Chapter 2

Road Map for Power Market Integration in the Brunei-Indonesia-Malaysia-Philippines (BIMP) Region

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Chapter 2

Road Map for Power Market Integration in the Brunei–Indonesia–Malaysia–Philippines (BIMP) Region[1]

Romeo Pacudan

The Brunei-Indonesia-Malaysia-Philippines (BIMP) region represents the eastern power market cluster of the ASEAN Power Grid. The current power supply and demand imbalances create opportunities for trade and initiate power market integration. The overarching goal of power market integration in the ASEAN is to achieve energy security, accessibility, affordability, and sustainability. Key benefits for the BIMP region includes least-cost option for importing countries, efficiency improvement through aggregation of demand, and lower reserve requirement. This chapter focuses on the possible power market integration structure and characterises the development stages to achieve the target integration arrangement. Due to disparity of electricity supply industry structures and regulatory frameworks, coordination of power system operators would be the most practical approach in market integration rather than consolidating the power market and power system operators. The proposed road map for the BIMP region is divided into four stages of development: (i) stage 1 – incremental development of regional transmission backbone infrastructure; (ii) stage 2 – incremental intra-Borneo power trade; iii) stage 3 – incremental inter-Borneo trade arrangements; and (iv) stage 4 – establishment of a multi-buyer, multi-seller regional power market. The proposed coordination of system operators requires standardisation of practices and harmonisation of measures related to electricity security regulation, planning coordination, cost allocation and wheeling charges, network codes and monitoring. Implementation of this road map faces various challenges but these could be overcome when clear and tangible economic benefits that would be derived from market integration would be underscored.

1. Introduction

Given its geographic arrangement, uneven distribution of energy resources, and disparate levels of economic development of member countries, the ASEAN regional power market is a fragmented market with three sub-regional market clusters that form the three regional power subsystems under the ASEAN Power Grid (APG).

This study focuses on the Brunei–Indonesia–Malaysia–Philippines (BIMP) power market, the market cluster under System C (eastern system) of APG (AIMS, 2010) and covers the power

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markets of Brunei Darussalam, Sabah, Sarawak, Kalimantan, and the Philippines. The other systems are System A (northern system), which covers Cambodia, Lao PDR, Myanmar, Thailand, and Viet Nam (referred to in this paper as the Greater Mekong Subregion [GMS] power market cluster); and System B (southern system) which includes Peninsular Malaysia, Singapore, and Sumatra (southern power market cluster).

The three ASEAN power market clusters under APG are at various stages of market integration, with the GMS cluster as the most advanced and the BIMP cluster as the least advanced. The first power trade in the GMS cluster occurred in 1971 while the first interconnection in the BIMP cluster started only in early 2016. Because of the strong support by the Asian Development Bank, the regional economic cooperation on power trade in GMS is more structured than that at the ASEAN level or at other subregional levels. The countries in the GMS cluster have adopted a road map to fully achieve subregional power interconnections (Zhai, 2010).

Strategies and action plans for the implementation of APG are formulated by the heads of ASEAN power utilities/authorities (HAPUA) and reported under the ASEAN Plan of Action for Energy Cooperation (APAEC). The strategies are focused on specific power trade or interconnections while the action plans are key studies to address economic, technical, legal, and regulatory issues related to cross-border trade (ACE, 2015). The APAEC 2016–2025 and the ASEAN Interconnection Master Plan Study 2010, however, did not characterise market integration at the ASEAN level nor at the sub-regional levels.

This paper raises the following key issues: what level of power market integration could be reasonably achieved in the BIMP region and how to characterise the development stages to achieve this level of integration. This paper reviews and situates the current interconnection initiatives under the framework for market integration and outlines a road map for greater power market integration in the BIMP region. This paper is structured as follows: Section 2 presents an overview of the BIMP power market, Section 3 characterises market integration in the BIMP region, Section 4 briefly discusses technical issues, Section 5 outlines the stages of the road map and provides recommendations to realise the road map, and Section 6 summarises the finding of the study.

2. Overview of the BIMP Power Market

2.1. Demand, Supply, and Energy Resources

Central to the BIMP power market is Borneo, the largest island in Asia and the third largest island in the world, and where power interconnections are centrally located. At present, Borneo's imbalances of electricity supply and demand offer an opportunity for trading electricity and developing the regional infrastructure. But with its huge energy resources for power generation, Borneo could, in the long term, trade its surplus capacity with markets outside the island.

Table 2-1 shows an overview of the BIMP power market. The population of Borneo (Kalimantan, Sarawak, Sabah, and Brunei Darussalam combined) is almost as big as that in Mindanao in the Philippines. Kalimantan and Mindanao have relatively lower electrification rates and lower electricity consumption per capita than Sarawak, Sabah, and Brunei Darussalam. The consumption per capita in Brunei Darussalam, however, is almost four times higher than those in Sarawak and Sabah. These disparities indicate prospects for power market growth and development in the BIMP region.

Table 2-1. Overview of the BIMP Power Market

	Unit	**Kalimantan**		**Sarawak**	**Sabah**	**Brunei Darussalam**	**Mindanao**
Capital		Pontianak	Balikpapan - Bontang	Kuching	Kota Kinabalu	Bandar Seri Begawan	Davao
Population 2010	Million	4.39	9.90	2.42	3.12	0.41	21.00
Regional Office		PLN	PLN	SESCO	SEB	DES	NGCP
Area	km^2	146,760	474,422	124,450	73,619	5,770	104,630
Population density	Population per km^2	30	21	19	42	70	201
Electricity consumers	Thousand	834	2,064	549	415	100	2,715
Electrification ratio	%	76	83	91	90	99.7	71
Peak demand 2014	MW	234	847	1,251	1,051	620	1,428
Energy sold 2014	GWh	1,371	5,154	6,575	6,353	3,259	7,506
Consumption per capita	kWh per person	312	520	2,717	2,036	8,022	357

DES = Department of Electrical Services, GWh = gigawatt hour, MW = megawatt, PLN = Perusahaan Listrik Negara, NGCP = National Grid Corporation of the Philippines, SESCO = Syarikat SESCO Berhad, SEB = Sabah Electricity Sdn Bhd.
Source: Asian Development Bank.

Table 2-2 shows electricity peak demand forecasts for 2022. Northern Borneo, consisting of the Malaysian states of Sabah and Sarawak as well as Brunei Darussalam, has peak demand that is almost three times higher than those of Indonesian provinces in Kalimantan. On the other hand, the peak demand of Mindanao in the Philippines is comparable in volume to each of the key markets of Sabah, Sarawak, and Kalimantan.

Table 2-2. Peak Electricity Demand Forecast

Eastern Subsystem	2013 (MW)	2022 (MW)	Average Yearly Increase (%)
West Kalimantan	234	856	7.6
Central–North–East	847	2,252	7.3
Total Kalimantan	**1,081**	**3,108**	**7.4**
Sarawak (Domestic)	1,251	1,996	4.1
Sarawak (SCORE)	2,217	3,500	10.8
Sabah	1,051	1,993	5.0
Brunei	620	1,004	5.5
Total Borneo	**6,220**	**11,601**	**7.0**
North Sulawesi	311	777	3.7
Mindanao	1,428	2,199	2.6
Philippines	11,305	16,486	2.9
Borneo + Mindanao	**7,648**	**13,800**	**6.3**

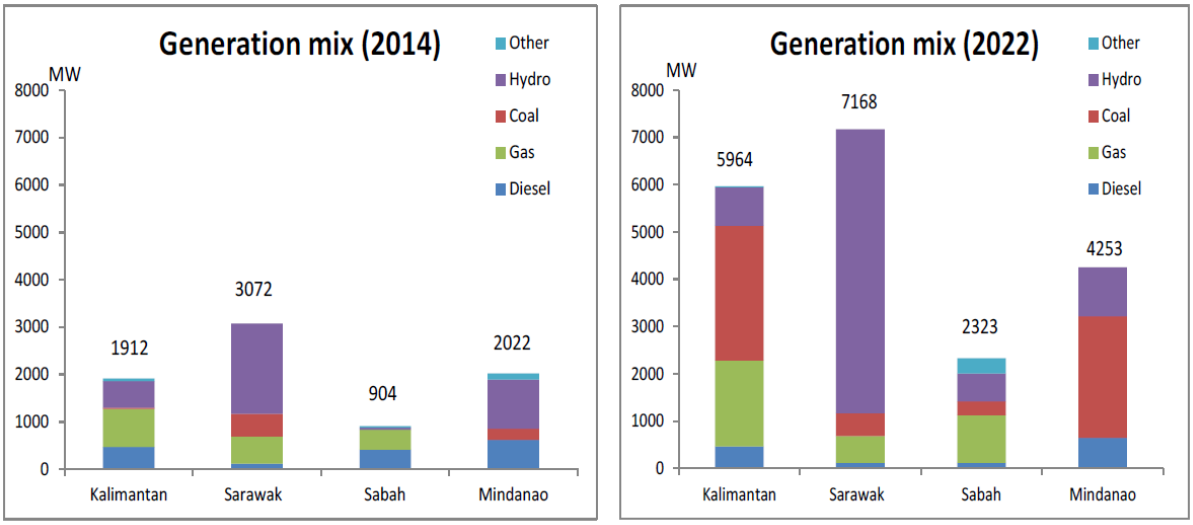
MW = megawatt, SCORE = Sarawak Corridor of Renewable Energy.
Source: Asian Development Bank.

The demand forecast also indicates the potential amount of electricity that can be integrated through power trade. The industry's rule of thumb for interconnectors is that their capacity should not exceed the size of the largest generating unit or not more than the reserve capacity which might be about 10–20 percent of peak load (ADB, 2014). This is to ensure that the importing market would continue to operate even when there had been a failure in the interconnectors.

Future demand prospects could also be driven by demand from industrial zones. In Sarawak, the Sarawak Corridor of Renewable Energy is promoting industrial development and currently attracting several energy-intensive industries. As part of its diversification policy, Brunei Darussalam is developing industrial parks that attract energy-intensive manufacturing and petrochemical industries. Sabah is also pursuing industrial investment through the Sabah Development Corridor Plan.

Figure 2-1 shows the power generation mix for the BIMP market cluster. In 2014, hydropower generation was dominant in Sarawak and Mindanao although it also had a significant share in Kalimantan. Natural gas was the main fuel for power generation in Brunei Darussalam and registered an important share in Kalimantan, Sarawak, and Sabah. The projections for 2022 show a significant increase in the share of hydropower in Sarawak while the use of coal would be increasing faster in Kalimantan and Mindanao.

Figure 2-1. Power Generation Mix



MW = megawatt.

Source: Asian Development Bank.

Borneo has significant energy resources for power generation that once developed would be sufficient to meet its long-term demand as well as demand from markets outside the island. Sarawak (Malaysia) and Kalimantan (Indonesia), with their huge hydropower and coal resources, are poised to become major power exporters in Borneo.

- Hydropower resources are abundant in Sarawak (Malaysia) and North Kalimantan (Indonesia). The hydropower potential in Sarawak is estimated to be around 20,000 MW while that in North Kalimantan is around 5,572 MW.
- Gas resources are found in Brunei Darussalam, East Kalimantan (Indonesia), and Sabah (Malaysia). Brunei's gas reserves stood at 13.8 trillion cubic feet in 2012. East Kalimantan has a liquefied natural gas facility in Bontang with a total capacity of 22.2 million metric tonnes per annum. With the non-renewal of some term contracts due to declining production, Bontang's liquefied natural gas is currently being diverted to supply the domestic market.
- Coal resources are found in East and Central Kalimantan (Indonesia) and, to some extent, in Sarawak. Kalimantan is considered to be one of Indonesia's coal-producing regions. Indonesia's measured reserves are estimated to be 12,466

million tonnes while the indicated reserves are around 20,533 million tonnes. Sarawak's coal reserves can fuel an estimated 5,000 MW of power capacity.

- Other renewable energy resources such as biomass, geothermal, solar, wind, and, to some extent, marine energy are also available in the island. These resources can be developed to augment domestic supply but not in a scale enough to support large-scale power exports.

2.2. Market Structure and Regulatory Environment

Power systems in Brunei Darussalam are managed by the Department of Electrical Services and the Berakas Power Management Company, in the Malaysian states of Sabah and Sarawak by the Sabah Electricity Sdn Bhd and the Syarikat SESCO Berhad, respectively. The power systems of the five Indonesian provinces in Borneo are managed by separate branch offices of the state-owned Perusahaan Listrik Negara. Peninsular Malaysia's power system is managed by the Tenaga Nasional Berhad while the grid network in the Philippines is managed by the National Transmission Corporation with the National Grid Corporation of the Philippines as its concessionaire.

Power industries in Borneo (Brunei Darussalam, Sabah, and the Sarawak states of Malaysia, and Kalimantan Province of Indonesia) are vertically integrated and, at the earlier stages of industry liberalisation, with limited private sector participation in generation (Table 2-3). Power systems and network operations are carried out by vertically integrated utilities and access to transmission and distribution networks are not open to independent power producers. Power sector regulations in Brunei Darussalam and Indonesia are carried out by government agencies. On the other hand, Malaysia has an independent regulatory body.

The Philippines is the only country in the BIMP region with competitive wholesale electricity market and partial retail market competition. The Philippines has an independent electricity market operator and third-party access to transmission network is allowed. Economic and technical regulations are carried out by an independent regulatory body.

Table 2-3. BIMP Power Market Structure and Regulatory Environment

Country	Market Structure	Regulatory Body	Independent Market Operator	Open Transmission
Brunei Darussalam	Single Buyer	Department of Electrical Services (government agency)	No	No
Indonesia	Single Buyer	Department of Energy and Mineral Resources (government agency)	No	No
Malaysia	Single Buyer	Energy Commission (independent body)	No	No
Philippines	Competitive	Energy Regulatory Commission (independent body)	Yes	Yes

Source: Author's compilation.

3. Power Market Integration

The overarching goal of the ASEAN market integration under APAEC 2016–2025 is to achieve energy security, accessibility, affordability, and sustainability for all ASEAN member states (ACE, 2015). These objectives are also in line with industrialised countries' objectives of promoting electricity market integration to enhance electricity supply security and promote economic efficiency (OECD/IEA, 2014; ESMAP, 2010).

Specifically, APG aims to assist the ASEAN member states in meeting increasing demand for electricity and improving access to energy services by enhancing trade in electricity across borders, optimising energy generation and development, and encouraging possible reserve sharing scheme (ASEAN Secretariat, 2011).

Based on these strategic objectives, the ASEAN Interconnection Master Plan II has identified optimal interconnection projects for all three ASEAN power market clusters: GMS power

market, southern power system market, and BIMP power market (HAPUA, 2010). Results of the 2010 study have been regularly improved, updated, and reported during annual meetings of the HAPUA working committee on the APG.

3.1. Interconnection Projects

The BIMP interconnection projects that cover the intra-Borneo and inter-Borneo interconnections are summarised in Table 2-4. APG has identified six interconnection projects for the planning horizon 2016–2025: four intra-Borneo projects and two inter-Borneo projects. In 'An Evaluation of the Prospects for Interconnections among the Borneo and Mindanao Power Systems (2014)', a study by the Asian Development Bank, at least 11 interconnection projects were identified for the same time horizon. The main difference is that the ADB study included projects in the four main Indonesian provinces in Kalimantan for the intra-Borneo interconnection projects as well as other inter-Borneo interconnection projects such as Kalimantan–Java, Kalimantan–North Sulawesi, and Sabah–Mindanao interconnections.

APG classifies interconnection projects into power purchase and economic exchange (HAPUA, 2010). Power purchase is a unidirectional trade of power and refers to delivery of bulk power to load centres. Economic exchange is a bidirectional trade transaction and refers to economic operation resulting from peak load diversity, peak shaving, and sharing of spinning reserve.

In addition to the strategic objectives of interconnection, clear and specific short-term benefits justify interconnections in the BIMP region. These are:

- Interconnection provides the least-cost option for importing countries and results in lower electricity prices. For example, under the Sarawak–West Kalimantan power trade, the average cost of power generation of PLN in Kalimantan is US$0.25 per kWh while the power supplied under the trade agreement is priced at US$0.10 per kWh. This would also be the case for other power purchase interconnection arrangements such as Sarawak–Sabah and East Kalimantan–Sabah. With huge hydropower resources, Sarawak as a power exporter has the lowest average power generation cost compared with other BIMP power supply markets (Figure 2-2).

Table 2-4. BIMP Interconnection Projects

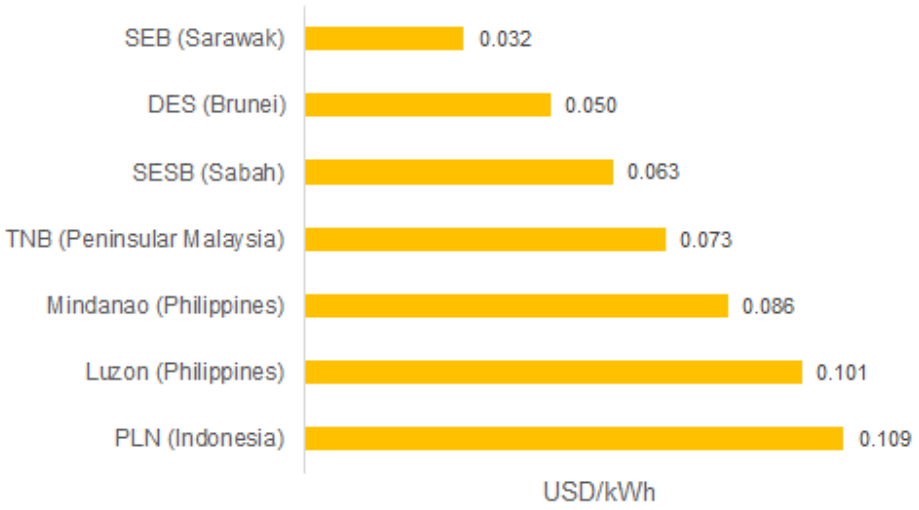
APAEC 2016–2025	Asian Development Bank Study
Sarawak–Peninsular Malaysia, 1,600 MW (2025). Power Purchase.	Sarawak–Peninsular Malaysia, 500 kV HVDC, 2,000 MW (2020)
Sarawak–West Kalimantan, 230 MW (existing). Initially power purchase, later economic exchange	Sarawak–West Kalimantan, 275 kV, 300 MW (existing)
Sarawak–Brunei, 30-100 MW (2019), 100 MW (post 2020). Economic exchange.	Sarawak–Brunei–Sabah, 275 kV, 300 MW (2016)
Sarawak–Sabah, 100 MW (2020). Power purchase.	Sarawak–Sabah, 250 HVDC, 300 MW (2025)
	Sarawak–Sabah–Luzon, 500 kV HVDC, 2000 MW (2025)
Philippines–Sabah, 500 MW (post 2020). Economic exchange.	Sabah–West Mindanao, HVDC, 600 MW (2025)
East Sabah–East Kalimantan, TBC MW (post 2020). Power purchase.	East Sabah–East Kalimantan, 275 kV, 600 MW (2020)
	West Kalimantan–South Kalimantan, 250 kV HVDC, 300 MW (2018)
	South Kalimantan–East Kalimantan, 275 kV, 600 MW (2018)
	South Kalimantan–Java, HVDC, 2,000 MW (2025)
	South Kalimantan–Northern Sulawesi, HVDC, 300 MW (2025)

Note: Power purchase refers to the delivery of bulk power from cheap energy resources to load centres. Economic exchange refers to economic operation resulting from peak load diversity, peak shaving, and sharing of spinning reserve.
Sources: ACE, P. Vongthanet, Asian Development Bank, HAPUA.

- Interconnection improves efficiency and reduces the average cost of generation. The Indonesian provinces in Kalimantan and the Malaysian state of Sabah currently use smaller and older diesel units for power generation. Interconnection will aggregate demand thus allowing utilities to invest in much bigger and more efficient systems. As a standard industry practice, sizing of power plant units are not higher than 10 percent of the peak demand (ADB, 2014).

- Interconnection also lowers reserve requirement and reduces the average cost of generation. Isolated utilities often require from 30 percent to 40 percent operating reserves while a well-interconnected grid requires only around 15 percent (ADB, 2014).

Figure 2-2. Average Power Generation Cost in BIMP (2014)



DES = Department of Electrical Services; SEB = Sarawak Energy Berhad; SESB = Sabah Electricity Sdn. Bhd; TNB = Tenaga Nasional Berhad.

Sources: SEB, SESB and TNB data - Energy Commission (2015); PLN data - PT PLN (2015); Philippine Data – Department of Energy (2015); DES data - author's estimates.

3.2. Market Coordination and Consolidation

Global experience has shown two main models in electricity market integration: consolidation of markets and system operation and coordination of system operators (OECD/IEA, 2014). Consolidation (such as the PJM[2] and MISO[3]) is the main approach in the US while coordination is the main model in Europe. Under consolidation, system operations are merged under a single entity controlling power plants over a control area. Coordination, on the other hand, coordinates neighbouring system operators and involves optimising and harmonising cross-border flows. Consolidation is most suited to real-time market integration in highly meshed networks but may not be feasible in regions where various institutional constraints and barriers exist (OECD/IEA, 2014). In this case, market coordination would be the best alternative although it requires strong coordination of electricity security regulatory frameworks.

[2] Pennsylvania-New Jersey-Maryland Interconnection
[3] Midcontinent Independent System Operator

At present, consolidation of power system operations in Borneo alone would not be possible politically. Coordination of system operation is, therefore, the most practical approach in the short-term for the BIMP region since power trade can be initiated without the need to introduce power sector reforms to modify national market structures and regulatory environment.

At the APG level, market consolidation could, however, be the target power arrangement for each market cluster in the long term (OECD/IEA, 2014). For example, the GMS power market cluster has outlined the evolution of the regional power market integration in the GMS power trade and interconnection road map[4]. The medium-term goal is to transform the regional market into a coordinated market structure but the long-term target is to develop a consolidated market arrangement.

At the ASEAN level, market integration could evolve first among countries within a cluster but two or more clusters could potentially converge in due course. This appears to be the case for the GMS market cluster and the southern market cluster with Lao PDR, Thailand, Malaysia, Singapore planning to pilot power integration project. The southern cluster would also be interconnected with the BIMP market cluster through the proposed Peninsular Malaysia and Sarawak interconnection. Market integration within each cluster of APG could evolve into either coordinated or consolidated market system. Integration of the three market clusters at the APG level could, however, progress toward a coordinated market system (OECD/IEA, 2015).

3.3. Coordination Arrangements

Various coordination models exist under a market integration framework. Coordination arrangements in liberalised European electricity markets are much more complex than what would be needed in a set of countries with vertically integrated power market structure.

At the ASEAN level, several trading arrangement models could be pursued given that most countries have different power market structures and objectives for power trade (OECD/IEA, 2015). Similarly, several coordination modalities in the BIMP region have been identified and could form part of the overall pathway for market integration.

- **Unidirectional trade.** The first intra-Borneo power trade is a unidirectional trade between utilities of Malaysia (SESCO) and Indonesia (PLN). PLN purchases 50 MW from SESCO during Phase 1 (first 5 years) on take-or-pay basis and 180 MW under a take-and-pay contract while Phase 2 of the contract stipulates 230 MW maximum capacity purchases (ADB, 2015). All contracted capacities are from hydropower plants. The border between the two countries is the point of interconnection. Each utility is responsible for the construction of the 275-kV transmission line and substations in each side of the border. Other

[4] The first phase is the development of bilateral trade between pair of countries, the second phase is the third-party access to transmission facilities, the third phase is the development of a regional backbone with multiple buyers–sellers entering cross-border transactions, and the fourth phase is the development of a regional competitive market (Zhai, 2010).

interconnection projects identified in APG that could constitute unidirectional trade include the Sarawak–Peninsular Malaysia, the Sarawak–Sabah, and the East Sabah–East Kalimantan projects (HAPUA, 2015).

- **Bidirectional power transactions**. These refer to the economic exchange arrangement described in AIMS II[5]. Under this trade model, two countries can trade excess capacity or take advantage of inter-temporal cost differences (OECD/IEA, 2015; HAPUA, 2010). Economic exchange may also include short-term transactions and support services during emergencies. Interconnections envisaged to have this type of trade arrangement are the Sarawak–Brunei and the Philippines–Sabah projects, and the eventual trading arrangement between Sarawak and West Kalimantan.
- **Power purchase from an independent power producer (IPP*).*** This trading arrangement is common in the GMS power market cluster. Under this model, a national utility can purchase power from an IPP operating in a neighbouring country. In the BIMP power market, so far, only one interconnection project—the East Sabah–East Kalimantan interconnection—has been identified to have this type of trading agreement. At present, PLN and SESB have a memorandum of understanding with a coal-fired power station IPP for the latter to supply power to Sabah and East Kalimantan (ADB, 2014).
- **Third-party access.** This trading arrangement has not been specified in the APG Master Plan, but the ADB study (2014) on BIMP interconnection has identified the possible evolution of the Sarawak–Brunei–Sabah interconnection into this model. In selling power to Sabah, Sarawak could wheel power through the existing Brunei network instead of investing on dedicated infrastructure linking the two Malaysian states. Brunei will be compensated through wheeling charges. With the transmission infrastructure, Brunei may also sell its excess power to Sabah.
- **Multi-buyer, multi-seller market.** In the long term, a multilateral market system would probably evolve in the BIMP power market once the regional transmission network had been established. This model allows trading between countries irrespective of their market arrangements. A subregional multilateral market system with liberalised electricity markets would be more complex, such as the case of the EU, than market systems with vertically integrated structure, such as the case of the BIMP region. Since there is no long-term power liberalisation plans for power markets in Borneo, the long-term market integration structure envisaged for the BIMP region could perhaps be a multilateral market system for countries or territories with disparate power industry structures (competitive market in the Philippines and vertically integrated power utilities in Borneo).

[5] ASEAN Interconnection Master Plan Studies.

4. Harmonisation of Power Systems

At the proposed levels of integration and the current structure of national electricity markets, technical harmonisation requirements for the BIMP region would be much simpler compared with the liberalised and competitive electricity markets in Europe.

Utilities in Borneo are using the conventional 50-Hz high-voltage alternating current (HVAC) based on the UK (Malaysia) or European (Indonesia) standards. Brunei Darussalam is currently upgrading its high-voltage network to 275-kV AC in anticipation of the power exchange between Sarawak and Sabah. Sarawak, on the other hand, is also building a 500-kV AC network in preparation for the expected power interconnection that would initially be operated at 275 kV.

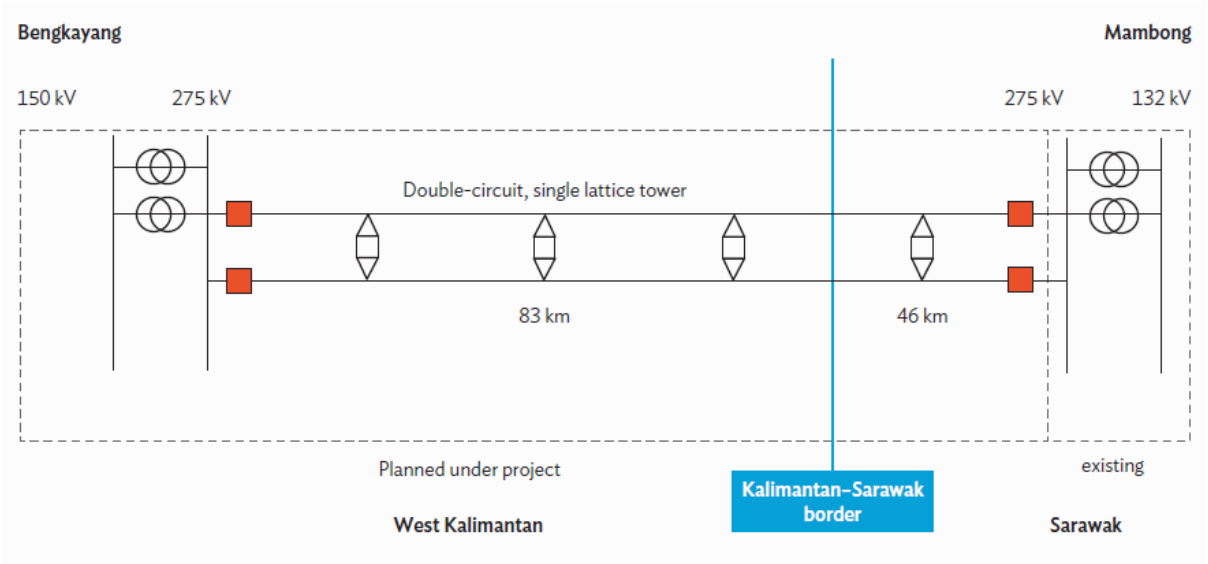
Interconnectors in the Kalimantan side are, however, based on PLN's sub-transmission standard of 150-kV AC, a voltage level that may not be appropriate for inter-provincial transmission lines. ADB (2014) is proposing to develop a 275-kV AC line connecting South Kalimantan to East Kalimantan (Eastern Corridor) to accommodate bigger load in the future. On the other hand, ADB (2014) is also proposing to change the planned 150-kV AC transmission line connecting West Kalimantan to South Kalimantan with HVDC-VSC [6] monopole link to accommodate future power exchange between Kalimantan and Sarawak. The existing interconnection between Sarawak and West Kalimantan is based on 275-kV AC (Figure 2-3).

The inter-Borneo interconnections are being planned using a 500-kV HVDC technology. In the case of Sabah–Philippines interconnection, where Sabah is operating at 50 Hz while the Philippines is at 60 Hz, the HVDC system will act as a buffer, isolating one system from the other and allowing each to operate independently (ADB, 2014).

According to ADB (2014), based on the planned intra- and inter-Borneo interconnections, no significant harmonisation issues need to be addressed. Definitely, technical issues may be encountered for long-distance transmission lines, but the voltage and stability issues can be properly addressed by technical studies.

[6] Voltage source converters (VSC).

Figure 2-3. 275-kV AC Sarawak–West Kalimantan Interconnection



HVTL = high voltage transmission line, km = kilometre, kV = kilovolt.
Source: Asian Development Bank.

5. Market Integration Road Map

The BIMP region is at a certain stage of power market integration. The market integration process at the subregional level is relatively slow and depends on the economic, technical, and political circumstances of electricity-trading countries. Based on the market coordination arrangements described earlier, this section attempts to outline a road map that characterises current as well as programmed developments (both technical and institutional) to realise a greater sub-regional market integration and to maximise the benefits of developing energy resources for power generation in the region.

As presented earlier, the long-term market integration arrangement for the BIMP region could be a multi-buyer, multi-seller market system for power systems with disparate industry structures. The section outlines the intermediate stages to reach this long-term market trading arrangement. Each stage is not time-bounded and stages may overlap each other.

Stage 1. Incremental development of regional transmission backbone infrastructure

The idea of power trade has been recognised by the BIMP countries since the first APG Master Plan in the 1990s. Power exchange has been considered in the long-term power and transmission development plans in some countries in the region. With power interconnection at the backdrop, countries have independently planned for developing a regional backbone that could optimise the use of regional energy resources and reduce reserve capacity requirements.

- Brunei Darussalam has upgraded its transmission network and started constructing a 275-kV transmission line (to be operated initially at 66 kV) in anticipation of the upcoming power exchange with Sarawak and potential wheeling of power from Sarawak to Sabah.
- SESCO has also started building a 500-kV backbone system (to be operated initially at 275 kV) to aggregate demand in the SCORE corridor. This network could be extended to Sabah in the future (without passing through Brunei) and perhaps toward Luzon in the Philippines. The line could also be used by PLN to transmit power to SCORE from a mine-mouth coal-fired power plant to be potentially constructed near the border between the two countries.
- PLN is planning to complement the recently completed Sarawak–West Kalimantan 275-kV transmission line by considering a loop that could complete a 275-kV ring around Borneo. This includes an HVDC link between West Kalimantan and South Kalimantan, a 275-kV line connecting South Kalimantan with East Kalimantan, and another 275-kV line that would connect East Kalimantan to North Kalimantan and all the way to Sabah.

Stage 2. Incremental intra-Borneo power trade based on projects with mutual benefits

The second stage will consist of trade arrangements, either power purchase or economic exchange, between two countries based on projects that generate mutual benefits. This includes the following:

- The recently completed 275-kV interconnection between Sarawak and West Kalimantan facilitating a power purchase by PLN of around 300 MW from SESCO. This would be converted to an economic exchange arrangement once PLN in Kalimantan is able to develop competitive power generation projects based on coal and natural gas.
- All intra-Borneo power purchase or economic exchange arrangements identified under the APG or the ADB study such as the Sarawak–Brunei, Sarawak–Sabah and East Kalimantan–Sabah interconnections.
- Power exchange between Sarawak and Sabah through Brunei transmission network. Brunei's benefits include wheeling charges, access to supply sources from the east and west as well as lower reserve requirements. Sarawak and Sabah may also access the fast-acting gas turbine spinning reserve in Brunei Darussalam.

Stage 3. Incremental inter-Borneo trade arrangements

Stage 3 will consist of all inter-Borneo power interconnections. The inter-Borneo interconnections would represent greater development of energy resources for power generation and accessing electricity markets outside Borneo. This includes the following trade arrangements[7]:

[7] Transfer capacities are estimated by ADB (2014). Power exports are set to be high to justify high cost of interconnection but not to exceed 10 percent of demand of the importing grid.

- Sarawak–Sabah–Philippines. These interconnections would be mainly supported by hydropower supply from Sarawak.
    i. Sabah–Luzon, 500-kV HVDC, 2,000 MW;
    ii. Sabah–Mindanao, 500-kV HVDC, 600 MW.
- Kalimantan–Indonesian Provinces. These interconnections would be supplied by gas-fired and coal-fired power generation in Kalimantan.
    i. South Kalimantan–Java, 500-kV HVDC, 2,000 MW.
    ii. East Kalimantan–North Sulawesi, 500-kV, 300 MW.
- BIMP power market cluster – Southern power market cluster. This will be mainly based on hydropower resources from Sarawak.
    i. Sarawak–Peninsular Malaysia, 500-kV HVDC, 2,000 MW
    ii. Sarawak–Peninsular Malaysia– other load centres in southern power market cluster

Stage 4. Establishment of multi-buyer and multi-seller market

This stage would be attained when a significant number of intra- and inter-Borneo trade arrangements had been achieved and when the regional infrastructure had been established. As presented earlier, this trading arrangement would be for utilities operating under disparate industry structures.

In previous stages, coordination would be mainly done by trading countries or utilities. In this stage, an independent cross-market operator needs to be established (OECD/IEA, 2015). This operator would be responsible for monitoring and management of electricity trade and would act as platform for connecting buyers and sellers. The establishment and the status of this body could be decided in a later stage but could be supervised through HAPUA.

Establishing an independent cross-market operator needs stronger commitments and greater cooperation from BIMP countries. Under stage 1, investment commitments to develop a regional backbone at their territories will mainly come from individual countries; in stages 2 and 3, investment commitments and cooperation would be carried out by trading parties; stage 4 requires multilateral investment commitments and greater cooperation since some of the functions of the national system operators could be assumed by the cross-market operator.

6. Conclusion

BIMP contains significant energy resources that could be developed to stimulate economic growth and development in the region. However, these resources are unevenly distributed. The current supply and demand imbalances create opportunities for trade and initiate power market integration at the subregional level. In the long-term, Malaysia's Sarawak and

Indonesia's Kalimantan could emerge as major power exporters in Borneo. Full development of the BIMP energy resources, however, would only be realised once the BIMP power market cluster is fully integrated in the much broader ASEAN power markets.

Power market integration can be initiated despite the disparity of electricity industry structures and regulatory frameworks between trading countries. Among the approaches for market integration, coordination of power system operators would be the most practical and appropriate for the BIMP power market cluster rather than consolidation of power market and power system operators.

Given the power industry structures and regulatory environment of the BIMP countries, the coordination models that could be applied include i) unidirectional trade, ii) bidirectional power transactions, iii) power purchase from IPP, iv) third-party access, and v) multi-buyer multi-seller market. The interconnection projects and planned power exchanges identified under APG for the BIMP market cluster could be characterised according to these coordination arrangements.

To fully realise the region's economic benefits from developing its energy resources for power generation, this paper outlines a road map for power market integration in the BIMP region. This proposed road map serves as the recommendation to governments in the region on how to proceed with regional power interconnections to achieve greater power market integration. The road map is divided into four stages of development.

- Stage 1. Incremental development of regional transmission backbone infrastructure;
- Stage 2. Incremental intra-Borneo power trade based on projects with mutual benefits;
- Stage 3. Incremental inter-Borneo trade arrangements; and
- Stage 4. Establishment of a multi-buyer, multi-seller regional power market.

The implementation of the road map requires individual country investment commitments. Stage 1 investments would be implemented by each of the countries in their territories. Investments under stage 2 and stage 3 would be carried out by trading parties. Stage 4 requires cooperation commitments from the BIMP countries since the establishment of a multi-buyer, multi-seller market requires multilateral financing and that some of the functions of the national system operators would be transferred to the cross-border market operator.

References

ACE (2015), *ASEAN Action Plan for Energy Cooperation (APAEC) 2016–2025*. Jakarta, Indonesia.

ASEAN Secretariat (2011), 'Master Plan on ASEAN Connectivity', Jakarta, Indonesia: ASEAN.

Asian Development Bank (ADB) (2015), *West Kalimantan Power Grid Strengthening Project*. Manila, Philippines: ADB.

Asian Development Bank (2014), 'An Evaluation of the Prospects for Interconnections among the Borneo and Mindanao Power Systems', Manila, Philippines: ADB.

Asian Development Bank (2011), 'Initial Environmental Examination: Strengthening West Kalimantan Power Grid', Manila, Philippines: ADB.

Bouttavong, B. (2015), Updates on Laos–Thailand–Malaysia–Singapore Power Integration Project, slide presentation: the 15th Meeting of the ASEAN Power Grid Consultative Committee (APGCC), Melaka, Malaysia.

Department of Energy (DOE) (2015), '26th Electric Power Industry Reform Act (EPIRA) Implementation Status Report', Manila, Philippines: DOE.

Energy Commission (2015), *Performance and Statistical Information on Electricity Supply Industry Malaysia*. Putrajaya, Malaysia: Energy Commission.

ESMAP (2010), *Regional Power Sector Integration: Lessons from Global Case Studies and Literature Review.* Washington, DC: ESMAP.

HAPUA (2015), *Final Report Project No. 1: Study on Taxation on Cross-Border Power Transaction*, Working Group No. 4 – Policy and Commercial Development, Jakarta, Indonesia.

HAPUA (2010), 'Executive Summary of the ASEAN Interconnection Master Plan Study No. 2', Jakarta, Indonesia: HAPUA.

IEA (2014), *Seamless Power Markets: Regional Integration of Electricity Markets in IEA Member Countries.* Paris, France: IEA.

IEA (2015), *Development Prospects of the ASEAN Power Sector: Towards an Integrated Electricity Market*. Paris, France: IEA.

PT PLN (2015), *Statistik PLN 2014*. Jakarta, Indonesia: Sekretariat Perusahaan PT PLN (Persero).

Vongthanet, P. (2016), Progress Report HAPUA Working Group No. 2 (HWG2) APG/Transmission, Slide presentation: The 32nd Meeting of HAPUA Council, The 23rd Meeting of HAPUA Working Committee, The 18th Meeting of the APGCC, Vientiane, Lao PDR.

Zhai, Y. (2010), Energy Sector Integration for Low Carbon Development in Greater Mekong Sub-region: Towards a Model of South-South Cooperation.