Chapter 3

Interconnection and Sustainable Development in the Greater Mekong Subregion

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Chapter 3

Interconnection and Sustainable Development in the Greater Mekong Subregion

Myanmar needs to increase its generation capacity in the short and medium term to meet rapidly growing demand. Blackouts are not uncommon even in big cities such as Yangon. In the short term, the government expects to double supply by 2020 by adding about 3,000 MW. Although different options are available, social, economic, and environmental constraints hinder efforts to secure steady, undisrupted power supply.

Hydropower is dominant in the energy mix, and although the potential for expansion is vast, major projects are not progressing as planned. Coal is expected to make up over one-third of the total power mix, according to the National Electricity Master Plan. However, social protests and national government policy guidelines indicate the difficulties in realising it. Solar energy has been proposed and projects are in the pipeline, but with little progress in implementation. Wind power has not moved beyond the pilot phase. Liquified natural gas (LNG) projects are expected to meet demand, but concerns still exist about financial viability, the price tag, the remaining time until the projects start, and the options after that.

Cheaper electricity imports from neighbouring countries have emerged as a possible alternative. Myanmar already has some small cross-border exchanges to meet its own demand. Recently, the government held exploratory discussions; signed MOUs with Lao PDR, China, and India; and announced an agreement to import 1,000 MW from Yunnan, China.

In this chapter, we analyse the possibilities for Myanmar to benefit from regional power trading, and the overall geopolitical consequences of regional power transfers. We thoroughly review academic and grey studies. Our analysis finds that power imports can have a direct positive impact on Myanmar's ability to reduce its power shortages. Nonetheless, investments in transmission infrastructure are needed to decongest the system. If done well, they can contribute to electrification of the periphery through benefit-sharing mechanisms. These interconnections (with China, Lao PDR, Bangladesh, and possibly India) can position

Myanmar at the centre of interregional energy cooperation between South Asia and Southeast Asia and China, which would foster economic and political cooperation elsewhere in the region.

Asia is gradually increasing interconnectivity. Sub-regions are integrating their electricity systems. Energy ministers have agreed to prepare a road map under UN-ESCAP's leadership. Myanmar is part of several regional initiatives and a neighbour to two sub-regions active in power interconnectivity – South Asia and Southeast Asia. Myanmar can become a 'power' bridge between South Asia and Southeast Asia and southern China. Myanmar should strategically balance its relationships with its neighbours and not become overdependent on any of them.

1. Introduction

1.1. Background

Myanmar needs to generate more electricity. The country suffers frequent blackouts and brownouts even in major cities such as Yangon and Mandalay. Regional power connectivity has been one of the hottest topics on Southeast Asia's energy agenda for the last 30 years. Regional economic cooperation was launched to promote peace after the end of the Cold War. Energy was a front runner in showing the benefits of regional cooperation. Since then, regional power trade has grown dramatically due to successful agreements and institutions. Integration, however, has not deepened, although it is fair to say that it has expanded. This has created new challenges. As Lao PDR has increased its hydro generation in the Mekong and its tributaries, for example, CSOs have stepped up their opposition to it.

Myanmar has been considered an important potential source of hydro-based power generation in the regional mix, but the situation is shifting. Hydropower generation has not been realised and the government has initiated negotiations for the possible importing of electricity from neighbouring countries.

1.2. Objective and Methods

This paper aims to understand the implications of developing the infrastructure required to import power for sustainable development.

So far, Myanmar has been considered only a potential exporter of electricity to the region based on its hydropower potential. It exports to China and has signed an MOU with Thailand (although no project has been realised yet). Myanmar also imports small amounts of electricity from its neighbours to electrify the border areas: from China for Muse, from India for Tamu, and from Lao PDR for Shan state. The government is in talks with neighbouring countries to import electricity to secure the national grid supply in the short and medium terms. The implications for sustainable development in Myanmar and the region need to be understood further.

Myanmar's interconnections with its neighbours are linked to geopolitical factors such as the rapidly increasing penetration of variable renewable energy, which drives the development of transboundary power trade or 'super-grids'. Research is being conducted to explain the drivers and consequences of super-grids (Overland, 2019; Scholten and Bosman, 2016), as well as particular case studies (Escribano, 2018). International initiatives are paying attention to the potential of transboundary power trade, such as the Regional and Global Energy Interconnection Initiative by the Clean Energy Ministry and IRENA's Clean Energy Corridors.

Regional research has focused on power connectivity in the GMS (ADB, 2008; Krongkaew, 2004; Yu, 2003). Formerly known as the Indochina Peninsula, the GMS covers all the countries crossed by the Mekong. Upstream countries (China, Myanmar, and Lao PDR) are endowed with high potential for hydropower generation, which can be used to export low-carbon generation to downstream countries (Thailand, Viet Nam, and Cambodia). However, developing power plants in the mainstream of the Mekong can have severe ecological and socio-economic effects across the basin.

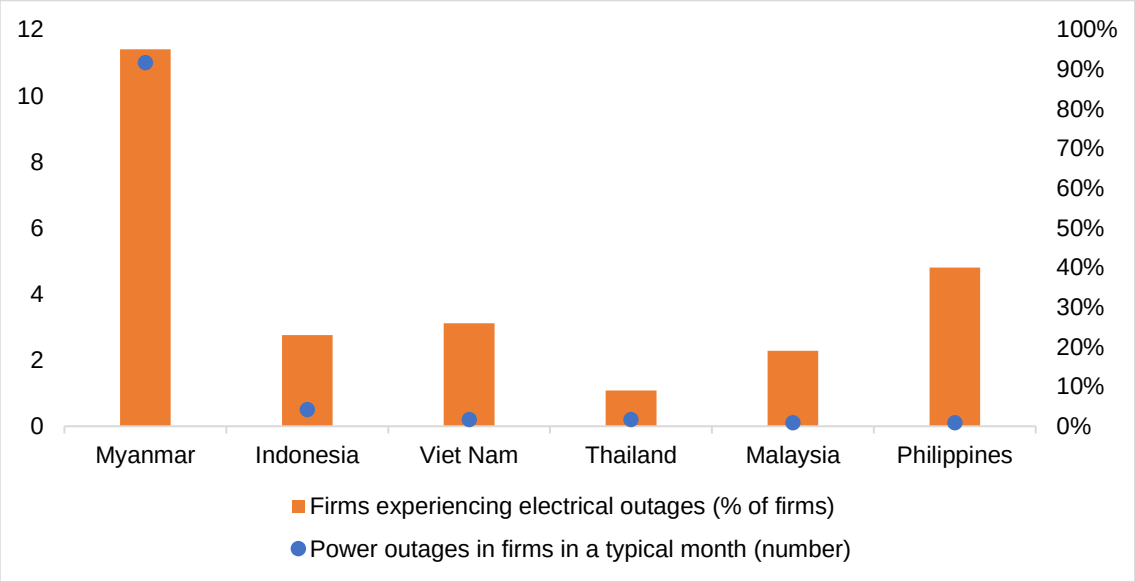
1.3. Structure

This chapter begins with an overview of the rationale for Myanmar's efforts to look for import opportunities and describes the possibilities being explored. The second part analyses the implications of regional power trade for the GMS's sustainable development. The next part explores how Myanmar can link South Asia and Southeast Asia and southern China. Finally, the chapter recommends policies for the country and international community to link new energy and revenue alternatives for sustainable development.

2. Myanmar's Tightening Power Supply and the Emergence of Imported Alternatives

Myanmar's State Counsellor has committed to increase the government's efforts to expand generation capacity to avoid shortages (Xinhua, 2019). The MOEE's new objective is to double generation capacity by 2021 (S. Naing and Lee, 2018). Myanmar suffers frequent power blackouts and brownouts (Phone Kyaw, 2017; Shin, 2014, 2016). The tightening between peak demand and installed capacity is strongly linked to dependency on hydropower generation, which is down during the dry season. Power shortages have a great impact on people's lives and businesses (Peel, 2017), especially in Myanmar (Figure 3.1). Studies and analyses have evaluated the economic impact of power outages in Cambodia (Hoekstra, 2019) and South Asia (4%–7% of GDP a year) (Zhang, 2019).

Figure 3.1: Power Outages Affecting Firms (per month and share of firms affected)



Source: World Bank data (https://data.worldbank.org/), IEA (2017).

Myanmar has various endogenous energy resources: vast hydropower potential, natural-gas fields, and a large potential for solar energy (Table 3.1). But social, environmental, economic, and political considerations have prevented their further development. Hydropower capacity remains constrained because of opposition to the construction of large-scale dams and the complexities of implementing projects in some areas where EAOs and the national government are in conflict (del Barrio Álvarez, Numata, Yamaguchi, and Yoshikawa, 2018). Solar projects have been delayed

or terminated, so that the first phase was connected in the summer of 2019 (Eleven Myanmar, 2019). While solar projects are not included in official capacity expansion plans (del Barrio Álvarez and Sugiyama, 2018), recent changes indicate renewed interest in promoting new solar projects (Lynn and Kean, 2019).

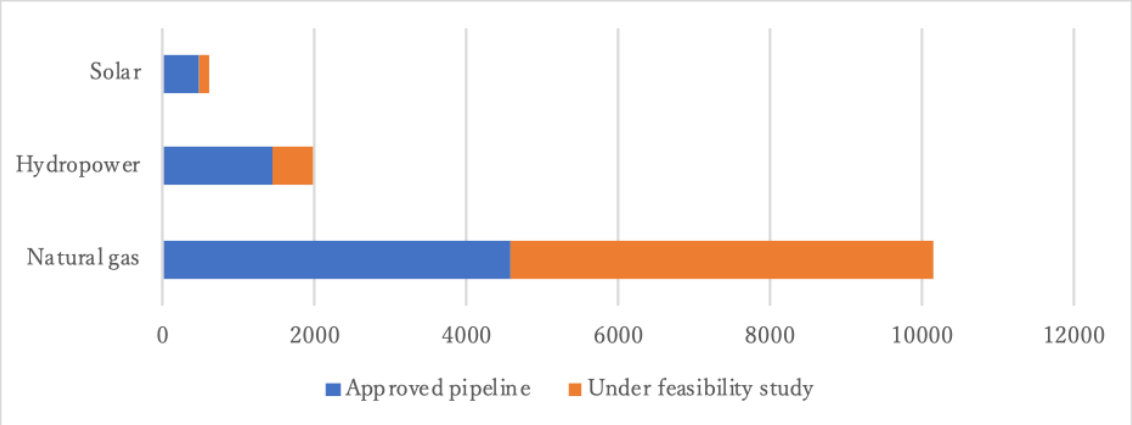
Table 3.1: Endogenous Energy Resources in Myanmar

Resource		Reserve
Hydropower		> 100 GW (estimate)
Crude oil	Onshore	102 MMbbl (proven)
	Offshore	43 MMbbl (proven)
Natural gas	Onshore	5.6 TCF (proven)
	Offshore	11 TCF (proven)
Coal		540 million tons (estimate)
Wind		365.1 TWh/year
Solar		52,000 TWh/year

MMbbl = million barrels, TCF = trillion cubic feet.
Source: MOEE (2018).

The pipeline of power generation projects is dominated by gas-fired plants, followed by hydropower and some solar energy plants (Table 3.2). In 2018, the MOEE signed four power purchase agreements (PPAs) for gas-fired power plants using imported LNG (Figure 3.2), which should allow doubling power generation by adding 3,100 MW in 2021 (S. Naing and Lee, 2018).

Figure 3.2: Ministry of Energy and Electricity's Pending Power Generation Projects (MW)



Source: Du Pont (2019).

Table 3.2: Approved LNG Projects

Project	Region	Power (MW)	Companies	Project Duration (months)
Mee Laung Gyaing	Ayeyawady Division	1,350	Zhofy (China), Supreme (Myanmar)	36 (first phase), 42 (completion)
Ahlone	Yangon Division	356	TTCL (Thailand)	28
Kanbauk	Dawei District	1,230	Total (France), Siemens (Germany)	36 (first phase), 48 (completion)
Kyaukphyu	Rakhine State	135	Sinohydro (China), Supreme (Myanmar)	28

Source: Kean (2018a, 2018b); Khidir (2019).

3. Emergence of the Regional Power-trade Option

Importing electricity from neighbouring countries has raised the idea that an alternative could be cost- and time-effective. Although the cases are not directly comparable, Thailand is importing electricity from Lao PDR at less than US$0.04/kWh, whilst Cambodia imports from Lao PDR at a rate of about US$0.09–US$0.10/kWh (Ministry of Energy and Mines, Lao PDR, 2015). Yunnan accounts for a large surplus of hydropower generation and Bangladesh benefits from imports of electricity from India. Table 3.3 summarises Myanmar's current and future power cooperation with its neighbours.

Table 3.3: Power Cooperation Between Myanmar and Its Neighbours

Thailand	MOUs signed. Thai companies have been seeking hydropower projects in Myanmar but plans are not progressing.
Lao PDR	MOU signed to explore further trade. Exports 3 MW for border electrification.
India	Bilateral cooperation at different levels, including on energy, is a priority. Exports power to electrify border towns.
China	Jointly developed hydropower in Shweli. Myanmar exports and imports small amounts for border electrification in Muse. Yunnan province has a large hydropower surplus, which sometimes needs to be curtailed. Three options for power trade are being explored. An agreement for the import of 1,000 MW has been announced.
Bangladesh	Its government has shown interest in importing electricity from China through Myanmar.

Source: Authors.

3.1. Thailand

Thailand imports natural gas from Myanmar and has been seeking to import electricity as well. Electricity would come from hydropower projects to be developed under schemes similar to those in Lao PDR. In 1997, an MOU was signed for Thailand to import up to 1,500 MW from Myanmar. The MOU expired in 2010 and, since then, new projects have been explored (EPPO, 2016).

Thailand could also provide valuable exports to south-east Mynamar, parts of which are still not connected to the national grid. Tanintharyi region depends on fuel oil generators, resulting in higher tariffs than those subsidised through the national grid (N. L. Aung, 2018).

3.2. Lao People's Democratic Republic

Lao PDR is often called the 'battery of Southeast Asia' because of its large hydropower potential and low internal electricity demand. It is the largest power exporter in the region and has been exporting electricity, including to Thailand, since the 1970s, after the construction of the Nam Ngum Dam. The construction of export-oriented dams restarted in the 1990s with the Xe Set hydropower dam, a front runner of the GMS programme. Since then, Lao PDR's hydropower export potential has continued to grow with the construction of additional dams. Electricity is mostly exported to Thailand and Cambodia. Studies are being conducted with Viet Nam for power trade (ANN, 2018). Lao PDR imports electricity mostly for areas bordering Thailand, China, and Viet Nam.

On 16 January 2018, Myanmar and Lao PDR signed an MOU for the export of 300 MW (Xinhua, 2018b), a qualitative upgrade from the current 5 MW that Myanmar imports from Lao PDR (Xinhua, 2018a) for its border areas. A joint working committee was formed to implement the MOU and held its first meeting in June 2018 (Pongkhao, 2018). The energy ministers of both countries met in February 2019 (Myanmar News Agency, 2019).

3.3. China

Myanmar and China have developed several joint energy projects. The gas and oil pipelines and the Shwelli power plant are the most representative of these efforts. Soon, one of four LNG power plants proposed in Myanmar will be built by a Chinese company. The China-

backed Asian Infrastructure Investment Bank contributed to the Mingyan gas-fired power plant. Cooperation has continued even after the paralysis of the Mytsone dam, which caused economic damage to Chinese developers, whose future remains unclear.

The large-scale expansion of hydropower capacity in Yunnan has triggered interest from China's government in exporting power to its southern neighbours, including Myanmar. Lao PDR imports energy from China at about US$0.08/kWh. Curtailment of hydropower in Yunnan opens an opportunity to optimise existing resources through transboundary power trade (Liu, Liao, Cheng, Chen, and Li, 2018; Magee and Hennig, 2017), which is part of China's foreign policy and international expansion efforts. Power interconnection is a pillar of the Belt and Road Initiative (Cohen, 2015; Duan, Ji, Liu, and Fan, 2018; Mathews and Huang, 2018; Hurley, Morris, and Portelance, 2018; Karim and Islam, 2018). China is becoming increasingly active in dam building abroad (Siciliano, Del Bene, Scheidel, Liu, and Urban, 2019).

In 2018, three projects for Myanmar to import energy from Kunming, China, were proposed. China Electric Power Equipment and Technology and the state-run China Southern Power Grid (CSG) will construct a high-voltage line to carry the imports. Yunnan International (a subsidiary of CSG) will utilise an existing transmission line. The projects can be completed in up to 5 years, sooner than the construction and connection of new hydropower plants (KDNG, 2017). The MOEE recently announced the decision to import up to 1,000 MW from China (N. Lwin, 2019).

3.4. India and South Asia

India once sought to increase its electricity supply by developing hydropower dams in Myanmar but abandoned the idea. Relations between the countries were suspended because of international sanctions imposed on the Myanmar military regime beginning in 1988. The political situation has evolved dramatically since sanctions ended and both governments are seeking increasing cooperation.

In 2016, the Ministry of Education of Myanmar and the Ministry of Renewable Energy of India signed an MOU to collaborate on capacity building in renewable energy. In December 2018, during a state visit of the President of Myanmar to India, the India–Myanmar Joint Statement was issued, signifying the deepening of relations between both nations (Government of India,

2018). The Myanmar–India Joint Steering Committee coordinates the promotion of cross-border electric power trade. Myanmar has joined the International Solar Alliance promoted by India. Both countries have agreed to increase cooperation through the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC). India is also a dominant actor in the South Asian regional power trade through the South Asian Association for Regional Cooperation (SAARC).[7] Although Myanmar is not a member of SAARC, the SAARC countries are members of a major regional initiative – the South Asia Subregional Economic Cooperation (SASEC).[8]

Hydropower Trade Between Bhutan and India

The Government of India and the Royal Government of Bhutan have signed an agreement to further develop hydropower through the public and private sectors. India's government agreed to import a minimum of 10,000 MW hydropower from Bhutan by 2020 to develop projects under the clean development mechanism, using India's carbon emission baseline. There are three projects running in Bhutan – Chukha (336 MW), Kurichu (60 MW), and Tala (1020 MW) (P. Wijayatunga and Fernando, 2013). India will provide electricity to Bhutan in winter.

Hydropower Trade Between India and Nepal

The exchange between India and Nepal has not grown in recent years because of the lack of commercial initiatives (P. Wijayatunga and Fernando, 2013). Nepal cannot meet its own demand. Two venture capital firms are constructing a 400 kW, 126 km transmission line between Dhalkebar and Muzaffarpur as part of a project that commenced in 2015.

India–Bangladesh Cross-Border Electricity Trade

Bangladesh is facing power shortages because of low generation capacity, insufficient energy resources, and inefficient turbines. Natural gas serves about 90% of total electricity generation. Trade in power between India and Bangladesh is in the planning stage. Two projects with a total capacity of 600 MW coal-based plants were built in 2015. The first HVDC of 500 MW between Berhampur (east India) and Bheramara (west Bangladesh) was

[7] Afghanistan, Bangladesh, Bhutan, India, Nepal, the Maldives, Pakistan, and Sri Lanka.
[8] Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, and Sri Lanka. ADB is the secretariat.

completed in 2013. India's part was supported by local funding and Bangladesh's by the Asian Development Bank (ADB).

India–Pakistan Electricity Trade

Pakistan is facing an approximately 30% shortage of peak demand. Since 2005, energy demand has been rising, and about 9,000 MW are needed in the next 3–4 years. There are no transmission lines between India and Pakistan, but they have been discussing electricity imports from India to meet Pakistan's energy requirements.

Central Asia–Afghanistan Power Transfer and Central Asia–South Asia (CASA-1000)

Afghanistan's power system is supported by 500 GWh from Turkmenistan, Uzbekistan, Tajikistan, and Iran. The project was motivated by the abundant hydropower in Tajikistan and the Kyrgyz Republic, and will benefit Pakistan and Afghanistan. Pakistan will be able to import 1,300 MW of electricity at $15 per MWh, down from $132 per MWh.

India has traditionally been an energy importer (Rahman, Wijayatunga, Gunatilake, and Fernando, 2011). Since 2017, however, it has been looking at possibilities to export electricity to its neighbour. Recently, it opened a short-term market to facilitate electricity exports (FE Bureau, 2019; IANS, 2019)

4. Regional Power Trade and Sustainable Development in the GMS

4.1. The GMS Energy Cooperation Programme

The GMS is home to one of the most advanced regional power-trade programmes in Asia. Since 1992, the six members countries – Cambodia, Yunnan and Guanxi provinces of China, Lao PDR, Myanmar, Thailand, and Viet Nam – have been developing numerous initiatives on infrastructure for regional cooperation and integration. Energy has been a key area of cooperation since the programme's inception. The development of the 45 MW Xeset hydropower plant in Lao PDR and an associated PPA with Thailand can be considered the forerunner projects of the programme.

On 21–22 October 1992, the First GMS Ministerial Conference was held at ADB's headquarters in Manila, Philippines, initiating a process to identify a priority energy project, evaluate potential impacts, and conduct feasibility studies and assessments of the barriers to

developing a regional electricity market in the GMS. In 1995, the first ADB-funded sub-regional energy sector study was commissioned. In 1999, the World Bank prepared the Power Trade Strategy for the GMS. In 2002, during the First GMS Summit of Leaders in Phnom Penh, Cambodia, the Intergovernmental Agreement on Regional Power Trade was signed by all member countries. The Regional Power Trade Coordination Committee (RPTCC) was created to supervise further developments. The design of the Regional Power Trade Operating Agreement, whose final report was submitted in 2004 at the third RPTCC meeting, includes a gradual process comprising the following (ADB, 2008; Alexander, 2018):

- Stage 1: One-way power sales under a PPA from an independent power producer in one country to a power utility in a second country, using established dedicated transmission lines
- Stage 2: Trading between two countries, initially using spare capacity in dedicated stage-1 transmission lines, and eventually using a third country's transmission facilities
- Stage 3: All countries interconnected with 230–500 kilovolt lines will introduce centralised operations with a regional system operator that will facilitate third-party participation in trading (entities other than generators, sellers and utilities, and purchasers)
- Stage 4: All countries accept legal and regulatory changes to enable a free and competitive electricity market with independent third-party participation

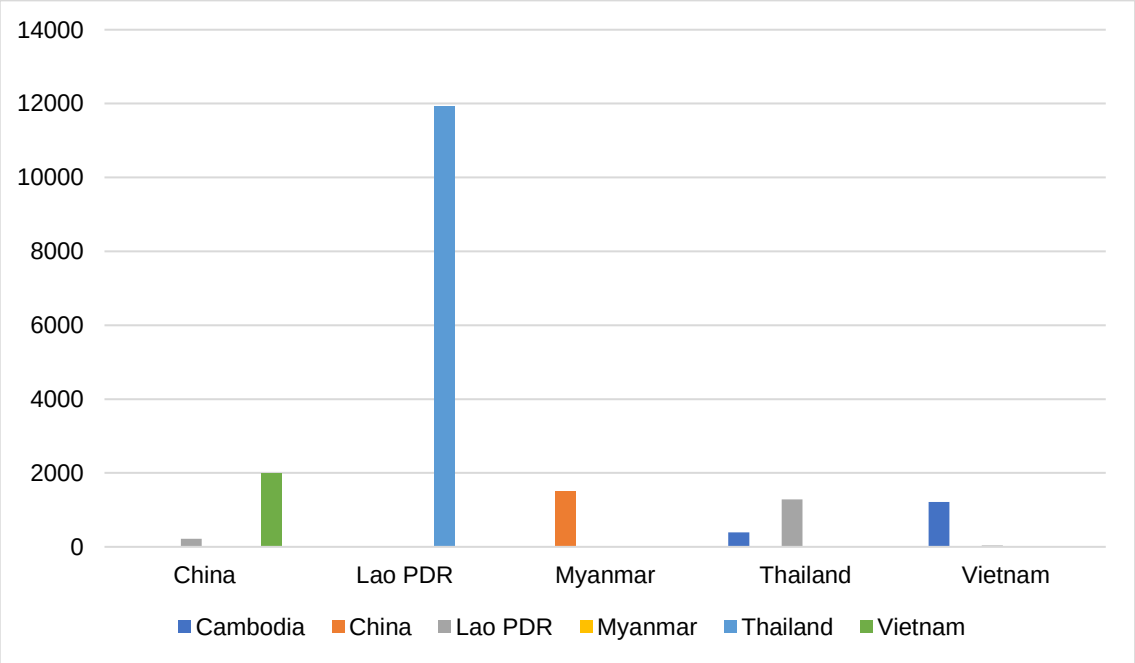
Since then, power exchanges in the region have kept growing (Table 3.4, Figure 3.3, and Figure 3.4).

Table 3.4: GMS Power Trade and Net Imports, 2010 (GWh)

Country	Imports	Exports	Total Trade	Net Imports
Cambodia	1,546	-	1,546	1,546
Lao PDR	1,265	6,944	8,210	(5,679)
Myanmar	-	1,720	1,720	(1,720)
Thailand	6,938	1,427	8,366	5,511
Viet Nam	5,599	1,318	6,917	4,281
China	1,720	5,659	7,379	(3,939)
Total	17,069	17,069	34,139	

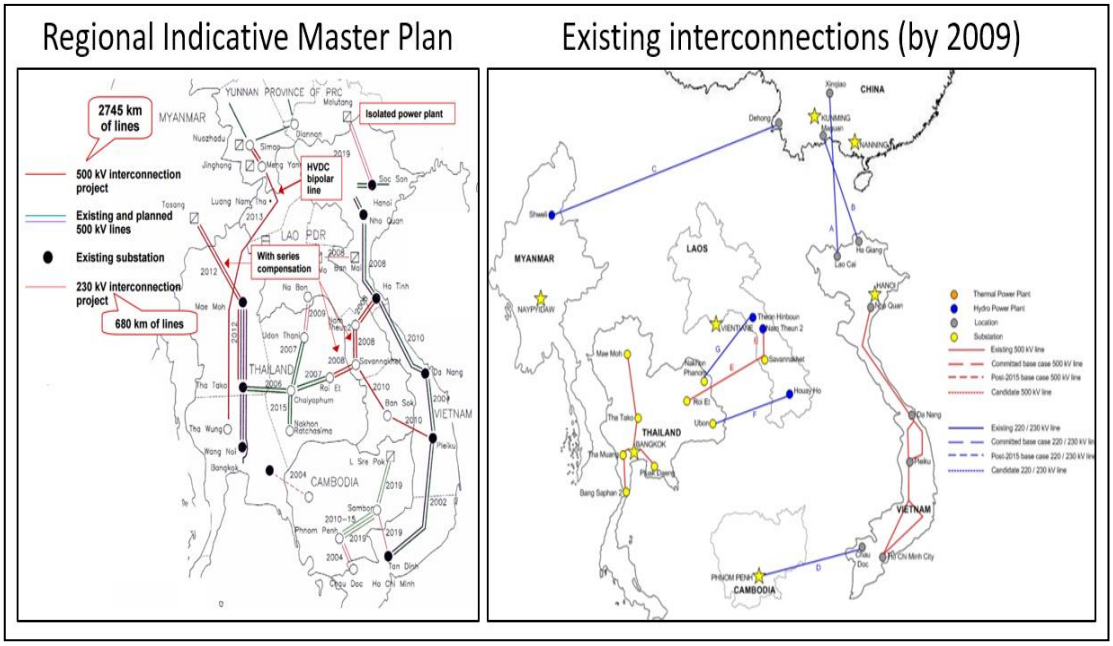
Source: Chi Nai (2015).

Figure 3.3: Power Exports in the GMS, 2014 (GWh)



Source: ADB (2016).

Figure 3.4: Planned and Existing Interconnections in the GMS



Source: ADB (2012), UNDESA (2005).

Similar progress has not yet been achieved in developing the institutional capacity to move beyond stage 1. For example, the constraints on third-party access to dedicated transmission lines developed for PPAs is a challenge for new projects (Antikainen, Gebert, and Møller, 2011). Agreement on wheeling charges for the use of a third-country transmission network appears to be impossible in the MOU signed by China and Thailand for the export of electricity from Yunnan. The imbalance between the development of physical infrastructure (hardware) and institutional aspects (software) has been pointed out by studies such as the 2013 ADB Assessment of the GMS Energy Sector Development:

> There has been remarkable progress in the GMS energy sector over the past 2 decades. Considerable success was also achieved in rolling out rural electrification in member countries. Rapid provision of large-scale, high-volume national grid systems; successful mobilization of indigenous resources; and the beginnings of cross-country trade also took place. These successes have been achieved mainly at the national level. Despite considerable political pronouncements that recognize the imperatives of regional cooperation, progress has not matched national achievements. The high-volume trans-boundary connections that have been made

to date within the GMS do not achieve a true interconnection of systems with synchronous operations, but are simply an extension of the national grids of the large- consuming countries into the territories of producers of (mainly) hydropower (ADB, 2013).

Recent developments are bringing a new impulse to the regional power cooperation programme. The power-trade agreement between Lao PDR and Singapore, with power going through Thailand and Malaysia, is promising and can have implications for third-country access agreements. The updating of the regional master plan and the negotiations to establish the Regional Power Coordination Center indicate a renewed effort to strengthen the programme's institutional structure. Projects including neighbouring countries, such as the ASEAN Power Grid and the China-supported Global Energy Interconnection project, can facilitate negotiation between member countries.

4.2. Sustainability of Regional Power Trade in the GMS

Several studies have been conducted in the GMS and ASEAN to evaluate the benefits of greater interconnectivity. The Energy Sector Strategy Study published in 2009 is one of the most referenced studies (ADB, 2013). Conducted by the ADB over 3 years, it contrasts integrated and non-integrated scenarios, providing the first proper quantification of the benefits:

- 19% reduction in overall energy costs up to 2030 (US$200 billion)
- 5.5% of total energy consumption reduction in overall dependence on imported resources
- 40% lower coal-based power generation capacity
- Greater integration of renewable energy sources and other off-grid solutions

Although this exercise was not conducted regularly (ADB, 2013), other studies have evaluated the implications of greater interconnectivity and different alternatives in the region.

Hydropower has commonly been considered a key factor in promoting greater interconnectivity, with several benefits for member countries (Piseth and Sophearin, 2014) (Table 3.5). Large-scale hydropower generation is found to be the main mechanism for power trade in the GMS. To attract more investors and to reduce investment risks in hydropower development, countries need to refine investment costs, acquire hydrological data, and mitigate social and environmental impacts. Intergovernmental joint investments and the involvement of international financial institutions can foster the necessary legal and legislative frameworks and enhance investment flow into an energy-export market. The Regional Power Coordination Center will play an important role in coordinating and accelerating regional power trade for regional market regulations, comprising agreed rules and the indicative planning priorities of interconnection.

Table 3.5: Expected Net Benefits of Hydropower-based Regional Connectivity in the GMS

Scenario year	Power Supply	Power Export	Capital Investment	Net Benefit	Distribution of Net Benefits (%)			
	(GWh)	(GWh)	(US$ million)	(US$ million)	LAO	THAI	CAM	VIE
2015	26,991	11,321	6,262	16,454	69	10	1	21
2030	110,898	74,320	23,081	40,431	76	13	1	11

Source: Piseth and Sophearin (2014).

The link between regional power trade in the GMS and the development of large hydropower dams in the Mekong's vulnerable ecosystems is a common concern. The use of hydropower resources in Lao PDR and Myanmar to export electricity to countries with more energy demand, such as Thailand and Viet Nam, has been advocated to reduce the need for thermal power generation in downstream countries and to attract foreign direct investment to upstream ones. Some have severely criticised the implications for the region's ecosystems and the reluctance to distribute economic gains. The Mekong River Commission (MRC) Secretariat commissioned the International Centre for Environmental Management to 'provide a broader understanding of the opportunities and risks' of developing hydropower dams in the Lower Mekong Basin. The strategic environmental assessment (SEA) is expected

to help countries better analyse the development impacts of more than a single project (unlike environmental impact assessments, which examine one project at a time).

The GMS SEA analyses the 11 dams planned in the Lower Mekong countries (Lao PDR, Thailand, Viet Nam, and Cambodia). MRC member countries committed, in the 1995 Mekong Agreement, to notify other riparian countries and aimed to reach an agreement whilst building mainstream dams. The procedure for notification, prior consultation, and agreement was first implemented for the Xayaburi dam in 2010 and Don Sahong in 2014, and it is in progress for Pak Beng and Pak Lay. All the projects are dams in Lao PDR. The experience with the first two was unsuccessful, with Lao PDR deciding to proceed with construction even though no agreement had been reached on either project (International Rivers, 2016). China has been working on several dams in Yunnan. China is not a member of the MRC and therefore not subject to the same requirements. The dams constructed or planned for each country are the following (Cronin and Hamlin, 2010; ICEM, 2010):

- China (Yunnan). Gonguoqiao (750 MW), Xiaowan (4,200 MW), Manwan (1,500 MW), Dachaosha (1,350 MW), Naozhadu (5,500 MW), Jinghong (1,500 MW), Galanba (250 MW), and Mengsong (600 MW)
- Lao PDR. Pak Beng (1,230 MW), Luang Prabang (1,410 MW), Xayaburi (1,260 MW), Pak Lay (1,320 MW), Sanakram (570 MW), Pak Chom (1,079 MW), Ban Khoum (2,000 MW), Lat Sua (800 MW), and Don Sahong (360 MW)
- Cambodia. Stung Treng (980 MW) and Sambor (2,600 MW)

The SEA team recommended, among others, (i) to defer the decisions of mainstream dams for 10 years, and (ii) to prevent the use of the Mekong mainstream as a test case for full-dam technologies. The MRC member countries have not reached a compromise. Lao PDR decided to proceed with the construction of Xayaburi in 2012 (Thien, 2017).

The International Energy Agency (IEA) published a special report, *World Energy Outlook*, focusing on Southeast Asia (IEA, 2015b), and prepared a study on developing transboundary energy markets in the region (IEA, 2015a), particularly in the ASEAN Power Grid. The study built upon previous IEA studies on regional electricity markets (IEA, 2014, 2016a, 2016b; Wittenstein, Scott, and Miza, 2016) and emphasised the regulatory aspects and the elements

required to develop regional electricity markets. Regional regulation's main responsibilities include (i) electricity security regulations, (ii) coordinated planning, (iii) cost allocation of transmission development, (iv) revision of network codes, and (v) system monitoring (IEA, 2015a). The study uses research on European integration to describe the benefits and challenges of the process and presents integrated resource planning as an alternative to power development plans.

Sponsored by the Konrad-Adenauer-Stifung, the National University of Singapore (NUS) analysed three international experiences with transboundary power trade, considering the GMS and ASEAN (Owen, Finenko, and Tao, 2015). Experiences in southern Africa, Europe, and the Nordic countries are contrasted to reveal the key drivers, challenges, and options to promote regional power trade. Four elements are necessary to integrate the electricity market: (i) coordinated physical infrastructure development, (ii) standardised and harmonised rules of operation, (iii) some form of market competition, and (iv) empowered governing or coordinating institutions (Finenko, Owen, and Tao, 2017).

Several important challenges lie ahead for the further integration of electricity markets in ASEAN. Several financial and technical issues remain unsolved in regional power transfers. Even if these barriers can be overcome, there are institutional concerns pertaining to the operation of a complex set of international interconnected grids. The social and environmental impacts of dams in the shared rivers should be further researched (Owen et al., 2015). The NUS authors propose three options: (i) multilateral trade of excess power via long-term contracts, (ii) multilateral trade with spot exchange, and (iii) fully competitive power markets.

Hydropower will face increasing competition from alternative power generation options (Boyle, 2018). The summer of 2018 saw two dam-related accidents, increasing cause for concern about the Swa Chaung Dam (Myanmar), which displaced 63,000 people, and Saddle Dam D of the Xe-Pian Xe-Namnoy hydropower project (Lao PDR) (Eyler, 2018; Kyaw, 2018; Son, 2019). Because of the accidents, Thailand has delayed the decision to purchase electricity from the Pak Beng Dam (International Rivers, 2018). Hydropower's role in a regional low-carbon energy system cannot be underestimated, but projects with large environmental and social impacts will be less attractive in the medium term. Basin-wide

planning and the development of more upstream dams with minor impact, along with transboundary power cooperation, are a more suitable solution (Chhengpor, 2018).

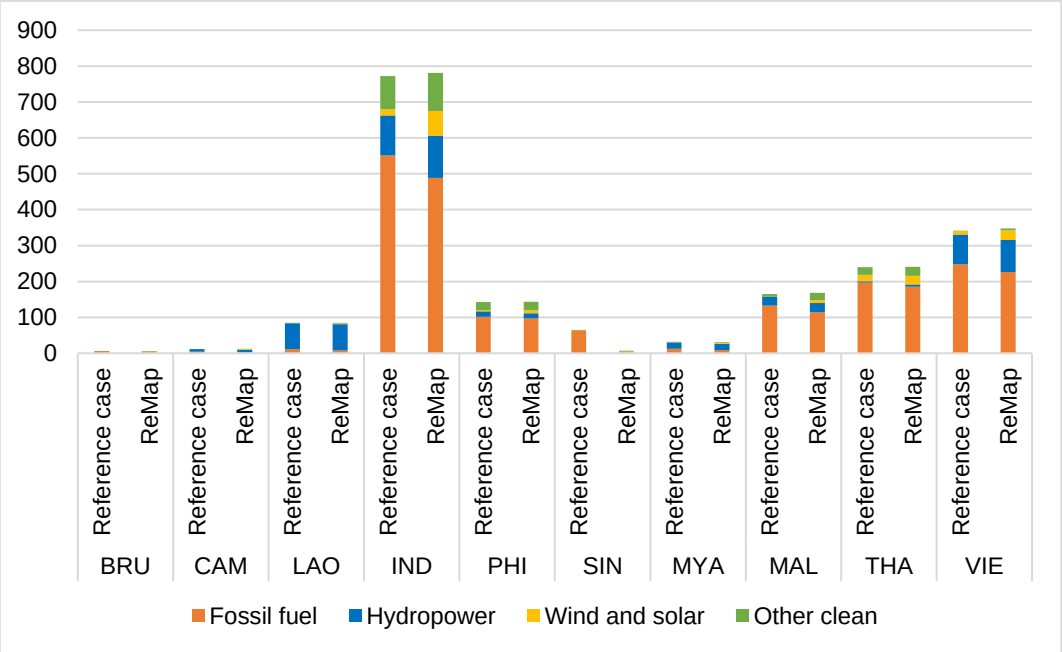
Recent studies consider broadly incorporating variable renewable generation as part of the regional strategy for power trade. The Renewable Energy Outlook was jointly developed by the IRENA and the ASEAN Center for Energy (ACE) (IRENA and ACE, 2016). Another joint study was done by the ACE, the Global Energy Interconnection Development and Cooperation Organization (GEIDCO), and the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) (ACE, GEIDCO, and ESCAP, 2018). Both studies show that increasing the use of variable renewables is linked to higher levels of interconnectivity. The studies' details and results are in Table 3.6 and Figure 3.5 to Figure 3.8.

Table 3.6: Scenarios Analysed in ReMap and the ACE–GEIDCO–ESCAP Joint Study

Study	Scenario	Detail
ReMap	Reference case	A business-as-usual scenario but including accelerated commitments already made by member countries
	ReMap	A scenario that allows realising ASEAN's goal of achieving a 23% share for renewable energy by 2025
ACE, GEIDCO, and ESCAP joint study	Accelerated development scenario	Maximisation of clean-power share in generation mix (62%) Transboundary power transaction required to be 10%
	Progressive development scenario	Moderated use of clean power (42%) Transboundary power transaction required to be 7%
	Low development scenario	Lowest share of clean energy (25%) Transboundary power transaction required to be 3%

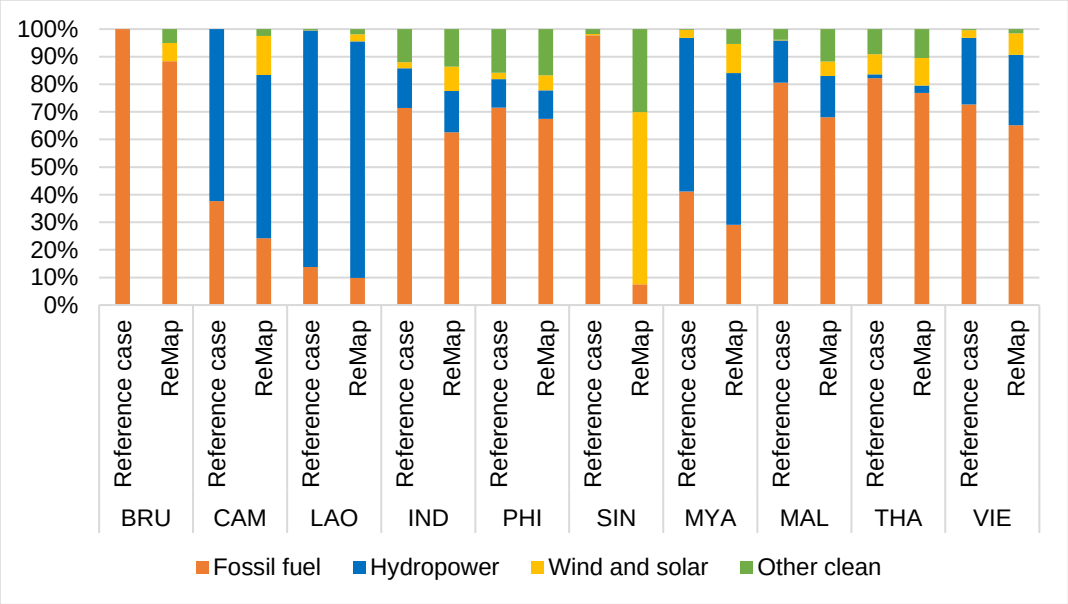
Source: Authors, from ACE et al. (2018); IRENA and ACE (2016).

Figure 3.5: ASEAN Countries' Overview for Reference Case and ReMap Scenarios (MW)



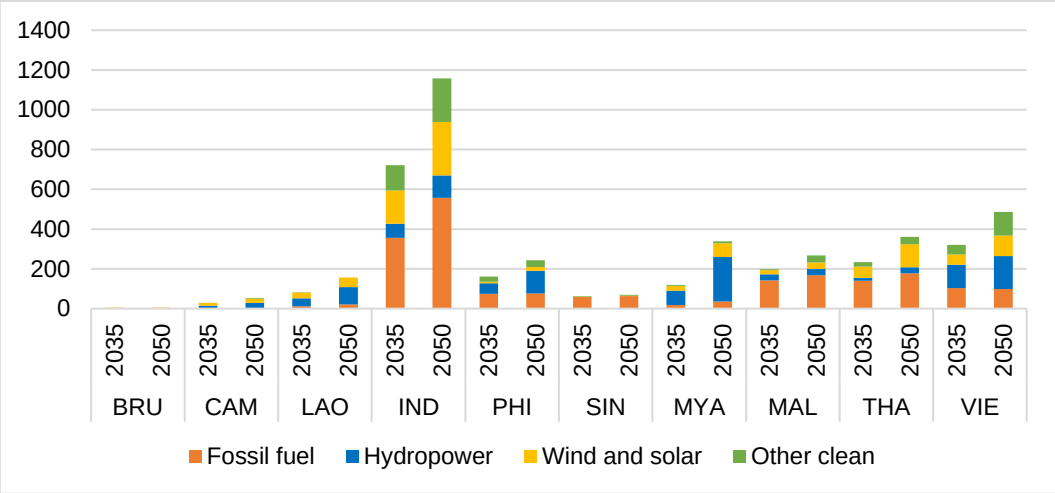
BRU = Brunei Darussalam; CAM = Cambodia; LAO = Lao PDR; IND = Indonesia; PHI = Philippines; SIN = Singapore; Mya = Myanmar; MAL = Malaysia; THA = Thailand; VIE = Viet Nam
Source: IRENA and ACE (2016).

Figure 3.6: ASEAN Countries' Overview for Reference Case and ReMap Scenarios (share)



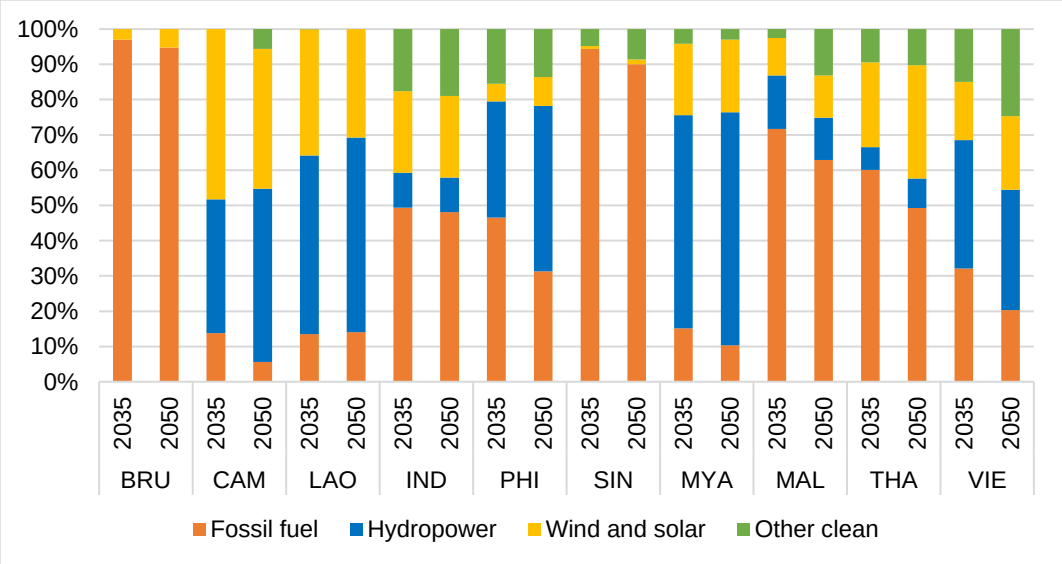
BRU = Brunei Darussalam; CAM = Cambodia; LAO = Lao PDR; IND = Indonesia; PHI = Philippines; SIN = Singapore; Mya = Myanmar; MAL = Malaysia; THA = Thailand; VIE = Viet Nam
Source: IRENA and ACE (2016).

Figure 3.7: ASEAN Countries' overview for Accelerated Development Scenario, 2035 & 2050 (MW)



BRU = Brunei Darussalam; CAM = Cambodia; LAO = Lao PDR; IND = Indonesia; PHI = Philippines; SIN = Singapore; Mya = Myanmar; MAL = Malaysia; THA = Thailand; VIE = Viet Nam
Source: ACE et al. (2018).

Figure 3.8: ASEAN Countries' overview for Accelerated Development Scenario, 2035 & 2050 (share)



BRU = Brunei Darussalam; CAM = Cambodia; LAO = Lao PDR; IND = Indonesia; PHI = Philippines; SIN = Singapore; Mya = Myanmar; MAL = Malaysia; THA = Thailand; VIE = Viet Nam
Source: ACE et al. (2018).

5. Conclusion

Importing power from neighbouring countries is an alternative for Myanmar to increase its electricity supply. Myanmar is exploring the possibility of importing energy from China and Lao PDR but does not yet have projects with them. Different options' techno-economic, socio-political, and environmental costs must be analysed. The social implications for communities living in the periphery should be evaluated so they can benefit from the power transmitted near them. The potential for power imports to foster sustainable development is critical.

The approach is in line with global energy trends, where the emphasis of regional power trade is shifting from energy security to energy sustainability. Initial studies focused on the regional use of hydropower resources in upstream countries. More recent analyses aim to minimise the socio-economic and environmental impacts caused by building dams on main rivers. The Mekong has attracted most of the attention. Projects being developed and their transnational impact should be re-evaluated. Myanmar has put all its large-scale hydropower projects on hold.

Southeast Asian countries are also looking to diversify their mix of variable renewable energy sources. The ability to increase generation capacity to keep pace with growing demand is essential for sustainable development. The IEA has prevented Southeast Asian countries from planning capacity additions well over their long-term needs to avoid economically burdening their governments and citizens (IEA, 2018).

This chapter reviews studies that assess the medium- to long-term impacts on Myanmar of regional power connectivity in the GMS. There is general agreement on the potential of renewable energy power trading to reduce the penetration of fossil-based fuels, but the use of fossil fuels will continue to grow in absolute terms for the foreseeable future. The power trade has been made possible mostly through point-to-point interconnections linked to large-scale hydropower dams. A basin-wide hydropower planning method is necessary to minimise negative externalities. The rise of solar and wind power in the region can become a positive driver in that direction, offering an even more economical alternative.

Myanmar is considered to be a large regional exporter of electricity because of its vast hydropower potential, which remains undeveloped. Regional studies analysing the benefits for Myanmar of importing electricity are scarce. Myanmar's links with China and Lao PDR are the most advanced amongst its connections. A Yunnan–Myanmar–Bangladesh transmission

power line is gaining a lot of attention. If realised, it would be the first formal power interconnection between South Asia and Southeast Asia and China. Lao PDR has also expressed its readiness to export electricity as demanded by Myanmar. For either option, however, new transmission capacity is needed, highlighting the importance of strengthening national power transmission and developing high-voltage lines in the country. Improving transmission infrastructure would also trigger the integration of endogenous variable renewables.

Myanmar is set to become a building block for interregional power trade. Its location between South Asia and Southeast Asia enables it to position itself as an important actor in spurring cooperation. It is a member of several regional economic cooperation initiatives in both sub-regions (Table 3.3, Table 3.7 and Figure 3.9). If Myanmar imports power, it can become the first building block for interregional connectivity between both sub-regions and southern China. The geopolitical implications of such cooperation are gaining attention (Parks, Maramis, Sunchindah, and Wongwatanakul, 2018; USAID, 2018).

Table 3.7: Myanmar's Participation in Regional Cooperation Programmes

	ACMECS	ASEAN	BCIM	BIMSTEC	GMS	LMC	SAARC	SASEC
Afghanistan							○	
Bangladesh			○	○			○	○
Bhutan				○			○	○
Brunei		○						
Cambodia	○	○			○	○		
China			○		○	○		
India			○	○			○	○
Indonesia		○						
Lao PDR	○	○			○	○		
Malaysia		○						
Maldives							○	○
Myanmar	○	○	○	○	○	○	○*	○

Nepal				○			○	○
Pakistan							○	
Philippines		○						
Singapore		○						
Sri Lanka				○			○	○
Thailand	○	○		○	○	○		
Viet Nam	○	○			○	○		

ACMECS = Ayeyawady-Chao Phraya-Mekong Economic Cooperation Strategy; ASEAN = Association of Southeast Asian Nations; BCIM = Bangladesh-China-India-Myanmar Forum; BIMSTEC = Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation; GMS = Greater Mekong Subregion Economic Cooperation Program; LMC = Lancang-Mekong Cooperation; SAARC = South Asian Association for Regional Cooperation; SASEC = South Asia Subregional Economic Cooperation.
*Myanmar holds observer member status in SAARC.
Source: Authors.

Establishing a solid interconnection between China and Myanmar will have important consequences for the region's energy landscape. China has an abundant surplus of hydropower generation in Yunnan and has been keen to export it to GMS countries at prices competitive with those of Lao PDR – about US$0.08/kWh (Eyler and Weatherby, 2017). The interconnection between China, Myanmar, and Bangladesh will allow the first interregional power exchanges to take place.