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Innovations for a Low-Carbon Economy in Asia: Past, Present, and Future

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<http://dx.doi.org/10.5772/intechopen.76363>

Abstract

Low-carbon technology development is crucial for country's economic and social transformation. It is often influenced by policy factors and multiple actors, both internal and external. This chapter explores the journey of low-carbon energy policymaking in four Asian countries: Based on critical analysis, three major conclusions are arrived in, about the dynamics of innovations in low-carbon energy policy making. First, a transition into a low-carbon energy economy involves distinguishable temporal and developmental phases, often characterized by hierarchy, aggregation, and space. In the initial period, technology policy choices are made to meet the growing concerns of energy security and access, later of reliability, and then of climate change. Past policies, technology-oriented top-down, are gradually being replaced or complemented by market-oriented policies. A second conclusion is that the ongoing low-carbon economic transition is enhanced by regional cooperation. Adoption of an action plan for regional energy cooperation created enabling environment for paradigm shifts in national energy policy making. Third, the flying geese model of economic integration points to a new way of regional cooperation to solve low-carbon energy policy dilemmas, with no formal involvement of policy institutions, but works according to market principles. To benefit as much as possible from that niche, developing countries need and create an environment more conducive to smooth the flow of low-carbon technology and services.

Keywords: climate change, energy security, low-carbon technology, regional cooperation

1. Introduction

Asian countries face a set of interconnected yet fundamental low-carbon technology and policy dilemmas. The region's rapidly industrializing economies, intensifying levels of urbanization,

and Paris Agreement have created unprecedented demand for low-carbon energy services. This is occurring amidst rising demands from increasing prosperity of middle-class population. Average energy use per capita of the Asian countries remains quite low—about 0.61 metric tons of oil equivalent per person—compared to 4.67 for Japan and 1.69 for the world. Indeed, as of 2015, this region has at least 134 million people, or 22% of the population, without access to electricity [1].

By 2030, energy demand is expected to double in the region. According to several projections [1–4], the increase in regional demand will account almost 30% of the world total [5]. Policy makers in this region, face challenges in developing and distributing the low-carbon energy resources, from their remote locations to those urban centers of production and livelihood, where they are needed most. Moreover, the economic, energy, and emission geography of Asian countries is highly uneven. While the Southeast Asia region is of equal size as European Union and has a greater population as a whole than North America, its coal, oil, gas, and other renewable energy resources such as hydro and biomass are unevenly distributed, as are the stages of their low-carbon technology development.

The challenge of low-carbon technology deployment in this region is rivaled by the difficulties associated with improving energy security and protecting the environment. While Asia has major energy importing economies, namely, Singapore, Philippines, and Vietnam, it also has major energy exporters like Indonesia, Malaysia, and Brunei. This region is home to thousands of low-lying islands comprising major portions of Indonesia and the Philippines that are extremely disadvantaged in terms of energy access. The region's experience with growing natural disaster has also placed significant pressure on its energy security and the maintenance of the energy infrastructure and, in particular, fragile energy supply lines and transmission lines. Following on from Paris Agreement in December 2015, these countries' attention is also now increasingly fixed in advancing viable and scalable low-carbon energy transformation options. Asian countries have also announced plans to construct mega power grids and trans-regional gas pipeline, which are envisioned to bring affordable and available low-carbon energy resources in an acceptable and sustainable manner. Such regional cooperation efforts, challenges as they may be, will increasingly become a major driving force for national low-carbon technology policies.

Are the energy policy choices made in the past relevant in the long-term solutions for low-carbon economy? Are the new policies replacing the older one in a smarter way to support the future needs of low-carbon economy? Would current regional cooperation plans, actors, and stakeholder networks formed during the different stages of energy transition contribute to low-carbon economy? Is there any observed effects of policy path dependency resulted from greater Asian economic cooperation that is desirable and open up new window of opportunity for tackling multiple energy challenges? With these questions in mind, this chapter explores the low-carbon energy transition that is taking place in Indonesia, Malaysia, the Philippines, and Thailand that involve different temporal and developmental phases. The first two are fossil energy exporters, and the other three are net oil importers and preoccupied with concerns over energy security. Based on extensive literature review,

drawing upon targeted information on policies and stakeholder networks, cooperation efforts evolved in these countries, and utilizing extensive analysis of governmental reports, this chapter examines the low-carbon energy policies of the past from a new angle of energy transition for sustainability.

The importance of such an exploration is threefold. First, the notion of transition provides an important lens through which we can understand the dynamics of low-carbon energy policy making and a host of other related issues related to low-carbon technology innovations. Relationship between economic development, industrialization, trade flows, and regional security all revolves around the basic access to and allocation of energy resources in a low-carbon way. Second, the prospects and challenges inherent with regional cooperation initiatives provide insights into the difficulties associated with large-scale low-carbon technology market transition. Third, an investigation on the path dependency in the transition low-carbon energy policy making that is associated with the other forms of economic integration such as flying geese industrial catchup paradigm helps to identify the key driving forces for modernizing the economies in a low-carbon way. Focusing on these three issues provide useful insights into how likely future low-carbon energy policies may evolve, to whether rhetoric of transition to low-carbon economy holds up under scrutiny.

2. Low-carbon energy policy development in Asia

2.1. Energy supply and demand outlook

With combined economic growth of 6%, the four economies Indonesia, Malaysia, the Philippines, and Thailand, which are rich in fossil energy reserves, have liberalized economic policies that have attracted many foreign investors. **Table 1** gives the energy profile of the countries.

Country	Oil reserve (billion barrels)	Natural gas reserve (trillion cubic feet)	Coal reserve (million MT)	Hydropower resource (GW)	Geothermal use (MWe)	Biomass (MT)	Per capita energy consumption (TPES/capita) (toe)	Population without access to electricity (%)
Indonesia	10	169.5	38,000	75	1,160	439	0.89	20%
Malaysia	3.4	84.4	1,025	25	—	137	3.00	1%
Philippines	0.26	4.6	346	9	1465	89	0.48	21%
Thailand	0.2	12.2	1,240	10	5	67	0.73	1%

Source: [6].

Table 1. Low-carbon energy resources and reserves in major Asian countries.

The use of high-carbon energy—coal, oil, gas, and electricity—has increased substantially in Indonesia, Malaysia, the Philippines, and Thailand, in the last 25 years, with an annual growth rate of 7%. The annual energy requirement of the countries is expected to increase by 4.2% over the next 25 years where the figure is just 1.7% for the world [4, 5]. Because of its large population, Indonesia is responsible for about half of the primary energy consumption of the region. The region is endowed with about 8% of the fossil fuel resources in the world. The diversity of available energy resources provides opportunity for cooperation. For example, nearly all of the coal reserves are located in Indonesia (83%) and Vietnam (10%); natural gas and oil are found in Brunei, Indonesia, Malaysia, and Vietnam. Indonesia and the Philippines possess substantial reserves of geothermal energy, ranking them as the second and fourth largest producers of energy from geothermal resources. Hydropower is abundant in Thailand, Indonesia, and Viet Nam. All the countries are endowed with biomass, a common noncommercial energy source for cooking, particularly in the rural areas.

In the Business-as-Usual (BAU) scenario, the total primary energy supply (TPES) of these countries is projected to increase steadily from 619 million tonnes of oil equivalent (Mtoe) in 2013 to 1685 Mtoe in 2040, growing at an annual rate of 4.7%. This projected growth is higher than the trends observed between 1990 and 2013, which averaged 4.2% per year [7]. Carbon emissions during the period are estimated to grow at the rate of 4.0% per year. The difference between TPES in the alternate policy scenario (APS) and the BAU scenario (**Figure 1**) shows approximately the potential of energy saving that could be achieved by these countries through the implementation of their advanced policies on energy efficiency in electricity power production and consumption, transport, residential, and industry sectors. Low-carbon technology policies such as energy efficiency improvement are expected to contribute to a reduction of energy demand of 13% by the end of 2035 [7].

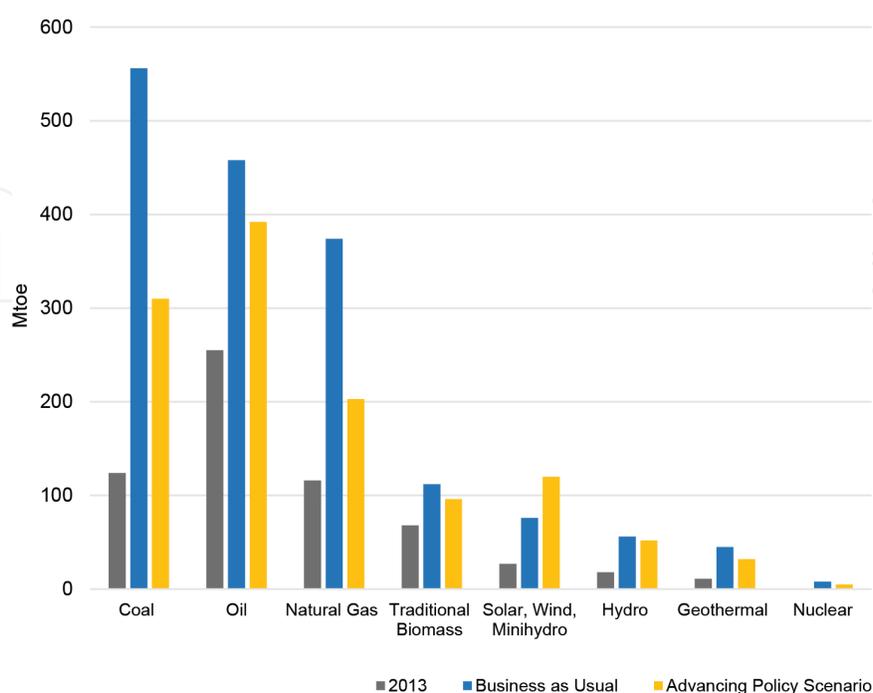


Figure 1. Comparison of future energy supply scenarios in 2030. Source: [8].

Coal and oil are cheaper and abundant compared with other sources of energy and hence going with the natural choice for the region to fulfill its sharp increase in the energy demand to support economic development. At the same time, they are the major source of air quality and greenhouse gas (GHG) emissions, accounting for 18% of carbon dioxide (CO₂) emission [9]. Further, the increasing energy security concerns as implied in **Table 2** have alarming implications for policy making. External costs related to air pollution from the combustion of fossil fuels will increase by 35%, from USD 167 billion annually in 2014 to USD 225 billion in 2025, which also equals to 5% of the regional gross domestic product (GDP) in 2025 [8]. Consequently, these countries will see rising costs for energy supply security and for controlling pollution.

2.2. The path of low-carbon energy policy development

Although these four countries are abundant in renewable energy resources, its low-carbon technology development and diffusion have been held back over a quite long period due to several economic, environmental, and social concerns and institutional constraints. There has been neither uniform strategy nor clear milestones for energy development prior to the 1950s, during which period, the choice of the policies was very much dependent on the framework conditions laid by colonial era governments. In Indonesia and Malaysia, the history of oil and mineral explorations was initially set by the Dutch and British governments. In the Philippines, it was under the influence of the USA. Currently coal and oil remain as the main energy sources, despite their efforts to diversify energy mix. Such dependency on fossil fuels began with the development of petroleum and mining industry, which took place in the nineteenth century. The extracted energy resources were mainly used to support industrial advancement of the colonial powers. Foreign entities played a major role in the exploration and extraction activities until the 1940s. Upon independence, with limited experience and expertise, the governments began to take over industry, including redirecting the trajectory of related policies and institutions. However, it was not easy to drastically deviate from the old institutional settings, industrialization patterns, shared economic beliefs, and sociopolitical values. Accordingly the transition path to low-carbon economy in Asia can be characterized by the following major stages.

2.2.1. Changing development perceptions and setting energy sector goals (1960–1980)

During this period, major economies in the region, especially Indonesia, Malaysia, Thailand and, the Philippines, have had stable energy policies, with the exploration of new

Countries	Self-sufficiency (energy production/total primary energy supply)			
	2000	2005	2010	2015
Indonesia	1.86	1.75	1.66	1.60
Malaysia	1.01	1.00	0.99	0.94
Philippines	0.57	0.58	0.53	0.43
Thailand	0.53	0.65	0.59	0.58

Source: [1].

Table 2. Energy self-sufficiency in major southeast Asian countries.

carbon-intensive energy sources, coal in Indonesia, oil and natural gas in Malaysia, hydro power in Thailand, and geothermal in the Philippines. This is due to shift from traditional agriculture to modern industrial economies, which increased the demand for energy. Both the accelerated introduction of high-carbon coal and oil into energy mix and experiences with differentiated tariff systems for industries, agriculture, and households led to changes in the policy perceptions of the national governments.

Governments of Thailand and Malaysia established central electricity authorities and provincial-level authorities to serve the new industrial units and fast growing towns. The functions of national monopolies such as Energy Generating Authority of Thailand, Perusahaan Listrik Negara (PLN) of Indonesia, Energy Development Corporation of the Philippines got strengthened over a short period of time. They were also instrumental in building modern electricity distribution systems that were integrated into the existing and expanded national power grids. This market niche allowed high profits for these state-owned enterprises. Offering stable energy supply at lower prices to large industries also helped the national governments to start luring several energy intensive industries. But this development is supported by external actors, outside the national regimes, namely, international financial institutional like Asian Development Bank (ADB) and World Bank, during which period the economic assistance to these five countries amounted to 121 billion USD [10].

Several technical cooperation studies were also initiated during this period with financial support by bilateral agencies like Japan Agency for International Cooperation (JICA) and German Technical Cooperation Agency (GTZ) with the aim of establishing effective energy policy at national level that have set targets for improving energy access, removing energy poverty and supporting industrial development. From the mid-1970s, the state-owned electricity utility companies also started adopting gas turbines and small renewable energy plants for peak load generation and off-grid electricity supply. This was the response to increasing number of power blackouts, when demand exceeded supply in urban centers, and to support mass electrification programs targeting the rural poor in Indonesia, Malaysia, and the Philippines. The expansion of electricity grid and economies of scale enabled the power generation and utility companies to expand their markets. The share of independent power producers such as large factories and industries was reduced to about 10 percent by the 1980s in Thailand [11].

The dominant actors in the network of carbon-intensive development regimes are the national governments, power generation, and utility companies, as well as international development partners (**Figure 2**). National governments, state-run power generation companies, and utilities form the core of energy policy making. The provinces, municipalities, and public are, nevertheless, kept at a distance from the energy policy regime and did not interfere with its functioning. With regard to the users, however, a distinction could be made between large power users, namely, industry, big factories, and small power users such as households. The latter was situated at the edge of the policy regime, not really exerting direct influence.

The oil crisis of 1973–1974 and 1979–1980 was an external shock to most of the Southeast Asian countries. Concerns over energy security were felt by entire network of actors. As a result, the Philippines established the national oil company in 1973; Malaysia passed the Petroleum Development Act in 1974, establishing its own national oil company PETRONAS. Thailand

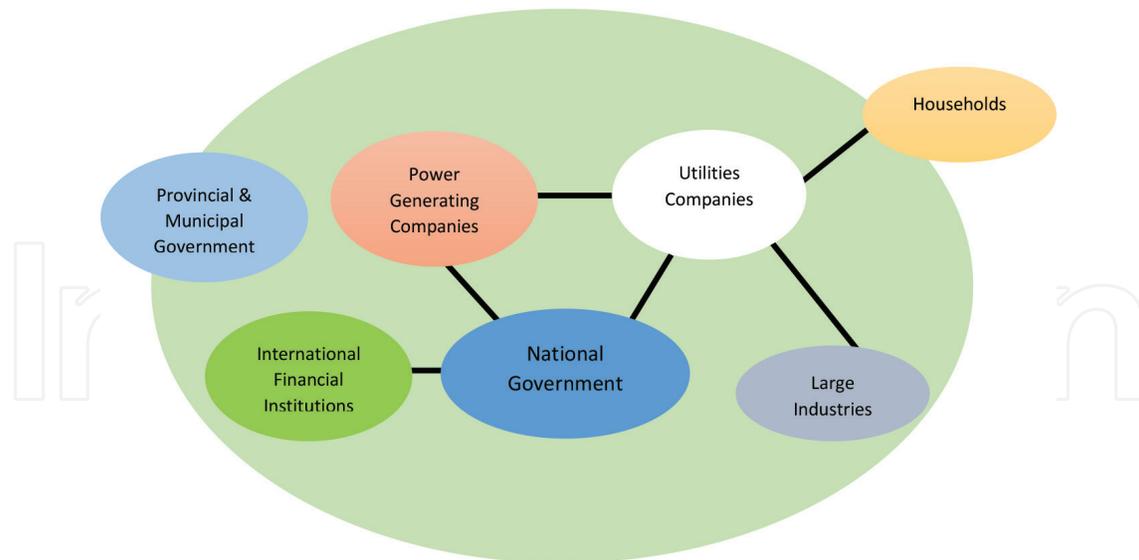


Figure 2. Actors and networks in the earlier carbon-intensive energy policy regime (mid-1970s).

took its first Energy Structural Adjustment Loan from the World Bank, and Indonesia started the first fuel subsidy program, which had profound implications on the economic systems in the coming years.

2.2.2. Changes in energy sector objectives, rules, and privatization (1980–2000)

Since the early 1980s, these countries have started witnessing high economic growth, and governments have gradually changed their energy policies in synchronization with industrial policies. The main approach to energy sector development has been deregulation, privatization of technology, and utility companies and market competition. This is partly attributed to countries like Indonesia, Thailand, Malaysia, and the Philippines becoming the part of the greater Asian economic integration process and the industrial production networks, as to be explained by flying geese pattern [12]. Most of the governments started to separate their legislative functions with regard to energy from the daily operation management, through formation-independent regulatory bodies or energy commissions. Under the build-own-transfer (BOT), build-own-operate (BOO), and joint venture mechanisms, the private sector has been encouraged to get involved in energy technology and infrastructure projects in terms of research, investment, construction, transmission, distribution, and daily operation management. In particular, Thailand and the Philippines have increasingly looked to private sector to finance energy developments. During mid-1990s, Thailand has privatized its energy development authority, deregulation of energy sector started in Malaysia, Indonesia permitted independent power producers (IPPs), and disinvestment of started in Philippines Energy Development Corporation. It has started agreements with private companies to construct geothermal power plants.

On the other hand, energy efficiency has been low in production, distribution, and industrial sectors. For instance, in 1995 about 28% generated electricity was lost during transmission in the Philippines and 13% in Thailand. In order to improve the efficiency of their energy sectors and achieve better economic returns, many governments have reduced subsidies for

energy production and consumption. The 1997 Asian financial crisis also found its impact on energy sector. After the crisis, energy prices have moved to being decided by market forces. Indonesia and Thailand, the countries most affected by 1997 financial crisis, were also under advice from international lenders to undertake structural reforms within the electricity sector to operate more efficiently by removing the subsidies.

With regard to energy efficiency policy, demand side management (DSM) has got increased attention in Malaysia and Thailand. Asian Development Bank (ADB), Economic and Social Commission of Asia Pacific (ESCAP), and Japan International Cooperation Agency (JICA) were instrumental in bringing many demonstration projects. On the other hand, privatization of electricity sector has required an increase of energy product sales to sustain the profits of newly privatized energy companies. Therefore, there has been little incentive for them to pursue DSM.

With regard to actors and networks, although the stakeholders remained the same, linkages in the social network changed, especially as a result of decreasing role of the national government on the energy policy regime, which has started a shift toward low-carbon development. The minor changes are illustrated in **Figure 3**. Provincial and municipal governments become part of core energy policy making. Community-based organizations had started influencing role, albeit indirectly. Subsequently, the pressure on the energy regime in countries like Indonesia and Thailand in the early 1990s came from increasing societal concerns about environmental impacts of large-scale private sector-initiated energy projects. This coupled with awareness on energy efficiency and the 1997 Asian financial crisis and its impact on high energy prices brought in the activities of international nongovernment organizations into the energy policy regime, though they are kept at the edge of the daily operational decisions (**Figure 4**).

2.2.3. Focus on renewable energy markets, social inclusion, and sustainability (2000–Present)

This was a dramatic time for all the four Asian countries, as energy supply security, economic integration, and climate change issues have started dominating the policy agenda

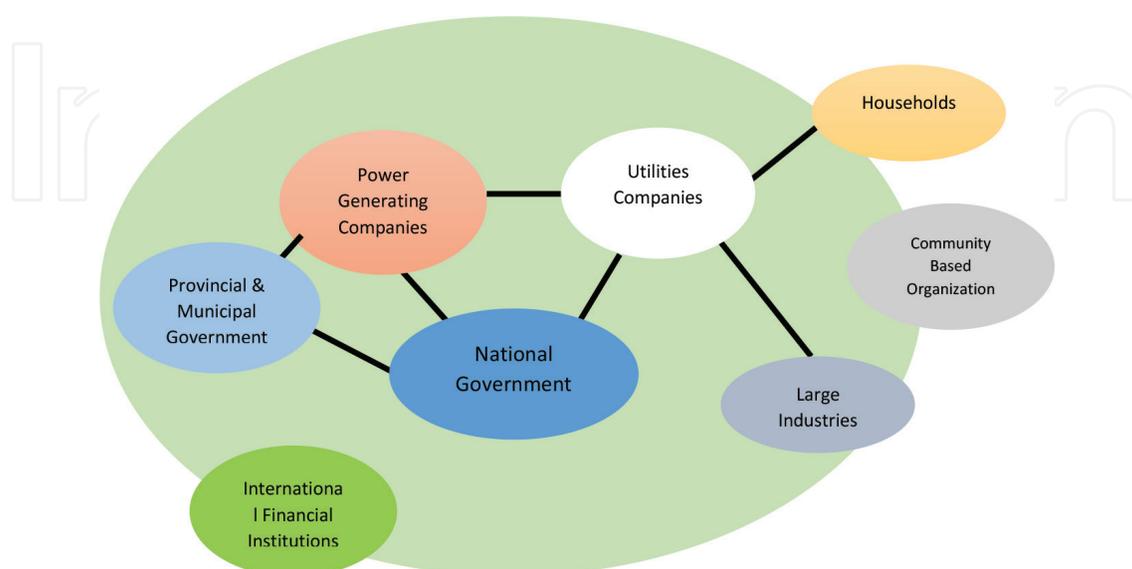


Figure 3. Actors and networks in the transition energy policy regime (mid-1990s).

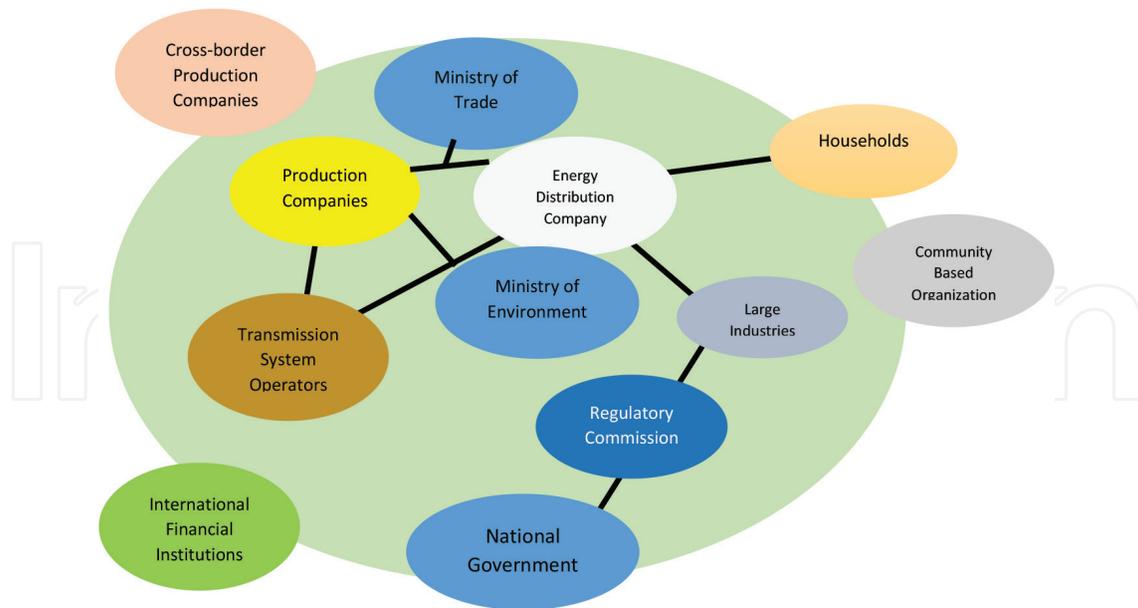


Figure 4. Actors and networks in the low-carbon technology policy regime (present). Source [17].

of national governments. The risks to energy security of supply became evident again during the food, fuel, and financial crisis of 2008. It had an effect on affordability of energy by low-income households, small-sized business, and other economic activities vulnerable to gasoline price volatility and high electricity tariff. Governments started finding niche in harnessing locally available renewable energy resources. Most of energy and electricity laws such as Thailand’s establishment of Ministry of Energy (2002), Malaysia’s National Biofuel policy (2006), Establishment of National Energy Council in Indonesia (2007), and the Philippines Renewable Energy Corporation (2008), helped to accelerate low-carbon energy deployment. **Table 3** illustrates the targets and policy instruments made available to increase the uptake of renewable energy in the study countries.

Renewable electricity production and supply to the grid by private actors, for example, solar and wind firms, are being accelerated, and a national standard-base tariff was established. The aim of these policy changes was to enhance market dynamism and efficiency.

Country	Renewable energy targets	Policy measures
Indonesia	23% share of renewable energy in the final energy mix	Feed-in tariff
Malaysia	4000 MW of installation capacity from renewable sources	Feed-in tariff, renewable energy standards
Philippines	38.6% share of renewable energy in the primary energy supply	Feed-in tariff Renewables Portfolio Standard, capital subsidies, tax incentives
Thailand	20% share of renewable energy in the power generation by 2036	Feed-in tariff, feed-in premium, biodiesel blending mandate

Source: authors.

Table 3. Renewable energy target and policy measures by 2030.

Country	Energy products subsidized	Energy policy reforms
Indonesia	Gasoline, diesel, kerosene for households and small business, LPG, and electricity	Increased price of gasoline by 44% and diesel by 22% in 2013. Promoting natural gas use in transport to reduce oil subsidies. Continuing successful kerosene to LPG conversion program in 2007. Electricity tariffs are set to rise by 20% in 2020, for all but consumers with the lowest level of consumption
Malaysia	Electricity, natural gas, and kerosene	Subsidies to gasoline and diesel were reduced in a bid to cut the budget deficit. Implemented a subsidy removal program in 2011 that gradually increase natural gas and electricity prices
Thailand	LPG prices controlled. Diesel and natural gas for vehicles. Electricity for poor households	Since 2013, increasing LPG prices every month for all but street vendors and consumers with the lowest level of energy consumption. Increased electricity tariff from 2013, which will be revised every 6 months

Source: authors.

Table 4. Fossil fuel subsidy reforms.

Removing pervasive subsidies is also a part of energy policy reforms being implemented during this period. In most of the countries, these fuel subsidies are targeted at gasoline and diesel as well as more socially sensitive products, namely, liquefied petroleum gas (LPG), kerosene, and electricity. As they were typically introduced to help improve the living conditions of the poor by making fuels affordable and accessible. However, they have resulted in market distortions while failing to meet their intended objectives. Fossil fuel subsidies in Southeast Asian countries amounted for \$ 51 billion in 2012 [5]. Spending on subsidies has been significant in Indonesia and Malaysia, both of which are starting to become increasingly dependent on energy imports. Growing recognition that subsidies are not sustainable and are having many unintended consequences, the governments introduced specific reforms as listed in **Table 4**.

In particular, market-oriented subsidy policies are so politically sensitive in the region, the pace and ambition of reform efforts often accompanied by creation of social-safety net programs, which were found successful. For example, in 2015, when the government of Indonesia made a decision to abolish the subsidies to carbon-intensive gasoline and diesel, that policy was integrated with stronger social protection programs. When it reduced its energy subsidies and raised fuel prices, the government established a program to transfer unconditional quarterly payment of \$30–15.5 billion poor households. The same move was undertaken when the fuel prices were raised in May 2008, with \$ 1.52 billion being allocated as direct cash transfer to low-income households. The conditional cash transfer programs are intended to increase the levels of education and health of poor communities. These experiences show that it is possible to design successful low-carbon policies, with adequate social welfare programs and make the transition as inclusive as possible (**Figure 4**).

Parallel to these events, the international negotiation on a Post Kyoto regime called for urgent need to address climate change. The Bali Road map adopted at the 13th Conference of Parties (COP 13) in 2007 set off a forward-looking energy policy decisions that need to be undertaken by all the countries. Southeast Asian countries responded to these challenges by launching

ambitious renewable energy and energy efficiency targets as they were obligated to reduce emissions on voluntary basis. On the other hand, the financial crisis of 2008 and the accompanied stimulus packages provided economic opportunities on tackling climate change actions that contributed for job creation, green growth, and increase competitiveness of small business. Despite the drop in oil prices in 2014, which provided enough political space for introducing subsidy reforms, it failed to improve energy efficiency, and climate change mitigation actions remained not high on the energy policy making priorities of these countries. At the same time, the formation of ASEAN Economic Community in 2015 paved the way for more integrated energy markets. Ratification of nationally determined contributions (NDC) as agreed in Paris-COP 21 by the governments provides another opportunity to work on a policy package with five mutually enforcing and closely interrelated dimensions of energy security, energy efficiency, a fully integrated regional energy market, a decarbonized economy, and financial innovations.

The actors and social networks have also changed substantially because of 2008 financial crisis and ongoing efforts on regional economic integration. The national governments become part of the regional economic policy landscape, as its formal powers and responsibilities to design energy policies with multiple objectives increased the policies of ministries of trade, environment, and infrastructure have started influencing energy policy making. And the growth of independent power producers and decentralized electricity systems of renewable energy producers and consumers, making them also part of the energy policy regimes to decide on environment and social priorities. The articles of association—Heads of ASEAN Power Utilities Authorities (HAUPA)— and the formal arrangement of the cooperation between the state-owned utilities promoted electricity trade across the borders. For example, the import of electricity by Thailand from Laos at lower prices has jumped from almost nothing in 1980 to 5000 MWh in 2000, which kept the push for further adjustments in the regulatory and institutional frameworks, to manage the complicated ownership between production companies and consumers located across the borders. New International transmission System Operators (TSO) responsible for the operation of balancing supply and demand and taking care of cross border connections also become part of the new energy policy regime.

2.3. Cross-country comparison on low-carbon technology policy pathways

Lessons from Indonesia, Malaysia, the Philippines, and Thailand taught that a number of factors mainly local renewable energy resource endowments, complex governance structures, and international players have combined effect on low-carbon economy transition. Taking a multi-level low-carbon energy transition analysis helped to identify two distinguishable patterns in technology policy pathways. Experiences from Indonesia and Malaysia show that numerous contextual factors shape the low-carbon technology policies. Both countries went through a process of decentralization from decades of monopoly or top-down policy making. On the other hand, countries like Thailand and the Philippines, which are very much dependent on imported oil, focused their efforts in integrating renewable energy technologies in the national energy mix. Unabated rise in oil prices and strains on public finance also helped this transition. This is reflected in the policy regime niches and market dynamics, as characterized in **Table 5**.

	Fossil fuel-rich countries (e.g., Indonesia, Malaysia)	Resource poor countries (e.g., Thailand, Philippines)	Policy regime rules
1980s	Wait-and-see attitude toward low-carbon energy transition	Active production by production companies because of economic and energy security concerns	Struggles over capacity and grid connection
1990s	Network fall apart, with small energy development companies become reactive	Increase in the renewable energy share in energy mix	Laws facilitate market liberalization independent power producers
2000s	Seen as a long-term option: large energy developing companies see it as an opportunity for low-carbon profiling	Close to dominant practice for attainment of energy security	Financial and regulatory incentives for scaling up the investment
2010s	Active production in local areas because of socioeconomic and environmental considerations	Tackling the grid-connection issues for accelerated deployment	Shift to high expectations on climate change mitigation and low-carbon green growth

Source: author.

Table 5. Policy regime influences on low-carbon energy technology market dynamics.

Renewable Electricity Power Act in the 1980s in Thailand and the Philippines marked starting point for radical reform that fastened the uptake of low-carbon energy technologies through liberalization and privatization. On the other hand, Indonesian and Malaysian energy markets are still dominated by state-owned enterprises. Attempts to shift the market conditions toward liberalization and low-carbon energy resource development are often stalled by administrative tribunals. Heavy fuel subsidies and regulated energy prices are dominant in the policy landscape until 2014. Nevertheless, nonsubsidized electricity prices in the Philippines is the highest in the region. With respect to incentives and support schemes for renewable energy, a comprehensive renewable energy act of 2008 in the Philippines and 2010 in Thailand embodied a set of policies and mechanism promoting renewable energy, although it took years for the national governments to implement its rules and regulations.

In contrast, only a few relatively weak-support policies for low-carbon technology diffusion exist, especially for geothermal in Indonesia and biofuel in Malaysia. The new institutions, the Directorate General for Renewable Energy and Energy Conservation (EBTKE), Indonesia, and Sustainable Energy Development Authority (SEDA), Malaysia, aims to further stimulate low-carbon technologies but is often with limited success. This has reflected in the fundamental difference in the energy mix, with high share of low-carbon renewables in the Philippines and Thailand, compared with a highly fossil fuel-dominated electricity production in Indonesia and Malaysia. Environmental issues and issues related to climate change are, at least rhetorically, more prominently articulated in the Philippines and Thailand, which are climate change hotspots.

Furthermore, there are commonalities in low-carbon energy policy making. The experience of the countries also shows that transformation in the policy regimes has been greatly influenced by external developments, such as oil crisis of the 1970s, the Asian economic crisis of

the 1990s, and global financial crisis of the 2000s. The change has been nonlinear as there has been sometimes even complete reversal of previous regulations. In the 1960s and early 1970s, coal was phased out by oil. The strategy was to use oil and natural gas supplies rapidly, before maximization of hydro power. But after the first oil crisis, gas has come to be seen as a strategic source of energy to be used sparsely. But after the second oil crisis, this strategy was reversed; attention shifted to coal and to increasing energy efficiency. It goes with the aphorism, often termed Sali's law: "Bad times may produce good policies, and good times fervently the reverse" [13].

3. Regional cooperation approaches for developing affordable low-carbon energy system

3.1. ASEAN energy integration plan, targets, and patterns

Since the late 1960s, the Southeast Asian countries have recognized that energy security is an issue that affects the entire region. Multilateral energy cooperation and regional networks are thought to create an enabling environment for appropriate energy policies at the national level. In 1967, five countries in the region—Indonesia, Malaysia, the Philippines, Singapore, and Thailand—declared establishment of the Association of Southeast Asian Nations (ASEAN). Brunei, Cambodia, Lao PDR, Myanmar, and Vietnam joined later in the 1990s. At the 2003 ASEAN summit, the Bali Concord was signed, which agreed on establishing an ASEAN community comprising three pillars, namely, Political and Security Cooperation (ASEAN Security Community), Economic Cooperation (ASEAN Economic Community), and Socio-Cultural Cooperation (ASEAN Socio-Cultural Community) by 2020. In response to the increasing economic challenges, the ASEAN Economic Community was established in 2015, which oversees the energy cooperation shift to low-carbon economy among member countries.

Indeed, ASEAN energy policy cooperation dates back to the first meeting of ASEAN Economic Ministers on Energy Cooperation held in 1980. The meeting discussed energy policies, institutional arrangements, and energy cooperation within ASEAN and between ASEAN and other countries or international organizations. The first Energy Ministers Meeting held in 1988 agreed to formulate a framework for energy cooperation aimed at improving the social welfare and economic growth by ensuring affordable, reliable, and sustainable energy supply. From then to now, the progress of the regional energy policy cooperation can be divided into three periods, as shown in **Table 6**.

During that period, the studied countries witnessed a stepwise approach, whereby a coalition of countries took decisions on consensus basis to address the common challenge of how to plan and develop a secure and robust energy sector. Their common action plan for cooperation focuses on energy planning, energy efficiency, renewable energy, clean coal technologies, nuclear energy, electricity trade, and infrastructure. For each topic, working groups were formulated; work programs were agreed upon with a modest budget for implementation. Central to the work was the exchange of experiences on the happening in each country by annual senior officials meetings, seminars, and conferences as well as capacity building and training

	First phase 1980–1990	Second phase 1990–2000	Third phase 2000–present
Energy security	Long-term national planning, with the focus on oil, gas, and coal use	Reach neighboring countries for harnessing shared hydro-resources	Alignment of policies in the wider ASEAN context
Energy markets	Knowledge sharing on potential demand and supply	Plans for regional power grid, oil and gas pipelines, and liberalized markets	Action plan on investments for integrated markets
Energy efficiency	Knowledge sharing on support mechanisms	Plans for regional standards and performance targets	Technical assistance and monitoring around implementation of directives
Low-carbon technologies	Research and training programs on renewables and fossil	Research networking on renewables and nuclear	Market pull and tech push initiatives
Clean energy and environment	Increasing awareness	Collective renewable energy targets	Embedding in energy policy decisions
Regional energy governance	Energy Ministers Meetings and Committee of Senior Officials Permanent and ad hoc subsector networking and working groups Energy Cooperation Task Force ASEAN Centre for Energy (ACE) and Economic Research Institute for ASEAN and East Asia (ERIA)		

Source: authors.

Table 6. An overview of regional energy policy cooperation in ASEAN.

schemes for national energy policy planners and experts. The aim was to make the cooperation efficient and relying primarily on consensus-based bottom-up governance system.

This mode of operation was made from the very beginning and has not changed much over the years. But gradually, it has become an important catalyst for cooperation in its own right, to develop ambitious national level, targets, action plans, and other mechanisms to support a well-functioning integrated energy system within the region and across the borders. With the establishment of ASEAN Centre for Energy (ACE) in 1999 and Economic Research Institute for ASEAN and East Asia (ERIA) in 2008, the cooperation benefited from having institutions that could focus exclusively on regional energy policy issues. This cooperation has led to some success, particularly setting and achieving ASEAN's low-carbon renewable energy targets, visualizing cross border energy trade and implementing targeted energy policy research and training programs. It has also resulted in several vision documents and numerous policy statements.

The ASEAN 2020 is the first vision document adopted in 2007, which called for an ASEAN energy cooperation aimed at forging closer economic integration with the region. The vision highlighted the need for improved energy cooperation through electricity grid interconnection arrangements and natural gas pipeline across the region along with the promotion of energy efficiency, conservation, and renewable energy. In 1999, ASEAN formulated an ASEAN Plan of Action for Energy Cooperation (APAEC) 1999–2004 and subsequently updated versions for 2004–2009, 2010–2015, and 2016–2025, with the aim to enhancing energy connectivity and

market Integration in ASEAN to achieve energy security, accessibility, affordability, and sustainability for all [4]. The adoption of such a vision represents a significant paradigm shift, elevating national policy efforts into realizing a single regional energy market within the framework of ASEAN Economic Community (AEC). They also created a policy framework for the AMS to achieve its overall low-carbon energy transition goals. In particular, electrical power integration offers a mechanism to further support renewable energy targets and to enable universal access to energy services for all its citizen in a low-carbon way.

3.2. Challenges to regional cooperation and low-carbon energy policy making

The ASEAN vision 2020 placed emphasis on the need to construct multilateral energy networks across the countries, and this priority was embodied in all subsequent decisions and plans. The ASEAN Power Grid (APG) was created as the flagship of such a vision with the purpose of delivering the main objectives of achieving long-term security, availability, and reliability of renewable energy supply, optimizing the region's energy resources and investments and allowing access to affordable energy to population across the region. APG consists of 14 bilateral and multilateral electricity interconnection projects. Since its inception in 1997, the APG has accomplished gradual progress, particularly through the deployment of several interconnections, many of which are fully operating on bilateral basis. However, the APG is yet to operate on multinational basis, so as to deliver its intended benefits.

Several studies [11, 14–16] of regional power integration have concluded that, regardless of the different types of models at work, some of the expected benefits from cross border energy infrastructure development are not realized, because they are not specifically targeted within the design of economic cooperation programs. The implication is that in designing regional cooperation programs, the challenge is to incorporate the proper mechanisms and incentives that would allow it to deliver its full benefits, notably for the deployment of low-carbon technologies, expansion of access to low-carbon electricity, and optimization of investments.

Nevertheless, these four countries have not yet identified appropriate indicators to measure the benefits of low-carbon development through completed interconnections. On the other hand, APAEC has set clear goals and quantitative targets for the year 2025. APAEC Phase II outlines seven main energy cooperation program areas: (i) the ASEAN Power Grid, (ii) the Trans-ASEAN Gas Pipeline, (iii) Coal and Clean Coal Technology, (iv) Energy Efficiency and Conservation, (v) Renewable Energy, (vi) Regional Energy Policy and Planning, and (vii) Civilian Nuclear Energy. While the program areas lay the foundation for greater regional energy cooperation and influence the rethinking on low-carbon energy policy making at national level, it remains unclear whether their implementation with current challenges relates to national interest, economic policy and institutional barriers, technical and financial capacity, as well as differing level of low-carbon energy development and security concerns among the countries.

The actors and governance structure of APAEC comprise a network of policy makers who work on consensus basis, with the rules and mode of operation determined by the council of ministers aided by senior officials from each country. The chairmanship of the ministerial council rotates annually as did the chairmanship of senior officials. The institutional networks are lean and rely on existing organizations with limited resources and human power. Hence,

it is important that the process of regional cooperation is not done entirely behind the closed doors of the high-level taskforces. It must be coproduced and coenvisioned by the people in order to have buy-in from the public. A vision of regional energy cooperation that reflects the values and preferences of the community is a vision that the community will feel they have a stake in protecting, securing, and making sacrifices for. It is with collective best interests that the decisions on APAEC are made, priorities are selected, and risk–benefit tradeoffs are just, equitable, and acceptable.

While the purported low-carbon benefits of regional cooperation are tradeoffs, so are the challenges. Challenges arising from climate change become more and more embedded in regionally coordinated energy policies. Though energy sector is partly responsible for climate change, albeit also one of the solutions to mitigate carbon emissions, recently adopted Paris Agreement has shown that international cooperation has larger role to play in the short and long terms. Achieving the multiple benefits of low-carbon energy transition, gaining required technology spillovers, and attracting investments for cross border projects warrant new models of regional cooperation. These countries can see flying geese pattern of industrialization and economic integration from this point of view, to unleash the power of next-generation low-carbon technologies.

4. Regional economic cooperation and low-carbon energy policy path dependencies

4.1. Regional economic development through flying geese model

The pattern of East Asia’s catchup economic growth and the process of industrial modernization and associated low-carbon energy policy path are chartered by “flying geese” model being the most well-known paradigm. It started in Japan; facilitated the emergence of production networks across Southeast Asia; permitted countries like Indonesia, Malaysia, the Philippines, and Thailand to catch up advancement in technology and skill up gradation; and narrowed the developmental gaps. This can be illustrated in **Figure 5**. In that framework, during the 1970s, newly industrializing countries, Korea, Taiwan, Singapore, and Hong Kong, followed Japan in developing industries that initially produced nondurable goods and then durable consumer goods and then capital goods. The ASEAN countries such as Indonesia, Malaysia, Thailand, and the Philippines followed the third tier in the 1980s. Japan is the leading goose in that model and used its technical and economic power to establish sophisticated industrial network with other Southeast Asian countries [18–19]. This is reflected in the export structure of Southeast Asian countries with Japan during that period.

In 1985, the order of the flying geese (FG) is clear; Japan is the leading goose, and Indonesia, Malaysia, Thailand, and the Philippines are catchup economies. However, by the year 2000, the slope of the FG becomes flatter. It seems that the FG pattern of economic integration has changed during 1985–1997, and Japan is now not a sole leading goose in the region, with Korea and China taking some part of the lead. The most prominent features of the gaggle of



Figure 5. Correlation of export structure of the second and third tier geese with the leading goose Japan. Source: [20].

flying geese are first, in the bid for regional integration, Japan relied solely on its economic power and technology prowess; second, Japan employed its Official Development Assistance (ODA) to consolidate its production network in East and Southeast Asia; and, third, the Japanese government made efforts to release the private capital to come up with Foreign Direct Investment (FDI) plans. The trade has increased from 2209 million USD in 1967 to 109,097 million USD. Foreign Direct Investment peaked in the 1970s, with the peak 30% in the 1970s and with an ODA constituting cumulative average flow of 1600 million/year during 1967–2002 (Ministry of Finance, 2005). The regional production network, established through FG model, is a form of informal economic integration. It involved no formal institution or intergovernmental agreement but worked according to the business logic of cross border activities.

5. Conclusion

The following conclusions about the dynamics of innovations in low-carbon energy policy making in Asia could be drawn.

First, a transition to low-carbon economy and shift in adaptation of new cleaner technologies have been unfolding in the last three decades. Major changes have occurred in the formal regulations, rules, actors, and networks of the policy regime that are initially planned to achieve long-term security, availability, and reliability of energy supply. Transition in low-carbon energy policy making in Indonesia, Malaysia, Thailand, and the Philippines involves three distinguishable temporal and developmental phases, often characterized by hierarchy, aggregation, and space. In the initial period, technology policy choices are made to meet the growing concerns of energy security and access, later of reliability, and then of climate change. These policy choices and institutional actors and networks, whether consciously or not, supported resource intensive growth. Guiding principles and drivers of energy policy

making also changed over a period of time. Past policies, technology-oriented top-down, are gradually being replaced or complemented by participatory, market-oriented policies.

A second conclusion is that the ongoing low-carbon economic transition is enhanced by regional cooperation. Adoption of an action plan for regional energy cooperation created enabling environment for paradigm shifts in national energy policy making. ASEAN energy cooperation demonstrated two successes: the liberalization energy markets for low-carbon renewables—both developed far beyond knowledge sharing, exchange of experiences, best practices and learning, reaching a position as a role model for regional cooperation. By means of high political- and operational-level endorsements, the necessary frameworks are being developed step by step and country by country in a pragmatic way, gradually opening up for cooperation of the willing. Yet, regional energy cooperation has proceeded slowly in the actual implementation of plans. A lot has been said in the form of meetings and declarations, but many of the statements are declaratory in nature and nonbinding and have no legal force.

The Southeast Asian way of consensus building has posed real limits to institutional building and actual functional cooperation. This is due to barriers such as complex and diverse nature of energy needs, differing national interests, national sovereignty, and lack of trust and industrial structure of the states in the region. Indeed, the institutional frameworks and human capacity necessary for regional cooperation in most issues remain poorly developed. A clear understanding of the tradeoffs and plan for institutional and human capacity needed—skills, training, education, and capacity building—is urgently needed. A region-wide policy in the energy sector would be futile, if it is implemented across the board without specific considerations on the interests of the countries. A stepwise cooperation for low-carbon technology diffusion requires greater awareness and flexibility of it to support the goal of a one integrated energy market for low-carbon energy resources. Nevertheless, the current *modus operandi* allows the member countries to complement each other and thus remain as an enabler of making the shift from one equilibrium of policy making to another in a stable way. Accelerated energy market integration should remain of prime importance for the ongoing energy transition in the next decades.

Third, the flying geese model of economic integration points to a new way of regional cooperation to solve low-carbon energy policy dilemmas, with no formal involvement of policy institutions and intergovernmental agreements, but works according to market principles and with a policy dependency. Though the Greater Asia is no longer in the historical paradigm of flying geese, it provides conditions for competitive learning across many policy options and provides the capacity to take advantage of knowledge and low-carbon technology spillovers. Success in low-carbon energy policy making is the result of the governments making use of its existing production networks and sizable manufacturing sector to establish a stable foundation for the low-carbon technology requirements. As the increase of the Greater Asian integration depends on regional production networks, they should become the driving force for integrated planning on short-, medium-, and long-term basis. To benefit as much as possible from that niche, Asian countries need to continue integrating with other leading countries and create an environment more conducive to smooth the flow of low-carbon technology, products, and services.

The reality is that low-carbon technology and energy policy making anywhere are becoming more complex. Pretending that low-carbon technologies can be diffused in isolation from other social, environmental, and economic policies. There is a need to increase reform advocacy for multi-sectoral coordination, educate the stakeholders on the co-benefits of low-carbon technology, and support new models of energy cooperation. Asia should also remain engaged with other parts of the world, because the peer pressure for the next generation of low-carbon technology diffusion is likely to come from them.

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