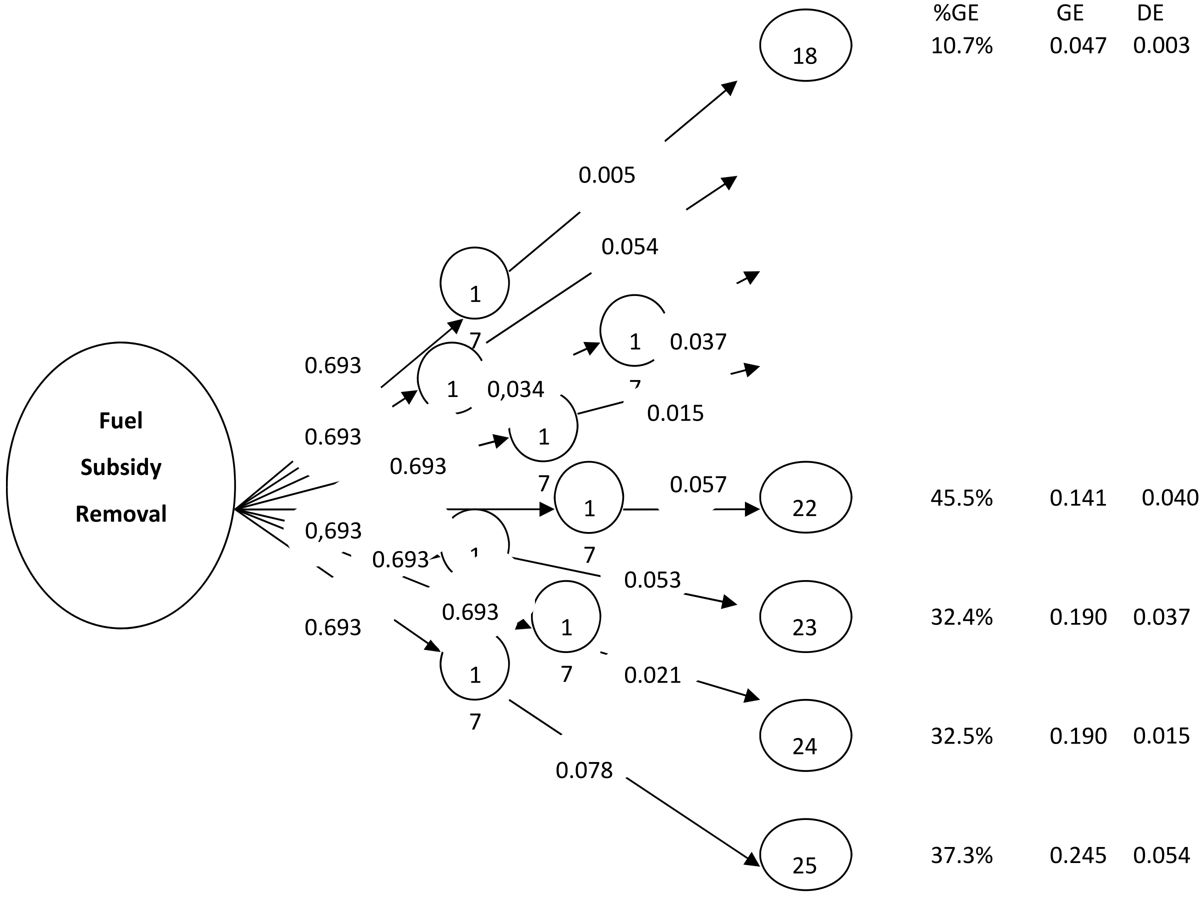
Figure 5: Distributional Effect of the Fuel Subsidy Removal



%GE	GE	DE
24.9%	0.120	0.022
71.9 %	0.695	0.345
26.5%	0.188	0.034
57.3 %	0.115	0.049
58.4%	0.295	0.121
4.9 %	0.191	0.006
9.6%	0.073	0.005
5.7%	0.266	0.010

Notes:
1: Labor in agriculture as wage and salary earner in the village
3: Labor in agriculture as non wage and salary earner the village
4: Labor in agriculture as non wage and salary earner the city
18: Labor
19: Agricultural Employers
20: Employers are free of low class, administrative staff, mobile vendors, free transport sector workers, personal services, manual labor (rural)
21: Not the labor force and the group is not clear (rural)
22: Entrepreneur free upper class, not the agricultural entrepreneurs, managers, military, professionals, technicians, teachers, workers and sales, administrative staff, upper class (rural)
23: Employers are free of low class, administrative staff, mobile vendors, free transport sector workers, personal services, unskilled laborers (urban)
24: Not the labor force and the group is not clear (urban)
25: Entrepreneur free upper class, not the agricultural entrepreneurs, managers, military, professionals, technicians, teachers, workers and sales, administrative staff, upper class (urban)

Figure 6: Distributional Effect of the Reallocation: Agriculture



Notes:

1: Labor in agriculturee as wage and salary earner in the village

3: Labor in agriculture as non wage and salary earner the village

4: Labor in agriculture as non wage and salary earner the city

18: Labor

19: Agricultural Employers

20: Employers are free of low class, administrative staff, mobile vendors, free transport sector workers, personal services, manual labor (rural)

21: Not the labor force and the group is not clear (rural)

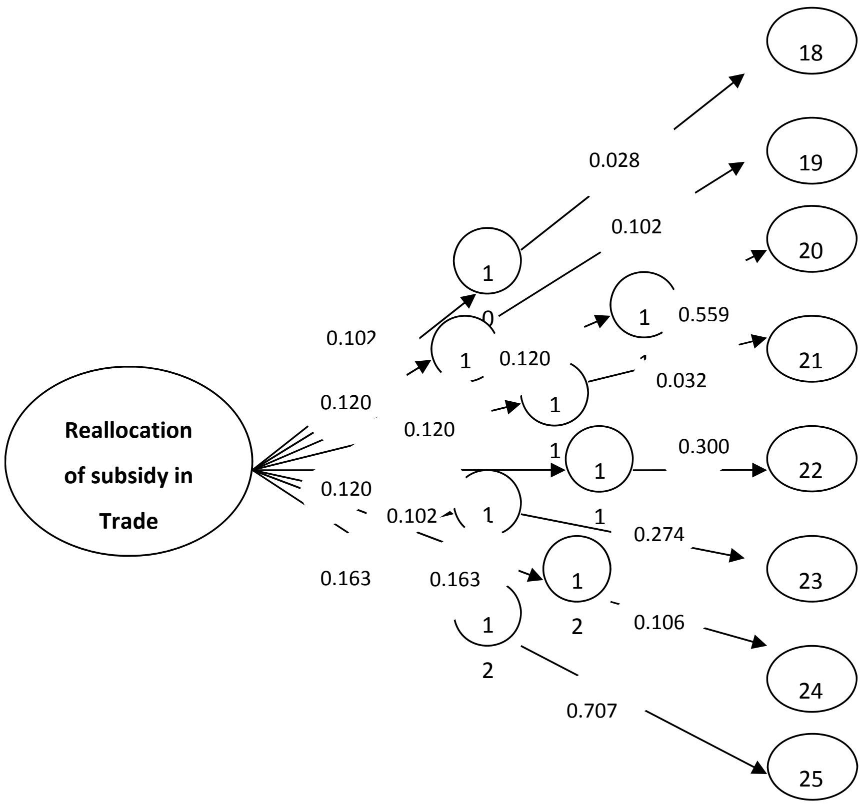
22: Entrepreneur free upper class, non agricultural entrepreneurs, managers, military, professionals, technicians, teachers, workers and sales, administrative staff, upper class (rural)

23: Employers are free of low class, administrative staff, mobile vendors, free transport sector workers, personal services, unskilled laborers (urban)

24: Not the labor force and the group is not clear (urban)

25: Entrepreneur free upper class, non agricultural entrepreneurs, managers, military, professionals, technicians, teachers, workers and sales, administrative staff, upper class (urban)

Figure 7: Distributional Effect of the Reallocation: Trade



Group	%GE	GE	DE
18	6.9%	0.058	0.003
19	7.5%	0.253	0.012
20	45%	0.206	0.067
21	9.3%	0.055	0.004
22	26%	0.194	0.036
23	15.9 %	0.264	0.028
24	22.1%	0.105	0.017
25	38.5%	0.432	0.115

Notes :

10: Clerical labor, sales, services and salary wage earners in the city

11: Clerical labor, sales, services are not receiving wages and salaries in the village

12: Clerical labor, sales, services are not receiving wages and salaries in the city

18: Labor

19: Agricultural Employers

20: Employers are free of low class, administrative staff, mobile vendors, free transport sector workers, personal services, manual labor (rural)

21: Not the labor force and the group is not clear (rural)

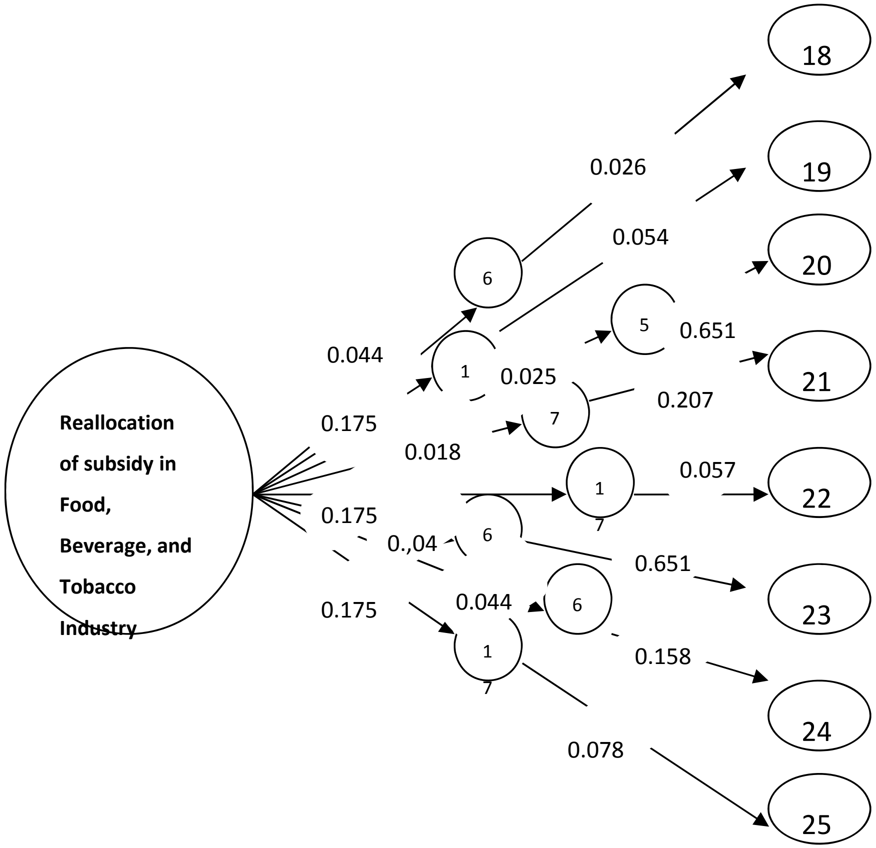
22: Entrepreneur free upper class, not the agricultural entrepreneurs, managers, military, professionals, technicians, teachers, workers and sales administrative staff, upper class (rural)

23: Employers are free of low class, administrative staff, mobile vendors, free transport sector workers, personal services, unskilled laborers (urban)

24: Not the labor force and the group is not clear (urban)

25: Entrepreneur free upper class, non agricultural entrepreneurs, managers, military, professionals, technicians, teachers, workers and sales administrative staff, upper class (urban)

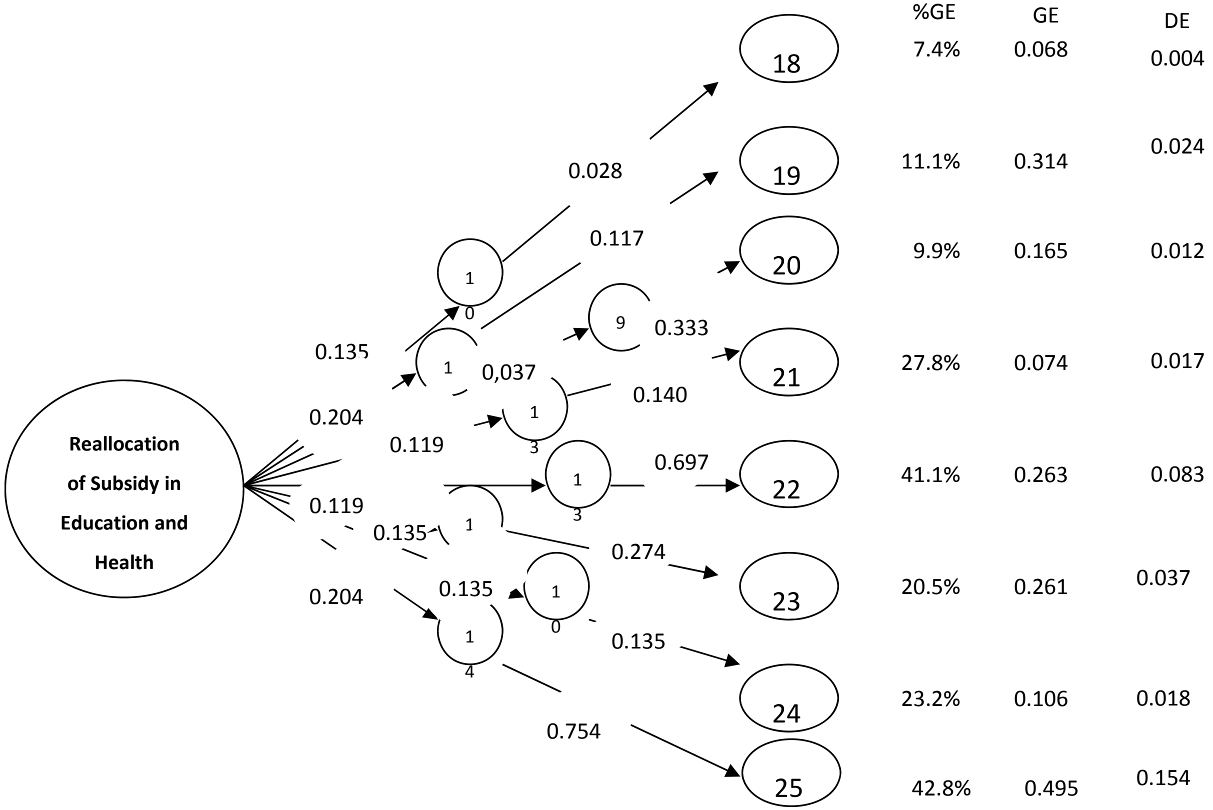
Figure 8: Distributional Effect of the Reallocation: Food Beverage and Tobacco Industry



	%GE	GE	DE
18	2.4%	0.078	0.001
19	4.9%	0.378	0.009
20	14.9%	0.173	0.016
21	7.5%	0.075	0.004
22	9.3%	0.203	0.010
23	21%	0.231	0.029
24	14%	0.080	0.007
25	9.7%	0.280	0.014

Notes :
5: Production, service, transportation, and manual labors receiving wages and salaries in the village
6: Production, service, transportation, and manual labors receiving wages and salaries in the city
7: Production, service, transportation, manual and unskilled labors are not receiving wages and salaries in the village
17: Capital
18: Labor
19: Agricultural Employers
20: Employers are free of low class, administrative staff, mobile vendors, free transport sector workers, personal services, manual labor (rural)
21: Not the labor force and the group is not clear (rural)
22: Entrepreneur free upper class, not the agricultural entrepreneurs, managers, military, professionals, technicians, teachers, workers and sales administrative staff upper class (rural)
23: Employers are free of low class, administrative staff , power, mobile vendors, free transport sector workers, personal services, unskilled laborers (urban)
24: Not the labor force and the group is not clear (urban)
25: Entrepreneur free upper class, not the agricultural entrepreneurs, managers, military, professionals, technicians, teachers, workers and sales administrative staff upper class (urban)

Figure 9: Distributional Effect of the Reallocation: Education and Health



Notes

9: Clerical labor, sales, services and salary wage earners in the village

10: Clerical labor, sales, services and salary wage earners in the city

13: Leadership labor, management, military, professional and technical wage earners and salary in the village

14: Leadership labor, management, military, professional and technical wage earners and salary in the city

18: Labor

19: Agricultural Employers

20: Employers are free of low class, administrative staff, mobile vendors, free transport sector workers, personal services, manual labor (rural)

21: Not the labor force and the group is not clear (rural)

22: Entrepreneur free upper class non agricultural entrepreneurs, managers, military, professionals, technicians, teachers, workers and sales administrative staff upper class (rural)

23: Employers are free of low class, administrative staff power, mobile vendors, free transport sector workers, personal services, unskilled laborers (urban)

24: Not the labor force and the group is not clear (urban)

25: Entrepreneur free upper class, non agricultural entrepreneurs, managers, military, professionals, technicians, teachers, workers and sales administrative staff upper class (urban)

5. Conclusions

The analysis of impact using SAM yields useful information regarding sectoral impact and provides analysis regarding country-wide impact of the removal of fuel subsidy. Simulation of Indonesia SAM shows that fuel subsidy removal would affect economy-wide variables such as output, GDP, and production factors' income. Simulation also shows that removal of fuel subsidy would affect income distribution of households, firms, and governments. Analysis of reallocations of fuel subsidy to four targeted sectors—i.e., agriculture; trade; food, beverage, and tobacco industry; and education and health—shows that the economy would be positively affected. However, the impact of reallocation would be relatively smaller than that of fuel subsidy removal.

Some policy implications can be drawn. *First*, the removal of fuel subsidy can affect the Indonesian economy through aggregate demand side (consumption. investment, government expenditure and net-export, which may result in demand-pull inflation) and aggregate supply side (cost of production, which may cause cost-push inflation). For the reasons of long-term efficiency, competitive advantage, and manageable economic, social and political instability, the GoI should have a clear long-term "scheduled" and "gradual" program of fuel subsidy reduction, and not the "big-bang" total removal of the fuel subsidy. *Second*, the GoI could consider a certain amount of subsidy which is adjusted with the increase of government fiscal capacity and let the domestic fuel price fluctuated as the ICP fluctuated. Societies (both domestic consumers and producers) will learn rationally and adjust logically with the fluctuation of domestic fuel price. *Third*, the GoI should not consider the "sectoral approach" to reallocate the fuel subsidy. Our analysis proves the impact of reallocation to four targeted sectors would bring relatively smaller positive effect than the negative effects of fuel subsidy removal. The GoI should consider programs such as "targeted fuel subsidy" to correct the misallocation the fuel subsidy (i.e. subsidy for the poor). As the poor will be affected most, the GoI should consider continuing compensation programs for the poor (example: *Bantuan Langsung Tunai* (BLT) or direct transfer) which take into account regional perspectives.

It is important to note some shortcomings of SAM output for policymaking. The multipliers are derived under a specific structure of the economy and dependencies between industry and sectors (Slee, *et al.* 2001). Schwarz (2010) notes that these dependencies vary between economies, and between regions within an economy. He also emphasized that the multiplier is derived using a dataset of transactions in a particular year. The multipliers, therefore, do not take into account the dynamics occurring within a year. The impacts of an equivalent removal of the fuel subsidy by IDR 1 billion will vary widely across year. Furthermore, overestimation of impact is imminent as substitution effects are not taken into account owing to fixed prices (Round, 2003). However, in the research we emphasize that the SAM model is not solving an optimizing equilibrium. We compare the multipliers of the initial condition where fuel subsidy exists (original SAM) – “distorted equilibrium” or disequilibrium)- with those of the new condition where fuel subsidy is removed and reallocated (simulated SAM) – another “distorted equilibrium” or disequilibrium. Therefore, the simulation is not appropriate to address efficiency issues.

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Appendix

Sectoral Reallocation Impact to Multiplier on Domestic Commodities.

		Reallocation Impacts in billion IDR			
		Agriculture	**Trade**	**Food Beverage and Tobacco Industry**	**Education and Health**
PRODUCTION SECTORS	Chemical and cement industry	0.0111	0.0115	0.0118	0.0116
	Food. beverage. and tobacco industry	0.0103	0.0106	0.0109	0.0107
	Trade	0.0083	0.0085	0.0087	0.0086
	Coal. metal. and oil mining	0.0078	0.0081	0.0082	0.0081
	Paper. printing. transportation tools. metal products. and other industries	0.0068	0.007	0.0072	0.0071
	Crop farming	0.0056	0.0058	0.0059	0.0058
	Government. defense. education. health. film. and other social services	0.0047	0.0048	0.0049	0.0049
	Livestock and livestock product	0.0035	0.0037	0.0037	0.0037
	Restaurant	0.0028	0.0029	0.003	0.0029
	Other crop farming	0.0026	0.0027	0.0027	0.0027
	Air and water transportation and communication	0.0026	0.0027	0.0028	0.0027
	Individual. households. and other services	0.0026	0.0026	0.0027	0.0027
	Bank and insurance	0.0025	0.0026	0.0026	0.0026
	Real estate and service firms	0.0025	0.0025	0.0026	0.0026
	Fishery	0.0024	0.0025	0.0026	0.0025
	Land transportation	0.0024	0.0024	0.0025	0.0024
	Electricity. gas. and drinking water	0.0022	0.0023	0.0023	0.0023
	Garment. textile. clothes. and leather industry	0.0016	0.0017	0.0017	0.0017
	Construction	0.0009	0.001	0.001	0.001
	Wood and wood products industry	0.0007	0.0007	0.0007	0.0007
	Transportation supporting services and warehousing	0.0004	0.0004	0.0004	0.0004
	Other mining industry	0.0003	0.0003	0.0003	0.0003
	Forestry	0.0002	0.0002	0.0002	0.0002
	Hotel	0.0002	0.0002	0.0002	0.0002

Source: calculated from SNSE (2008)

CHAPTER 9

Economic Impacts of Subsidy Rationalization in Malaysia

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Subsidy rationalization efforts by governments remain constrained as many policy plans have been delayed based on argument that subsidy policies have objectives that go beyond economic rationale. This paper examines Malaysia's energy subsidy experience, in terms of the direct and indirect effects of subsidy distribution and reallocation, and considers whether the rationale for subsidy policy in the case of energy has been justified. Subsidy removal impacts how efficient an economy performs in terms: of energy product prices; cost of production; transportation services; government budget; household consumption: and general level of prices. As a subsidy row is non-existence in the 2005 published Malaysian input-output (I-O) table which would inform current policy, we create a subsidy row in the form of total fuel subsidy which has been constructed to assess the expected impacts of phasing out fuel subsidies in the short, medium and long run. This study employs Leontief's and a computable general equilibrium (CGE) model based on national and social accounts of the Malaysian economy, disaggregating and constructing a hybrid energy I-O matrix and partitioning the I-O table into energy and non-energy blocks. An explicit representation of the impacts of energy products; especially those which have received greater amounts of subsidy is embedded in this modelling. The modelling informs energy pricing, the domains of government intervention in energy markets, and the international experience in mitigating the negative impact of energy pricing reform. Features of the petroleum sector in the Malaysian economy and its interactions with the main economic variables are considered. I-O analysis is used to set a reallocation scheme using changes in wage levels and value added impacted by total fuel subsidy particularly on autonomous spending by households and growth. Finally, the CGE analysis, which is superior in substitution effects compared with I-O analysis, will explain the overall macroeconomic impacts of phasing out subsidies and the impacts of reallocation into related sectors using government expenditure. In conclusion, policy options reliant on cheap energy inputs and delays in subsidy rationalization pose a significant threat for Malaysia's continuing economic competitiveness in the region.

1. Introduction

The East Asian (EA) region's energy market integration was purposely mooted as an approach to achieve overall regional economic development and to narrow development gaps amongst EA member countries. Endowed with varied energy resources in terms of supply, demand and availability, the EA region needs a coordinated approach to harness and utilize the full potential of energy resources to fuel economic growth in the region. It is estimated that the region will spend USD 6-10 trillion of investment over the next couple of decades in the energy sector to meet future demand (UNEP 2004). This investment is expected to affect domestic and regional economies and will create distortion in the energy market; phasing out energy subsidies is amongst the most prevalent challenges of regional energy market integration. Despite these challenges, policy makers in Malaysia have justified delaying subsidy removal programmes with argument that subsidy removal policy goes beyond the economic rationale.

1.1. Background

Two key tasks for policy makers amongst various actions required for Energy Market Integration (EMI) is the removal of energy price distortions and the creation of an enabling environment for investment in the sector. Energy commodities across the region are taxed and subsidized at various levels. These taxes and subsidies engender huge market distortion and hinder harmonization of the EA energy market.

There are diverse energy and non-energy subsidies in Malaysia, most of which are intended to ease the conditions of poor groups particularly during crude oil price increase. Table 1 shows that the majority of energy subsidies are concentrated on petrol products and petroleum refinery. Total expenditure on fuel subsidy has been influenced by increased investment and the recent rise of crude oil prices. Table 1 further illustrates that Fuel subsidies are often offset by tax exemption and levies amounting to 10.4 % of total government expenditure in 2005. In the same year operating expenditure was recorded at RM10.9 billion and doubled to RM23.7 billion in 2011 as announced in the 2011 budget by the Ministry of Finance (Bernama, 2010). Remaining subsidies are becoming a relatively smaller share of total operating expenditure as compared to the increasing share attributed to fuel subsidy as shown in Table 1.

Energy subsidy is considered an effective policy tool which may assist poor groups in a population. However, fuel subsidy is indiscriminately employed in Malaysia and impacts all fuel consumers. This has led to queuing and blockades at petrol stations before announcements of fuel price increases. It has been argued that the unexpected timing and magnitude of fuel price increases have intensified public anger (Straits Times, 2006). For example, it has been suggested that a subsidy reduction of 1 cent for the retail price of petrol could represent a reduction of Government expenditure by as much as RM134 million (Malay Mail, July 2010). The negative economic effects resulting from transfer of payment through fuel subsidy depending on types, size and the structure of the economy and compelling evidence that subsidy causes large economic costs in the long run suggests that fuel subsidy rationalization is an important policy consideration.

Table 1 shows that petroleum subsidy alone amounted to almost RM18 billion in 2008. Total fuel subsidy is about 8.9% of total government expenditure or about 3.65% of gross domestic product (GDP). About RM15.9 billion worth of petrol and diesel subsidy is expected to be incurred in 2011 compared to RM9.6 billion that was spent in subsidising products in 2010. Direct fuel subsidies have increased significantly over the years placing growing pressure on government finances and exacerbating national deficit for over a decade. The fiscal ramifications of fuel subsidy impacts other parts of Malaysia's national accounts including the balance of payments, trade and others.

Subsidy budget is substantial and has grown annually at an exponential rate since the 1990s, the highest rate occurring in 2008. For example, in 2005 the total bill for fuel subsidy was about USD 3.66 billion[1] (RM10.9 billion), which amounted to USD 138 per capita fuel subsidy. This per capita subsidy value is higher than that of Malaysia's neighbouring country Indonesia, which spent in the same year USD 10.1 billion on total subsidy, but which has a lower fuel subsidy per capita of only USD 43.91.

[1] Sourced from the EIA 2011.

Table 1: Fuel Subsidy in Malaysia 1990 to 2010

Year	Total subsidies (RM million)	Of which: Fuel subsidies (RM million)	Total government expenditure (RM million)	Total government	
				Total subsidies	Fuel subsidies
1990	494	27	35,715	1.4	0.1
1991	965	401	37,861	2.5	1.1
1992	560	15	41,763	1.3	0
1993	589	23	42,341	1.4	0.1
1994	588	55	46,341	1.3	0.1
1995	612	123	50,624	1.2	0.2
1996	850	180	58,493	1.5	0.3
1997	958	228	60,415	1.6	0.4
1998	1,151	500	62,688	1.8	0.8
1999	1,136	458	69,313	1.6	0.7
2000	4,824	3,170	84,488	5.7	3.8
2001	4,552	2,881	98,992	4.6	2.9
2002	3,677	1,651	105,676	3.5	1.6
2003	2,679	1,006	114,577	2.3	0.9
2004	5,796	3,343	120,162	4.8	2.8
2005	13,387	10,984	128,278	10.4	8.6
2006	10,112	7,558	143,501	7	5.3
2007	10,481	7,473	163,649	6.4	4.6
2008	35,166	17,556	196,346	17.9	8.9
2009	20,345	6,190	206,582	9.8	3.0
2010	23,106	9,605	204,426	11.3	4.7

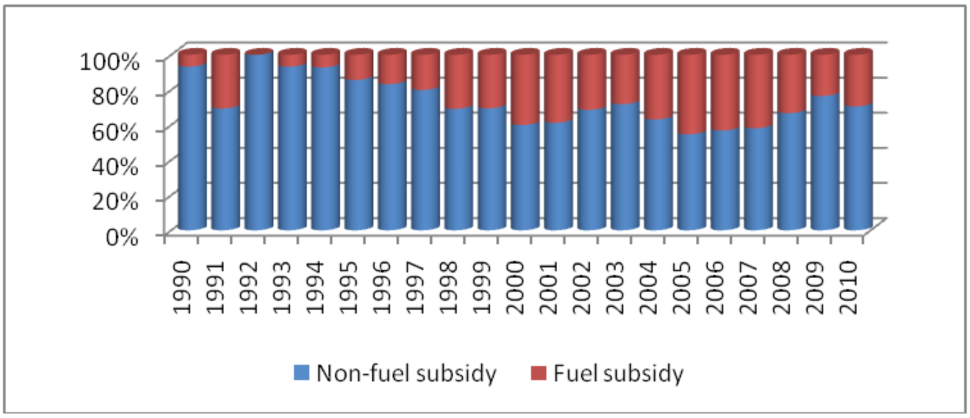
Source: Ministry of Finance, Malaysia (2010/2011) and various issues of Economic Reports.

Subsidy also comprises a significant part of electricity tariff determination in Malaysia. The national oil corporation, PETRONAS, subsidizes gas price pass-through to the National Power Corporation (TNB). However, the former has to import slightly more than one-third of its gas, which is priced at three and a half times that of the domestic price; the gas then has to be supplied to the latter. Any interruption or curtailment of gas supply experienced by the power corporation will result in rising operating costs and because the gas price is heavily subsidized, likely causes hikes in electricity tariffs. To protect low income households, special rebates were given for electricity units consumed during the recent electricity tariff hike. While commercial users are directly affected by having to pay higher tariff, other industries and consumers face a higher general price level indirectly.

One of the most pertinent issues related to energy security is the assurance of an uninterrupted electricity supply; fuel supply at power generation plants has to be made available. Pressures arising from increases in international coal prices have led the TNB to increase electricity tariffs. This situation will be further exacerbated in the future as although the corporation's generation mix currently comprises only one-third of coal while one-half is gas, the gas prices paid by the corporation are subsidized. In the future the corporation's generation mix will have to rely less on gas, and more on imported coal, implying that electricity prices will be higher.

Figure 1 illustrates a sharp increase in fuel subsidy as a percentage of total subsidy during 2005-2007. This increase is due to the rising crude oil prices in recent years. Therefore, although subsidies lower costs of production, they can also contribute to escalating expenditure on subsidy. Undesirable impacts of this feature include inefficient energy use, undermining returns on investments, and promoting reliance on outdated and dirtier technology that has negative environmental impacts.

Figure 1: Fuel Subsidy over Total Subsidy by Percentage, 1990-2010



Source: Ministry of Finance, Malaysia (2010/2011) and various issues of Economic Reports

The negative impacts of subsidy has recently led to a consideration of reform in energy subsidy in the 10th Malaysia Plan (2010 to 2015; EPU, 2010). The plan entails price liberalization to bring subsidized prices of fuel products closer to their market clearing level while remaining subsidies are targeted at the needy. The over-riding goal of subsidy rationalization is to address fiscal imbalances in order to improve, not only the production system's efficiency but also efficiency in allocation. The limitation of this rationale is that subsidy cannot be completely undertaken since some of these policies go beyond economic rationale. However, this negates the fact that direct effects are always more manageable than indirect effects based on varying consumption patterns which can be unpredictable.

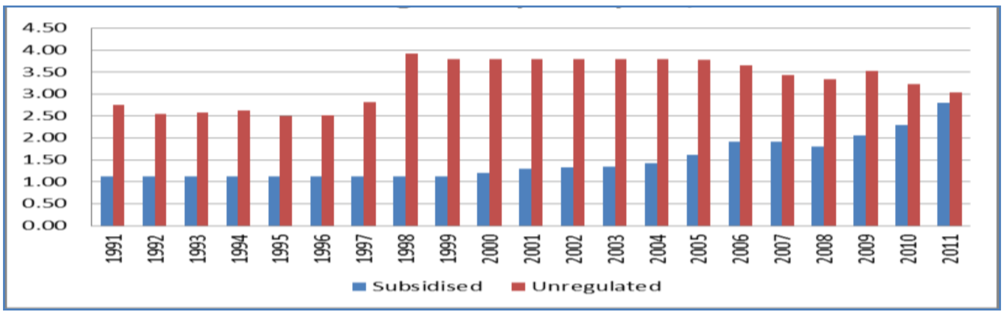
Key Reasons Why Subsidy Needs to Be Rationalized

Demand and supply of crude oil have a significant influence on total fuel subsidy. Total fuel subsidy surmounted an unsustainable trend since it is closely linked to world commodity prices, in particular the high side of crude oil prices. In addition, a recent study by the International Monetary Fund (IMF) revealed that some subsidies are not well targeted and largely benefit higher income groups. This study suggests that subsidized goods and services lead to over consumption and furthermore, do not encourage industry to upgrade and improve productivity where input costs are subsidized. The unintended consequences of subsidies, therefore, may contribute to long-term economic weakness.

Despite the Malaysian government's decades of effort to keep petrol price the lowest at the pump price compared to other ASEAN countries, especially for RON95, the cost of maintaining this strategy has had substantial impact on government expenditure and impact on the economy. Fuel subsidy intended to target on poor groups were widely accessible to all income groups.

Another stumbling block in Malaysian energy reform has been a dependency on the world price of imported products and all related direct and indirect costs, such as costs of refining, transportation, storing, import duties and taxes. Malaysia's petroleum pricing policy does not take into account the *foregone opportunity cost of production share* that is sold entirely in the domestic market under the subsidized price. Thus, the domestic prices of petroleum products were kept almost constant for a specified period, but demand for some of these products have fluctuated at different points of time. Figure 2 illustrates the irregular patterns of consumption of subsidized and unregulated petrol price since 1991 commencing from an initially large gap, but with the gap diminishing over time towards 2011.

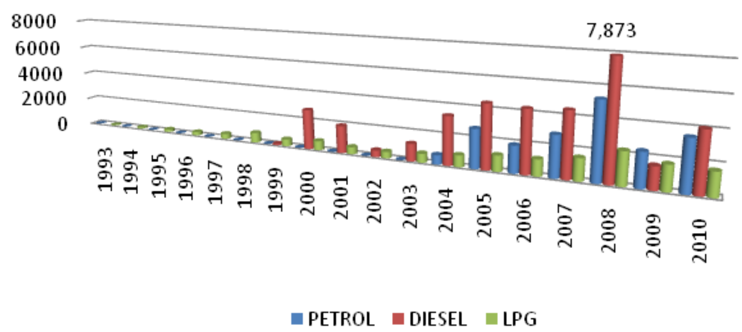
Figure 2: Subsidized and Unregulated Petrol Prices, 1991-2011



Source: Ministry of Domestic Trade and Consumers Affairs.

Assuming subsidized and unregulated petrol prices are mainly influenced by world's crude oil prices, the amount of subsidy per liter of petrol products had reduced in this period of time despite increases in world's price of crude oil. The subsidy gap between subsidized and unregulated petrol prices had since narrowing probably due to serious subsidy rationalizing efforts. This is illustrated by subsidized and unregulated prices respectively represented by the blue and red bar in Figure 2. The existing pattern denotes that subsidized petrol experienced structural rigidities and a slow rate of replacement of energy capital stock. In contrast, unregulated petrol has very little demand in the short run because of structural rigidities, and this may be indicative of an influence of substitution of fuel to subsidized fuel. The closing gap between subsidized and unregulated petrol indicates an undermining of return on investment and consequently on the ability and incentive to invest in new infrastructure. This situation also encourages reliance on outdated and dirtier technology.

Figure 3: Fuel Subsidy, 1993-2010 (million RM)



Source: Ministry of Domestic Trade and Consumers Affairs.

Figure 3 shows that despite a record spike in the crude oil price of USD145 per barrel in 2008, fuel intake did not lower but led to a record consumption of diesel amounting RM7.8 billion. In addition, this does not include tax exemptions to oil producers when price of fuel is above the market price. Overall, total fuel subsidy increased to a record of RM15.4 billion in 2008, a trend being set with subsidy lowering the cost of production responding to the increase in demand for diesel and a corresponding record high in fuel consumption. This is believed to have raised informal and illegal activities such as fuel hoarding, siphoning and illegal trade particularly at the Malaysian borders and at sea. It has also undermined efficiency efforts in the productive system, lowering Malaysia's competitiveness amongst countries in the region.

Table 2 summarized the energy industry in the Malaysian economy that comprised of primary, secondary and tertiary energy production respectively represented by three main sectors i.e. Crude oil, natural gas and coal; Petroleum refinery; and Electricity and gas for 2000 and 2005. The main bulk of fuel subsidy is estimated to fall in the dimension of Petroleum refinery which valued at 72.9 % of total energy purchase in 2005 as shown in Table 3, with Electricity and gas constitutes another 20.7 %. Assuming the size of the energy bill influences the share of subsidy, then the bigger the value of energy purchased, the higher fuel subsidy is spent which could lead to a soaring expenditure bill if the trend of crude oil price remains rising. This situation would subsequently have adverse ramifications on Malaysia's output and GDP.

Table 2: Aggregate Energy Sectors and Their related Inputs by MSIC, 2000 and 2005

Energy Industry Commodity Group	Commodity Description
Crude oil, natural gas and coal	Petroleum oils, crude
	Natural gas, in gaseous state
	Coal
Petroleum production*	Diesel
	Petrol RON 97 below and above
	Furnace oil
	LPG
	Other Fuel
Electricity and gas	Electricity
	Gas

**Note*: The I-O Table 2005 termed Petroleum production as Petroleum Refinery
Source: I-O Table 2005, Department of Statistics

In terms of types and variation of subsidies, the 2005 I-O table clearly identifies energy inputs amounting to about RM53 billion, highlighted in Table 3. Most subsidies, especially fuel, are granted by the government to producers or distributors in energy industry to prevent a decline of that industry (e.g., as a result of continuous unprofitable operations) or an increase in the prices of its products or simply to encourage it to hire more labour (as in the case of a wage subsidy). Some of these subsidies were even used to encourage the sale of exports; subsidies on some foods to keep down cost of living, especially in urban areas; and subsidies to encourage the expansion of farm production, to achieve self-reliance in food production. Nevertheless, fuel subsidy is intended to ease the burden of the poorest group especially in times of oil price increase.

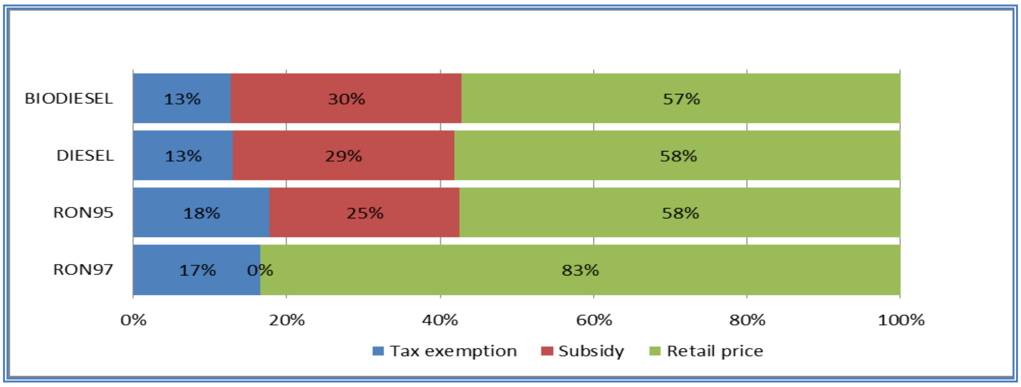
Table 3: Energy Purchased by Energy Sectors in Years 2000 and 2005, Domestic Production at *basic values*, RM'000

COMMODITY * COMMODITY (RM'000)	Crude petrol,		Petrol & coal products		Electricity & gas	
	2000	2005	2000	2005	2000	2005
Crude oil,	483,690	0	11,565,797	30,436,185	7	0
Petrol & coal	155,736	3,379,324	2,224,440	7,862,719	1,292,593	6,536,770
Electricity &	29,893	29,337	274,857	396,727	663,745	4,458,645
Total in 2005		3,379,324		38,695,631		10,995,415

Source: DOS I-O table 2000 and 2005

Energy dynamically works within a multi-complex, inter-industry environment, and subsidy only constitutes a small share of energy inputs; previous studies had proven the increasingly critical role of both energy inputs and subsidies. Since the combination of energy inputs and fuel subsidy have significant influence mainly on production system input material, subsidy escalates the risk of a country's susceptibility with the rising of crude oil prices.

Figure 4: Determination of Automatic Pricing Mechanism, 2011 (Prices in Terms of %)



Source: Ministry of Domestic Trade and Consumerism

Figure 4 shows different magnitudes in tax exemption, subsidy and retail price for different fuel products in 2011. Fuel subsidy on refined petroleum products were used to supply petrol pump stations' products such as diesel and gasoline since the 1970s, while others like LPG which emerged in the 1980s have no significant influence. Concurrently, subsidy on RON97 has been floated in the market in 2008 as an initial preparation to rationalize subsidy. However, as shown in Figure 4, RON97 fetches a high proportion of retail price (83%) and in terms of market control has less than 10 per cent consumed by motorist, thus, it does not significantly lowered the overall effect of subsidy. In terms of environmental effects, despite RON95 being considered pollution-free, it consists of benzene that acts as booster replacing lead (Bernama Auto News, 2010). RON97 has less impact in terms of pollution emissions, but is not widely consumed as it is marginally more expensive than RON95.

Given this background, our research examines the economic impacts from the removal and reallocation of fuel subsidy on the Malaysian economy. This is undertaken by analysing economy-wide impact effects, sectorial and welfare ramifications, and suggests redistribution of fuel subsidy. We employ I-O and computable general equilibrium (CGE) models to estimate the economy-wide impacts of removing and reallocating fuel subsidy. The I-O model will be based on the Malaysian 2005 I-O table whereas the CGE model will be primarily constructed on the MIER-CGE database with necessary modification to accommodate the objectives of this study. Undertaking energy subsidy removal, the I-O model identifies and evaluates the amount of fuel subsidy purchased by sectors of the economy on selected fuel products including commodities like gasoline, LPG, kerosene, cooking gas, etc. In addition, the MIER-CGE database, also built based on the I-O table 2005, will capture fuel subsidy removal using an indirect tax on aggregate commodities such as Petroleum refinery as well as Electricity & gas. In considering the reallocating of subsidies we propose strategies aligned to recent economic issues and challenges in relation to welfare and growth.

1.2. Previous Study

Emerging in the literature on subsidy are empirical studies based on different countries in the world, for example, the Energy Sector Management Assistance

Program (ESMAP, 2004), Manzoor, *et al*. (2009), Aboulmein, *et al*. (2009) and Oktaviani, *et al*. (2005). ESMAP (2004) looks at global fossil fuel subsidy and how its negative impacts on economies and environment.

Manzoor, *et al*. (2009) use CGE/MPSG modeling based on Iranian data working with the assumption of an implicit rent payment to the specific government ownership of mineral resources in extraction of oil and gas. Their study shows that subsidy removal results in shrinking of output, reduction in urban and rural welfare of 13% and 12% respectively and also hyperinflation.

Aboulmein, *et al*. (2009) study the impact subsidy removal in Egypt over a 5-year period using a CGE model and found that without offsetting any policy actions, GDP growth would be reduced by 1.4 percentage points over the base year and depress welfare levels of households at all levels of income distribution. They found that inequality was reduced at the expense of the richest quintile.

Oktaviani, *et al*. (2005) employed a recursive CGE model and found that budget deficit, exchange rate fluctuation, and high fuel world price provide a burden on its budget capacity to stimulate the Indonesian economy. The Indonesian government has designed several fiscal policies which include reduction of fuel subsidy. Oktaviani, *et al*. (2005) analyze the impact of fuel subsidy reduction on macroeconomic variables, agricultural sector, and income distribution. Their results show that the *reduction in fuel price subsidy tends to increase prices of industrial outputs* highly dependent on fuel, such as the transportation and fishery sectors. In contrast, the change in fuel price does not influence prices in the paddy sector. They found that wage of skilled labour, land rent, and capital rent declined steadily in response to changes in fuel price. They also found households would incur income losses following the reduction in fuel subsidy, decreasing the overall welfare of households. Incomes are not evenly distributed within Indonesian society (household groups). An increased fuel price at consumer level reduces the Indonesian real GDP, and their paper suggests compensation by reducing fuel subsidy directly to the poor people as a possible policy measure. It is argued that compensation should be given indirectly to the poor people through the development of infrastructure, which mitigate supply side bottlenecks in the Indonesian economy.

The United Nations Environment Programme (UNEP, 2004) posits that implications of subsidy rationalization on production and imports will specifically influence "subsidies that are current unrequired payments that government units, including non-resident government units, make to enterprises on the basis of the levels of their production activities or the quantities or values of the goods or services which they produce, sell or import". Subsidies are not payable to final consumers and current transfers that government make directly to households as consumers are treated as social benefits. Subsidies also do not include grants that government may make to enterprises in order to finance their capital formation, or compensate them for damage to their capital assets, such grants being treated as capital transfers.

Considering the above definitions, it is critical for subsidies to be observed from the standpoint of a non-productive element encroaching into productive sectors especially in the energy sectors whereby the Malaysian economy is very dependent upon energy material inputs in sustaining growth. For that matter, a comprehensive examination on how subsidy removal may affect the economy is essentially a pre-requisite in the quest to raise economic growth.

2. Methodology

Since our main objective is to assess the expected impacts of phasing out subsidies of energy products in the short, medium and long runs, we must construct a fuel subsidy row and a hybrid energy I-O matrix partitioning it into energy and non-energy blocks. The structure of the matrices will enable an explicit presentation of the impacts of energy products; especially those receiving the greater amounts of subsidy. Households are also disaggregated according to expenditure level, so that impacts of different policies on poor households can be analyzed.

In the I-O analysis, the technical coefficients provide valuable information on the structure of input for a specific industry, i.e., oil or fuel industry purchase is used by other non-oil sectors in the production process and so on. The term input coefficient refers to the quantity of inputs required from each industry to produce one dollar's worth of a given industry's output. The proportions in which different inputs enter the production process of a particular industry are assumed to be constant over time. The input coefficient can be presented as a direct effect that is generally derived from the I-O table.

The construction of an I-O model originates from a cross-section of observed data for a particular economic area of a nation or region. Inside an economic system, every type of activity must be divisible into a number of producing sectors and has an impact on agents within the economy. The I-O analysis creates a picture of a regional economy describing flows to and from industries. In a practical sense, no one industry can survive in isolation from others since the expansion of exchange of goods between sectors raises the importance of interdependencies which results in a network of linkages between industries and those who depend on them for products and household income.

These impact studies are concerned with how one sector has three kinds of effects on the overall economy; direct effects, indirect effects and induced effects. As the two former effects have been defined earlier, we next define the induced effects as "economic activities from the consumption of goods and services using incomes generated from the direct and indirect effects" (Xu, 2002). The direct economic impact of a sector includes only its direct effects but the total impact includes all three effects generated by the oil sector. Nevertheless, the underlying assumptions are crucial in analyzing total impact.

An I-O model is the simplified representation of the production side of the economy where the set of producers of analogous goods and services from a homogenous industry interact with other industries in the economy. Each industry requires different combination of inputs to produce its output, procured from other domestic industries or from suppliers of intermediate inputs. To construct the I-O system, the following assumptions were used: where each industry in the economy produces only homogeneous products, production of each industry is based on fixed proportion between input and output ratios; production in each industry is subject to constant return to scale, so a change in one unit of input will result in an exact proportional change in output; prices are fixed and supply is perfectly elastic i.e. the model is demand-driven (O'Connor & Henry, 1975).

All these assumptions are less realistic since prices are not free from inflation and in fact do fluctuate due to substitution effects through either input use or final consumption. Apart from that, in economies of scale supply is inelastic. However, these assumptions are less restrictive and are outweighed by the fact that I-O analysis can show interdependencies between sectors and is accepted worldwide in economic impact analysis. The basic inter-industry relationship in the I-O model can further be simplified, using the following notations: X_i for total output of sector *j*, then X_{ij} for output in sector *i* used in sector *j*, and Y_i for total final demand for sector *i*'s product. This relationship is summarized as in Table 4 as follows:

Table 4: Inter-industry Matrix Representation of An I-O model

Item	Purchasing sector	Total	Final Demand	Total
Producing sector	1 x_{11} x_{12}…x_{1n}	W_1	Y_1	X_1
	2 x_{21} x_{22}…x_{2n}	W_2	Y_2	X_2
	3 x_{31} x_{32}…x_{3n}	W_3	Y_3	X_3
	…	…	…	…
	N x_{n1} x_{n2}…x_{nn}	W_n	Y_n	X_n
Total Inputs	U_1 U_2 U_3…U_n			
Primary Inputs	V_1 V_2 V_3…V_n	V	V	
Total Production	X_1 X_2 X_3…X_n	Y	X	

Source: Miller & Blair (1985)

Table 4 indicates that if there are *n* sectors, then we read each producing sector in the left hand corner as purchasing sector and sales to final demand (first row) as follows:

$$X_1 = x_{11} + x_{12} + x_{13} \ldots\ldots\ldots\ldots\ x_{1n} + Y_1 \qquad \ldots(1)$$

This equation (1) is summarized in the following equation (2),

$$X_i = \sum_{j=1}^{n} x_{ij} + Y_i \qquad i = 1\ldots..n \qquad \ldots(2)$$

If all sectors are arranged accordingly, they could be interpreted as an accounting identity. Under equilibrium conditions, the quantity of output supplied equals the quantity of input demanded. In this form the demand of any sector's input is proportional to the output sector *j*'s demand, for the output sector *i* is proportional to the total output of industry *j*. It could then be written as follows:

$$X_{ij} = a_{ij}X_j \qquad \ldots(3)$$

Where a_{ij} = coefficient of proportionality of I-O coefficient.

This coefficient value could be zero if sector *j* does not consume any input from other sector *i*. This value must be positive and lies between one and zero. Substituting (3) in (2), we obtained the following equation (4);

$$X_{ij} \quad = \quad \sum a_{ij}X_j \ +Y_j \qquad (\ i = 1 \ldots. n\ ) \qquad \ldots (4)$$

Rewriting equation (4) in matrix form we have the following equations:

$X_1 \ = \ - a_{11}X_1 - a_{12}X_2 - a_{13}X_3 \ldots\ldots\ldots\ldots\ldots. a_{1n}X_n = Y_1$

$$X_2 - a_{21}X_1 - a_{22}X_2 - a_{23}X_3 \ldots\ldots\ldots\ldots\ldots. a_{2n}X_n = Y_2 \qquad \ldots\ (5)$$

$$X_n - a_{n1}X_1 - a_{n2}X_2 - a_{n3}X_3 \ldots\ldots\ldots\ldots\ldots. a_{2m}X_n = Y_n$$

Based on (5) we can rewrite in diagrammatic matrix form as follows:

$$\begin{pmatrix} 1 - a_{11} & -a_{12} & \ldots. & -a_{1n} \\ -a_{22} & 1\text{-}a_{22} & \ldots. & -a_{2n} \\ \ldots. & \ldots. & \ldots. & \ldots. \\ -a_{n1} & -a_{n2} & \ldots. & 1\text{-}a_{nm} \end{pmatrix} \text{x} \begin{pmatrix} X_1 \\ X_2 \\ \ldots. \\ X_n \end{pmatrix} = \begin{pmatrix} Y_1 \\ Y_2 \\ \ldots. \\ Y_m \end{pmatrix} \qquad \ldots (6)$$

The following matrix *A* is defined as the matrix of I-O coefficient, and we can rewrite equation (6) as follows:

$$A = \begin{pmatrix} a_{11} & a_{12} & \ldots. & a_{1n} \\ a_{21} & a_{22} & \ldots. & a_{2n} \\ \ldots. & \ldots. & \ldots. & \ldots. \\ a_{n1} & a_{n2} & \ldots. & a_{nm} \end{pmatrix} \qquad \ldots (7)$$

In equations (7), the first term on the left-hand side is equal to the identity matrix of I-O coefficient. This product is multiplied by the output *nx1* matrix (or column vector); it can be denoted as *X* which is equal to the final demand *nx1* matrix (or column vector) termed as Y. The I-O system can be rewritten as follows:

$$(I - A)_{\text{nxn}}\, X_{nx1} = Y_{\text{nx1}} \qquad \ldots (8)$$

If equation (8) is multiplied on both sides by the inverse matrix we obtained:

$$(\ I - A\ )^{-1}(\ I - A\ )\ X \ = (\ I - A\ )^{-1}Y \qquad \ldots\ (9)$$

Since $(I-A)^{-1}(I-A) = I$, the identity, is then

$$IX = (I-A)^{-1}Y \quad \ldots (10)$$

Finally, we will derive the following equation (11);

$$X = (I-A)^{-1}Y \quad \ldots (11)$$

Equation (11) holds the condition that matrix $(I-A)$ has an inverse matrix in the form of $(I-A)^{-1}$ which is popularly known as Leontief's inverse matrix. This concept is used to calculate impact analysis in this study. Given X as the total output, we can solve the impact as this is equal to the inverse matrix multiplied by the final demand. Hence, any change in the final demand, when multiplied by the inverse matrix, will change the total output. The inverse matrix is also in a table produced by the DOS and can be derived by the spread sheet using appropriate computer functions.

The proposed study starts with a brief overview of the main approaches to energy pricing; the domains of government intervention in energy markets, and the international experience in mitigating the negative impact of energy pricing reform. This is then followed by description of the features of the petroleum sector in the Malaysian economy and its interactions with the main economic variables. Next, an I-O analysis will be conducted to measure the direct impact of raising prices of petroleum products on costs of production of different sectors in the economy. The analysis shows the relative effect of each petroleum product under different scenarios of various levels of increases in energy prices.

2.1. Construction of I-O Framework

Since subsidy row is not yet available in the I-O table 2005, we construct our own subsidy row to simulate the impact of subsidy removal. Fuel subsidy matrix is computed from the I-O table 2005 in relation to energy commodities i.e. Crude oil, natural gas & coal, Petroleum refinery and Electricity & gas. The constructed fuel subsidy matrix from purchases of fuel input excludes Crude oil, natural gas & coal as it does not have a direct relation to fuel subsidy since it is mainly for exports. Both the Petroleum refinery and Electricity & gas rows were first treated outside the I-O table in computing fuel inputs and subsidy portion in these commodities deriving the following diagrammatic description of total fuel subsidies.

$$\overset{\text{Crude oil, natural gas \& coal}}{\begin{bmatrix} \\ \\ \\ \end{bmatrix}_{120x1}} + \overset{\text{Petroleum refinery}}{\begin{bmatrix} \\ \\ \\ \end{bmatrix}_{120x1}} + \overset{\text{Electricity \& gas}}{\begin{bmatrix} \\ \\ \\ \end{bmatrix}_{120x1}} = \overset{\text{Total fuel subsidy}}{\begin{bmatrix} \\ \\ \\ \end{bmatrix}_{120x1}}$$

The vector of total fuel subsidy is then moved into the row-wise primary quadrant to be placed just below the domestic tax row as diagrammatically shown in Table 4. Then, we create three new rows of subsidies with these following transactions:

i. Domestic tax (including fuel subsidy)
ii. Domestic tax (excluding fuel subsidy); and
iii. Total fuel subsidy.

Table 4: Augmented Input-Output Table 2005

Item	**Purchasing sector**	**Total**	**Final Demand**	**Total**
Producing	$1 \quad x_{11} \quad x_{12} \dots x_{1n}$	W_1	Y_1	X_1
Total Inputs	$U_1 \quad U_2 \quad U_3 \dots U_n$			
Primary Inputs	$V_1 \quad V_2 \quad V_3 \dots V_n$	V	V	
Domestic tax (incl. fuel subsidy)	***(existing row)***			
Domestic tax (excl. fuel subsidy)	***(constructed row)***			
Total fuel subsidy	***(new row constructed)***			
Total	$X_1 \quad X_2 \quad X_3 \dots X_n$	Y	X	

Source: Fuel subsidy data from Economic Report 2010/2011 and I-O Table 2005

The improved total fuel subsidy row is later computed into the intermediate quadrant by multiplying and introducing the proportion of subsidy in each sector. Having this new structure, the normal process of direct and indirect effect of Leontief's model can be performed. Firstly, we divide each intermediate input with its total to produce technical coefficient which represents direct effects. If the subsidy is phased out, technical coefficients in the intermediate demand will be higher values in terms of its proportion. This technical coefficient expansion is similar to the one in developed countries. Contrarily, the primary quadrant becomes less in terms of share than previously. Table 5 shows the proportion of petroleum product's input in the intermediate input of the economy and the total product mix of fuel located at the total intermediate input as used by all sectors in the economy amounted to RM53.9 billion.

Table 5: Preliminary Data on Intermediate Input for Petroleum Refinery in 2005

Aggregate value	Basic price (in RM billion)	Sectoral share of total output
Total fuel subsidy	24.8	1.55%
Total fuel product mix	53.9	3.36%
Total intermediate input	729.6	45.49%
Total output	1,603.9	100.00%

Source: Estimated from the I-O Table 2005

2.2. Construction of MIER-CGE Model

Classified as an applied general equilibrium (AGE) model, the MIER-CGE model was adopted from Orani-G[2]. The model has a wide potential to be used as a tool for practical policy analysis particularly in examining fuel subsidy in terms of substitution effects that the I-O model falls short on. Although this initial version was static, with applications confined to comparative-static analysis, it is possible to upgrade the model containing dynamic elements, arising from stock/flow accumulation relations: between capital stocks and investment, and between foreign debt and trade deficits. Other extensions to the basic model can include systems of government accounts, and regional breakdowns of model results. We use Gempack as the main software to solve AGE models and process the translation of model specification into a model solution program. The Gempack user needs no programming skills; instead, by creating a text file, a list of the equations of the model can be derived. Another solution program, Tablo, then translates this text file into a model-specific program which solves the model.

2.2.1. Model Structure

Typical to a static AGE model, the model consists of equations describing, for some time period, producers' demands for produced inputs and primary factors; producers' supplies of commodities; demands for inputs to capital formation;

[2] The MIER-CGE is constructed under research collaboration between the Malaysian Institute of Economic Research (MIER) and Department of Economics, Faculty of Economics and Management, Bogor Agricultural University (IPB), Indonesia.

household demands; export demands; government demands; the relationship of basic values to production costs and to purchasers' prices; market-clearing conditions for commodities and primary factors; and numerous macroeconomic variables and price indices.

Demand and supply equations for private-sector agents are derived from solutions of optimization problems (cost minimisation, utility maximisation, etc.) which are assumed to underlie the behaviour of the agents in conventional neo-classical microeconomics. The agents are assumed to be price-takers, with producers operating in competitive markets which prevent the earning of pure profits. Like the majority of AGE models, MIER-CGE is designed for comparative-static simulations and replicates the equation system of Orani-G Model of Australian Economy (Horridge, *et al*. 1998). The detailed data structure of MIER-CGE is diagrammatically shown in Figure 5.

Classification is also made based on sources of commodities (domestic or imported), type of labour, and other factor inputs. In the final step, the database constructed must be balanced as required by any CGE model. The column headings in the main part of the figure (an absorption matrix) identify the following demanders: domestic producers divided into I industries; investors divided into I industries; a single representative household; an aggregate foreign purchaser of exports; government demands; and changes in inventories.

Entries in each column exhibit the structure of purchases made by agents identified in the column heading. Each of the C commodity types identified can be obtained locally or imported from overseas. The source-specific commodities used by industries as inputs to current production and capital formation consumed by households and governments, are exported, or are added to or subtracted from inventories. Only domestically produced goods appear in the export column. M of the domestically produced goods are used as margins services (wholesale and retail trade, and transport) which are required to transfer commodities from their sources to their users. Commodity taxes are payable on purchases. As well as intermediate inputs, current production requires inputs of three categories of primary factors: labour (divided into O occupations), fixed capital, and agricultural land. Production taxes include output taxes or subsidies that are not user-specific. The ‘other costs’ category covers various miscellaneous taxes, e.g. municipal taxes or charges.

Figure 5: MIER-CGE Database flows

		Absorption Matrix					
		1	2	3	4	5	6
		Producers	Investors	Household	Export	Government	Change in Inventories
	Size	← I →	← I →	← 1 →	← 1 →	← 1 →	← 1 →
Basic Flows	↑ C×S ↓	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margins	↑ C×S×M ↓	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
Taxes	↑ C×S ↓	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
Labour	↑ O ↓	V1LAB					
Capital	↑ 1 ↓	V1CAP					
Land	↑ 1 ↓	V1LND					
Production Tax	↑ 1 ↓	V1PTX					
Other Costs	↑ 1 ↓	V1OCT					

C = Number of Commodities
I = Number of Industries
S = 2: Domestic, Imported,
O = Number of Occupation Types
M = Number of Commodities used as Margins

	Joint Production Matrix
Size	← I →
↑ C ↓	MAKE

	Import Duty
Size	← 1 →
↑ C ↓	V0TAR

Source: MIER_CGE model

Each cell in the illustrative absorption matrix in Figure 5 contains the name of the corresponding data matrix. For example, V2MAR is a 4-dimensional array showing the cost of M margins services on the flows of C goods, both domestically produced and imported (S), to I investors. In principle, each industry is capable of producing any of the C commodity types. The MAKE matrix at the bottom of Figure 5 shows the value of output of each commodity by each industry. Finally, tariffs on imports are assumed to be levied at rates which vary by commodity but not by user. The revenue obtained is represented by the tax vector, V1TAX.

The MIER-CGE model employed in this paper analyses the impacts of energy price changes on economic growth and income distribution. The MIER-CGE model is a non-linear simultaneous equation model which accommodates price and quantity variables adjustment as input factor market equalizer or commodity market equalizer in economic simulation. In other words, MIER-CGE model simulates the optimal condition of consumers and producers in an economy. In addition, the CGE model also simulates government role as an economic actor. Generally, this model comprehends all transactions in money cycle, commodity cycle and services cycle in economic mechanism (Lewis, 1991). If we add some dynamic equations which represent a time factor, the equations will change from I-O model to MIER-CGE model.

Table 6: Sets, Subsets, and Disaggregation of MIER-CGE Model

Sets	Subsets	Disaggregation
Institutions		Producers, investors, households, aggregate foreign purchaser of exports; government.
Household		One representative household
Industries/Commodities		120 industries based on 2005 Malaysian I-O Table
Production Factors	Labour	Unskilled and Skilled Labour
	Capital	
	Land	
Source	Domestic	120 industries based on 2005 Malaysian I-O Table
	Import	120 industries based on 2005 Malaysian I-O Table
Margin		11 Industries

Source: MIER-CGE model.

2.2.2. Advantage using MIER-CGE Model

The MIER-CGE model is employed for several reasons; (i) it accommodates price variable adjustment fall-short by other models, such as I-O and SAM; (ii) the CGE model has good ability to accommodate structural changes in the economies; and (iii) Dynamic CGE which uses Malaysia's SAM data can provide possibilities to substitute energy input factor with capital and labour more accurately. As such, it can identify economic impacts of price changes due to subsidy removal, and compensation of reducing the fuel subsidy or escalation of energy price. Structurally the MIER-CGE model utilizes efficiency of economic growth and household incomes. The MIER-CGE model for Malaysia is constructed from seven blocks, namely: Production, Household, Government, Investment and Capital, Export-Import, Market Clearing, and Inter-temporal with equations portraying the dynamic that connects the economy of the current year with past years.

Table 7: Database Component of MIER-CGE

N	Head	Ty	Dimension	Coeff	Total	Name
1	1BAS	RE	COM*SRC*IND	V1BAS	1.08E+	Intermediate Basic
2	2BAS	RE	COM*SRC*IND	V2BAS	1.16E+	Investment Basic
3	3BAS	RE	COM*SRC	V3BAS	2.33E+	Households Basic
4	4BAS	RE	COM	V4BAS	5.77E+	Exports
5	5BAS	RE	COM*SRC	V5BAS	634746	Government Basic
6	6BAS	RE	COM*SRC	V6BAS	602642	Inventory Changes
7	1-	RE	COM*SRC*IND*	V1MAR	0	Intermediate Margins
8	2-	RE	COM*SRC*IND*	V2MAR	0	Investment Margins
9	3-	RE	COM*SRC*MAR	V3MAR	0	Households Margins
1	4-	RE	COM*MAR	V4MAR	0	Exports Margins
1	5-	RE	COM*SRC*MAR	V5MAR	0	Government Margins
1	1TA	RE	COM*SRC*IND	V1TAX	121601	Intermediate Tax
1	2TA	RE	COM*SRC*IND	V2TAX	198308	Investment Tax
1	3TA	RE	COM*SRC	V3TAX	134166	Households Tax
1	4TA	RE	COM	V4TAX	159231	Exports Tax
1	5TA	RE	COM*SRC	V5TAX	771710	Government Tax
1	1LA	RE	IND*OCC	V1LAB	1.46E+	Labour
1	1CAP	RE	IND	V1CAP	3.52E+	Capital
1	1LN	RE	IND	V1LND	115460	Land
2	1-Oct	RE	IND	V1OCT	-28	Other Costs
2	MAK	RE	COM*IND	MAKE	1.6E+0	Multiproduct Matrix
2	0TA	RE	COM	V0TAR	0	Tariff Revenue
2	SLA	RE	IND	SIGMA1LA	60	Labour Sigma
2	P028	RE	IND	SIGMA1PRI	112.7	Primary Factor Sigma
2	1AR	RE	COM	SIGMA1	353.1	Intermediate Armington
2	SCET	RE	IND	SIGMA1OU	0.4	Output Sigma
2	2AR	RE	COM	SIGMA2	240	Investment Armington
2	3AR	RE	COM	SIGMA3	240	Households Armington
2	P021	RE	1	FRISCH	-2.88	Frisch Parameter
3	XPE	RE	COM	EPS	107.03	Household Expenditure
3	P018	RE	COM	EXP_ELAST	-649.45	Traditional Export
3 2	EXN T	RE	1	EXP_ELAST _NT	-10	Non-Traditional Export Elasticities

Source: MIER-CGE model 2012.

2.2.3. Balancing the MIER-CGE Database

The Gempack program has produced two documents, namely MIER.har (database) and summary.har (check for database balancing). Before the next process is carried out, checking the database is crucial. At the sector level, balancing its level is indicated by the similarity of total input and total value of sales in each industry (Dixon, *et al.* 1992). At the aggregate level the balance is shown by the equal value of GDP from the expenditure side and revenue side. This refers to the concept of balance, i.e. a database is called balanced if: (1) the aggregate GDP as the expenditure to GDP income side, and (2) the total cost equal to the total value of sales and profits in each sector or industry to be zero (Warr, 1998).

The result of CGE analysis, which measures overall impacts of phasing out subsidies subject to alternative scenarios in the medium-run is then considered. This includes estimation of the effects of raising prices of various energy products on relevant macroeconomic variables, namely, prices, investment, growth rates of GDP and of sectoral value added, deficit in government budget, resource gap and welfare of different groups of urban and rural households.

GDP from expenditure and revenue side as well as the total value of sales and costs in each industry is shown in Table 8. In this table, the expenditure side of GDP is the sum of expenditure components of each economic agent, such as household consumption, private investment, government's spending, and net exports amounting to RM 539.2 million. This value is equal to the value of the GDP that is the sum of revenues and earned income of owners of production factors (land, labour, capital, subsidies and indirect taxes). The sales value for each sector is also in the summary.har. The sales value is the sum of the components of the sales of each sector as intermediate and investment goods, sales to households abroad (exports), and the government. The sectoral total sales have to be equal with the cost of each sector. Total costs in each sector is the sum of several components, which include the purchase of domestic goods, intermediate goods imports, spending on the margin, the payment of indirect taxes, labour costs (wages), capital costs (interest), land rent and tax payments on production (value added tax). The CGE model assumes identical value of sales and production costs in each sector and implies a zero rate of return in accordance with the properties of perfect competition. Once the database consisting 120 sectors is believed to be balanced on aggregate and sectoral level, the data processing can be utilized in the policy simulation process. The final constructed database (mier.har) is readily available for policy simulation as shown in Table 8.

Table 8: Malaysia GDP from Expenditure and Income Side, 2005 (RM'000)

No	Expenditure	Value	No	Income	Value
1	Consumption	246,838,400	1	Land	11,546,087
2	Investment	118,295,632	2	Labour	145,723,024
3	Government	64,246,340	3	Capital	352,003,072
4	Stocks	602,642	4	Other Cost	-28
5	Exports	578,133,888	5	Indirect Taxes	29,923,882
6	Imports	-468,920,864			
	Total	539,196,037		Total	539,196,037

Source: MIER-CGE model.

2.3. Final closure

Considering the first issue of energy subsidy removal, the I-O model identifies and evaluates the amount of fuel subsidy purchased by sectors of the economy on selected fuel products including commodities like gasoline, LPG, kerosene, cooking gas, etc. In addition, the MIER-CGE database built, also based on the I-O table 2005, captures fuel subsidy using simulations on indirect tax on aggregate commodities such as petroleum, coal products and electricity and gas. Reallocating subsidy will consider three optional strategies in what manner government would opt spending on pro-poor, pro-wage, and/or pro-growth. For both models, we compare simulations of baseline and post removal of subsidy which is expected to provide some insights on economy-wide, sectoral and welfare impacts of fuel subsidy reduction (and/or removal) on the economy, environment and society as a whole. Although it is widely presumed in the real world, that energy subsidy removal will negatively affect the economy as the access to energy will be restricted due to price increase, in the long run, it is expected that the subsidy free economy will reduce distortion and encourage efficiency and thus, lower the cost of production.

3. Results and Findings

3.1. Direct Effect

In terms of the first phase of country-wide impact, the direct effect of subsidy share of the whole output of the economy is approximately estimating the requirement for direct inputs in various level of input and output. Directly, fuel subsidy comprises 3.40 % of total intermediate input and only 1.55 % of total output of the economy as shown in the following Table 9.

Table 9: Fuel Subsidy Share in the Economy

Dimension	Value ('000)	Subsidy value* ('000)	Subsidy over share of intermediate input and total output (in per cent)
Total Intermediate input	729,583,619.47	24,806,023.95	3.40
Total output	1,603,906,678.89	24,806,023.95	1.55

Note: *estimated subsidy value from I-O model
Source: I-O Table 2005

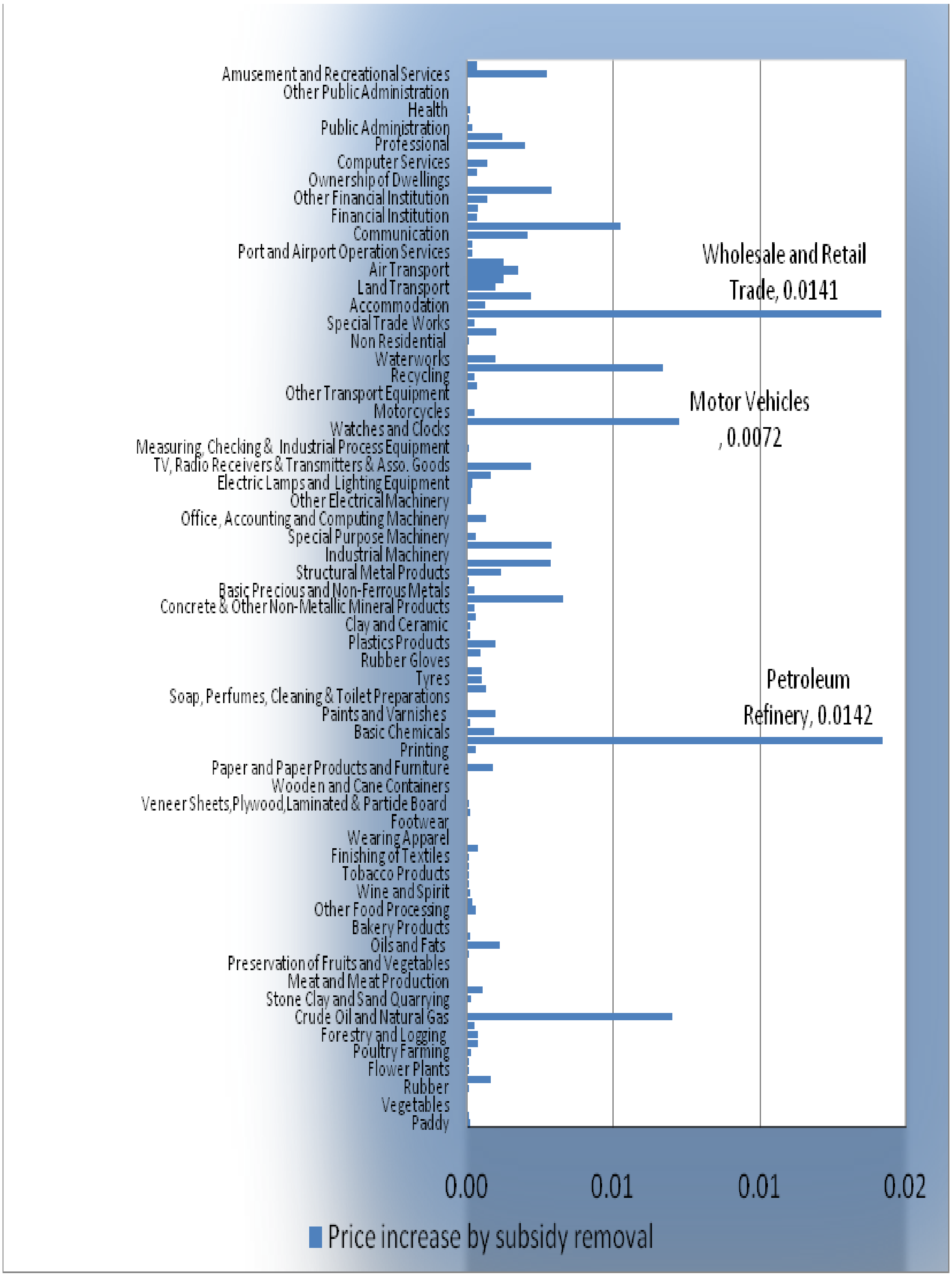
In trying to simplify and make sense of these numbers; considering fuel subsidy removal comprises about 3.40 % of intermediate input, in other words, for every ringgit spent for the purchase of energy input, subsidy will comprise of about 3.40 cents of the total costs of intermediate inputs. Similarly, in terms of total output, for every ringgit of output produced in the economy, subsidy will cost about 1.55 cents of output.

The direct effect of removing fuel subsidy in the economy suggests that initially there will be an inflationary pressure in the market that will especially affect the heavily depended oil sectors such as Petroleum refinery (0.0142), Wholesale and retail trade (0.0141), and Motor vehicles (0.0072), since their input costs will increase subsequent to subsidy removal as shown in the following Figure 6.

Ranked Sectors by Direct Effects of Post-subsidy

The following Figure 7 shows sectors in the economy ranked from the highest effects after subsidy removal. The initial or direct effect of oil subsidy removal has the effect of generating an increase in domestic fuel products. Oil subsidy removal computed into the intermediate input quadrant of the I-O table affects the technical coefficient that connotes increases in price. In the long-run it will encourage lowering of costs in producing goods due to the increase in price. Similarly, the phasing out of gas subsidy will initially generate an increase in domestic prices for gas inputs.

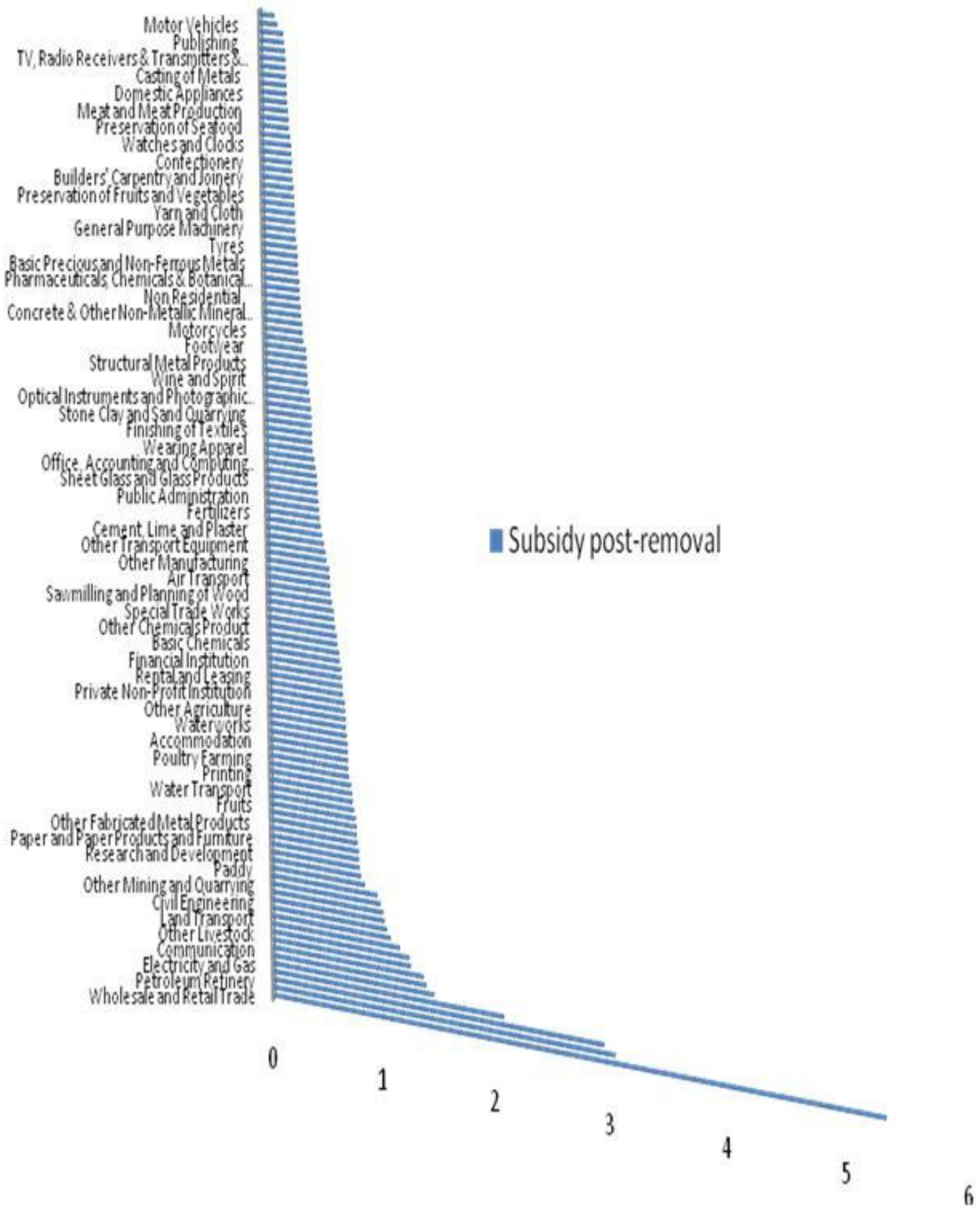
Figure 6: Price Increase by Removal of Subsidy



Source: Estimated from I-O Table 2005

Note: Each of the 120 sectors is represented by a bar, but only 60 sectors were label as displayed at the left hand side due to limited space of this figure.

Figure 7: Impact of Removing Fuel Subsidy by Highest Ranked Sectors, 2005 (%)



Source: Estimated from the I-O Table 2005

3.2. Total Effect:

The entire effects of subsidy removal, also referred to as multipliers, are basically derived from many direct and indirect (include induce) effects that amount in the inversed matrix represented by the equation $(I-A)^{-1}$. Thus, the baseline is represented by $(I-A_o)^{-1}$ matrix and post-subsidy removal matrix by $(I-A)^{-1}*$, with the symbol star, i.e.* represents augmented inversed matrix. The overall output multipliers direct, indirect and induced from the weighted average of all sector's output multipliers describe an increase in the economy's overall output resulting from a ringgit increase in output as fuel subsidies are removed or redistributed from the economy. The differences in impact can be clearly shown by comparing the baseline with post-subsidy scenarios. Similarly, it results in more value added and workers enjoying more income (0.34) times as shown in Table 10.

Table 10: Estimates of Multipliers before and after Subsidy Removal, 2005

Simulations	**Output (Weighted)**	**GDP**	**Workers Income**
Base point	1.87	1.33	0.09
Subsidy removal	1.93	1.41	0.43
Differences	0.06	0.08	0.34

Source: Estimated from the I-O Table 2005

In terms of output, Table 10 shows that the removal of subsidy will increase 0.06 index of output multiplier effect. In other words, a ringgit removal of subsidy will increase an output of six cents at the final demand. These trends of increase were also found for GDP that increase by almost ten cent (0.08) at the final demand. The most encouraging effect comes from worker's income that experiences an increase of 34 cents from subsidy removal.

Sectoral Impact

Having a new structure of post-subsidy, we work-out the normal assessment process of direct and indirect effect of Leontief's model. Firstly, we divide the total input with the share of a sector to get the direct effect in terms of technical coefficient. Next, we transformed the A-matrix into an inversed matrix, $(I-A)^{-1}$. If the subsidy is phased out, the technical coefficient in the intermediate demand will be higher in terms of its share. This expansion of technical coefficient is similar to efficient values practiced by developed countries. Contrarily, the primary quadrant is offset and becomes less in terms of share than previously. These post-removals of subsidy have varying degrees of index in terms of multiplier effects over different sectors depending on how much subsidy influenced in their inputs.

The higher the multiplier index represents the greater influence of subsidy in their production components, whereas the lower the index shows lower or very small relation to the effects of fuel subsidy. Heavily subsidize prone sectors are sectors with high dependence on energy such as Wholesale and retail trade, Petrol refinery, Electricity and gas as well as Communication. Whereas, less subsidy effected sectors are found in Own dwellings, Motor vehicles, Publishing etc. The compelling differences in both of these situations depend on the magnitude of types, size and the structure of the economy. Sectors heavily dependent on oil subsidy would not let go the opportunity in terms of low costs in inputs through incentives and exemption available in the market. Further, this incentivizes many other sectors to use more of the lower costs of energy inputs as shown in Figure 3. This phenomenon is also found by Khalid and Zakariah (NEB, 2012) who demonstrated increased spending on cheaper oil in household expenditure for all household level especially for higher income group. Low energy inputs like diesel and kerosene has become extensively used by households.

3.3. Macroeconomic Results from MIER-CGE Model

It is further noted that productivity is mostly damaged by rising prices, rather than by absolute price levels. In fact, countries with different price levels can compete equally in the global market thanks to other competitiveness factors (e.g., infrastructure and human capital, or knowledge). In this context, countries with lower energy intensity, which are often the ones with higher energy prices, will be less vulnerable to future energy price increases. Malaysia in this respect is in a disadvantageous situation relative to current competitors that confront higher absolute prices, but have reached lower energy intensity.

Table 11 exhibit results of the affected sectors. The model simulates a price changing scenario owing to the price escalation in cost of production in energy utilization by industry sector and household sector due to fuel subsidy removal represented by an increase in indirect tax. Some preliminary findings about the impact on the economy reveal that government will have a perpetual overall budget deficit, a big proportion of which comprise of subsidy.

Table 11: Effects of Subsidy Removal across Sectors

Description	10% increase	20% increase	30% increase
(Balance of trade)/GDP (change)	0.31	0.61	0.92
Aggregate employment: wage bill weights	144.72	289.43	434.15
Overall wage shifter	-259.25	-518.49	-777.74
Uniform % change in powers of taxes on intermediate usage	0	0	0
Uniform % change in powers of taxes on investment	0	0	0
Uniform % change in powers of taxes on household usage	0	0	0
Ratio, consumption/GDP	-23.5	-47	-70.5
Upward demand shift, non-traditional export aggregate	0	0	0
Right demand shift, non-traditional export aggregate	0	0	0
Uniform % change in powers of taxes on non tradtnl exports	0	0	0
Uniform % change in powers of taxes on tradtnl exports	0	0	0
Uniform % change in powers of taxes on government usage	0	0	0
Overall shift term for government demands	0	0	0
Ratio between f5tot and x3tot	0	0	0
Economy-wide "rate of return"	-26.8	-53.61	-80.41
Imports price index, C.I.F., $A	0	0	0
GDP price index, expenditure side	-33.03	-66.05	-99.08
Duty-paid imports price index, $A	0	0	0
Real devaluation	33.03	66.05	99.08
Terms of trade	-7.78	-15.56	-23.34
Average capital rental	57.51	115.03	172.54
Average nominal wage	-259.25	-518.49	-777.74
Consumer price index	-16.16	-32.32	-48.48
Price, non-traditional export aggregate	-6.67	-13.34	-20.01
Exports price index	-7.78	-15.56	-23.34
Government price index	-111.83	-223.66	-335.49
Inventories price index	-265.37	-530.74	-796.11
Exchange rate, RM/$world	0	0	0
Number of households	0	0	0
Average real wage	-243.09	-486.17	-729.26
Utility per household	0	0	0
C.I.F. $A value of imports	29.29	58.58	87.87
Nominal GDP from expenditure side	7.34	14.68	22.03
Nominal GDP from income side	7.18	14.36	21.53
Value of imports plus duty	29.29	58.58	87.87
Aggregate tariff revenue	-6.73	-13.46	-20.19
Aggregate revenue from all indirect taxes	-10	-20	-30
Aggregate payments to capital	57.51	115.03	172.54
Aggregate payments to labour	-114.53	-229.06	-343.59
Aggregate payments to land	53.19	106.37	159.56
Aggregate "other cost" ticket payments	52.44	104.88	157.32
Aggregate revenue from indirect taxes on intermediate	20.81	41.62	62.42
Aggregate revenue from indirect taxes on investment	-27.84	-55.69	-83.53

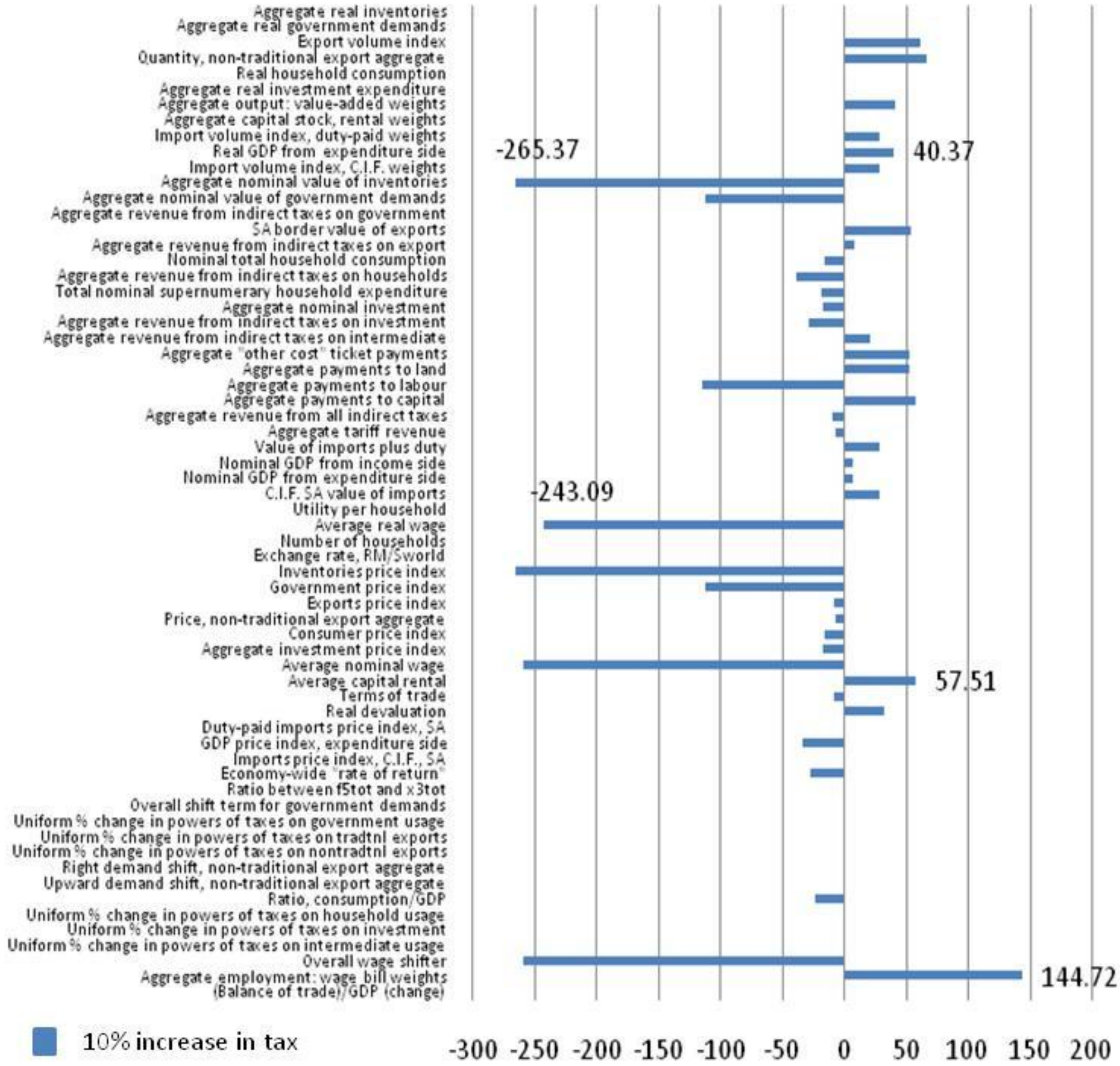
Description	10% increase	20% increase	30% increase
Aggregate nominal investment	-16.7	-33.4	-50.11
Total nominal supernumerary household expenditure	-17.98	-35.96	-53.93
Aggregate revenue from indirect taxes on households	-38.11	-76.21	-114.32
Nominal total household consumption	-16.16	-32.32	-48.48
Aggregate revenue from indirect taxes on export	8.93	17.87	26.8
A border value of exports	53.63	107.25	160.88
Aggregate revenue from indirect taxes on government	-0.01	-0.02	-0.03
Aggregate nominal value of government demands	-111.83	-223.66	-335.49
Aggregate nominal value of inventories	-265.37	-530.74	-796.11
Import volume index, C.I.F. weights	29.29	58.58	87.87
Real GDP from expenditure side	40.37	80.74	121.1
Import volume index, duty-paid weights	29.29	58.58	87.87
Aggregate capital stock, rental weights	0	0	0
Aggregate output: value-added weights	41.41	82.82	124.23
Aggregate real investment expenditure	0	0	0
Real household consumption	0	0	0
Quantity, non-traditional export aggregate	66.71	133.41	200.12
Export volume index	61.41	122.81	184.22
Aggregate real government demands	0	0	0
Aggregate real inventories	0	0	0

Source: MIER-CGE model.

By simulating three phases of increases in indirect taxes of 10%, 20% and 30% representing removal of fuel subsidy will demonstrate that the budget deficit, exchange rate fluctuation and high fuel world price provides a pressure on budget capacity to stimulate the Malaysian economy. The government has designed several fiscal policies, including reducing fuel subsidy, and our results show the impact of reducing fuel subsidy on macroeconomic variables, agricultural sector, and income distribution. To concentrate on more detail, Figure 8 illustrates an increase of 10% indirect tax exogenously in the CGE model.

Figure 8 confirms that wages of skilled labour decline steadily in response to the change in fuel price, whereas increases in land and capital rental will probably arise from substituting subsidy removal. *Households will lose their income following the reduction in fuel subsidy, which then decreases the welfare of households. Since incomes are not evenly distributed within society according to household groups* (as proven by Khalid and Zakariah (NEB, 2012)) an increased fuel price at consumer level will, in particular, hit hard the poor group and *declines their real GDP*.

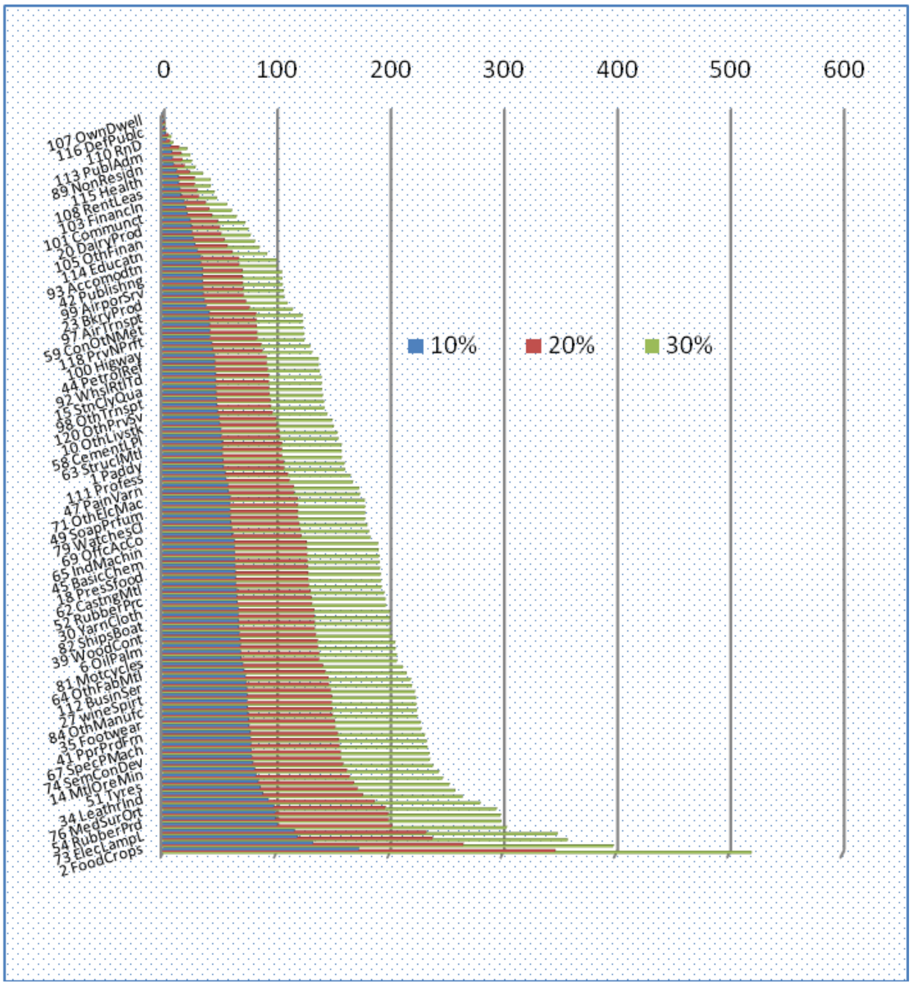
Figure 8: Change of 10 % Indirect Tax on Macroeconomic Variables, 2005



Source: I-O table 2005.

The *reduction in fuel subsidy tends to increase prices of industrial outputs* that are highly depended on fuel, such as manufacturing, transportation and fishery sectors. Figure 9 illustrates the ten lowest sectors of the economy includes sectors related to crude oil, many of them not being directly subsidized, this means that by lowering indirect tax in terms of fuel subsidy will impact some sectors, sectors that do not depend on fuel oil as main inputs. The change in fuel price influenced by subsidy removal does not have significant effects on sectors such as Dwellings, Other Public Administration and Defense and Public Order.

Figure 9: Sectoral Output Post-subsidy Removal (in %)



Source: Estimated from MIER-CGE model

3.4. Reallocation of Subsidy

By employing the I-O model the total effect of subsidy removal in the long run exhibits structural reform of the current economic structure anticipated to be more technologically efficient (with lower technical coefficient compared to the basic prices of A-matrix) and enhances value added (VA) (which include wages and operating surplus (OS)). The total output portrays that subsidy reform spurs redistribution of total output by reducing intermediate input but enhancing VA and/or OS. An introduction of subsidy rows, with negative sign, adjusts (net) domestic taxes row.

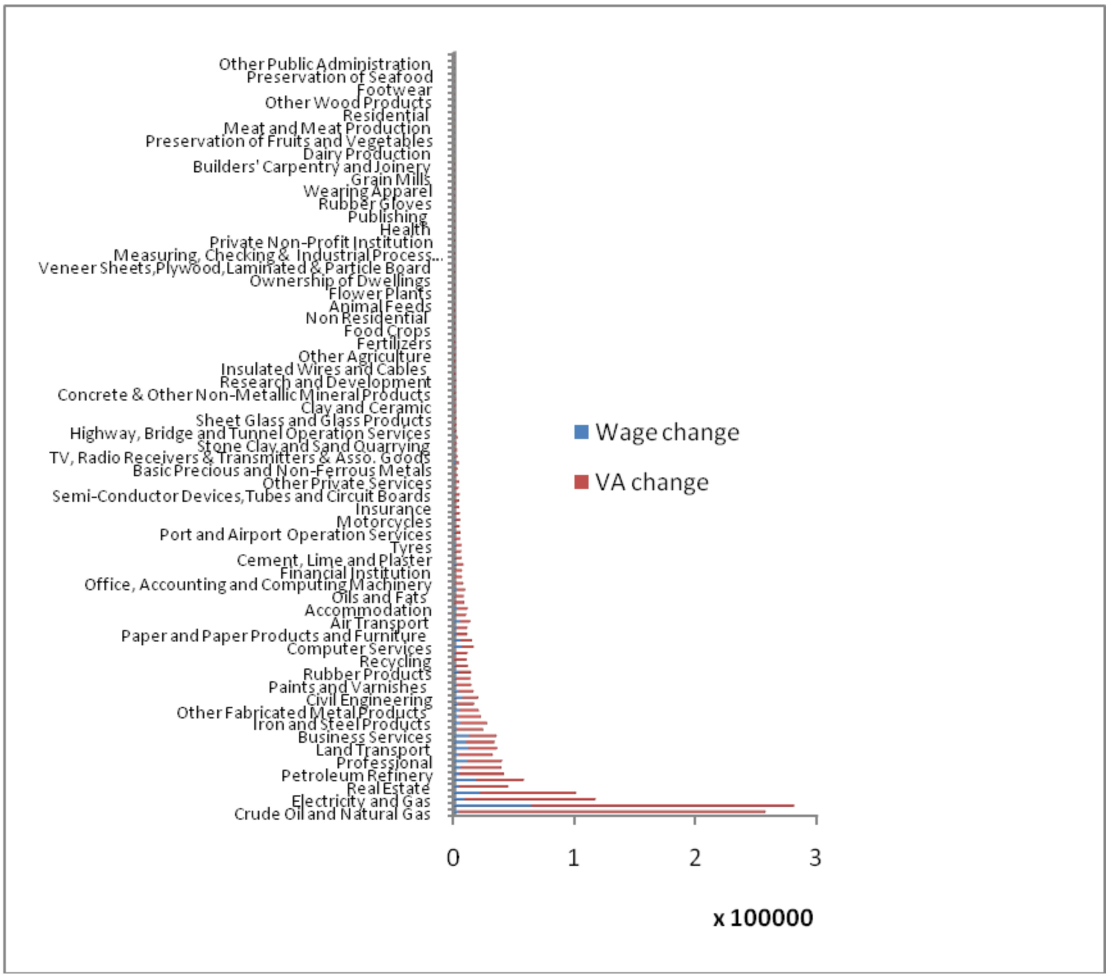
Removing subsidy as shown in the I-O model, is equivalent to an introduction of a dummy row with identical values of the subsidy row but with the positive sign, and has the effect of enhancing VA and/or OS. Since the value of column total remains unchanged, (the introduction of dummy row above) this has to be followed by a reduction of an equivalent value in the intermediate input quadrant, distributed along the column by the total intermediate input share; this represents the effect of improved efficiency in production, reflected by smaller input coefficient and higher VA and OS, and a structural reform due to subsidy reduction. Comparing the technical coefficients, *ex-ante* and *ex-post*, measures the technological enhancement due to subsidy removal.

The highest VA and CE comprises of Crude oil and natural gas, Wholesale and retail trade, Electricity and gas, Banks, Real estate, Amusement and recreational services, Petroleum refinery, Communication, professional services and Other mining and quarrying as shown in Figure 10 (Estimated results are list in Appendices, Table A1). Whereas sectors with the lowest VA and CE comprise Wooden and cane containers, Other public administration, Domestic appliances, Preservation of seafood etc. This assumed that the structure of the economy is the same with autonomous expenditure as with subsidy. If the reallocation policy changes according to poor, wage or growth, then the scope of dimension need to be changed accordingly.

Subsidy removal has double-edge effects - efficiency effects, reflected by reduction in technical coefficients in the A-matrix and allocative effects, reflected by enhancement in VA and/or OS through increased autonomous expenditure as a result of reallocating the extra fund from removal back to the system. The new A-matrix after removal, say A', can be derived by letting the subsidy of sector *j* reduce its intermediate inputs in all *i* sectors based on the existing sectoral total intermediate input share. The A' matrix will be technically more efficient than the A matrix because the A' consists of lower technical coefficients, thereby exerting a positive impact on the factor inputs (but output multiplier is lower too, to give way for higher factor inputs; thus leading to higher primary factor input multipliers).

Removal will directly reduce factor inputs, therein exerting a negative impact on GDP. Extra funds from the removal will have to be channeled back to the economic system through autonomous expenditure, which has positive impact on the factor inputs. The net result from removal depends on whether the positive impact on factor input due to technical gains and allocative effects outweigh the negative impacts of the direct removal.

Figure 10: Reallocation of Subsidy after Removal (at Level of Change in RM)



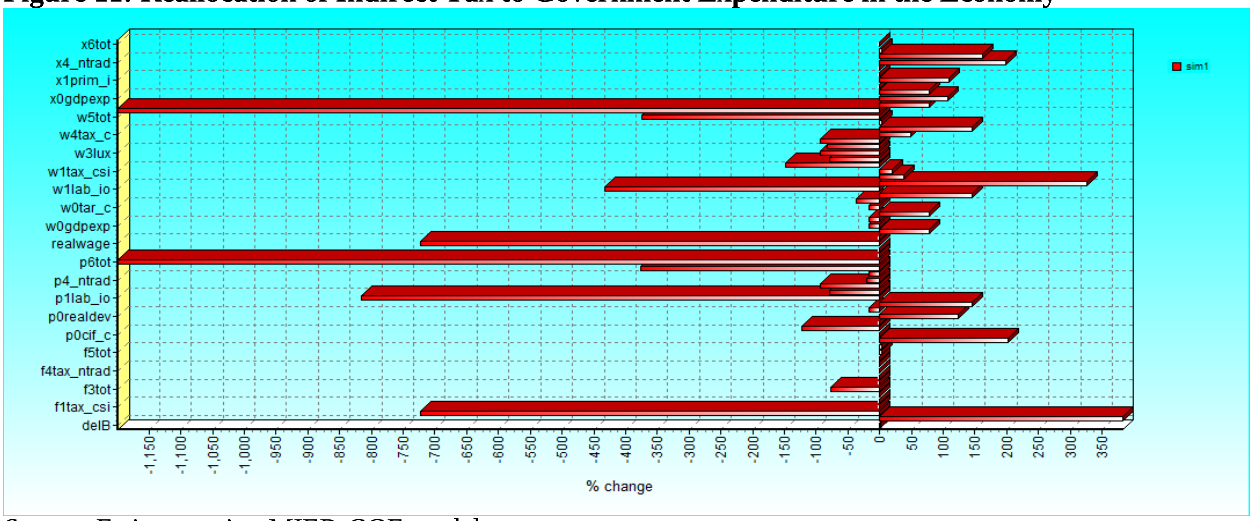
Source: Estimates from I-O Table 2005

Subsidy, regardless of whether applicable to producer or consumer, is naturally a transfer payment; therein unlike autonomous expenditure, subsidy does not create value-added. However, on the other hand consumer subsidy will increase disposable income, which will perhaps increase households' consumption (C) while producer subsidy will reduce costs of production, which will increase margin and probably investment (I). The positive effect of subsidy will only materialise if there is an increase of C or I, whichever is the case, respectively. Subsidy removal, therefore, will reduce GDP because there won't be any corresponding increase in either C or I as subsidy is removed. The amount of subsidy removed, instead, can be used to push government expenditure (G) up. In all the three cases, increase of C, I or G is all that matters because it is the autonomous expenditure that will at the end create value. Thus, pro-poor strategy will be guided by how this removal behaves between sectors.

The moment subsidy is removed; two separate effects can be traced: (i) the instant subsidy is removed, the value of indirect taxes is reduced because subsidy is the negative element. In order to let the value of total input remain intact, VA has got to be increased by the equivalent amount, which requires some amount of autonomous expenditure, presumably in the form of G. Given the intended increase in value-added, it is possible by using I-O formulation to estimate the necessary amount of autonomous expenditure required to support the intended increase, which previously shaped the pattern of G. (ii) The moment subsidy is removed, the cost of production, which was previously borne by government will have to be borne by producer in the form of increases in the cost of intermediate input, A* = A x *s*, where $1>s>0$, but inevitably a decrease in primary input while total input will remain unchanged, passes the cost increase to consumers in the form of *an* increase in *p*; i.e. change(P) = $(I - A)^{-1}$ *s*, where *s* is the vector of subsidy; reducing real but maintaining nominal GDP.

In taking into account relocation scheme using the MIER-CGE model, we relocate the approximate total fuel subsidy amounting to RM 24 billion into the government expenditure and derived the following graph as in Figure 11. We ran indirect tax and government expenditure exogenously over all sectors selecting sectors with significant taxation coefficients.

Figure 11: Reallocation of Indirect Tax to Government Expenditure in the Economy



Source: Estimate using MIER-CGE model

Reallocating-Pro-wage and Pro-growth

In reallocating fuel subsidy into the above policies, we simulate by redistributing subsidy into the intermediate and later it is inversed. The pro-poor strategy as discussed above is computed when the inversed is multiplied with total fuel subsidy to get total effects on value added and compensation of employee. Although the extensions can be clearly detailed using price-shift modeling, it is not attempted here. Next, pro-wage distribution can be executed by the same method but using the compensation of employee or worker's income. Finally, pro-growth strategy is modeled by examining capital and technology using the baseline intermediate demand and comparing it to the latest intermediate output. An in-depth study can be undertaken by involving the operating surplus in the primary quadrant or the capital stock to analyse change in technology. However, the pro-growth strategy which tend more to be production expansion will naturally be contrasted to the poor reallocating programme since the dimensions will be different.

4. Analysis

Sensitivity of price depends on many factors. The first two illustrated by the I-O model will be in terms of direct and indirect effects for country-wide, sectoral and households. Industry behaves in varying degrees to adjustment in the phasing out of subsidy. Some may adjust input in unexpected ways in economizing the use of energy by substituting other energy sources and passing some of the burden of the higher costs to their customers by raising price of goods or products. There are significant variations between industries since they use different proportion of energy inputs and generate different amounts of output. As such the less energy intensive industry and domestic resources-based industry are less prone towards the restructuring of subsidy.

Government as an active economic agent *should compensate reducing the fuel subsidy removal by direct assistance such as cash hand-outs to poor people provided it spurs productivity and increases welfare*. The compensation can also be given indirectly to the poor through the development of infrastructure, which may solve some supply side bottlenecks in the economy. Typically energy subsidy and policy interventions will focus on energy pricing and government intervention as main tools. Energy pricing must ensure economic efficiency, social equity and financial viability by adhering to the principles of recovering long-run marginal cost while preserving the environment from externalities and attempting to provide commercial energy access for everyone. Most commonly applied, *marginal cost pricing* ensures revenue generated is sufficient to cover the operating costs of the utility, and consumers will evaluate accurately the cost of their decision to consume an extra unit of energy. While *short-run marginal cost pricing* comprises the cost of crude fuels and other materials, labor costs and maintenance, excluding capital costs, its *long-run version* includes the cost of increasing output by expanding capacity. The former is preferred as it is not only easier to estimate but also encourages an efficient use of existing capacity.

Historical cost recovery pricing, on the other hand, sets energy product price at a level that allows recovery of past expenditures while permitting an acceptable market rate of return to be earned, but it can send incorrect economic signals, particularly when the set price does not equal marginal cost. It does not promote efficiency as the rate of return is fixed. Another type of pricing mechanism, *market pricing,* involves trading energy between suppliers and consumers at the market price. Bids are accepted in the market place from producers of energy to produce at a given price, thus encouraging competition among producers and leading to efficiency. However, market imperfections may prevail in practice, leading to inefficiency and uncertainty. *Discriminatory energy pricing* is used to extract higher revenues by differentiating prices, applicable only when differentiated user groups are clearly identifiable, therein income redistribution and fostering economic development may be achieved through low energy pricing to specific sectors. The method is quite common in pricing electricity and natural gas but not so in petroleum products because of difficulties in preventing resale and arbitrage. *Opportunity cost pricing* is based on the value of energy would have been if it could be offered and purchased outside the country rather than consumed domestically, as such it uses international prices to measure the domestic cost of energy and thereby its local price, consequently exposing domestic prices to instability and differences in social, economic and natural circumstances are also ignored. Similar to the case of Iran (UNEP, 2003) a two-tiered pricing structure for oil products for power plants and for other consumers is used in Malaysia.

Given the above pricing mechanisms, what policy options are available to influence energy pricing? *Energy taxation* can be used to raise revenues effectively provided the demand for energy resources is relatively inelastic while c*ross subsidies*, usually resulting in allocative inefficiency, impose excess charges (prices greater than the cost of supply) to some users in order to subsidize other users (who pay prices less than the cost of supply). Another option would be through the adoption of *lower rates of return* by publicly owned energy utilities, but confusion remains over the degree to which the rate of return should be lowered to directly benefit consumers. Last but not least, *direct subsidies* may be granted by government funding for selected beneficiaries directly.

All the above options could be re-categorized under rationalization not reform policies in three most significant sub-level examinations particularly in removing subsidy in terms of private consumption, producer subsidy and tax foregone and combination of both consumer and producer. Attempts to reduce subsidies to fuel prices through price differential at points of sale for a category of consumers have proved to be ineffective in most countries, leading to development of informal/black fuel markets and smuggling. Notwithstanding an exclusive emphasis on the poor, it is important to identify more desirable uses of energy and petroleum products as we pursue budgetary savings from the reduction of fuel subsidies.

Targeting of fuel subsidies to the very poor should embrace a possibility of identifying *more effective social protection mechanisms* that protect the poorest households from increases in fuel prices, yet still have substantial savings left over to allocate to higher priority expenditures or tax cuts that benefit the population at large. To mitigate the adverse impact of energy price subsidy reforms, some countries adopt unconditional cash transfers either directly or indirectly through coupons and/or smart cards limiting certain quantities of petrol/LPG at subsidized prices. *Direct cash transfers* to beneficiaries via magnetic cards have been used to distribute coupons and implemented in some countries. A method to reform subsidies to fuel prices through conditional cash transfers has now become more popular to ensure greater social protection in development and has been practiced by Brazil, Chile, Indonesia and Turkey. An alternative method is by *transferring through smart cards or coupon systems*, therein limiting purchases of petroleum products, for example, kerosene. This method allows identification of households at a subsidized price and has been experimented with in Malaysia, Indonesia and Iran.

Yet another indirect measure may include packaged fuel price increases with a set of compensatory measures within a comprehensive safety net of the population, perhaps in the form of elimination of fees for attending primary and junior secondary school, enhancement of primary health care among poor groups, and/or an increase in the minimum wage. In all instances, in order to ensure prudent public expenditures on distortionary and badly targeted fuel subsidies, *managing energy prices* must insulate price setting as much as possible from political pressure.

At the end of the exercise, these analyses are expected to show that fuel subsidy reduction will improve economic efficiency as a whole to the economy due to mitigating market distortion as well as energy efficiency, which will result in a win-win situation for the government, economy and environment. These results are hoped to assist policy makers to opt on setting up a road map for energy subsidy reduction or removal and reallocate subsidy as a step towards energy market integration. On the other hand, results from the energy sectoral investment simulation provide insights on benefits of investments in each energy sector. This can help the policy makers prioritize investment decisions for the high impact sectors and to create an enabling environment to expedite the investment process to harness higher benefits in the market.

5. Conclusions

Research into the nature of fuel subsidy, how it influences output, value added and income which are redistributed and compensated to those most likely to be affected by its removal, will help design subsidy rationalisation strategy. Commercially sound discount when costs are low or demand is price sensitive are very influential in measuring the risks in public policy. However, although there are many reasons for discount, argument for the application of discount is not as strong as when price is sensitive.

Emphasis on cheap energy input in the production system is not a good policy to help the poor. Nor is it good policy for industrial customers. From an economic efficiency perspective, there is no case for subsidizing energy consumption by a particular industry. This will result in an inefficient allocation of resources and reduce national income and in the long-run contribute to loss of competitiveness. The preferred pricing policy from this perspective is to charge customers according to their fill supply costs and subscribe to the concept of value for money policy.

Phasing out subsidies impacts the structure, sectoral performance and welfare of the economy. Delaying the removal of subsidies will further exacerbate disadvantages as discussed in this paper and reduce Malaysia's competitiveness if market prices continue to rise. Tolerating delayed subsidy removal will only create more economic problems and the option recommended is to rationalize gradually to reap more efficient fuel utilization and efficiency in the future. It is also recommended that Malaysia should not only pursue policies of subsidy rationalization, but also consider the adoption of a goods and sales tax (GST) and minimum wage should it aspire to be competitive. Losing competitiveness will permit neighbouring countries like Indonesia, Thailand, and Vietnam to surpass Malaysia's development path as these countries have demonstrated a more serious commitment to advance their economies by undertaking GST, minimum wage and subsidy rationalization.

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Appendixes

Table A1: Estimated Results as used in Figure 10-Reallocation of Subsidy after Removal (level change in RM)

	Change	
Sector	**CE**	**VA**
Crude Oil and Natural Gas	3,834.9	252,549.9
Wholesale and Retail Trade	64,075.2	216,007.0
Electricity and Gas	9,341.0	106,993.2
Banks	21,834.2	78,466.2
Real Estate	4,516.3	39,910.1
Amusement and Recreational Services	18,527.3	38,621.6
Petroleum Refinery	4,564.8	36,489.4
Communication	5,794.3	33,108.2
Professional	11,385.5	27,825.2
Other Mining and Quarrying	4,202.9	27,439.3
Land Transport	12,168.3	23,295.8
Oil Palm	10,286.6	22,744.6
Business Services	12,725.3	22,222.9
Waterworks	2,256.8	21,570.0
Iron and Steel Products	5,568.1	21,386.5
General Purpose Machinery	4,102.9	17,931.3
Other Fabricated Metal Products	5,062.7	15,126.3
Other Transport Services	3,395.2	12,895.6
Civil Engineering	7,326.3	12,417.1
Structural Metal Products	3,885.9	11,971.1
Paints and Varnishes	2,393.2	11,557.8
Basic Chemicals	1,862.9	11,483.2
Rubber Products	4,104.7	9,615.5
Forestry and Logging	1,541.5	9,613.7
Recycling	469.1	9,596.6
Water Transport	1,383.5	9,502.5
Computer Services	6,629.0	9,347.7
Restaurants	5,832.6	8,772.1
Paper and Paper Products and Furniture	2,356.4	8,351.9
Plastics Products	2,494.9	8,159.3
Air Transport	5,329.1	7,987.6
Other Financial Institution	1,794.0	7,962.2
Accommodation	2,926.2	7,932.9
Other Chemicals Product	742.7	7,506.0
Oils and Fats	1,201.7	6,594.5
Motor Vehicles	2,577.0	6,322.6
Office, Accounting and Computing Machinery	1,122.2	6,231.4
Other Livestock	902.8	5,490.1
Financial Institution	906.7	5,470.9
Rental and Leasing	2,360.7	5,187.6
Cement, Lime and Plaster	1,166.3	4,614.5

Sector	Change	
	CE	Sector
Other Manufacturing	1,214.6	4,453.2
Tyres	1,811.3	4,068.9
Rubber Processing	735.4	4,020.6
Port and Airport Operation Services	1,400.3	3,780.8
Printing	930.1	3,406.9
Motorcycles	1,508.3	3,360.7
Other Textiles	1,101.9	3,314.1
Insurance	765.4	3,255.4
Special Purpose Machinery	723.9	3,254.0
Semi-Conductor Devices, Tubes and Circuit Boards	1,073.3	3,248.3
Rubber	669.9	2,761.4
Other Private Services	1,246.9	2,729.7
Other Electrical Machinery	370.7	2,297.9
Basic Precious and Non-Ferrous Metals	558.4	2,177.4
Public Administration	1,771.6	2,071.3
TV, Radio Receivers & Transmitters & Asso. Goods	928.9	1,770.6
Poultry Farming	612.0	1,727.0
Stone Clay and Sand Quarrying	569.0	1,616.5
Education	1,110.5	1,562.4
Highway, Bridge and Tunnel Operation Services	383.5	1,492.9
Electric Lamps and Lighting Equipment	482.2	1,458.4
Sheet Glass and Glass Products	513.5	1,386.8
Fishing	265.0	1,149.0
Clay and Ceramic	331.0	1,025.1
Special Trade Works	589.8	1,006.0
Concrete & Other Non-Metallic Mineral Products	351.8	981.9
Other Food Processing	202.0	952.7
Research and Development	630.2	939.0
Wine and Spirit	203.4	923.7
Insulated Wires and Cables	259.2	907.2
Sawmilling and Planning of Wood	265.7	872.4
Other Agriculture	261.5	857.8
Paddy	448.8	840.4
Fertilizers	210.7	788.4
Finishing of Textiles	136.6	708.3
Food Crops	332.0	675.6
Optical Instruments and Photographic Equipment	164.5	662.1
Non Residential	406.6	625.8
Casting of Metals	186.4	619.4
Animal Feeds	55.7	614.2
Yarn and Cloth	151.5	498.3
Flower Plants	200.7	487.8
Tobacco Products	88.0	445.2
Ownership of Dwellings	0.1	436.4
Defence and Public Order	379.1	434.5

	Change	
Sector	**CE**	**Sector**
Veneer Sheets,Plywood,Laminated& Particle Board	121.0	415.9
Ships & Boats Building, Bicycles & Invalid Carriages	91.6	370.4
Measuring, Checking & Industrial Process Equipment	181.3	363.6
Watches and Clocks	101.9	352.4
Private Non-Profit Institution	211.2	349.3
Other Transport Equipment	67.3	347.0
Health	170.9	343.6
Soap, Perfumes, Cleaning & Toilet Preparations	42.4	340.2
Publishing	66.9	239.1
Electrical Machinery and Apparatus	96.5	223.6
Rubber Gloves	143.1	220.2
Leather Industries	69.7	216.8
Wearing Apparel	60.0	215.4
Metal Ore Mining	64.1	204.1
Grain Mills	53.5	200.1
Fruits	96.7	173.7
Builders' Carpentry and Joinery	84.5	161.7
Soft Drink	36.4	156.9
Dairy Production	17.6	125.7
Pharmaceuticals, Chemicals & Botanical Product	28.7	96.6
Preservation of Fruits and Vegetables	14.6	75.4
Vegetables	44.4	73.7
Meat and Meat Production	42.8	73.3
Industrial Machinery	10.2	52.9
Residential	34.6	52.4
Confectionery	5.8	47.0
Other Wood Products	16.2	46.4
Bakery Products	16.6	45.9
Footwear	10.2	28.1
Medical, Surgical and Orthopaedic Appliances	4.9	19.1
Preservation of Seafood	3.1	11.9
Domestic Appliances	0.5	2.0
Other Public Administration	1.1	1.2
Wooden and Cane Containers	0.2	0.4

Source: Estimates from I-O Table 2005

CHAPTER 10

Study on the Impact of Electricity Tariff Increase on the National Economy of Vietnam

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The electricity price in Vietnam in 2011 was around 6 US ¢/kWh which is lower than the Long Run Marginal Cost (LRMC) of 9.5 US ¢/kWh. This low price discourages energy productivity enhancement and affects energy supply security. Thus, the Government of Vietnam plans to increase the electricity tariff. This study examines the impacts of increasing electricity tariff to the LRMC on prices of consumer goods and services and the likely distribution impacts by household income quintiles using a static Input-Output approach. The study found that such an increase would drive up the prices of all other products. The price impact, however, is not large. The distribution impact by household income quintiles is also not large. Although the impact is not large, it would be socially difficult to implement this increase at once, particularly given that Vietnam is facing high inflation rates. A roadmap for electricity tariff increase is thus discussed.

1. Background

Vietnam's high economic growth rate has led to increasing demand for electricity. Between 2001 and 2010, electricity production (including imported electricity) increased from 31.13 billion kWh to 100 billion kWh; electricity sales from 25.8 billion kWh to 86.8 billion kWh and installed capacity from 7,872 MW to 21,542 MW, reaching an average annual growth rate of 13.8%, 14.4% and 12%, respectively. Generation mix in 2010 was gas fired power plants 41%, hydro power plants 37.7%, coal fired power plants 11% and the rest are oil, renewables and import from China. As an emerging economy, electricity demand is expected to keep growing significantly in the forthcoming period, 2010–2030. The Power Development Plan No. 7 forecasted that electricity demand would increase from 100 billion kWh in 2010 to 695 billion kWh by 2030, at an average annual growth rate of 10% per year (PM, 2011b). Vietnam is expected to become a net energy importer by around 2015.

Such rapid development raises a number of questions for the Government of Vietnam, including (i) how to secure funds to finance such an aggressive power source development, and then (ii) how to manage the power sector effectively and efficiently. Currently, the power sector of Vietnam is dominated by the Electricity of Vietnam (EVN), a government-owned utility. EVN has a majority in generation capacity (around 65% in 2010), and a monopoly role in transmission and sales of electricity. Electricity retail tariff in Vietnam is governed by the Government, and the Government of Vietnam maintains uniform national electricity tariff across the country which is highly subsidized. The weighted average retail electricity tariff in Vietnam in 2011 was only 6.0 US¢/kWh while the Long Run Marginal Cost (LRMC) was 9.5 US¢/kWh. The subsidy amount in 2010 was estimated at 2.69 billion USD, equivalent to 2.83% of GDP in the same year (IEA, 2011). EVN's revenue in 2010 was around USD 4.5 billion while the required investment capital is estimated at between USD 6-7 billion per year over 2011-2030.

To address these challenges the Government of Vietnam plans to restructure the power sector. The roadmap which has been approved by the Prime Minister specifies that the power market in Vietnam will be established through three sequential developments: *competitive generation power market, competitive wholesale power market and competitive retail power market.* Phase I starts in 2009, phase II in 2017 and phase III in 2024 (PM, 2006).

To do this, however, the electricity retail tariff to users, and subsequently the purchasing price for power from power producers, must first be increased. This is because the weighted average retail electricity tariff in Vietnam was generally lower than that of most countries (for example, the electricity price in Thailand in 2011 was 10.6 US¢/kWh) (ADB, 2012b) and, therefore, not attractive for local and foreign enterprises to invest in new generating capacity in Vietnam. This situation is also unfavorable for Vietnam with regard to the promoted plan of regional power interconnection grid (for example, the electricity imported from China is currently paid at a higher level than the purchasing price to power producers).

This problem has been recognized by the Government of Vietnam. As a response, the Government of Vietnam plans to increase the electricity tariff to reflect the production cost to improve energy supply security and to improve energy productivity (PM, 2009 and PM, 2011a).

This action will definitely have impacts on other sectors, on macroeconomic indicators and social welfare. In this study, we examine two broad questions: First, what would be the impacts of rising electricity tariff on prices of other sectors of the economy? In connection with this question, electricity intensity of various sectors will be first explored. Second, what are the likely distributional impacts induced by this price rise?

To answer the above questions this paper presents the methodology used to examine the impacts of electricity price increase on other sectors in Section 2. Section 3 discusses the results and Section 4 considers some policy recommendations.

2. Methodology and Data Preparation

Because electricity is used as inputs to produce most of the goods and services, a higher electricity price can affect the prices of other sectors of an economy both directly and indirectly.

The I–O model describes the interdependence of all sectors in the production and consumption of products. It shows the input requirement for a sector and at the same time specifies how that sector distributes its production output to other sectors. In this regard, the I–O model is able to analyze the relationships among sectors, evaluate the impacts from one sector to other sectors, and can thus be used to quantify the effects from the electricity sector.

The I–O model was first proposed by Leontief in 1936. Since then it has been applied to various areas. It has also been widely applied in energy-related contexts including electricity. Using the I–O model, Pfaffenberger, *et al.* (2003) examined the impacts from the development of renewable energy technologies such as wind turbine and solar photovoltaic on the economy of Germany in terms of creating job. Tiwari (2000) used I-O modelling to estimate energy intensities of different sectors in India. Similarly, Pachauri & Spreng (2006) also used the I–O model to determine the indirect energy requirements of Indian households. Hadley, *et al*. (2001) examined the impacts from the restructuring of the power sector on Oklahoma in the USA.

The I–O model has been introduced at some universities in Vietnam since the mid-1960s (Dong, *et al*. 2006). However, it was not until 1989 that the first national I–O table of 54 sectors was made. To date, four national I–O tables have been created. The latest table consists of 138 sectors for 2007 and was released in 2010. There have been several studies applying these I–O tables. For example, Bo (2002) applied the I–O table to examine the role of the construction sector in the national economy. Tuyet & Ishihara (2006) used the I–O tables of 1996 and 2000 to examine the changes in energy intensities of different sectors between 1996 and 2000. Recently, a research group from the National University of Economics has used the I-O table of 2005 to examine the impacts of rising petroleum products on the economy (Thanh, *et al*. 2008). Khanh (2008) examined the impact of a rise in electricity tariff on prices of consumer goods and services in Vietnam. There has, however, been no study consisting of a complete and updated examination of the sectoral impacts of electricity prices in the Vietnamese economy.

With salient features in impact investigation and related applications as described above, in this research, the I-O model is chosen to examine the impacts from electricity tariff increase on the prices of other sectors in Vietnam. For this purpose, the following subsection will focus on the description of the I-O model and its adaptability to this specified task.

2.1. The General Framework of I-O Model

The I-Omodel is a set of linear equations, which represent the relationships among sectors of an economy over a stated period of time, say, a year. The I-O model for an economy consisting of n sectors can be expressed as

$$X_i = \sum_{j=1}^{n} X_{ij} + F_i = \sum_{j=1}^{n} a_{ij} X_j + F_i \qquad (1)$$

or

$$X_j = \sum_{i=1}^{n} X_{ij} + V_j = \sum_{i=1}^{n} r_{ij} X_i + V_j \qquad (2)$$

where X_i is the total gross output of sector i ($i=1,.....,n$); a_{ij}, defined as the delivery from sector i to j (X_{ij}) per unit of sector j's output (X_j) are known as direct input or technical coefficients; r_{ij} are direct output coefficients, obtained by dividing the purchase by sector i from sector j by X_i total gross input of sector i; F_i is final demand for sector i; and V_j is the value added in sector j.

Equation (1) shows that the total production of any sector is equal to the sector's products used by all sectors in the economy plus the amount demanded for final use by consumer, exports, investment and government minus imports. Equation (2) indicates that the total production of any sector is equal to the total purchase made by the sector from all sectors in the economy plus value added (i.e., wages, salaries, profit, taxes, etc.) in this sector.

2.2. Deriving electricity intensity

Equation (1) can be expressed in matrix form as

$$X = AX + F \tag{3}$$

or

$$X = (I - A)^{-1} F \tag{4}$$

Where X represents vector of gross output, $(I\text{-}A)^{-1}$ is the Leontief's inverse matrix, I is the identity matrix, A is the coefficient matrix, and F is the vector of net final demand. The elements of inverse matrix represent the total direct and indirect requirement by sector per unit of final demand. Thus, Eq. (4) can be used to compute the electricity requirement as a result of a given change in final demand F of each sector.

2.3. Sectoral Price Effects

Equation (2) can be rewritten in terms of prices as follows:

$$P_j = \sum_{i=1}^{n} r_{ij} P_i + V_j \tag{5}$$

The equation states that the price which each productive sector of the economy receives per unit of its output must equal the total outlays incurred in the course of its production. These outlays comprise not only payments for inputs purchased from the same and from the other industries, but also the value added (i.e., wages, salaries, profit, taxes, etc.), which essentially represent payments made to exogenous sectors. Thus,

$$P = (I - R)^{-1} V \tag{6}$$

Equation (6) is the Leontief Price Model and can be used to assess the impact on prices throughout the economy of an increase in value-added cost in one or more sectors (Miller & Blair, 1985). However, Equation (6) cannot exactly assess the impact from a change in the price change of one sector (the electricity sector for example) on the other sector since that sector is part of the I-O matrix. To address this, that sector must be treated externally and is included in the value added.

Adding superscript * to the new matrices and superscript E to the vector related to the examined sector gives: $P^{*} = (I - R^{*})^{-1}\left(V^{*} + R^{E}P^{E}\right)$. The assumption ΔV*=0 (no change in the value added) yields:

$$\Delta P^{*} = (I - R^{*})^{-1} R^{E} \Delta P^{E} \qquad (7)$$

Eq. (7) can be used to investigate the impacts of a change in the electricity price on the prices of other sectors. It is worth noting that Eq. (7) provides us with the sum of both direct and indirect impacts of a rise in P^E on P*. The direct effect shows the intermediate price response of a sector, whereas the total effect determines the price changes after taking into account the sectoral inter-dependencies.

The overall impact of ΔP* on the Consumer Price Index (CPI) is then estimated by calculating weighted average of the sectoral price changes, based on their shares in total private consumption.

Given the estimated sectoral prices rises, the distribution impacts by household income quintiles can then be examined by matching sectoral price changes with household spending pattern described in household expenditure survey. The General Statistics Office has been conducting a Household Expenditure Survey every two years since 2002. The expenditure on different consumer goods and services by the percentage of total spending by household income quintile is gathered.

2.4. Data Preparation and Assumptions

To simulate the impact of an increase in electricity tariff on the prices of other sectors in Vietnam, we use the I-O table for 2007. This I-O table consists of 138 sectors and is the latest available (GSO, 2010). To facilitate the calculation, these 138 sectors are aggregated into 50 sectors as shown in Table 1. The I-O system is based on the following assumptions: (i) fixed input/output ratios, and (ii) fixed input ratio, due to the linearity of the model, and (iii) exogeneity of primary inputs and final demand components.

For the modeling purpose, this study assumes an increase by 3.5 US¢/kWh which is exactly the difference between the present average tariff and the LRMC or a 58.3% increase over the present average tariff.

For exploration of the distributional consequences of the simulated price changes, the household expenditure survey for 2006 is used (GSO, 2008). As this survey result is one year older than the I-O table used in this study, it is assumed that the expenditure pattern by household quintile in 2007 was similar to that of 2006.

3. Empirical Results

Table 1 shows the electricity requirement as input, both direct and indirect for a unit increase in the activity of various sectors which can be regarded as electricity intensity.

Excluding electricity sector, water processing is the most electricity intensive sector (0.224). This is not surprising as electricity is the main direct intermediate input for its production (0.181). Other sectors that also have high electricity intensities include gas (0.148), paper & paper products (0.097), chemicals & chemical products (0.095). There are 22 sectors with electricity intensities of more than 0.05. The least electricity intensive sector is coke coal (0.011). The weighted average electricity intensity based on the sectoral shares in total gross output is estimated at 0.074, meaning to generate USD 1, Vietnam would need on average USD 0.074 worth of electricity input. Excluding electricity from the list as it could distort the result, the average would become 0.045.

Table 2 shows impacts from a rise of 58.3 % in the electricity tariff (from 6.0 to 9.5 US¢/kWh) on the prices of other sectors both directly and indirectly. Six sectors experience a direct price of more than 1.5 % in their prices: Water processing (10.56%); Gas (6.96%); Sport, entertainment (3.41%); Hotel and restaurants (2.28%); Paper and paper products (1.96%); Chemical & Chemical products (1.96%). These sectors are thus relatively more reliant on electricity and therefore an increase in electricity immediately impacts on their production costs.

Table 1: Direct and Total Electricity Use of Various Sectors for $1 Increase in Final demand in 2007

Nr.	Sector	Electricity intensity		Ratio
		Direct	Total	
1	Crops	0.006	0.033	0.18
2	Livestock and poultry	0.007	0.043	0.16
3	Agricultural services	0.021	0.062	0.34
4	Forestry	0.003	0.019	0.17
5	Fish & other marine products	0.008	0.045	0.17
6	Metallic ores & non-metallic minerals	0.010	0.022	0.43
7	Processed, preserved meat and by-products	0.006	0.046	0.12
8	Processed, preserved fishery and by-products	0.012	0.059	0.21
9	Processed preserved vegetables and fruit	0.010	0.050	0.21
10	Milk and by-milk	0.007	0.044	0.16
11	Rice and Flour (all kinds)	0.011	0.049	0.23
12	Cacao, chocolate and candy, cake products from flour	0.018	0.058	0.31
13	Café	0.009	0.030	0.31
14	Animal feed	0.007	0.048	0.15
15	Beverages, alcoholic & non-alcoholic	0.015	0.050	0.30
16	Cigarettes	0.006	0.046	0.12
17	Textiles	0.016	0.079	0.21
18	Leather & leather products	0.022	0.067	0.33
19	Wood products	0.016	0.047	0.35
20	Paper & paper products; printed matters	0.034	0.097	0.35
21	Coke coal and other by-product cokes	0.002	0.011	0.15
22	Gasoline, lubricants	0.005	0.035	0.13
23	Chemicals & chemical products	0.034	0.095	0.36
24	Medicines	0.014	0.052	0.27
25	Rubber products	0.002	0.020	0.09
26	Plastic products	0.007	0.050	0.14
27	Non-metallic mineral products	0.024	0.055	0.43
28	Cements	0.012	0.041	0.28
29	Basic metals & fabricated metal products	0.011	0.058	0.19
30	Electronics apparatus	0.008	0.053	0.16
31	Machinery, electric equipment	0.006	0.026	0.23
32	general-purpose machinery	0.025	0.065	0.38
33	Cars and other transport means	0.013	0.058	0.22
34	Motor vehicles, motor bikes	0.014	0.056	0.25
35	Bed, cabinet, tables, chairs	0.012	0.041	0.30
36	Other products	0.014	0.045	0.30
37	Electricity	0.138	1.169	0.12
38	Gas	0.119	0.148	0.81
39	Water processing	0.181	0.224	0.81
40	Management and waste water handle, waste	0.024	0.043	0.55
41	Construction	0.005	0.038	0.14
42	Transport	0.005	0.026	0.20
43	Post & telecommunication services	0.016	0.043	0.38
44	Hotel & restaurant services	0.039	0.059	0.66
45	Finance	0.008	0.023	0.35
46	Tourism	0.008	0.026	0.32
47	Education	0.020	0.038	0.52
48	Healthcare	0.016	0.046	0.35
49	Sports ; entertainment	0.058	0.086	0.68
50	Other service	0.019	0.036	0.52

Table 2: Effects from a 58.3% Rise in Electricity Tariff to Prices of Other Sectors

Nr.	Sector	Effects of 58.3% rise in electricity tariff on prices of other sectors	
		Direct impact (%)	Total impact (%)
1	Crops	0.34	1.62
2	Livestock and poultry	0.40	2.14
3	Agricultural services	1.23	3.10
4	Forestry	0.19	0.97
5	Fish & other marine products	0.44	2.23
6	Metallic ores & non-metallic minerals	0.56	1.11
7	Processed, preserved meat and by-products	0.32	2.31
8	Processed, preserved fishery and by-products	0.71	2.94
9	Processed, preserved vegetables and fruit	0.61	2.50
10	Milk and by-milk	0.41	2.18
11	Rice and Flour (all kinds)	0.66	2.46
12	Cacao, chocolate and candy, cake products from flour	1.06	2.91
13	Cafe	0.54	1.51
14	Animal feed	0.42	2.41
15	Beverages, alcoholic & non-alcoholic	0.87	2.52
16	Cigarettes	0.32	2.30
17	Textiles	0.95	3.94
18	Leather & leather products	1.28	3.33
19	Wood products	0.94	2.32
20	Paper & paper products; printed matters	1.96	4.82
21	Coke coal and other by-product cokes	0.10	0.57
22	Gasoline, lubricants	0.28	1.75
23	Chemicals & chemical products	1.96	4.73
24	Medicines	0.83	2.59
25	Rubber products	0.10	0.99
26	Plastic products	0.41	2.48
27	Non-metallic mineral products	1.39	2.76
28	Cements	0.68	2.05
29	Basic metals & fabricated metal products	0.63	2.91
30	Electronics apparatus	0.48	2.63
31	Machinery, electric equipment	0.35	1.30
32	general-purpose machinery	1.43	3.25
33	Cars and other transport means	0.74	2.91
34	Motor vehicles, motor bikes	0.82	2.79
35	Bed, cabinet, tables, chairs	0.73	2.06
36	Other products	0.79	2.23
37	Electricity	-	58.3
38	Gas	6.96	7.36
39	Water processing	10.56	11.15
40	Management and waste water handle, waste	1.39	2.15
41	Construction	0.31	1.88
42	Transport	0.31	1.31
43	Post & telecommunication services	0.96	2.14
44	Hotel & restaurant services	2.28	2.95
45	Finance	0.47	1.16
46	Tourism	0.49	1.32
47	Education	1.17	1.90
48	Healthcare	0.94	2.32
49	Sports ; entertainment	3.41	4.30
50	Other service	1.10	1.82

Further, the indirect effect (total effect minus direct effect) exceeds 1.5 % for 24 sectors and 2% for the following 9 sectors: Textile (2.99%); Paper & paper products (2.86%); Chemicals & chemical products (2.77%); Basic metals & fabricated metal products (2.28%); Processed preserved fishery and by-products (2.23%); Cars and other transport means (2.17%); Electronics apparatus (2.15 %); Plastic products (2.07 %); Leather & leather products (2.05%). The price increase in these sectors is mainly due to inter-dependencies amongst industries. These sectors might not use electricity significantly as an intermediate input, but they need to buy intermediate inputs from those sectors in which electricity constitutes a higher proportion of total intermediate inputs cost. For example, the plastic product purchases only a negligible percentage of its intermediate input from the electricity sector (with direct coefficient of 0.0071).

The total impacts in Table 2 indicate that the electricity price rise would increase in the following 5 sectors more than 4 %: Water processing (11.15%); Gas (7.36%); Paper & paper products (4.82%), Chemical & chemical products (4.73 per cent) and Entertainment & Sport (4.3%). The impact on a sector is comparable to its electricity intensity shown in Table 1. From this simulation, it would be possible to say that the impact on the iron and steel sector, if electricity price rises is not as much as is expected (overall only 2.9% in this rise scenario), the sector ranks 13th in the list of 50 sectors.

These increases in prices would lead to an increase in the CPI (Consumer Price Index) of 4.2%, based on their shares in total private consumption. These increases in prices could relate to household expenditure by quintiles to assess distribution impacts. Unfortunately, like most countries, the I-O tables of Vietnam do not provide such information so we have to employ another method.

The General Statistic Office has been conducting Household Expenditure Surveys every two years since 2002, and this data can be used to assess distribution impacts by household income quintiles. In this study, we use the 2006 survey which is the closest to the year of the I-O table used in this study - 2007. Table 3 summarizes the expenditure on different consumer goods and services by the percentage of total spending by household income quintiles.

A relative measure is needed to identify which expenditure items are relatively more important for the "poor" (first quintile) and for the "rich" (fifth quintile), respectively. In Table 3, the approximate relative measure is the quotient of the percentage share of the first quintile to the percentage share of the fifth quintile. If it is more than one, we say that the poor spend a higher proportion of their total expenditure on that item than the rich, and vice versa.

As we can see in Table 3, the first five items have relative measure more than one which thus indicates the poor spend a higher portion of their total expenditure on those items than the rich. These are all basic needs for life sustenance: Food; Fuel; Foodstuff; Healthcare; Garment. To be able to see the impacts from the electricity price increase on these items by income quintile, items in Table 2 have been regrouped to match those in the household expenditure survey.

Table 3: Share of Household Expenditure on Different Goods and Services by Household Income Quintile Group (Per cent)

Expenditure item	**Income quintile**					**Relative measure**	**Rank**
	Group 1	Group 2	Group 3	Group 4	Group 5		
Food	25.22	18.80	14.35	10.23	6.19	4.08	1
Fuel	4.45	3.46	3.13	2.99	2.35	1.90	2
Foodstuff	30.17	31.21	30.16	28.35	25.28	1.19	3
Healthcare	6.82	6.82	6.84	6.55	5.84	1.17	4
Garment, hat, shoes, sandals	4.95	4.79	4.75	4.46	4.27	1.16	5
Drinking and smoking	2.87	2.94	3.02	3.10	3.24	0.89	6
Education	5.39	6.54	6.68	6.93	6.17	0.87	7
Furniture	6.82	7.38	8.36	9.04	10.78	0.63	8
Others	2.18	2.76	3.13	3.31	3.51	0.62	9
Electricity	2.07	2.39	2.52	2.70	3.53	0.59	10
Travel & telecommunic.	5.84	7.86	9.34	11.86	15.59	0.37	11
Housing, water, sanitation	0.55	0.59	0.90	1.48	1.59	0.35	12
Outdoor meals	2.47	4.23	6.42	7.95	8.79	0.28	13
Culture, sport, recreation	0.20	0.24	0.40	1.03	2.89	0.07	14
Total	100.00	100.00	100.00	100.00	100.00		

Table 4 shows that a rise in electricity tariff increases the cost of producing these items not more than the other items, except Fuel (5.39%), but since their shares in household expenditure are quite high, for example Foodstuff (30.17%) and Food (25.22%) for the first quintile, the overall impacts for these commodity groups are quite high.

In terms of the impact on the electricity prices themselves, the lower quintile suffers the less loss. This is because their payment for electricity represents a smaller share in their annual expenditure than the "rich". This result is influenced by the fact that a number of households in rural areas are still without access to electricity. They are poor and have relatively lower electrification rates than better income households. Unfortunately, the survey results could not provide this detailed information.

Table 4: Impact for Each Commodity Group by Income Quintile (Per cent Increase in Expenditure)

Expenditure item	Total price increase	Percent increase in expenditure by income quintile				
		Group 1	Group 2	Group 3	Group 4	Group 5
Food	1.82	0.46	0.34	0.26	0.19	0.11
Fuel	5.39	0.24	0.19	0.17	0.16	0.13
Foodstuff	2.73	0.82	0.85	0.82	0.77	0.69
Healthcare	2.23	0.15	0.15	0.15	0.15	0.13
Garment, hat, shoes, sandals	3.36	0.17	0.16	0.16	0.15	0.14
Drinking and smoking	2.40	0.07	0.07	0.07	0.07	0.08
Education	1.95	0.10	0.13	0.13	0.14	0.12
Furniture	2.07	0.14	0.15	0.17	0.19	0.22
Others	2.19	0.05	0.06	0.07	0.07	0.08
Electricity	58.3	1.21	1.39	1.47	1.57	2.06
Travel and telecommunication	2.47	0.14	0.19	0.23	0.29	0.38
Housing, water, sanitation	2.11	0.01	0.01	0.02	0.03	0.03
Outdoor meals	3.02	0.07	0.13	0.19	0.24	0.27
Culture, sport, recreation	3.39	0.01	0.01	0.01	0.04	0.10
Total		3.65	3.84	3.94	4.06	4.54

4. Policy Implications

The results from above show that the impacts are not large and could be, in reality, even smaller as sectors could cut the benefit or rearrange their activities in favor of other factors of production including labor and capital, but it would be socially difficult to implement this increase at once, particularly given the high inflation rate the country is facing. The inflation rates in 2008, 2009, and 2010 were 23.0%, 6.9%, and 9.2%, respectively (ADB, 2012a). Also, the present slowdown of the market, lack of access to credit by producers, and increasing labor cost do not favor this. It is thus proposed that the increase in electricity tariff be gradual and separate by sectors. The results in Table 2 might help policy makers design such a policy. To assist policy makers developing roadmaps for introducing electricity tariff increase, the CPI increase as a function of electricity increase level has been performed (Table 5).

Table 5: CPI Increase as a Function of Electricity Price Increase (in Percentage)

Percentage increase in electricity tariff	Percentage increase of CPI
10	0.72
20	1.44
30	2.16

In parallel with measures to increase tariff, the power sector should consider improving efficiency performance as this would relieve the pressure of investment and tariff increase. The improvements would accrue to both demand and supply sides. On the supply side there is improvement in efficiency of generation and distribution. For example, coal fired power plants currently representing 11% installed capacity and about 15% of power generation output of the total system have efficiencies of between 28-32% which are about 10% lower than the world average levels. Transmission and distribution losses at the present are estimated at 10%. On the demand side there is the improvement on energy productivity. The electricity intensity in Vietnam is higher than most countries, including those with the same level of GDP per capita indicating high electricity saving potentials and Table 1 could help identify the specific sectors.

Finally, the large difference of electricity intensity of sectors might suggest a restructuring of the economy in the long run for the sustainable development of the country. The idea is electricity intensive sectors that contribute less to the GDP might be reorganized and tertiary industry might be encouraged.

However, it is important to note some shortcomings of I-O analysis. The I-O table used in this analysis is for the year 2007. The present economic structure might be different from that of 2007. These results are also limited by the assumptions of the I-O model: (i) fixed input/output ratio, and (ii) fixed input ratio. Likewise, the household expenditure survey results used in this study were for the year 2006.

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