Chapter 6

Three Tiers of Soft and Hard Infrastructure Development

ERIA CADP research team

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Chapter 6

Three Tiers of Soft and Hard Infrastructure Development

6-1. The Representative Projects for Developing Hard Infrastructure for Connectivity and Innovation

CADP 2.0 intends to link infrastructure development with industrialisation and emphasises the importance of setting proper technical grades and specifications suited to each development stage. Chapter 2 presents a conceptual framework for CADP 2.0, and Table 2.3 tabulates infrastructure development for connectivity and innovation with three tiers.

This chapter connects the conceptual framework with actual infrastructure projects. We list 120 projects by tier, sector, and target outcome (i.e. connectivity or innovation), which are selected from the 761 projects in the long list of representative prospective projects (Appendix 1). Tiers 1, 2, and 3 have 38, 68, and 14 projects, respectively. By sector, the projects are classified into the following nine categories: road/bridge (41), railway (21), energy/power (18), port/maritime (17), industrial estate/special economic zone (SEZ) (8), airport (6), urban development (5), telecommunications (3), and waterway (1) (Table 6.1.1).

As shown in Table 6.1.1, 87 and 33 projects are hard infrastructure projects for connectivity and innovation, respectively. Tier 2 includes a large number of projects for connectivity (57 projects) while Tier 1 is filled with projects for innovation (21 projects). Urban transport projects in Tier 1 are classified here as infrastructure projects for innovation whereas the mass transport system to link with neighbouring industrial agglomerations is categorised for connectivity.

Table 6.1.1. Summary of 120 Representative Hard Infrastructure Development Projects for Connectivity and Innovation

Tier	Sector	Category	Connectivity	Innovation	Total
Tier 1	Airport	Airport expansion to cater massive movements of passengers and freight	1		1
		Construction of new airport to support/substitute existing airport	2		2
	Energy/Power	Stable, ample, and clean electricity and energy supply for final users		3	3
	Port/Maritime	Development of sizeable port to cater to massive container transactions and specialised loading facilities	4		4
	Railway	Access railways to gateway ports/airports		1	1
		Railways for connecting metropolitan areas and other cities	5		5
		Urban public transport system (subway, LRT, MRT) and railways to connect urban and suburban areas		6	6
	Road/Bridge	Access roads/bridges to gateway ports/airports		1	1
		Highway system, bridges, and bypass roads in and around metropolitan areas	1	6	7
		Highway system, bridges, and roads for connecting metropolitan areas and other cities	4		4
	Urban Development	Comprehensive urban development		1	1
		Development for collaboration of research studies		1	1
		Science city development		1	1
		Transit-oriented development		1	1
			17	21	38
Tier 2	Airport	Construction of new airport	1		1
		Upgrading of major airports for both passengers and cargoes	2		2
	Energy/Power	Stable and ample electricity and energy supply for final users	10		10
	Industrial Estate/SEZ	SEZs development		7	7
	Port/Maritime	Dry port development	1		1
		Port development	5		5
		Upgrading major ports to enhance handling capacity	4		4
	Railway	Construction of new arterial railway	4		4
		Development and upgrading of regional arterial railway networks	4		4
		Modernisation and rehabilitation of railway in urban area	1		1
	Road/Bridge	Construction of bridge to connect regions	4		4
		Cross-border facilities	2		2
		Road for connecting industrial centres, logistics hubs, neighbouring industrial agglomerations; strengthening of network and the economic corridor	18		18
	Telecommunication	Development/upgrading of trunk telecommunications network		3	3
	Urban Development	Comprehensive regional development		1	1
	Waterway	Improvement of water transportation facilities	1		1
			57	11	68
Tier 3	Energy/Power	Development of power plants taking advantage of location advantages	5		5
	Industrial Estate/SEZ	Agriculture development		1	1
	Port/Maritime	Upgrading of local ports	3		3
	Road/Bridge	Construction of bridge to connect regions	1		1
		Road connection for various economic activities	2		2
		Upgrading rural road for various economic activities	2		2
			13	1	14
Total			87	33	120

Note: LRT = light rail transit, MRT = mass rapid transit, SEZ = special economic zone.
Source: ERIA CADP research team.

Table 6.1.2. Representative Prospective Projects for Tier-wise Development Strategies: Hard Infrastructure for Connectivity

Sector	Category	Project Name	Country
Tier 1			
Road/Bridge	Highway system, bridges, and roads for connecting metropolitan areas and other cities	Ha Noi–Hai Phong Highway	Viet Nam
		Moc Bai–Ho Chi Minh City	Viet Nam
		Motorway: Bang Yai–Ban Pong–Kanchanaburi	Thailand
		Phnom Penh–Ho Chi Minh City Expressway	Cambodia, Viet Nam
	Highway system, bridges, and bypass roads in and around metropolitan areas	East Jakarta industrial area (Cikarang) road network development	Indonesia
Railway	Railways for connecting metropolitan areas and other cities	High-speed rail link (Kuala Lumpur to Singapore)	Malaysia, Singapore
		Java high-speed railway construction	Indonesia
		Ha Noi–Vinh high speed	Viet Nam
		HCMC–Nha Trang high speed	Viet Nam
		High-speed train project: Bangkok–Chiang Mai	Thailand
Port/Maritime	Development of sizeable port to cater massive container transactions and specialised loading facilities	Cilamaya (its alternative) port development	Indonesia
		New container port at Diamond Harbor	India
		Lach Huyen Port Infrastructure Construction Project (Hai Phong)	Viet Nam
		Coastal Terminal Development Project of Laem Chabang Port	Thailand
Airport	Airport expansion to cater massive movements of passengers and freight	NAIA Development Project (New Manila International Airport Development)	Philippines
	Construction of new airport to support/substitute existing airport	Karawang new airport	Indonesia
		Long Thanh International Airport	Viet Nam
Tier 2			
Road/Bridge	Road for connecting industrial centres, logistics hubs, neighbouring industrial agglomerations, strengthen network and the economic corridor	Kaladan Multimodal Transit Transport Project	Myanmar
		Cavite Laguna (CALA) Expressway Project (The CALA East−West national road project)	Philippines
		Central Luzon Link Expressway (CLLEx), Phase I	Philippines
		Arterial Road Bypass Project, Phase II (Arterial highway bypass construction project (ii)	Philippines
		Upgrade of NR8 East–West Transport Route; AH15 (Ban Lao–Nan Phao) (215 km)	Lao PDR
		NLEX-SLEX Connector Road Project	Philippines
		Improvement of NR.9: East–West Economic Corridor (184 km)	Lao PDR
		Upgrade of NR12: Tang Beng–Na Phao border (91 km)	Lao PDR
		Upgrade of NR13N and 13S: Phase 1: [13N] Sikeut–Phonhong, [13S] Don Noun–Ban Hai Bridge; Phase 2: [13N] Phonghong–Vang Vieng, [13S] Ban Hai–Paksan	Lao PDR

		Jinghong–Daluo Expressway	China
		Trans-Sumatra Toll Road (Palembang–Bandar Lampung)	Indonesia
		Manado–Bitung toll road	Indonesia
		Trilateral Highway (Thailand–Myanmar–India)	Thailand, Myanmar, India
		4-laning of Siliguri–Guwahati, National Highway 31C	India
		4-laning of Kolkata–Siliguri, National Highway34	India
		Truong Luong–My Thuan Highway	Viet Nam
		My Thuan–Can Tho Highway	Viet Nam
		National Highway No. 5 Improvement Project	Cambodia
	Construction of bridge to connect regions	Korea–Myanmar Friendship Bridge	Myanmar
		New Thaketa Bridge Construction	Myanmar
		Bach Dang Bridge (part of Ha Long–Hai Phong Highway)	Viet Nam
		Construction of Temburong Bridge	Brunei Darussalam
	Cross border facilities	Thanaleng Border-Crossing Infrastructure Improvement	Lao PDR
		New border checkpoint in Poipet for cargo	Cambodia
Railway	Construction of new arterial railway	Boten (Chinese border)–Vientiane rail link	Lao PDR
		SKRL spur line (L): Vientiane–Thakek–Mu Gia	Lao PDR
		Yuxi–Mohan (Lao border) Railway	China
		Dali–Ruili Railway (Baoshan–Ruili section)	China
	Development and upgrading of regional arterial railway networks	Yangon Mandalay Rail Line Modernization Work	Myanmar
		Mandalay–Myitkyina Track and Signaling Upgrading Project	Myanmar
		North–South Railway Project (South Line)	Philippines
		Medan–Kualanamu (North Sumatra) elevated track	Indonesia
	Modernisation and rehabilitation of railway in urban area	Yangon Circular Railway Line Upgrading Project	Myanmar
Port/Maritime	Upgrading major ports to enhance handling capacity	Davao Sasa Port Modernization Project (Davao port: Development of quay crane and expansion of container terminal)	Philippines
		Sihanoukville Port Multi-Purpose Terminal	Cambodia
		Project for Strengthening Competitiveness of Sihanoukville Port (Package1)	Cambodia
		Muara container terminal extension	Brunei Darussalam
	Port development	Kaladan Multimodal Transit Transport Project	Myanmar
		Kuala Tanjung port development	Indonesia
		Bitung port development	Indonesia
		Pakbara deep sea port construction	Thailand
		Phnom Penh New Port Improvement Project	Cambodia
	Dry port development	Vientiane Logistics Park (VLP)	Lao PDR

Airport	Construction of new airport	Hanthawaday International Airport	Myanmar
	Upgrading major airports for both passengers and cargoes	Mactan-Cebu International Airport Passenger Terminal Building	Philippines
		Expansion of the Vientiane International Airport Terminal	Lao PDR
Energy/ Power	Stable and ample electricity and energy supply for final users	National Power Transmission Network Development Project	Myanmar
		M3-Block Gas Project	Myanmar
		Shweli 3 Hydropower Project	Myanmar
		Myingyan Power Generation Project (225 MW)	Myanmar
		Ninh Thuan 1&2 Nuclear Power Plant	Viet Nam
		Trans Borneo Power Grid Project (Sarawak–West Kalimantan) (Part of ASEAN Power Grid)	Indonesia, Malaysia
		Lao PDR–Viet Nam Power Transmission Interconnection (Hat Xan–Plei Ku)	Lao PDR, Viet Nam
		Xayaburi Hydropower (1285 MW) - exporting to Thailand	Lao PDR
		Jawa–Sumatra transmission connection	Indonesia
		Power Transmission Line from Lao Border–Stung Treng–Phnom Penh	Cambodia, Lao PDR
Waterway	Improvement of water transportation facilities	Further Maintenance and Improvement of the Upper Mekong River Navigation Channel from the PRC (at Landmark 243) and Myanmar to Luang Prabang in the Lao PDR	China
Tier 3			
Road/Bridge	Road connection for various economic activities	Pan Borneo Highway (Sabah–Sarawak)	Malaysia
		Balikpapan–Samarinda Toll Road, East Kalimantan	Indonesia
	Upgrading rural road for various economic activities	Upgrade of NR 13N: Oudomxay–Pakmong	Lao PDR
		Upgrade of NR 14A: Mounlapamok–Pakselamphao	Lao PDR
	Construction of bridge to connect regions	Xekong bridge	Lao PDR
Port/Maritime	Upgrading of local ports	Maloy port development in East Kalimantan	Indonesia
		Sorong port development (West Papua)	Indonesia
		Batam port development	Indonesia
Energy/ Power	Development of power plants taking advantage of location advantages	Wind Power plant development in Savannakhet, Attapeu, Salavan, and Xekong	Lao PDR
		Sarulla geothermal power plant	Indonesia
		Muaralabuh geothermal power plant	Indonesia
		Takalar steam coal power plant in South Sulawesi	Indonesia
		Andhra Pradesh state Coal fired power plant	India

Source: ERIA CADP research team.

Table 6.1.3. Representative Prospective Projects for Tier-wise Development Strategies: Hard Infrastructure for Innovation

Sector	Category	Project Name	Country
Tier 1			
Road/Bridge	Highway system, bridges and bypass roads in and around metropolitan areas	Metro Manila C6 Expressway Project	Philippines
		Metro Manila Skyway Stage 3	Philippines
		East Jakarta industrial area (Cikarang) road network development	Indonesia
		Hanoi Ring Road	Viet Nam
		Satellite ring road in Bangalore	India
		Peripheral ring road around Chennai	India
	Access roads/bridges to gateway ports/airports	NAIA Expressway Project (Phase II)	Philippines
Railway	Urban public transport system (subway, LRT, MRT) and railways to connect urban and suburban areas	Manila LRT line extension	Philippines
		Klang Valley MRT construction	Malaysia
		Jakarta MRT construction	Indonesia
		Ha Noi urban railway construction	Viet Nam
		Ho Chi Minh City urban railway construction	Viet Nam
		Bangkok MRT network development	Thailand
	Access railways to gateway ports/airports	Railway connecting Soekarno Hatta Airport and Halim Airport	Indonesia
Energy/ Power	Stable, ample and clean electricity and energy supply for final users	Batangas–Manila (BatMan) 1 Natural Gas Pipeline Project	Philippines
		Sumatra-Peninsular Malaysia HVDC Interconnection Project	Indonesia, Malaysia
		Sarawak-Peninsular Malaysia (SARPEN) HVDC Transmission Project	Malaysia
Urban Development	Comprehensive urban development	Iskandar Malaysia	Malaysia
	Transit-oriented development	MRT Lebak Bulus station square development	Indonesia
	Development for collaboration of research studies	Academic research cluster development	Indonesia
	Science city development	Amata Science City in Chon Buri's Nakorn district	Thailand
Tier 2			
Industrial Estate/SEZ	SEZs development	Thilawa SEZ Development Project	Myanmar
		Dawei SEZ Development Project (Dawei SEZ and Cross-Border Corridor Development)	Myanmar
		Kyaukpyu SEZ Development Project	Myanmar
		Myotha Industrial Park	Myanmar
		Industrial Estate Development in Pakse SME SEZ, Champasak Province	Lao PDR
		Joint PRC—Viet Nam Cross-Border Economic Zones (CBEZs)	China, Viet Nam
		Techno Park Poipet	Cambodia

Telecommunication	Development / upgrading of trunk telecommunication network	Communication Network Improvement Project	Myanmar
		Submarine Optical Fiber Cable connecting to AAG (Asia America Gateway)	Cambodia
		Submarine Optical Fiber Cable connecting to ASE (Asia Submarine Cable Express)	Cambodia
Urban Development	Comprehensive regional development	Sihanoukville Comprehensive development	Cambodia
Tier 3			
Industrial Estate/SEZ	Agriculture Development	Da Lat Agriculture High-tech Zone	Viet Nam

Note: HCMC = Ho Chi Minh City, NLEX-SLEX = North Luzon Expressway–South Luzon Expressway, LRT = light rail transit, MRT = mass rapid transit, SEZ = special economic zone.
Source: ERIA CADP research team.

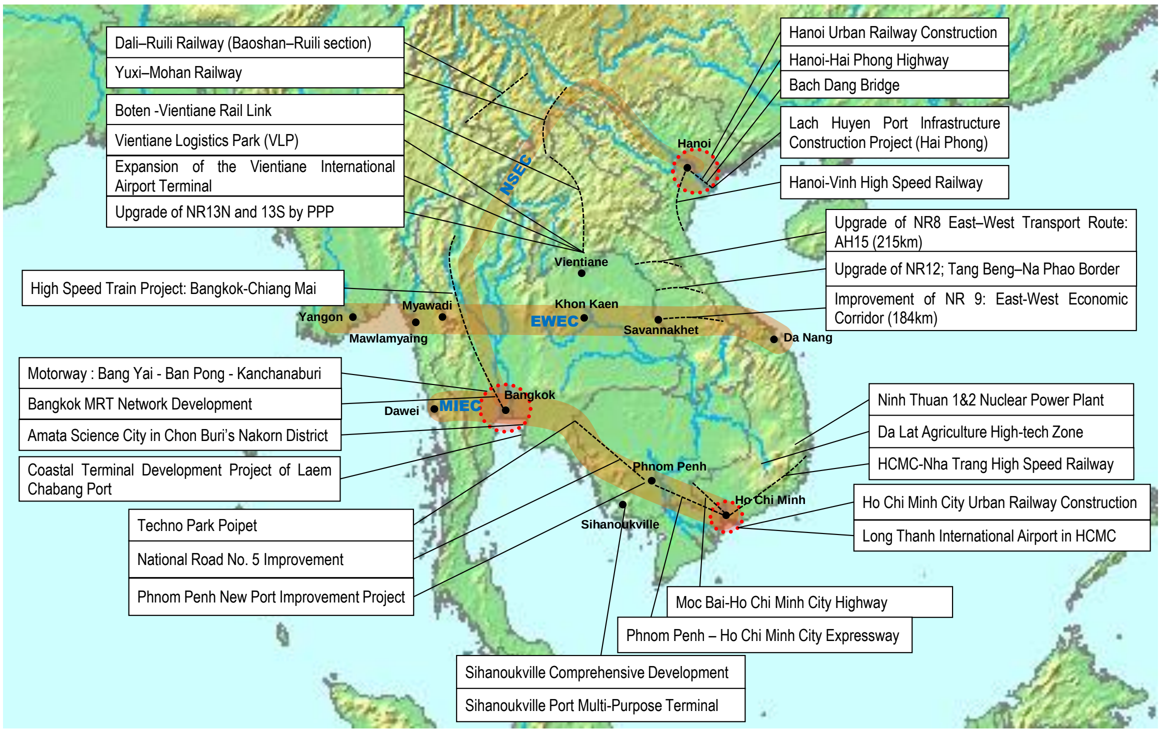
Table 6.1.4 classifies 761 projects in the list of representative prospective projects (Appendix 1) by country and subregion. About two-thirds of the projects (517 projects) are planned in the Mekong Subregion. Figures 6.1.1 to 6.1.4 map out the representative prospective projects selected from the long list.

Table 6.1.4. Summary of the Representative Prospective Projects Listed in Appendix 1, by subregion and by country

	Total	Mekong	BIMP+	IMT+	BIMP+ IMT+	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Thailand	Viet Nam	China	India	Brunei, Malaysia	Cambodia, Lao PDR	Cambodia, Viet Nam	Cambodia, Lao PDR, Myanmar, Thailand, Viet Nam	Indonesia, Malaysia	Lao PDR, Thailand	Lao PDR, Viet Nam	Lao PDR, Cambodia, Thailand	Lao PDR, China, Thailand	Malaysia, Singapore	Myanmar, Thailand	Thailand, Myanmar, India	China, Myanmar	China, Thailand	China, Viet Nam
Total	761	517	170	72	2	4	68	116	61	25	87	77	115	152	7	20	1	2	4	2	2	3	1	1	1	2	1	1	3	1	4
Tier 1	222	146	54	21	1		1	28		20		25	47	81		15				2	1					2					
Tier 2	432	319	75	37	1	4	65	44	29	1	84	46	64	65	6	4	1	1	4		1	1	1	1	1		1	1	2	1	4
Tier 3	107	52	41	14			2	44	32	4	3	6	4	6	1	1		1				2							1		
Road/Bridge	222	163	49	10		3	31	20	20	3	19	30	20	58	2	6		1	2			2						1	2		2
Railway	120	85	22	13			10	15	4	3	8	11	39	21	3	2			1							2			1		
Port/Maritime	73	33	26	14		1	5	28	3	2	9	6	13	5		1															
Other Transportation	7	5	2								4	2			1																
Airport	52	22	22	8				13	5	4	4	12	6	7		1															
Industrial Estate/SEZ	45	41	1	3			2		4		9	1	11	12	1	4															1
Energy/Power	169	113	33	21	2		15	30	20	10	24	10	15	28		5	1	1	1		2	1	1	1	1		1			1	1
Telecommunication	10	10					3				3		2	1						1											
Urban Development	9	6	2	1			1	2		1			2	3																	
Water Supply/Sanitation	36	22	12	2				7	1	2	5	5	5	10		1															
Others	18	17	1				1	1	4		2		2	7						1											

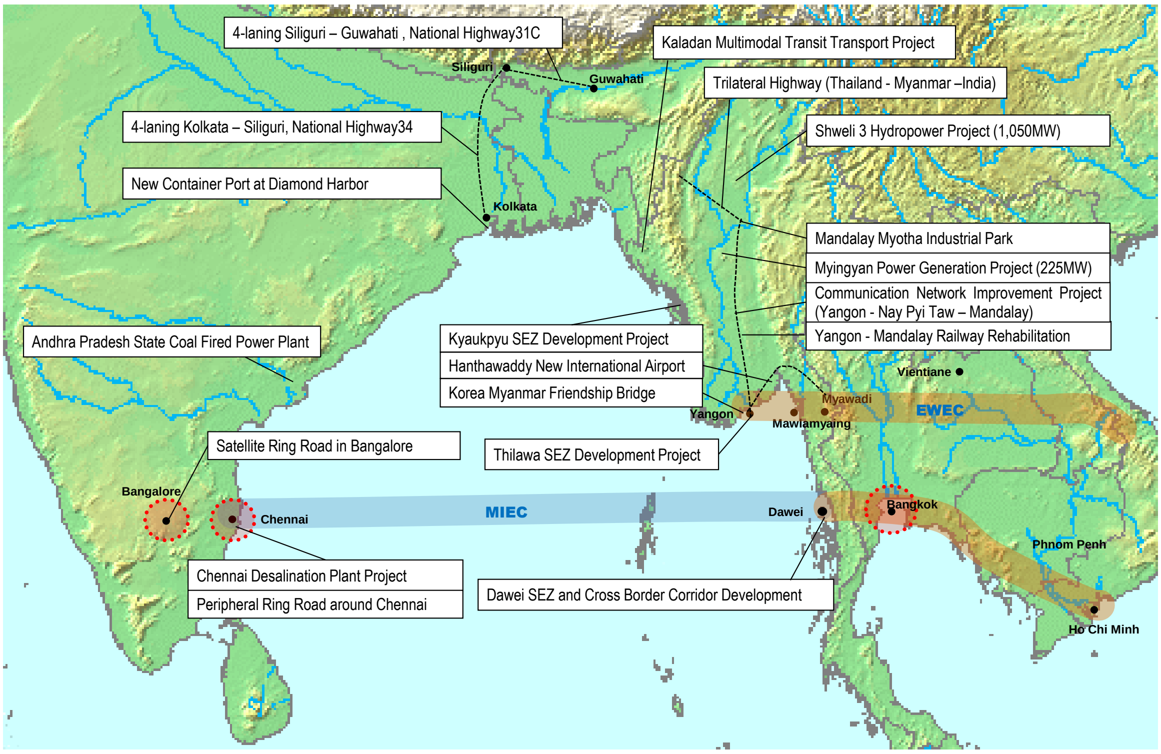
Source: ERIA CADP research team.

Figure 6.1.1. Selected Representative Infrastructure Projects in the Mekong Subregion



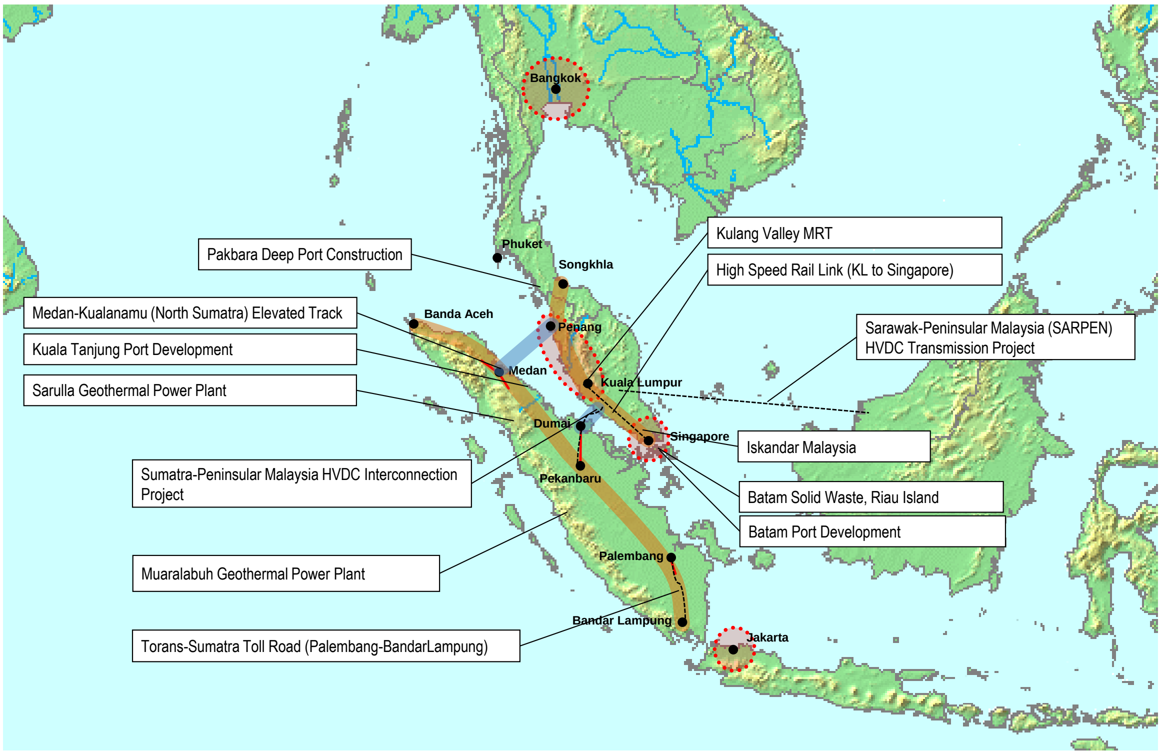
Note: HCMC = Ho Chi Minh City.
Source: ERIA CADP research team.

Figure 6.1.2. Selected Representative Infrastructure Projects in MIEC and East India



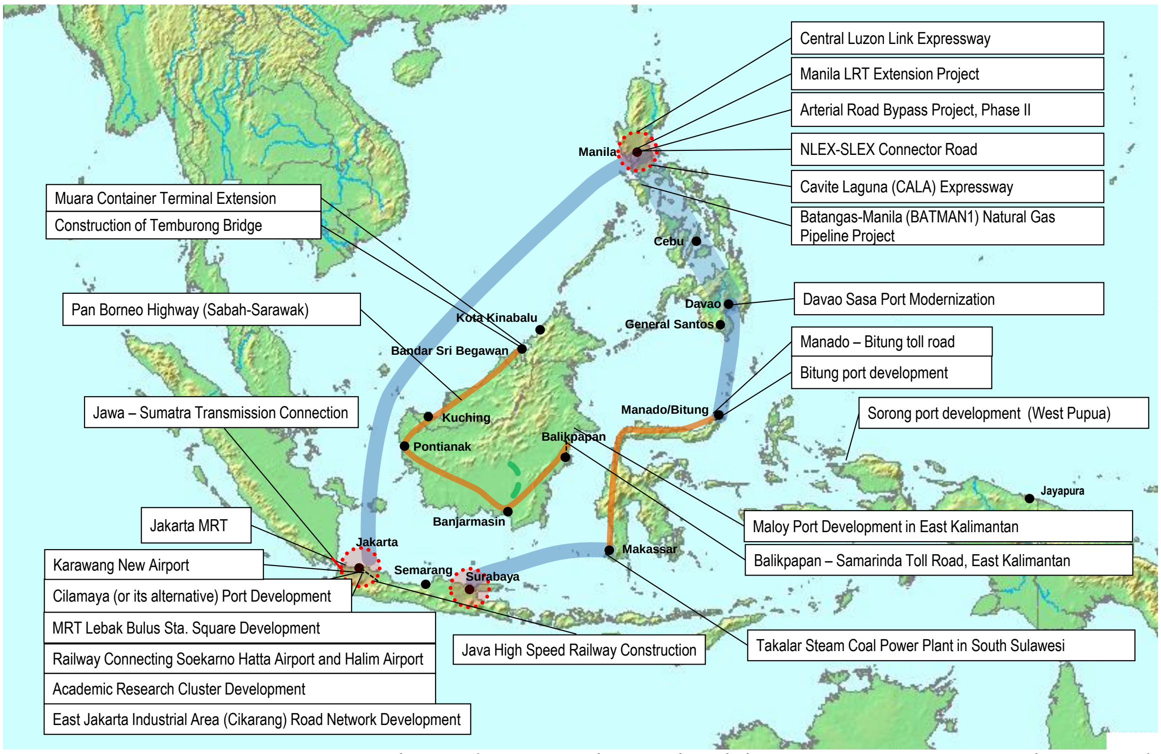
MIEC = Mekong–India Economic Corridor, SEZ = special economic zone.
Source: ERIA CADP research team.

Figure 6.1.3. Selected Representative Infrastructure Projects in the IMT+ Subregion



Note: HVDC = high voltage direct current, IMT+ = Indonesia-Malaysia-Thailand Growth Triangle and surrounding regions, MRT = mass rapid transit.
Source: ERIA CADP research team.

Figure 6.1.4. Selected Representative Infrastructure Projects in the BIMP-EAGA+ Subregion



Note: BIMP-EAGA+ = Brunei Darussalam-Indonesia-Malaysia-The Philippines East ASEAN Growth Area and surrounding regions, MRT = mass rapid transit, NLEX-SLEX = North Luzon Expressway–South Luzon Expressway
Source: ERIA CADP research team.

The following subsections describe outlines of the highlighted sectors for each tier and the two infrastructure categories.

6-1-1. Hard infrastructure for connectivity

6-1-1-1. Tier 1

◇ Railway

Railway projects in Tier 1 include those for connecting metropolitan areas with other cities, which include Singapore–Kuala Lumpur, Java (Jakarta–Bandung), Ha Noi–Vinh, Ho Chi Minh City–Nha Trang, and Bangkok–Chiang Mai high-speed railway projects. The following benefits are expected from these railway developments:

- reduction in transportation time between cities
- boosting of regional interactions
- mitigation of road congestions
- reduction in CO_2 emissions
- increase in tourists
- promotion of urban amenity
- promotion of human resource development and connectivity among industrial agglomeration areas.

Thus, while railway projects generate a lot of positive externalities, we still need to carefully assess economic and financial viability. First, projects should bring in large economic effects, including positive externalities. Second, if projects themselves are not financially viable due to positive externalities, we must design a proper demarcation between public and private involvement. Typically, construction requires some public involvement while operations and maintenance should stand alone with private businesses. In cases of middle- and long-distance railways, possible competition with highway connection and air transportation must be considered.

◇ Airport

Responding to a drastic demand growth of air passengers, expansion of the existing airports and construction of new airports are planned in capital cities and metropolitan areas. In case of expansions, the surplus land space of the original sites is utilised in many cases. Before constructing new airports, quite a long time is needed to obtain consensus of residents, land, and environmental assessment.

In Ho Chi Minh City, Viet Nam, because the capacity of Tan Son Nhat International Airport is reaching its limit, Long Thanh International Airport is planned to be built 35 km east of Ho Chi Minh City in Dong Nai province, the first phase of which will be completed in 2025. As new airports tend to be constructed in distant locations, developing infrastructure for airport access is critical to the fast, punctual, and long-distance movement of people.

6-1-1-2. Tier 2

◇ Road/Bridge

Many projects in Tier 2 are selected from the perspective of connecting industrial centres, logistic hubs, and neighbouring industrial agglomerations as well as strengthening networks and economic corridors. In particular, Cambodia's National Highway No. 5 Improvement Project is important in view of the development of the Mekong–India Economic Corridor (MIEC). Improvement of National Road No. 9 in Lao PDR is also important in view of the development of the East–West Economic Corridor (EWEC). Truong Loung–My Thuan–Can Tho Highway strengthens network in the Mekong delta area. The Trans Sumatra toll road enforces rapid and fair economic growth in the island.

The construction of bridges, such as the Korea–Myanmar Friendship Bridge, Bach Dang Bridge (part of Ha Long–Hai Phong Highway), and Temburong Bridge in Brunei, coupled with approaching roads to connect regions along the corridor, is expected to drastically reduce transportation time and strengthen connectivity.

The enhancement of cross-border facilities, such as the Thanaleng Border-Crossing Infrastructure Improvement in Lao PDR and the new border checkpoint in Poipet for cargo, is important in the Mekong Subregion for economic integration.

◇ Port/Maritime

Port/Maritime is a critical infrastructure needed for a country to participate in domestic and international production networks. Mass transportation of natural resources and establishment of inter-island logistics are particularly important for local development. Indonesia as a maritime country has 24 strategic port development plans, of which Kuara Tanjung and Bitung ports are expected to be new international hub-ports.

6-1-1-3. Tier 3

◇ Energy/Power

Tier 3 projects aim to develop infrastructure, enabling to make better use of locally available resources for local development. In the case of infrastructure development of the energy sector in Tier 3, a special focus is placed on the development of power plants utilising location advantages. The list of representative projects includes power projects under categories of hydro, geothermal, wind, and other renewable energies that would help energy conservation and environmental concerns such as the Sarulla and Muara Labuh geothermal power plants in Sumatra island; Shweli 3 Hydropower Project in Myanmar; and wind power plant development in Savannakhet, Attapeu, Salavan, and Xekong.

Power grid/transmission projects, such as inter-island and some cross-border power transmission interconnections, including some projects categorised under other tiers, are also an important foundation to formulate the efficient use of power for the whole region.

◇ Road/Bridge

In Tier 3, standard/semi-standard grade infrastructure for connectivity for various economic activities—such as agriculture/food processing, mining, labour-intensive industries, tourism, and others—are required. Since Tier 3 regions consist mainly of rural and island areas, which are far from metropolitan or large cities, Tier 3 projects include some parts of Lao PDR and Indonesia.

6-1-2. Hard infrastructure for innovation

6-1-2-1. Tier 1

◇ Urban Development

Various types of urban development projects are listed as hardware for innovation. As an example of large-scale multipurpose development, Iskandar Malaysia is set to become Southern Peninsular Malaysia's most-developed region, where living, entertainment, and business will seamlessly converge within a bustling and vibrant metropolis.

The MRT Lebak Bulus station square project in Indonesia combines the development of a large land space in front of the station and of the city railway. The project aims to amplify the traffic networks and enhance urban amenities through development of bus terminals, park-and-ride parking, hotels, and commercial facilities.

Academic research cluster development should contribute to promoting collaborations between research institutes and private companies and facilitating innovation of various aspects. The Amata Science City is a multi-city development plan in Chon Buri, Thailand. It is planned to be a source of innovation that may push up the value added of Thai industry, strengthen the country's competitiveness against the surrounding nations, provide solutions for environmental concerns, and cause the emergence of new industries associated with technical innovations.

◇ Railway

Railway projects in Tier 1 include those for the urban public transport system (subway, LRT, MRT) and railways to connect urban and suburban areas. Representative projects are the Manila LRT line extension, Klang Valley MRT construction, Jakarta MRT construction, Ha Noi urban railway construction, Ho Chi Minh City urban railway construction, and Bangkok MRT network development. Those projects are needed mainly to ease road congestion in metropolitan and large cities caused by heavy traffic.

Airport access railway has an advantage over congested roads because of its punctuality. There is a plan to connect Soekarno Hatta Airport and Halim Airport by railway.

These construction projects would increase urban amenities and promote innovation.

6-1-2-2.Tier 2/3

◇ Industrial Estate/SEZ

A highlighted project is the Dawei SEZ development, which will accelerate the international division of labour along the MIEC and drastically improve the logistic environment leading to India, South Asia, and the Middle East. Another project on industrial estate/SEZ, the Da Lat Agriculture High-tech Zone project in Viet Nam, aims to enhance agricultural productivity based on the recognition of huge growth potential.

◇ Telecommunication

Under the current telecommunication society, innovation development and upgrading of trunk telecommunication network are important. An example is the Communication Network Improvement Project in Myanmar and Submarine Optical Fiber Cable connecting projects in Cambodia.

6-2. Proper Technical Grades of Transport Infrastructure

CADP 2.0 proposes a new approach of categorising infrastructure projects according to the targeted project outcomes (i.e. for connectivity and innovation). Tiers 1 and 2 projects are categorised into (i) infrastructure for connectivity and (ii) infrastructure for innovation.

To supplement the categorisation of the infrastructure projects described above, the following subsections provide technical features of transport infrastructure. Engineering-based knowledge is useful for considering transport infrastructure appropriate to the three tiers at different development stages and for achieving particular outcomes of connectivity enhancement and innovation.

6-2-1. Roads

Proper road grades for different development stages can be determined by considering various practical elements such as traffic of heavy vehicles, cost of land acquisition, construction and maintenance, and level of services provided. The matrix below provides a guideline of references.

Table 6.2.1. Proper Road Grades

	Multilevel/Ground	Number of Lanes/Width	Pavement
Tier 1	Multilevel (elevated or underground)	depends on planned traffic volume	high grade pavement
Tier 2	Ground (over/under pass for some intersections)	depends on planned traffic volume	high grade/standard pavement
Tier 3	Ground	depends on planned traffic volume	standard/semi-standard

Source: ERIA CADP research team.

Graphic 6.2.1. Image of Road Grades

High grade Medium grade Low grade

Source: Ikumo Isono for medium and low grade, METI for high grade ttp://www.kanto.meti.go.jp/webmag/series/token/images/1204token-1.jpg.

Tier 1 needs to develop and maintain high-quality transport infrastructure that ensures efficient, on-time, and safe movements of people and goods by automobiles without deteriorating urban amenities and the environment. Newly constructed roads at the centre of cities should often be elevated or built underground to mitigate congestion and effectively use land. Some advanced cities tend to build underground for better views regardless of the cost. Four or more lanes are recommended, but in reality two lanes are typical because of the difficulty in acquiring land. As for pavement, some new technologies to reduce noise and vibrations and to accelerate drainage should be adopted for environmental and safety concerns. Projects such as the Ha Noi–Hai Phong Highway in Viet Nam and the NLEX–SLEX (North Luzon Expressway–South Luzon Expressway) Connector Road in the Philippines are planned by high grade.

The road network development in Tier 2 shall assure physical connections of industrial agglomerations in a reasonably short time. Over- or underpass is necessary for some main road intersections. The width of roads where large vehicles usually pass should be able to accommodate those vehicles. Higher-grade pavements with easy drainage and anti-abrasion are preferable for safe driving. Some national roads in Cambodia are planned to be improved to medium grade.

The priority in Tier 3 is establishing physical networks (connections) even with moderate specification roads for less construction costs. At the same time, certain provisions for future expansion and upgrade should be incorporated in the original plan.

6-2-2. Railways

Railways are an important transportation mode that can complement and alternate with road transportation. Compared with road transportation, railways have several advantages, such as punctuality, large transport capacity, and safety and low CO_2 emissions, as well as disadvantages, such as huge investment costs and the lack of door-to-door services. Considering these technical features of railways and the demand condition in each tier, proper technical grades of railways are summarised in Table 6.2.2.

Table 6.2.2. Proper Railways Grades

	Ground/Elevated/ Underground	**Single track/ Double track**	**Electrified/ Non-electrified**
Tier 1	Elevated/Underground	Double track	Electrified
Tier 2	Ground	Double track	Electrified (Non-electrified)
Tier 3	Ground	Single track	Non-electrified

Source: ERIA CADP research team.

Tier-1 metropolitan and large urban areas are where the railway transportation system is more likely to be economically viable and better suited for realising efficient, speedy, accurate, and safety transportation services. From the viewpoint of safety and road congestion mitigation, intersections of railways and roads shall be avoided as much as possible. Also, for effective use of land, elevated or underground railway is highly recommended. Double track with electrification is required to handle a large number of trains. Utilisation of devices for safety enhancement, such as platform doors, and for facilitation of passenger flows, such as escalator/automatic ticket gates coupled with smart cards, is recommended for use in passenger stations. MRT extension/construction in Bangkok and Jakarta are planned with such specifications.

Graphic 6.2.2. Image of Railways Grades

Elevated, Double Track, Electrified | Ground, Double Track, Electrified | Ground, Single Track, Non-electrified

Source: ERIA CADP research team.

Tier 2 needs railways to have better inter-city transport systems. Ground railways are good enough for main line regional connection in consideration of construction cost. Double track may be suited to handle a number of trains. For example, in Thailand, there are some doubling track plan such as Nakhon Pathom–Hua Hin, and Lopburi–Paknampho.

Electrification is generally recommended, but diesel trains can minimise on-ground facilities and equipment at the early stage.

In Tier 3, middle-distance railways to carry natural resources and tourists can be ground, single track, and non-electrified to save costs.

6-2-3. Airports

Various factors may affect necessary facilities for airports. Movements of passengers and cargoes depend not only on the size and nature of hinterland economies but also on the movements for transit and tourism in the surrounding area. Air traffic is disproportionately high at hub airports such as Bangkok and Singapore compared to their economy and population sizes. The number of airport passengers is also relatively large at airports close to tourist destinations.

Although it is difficult to definitely grade airport facilities by the three tiers of development stage, the following values are widely used for airport development planning.

- Runway capacity: One runway has an annual capacity of 150,000 movements of aircrafts.
- Total floor space of passenger terminal: 10,000 m^2 floor space for 1 million airline passengers per year.
- Total floor space of air cargo terminal: 1 m^2 floor space per 10–20 tonnes of cargo volume.

Necessary runway length depends on the take-off and landing distance for each type of aircraft and other conditions, such as climate and operational hour. Basic take-off and landing distances for twin-prop regional aircrafts such as ATR 42 and ATR 72 are around 1,000–1,200 metres. A single-aisle narrow-body jet aircraft such as Airbus A320 and Boeing B737 needs a 2,500-metre runway. Large international airports, where double-aisle wide-body jet aircraft such as Airbus A330 and Boeing B777 can take off, tend to have 3,000–4,000-metre runways. In Cambodia, international airports in Phnom Penh and Siem Reap have 3,000- and 2,550-metre runways, respectively (Website of Cambodia Air Traffic Services, http://www.cats.com.kh/).

These figures indicate that if single-aisle jet aircrafts, which are numerous in small to midsized airports in Asia and have a capacity of approximately 180 seats, could fly 150,000 times annually with a load factor of 70 percent (126 passengers per flight) using a 2,500-metre runway at an airport, the airport would require capacity to handle 18.9 million passengers annually by having a 189,000 m^2 passenger terminal. A thorough planning of cargo handling facility will be required should the airport expect to handle double-aisle wide-body aircrafts.

Noi Bai Airport, Luang Prabang Airport, and Kuala Lumpur Airport were improved and extended for their growing demand. Local airports in Indonesia likewise have expansion plans.

6-2-4. Ports

Designing ports takes into account various components, including total land space, water depth, capacity of container yard and terminal, length and number of berths, number and capacity of cranes, and so on. In general, these elements are closely related to the following determinants of cargo throughput:

Graphic 6.2.3. Image of Airport Grades

Suvarnabhumi International Airport

Siem Reap International Airport

Source: ERIA CADP research team.

- Size of port hinterlands that affect the cargo volume of consumer commodities
- Size and type of surrounding industrial estates that affect the volume of export and import cargo
- Degree of trans-shipment hub-port role played, which depends on the location of port, and government policy and its operation and management capacity.

Vessel size is a key engineering factor that constrains the length and water depth of ports. Panamax is a standard, middle-sized container ship that fits in the lock chamber of the Panama Canal that is about 1,000 ft. (304.8 m) in length, 110 ft. (33.5 m) in width, and 42 ft. (12.8 m) in depth and allows the passage of vessels carrying up to 5,000 TEU (twenty-foot equivalent unit). The Panama Canal is expanding the lock chamber to 1,400 ft. (426.7 m in length) x 180 ft. (54.9 m in width) x 60 ft. (18.3 m in depth) that allows the Post-Panamax vessels carrying up to 13,000 TEUs to pass through the Panama Canal (see websites of Panama Canal, http: //www.pancanal.com/, and Panama Canal Museum, http://museodelcanal.com/). Technical requirements for port and related facilities will be upgraded according to innovations in the ship building industry and international vessel transport networks.

Data on these elements help central and local governments and port operators to forecast the size, type, and number of vessel calls and cargo throughput at the port and to draw up a strategic master plan to design capacity and facilities of the port and port terminals. However, the practical size and capacity of existing ports may be smaller than the ideal ones mainly due to the constraints of land space and water depth. As a countermeasure to these constraints, new ports have been developed at the locations not so far from the original port cities, examples of which are Bangkok port/Laem Chabang port, Saigon port/Cai Mep Thi Vai port, and Chennai port/Ennore port. Malaysia applies the same strategic way of thinking for the development of the Malaysia–Singapore border area including the Port of Tanjung Pelepas that has increased its container throughput by accommodating vessels avoiding the congestions on the sea route to Singapore.

Table 6.2.3. Standard Values of Main Dimensions of Berths for Container Ship (in cases where design ship cannot be identified)

Self-weight Tonnage DWT (t)	Length of Berth (m)	Water Depth of Berth (m)	Container Capacity (TEU)
10,000	170	9.0	500 – 890
20,000	220	11.0	1,300 – 1,600
30,000	250	12.0	2,000 – 2,400
40,000	300	13.0	2,800 – 3,200
50,000	330	14.0	3,500 – 3,900
60,000	350	15.0	4,300 – 4,700
100,000	400	16.0	7,300 – 7,700

Source: MLIT and PARI (2009), p.687.

Graphic 6.2.4. Image of Port Grades

Laem Chabang Port

Da Nang Port

Note: Ishida (2011) tabulates indicators on scales of major port terminals in the Mekong Subregion.
Source: ERIA CADP research team.

6-3. Energy Infrastructure Investment

Energy infrastructure includes power plant, transmission line, refinery plant, liquefied natural gas (LNG) receiving terminal, gas pipeline, and all energy projects.

They are basically categorised as follows:

Tier 1 - Stable, ample, and clean electricity and energy supply for final users

Tier 2 - Stable and ample electricity and energy supply for final users

Tier 3 - Development of power plants taking location advantages for local supply of electricity

As there are many types of energy infrastructure, some detailed categorisation is mentioned in the following paragraph.

Because energy use also depends on economic development, energy infrastructure can also be categorized into three tiers. The low income group uses biomass, charcoal, and coal briquettes (Tier 3). The middle income group shifts to petroleum fuel including LPG (Tier 2), and the high income group uses electricity and piped gas (Tier 1) to maintain a better life and shift from agricultural activities to manufacturing and services activities. The second classification is based on conventional and unconventional types. Basically conventional energy is similar to Tier 2 or 3 whereas unconventional energy represents Tier 1. The third classification is based on the advanced level of energy technology. Energy infrastructure projects that apply highly advanced technology are classified under Tier 1 and traditional energy technology projects in Tier 3.

But choice of energy infrastructure sometimes does not necessarily follow economic development. For example, people living in rural areas who usually have low income may use photovoltaic (PV), wind, and mini-hydro system, which are classified as unconventional or renewable energy, if they want to have electricity to meet developmental needs.

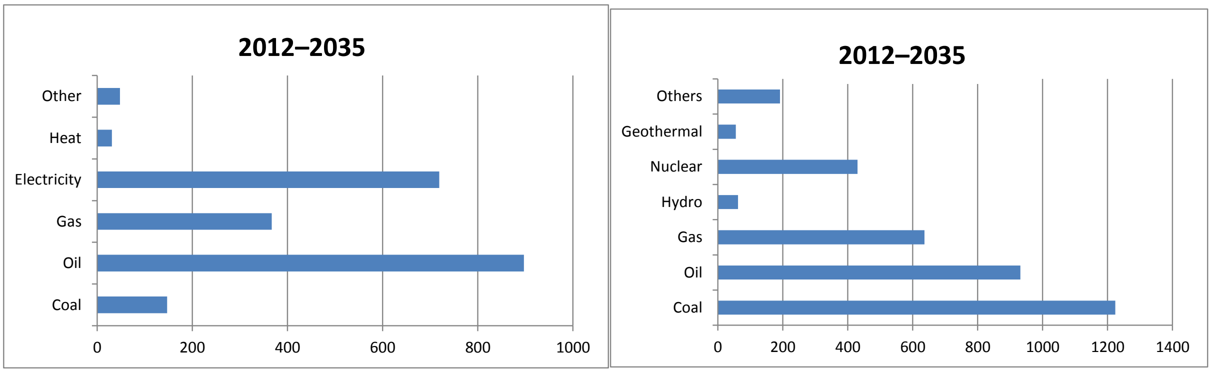
Basically the energy development plan of East Asia Summit (EAS) countries consider four energy issues: locally available energy resources, energy efficiency, low carbon energy, and supply security. Usually high income countries emphasise energy efficiency, low carbon energy, and supply security. On the other hand, low income countries prioritise locally available energy and low-cost energy technology. In this regard, energy infrastructure investment is introduced along with the energy issues touching on the three categories in this section.

6-3-1. Basic principle

How is future energy infrastructure investment identified? There are two points of view: future energy demand and energy policies affected by energy and environment trends. How about future energy demand? According to *Energy Outlook and Analysis of Energy Saving Potential in East Asia*’ published by ERIA in 2015 (Kimura and Han, 2015), fossil fuel is still dominant and plays an important role in this region (Figure 6.3.1).

Figure 6.3.1. Energy Demand Increment of Energies in the EAS Region (from 2012 to 2035)

Final Energy Demand (MTOE) **Primary Energy Demand (MTOE)**



Source: Kimura and Han (2015).

In terms of final energy demand level, oil and electricity will increase significantly from 2012 to 2035, followed by natural gas and coal. On the other hand, at primary energy demand level, coal will mark the highest increment, followed by oil, natural gas, and nuclear energy. Based on the energy demand project, electricity supply infrastructure, especially power generation, and oil and gas infrastructure are crucial.

On the other hand, what are the current key energy policies? They are as follows:

- Curtailing the increment of energy demand by promoting energy efficiency
- Responding to environmental challenges such as climate change related to CO_2 emissions from energy combustion
- Increasing energy supply security.

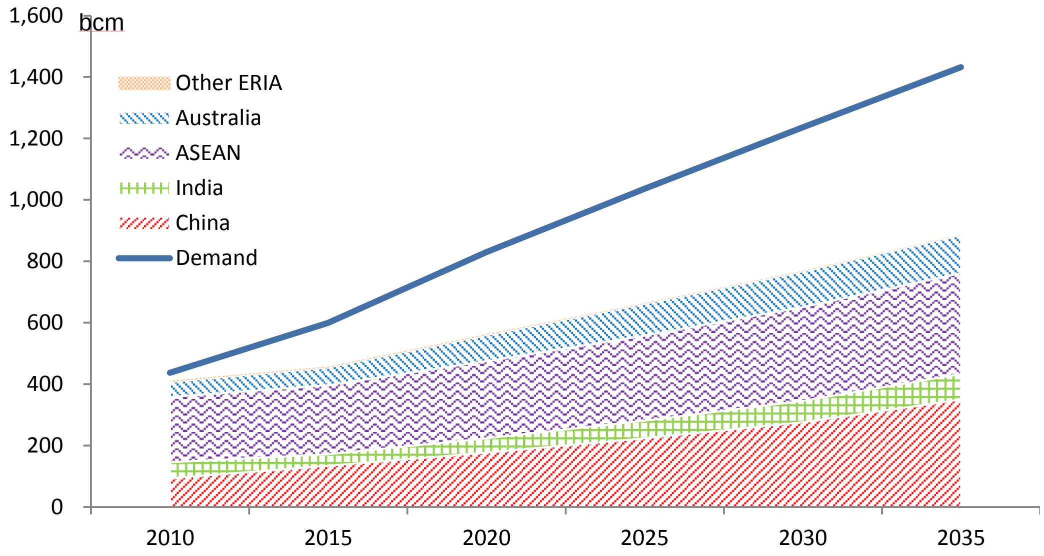
Energy efficiency needs aggressive use of high efficiency industrial equipment such as boiler and compressor and highly fuel-efficient vehicles, and application of green buildings.

The usage of high efficiency type thermal power plants such as clean coal technology (CCT), especially Ultra Supercritical (USC), and high efficiency type natural gas power generation is included. Subcritical type coal power generation plants are also included as current power generation projects. Natural gas power generation is considered environmentally clean and has high thermal efficiency. In this regard, all Asian countries consider natural gas as a major power generation source. Several natural gas power generation projects applying combined cycle gas turbine (CCGT) technology are also included. These projects are in principle considered as Tier 2.

On environmental challenges, shifting to low carbon technologies and energies is recommended. Final energy demand sector could apply low carbon technologies directly, but the power sector has huge potential to apply low carbon technologies and energies as well. The low carbon energies consist of hydropower, nuclear power, geothermal power, PV/wind power, etc. Cambodia, Lao PDR, Myanmar, and Viet Nam or the CLMV countries have a large hydropower potential. Viet Nam started nuclear power generation projects with support from Russia and Japan. Some geothermal projects are also included, as Indonesia and the Philippines have large potential of geothermal energy. PV/wind/other RE (renewable energy) power generation are also included, such as power generation by incineration plants in Indonesia, Lao PDR, Myanmar, Thailand, and India. Natural gas power plants are also classified as low carbon emission plants vis-à-vis coal and oil power generation plants as earlier mentioned. According to ERIA's study on natural gas market (Kutani and Li, 2015), about 550 BCM will be imported as LNG (Figure 6.3.2). In this regard, a remarkable number of LNG-receiving terminals will be constructed besides upstream ports; this report includes some of the LNG-receiving terminals. These projects are in principle considered Tier 2 or Tier 1, depending on the use of the energy and the level of technological advancement. Specifically, if it is developed for the electrification of the local community and makes use of indigenous energy resources, it is considered Tier 2. If it is developed to supply cleaner energy to the grid for towns and cities, it is considered Tier 1.

Regarding energy security, oil stockpiling, power grid interconnection, and increase of fossil fuel supply are highlighted in the region. Due to the rapid and continuous increase in oil demand, an oil stockpiling system should be installed in this region in addition to that of EAS and OECD countries such as Australia and Japan. But stockpiling projects are not included in Appendix 1 because of their uncertainty and the small investment.

Figure 6.3.2. Natural Gas Demand Supply Gap (BCM)



Source: Kutani and Li (2015).

Power grid connection is another method to secure electricity supply. After the great earthquake and tsunami in March 2011, the eastern part of Japan faced a serious lack of electricity supply due to the shutdown of nuclear power plants. Some experts say that if Japan's power grid were connected to neighbouring countries such as South Korea and Russia, its supply capacity could have been maintained. Currently, several ideas on power grid interconnections, such as the East Asia Super Corridor and EAS Super Corridor (China–ASEAN–India), have been put forward. There are also ongoing projects such as the GMS (Greater Mekong Subregion) Initiative and the ASEAN Power Grid Interconnection initiative. The basic concept of the ASEAN Power Grid is the interconnection of the national power grids of each ASEAN country. Consequently, the construction of national transmission lines and cross-border interconnections are and will be made by ASEAN countries, and this report includes these projects. Again, these projects are considered Tier 2 or Tier 1, depending on the use of the energy and the level of technological advancement. If the interconnection results mainly in the optimal use of energy resources, especially clean energy, crosses the border, and supplies the main grid of the importing country, it is considered Tier 1.

ASEAN has another connectivity initiative, namely, the Trans ASEAN Gas Pipeline (TAGP). At the beginning, TAGP was planned to connect each ASEAN country by pipeline. However, the ASEAN Council on Petroleum (ASCOPE) changed the plan. TAGP now consists of two types of interconnection—through pipeline and through LNG. The infrastructure for LNG includes liquefaction and regasification facilities. LNG is thus referred to as virtual pipeline. TAGP also included a national gas pipeline settlement. This report includes several national pipeline projects in the Philippines, Thailand, and India which are considered Tier 2 or Tier 1, depending on the use of the energy and the level of technological advancement. If the interconnection results mainly in the optimal use of natural gas resources across-border and supplies high-efficiency natural gas power plants of the importing country, it is considered Tier 1.

Increase of regional fossil fuel supply is essential to maintaining the security of energy supply. But experts say that oil and natural gas production of producing countries in this region will decline in the future, except for Myanmar which could increase natural gas production due to its high reserves.

Oil will still be the dominant energy in this region, used in industry production activities, transportation, and power generation (mainly for backup power system in industry, commercial, and building sectors). Specifically, increase in crude oil demand means that the demand for petroleum products, such as gasoline and diesel oil, increases. Consequently, this region will need to increase the capacity of petroleum refinery plants. Whereas petroleum demand has already saturated in some developed countries in this region, such as Japan, that of emerging countries will increase rapidly and continuously. In this regard, petroleum companies of developed countries will invest and construct petroleum refineries in this emerging area. Some petroleum refinery projects in Viet Nam are included as Tier 2 projects.

6-3-2. Clean Coal Technology

Coal demand in EAS economies still has the largest share of primary demand, although its share will decline from 52 percent in 2012 to 44.9 percent in 2035 (Kimura and Han, 2015). The demand for coal is largely due to the increasing use of coal to generate power to meet electricity demand. Demand for power generation is projected to grow at 3.3 percent per year on average from 2012 (8,717 TWh) to 2035 (18,530 TWh). The share of coal-fired generation is projected to continue to be the largest and will remain about 60 percent of the total until 2035. The share of natural gas is projected to be stable at around 12 percent from 2012 to 2035. The nuclear share (3.4 percent in 2012) is forecasted to increase to 10.5 percent in 2035.

Most of the coal demand in the region is expected to be addressed by Indonesia as it has abundant low-rank coal with low ash and low sulphur content that offers advantages in both price and environmental compliance (Otaka and Han, 2015). As emerging Asian economies will continue to rely on coal to steer economic growth, the proliferation of more sustainable energy development such as clean coal technologies (CCTs) will need to be deployed urgently to mitigate the negative effects on the region's environmental security, such as the potential of rising greenhouse gas (GHG) emissions from burning coal.

To date, the best available and mature technological developments on CCT to generate power from coal are combustion and gasification technologies.[11] CCTs for coal combustion generally deploy higher steam conditions, i.e. ultra-supercritical (USC), supercritical (SC), and subcritical technologies. USC and supercritical SC technologies, however, are more suitable for larger units. For units of less than 400-megawatt electrical output, the advantages of the higher steam conditions may not be realised. Integrated gasification combined cycle, though less mature than combustion technologies, can potentially offer high efficiencies from smaller capacity units.

Considering the level of development, least developed countries will likely use low-efficient coal-fired power plant such as sub-critical technology (Tier 3 of technological grade). Once a country moves up to the middle income level with better per capita income and distribution, people will demand for better social well-being, including environmental quality. Thus, middle income countries may select highly efficient coal-fired power plants with SC technology (Tier 2 of technological grade). Advanced countries with stringent

[11] The clean coal technologies (CCTs) in this paper refer to ultra-supercritical technologies for combustion and to integrated gasification combined cycle. Though there have been debates about whether CCTs also include carbon capture and storage (CCS) because CCS is not commercialised, it is not considered for the CCT deployment to emerging Asia.

environmental standards may consider highly efficient and low emission technologies, such as USC technology or integrated gas combined cycle technology (Tier 1 of technological grade).

The dissemination of CCT technologies for the clean and efficient use of coal in emerging Asia is of pressing importance. ERIA's 'Study on the Strategic Usage of Coal in the EAS Region: A Technical Potential Map and Update of the First-Year Study' (Otaka and Han, 2015) concludes that the application of inefficient technologies and ineffective environmental standards and regulations would lead to a waste of valuable coal resources. Thus, EAS economies may need to consider upgrading technological grades from Tier 3 to Tier 2 and to Tier 1.

The inclusion of mega projects for coal-fired power plants in the project list of CADP 2.0 illustrates the increasing use of USC in large economies in ASEAN region as countries move forward to limit CO_2 and GHG emissions, i.e. practically, most fleets of coal-fired plants in Central Java, Indonesia will be using the USC technology (Tiers 2 and 1). Likewise, Thailand is upgrading the existing subcritical coal-fired power plant with the first-ever USC coal-fired power plant in Mae Moh, located in Lampang which is expected to send electricity to grids by 2018 (moving from Tier 3 to Tier 1). In the project list, gas-fired power plants along hydropower development are included as part of the region's power generation mix. However, the speed of CCT deployment remains critical for emerging EAS economies.

To facilitate informed decision-making, ERIA's study on the strategic usage of coal in the EAS region (Otaka and Han, 2015) examined various technologies (USC, SC, and subcritical), comparing their generation cost by boiler types and coal price (Table 6.3.1). The study found that financing costs also account for a significant share of total generation costs. In this analysis, two IRR (internal rate of return) cases were included. Results show that USC loses cost-competitiveness in higher IRR case, implying higher financing cost. For example, at coal prices of USS50/tonne, USC is most cost-competitive (at US$6.77/kWh) when IRR is 9.5 percent. However, when IRR is increased to 15 percent, USC is less cost-competitive (at US$8.27/kWh) than SC and subcritical. Therefore, USC may be less viable in countries that do not have access to low-interest loans. This result also implies that the USC technology has a barrier of higher upfront cost than the SC technology and conventional plants. Thus, among other policies, an attractive financial scheme to bring down upfront cost, such as long-term financial scheme with low interest rate, will be necessary to ensure the up-taking of USC technology in emerging EAS economies.

Table 6.3.1. Generation Cost by Boiler Type and Coal Price

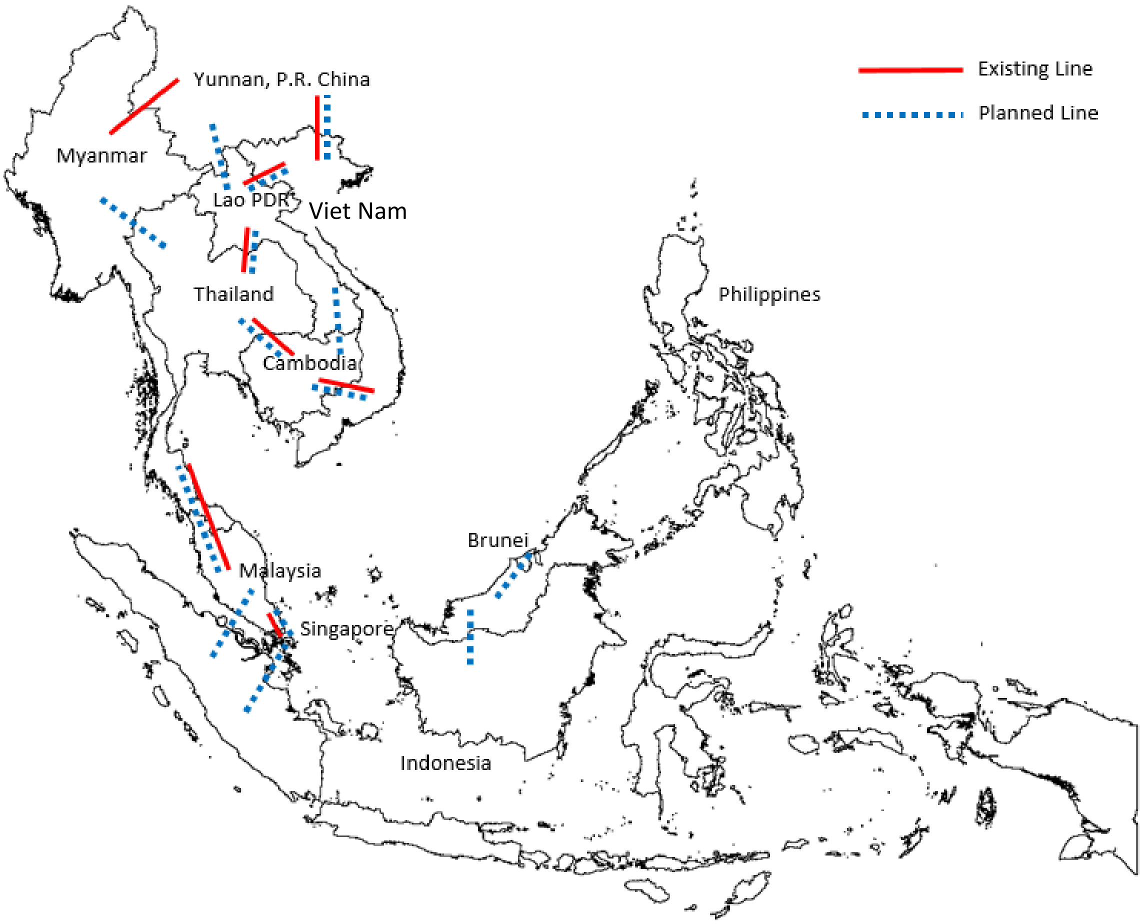
		Boiler Type		
		Ultra Super Critical (USC)	Super Critical (SC)	Sub-critical
Capacity		1,000 MW		
Coal CV / Price		4,000 Kcal/kg (GAR) / 50 USD/ton		
Thermal Efficiency (LHV)		42.1%	41.1%	38.2%
Initial Cost (million USD)		1,931	1,897	1,787
Coal Consumption (tons/year)		3,578,263	3,665,326	3,943,583
CO2 Emission (tons/year)		5,102,914	5,227,073	5,623,893
Generation Cost (USD cent/kWh) (@USD60/ton)	IRR= 9.5%	7.29	7.33	7.43
	IRR=15.0%	8.79	8.80	8.81
Generation Cost (USD cent/kWh) (@USD50/ton)	IRR=9.5%	6.77	6.79	6.85
	IRR=15.0%	8.27	8.26	8.24
Generation Cost (USD cent/kWh) (@USD40/ton)	IRR=9.5%	6.25	6.26	6.27
	IRR=15.0%	7.75	7.73	7.66

Source: ERIA CADP research team.

6-3-3. Power grid interconnection

The ASEAN Power Grid and the GMS Initiative are the two key initiatives to drive regional power grid interconnectivity among ASEAN countries (Figure 6.3.3). Both have been making steady progress in the form of bilateral interconnection projects with long-term power purchasing agreements. Such is perceived as the first stage towards the fully functioning regional grid for multilateral trading of power (Li and Chang, 2015).

Figure 6.3.3. ASEAN Power Grid Interconnectivity – Existing and Planned



Source: ERIA CADP research team.

A fully functioning regional grid bears many benefits to countries involved. Through such interconnection, cheaper renewable energy resources which are abundant in the region, especially hydropower in the GMS, could be further developed. In addition, the interconnected grids can take advantage of the varying peak and non-peak hours in different countries and thus save a large portion of the investment in expensive peak power generation capacities. ERIA (2013) estimated some US$11 billion net savings in the cost of electricity generation for all ASEAN countries plus two Southwest China provinces and Northeast India in 20 years, despite the high initial costs of investment in interconnecting transmission lines. The other independent estimation by Chang and Li (2012) presents a net savings of US$20.9 billion for ASEAN alone in 20 years.

Furthermore, the interconnection of grids in the region enhances the overall capacity of countries to adopt renewable sources of power generation, such as solar PV and wind turbines. Chang and Li (2015) show that, with power grid interconnection among ASEAN countries and by implementing a feed-in-tariff (FiT) policy for renewable energy, renewable energy adoption could be increased by some 70 percent compared to the baseline scenario with no interconnection and no FiT, while the total cost of electricity generation increases by only 8 percent. With less aggressive FiT policy, an increase in the total cost by 1 percent can increase the adoption of renewable energy by some 30 percent.

However, the high upfront cost of new transmission lines for cross-border interconnection and the uncertainty of future demand for imports and exports of electricity through these transmission lines complicate the financial decisions to invest. The financial feasibility of each proposed cross-border transmission line needs to be carefully studied. A study by ERIA (2014) identified that a power grid interconnection among Lao PDR, Malaysia, Singapore, Thailand, and Viet Nam is financially feasible and should be prioritised (Table 6.3.2). This finding coincides with the initiative by the governments of Lao PDR, Thailand, Malaysia, and Singapore to develop interconnections and demonstrate a multilateral framework for cross-border trade of power.

Table 6.3.2. Possible Interconnection and Cumulative Costs and Benefits (2025–2035)

Case		Gross benefit (A)		Cost (B)		Net benefit (C)=(A)-(B)		Benefit/Cost ratio (D)=(C)/(B)
		[Million US$]	[US¢/kWh]	[Million US$]	[US¢/kWh]	[Million US$]	[US¢/kWh]	[-]
B	THA—LAO	21,387	3.77	1,506	0.26	19,881	3.51	13.2
E	VNM—LAO—THA	24,707	3.68	2,097	0.32	22,610	3.36	10.8
G	LAO—THA—MYS—SGP	27,490	3.88	2,000	0.28	25,490	3.60	12.7

Source: Fukasawa, Kutani, and Li (2015).

6-3-3-1. Challenges: Regulatory Connectivity

However, further institutional issues still stand as barriers to the realisation of a fully interconnected power grid in the region. Challenges in setting up the following remain: (i) a regional regulators' group/regional regulatory body to harmonise regulations and standards relevant to grid interconnection, (ii) a regional operators' group or regional system operator to synchronise actions in balancing the grid and the cross-border power exchange systems, and (iii) a regional system planners' group to coordinate and optimise the future investment plan of power stations and the grid.

All these three points concern the soft infrastructure development in the region in order to match the hard infrastructure development of power grid interconnection and thus achieve the most benefits of it. Such soft infrastructure can also be referred to as regulatory connectivity.

In response to the challenges listed above, as components of the road map towards the materialisation of the ASEAN Power Grid, two research projects will jointly be carried out by ERIA and The Heads of ASEAN Power Utilities/Authorities (HAPUA).

The first is a Study on the Formation of the ASEAN Power Grid Transmission System Operators (ATSO) Institution. There are two layers of objectives: (i) to establish the roles, structures, operational guidelines, and processes of the ATSO institution; and (ii) to provide the detailed implementation plan for the creation and operation of the ATSO.

The second is a Study on the Formation of the ASEAN Power Grid Generation and Transmission System Planning (AGTP) Institution. The objective is to propose applicable procedures, structures, roles, and mechanisms to establish and maintain the AGTP.

The ATSO and the AGTP institutions, once achieved, will be symbolic of the regulatory connectivity in ASEAN.

6-3-4. Overall investment amount

ERIA's study estimated that US$13 trillion in cumulative investment will be required until 2035 to realise the energy saving potential through energy efficiency and conservation. This will need to be invested in highly efficient power sector, transportation, building, and other energy infrastructure.

ERIA's study on the strategic usage of coal (Otaka and Han, 2015, forthcoming) also quantifies the investment opportunities in the EAS region from the increase in coal-fired power generation. The results suggested that about US$1700 billion investment is needed to meet the rising 898 gigawatt (GW) generated from a coal-fired power plant in EAS economies by 2035. Further, about US$300 billion investment in coal field development is required to meet the demand of 1,943 metric tonnes (MT) coal per year by 2035.

The Southeast Asia Energy Outlook (IEA and ERIA, 2015) estimated that ASEAN alone will need US$2.5 trillion in cumulative investment in energy infrastructure to 2040 in order to secure the region's growing energy demand. More than half of the total is required for the power sector. ASEAN will also need about US$420 billion to improve energy efficiency over the period to 2040.

6-4. Policy Issues Regarding Soft Infrastructure Post 2015

The importance of soft infrastructure has been gaining more attention recently because of the remarkable progress of hard infrastructure development in ASEAN. Soft infrastructure can contain a wide range of soft aspects such as software, information systems, legal instruments, and regulations. Although various soft issues—including both technological and institutional barriers—should be overcome before making better use of hard infrastructure, institutional issues are practically more troublesome and require substantial time and efforts to solve. Not only creation but also harmonised implementation of quality regulations among ASEAN Member States affect domestic and cross-border business performance.

As assessed in Chapter 5, among infrastructure for connectivity and innovation, substantial progress has been made in the development of infrastructure for connectivity. ASEAN Member States have been ratifying legal instruments and subregional agreements related to the ASEAN Economic Community (AEC). Nevertheless, it will take more time and patience for the member states to conform related domestic laws and regulations to said international agreements. International cooperation is also needed to harmonise interpretation and implementation of such agreements and regulations.

Chapter 5 illustrated the difficulty in implementing international agreements with the example of the CBTA. Although the launch of single window and single stop customs inspections at the Lao PDR–Viet Nam border crossing point in 2015 marked a milestone in the history of trade and transport facilitation in the GMS, it should be noted that the CBTA was signed by GMS countries in 1999 and ratified in 2003. Such time-consuming task can be demanded to develop the ASEAN Single Window (ASW) that will involve difficult coordination among ministries within a country.

Development of infrastructure for innovation must be prioritised after 2015 especially in Tier 1 regions where manufacturing and service activities should be more knowledge-based and innovative. Innovation can be realised by creating new knowledge from existing knowledge. Knowledge transfer and spillover are key mechanisms to generate innovation. As previous studies on innovation in Southeast Asia had investigated (e.g. Kimura, Machikita, Ueki, 2015), firms in the region tend to achieve innovation, using knowledge externally available for the firms. Infrastructure should be designed appropriately to create business environments that facilitate knowledge transfer and spillover, and foster human resources.

A better understanding on knowledge is needed to consider what infrastructure is essential for innovation. Knowledge can be categorised into two types: explicit/codified and tacit knowledge. 'Explicit knowledge can be expressed in formal and systematic language and shared in the form of data, scientific formulae, specifications, manuals, and such like. It can be processed, transmitted and stored relatively easily' (Nonaka, Toyama, Konno, 2000). Patent is a form of explicit knowledge. Licensing of intellectual property is a transmission channel of knowledge. In contrast to explicit knowledge, tacit knowledge is subjective insights, intuitions, and hunches that are highly personal and hard to formalise and often time and space specific. Knowledge is created through interaction between tacit and explicit knowledge and among individuals (Nonaka, Toyama, Konno, 2000).

Innovative activities need a freer flow of people and quality hard/soft infrastructure and services supporting the interactions and innovative activities. In addition to reliable transport infrastructure and services, transport facilitation and other soft infrastructure enable people to move timely and smoothly to transfer knowledge locally and internationally. Stable and clean power supply enables the use of precise high-tech equipment for research and development. Ubiquitous secure communication environments allow the conduct of innovative activities anytime and anywhere. Appropriate intellectual property law and cybersecurity help in exchanging knowledge and information in more secure environments. Quality living and business environments attract talents (e.g. inventors, researchers, entrepreneurs), which help develop quality business support services and educational institutions.

As the AEC envisions the free flow of services and skilled people, which will promote innovations, ASEAN Member States signed the ASEAN Framework Agreement on Services and have developed mutual recognition arrangements for eight professionals (i.e., engineers, architects, nurses, doctors, dentists, accountants, surveyors, and tourism professionals). However, there are still institutional limitations on the free flow of people and services. Even though ASEAN Member States signed the ASEAN Agreement on the Movement of Natural Persons (MNP), the agreement has not entered into force. The MNP agreement covers business visitors, intra-corporate transferees, and contractual service suppliers. But the commitments vary widely across the countries. The agreement does not cover non-services sectors (Fukunaga and Ishido, 2015), indicating that manufacturing firms will not find it easier to send engineers between factories in ASEAN for technology transfer.

In order to promote innovation, adequate regulatory coherence within and among ASEAN Member States (i.e. regulatory connectivity) is fundamental. Excessive redundant documentation requirements and complicated burdensome procedures for trade, transport, and business trips result in a higher cost of doing business. Regulatory practice and regulatory management system should be improved continuously to address these implementation problems leading to enhanced business environments for connectivity and innovation.