

## **Candidate Cross-Border Interconnections for the Transmission Highway in ACMECS**

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### Chapter 5

## Candidate Cross-Border Interconnections for the Transmission Highway in ACMECS

#### 5.1 Summary of Candidate Interconnections

Figure 5.1 shows the locations of the interconnections assumed to be newly constructed. Table 5.1 shows their voltages and distances.





Source: Authors.

|     | Section.                         | Voltage<br>(kV) | No.<br>Circuits | Length<br>(km) |
|-----|----------------------------------|-----------------|-----------------|----------------|
| (1) | MK. Pakbeng – (Mae Moh–Tha Tako) | 500 kV          | 2               | 415            |
| (2) | (Mae Moh–Tha Tako) – Mawlamyaing | 500 kV          | 2               | 280            |
| (3) | Vientiane-Bunkan                 | 230 kV          | 2               | 58             |
| (4) | Xekong–Roi Et                    | 500 kV          | 2               | 368            |
| (5) | Roi Et–Chaiyaphum                | 500 kV          | 2               | 230            |
| (6) | Chaiyaphum–Tha Tako              | 500 kV          | 2               | 160            |
| (7) | Tha Tako – (Mae Moh–Tha Tako)    | 500 kV          | 2               | 150            |
| (8) | Chaiyaphum–Banteay Meanchey      | 500 kV          | 2               | 380            |
| (9) | Thanh My–Xekong                  | 500 kV          | 2               | 108            |

#### Table 5-1 Sections of Interconnections Assuming New Construction

Source: Authors.

#### 5.2 Surge Impedance Loading (SIL)

To assess the 'loadability' of transmission lines, engineers generally use the concept of surge impedance loading (SIL). SIL is generally accepted in the industry as a convenient reference to estimate loading limits on transmission lines. Equation (1) expresses the formulation of SIL.

$$SIL = \frac{kV^2 \times 10^3}{Z_0} MW \tag{1}$$

Where:

SIL: surge impedance loading

kV: voltage of transmission line

Zo: surge impedance

SIL depends on the voltage of the transmission line. In other words, since the surge impedance is almost constant once the number of conductors is determined, the transmitted power can be obtained regardless of the voltage.

The SIL curve is shown in Figure 5-2. This figure means that when SIL is 1 and the length of the transmission is 300 miles (480 km), the loadabilities of the transmission line are 910 MW/cct at 500 kV and 132 MW/cct at 230 kV, respectively. Also, when SIL is 1, the transmission lines of that length operate with very little or no reactive power supplied from either end, owing to the equalisation of stored inductive and capacitive energy that oscillates between the magnetic and electric fields of the transmission line. However, suppose the power flow becomes a heavily loaded condition, the reactive power consumption increases, and the power system voltage drops. Therefore, the reactive power should be compensated to maintain the power system voltage.

Based on the above, this study assumes that the transmission line capacities are about 1,000 MW/cct at 500 kV and about 150 MW/cct at 230 kV, respectively. When converted into the annual capacity, it is about 8.8 TWh/year at 500 kV and 1.3 TWh/cct at 230 kV.



Figure 5-2 Curve of Surge Impedance Loading

Source: Dunlop, Gutman, and Marchenko (1979).

#### 5.3 Assumptions for Estimating the Construction Cost of Candidate Cross-Border Interconnections

The interconnections are assumed to be 500 kV except for (3) Vientiane–Bunkan of 230 kV double circuits per route (Table 5-1). The costs of substations are assumed to prepare switchyard facilities for double circuit transmission lines. Table 5-2 shows the set unit costs.

| 0.62 |
|------|
| 6.2  |
| 0.31 |
| 3.0  |
|      |

Table 5-2 Unit Prices for Transmission Lines and Substation Switchyard Facilities

Source: Authors.

The cost estimate for each section of the interconnections is shown in Table 5-3.

|   |   | Length                   | s/s    | T/L    | Total                          |                                  |                       | Length               | s/s      | T/L      | Total  |  |
|---|---|--------------------------|--------|--------|--------------------------------|----------------------------------|-----------------------|----------------------|----------|----------|--------|--|
|   |   | km                       | m.US\$ | m.US\$ | m.US\$                         |                                  |                       | km                   | m.US\$   | m.US\$   | m.US\$ |  |
| 1 | 500 kV MK. Pakbeng - (Mae Moh - Tha Tako) |                          |        |        | 5                              | 500 kV Roi Et - Chaiyap          |                       |                      |          |          |        |  |
|   | MK. Pakbeng                               |                          | 6.2    |        | 6.2                            |                                  | Roi Et                |                      | 6.2      |          | 6.2    |  |
|   |   | 95                       |        | 58.9   | 58.9                           |                                  |                       | 230                  |          | 142.6    | 142.6  |  |
|   | Border                                    |                          | 12.4   |        | 12.4                           |                                  | Chaiyaphum            |                      | 6.2      |          | 6.2    |  |
|   |   | 170                      |        | 105.4  | 105.4                          |                                  | Total                 | 230                  | 12.4     | 142.6    | 155    |  |
|   | Mae Moh                                   |                          | 12.4   |        | 12.4                           | 6                                | 500 kV Chaiyaphum - T | 'ha Tako             |          |          |        |  |
|   |   | 150                      |        | 93     | 93                             |                                  | Chaiyaphum            |                      | 6.2      |          | 6.2    |  |
|   | (Mae Moh - Tha Tako                       | <b>)</b> )               | 6.2    |        | 6.2                            |                                  |                       | 160                  |          | 99.2     | 99.2   |  |
|   | Total                                     | 415                      | 37.2   | 257.3  | 294.5                          |                                  | Tha Tako              |                      | 6.2      |          | 6.2    |  |
| 2 | 2 500 kV (Mae Moh - Tha Tako) - Myanmar   |                          |        |        | Total                          | 160                              | 12.4                  | 99.2                 | 111.6    |          |        |  |
|   |   |                          | 6.2    |        | 6.2                            | 7                                | 500 kV Tha Tako - (Ma | e Moh - <sup>-</sup> | Tha Tako | <b>)</b> |        |  |
|   |   | 180                      |        | 111.6  | 111.6                          |                                  | Tha Tako              |                      | 6.2      |          | 6.2    |  |
|   | Myawady                                   |                          | 12.4   |        | 12.4                           |                                  |                       | 150                  |          | 93       | 93     |  |
|   |   | 400                      |        | 62     |                                |                                  | Middle between Mae    |                      | 6.2      |          | 6.0    |  |
|   |   | 100                      | 100    |        | 62                             |                                  | Mo & Tha Tako         | 6.                   |          |          | 6.2    |  |
|   | Mawlamyaing                               |                          | 6.2    |        | 6.2                            |                                  | Total                 | 150                  | 12.4     | 93       | 105.4  |  |
|   | Total                                     | 280                      | 24.8   | 173.6  | 198.4                          | 8                                | 500 kV Chaiyaphum - B | ı - Banteay Meanchey |          |          |        |  |
| 3 | 230 kV Vientiane - Bu                     | 30 kV Vientiane - Bunkan |        |        | Chaiyaphum                     |                                  | 6.2                   |                      | 6.2      |          |        |  |
|   | Thabok                                    |                          | 3      |        | 3                              |                                  |                       | 200                  |          | 124      | 124    |  |
|   |   | 58.03                    |        | 17.99  | 17.9893                        |                                  | Nakhon Ratchasima     |                      | 12.4     |          |        |  |
|   | Bungkan                                   |                          | 3      |        | 3                              |                                  |                       | 180                  |          | 111.6    | 111.6  |  |
|   | Total                                     | 58.0                     | 6.0    | 17.99  | 24.0                           |                                  | Banteay Meanchey      |                      | 6.2      |          | 6.2    |  |
| 4 | 4 500 kV Xekong - Roi Et                  |                          |        | Total  | 380                            | 24.8                             | 235.6                 | 248                  |          |          |        |  |
|   | Xekong 6.2                                |                          |        | 6.2    | 6.2 9 500 kV Thanh My - Xekong |                                  |                       |                      |          |          |        |  |
|   |   | 128                      |        | 79.36  | 79.36                          |                                  | Thanh My              |                      | 6.2      |          | 6.2    |  |
|   | Lak25                                     |                          | 12.4   |        | 12.4                           |                                  | ·                     | 43                   |          | 26.66    | 26.66  |  |
|   |   | 60                       |        | 37.2   | 37.2                           |                                  | Monsoon Wind Farm     |                      | 12.4     |          | 12.4   |  |
|   | Ubon Ratchathani                          |                          | 12.4   |        | 12.4                           |                                  |                       | 65                   |          | 40.3     | 40.3   |  |
|   | -   | 180                      |        | 111.6  | 111.6                          |                                  | Xekong                |                      | 6.2      |          | 6.2    |  |
|   | Roi Et                                    |                          | 6.2    |        | 6.2                            |                                  | Total                 | 108                  | 24.8     | 66.96    | 91.76  |  |
|   | Total                                     | 368                      | 37.2   | 228.2  | 265.36                         | 55.36 Transmission Highway total |                       |                      |          |          |        |  |
|   | · · · · ·                                 |                          |        |        |                                | Including Thailand domestic      |                       |                      |          | 1,494.0  |        |  |
|   |   |                          |        |        |                                | Without Thailand domestic        |                       |                      |          | 1,122.0  |        |  |

Table 5-3 Costs of Each Section of Interconnections

Source: Authors.

#### 5.4 Overview of Each Transmission Line Route

#### 5.4.1 Route (1): 500 kV MK. Pakbeng – (Mae Moh–Tha Tako)

MK. Pakbeng in the Lao PDR is a planned IPP and, although not a definite project, is a strong candidate for export to Thailand. MK. Pakbeng will likely be connected to EGAT's Mae Moh substation by a 500 kV export-dedicated transmission line. Four 500 kV circuits are currently operating from Mae Moh to Tha Tako. In this project plan, a new switching station from Mae Moh to Tha Tako and a new transmission line from the Mae Moh substation to this switching station are planned to be built. The power will flow from MK. Pakbeng to EGAT. In the rainy season, the surplus power from the Lao

domestic grid will be added to MK. Pakbeng. During the dry season, the amount of electric power transmitted to Thailand will be less because the electric power will be supplied to the domestic grid of the Lao PDR.



Figure 5-3 500 kV MK. Pakbeng – (Mae Moh–Tha Tako)

Source: Authors.

#### 5.4.2 Route (2): 500 kV (Mae Moh-Tha Tako) - Mawlamyaing

This transmission line is an interconnection between the grids of EGAT and the Department of Power Transmission and System Control in Myanmar. A 230 kV transmission line was completed between Mawalamyaing and Myawaddy in Myanmar. This project assumes constructing a new 500 kV transmission line from the switching station on the route from Mae Moh to Tha Tako to Mawlamyaing via Myawaddy. The power will flow from Thailand to Myanmar.





Source: Authors.

#### 5.4.3 Route (3): 230 kV Vientiane–Bunkan

This transmission line is a 230 kV interconnection between the systems of the EDL and EGAT. Currently, a 115 kV single circuit line operates from EDL's 115 kV Pakxan substation near Vientiane to the Bungkan substation in the EGAT system. In recent years, the power plant capacity of the EDL system increased, leading to a rise in the power flow of this interconnection. The project involves constructing a new 230 kV interconnected transmission line along the route of this transmission line. The power will flow from the Lao PDR to Thailand during the rainy season and from Thailand to the Lao PDR during the dry season.





Source: Authors.

#### 5.4.4 Route (4): 500 kV Xekong-Roi Et

Xepian–Xenamnoi's IPP is constructing a 500 kV Lak 25 substation in Champasak province, Lao PDR, and a 500 kV transmission line from Lak 25 to EGAT's Ubon substation. In addition, the transmission lines assumed for the project are those from Xekong province to Lak 25 in the Lao PDR and between Ubon and Loi Et. Thus, the transmission power will flow from the Lao PDR to Thailand.





Source: Authors.

# 5.4.5 Route (5): 500 kV Roi Et–Chaiyaphum, Route (6): 500 kV Chaiyaphum–Tha Tako, Route (7): 500 kV Tha Tako – (Mae Moh–Tha Tako)

Routes (5), (6), and (7) in Table 5-1 are 500 kV transmission lines for transmitting power from the Lao PDR received in eastern Thailand to central and western Thailand. Some existing 500 kV lines were already constructed. And depending on the amount of the power flow, the existing lines could be used for the project.





Jource. Authors.

#### 5.4.6 Route (8): 500 kV Chaiyaphum–Banteay Meanchey

A 115 kV line connects Thailand and Cambodia. The new interconnection is assumed to be between the Cambodian border point of 115 kV interconnection and Nakhon Ratchasima. The transmission line between Chaiyaphum and Nakhon Ratchashima in Thailand is also a transmission line for the project. The power will flow from Thailand to Cambodia.



#### Figure 5-8 500 kV Chaiyaphum–Banteay Meanchey

Source: Authors.

#### 5.4.7 Route (9): 500 kV Thanh My-Xekong

There is a plan for a wind farm in Xekong province, Lao PDR. Our project assumes that the transmission line will consist of double circuits from the wind farm to the Thanh My substation in Viet Nam. The power will be transmitted to Viet Nam in addition to power from neighbouring domestic power plants on the domestic grid of the Lao PDR. The power will flow from the Lao PDR to Viet Nam.



Figure 5-9 500 kV Thanh My–Xekong

Source: Authors.