Chapter 4

Existing Cross-Border Interconnections in ACMECS Countries

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Chapter 4

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4.1 Types of Cross-Border Interconnections

Generally, cross-border interconnections are broadly categorised into four types:

1) Cross-border interconnection between main lines (system–to–system AC)
2) DC linkage (system–to–system DC)
3) Cross-border interconnection of generators isolated from the main system (G–to–System)
4) Cross-border interconnections supplying only demand areas isolated from the main system (system–to–L)

The following describes the characteristics of each type.

1) Cross-border interconnection between main lines

This is a mode in which the main systems are interconnected directly by alternating current (AC) and synchronised as an AC system with the same power frequency. It is necessary to balance the output from all the generators synchronised with the grid and the total value of all the loads to maintain the power system frequency. At the same time, the power flow of the cross-border interconnection lines should always be controlled at an appropriate value.

The main power system is planned in such a way as to avoid large power supply interruptions in the domestic power supply system even when severe faults occur, such as a fault on the route of transmission lines with double circuits, because the main system supplies the domestic power demand. To realise this, the plan is structured to have sufficient power generation capacity to automatically control the power supply and demand balance via power generators synchronously connected to the interconnection when the power flow in the interconnection shuts down.

When the interconnection line is connected to the power system via one route with double circuits and the one route fails, the power flow in the interconnection line instantaneously drops out from the system, the power supply and demand balance of the system collapses, and the system frequency fluctuates wildly.

To keep the frequency at the permissible value, it is necessary to adjust the power supply and demand balance via automatic adjustment of the output by the generator's governor, disconnection of the generator, or an emergency response such as load shedding, .

However, maintaining the supply and demand balance will be difficult if the power system has less margin for adjustment. In the worst case, the system frequency can exceed the allowable value, causing a large-scale power supply interruption in the overall system.

To avoid this and maintain the frequency at an allowable value via power output adjustment, disconnection of the synchronously connected power generators, or partial load shutdown even when one route with double circuits fails, it is necessary to limit the power flow of the line. The power system should also have sufficient controllable capacity for synchronous power generation facilities.

2) DC linkage (system–to–system DC)

Cross-border Interconnection can be carried out via direct current (DC) power transmission lines with an AC/DC converting station or AC/AC converting stations at both ends. The power flow in the connecting line can be maintained at a specific value. The power flow in the cross-border interconnection line can also be specified regardless of the balance between the power generation amount in the system and the demand for electric power. This specified value can easily be changed. For this reason, the influence on the frequency of the neighbouring countries is small, and these countries can follow the frequency control methods by controlling generator outputs. However, the disadvantage is that the costs of AC/DC converter stations are high, and the converter temporarily stops due to instantaneous voltage drop in the case of a fault at an AC transmission line.

In DC interconnection, the converter controls the power flow in the cross-border interconnection line. As a result, the generators are not synchronised with the power system of the neighbouring country. Therefore, the degree of restriction in the generators' specification by the grid code of the neighbouring country is small.

However, the generators should control the power output and maintain the frequency according to the power flow of the cross-border interconnection line. In addition, to operate the DC transmission line stably, power system stability should be maintained to prevent interaction between AC and DC. Therefore, it is necessary to make the short-circuit capacity (inverse number of the system capacity) at the interconnection point on the AC system sufficiently large relative to the capacity of the interconnection line. However, stability can be maintained if self-excited[2] converters are adopted. For this reason, to adopt DC linkage in a power system whose capacity is small, and when it is difficult to adjust the frequency in the system itself, synchronising the system with that of neighbouring countries with larger capacities is desirable.

3) Cross-border interconnection of generators isolated from the main system (G–to–system)

The transmission lines operated by the export IPPs as export-exclusive interconnections are operated as interconnections of generators isolated from the main system. A group of generators directly connected to a neighbouring country's system by a dedicated transmission line drops out of the grid in the event of a one-route accident on the dedicated transmission line. However, if the system capacity of the neighbouring country is sufficiently large, it is possible to maintain the correct frequency using synchronous generators within the neighbouring country. In addition, the dropout of the generator group will not affect the power supply of its own country. For this reason, with respect to a power plant or a group of power stations independent from the main system, the generator group is permitted to fall off during a one-route accident on the interconnection line. Of course, the power flow in the interconnection line needs to be made small enough for the other countries.

So far, we have described the types of cross-border interconnections. For example, for an AC interconnection, the generators are synchronised with the power system of the neighbouring country. For this reason, as described above, cooperation on the grid codes for interconnected systems is necessary. Also, the specifications of the generators and protection relay devices' installation must

[2] In these machines, instead of a separate voltage source, the field winding is connected across the main voltage terminals.

satisfy the requirements of neighbouring countries' grid codes. In addition, the generators follow the power dispatching orders from the neighbouring country. Alternatively, the home country must control the power flow in the cross-border interconnection properly and in cooperation with the power dispatching orders from the neighbouring country.

4.2 Existing Cross-Border Interconnections in ACMECS Countries

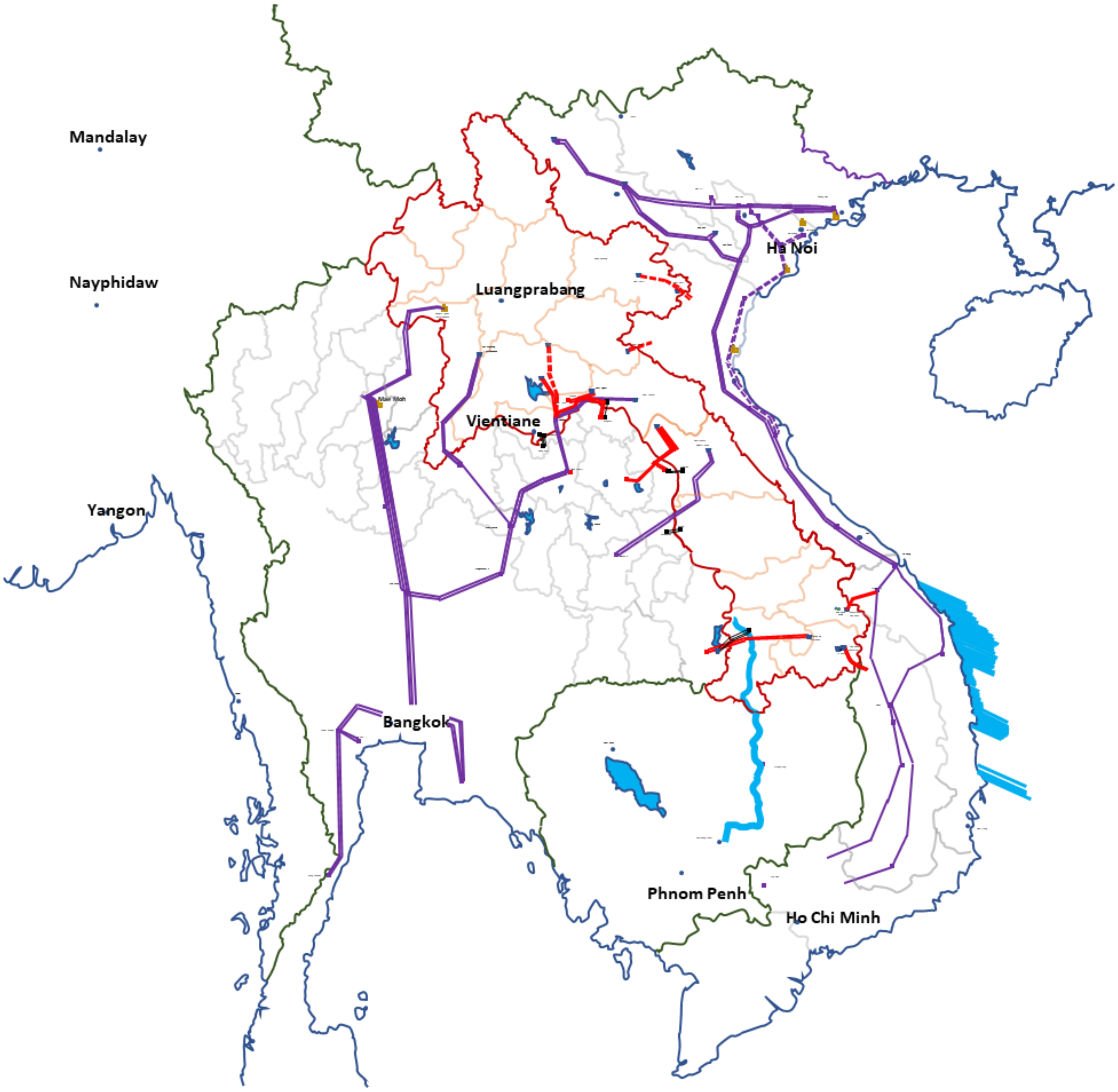
ACMECS already has many cross-border interconnections. However, many of them are transmission lines with low voltage levels. Table 4-1 shows the existing cross-border interconnections with voltage levels greater than 220 kV; Figure 4-1 depicts these cross-border interconnections.

Table 4-1 Existing Cross-Border Interconnections in ACMECS, at 220 kV or More

Country (From)	Country (To)	Section	Voltage [kV]	No. Circuits	Length [km]
Lao PDR	Thailand	Nam Theun 2 (HPP) - Roi Et 2	500	2	304
Lao PDR	Thailand	Nam Ngum 2 - Na Bong – UdonThani 3	500	2	187
Lao PDR	Thailand	Hongsa (TPP) - Nan - Mae Moh 3	500	2	325
Lao PDR	Thailand	HoouayHo (HPP) – UbonRachaThani 2	230	2	230
Lao PDR	Thailand	Theun Hinboun (HPP) - Ban Veun SwS - Nakhon Phanon 2	230	2	176
Lao PDR	Viet Nam	Xekaman 3 HPP - Thanh My	220	2	111
Lao PDR	Viet Nam	Xekaman 1 HPP (Hatxan) - Pleiku	220	2	115
Viet Nam	Cambodia	Chou Doc - Takeo - Phnom Penh	220/230	2	120

Source: World Bank (2019), JICA (2020b), MEM, MME data, modified by the author.

Figure 4-1 Existing Cross-Border Interconnectors and Main 500 kV Transmission Lines in ACMECS

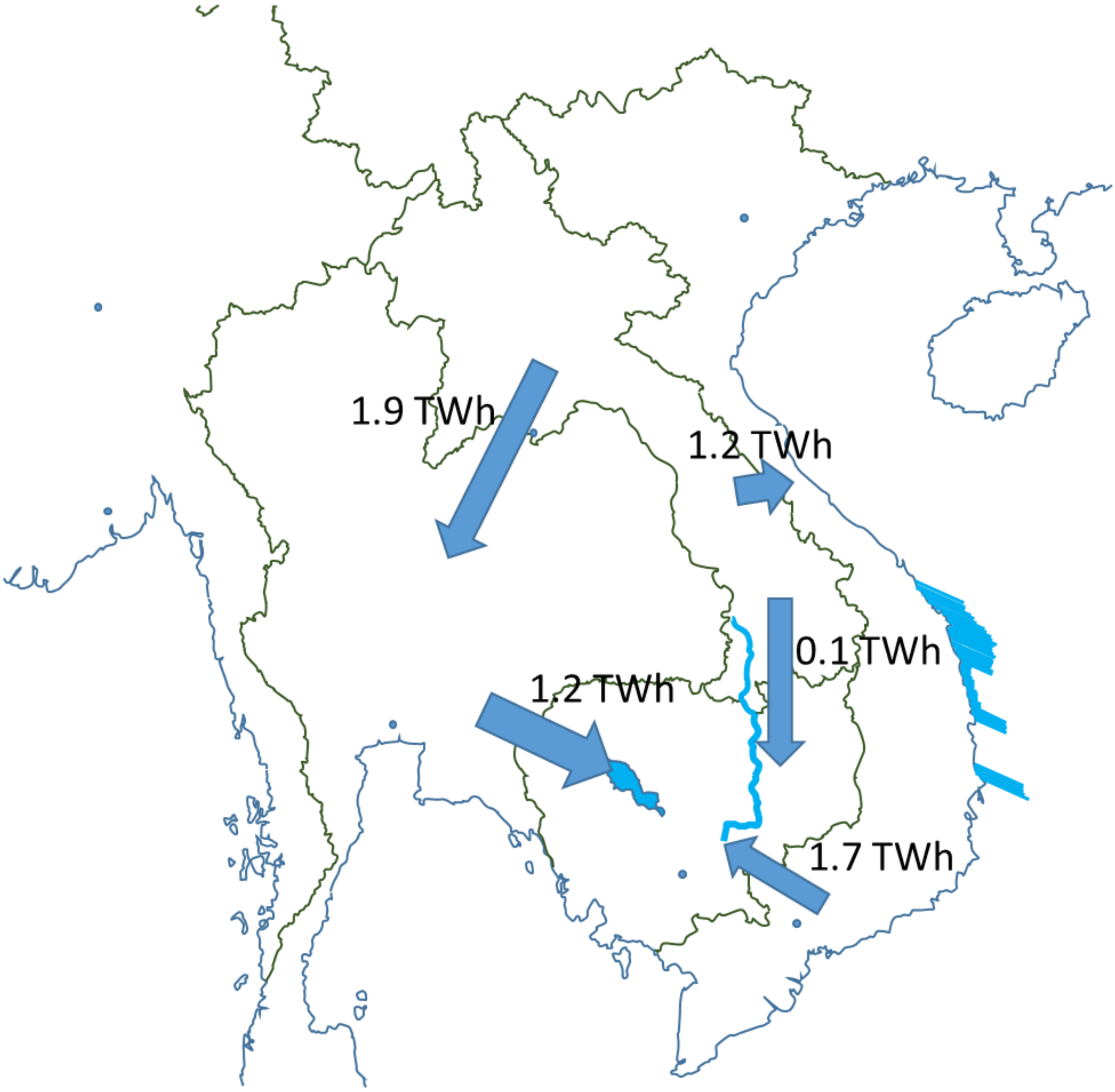


Source: Authors.

4.3 Current Power Exchange amongst ACMECS Countries

The overview of the current power exchange in ACMECS is shown in Figure 4-2. As of 2019, the Lao PDR exported 1.9 TWh of electricity to Thailand, 1.2 TWh of electricity to Viet Nam, and 0.1 TWh of electricity to Cambodia. Thailand exported 1.2 TWh of electricity to Cambodia, and Viet Nam exported 1.7 TWh of electricity to Cambodia. Figure 4-2 shows that the Lao PDR plays a central role in electricity exports in ACMECS countries.

Figure 4-2 Overview of Current Power Exchange in ACMECS (as of 2019)



Source: EGAT, EVN, MME data, modified by the author.