Power Systems Technology Center,
a Division of Manitoba Hydro International Ltd.

Harmonizing the Greater Mekong Sub region (GMS) Power Systems to Facilitate Regional Power Trade: Regional Power Master Plan

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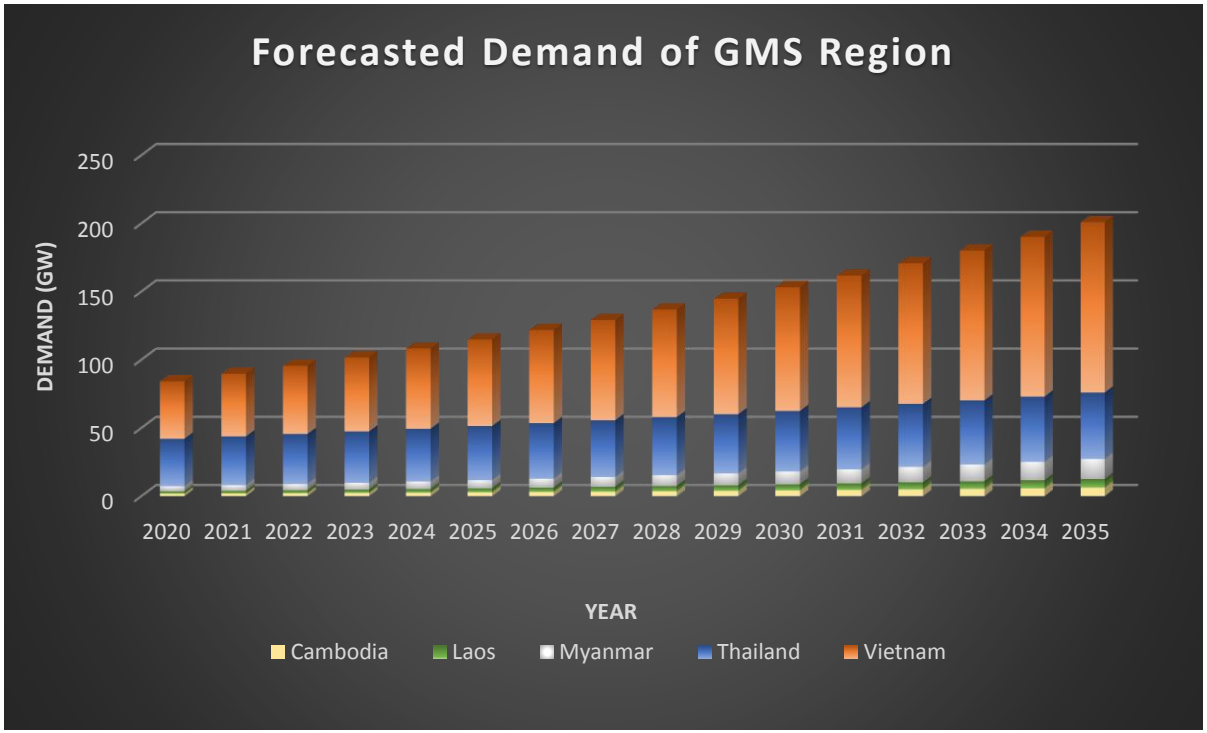
Outline

- Background
- Study Objectives and Methodology
- Regional Transmission Plan
  - Benefits of cross border power trade
- Regional Generation and Transmission Plan
  - Preliminary results
- Conclusions
- Remaining work and work plan

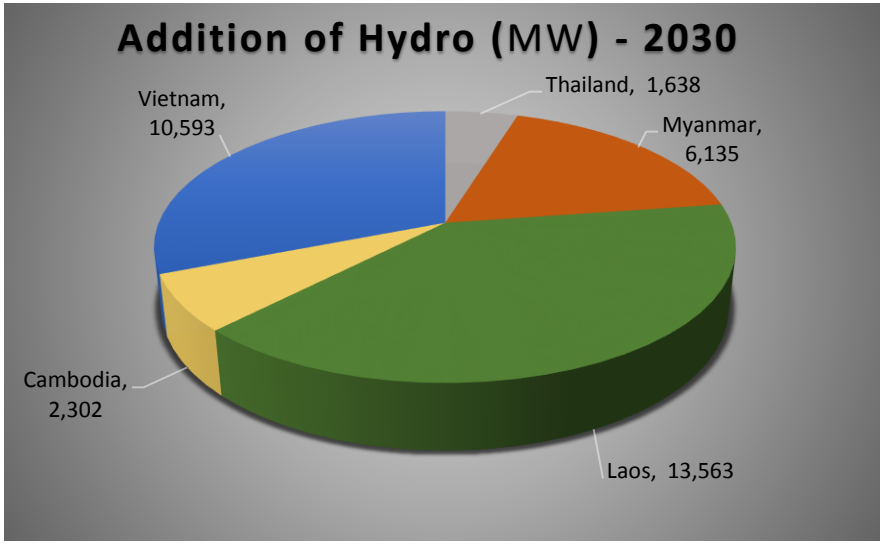
Background: GMS load demand

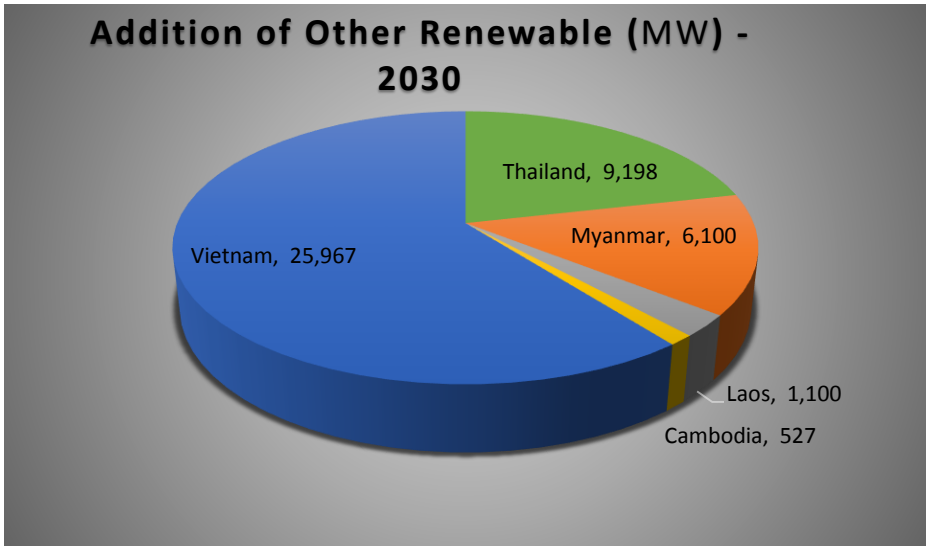


- Greater Mekong Sub (GMS) region has an increasing power demand.
  - Main contributors to the regional load demand are Thailand and Vietnam

Note: China (Yunnan and Guangxi provinces) is modeled as a single node with excess power for export.

Background: GMS renewable generation potential





- The load and the generation resources in the region are unevenly distributed.
  - Laos, Vietnam, Myanmar and Cambodia have high hydro power potentials whereas Vietnam and Thailand have high wind and solar potential.

Note: Above pie charts show how much hydro and other renewable (wind/ solar) generation is planned to be introduced by year 2030.

Background: Regional Power Trade

Moving towards import or export as a whole region will be economical than considering power development at country level or on bilateral basis. Cross-border regional power trade has several major benefits for the entire region.

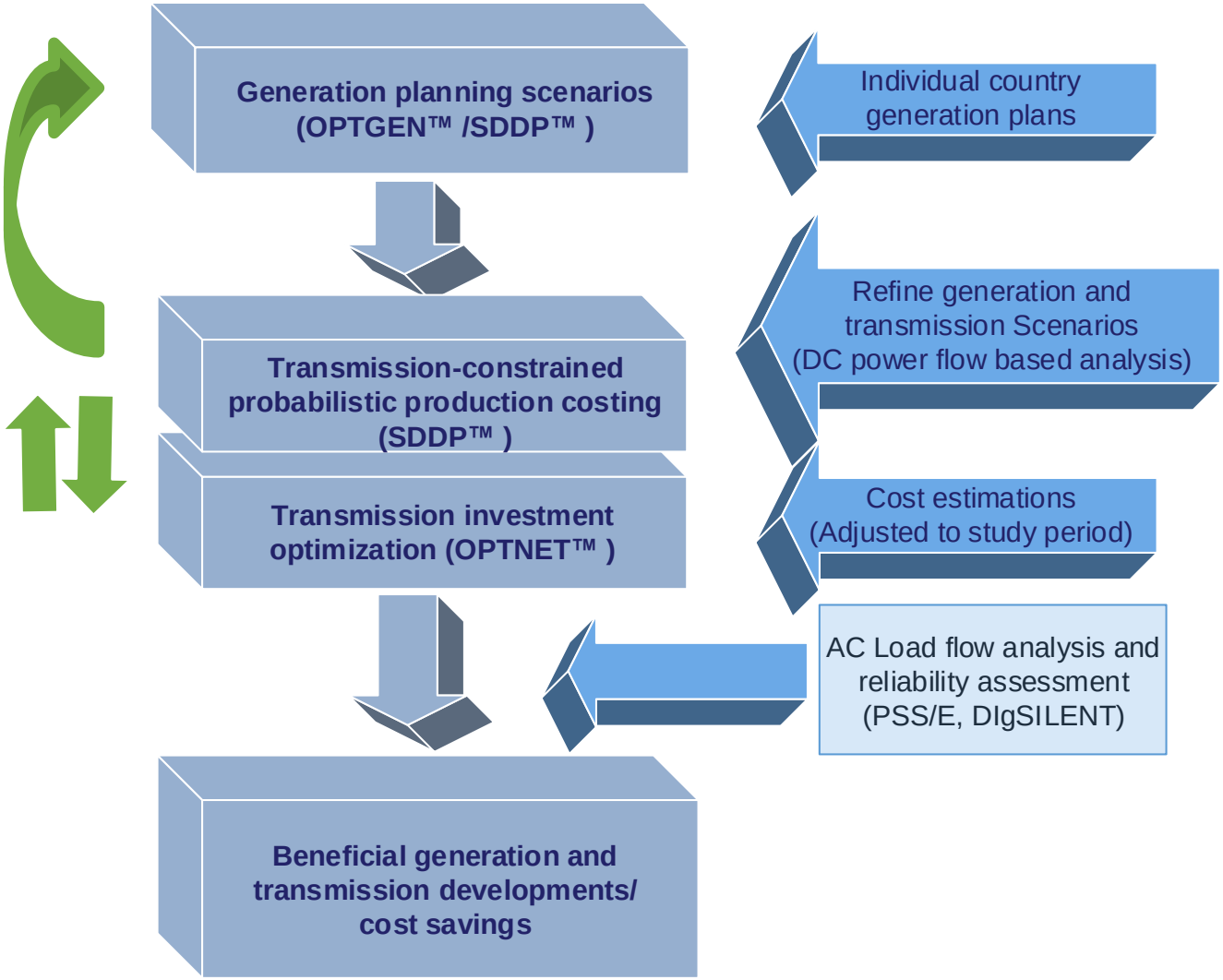
- Improved economic benefit to both power exporters and importers
- Minimizing Greenhouse Gas (GHG) emission
- Improvement in the quality and reliability of the regional power system
  - Shared reserves, improved frequency regulation, etc.

Study objectives

Development of the Generation/Transmission Development Master Plan for the power trade in the GMS region.

- Determine optimal regional generation planning scenarios (for the period from year 2022 to year 2035) based on individual country generation plans.
- Determine the optimal cross-border power transmission scenarios to facilitate generation plan for the study period from year 2022 to year 2030.
- Determine and rank most economically and technically feasible cross-border transmission expansions and corresponding regional generation development scenarios.

Study Methodology: Study Process



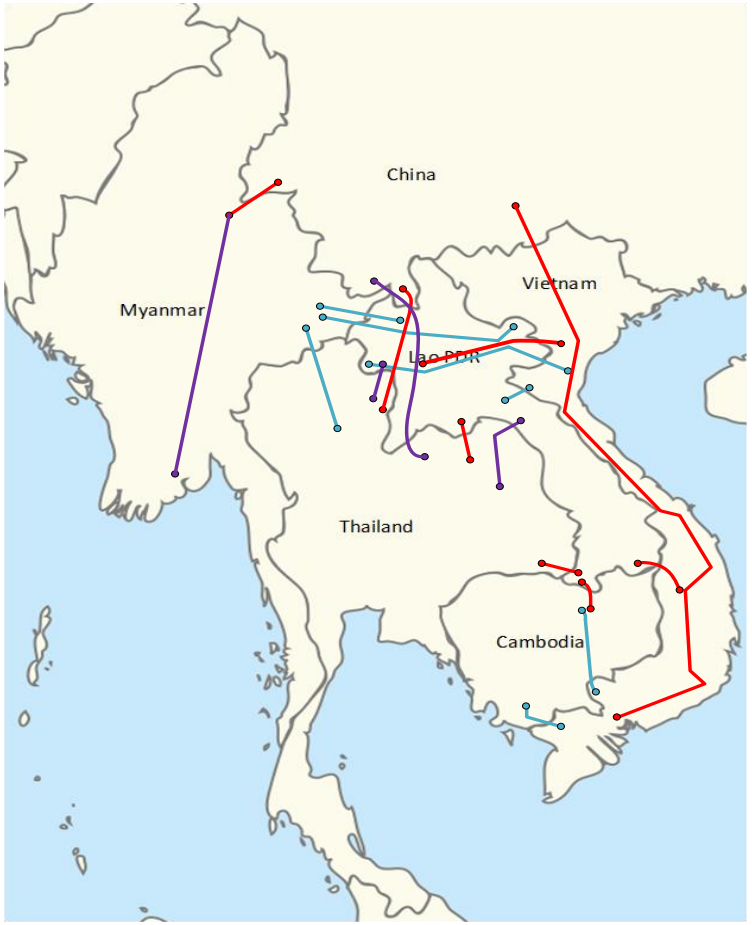
Study Results

- Preliminary transmission planning study (Preliminary check of cost savings)
  - Individual country generation plans were used (No further generation planning was performed)
  - Cross border transmission was modeled with each country was modeled with one or few nodes
  - Significant cost savings were identified
- Generation and transmission planning study
  - Individual country generation plans are modified in generation planning
  - Cross border transmission as well as bulk transmission corridors within the country were adequately modeled

Study Results:
Preliminary transmission planning study

Scenarios

- ❑ Scenario 1 - Base Case (Existing and Under Construction Cross-Border Interconnections)
- ❑ Scenario 2 – With Planned and Proposed Cross Border Transmission Interconnections
- ❑ Scenario 3 - Proposed underutilized interconnections removed
- ❑ Scenario 4 - Increased capacity of the highly utilized interconnections

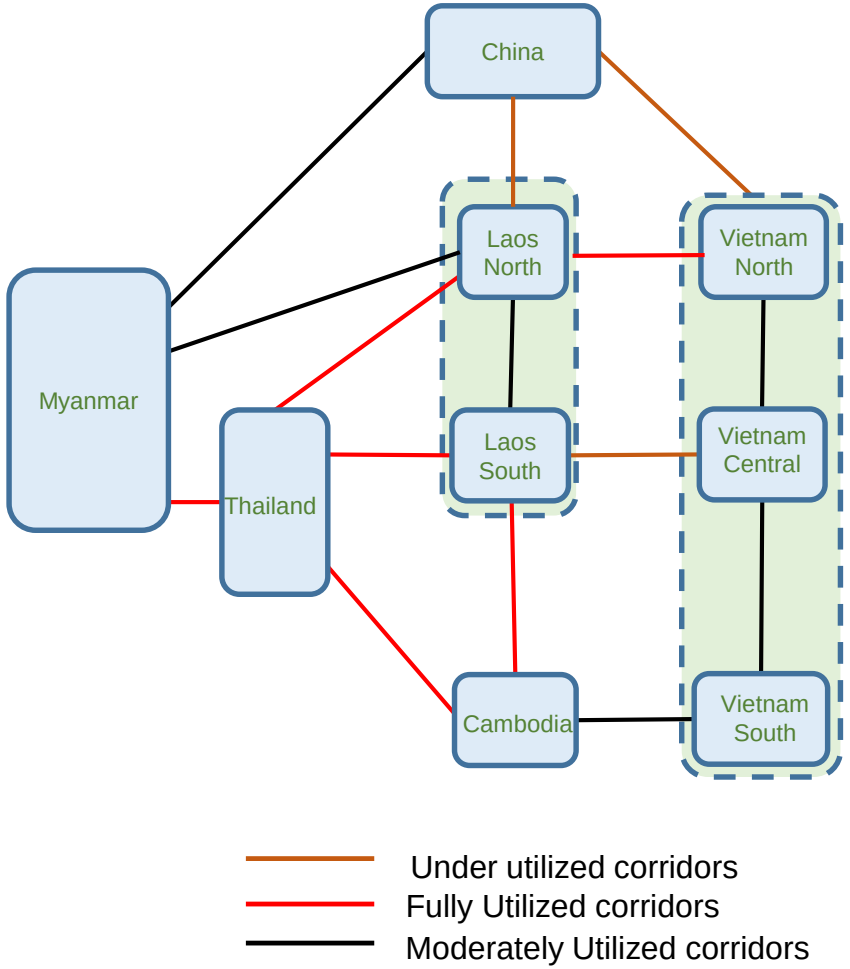


Existing/Planned and Potential Interconnections

Study Results:
Preliminary transmission planning study

- Main outcomes (study year 2025)

Scenario Name	Season	Operational Cost ($ Billions)	Annual Operational Cost ($ Billions)
Scenario 1 (Base Case)	Wet	15.2	34.5
	Dry	19.3	
Scenario 2	Wet	13.6	31.0
	Dry	17.4	
Scenario 3	Wet	13.6	31.3
	Dry	17.7	
Scenario 4	Wet	11.1	27.7
	Dry	15.6	

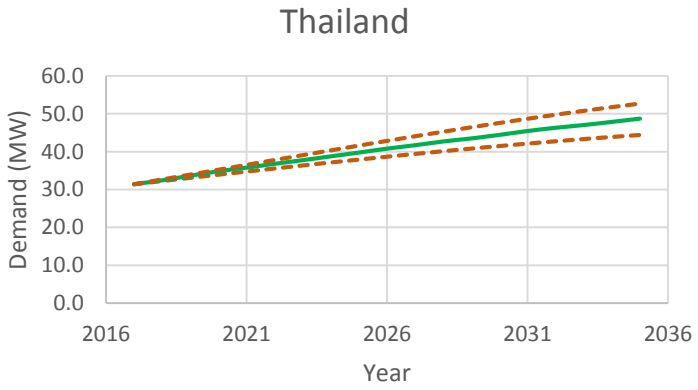


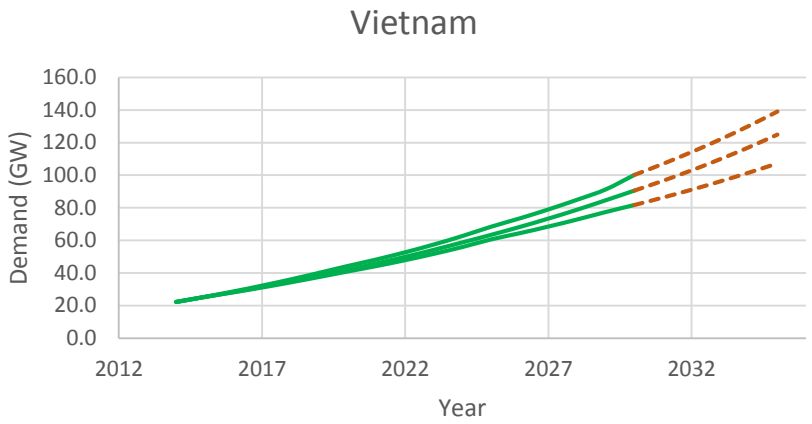
- Increasing cross-border interconnections reduces the operational cost of the region by $3.5 -6.8 Billion
- Further analysis is required to develop power trade master plan

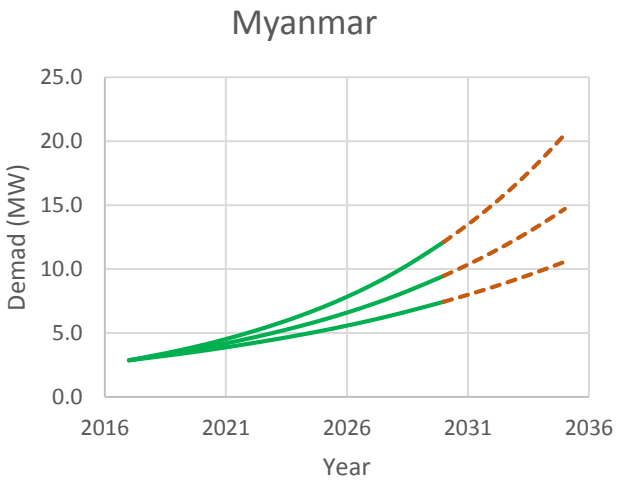
Modelling:

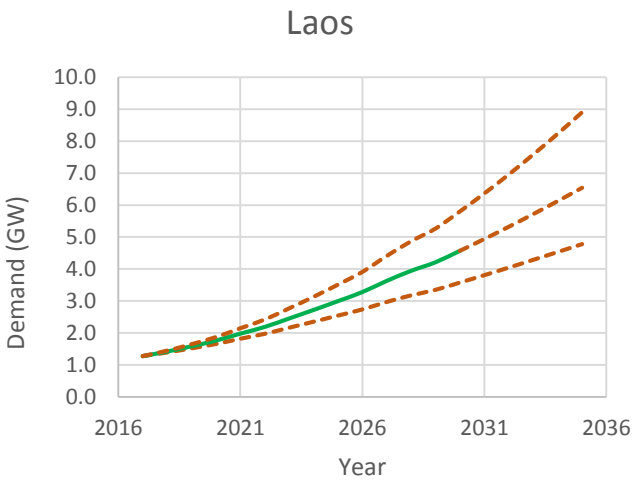
Generation and transmission planning

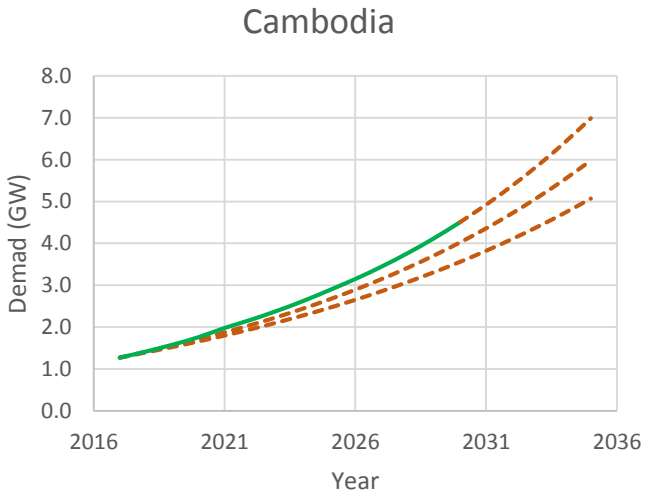
Load forecast









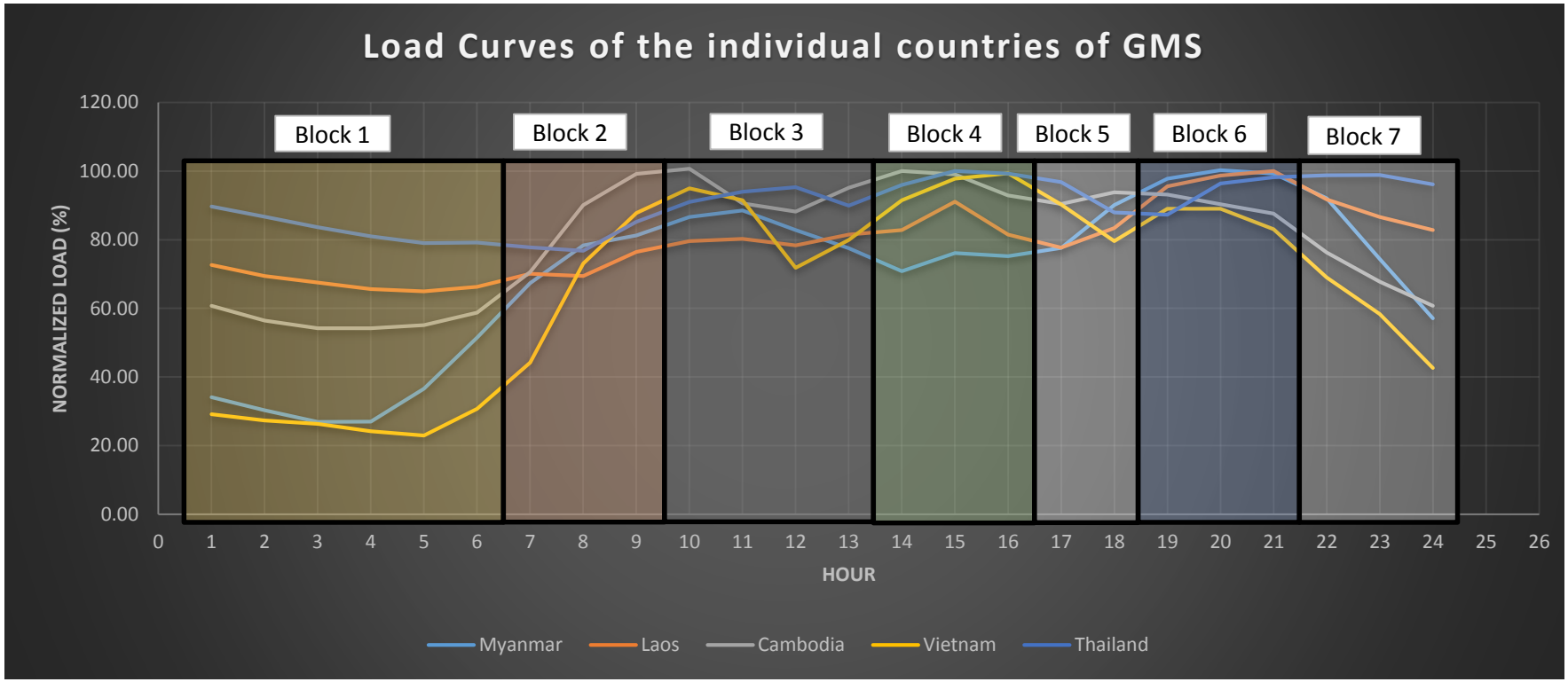


Note: Thailand High & low load growth scenarios obtained by scaling the medium load growth data. Cambodia medium & low load growth scenarios are obtained by reducing the high growth scenario.

Modelling:

Generation and transmission planning study

Load Blocks



Block	1	2	3	4	5	6	7
Hours	(1-6)	(7-9)	(10-13)	(14-16)	(17-18)	(19-21)	(22-24)

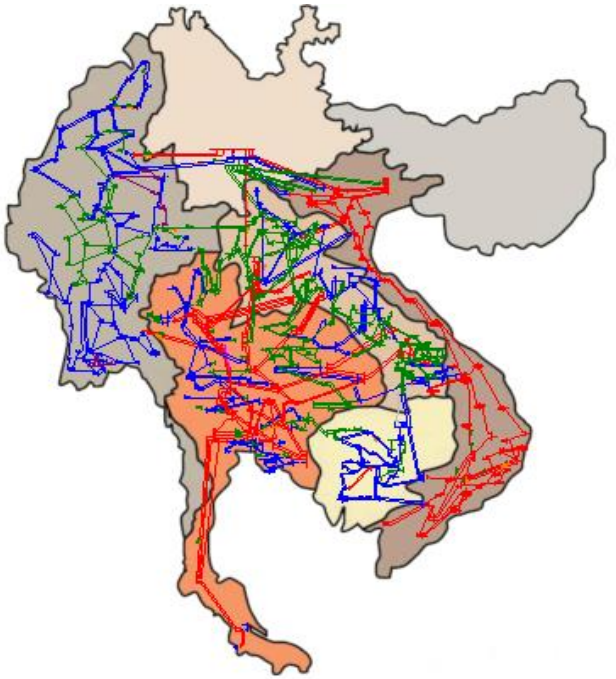
- 7 Load blocks are selected to capture load curve characteristics of each country & availability of renewables (day/night)

Modelling:

Generation and transmission planning

Regional network model

- Transmission system model for GMS region
  - More than 650 buses and 1500 lines
  - A complete load flow model (PSS®E)
- Simplified model for Stochastic Transmission planning (SDDP/OPTNET)
  - Around 200 buses
  - Retain P-δ characteristics and thermal limits of main corridors



Country	Number of Buses			
	500 kV	230 kV	115<230 kV	Total
Vietnam	53	8	3	64
Thailand	31	109	140	280
Laos	16	35	82	133
Myanmar	2	71	41	114
Cambodia	2	28	31	62
Total	**104**	**251**	**298**	**653**

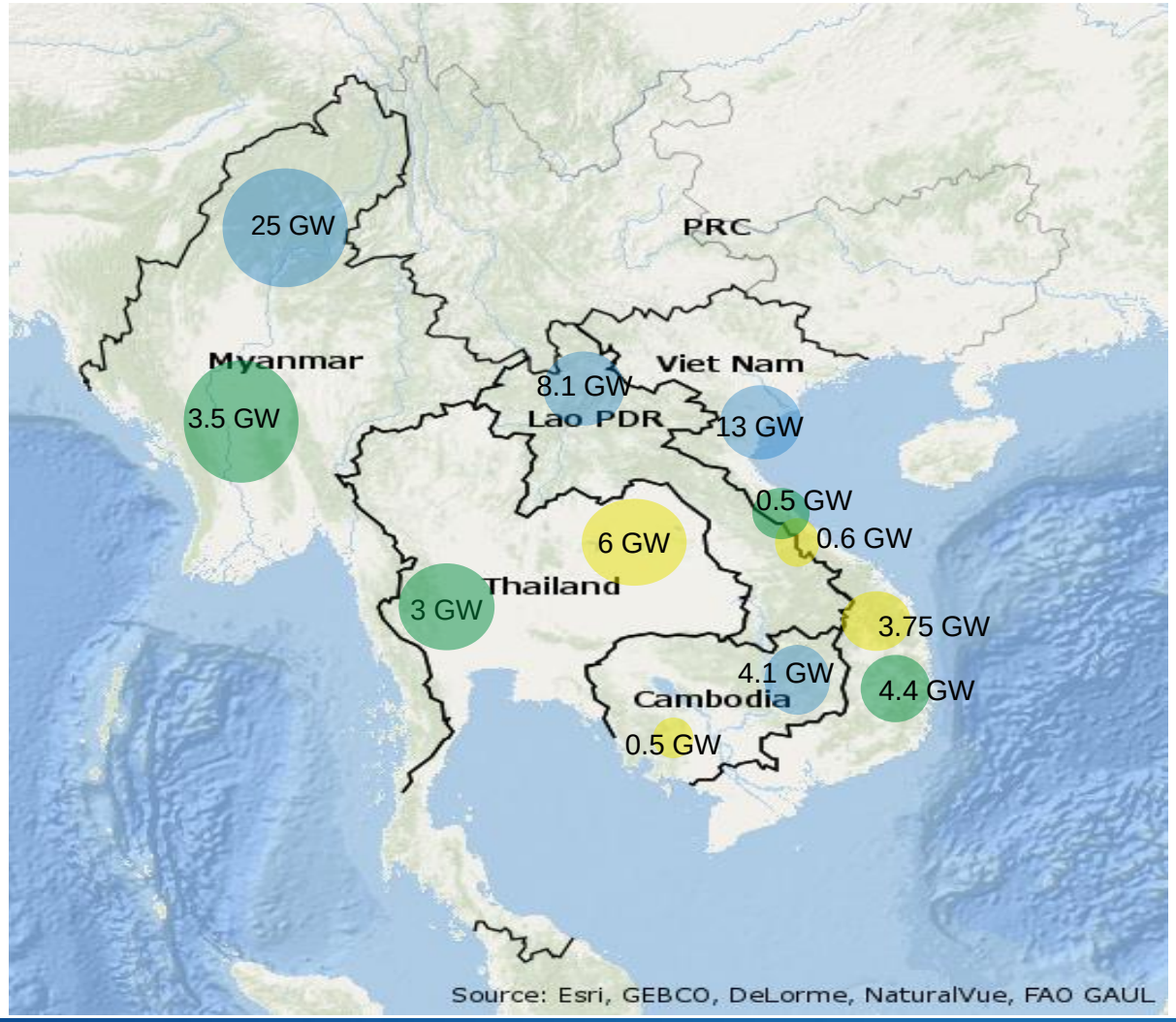
Regional network model for generation planning

- Model for Generation expansion planning (OPTGEN/SDDP)
  - Around 30 buses
  - Retain thermal limits of main transmission corridors

Modelling:

Generation and transmission planning

Planned/ Potential generation



Legend:

- Planned/Potential Hydro
- Planned/ Potential Solar
- Planned/ Potential Wind

Study Results:
Generation and transmission planning

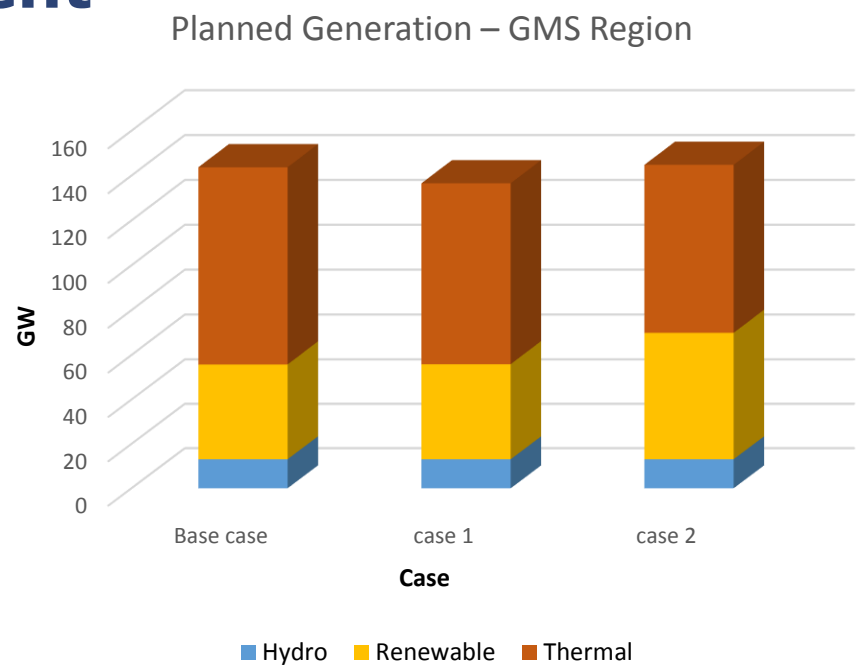
Preliminary results

- Base case
  - Potential generation added based on planning data from individual countries
  - Existing and already planned cross-border interconnections

- Alternate case 1 (High cross-border transfer)
  - 12 candidate cross-border interconnections are added to base case
- Alternate case 2 (Low cost of renewable technology)
  - 5 GW and 12 GW of candidate wind/solar generation added to Thailand and Vietnam systems respectively to alternate case 1.

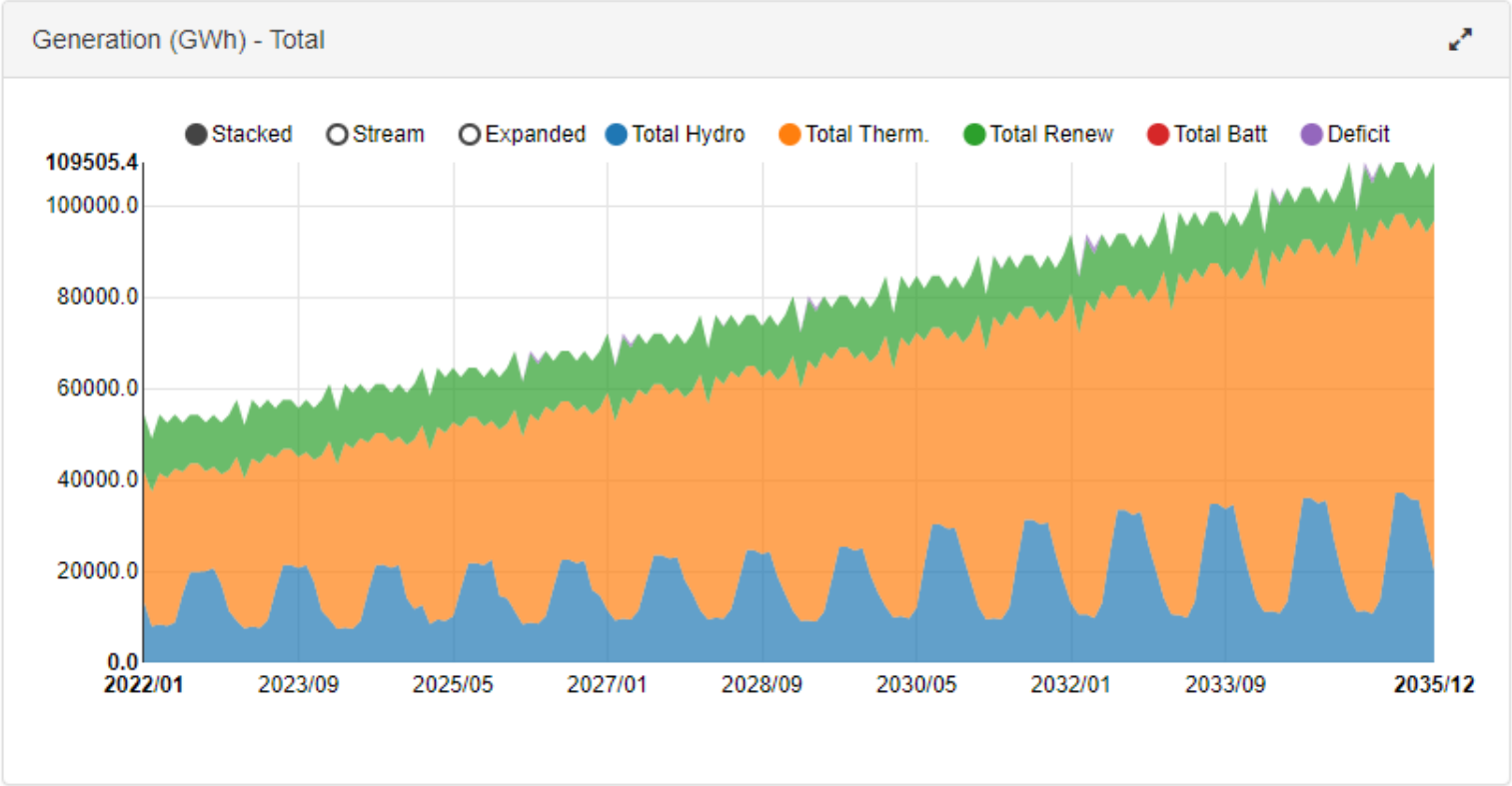
Note: Medium Load growth scenario is used for the analysis

Preliminary results: Regional generation development



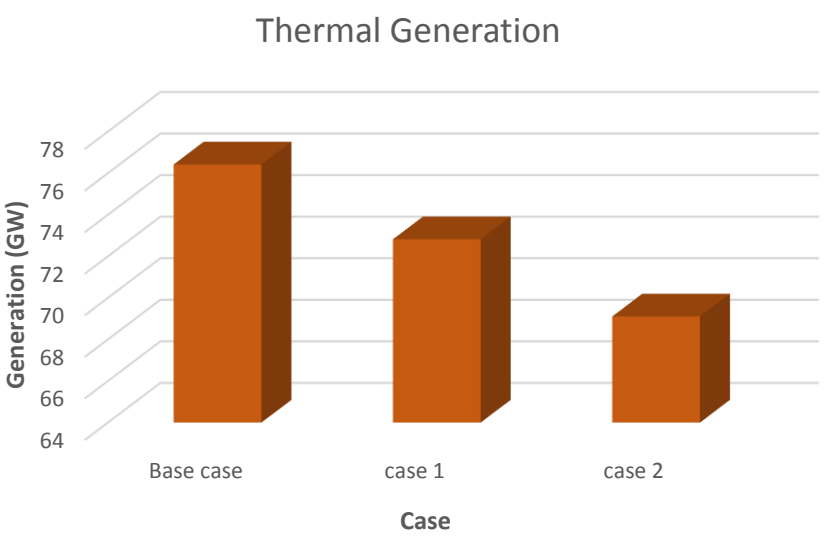
- Generation development in case 1 is less than base case due to better utilization of regional generation using improved cross-border interconnections
- More renewable generation built in case 2 as expected

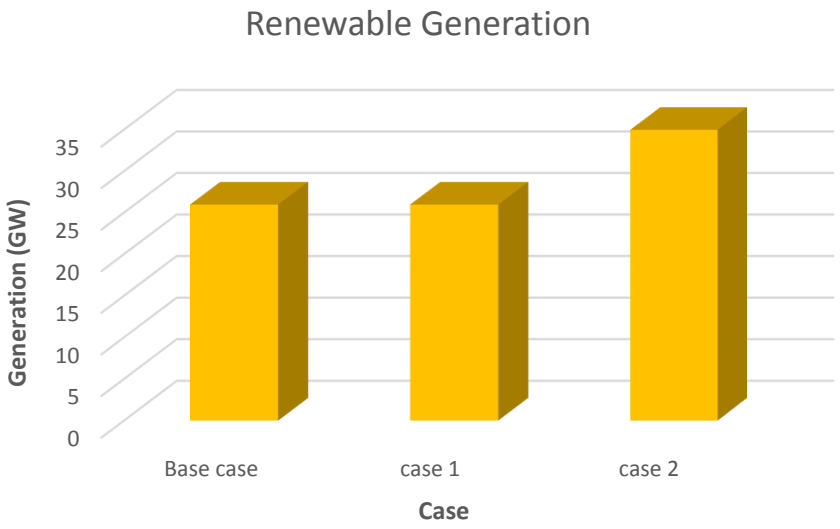
Preliminary results: Regional generation development



Base case

Preliminary results: Generation development in Vietnam





- Thermal generation reduced in case1 as imports increase
- Mainly Laos-Vietnam and China – Vietnam candidate interconnections are selected to be build in optimization for case 1 and case 2
- Total of about 7 GW of cross-border interconnections were selected in case 1 and case 2

Data requirement:
Generation and transmission planning

- Policy Decisions by individual countries
  - Generation development directions (e.g. high VRE penetration, reduce fossil fuel based generation)
  - Provision of subsidies to certain technologies
- Historic fuel price/ sale price variation of generation for individual countries
- Potential cross-border interconnections and power sales prices between countries
- Box prices for generation/transmission upgrades
- Additional data on availability of Wind, solar and hydro (seasonal water discharge variation, annual and daily variation of wind solar)

Conclusions

- Simplified transmission planning studies showed significant benefit in cross-border power trade. This requires further analysis with adequate details of the regional network.
- A high voltage transmission network model is developed for the GMS region to be used in planning studies.
- Number of scenarios are identified to capture the uncertainties regarding generation development of the GMS region.
- Preliminary regional generation and transmission planning studies are carried out for several scenarios with the use of generation plans of individual countries.
  - The generation developments were better utilized with development of cross-border interconnections
  - Lower wind and solar costs would reduce the development of thermal generation

Remaining work

- Collect additional data to improve the accuracy/uncertainty
- Complete analysis of critical generation planning scenarios for GMS region
  - Analyze optimized generation planning scenarios and group them for further analysis
  - Identify representative generation planning scenarios to be used in transmission planning
- Identify credible cross border transmission solutions
  - Identify the most economical and technically feasible transmission scenarios, corresponding upgrades and generation development
- Verify overall plan using the regional transmission system model (PSS®E)
- Final study report

Work Plan

	Action	Timeline
1	Send questionnaire to member countries requesting additional data ❑ To improve the accuracy and reduce uncertainties associated with the study results	April, 2019
2	Visit member counties for discussions ❑ Meet relevant authorities and ADB local representatives ❑ Gather additional data ❑ Discuss specific directions/requirements	May, 2019
3	Preliminary draft report	October, 2019
4	Final draft report	December, 2019

Thank You