Chapter 6

Facilitating the Penetration of Renewable Energy into the Power System

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CHAPTER 6

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The ASEAN Vision 2020, four pillars of energy cooperation, was defined in 1997 as including the ASEAN Power grid (APG), the Trans ASEAN gas pipeline, energy efficiency and conservation, and development of new and renewable energy sources. We have developed analyses into the four sections: (i) to examine renewable energy policy in both developed and developing countries; (ii) to measure the diversity index of the power generating systems of the East Asia Summit (EAS) area and individual countries; (iii) to investigate the future path of renewable energy utilization in power generation; (iv) to make policy recommendations on how to optimize the penetration of renewable energy sources in the context of energy market integration. There are three main findings from this study. First, European countries can provide lessons on how to promote renewable energy using a feed in tariff policy and a renewable portfolio standard. Second, experiences from Indonesia and Malaysia show both similarities and differences in policies promoting renewables, such as in terms of incentives, criteria, regulations, and institutional arrangements. Third, historical data indicates that since the mid-1980s, East Asia Summit (EAS) countries have shown reduced diversity in their primary energy power supply mix, and their share of renewable energy has tended to decrease. In future, the share of electricity production from renewable energy is expected to decrease further, especially the share of hydropower, while the share of renewable energy other than hydropower will increase marginally. Finally we suggest that it is necessary to enhance the trilogy dialogue among the EAS members in addressing the issues of: (1) improving the diversification ratio; (2) increasing the share of renewable energy; and (3) reducing emissions intensity. The trilogy dialogue aims to develop: (1) renewable energy targeting; (2) intensity targeting (kgCO2/kWh); and (3) renewable energy consumption per capita (kWh/capita).

1. Background

The ASEAN Vision 2020 with its four pillars of energy cooperation was stated in 1997 as the four pillars are the ASEAN Power grid (APG), the Trans ASEAN gas pipeline, energy efficiency and conservation, and the development of new and renewable energy sources. In 1999 HAPUA, an ASEAN inter-governmental energy organisation was asked by the ASEAN Senior Official Meeting on Energy to prepare an ASEAN interconnection Master plan Study (AIMS). The AIMS was divided into three regions: (i) Greater Mekong Sub Region (GMS) (Thailand, Viet Nam, Lao PDR, Cambodia and Myanmar); (ii) Indonesia – Malaysia – Singapore (IMS); and (iii) Trans Borneo Power Grid (East Malaysia, Brunei and Kalimantan).

Promoting energy market integration (EMI) in East Asia has become a challenging development goal. Following the Energy Ministers' Meeting (EMM) and Energy Cooperation Task Force (ECTF), Shi and Kimura (2010) discussed four key issues with regard to the promotion of EMI. These were removal of trade and investment barriers, enhancing linkage in energy infrastructure, energy pricing reform, and liberalisation of domestic energy markets.

Within the energy market integration framework, one of the sectors needing to be studied deeply is the electricity sector. Wu (2012) argues that an integrated electricity market can improve efficiency, reduce the cost of production, and raise standards of service. However, Wu (2012) also points out that developing interconnectivity in grid systems and trade among the EAS's members will be a task requiring many years. Furthermore, Chang and Li (2012) mentioned that geographical location is the main obstacle because this determines the transmission losses and costs. Chang & Li (2012) believe that market integration in ASEAN countries can encourage development of power generation from renewable energy such as geothermal, hydro, and wind.

Current rising demand for electricity has been mainly supplied by fossil fuel. Table 1 shows that fossil fuel remains the major source of electricity production. It can be seen that over the last four decades, electricity production from oil has decreased rapidly. At the same time, the share of coal and natural gas has tended to increase. Cambodia's power system remains highly dependent on oil, while in

Indonesia and Singapore the share of electricity production from oil has decreased to 23% and 18.8% respectively. Table 1also shows that the average share of gas in the ASEAN-10 countries is higher than the six partner countries.[1] Natural gas has become the backbone of power supply in Brunei, Malaysia, Singapore and Thailand. Natural gas has low emission intensity (ton CO2/TJ)[2]; in view of this, developing natural gas infrastructure and deepening gas utilization will have a positive impact on the environment. On the other hand, in Australia, China and India the share of coal is still relatively high (above 60%), while in Indonesia, Korea, and the US, the share of coal for electricity production is about 40%. Due to the wide variety in fossil fuel utilization and the inflexibility of plants and systems, there is a possibility that power systems may face "double traps", i.e. a "carbon lock" and rising generating cost, if decision makers fail to consider diversification in energy use, energy efficiency and conservation.

For the 16 member countries of the EAS, the shares of electricity production from renewable sources are still relatively low, except in the Philippines and New Zealand. As seen from Table 1, between 1990 and 2009, for some countries such as Brunei, Malaysia, Myanmar, and Vietnam, the share of renewable sources is still zero, and in Singapore, the share has increased only marginally.

Table 1 Electricity production by sources (% of total)

No	Country	Oil		Coal		Natural gas		Renewable sources, excluding hydroelectric*	
		1971	2009	1971	2009	1971	2009	1990	2009
1	Brunei Darussalam	1.6	1.0	NA	0.0	98.4	99.0	0.0	0.0
2	Cambodia	NA	95.6	NA	0.0	NA	0.0	NA	0.5
3	Indonesia	56.0	22.8	NA	41.8	0.0	22.1	3.4	6.0
4	Lao PDR	NA	NA	NA	NA	NA	NA	NA	NA
5	Malaysia	72.4	2.0	NA	30.9	0.0	60.7	0.0	0.0
6	Myanmar	23.2	8.9	3.9	0.0	3.9	19.6	0.0	0.0

[1] Partner countries consist of Australia, China, India, Japan, Korea, and New Zealand.
[2] Emissions intensity for oil, coal and gas is 74.1 tonCO2/TJ, 101.2 tonCO2/TJ, and 56.1 tonCO2/TJ respectively (IPCC, 2006).

7	Philippines	99.9	8.7	0.1	26.6	0.0	32.1	22.4	16.8
8	Singapore	100.0	18.8	NA	0.0	0.0	81.0	0.0	0.1
9	Thailand	53.6	0.5	6.1	19.9	0.0	70.7	0.0	4.0
10	Vietnam	0.0	2.5	73.3	18.0	0.0	43.4	0.0	0.0
11	Australia	3.4	1.0	71.0	77.9	3.3	13.7	0.5	2.6
12	China	7.9	0.4	70.5	78.8	0.0	1.4	0.0	0.8
13	India	6.3	2.9	49.1	68.6	0.6	12.4	0.0	2.2
14	Japan	62.6	7.2	11.9	26.8	1.4	27.4	1.4	2.5
15	Korea, Rep.	80.6	4.4	6.9	46.2	0.0	15.6	0.0	0.4
16	New Zealand	2.0	0.0	4.8	7.6	0.3	20.6	8.2	15.9

Note: *includes geothermal, solar, tides, wind, biomass, and biofuels. NA is not available.
Source: World Development Indicators, World Bank, 2012

In this study, we argue that there is a need for a more in-depth study of the potential of renewable energy in the power sector in the context of EMI. We investigate four elements: (i) renewable energy policies in developed and developing countries; (ii) the diversity index of the power generating systems of EAS countries and its individual members (iii) the future path of renewable energy utilization in power; (iv) policy recommendations on how to optimise the penetration of renewable energy sources in the context of energy market integration.

2. Data and Methodology

We conduct two main analytical studies. First, a qualitative analysis focuses on policy relating to renewable source utilization in the power sector. Second, a quantitative analysis is designed to address the second and third objectives (see above). It focuses on the diversity index and energy composition forecasting by applying a time series (ARMA) analysis and the Markov model.

2.1. Diversity Index

Power generation diversity is one of the key development indicators used by energy policymakers. According to Costello (2007), diversity is a concept that has different interpretations and dimensions. There are several ways to measure diversity, such as the entropy index, the Herfindahl-Hirschman index (HHI), the Shannon-Weiner index (S-WI) and the integrated multi-criteria diversity index. Costello (2007) and Hickey, *et al*. (2010) used the S-WI index to measure diversity. The index is expressed as follows (Costello, 2007 and Hickey, *et al*. 2010).

$$DI = \sum - S_i \ln(S_i) \qquad 1)$$

where the diversity index (DI) directly relates to the share of generation by the i-th type of generation (i.e. Si). This index measures the changes in installed capacity composition among all power plant energy sources. The higher the index, the more desirable, because this shows more types of generation technologies and fuel sources in the system, and also shows more balance and diversity in input use.

2.2. ARMA Model

We developed an autoregressive moving average (ARMA) for the 'business as usual' scenario analysis. A business as usual scenario means that the long term energy mix depends on past information. We applied a Box-Jenkins approach to modelling the stochastic process (Greene, 2003).

2.3. Markov Model

We developed a Markov model (MM) for policy scenario analysis. MM is a stochastic or probabilistic model. A Markov model assume the future phenomenon depends upon only the recent past data. The model is very useful in addressing three basic issues: (i) forecasting the structure of electricity output by sources; (ii) showing the stability of structural change; and (iii) showing how fast the system can reach the steady state.

3. Renewable Energy Policy in the Electricity Sector: Commitments and Challenges

3.1. Developed Countries Perspective

European countries have shown strong commitment to promoting renewable energy. In 1990, the UK introduced a Non-Fossil Fuel Obligation (NFFO). Base on NFFO, the Public Electricity Suppliers (PESs) need to secure the specific amount of electricity production from renewable energy sources. As a consequence, the PESs need to enter into contracts with the Non-Fossil Purchasing Agency Ltd. The target of this policy was to achieve 10% of UK electricity production from renewable energy by 2010. Kettle (1999) said that NFFO had created a competitive environment among the contractors, and that it had driven prices down.

In 2002 renewable obligations (ROs) were started and now the UK also has Renewable Obligation Certificates (ROCs). ROCs require the electricity suppliers to increase the share of electricity production from renewable energy. ROCs can be traded and when the suppliers do not have sufficient ROCs to meet their obligations, they must pay for the equivalent amount. This scheme is called a ‘buy-out’ fund. Kannan (2009) argued that in the medium term the decarbonisation of power plants depends on two technologies, namely carbon capture and storage (CCS) and renewable energy. The wind generating capacity in UK is expected to reach 20% of the total capacity in the European Union, but it will still be less than that installed in Spain or Germany (Kannan, 2009). The critical challenge for the UK is on investment in transmission capacity from Scotland to England (Kannan, 2009). In the case of the UK, Kannan (2009) proposed two main policies that need to be in place; first, preparing long term policy instruments to achieve the emissions reduction target, such as carbon price signals, accelerated demonstration of CCS, and financial incentives for capital intensive low carbon technology and secondly, promoting demand-side energy efficiency improvement.

Germany introduced a feed-in law in 1991. Further, the Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz / EEG) is believed to be one of the most successful instruments in promoting renewable energies (Lehmann, 2011). The act requires that in 2020, the share of renewable energy sources in electricity supply reaches at least 35% and their share in the total gross final consumption of energy at least 18%. Huenteler, *et al*. (2012) argued that designing renewables policy is subject to a continuous learning and adaptation process. Even now, in Germany, there are three main political challenges that need to be addressed (Huenteler, *et al*., 2012): mounting costs, low R&D intensity (R&D per sales unit), and rising net imports. These problems have resulted in conflicting policy objectives.

In Germany, the feed in tariff / FIT aims to integrate three area of policy (Huenteler, *et al*., 2012): environmental policy, economic policy, and technology policy. Although industrial policy was not explicitly mentioned, according to the Minister of the Environment, FIT provides protection to the local solar industry (Photon, 2012, as cited in Huenteler, *et al*., 2012). Hoppmann, *et al*. in 2011 (as cited in Huenteler, *et al*., 2012) argued that the generous FIT incentivised firms to reallocate resources to new production capacity and, in relative terms, away from R&D. Schroer (2010) and Wetzel (2011), (as cited in Huenteler, *et al*., 2012) said that the FIT was termed a 'failed' industry and technology policy. Huenteler, *et al*. (2012) also argued that market subsidies on renewable energy rather than research funding in Germany appears to have created incentives to favour deadweight effects over long term research.

In 2002, the Japanese government adopted its Basic Act on Energy Policy, with three goals (EIA, 2008, as cited in Duffeld and Woodall, 2011): securing a stable supply of energy, ensuring environmental sustainability, and utilising market mechanisms. In promoting clean energy, the Japanese energy industry has faced challenges from other countries. For example, Japan's solar cell industry, one of the largest in the world, was surpassed in 2008 by those of Germany and China (Duffeld and Woodall, 2011). Further, in late 2009, a Korean consortium out-bid a Japanese nuclear power plant manufacturer to build four nuclear reactors in the UAE (Duffeld and Woodall, 2011).

Since 2003, Japan has implemented a Renewable Portfolio Standard (RPS) and this has become its main renewable energy policy instrument. The power utility companies need to supply a certain amount of power from renewable energy. However, the target was set at a very low level (1.63% of electricity output by 2014) (IEA, 2008 as cited by Moe, 2012). Japan has prioritized its feed-in tariff (FIT) as its main policy. The FIT was introduced in 2009, but as Moe (2008) pointed out it was implemented belatedly and half-heartedly by an institution that does not believe in its usefulness'. Initially, the FIT applied to solar. Bhattacharya and Kojima (2012) argued that the Japanese government needs to pursue a more proactive role in reducing the cost related to the development of renewable energy. Fiscal support and risk analysis for renewable energy needs to be promoted.

According to the Japanese Basic Energy Plan 2010, there is to be a "zero-emission power supply ratio" in 2030. Nuclear power and renewable energy such as wind, solar, and biomass are expected to increase substantially. However, the supply of hydroelectric power will not much change because its potential has already been largely exploited (IEA, 2008, as cited in Duffeld and Woodall, 2011). In addition, the situation has been changed by the Fukushima disaster. According to a recent poll, 85% of respondents are currently in favour of the phasing-out or immediate cessation of nuclear power generation (Moe, 2012). Thomas (2012) said that post the Fukushima disaster, a blend of energy efficiency and renewable energy, will be the key factor in reducing Japan's dependency on nuclear. In June 2011 Prime Minister Naoto Kan planned to increase the share of renewable energy in the power supply to about 20% by 2020, and on August 2011 he also extended the feed-in tariff (FIT)[3] (Huenteler, *et al*. 2012). The new FIT has started in July 2012 and it covered solar photovoltaics (PV), wind power, small hydro, geothermal and biomass (Huenteler, *et al*. 2012).

In June 2011, the Japanese government announced a goal of putting PV systems on 10 million roofs by 2030. There are two reasons why PV has taken on an important role. First, "PV is partly on the inside of the vested interest structure, while wind power is the ultimate outsider and decidedly on the outside" (Moe, 2012). Second, "PV plants are quick to install and they are suitable to fill the current gap between electricity capacity and peak demand around noon" (Huenteler, *et al*., 2012). Following the lessons learned in promoting renewable energy in Germany, Huenteler, *et al*. (2012) provided three main conclusions in respect of by Japan. First, the government needs to minimize the industry interest in the regulatory

[3] According to Huenteler, *et al*. (2012: p7) 'A feed-in tariff guarantees the power producer a fixed electricity purchase tariff for a specified period (often 10–20 years), typically in combination with preferential grid access for the electricity produced.'

process. This is important in order to obtain more effective policy on renewables. Second, the effectiveness of policy learning and refinement is possible if there is a balance of powers and objectives under a political framework. Third, it is important to keep a transparent process in determining FIT. Huenteler, *et al*. (2012) also said that an integrated policy framework that aims to balance energy security, environmental policy, climate policy, and economic and industrial policy needs to be enhanced by government in the long run.

3.2. Developing Country Perspectives

At the 29th ASEAN Ministers for Energy Meeting in September 2011, there was a consensus among the ASEAN member states that a collective target of 15% of renewable energy’s share in the region’s total installed power capacity by 2015 should be adopted(Suryadi, 2012). However, it seems that there is no mandatory obligation involved. For example in the case of Indonesia, according to Presidential Regulation Republic of Indonesia No 5/2006, the share of fossil fuel, especially natural gas and coal, in the total primary energy mix in 2025 will still dominate.

Accelerating renewable energy utilisation, for instance hydropower, has faced difficult problems especially in the Greater Mekong Sub-region. Hebertson (2012) pointed out that developing the Lower Mekong dams would bring significant social, economic and environmental cost. Development of the Xayaburi Dam, for example, has polarised opinion. Lao PDR and Thailand support the Dam and Cambodia and Vietnam oppose it. Further, Hebertson (2012) pointed out three lessons from the Xayaburi dam. First, energy planning should not take place behind close doors. Second, strategic environmental assessments should become a regular part of energy planning. Third, when advocates say that hydropower is “renewable”, more questions are needed about the overall impact of a scheme, for example on downstream water users.

According to the National Energy Blueprint 2005 – 2025, Indonsia had determined 12 milestones of alternative energy, seven of which are renewable energy sources such as geothermal, biodiesel, bioethanol, solar cell, micro-hydro, biomass/waste, and wind. Following the Minister of Economic and Mineral Resources (MEMR) regulation No 02/2010 jo MEMR regulation No 15/2010, and jo

MEMR regulation No 01/2012, PT.PLN (a State Owned Company in the Electricity Sector) focuses on geothermal and hydropower. Currently, the government is attempting to promote pumped storage and hydropower reservoirs to serve peak power demands. Similarly, to enhance rural electrification, several sources of renewable energy can be used such as hybrid PV, hybrid wind, microhydro, and biomass. Government has also developed a research and development programme on thermal solar power, OTEC (ocean thermal energy conversion) and fuel cells.

The Malaysian government has shown strong commitment to the promotion of renewable energy. McNish, *et al*., (2010) said that in 2001, the Malaysian government launched the Small Renewable Energy Production (SREP) Programme. The SREP aimed to achieve 500 MW of renewable energy capacity nationwide by 2005. However in July 2009, there was still only about 43.5 MW of grid-connected renewable power in Malaysia. In 2005, Malaysia and the United Nations Development Programme developed the Building Integrated Photo-Voltaic (BIPV) project (McNish, *et al*., 2010). The goal of this program is to achieve 1.5 MW of distributed solar capacity by 2010 (McNish, *et al*., 2010). Malaysia has implemented several policies to reduce dependency on oil such as (McNish, *et al*., 2010): the Green Technology Financing Scheme (GTFS), the Energy Efficiency Master Plan, the Renewable Energy Policy and Action Plan, and the National Green Technology Action Plan.

According to the 9th Malaysia Plan 2006-2010, the targeted power generation mix in 2010 was: 51% natural gas, 26% coal, 9% hydro, 8% oil, 5% diesel, and 1% biomass[4]. Thus in 2010, the share of renewable energy was to reach about 10%. The Malaysian Sustainable Energy Development Authority (SEDA) has seven functions: (i) to implement, manage, monitor and review the Feed in Tariff system; (ii) to advise the Minister and government entities on all matters relating to sustainable energy; (iii) to promote and implement national policy objectives for renewable energy; (iv) to implement sustainable energy laws, including the renewable energy act, and to recommend reforms; (v) to promote private sector investment in the sustainable energy sector; (vi) to promote measures to improve public awareness;

[4] SEDA was established on 1 September 2011 under the SEDA act 2011.

and (vii) to act as a focal point on matters relating to sustainable energy and climate change matters relating to energy. There are five strategic thrusts of national renewable energy policy: (i) introduction of legal and regulatory frameworks; (ii) provision of a conducive business environment for renewable energy; (iii) intensification of human capital development; (iv) enhancement of renewable energy research and development; and (v) create public awareness and renewable policy advocacy programmes.

According to Indonesian Energy Law No 30/2007, Indonesia also has a similar organisation to SEDA, namely the Dewan Energi Nasional (National Energy Council). The National Energy Council has four main tasks. First, designing national energy policy that can be guided for government before it is approved by the parliament. Second, stating the general plan of national energy policy. Third, determining steps to measure the energy crisis. Fourth, monitoring and evaluating the implementation of energy policy across the sector.

In terms of renewable energy law, Malaysia is one step ahead of Indonesia. On April, 27th 2011, a renewable energy act was passed in Parliament. The act consist of 9 main elements, namely: (i) preliminary; (ii) FIT system; (iii) connection, purchase, and distribution of renewable energy; (iv) Feed in Tariff; (v) renewable energy fund; (vi) information gathering powers; (vii) enforcement; (viii) general; and (ix) saving and transitional. To follow up the act, the government produced 11 subsidiary regulations in the same year.

Both Indonesia and Malaysia have issued a feed in tariff policy. The Indonesian government has determined the feed in tariff for renewable energy based on the Ministry of Energy and Mineral Resources Regulation (MEMR) No 4/2012. There are two main elements of feed in tariff. First, PT. PLN must buy electricity and excess capacity from renewable energy producers. Second, the price is fixed without negotiation and approval from the Ministry of Energy and Mineral Resources. PT. PLN can buy the electricity above the feed in tariff, based on its own evaluation, but it has to obtain approval from the Ministry.

This regulation applies to renewable energy projects with capacity below 10 MW. There are four main areas of renewable energy, namely renewable energy in general, biomass and biogas, city waste (zero waste) and city waste (sanitary landfill). The feed in tariff not only depends on type of renewable energy but also type of connection and region. Outside Java such as in Maluku and Papua, government provides increased incentive by increasing the F- value.

In December 2011, the Malaysian government applied a feed in tariff to four types of renewable energy (biogas, biomass, small hydro, and solar PV) [5.] There are two types of FIT, known as basic and bonus. In the case of biogas, the basic FIT depends on capacity. The FIT rate increases when the capacity decreases. The capacity ranges between 4 MW and 30 MW. The bonus is added to the basic rate if the renewable energy installation fulfills one of the following conditions: gas engine technology with electrical efficiency of above 40%; use of locally manufactured or assembled gas engine technology; and use of landfill or sewage gas as fuel source. In the case of biomass, the feed in tariff is provided for capacity between 10 MW and 30 MW. The bonus rate is provided when at least one of the following conditions exists; use of gasification technology, use of steam based electricity generating systems with overall efficiency above 14%, use of locally manufactured or assembled gasification technology, and use of municipal solid waste as fuel source.

In the case of small hydropower, there is no bonus rate and an FIT applies when the installed capacity is between 10 MW and 30 MW. Finally in the case of solar PV, a basic renewable energy installation is between 4 kilowatts and 30 MW. Bonus on FIT will be provided when one or more of the following criteria is met: used as installations in buildings or building structures; used as building materials; use of locally manufactured or assembled solar photovoltaic modules; use of locally manufactured or assembled solar inverters. The effective period (commencing from the FIT commencement date) is also different among the type of renewable energy. For example the effective periods for biogas, biomass, hydropower, and solar PV are 16 years, 16 years, 21 years, and 21 years respectively. Up to 31 October 2012, according to the chairman of SEDA, in 2012, SEDA allocated 2,000 solar rooftop programmes and in 2013, SEDA will increase the allocation to about 10,000. This programme aims to boost public investment in solar power systems. The programme

[5] To finance the FIT policy, the Malaysian government provided US$ 60.4 million to its renewable energy fund, but the fund needs to pay this back (Green Prospect Asia, 2012). Because there is no subsidy for FIT and no additional cost to tax payers, the government adds 1% additional tariff for consumers who consume 300kWh or above (Green Prospect Asia, 2012).

runs as follows: maximum 12 kWper application, each individual maximum submit 2 applications, and application send thorugh e-FiT application online system. Green Prospect Asia (2012) mentioned four key challenges that need to be addressed by the Malaysian government: (i) sustaining funds to support FIT; (2) managing the mix of new and mature RE technologies; and (iii) providing adequate infrastructural and other support for continued renewable energy growth.

The Indonesian Renewable Society (METI) suggested that the Indonesian government provide not only FIT in to promote photovoltaic generation (PV), but also fiscal incentives. Generally speaking the proposed FIT for PV is generous. For example, FIT for PV for all capacities is about 35 US cents /kWh for the first 10 years and about 13 cents /kWh for the next 10 years. Further, if the PV module uses at least 40% of local content, the FIT rises to 40 US cents /kWh. METI urges four actions from government, namely: a free tax for PV that produces locally, duty free and free tax for PV components (e.g. EVA and glass), free tax for independent power producers (IPP) that can develop PV, and fiscal incentives for consumers substituting PV in place of fossil fuel.

Thus, comparing the criteria for FIT in Indonesia and Malaysia, it seems that both countries attempt to enhance their supply chains by promoting domestic labour absorption, creating backward and forward linkage to local industries. However, setting the level of FIT is still a big issue. Failure to take account of externalities such as environmental and social cost can lead to wrong directions in the future path of renewable energy.

In Indonesia, there are three major sources of funds for new power investment. These are the State's official funds, PT.PLN's self financing and foreign funds. Foreign funds result from issuing obligations (bonds), multilateral loans such as IBRD and ADB and bilateral loans from JICA, AFD, and China. PT.PLN has utilized "green funds" from the Clean Development Mechanism and voluntary carbon mechanism. Because the financial condition of PT.PLN depends on the margin of public service obligation (PSO), it has a limited capacity to obtain loans. The margin of PSO depends on government subsidy for the electricity tariff. We also argue that lack of investment may affect the Indonesian government's capacity to develop infrastructure such as a grid connection between Indonesia and Malaysia (see Box 1) and there is also uncertainty in the stability of power purchase.

BOX 1

According to PT.PLN's business plan 2009-2018, in the area of Kalimantan PT.PLN plans to buy (import) electricity from SESCo. An interconnection between Sarawak and West Kalimantan will be constructed with transmission at 275 kV. The transmission is designed to supply electricity at 200 MW capacity. SESCo is connected with Benkayan's system in Indonesia and Mambong in Sarawak-Malaysia. Indonesia has responsibility for construction of a 180 km transmission line between Benkayan and Malaysia's cross border and inter bus transformer (IBT) at 250 MVA. A power trading or energy exchange will be started in 2015. From the Indonesian perspective, there are two benefits of power trading. First, it can support the steam coal (peat steam) project– Pontianak 1, if the project is delayed due to environmental constraints. Second, power trading can increase the power reserve that is necessary to improve system security. Furthermore, Indonesia can also sell electricity to SESCo. Electricity trading will be promoted under the independent power producer (IPP) scheme. The document indicates that power trading will be started in 2015 with capacity of 50 MW until 2018. As seen from the table, in 2015 West Kalimantan will buy about 34% of its total electricity balance from SESCo. However, the share will tend to decrease and will be below 10% between 2019 and 2021.

Energy Balance in West Kalimantan (GWh)

Year	PT.PLN	SESCo	Total	Share of SESCO to total (%)
2012	1,374	0	1,374	0
2013	1,725	0	1,725	0
2014	1,993	0	1,993	0
2015	1,443	733	2,176	34
2016	1,798	727	2,525	29
2017	1,970	737	2,707	27
2018	2,141	738	2,879	26
2019	2,833	227	3,060	7

2020	3,162	142	3,304	4
2021	3,250	317	3,567	9

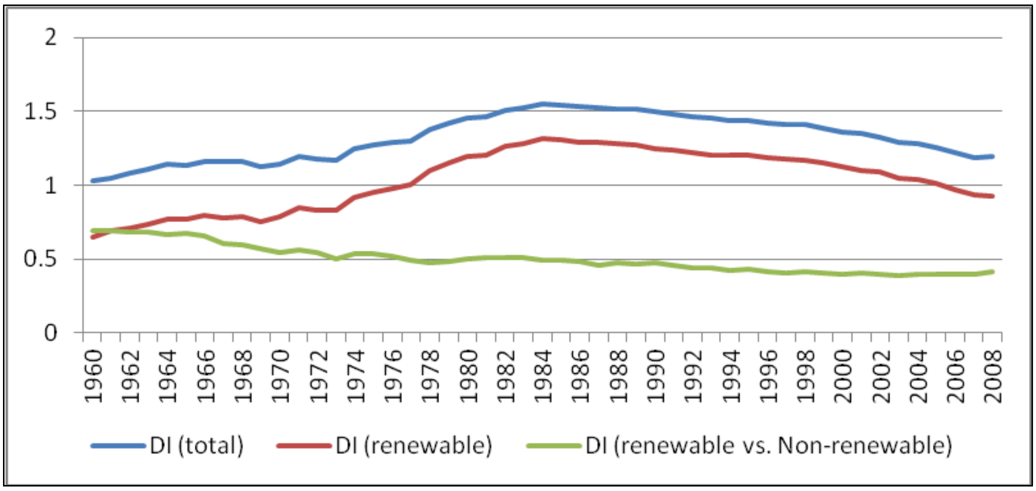
Source: PT.PLN's Business Plan 2012-2021

4. Diversity of Power Generation and Future Path of Renewable Power Generation

4.1. Diversity Index

As seen from Fig. 1, between 1960 and the mid 1980s the diversity index (DI) in the group of countries listed below the figure tended to increase, but after that it decreased gradually. This indicates that electricity production concentrated only on certain types of fossil fuel. The renewable vs. non renewable DIs show that electricity production from renewable energy tends to decrease.

Figure 1: Diversity Index



Note: Countries - Brunei Darussalam, Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Vietnam, Australia, China, India, Japan, Korea Rep., New Zealand.

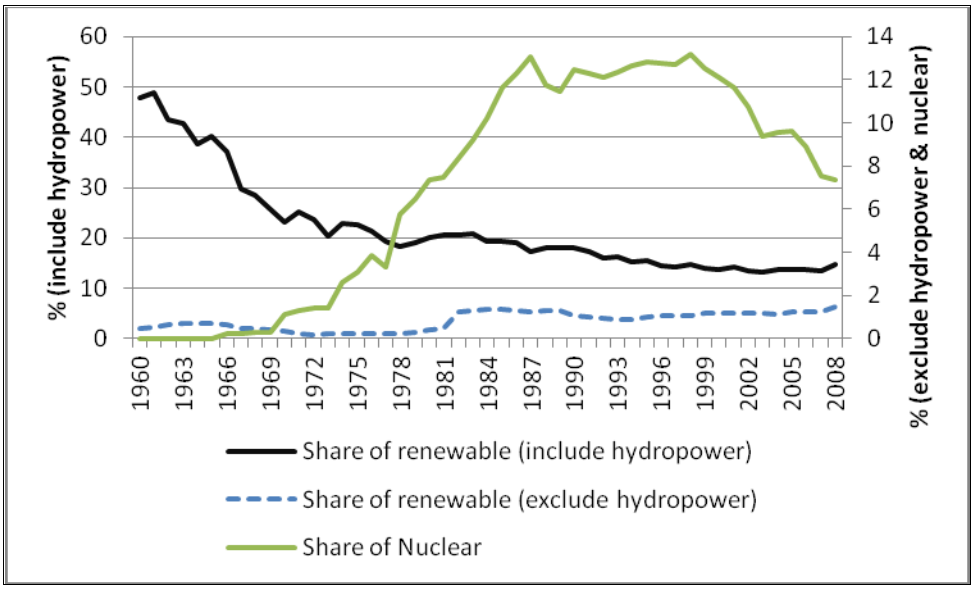
Table 2 indicates that the diversity index between 1990 and 2008, in seven countries, decreased substantially. These were Thailand, Malaysia, China, Japan, Myamar, Australia, and Korea. In Vietnam, New Zealand, Cambodia, Singapore, Indonesia, India, Brunei Darussalam and the Philippines an increasing trend can be seen. Thus we can conclude that because most EAS countries tend to become less diverse in their power systems, the diversity index in the EAS region tends to decrease.

Table 2: Diversity Index by Country

Year	Brunei Darussalam	Cambodia	Malaysia	Myanmar	Singapore
1980	0.064	NA	0.731	1.325	0.000
1990	0.053	NA	1.469	1.324	0.000
2000	0.052	0.000	1.003	1.303	0.495
2008	0.054	0.305	1.105	1.213	0.510
Year	**Thailand**	**Japan**	**Australia**	**China**	**Korea, Rep.**
1980	0.841	1.638	1.137	1.291	0.909
1990	1.496	1.799	0.974	1.111	1.483
2000	1.270	1.724	0.846	1.005	1.340
2008	1.106	1.734	0.938	0.988	1.251
Year	**Indonesia**	**Vietnam**	**Philippines**	**India**	**New Zealand**
1980	0.825	1.341	1.217	1.316	1.012
1990	1.471	1.237	1.459	1.247	1.148
2000	1.641	1.412	1.553	1.241	1.254
2008	1.580	1.448	1.700	1.284	1.410

We investigated the share of renewable source from the 16 member countries of the East Asia Summit region. (EAS). As seen from Figure 2, the share of renewable energy (including hydropower) decreased substantially between 1960 and 2008 from about 50% to about 15%. We also see that the share of renewable energy increased marginally from about 0.5% in the 1960s to about 1.5% in 2008. This indicates that development of renewable energy in the EAS countries has lagged behind the situation in the 1960s. We also see that that the share of nuclear power increased rapidly, peaking at about 13% in 1987. Then it decreased to about 7.4% in 2008.

Figure 2: Share of Electricity Production from Renewable Energy and Nuclear



Although the share of renewables has decreased substantially, the average CO2 emissions per kWh from electricity generation decreased (Table 3). Between 1990 and 2010, the average emissions from the 9 ASEAN countries (except Lao PDR) decreased from 652 grams of CO2 per kWh to about 581 grams or by about 11%. However, some countries have not been able to reduce their emissions intensity, such as Indonesia, Malaysia, and the Philippines. Between 1990 and 2000, the average emissions intensity in China and India increased by 4.7%, but between 2000 and 2010, it decreased by about 6%. In the case of developed countries, the emissions intensity increased between 1990 and 2010, but it slightly decreased between 2000 and 2010. We can see that in the case of Indonesia, Malaysia and the Philippines, although the diversity index tended to increase between 1990 and 2008, the emissions intensity tended to increase between 1990 and 2010 (see Table 3 and Table 4). Thus more diverse electricity output does not necessary lower emissions intensity. This is because, despite the increasing diversity in power supply, there is still a substantial bias towards fossil fuel such as coal and natural gas.

Table 3: CO_2 Emissions per kWh from Electricity Generation

No	Country	1990	2000	2010
1	Australia	817	853	841
2	Japan	435	402	416
3	Korea	520	529	533
4	New Zealand	109	165	150
5	Brunei Darussalam	924	795	798
6	Cambodia	NA	834	804
7	India	812	920	912
8	Indonesia	679	654	709
9	Malaysia	677	495	727
10	Myanmar	510	457	262
11	Philippines	341	493	481
12	Singapore	908	762	499
13	Thailand	626	567	513
14	Vietnam	552	427	432
15	China	894	865	766
	Average (15 countries)	629	615	590
	Average (9 ASEAN countries)	652	609	581
	Average (8 ASEAN countries, exclude Singapore)	615	590	591
	Average China & India	853	893	839
	Australia, Japan, Korea, and New Zealand	470	487	485

Source: Calculated from IEA database, 2012.

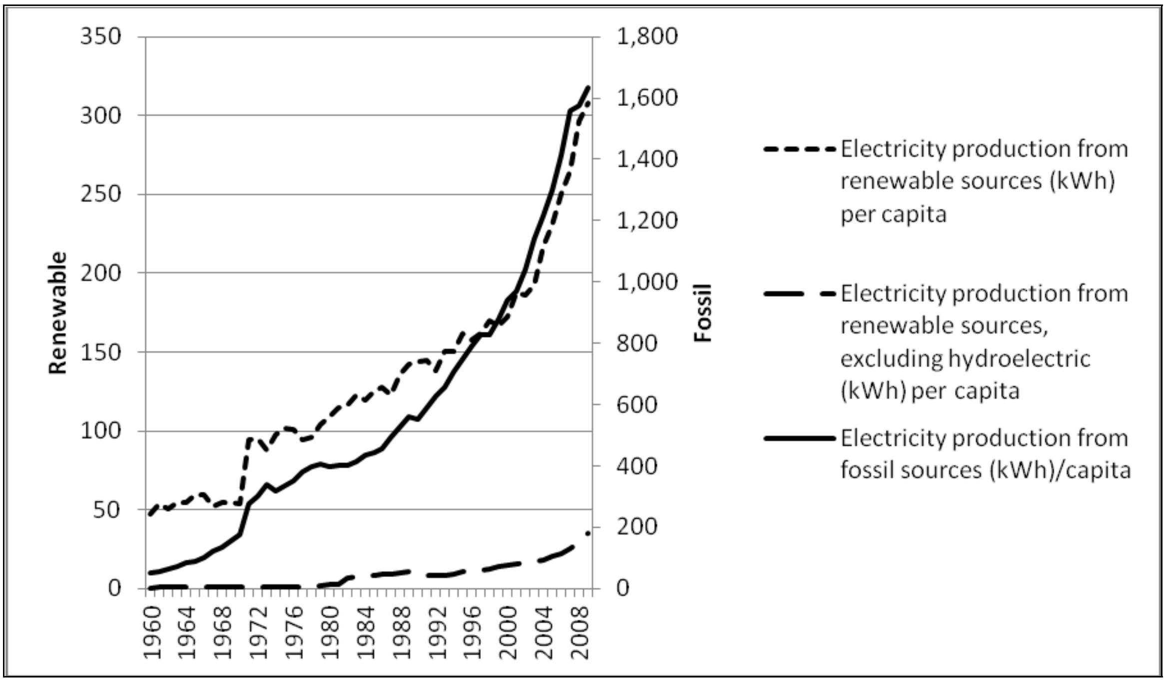
4.2. ARMA and Markov Models

We developed the ARMA and Markov models to analyze two patterns of diversity index. We selected Malaysia and Japan for their decreasing trend; New Zealand, the Philippines, and Indonesia to represent increasing trends.

Historical data leads to two main findings: (i) decreasing trends in energy diversity; and (ii) decreasing shares of renewable energy. Even in the future, the ARMA and Markov models confirm that the share of electricity production from hydropower will tend to decrease while the share of renewable energy (excluding hydropower) will increase marginally except in New Zealand (for detailed information please refer to the Appendix). This implies that there is risk of lack of energy diversity and a carbon lock situation among the 16 member countries of the EAS. The models also indicate that clean fossil fuel such as natural gas and oil will become less important. In some countries, such Indonesia, Malaysia and the Philippines, the share of oil will even fall to zero. However, due to lack of natural gas infrastructure and the relatively high cost of LNG, coal is the best substitute for oil. Thus, carbon intensity (tonCO2/MWh) will become difficult to control.

As seen from Figure 3, the historical data indicate that electricity consumption per capita from renewable energy increased from about 47 kWh/capita to about 308 kWh/capita about 6.5 times. However, electricity consumption from fossil fuel increased much faster than from renewable sources, from about 51 kWh/capita to about 1,635 kWh/capita. This indicates development of renewable energy was lagging far behind the growth in use of fossil fuel.

Figure 3: Electricity consumption per capita (1960 – 2009)



Source: Calculated from World Development Indicators

Although the Markov model is very sensitive to the assumptions of transitions among the energy sources, we highlighted three main findings. First, the share of renewable energy can increase significantly in the future if there is a consistent policy for promoting it. Thus, it is important to increase gradually share of renewable energy. Second, the share of renewables can increase if there is a commitment to reduce the share of fossil fuel and provide more opportunity for renewable energy to substitute oil, for example. Third, because the share of coal will tend to increase in the future, it is necessary to determine a minimum standard of permissible steam coal technology, such as ultra-supercritical.

5. Conclusion

Renewable energy must be part of any sustainable energy mix. Promoting renewable energy needs to enhance value added and reduce greenhouse gases emissions. European countries can provide lessons on how to promote renewable energy. Germany is a pioneer of climate protection and is urging a 30 per cent reduction in EU GHG emissions. Germany has implemented both command-and-control and market-based policies to promote the share of renewable energy in its power system. Formulating policy on renewable energy is a continuous learning and adaptation process. This is because an energy policy has multidimensional impacts on environmental, economic, technological, and industrial policy. Thus in formulating renewable energy policy, there can be no “one size fits all” policy. Germany also realizes that a too-generous FIT policy, rather than investment in research and development has a negative impact on long term research incentives. The objective of FIT needs to be clearly addressed, especially how to encorporate FIT policy in promoting industrial and technology policy. The general conclusion indicates that FIT should be close enough to the market price.

The effective implementation of a Renewable Portfolio Standard (RPS) needs strong political will from government. Setting up a reasonable target for renewable energy is important. Too low a target can reduce programme credibility while too ambitious a target indicates too many unsolved national energy problems. It is thus important to increase the share of renewable energy gradually (by very small amounts), instead of taking a “big bang” approach. This approach will provide a more realistic way of increasing capacity in areas such as such as human resources and institutional arrangements.

The comparisons between Indonesia and Malaysia indicate similarities with developed countries in certain policy areas, such as FIT. Both Indonesia and Malaysia have done their best to promote renewable energy in their power systems. Both Indonesia and Malaysia have published indicative targets on the shares of renewable energy in their future primary energy mixes. They have also both implemented FITs, but have different schemes. We indentify three major differences between the two countries. First, Malaysia has a higher upper bound of renewable energy capacity limit, at 30 MW, while in Indonesia the limit is about 10 MW. Second, incentive formulation is different, such as in bonus formulation in the case of Malaysia and regional incentives in the case of Indonesia. Third, Malaysia has implemented its renewable energy act and therefore has a mandatory obligation to increase the usage of renewable energy, while Indonesia does not have such an act. Further, SEDA has the highest authority to execute the regulations in Malaysia, and to promote development of renewable energy. In Indonesia, the National Energy Council shares similar functions with SEDA.

Although renewable energy has been promoted among the member countries of the East Asia Summit (EAS), the diversity index indicates that growth of electricity production from fossil fuel has grown much more than renewable energy. According to historical data, the primary energy mix in power supply has become less diversified and the share of renewable energy has tended to decrease. Some countries, such as Indonesia, the Philippines and Japan, have used coal more intensively rather than grow renewable energy.

Both the ARMA and Markov models indicate that, in the future, the share of electricity production from renewable energy will tend to decrease, especially the share of hydropower, while the share of renewable energy (excluding hydropower) will increase marginally. The two models confirm that fossil fuel will remain the backbone of power systems (except in New Zealand). Thus facilitating the penetration of renewable energy into the power system needs to be further discussed among EAS members.

6. Policy Recommendations

This study shows that encouraging the penetration of renewable energy into the power system depends on five main components. First, it is important to enhance the renewable energy policy dialogue between developed and developing countries. Because most developing countries are in the early stages of implementing a renewable portfolio standard and feed in tariff, it is important to frame the multidimensional aspects of energy policy in the context, for example, of industry, trade, research and development policy. Developing countries can benefit from the prior experience of their developed neighbours.

Second, financing of new power generation will become a major obstacle. Most new power investment depends on non state funds or unsustainable sources. Thus renewable energy investment needs to be economically sound. Further, it is also important to share the best practices in sharing the FIT in the region. However, failure to consider externalities and providing fossil fuel subsidies have eroded the competitiveness of renewable energy. Further, macroeconomic instability has driven interest rates up and led to shorter loan tenors and higher equity requirements. Next, government interventions in state electricity companies, such as in pricing policy, lead to a lack of investment funds from the companies' own resources. As a result, it becomes difficult for developing countries to diversify their energy mixes toward renewable energy. Thus there is a renewable energy "trap" in many developing countries. Cooperation in research and development needs to be enhanced in order to reduce the investment cost of renewable energy. Revolution on information-communication-technology (ICT) can be of the models in developing renewable energy in the future.

Third, every country has a different capability in the area of renewable energy. This depends on endowment factors and energy policy. For example, in the case of Indonesia and Malaysia, it may be possible to reach a 30% target in the 2040s while in the Philippines the same taget can be attained in 2020. However, there are still many risks and uncertainties in reaching this target.

Fourth, demand-side management can reduce pressure on new power investment that will be supplied mostly by steam coal power plant. Further, demand-side management will also provide more time for renewable energy to be more competitive. Thus it is important to increase the level of knowledge of how to use energy effectively.

Finally, we suggest that the trilogy of green power system dialogue among the EAS members be enhanced in addressing the issues of: (1) improving the diversification ratio; (2) increasing the share of renewable energy; and (3) reducing emissions intensity. The trilogy dialogue aims to set three kinds of targets: (1) renewable energy targeting; (2) intensity targeting (kgCO2/kWh); and (3) renewable energy consumption per capita (kWh/capita).

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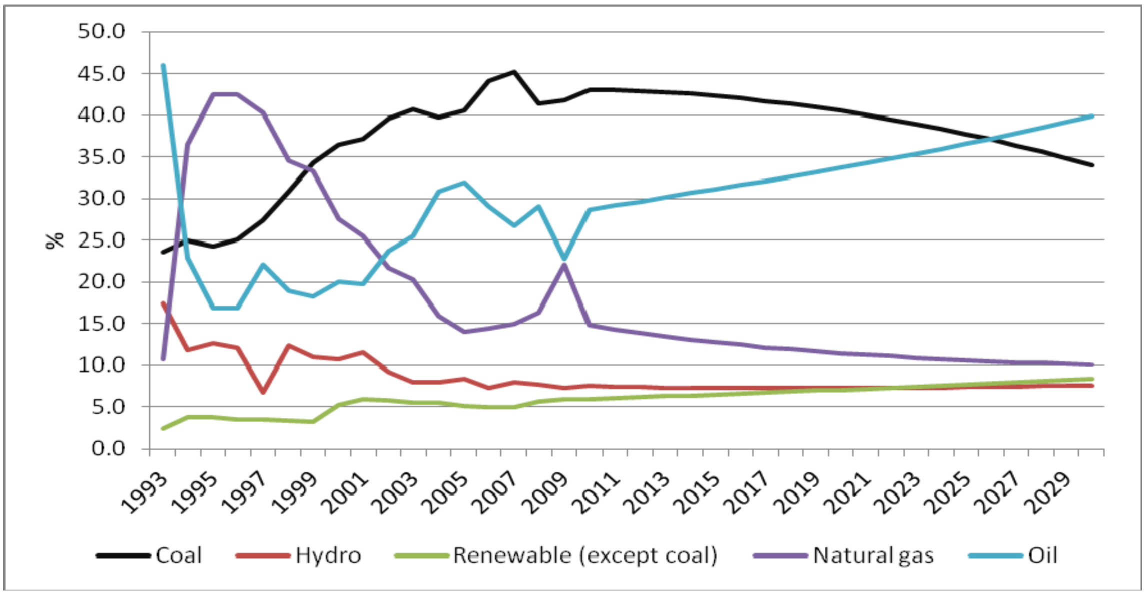
Appendix

1. Indonesia

Figure A1: Share of Electricity Production by sources (1993 – 2030) in Indonesia



Note: Results from ARMA model

Table A1: Change in Share between 1998 and 2009

		Share (%)	
Electricity production	1998	2009	Author's assumption
Hydroelectric	12	7	8
Renewable	3	6	7
Coal	31	42	46
Natural gas	34	22	21
Oil	19	23	18

Note: Author's assumption indicates the situation that is possible to achieve in the medium term

Table A2: Share of Electricity Production by Sources

Year	Hydroelectric	Renewable	Coal	Natural gas	Oil
2009	0.073	0.060	0.418	0.221	0.228
2010	0.083	0.070	0.458	0.211	0.179
2011	0.093	0.077	0.489	0.202	0.140
2012	0.102	0.084	0.513	0.192	0.109
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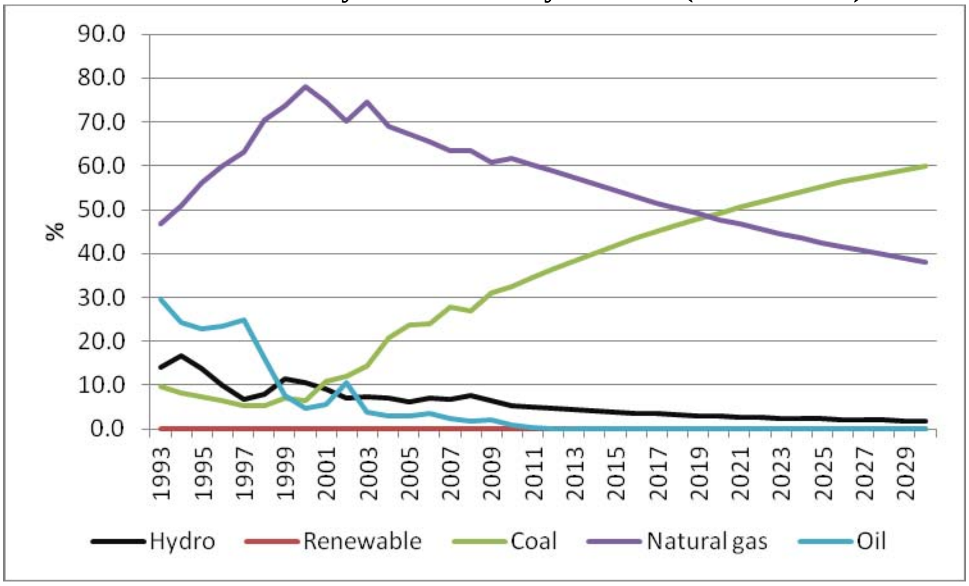
2037	0.233	0.105	0.600	0.061	0.000
2038	0.236	0.105	0.600	0.058	0.000
2039	0.239	0.105	0.600	0.056	0.000
2040	0.241	0.105	0.600	0.053	0.000

Source: Author's calculation from Markov model

2. Malaysia

Figure A2: Share of Electricity Production by Sources (1993 – 2030) in Malaysia



Note: Results from ARMA model.

Table A3: Change in share between 1998 and 2009

	Share (%)		
Electricity production	1998	2009	Author's assumption
Hydroelectric	10.71	6.35	8
Renewable	0.00	0.00	1
Coal	6.59	30.92	35
Natural gas	77.93	60.73	55
Oil	4.78	2.00	1

Note: Author's assumption indicates the situation that is possible to achieve in the medium term

Table A4: Share of Electricity Production by Sources

Year	Hydroelectric	Renewable	Coal	Natural gas	Oil
2010	0.083	0.010	0.349	0.548	0.010
2011	0.101	0.015	0.385	0.494	0.005
2012	0.118	0.018	0.417	0.445	0.003
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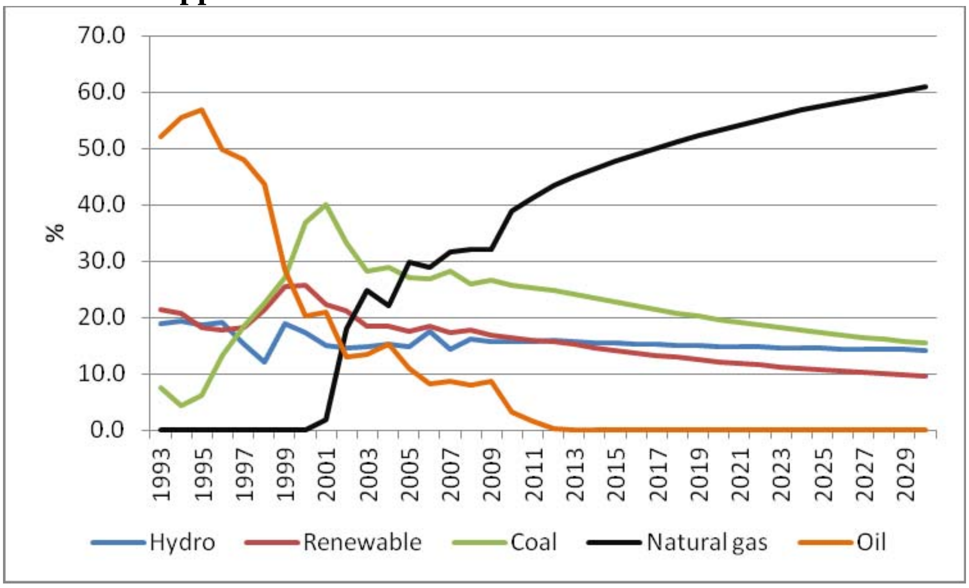
2042	0.259	0.020	0.701	0.020	0.000
2043	0.260	0.020	0.702	0.018	0.000
2044	0.261	0.020	0.703	0.016	0.000
2045	0.261	0.020	0.704	0.015	0.000

Source: Author's calculation from Markov model

3. The Philippines

Figure A3: Share of Electricity Production by Sources (1993 – 2030) in the Philippines



Note: Results from ARMA model

Table A5: Change in share between 2002 and 2009

Electricity production	2002	Share (%) 2009	Author's assumption
Hydroelectric	15	16	17
Renewable	21	17	18
Coal	33	27	30
Natural gas	18	32	33
Oil	13	9	3

Note: author's assumption indicates the situation that is possible to achieve in the medium term

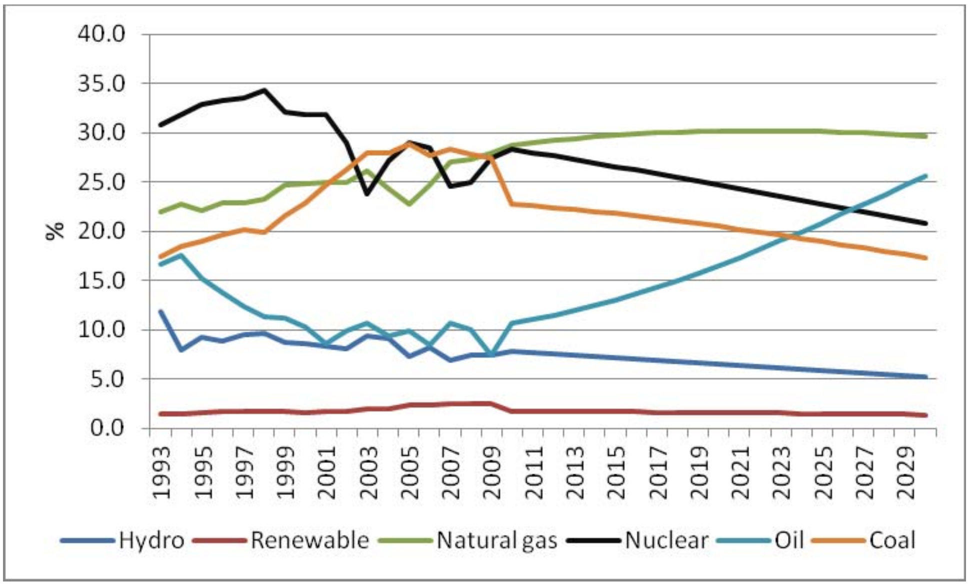
Table A6: Share of Electricity Production by Sources (%)

	Hydroelectric	Renewable sources, excluding hydroelectric	Coal	Natural gas	Oil
2009	15.8072	16.7778	26.6081	32.1167	8.6901
2010	16.7728	17.7434	29.5048	33.0823	2.8967
2011	17.0947	18.0653	30.4704	33.4042	0.9656
2012	17.2019	18.1725	30.7922	33.5114	0.3219
2013	17.2377	18.2083	30.8995	33.5472	0.1073
2014	17.2496	18.2202	30.9353	33.5591	0.0358
2015	17.2536	18.2242	30.9472	33.5631	0.0119
2016	17.2549	18.2255	30.9512	33.5644	0.0040
2017	17.2554	18.2260	30.9525	33.5649	0.0013
2018	17.2555	18.2261	30.9529	33.5650	0.0004
2019	17.2556	18.2262	30.9531	33.5651	0.0001

Source: Author's calculation from Markov model

4. Japan

Figure A4: Share of Electricity Production by sources (1993 – 2030) in Japan



Note: Results from ARMA model

Table A7: Change in share between 2002 and 2010

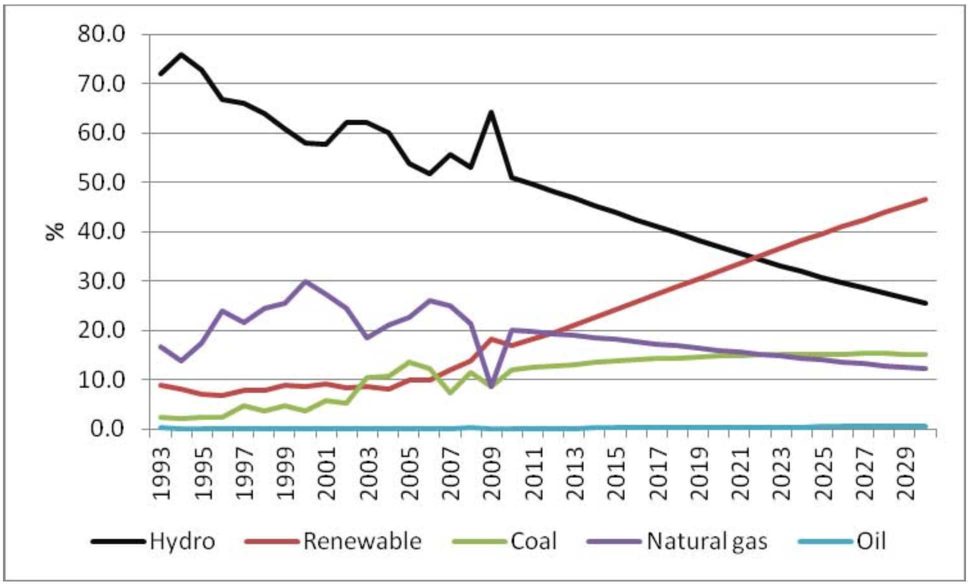
Electricity production	Share (%) 2000	2010
Hydroelectric	9	7
Renewable	2	3
Coal	23	28
Natural gas	25	28
Nuclear	32	28
Oil	10	7

Table A8: Share of Electricity Production by Sources (%)

	Hydroelectric	Renewable, excluding hydroelectric	Coal	Natural gas	Nuclear	Oil
2011	5.506	3.355	31.770	30.255	24.071	5.043
2012	4.283	3.967	35.390	31.768	21.062	3.530
. . . 2043	0.002	6.107	58.257	35.298	0.336	0.000
2044	0.001	6.107	58.299	35.298	0.294	0.000
2045	0.001	6.107	58.336	35.299	0.257	0.000

5. New Zealand

Figure A5: Share of Electricity Production by Sources (1993 – 2030) in New Zaeland



Note: Results from ARMA model.

Table A9: Change in Share between 2002 and 2010

	Share (%)	
Electricity production	2000	2010
Hydroelectric	58	55
Renewable	8	18
Coal	10	5
Natural gas	24	22
Oil	0	0

Table A10: Share of Electricity Production by Sources (%)

	Hydroelectric	Renewable	Coal sources	Natural gas	Oil
2010	55.210544	18.163744	4.619680554	22.0015637	0.00446778
2011	52.3548262	25.162766	2.309840277	20.1681001	0.00446778
2012	49.6468179	30.706369	1.154920139	18.4874251	0.00446778
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2042	10.0909556	88.545576	1.0756E-09	1.35900045	0.00446778
2043	9.56900963	89.180772	5.37802E-10	1.24575041	0.00446778
2044	9.07406086	89.779533	2.68901E-10	1.14193788	0.00446778
2045	8.60471288	90.344043	1.3445E-10	1.04677639	0.00446778