






# Regional Power Master Plan

## Harmonizing the Greater Mekong Sub region (GMS) Power Systems to Facilitate Regional Power Trade

Dharshana Muthumuni
Bathiya Jayasekara

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

mhi.ca

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# Outline

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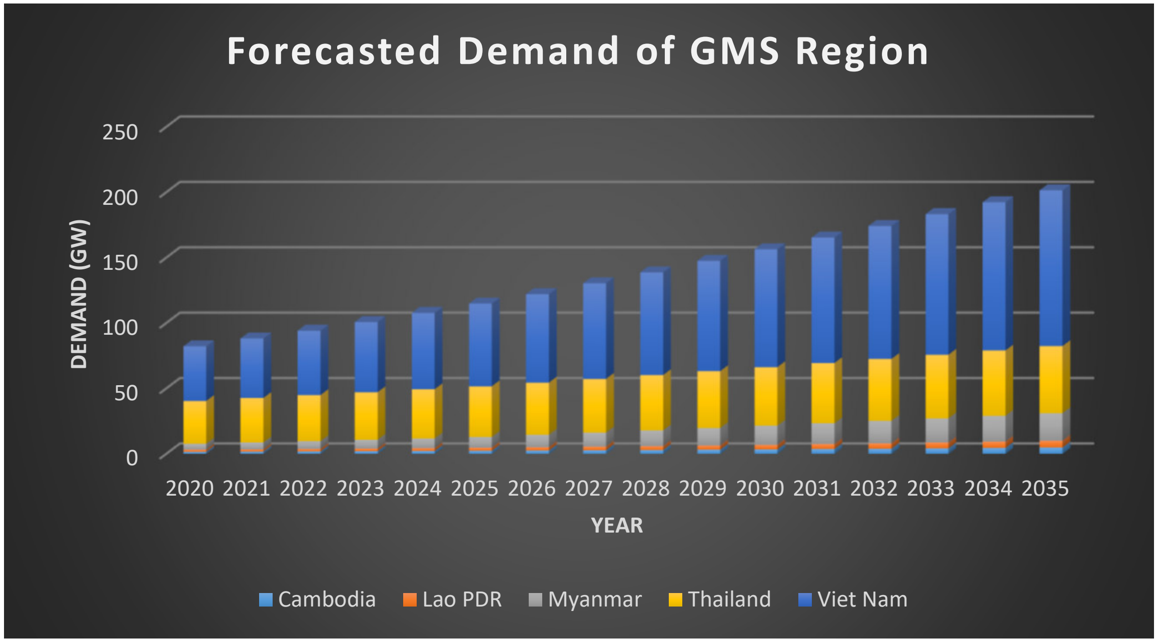
- ❑ Project Background
- ❑ Study Objectives and Methodology
- ❑ GMS Study Model and Scenarios
- ❑ Selected Results
  - Summary of Cost Benefit
  - Benefits of Cross-border Power Trade/ VRE Development
  - Summary of Regional Generation & Transmission Plans
- ❑ Key Study Outcomes

# Project Background

# Project Background – Expected Load Growth




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

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

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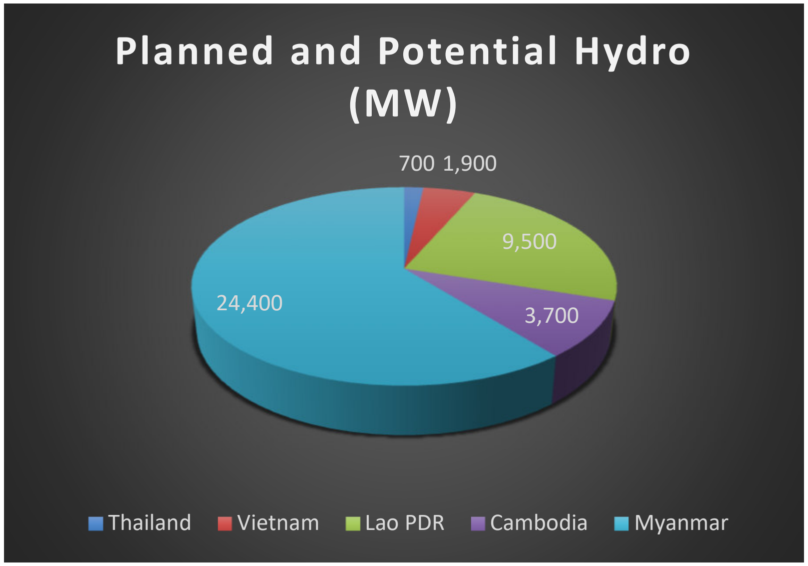
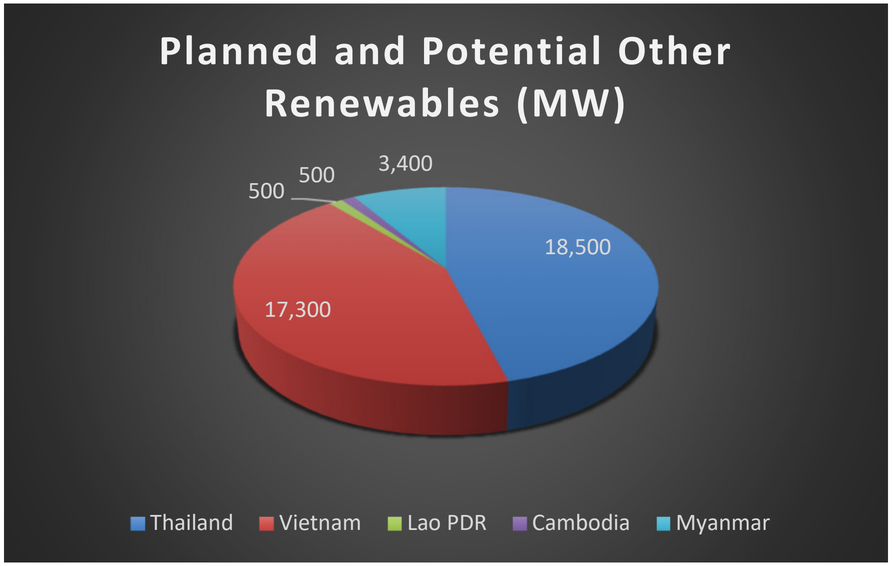
# Project Background




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

# Study Objectives and Methodology

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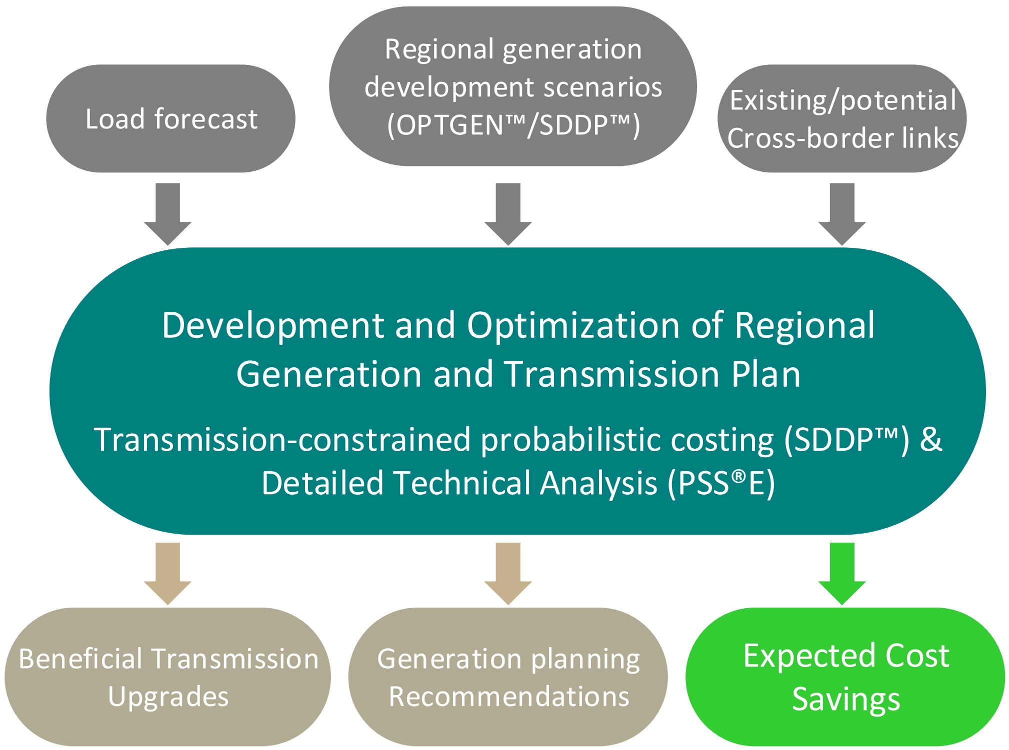
# Study Objectives

- The main objective of this project is to perform studies to develop a regional generation and transmission master plan for the Greater Mekong Sub-Region (GMS).
  - Determine **optimal regional generation planning scenarios** (for the period from year 2022 to year 2035).
  - Determine the **optimal cross-border power transmission scenarios** to facilitate generation plan for year 2022 to 2030.
  - Perform PSS®E based load flow studies to verify the technical feasibility of the proposed plans and identify additional system upgrades (if required).
  - Determine the **most 'economically' and technically feasible** cross-border transmission expansion plans and corresponding regional generation development scenarios.

# Study Methodology

- Load forecast, existing generation plans and cross-border power trade plans are used to develop the regional generation and transmission plan

**Key inputs and expected outcomes of regional plan development**



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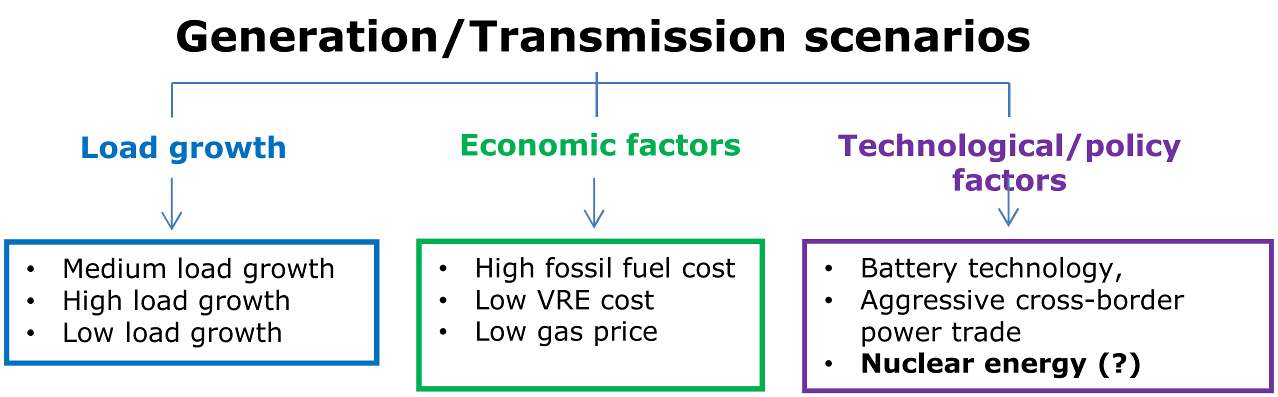
# Study Methodology

- A number of regional generation development scenarios are developed to include the uncertainty associated with the data inputs to generation/transmission plan
- Uncertainty in load growth, economic, technological and policy related factors are considered in the analysis.



# GMS Regional Study Model and Scenarios

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# OPTGEN™/SDDP™ Study model - Scenarios

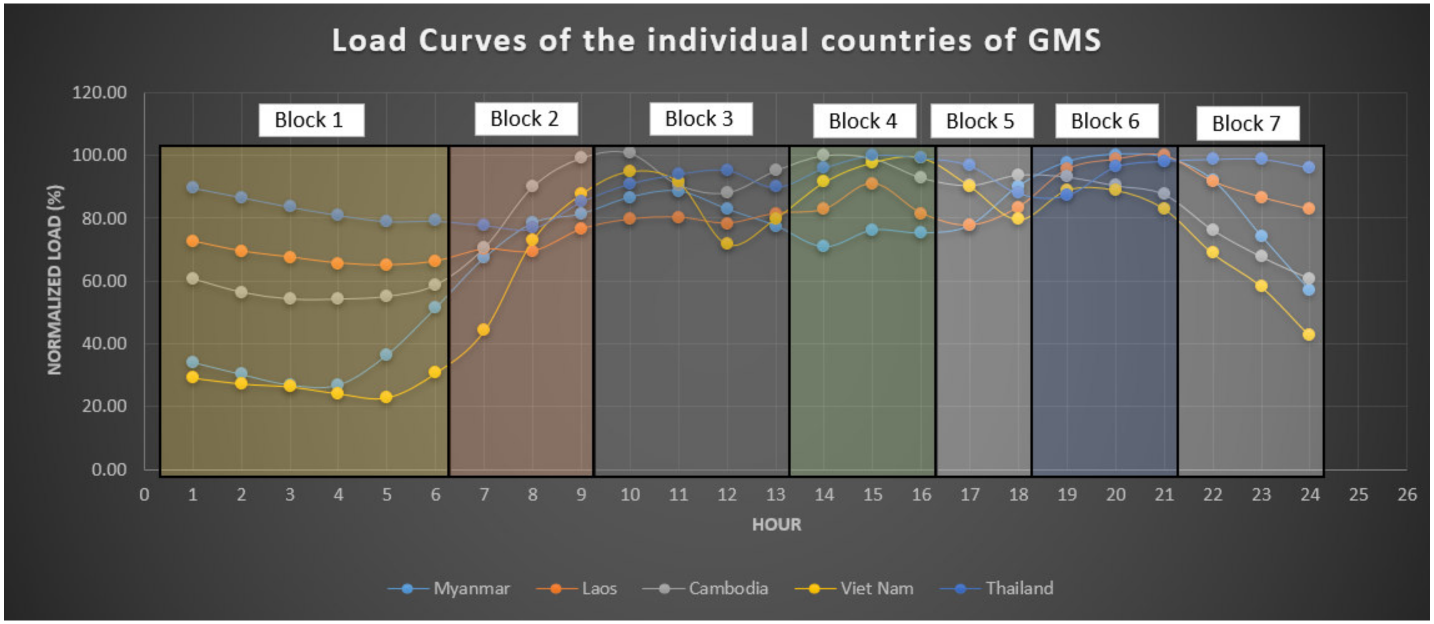
- 33 (11 x 3) main study scenarios were used to account for the uncertainty in

| Scenario Summary | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Economic factor | Technological/Policy factor | | | | | | | | | | | |
| | Base | | | Solar-battery storage | | | Nuclear | | | High cross-border power trade | | |
| **Base** | **M** | **H** | **L** | M | H | L | M | H | L | M | H | L |
| **VRE cost reduced** | M | H | L | M | H | L | | | | M | H | L |
| **High fossil fuel price** | M | H | L | | | | M | H | L | M | H | L |
| **Low gas price** | M | H | L | | | | | | | | | |

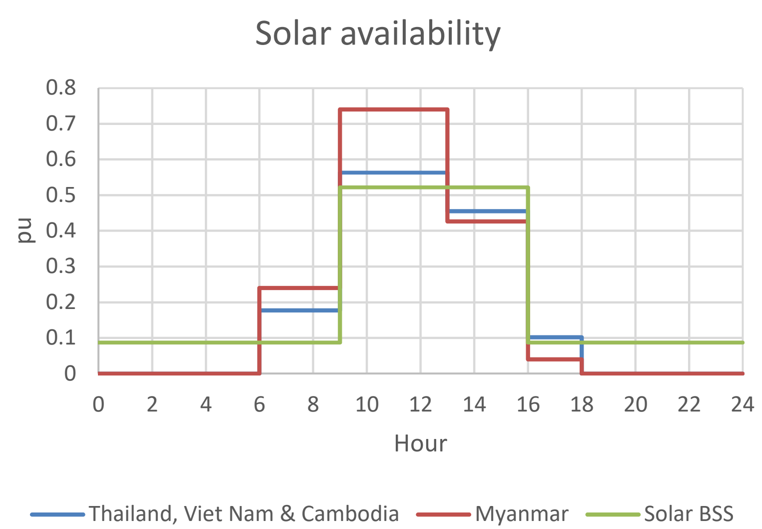
- ***Base* study scenarios** are developed assuming the most likely generation and transmission development options (Based on current generation plans – optimized transmission considering cross border power trade)
- In addition, **3 *reference* study scenarios** are developed for comparison of costs
  - Generation and transmission development inputs are same as 'Base' study scenarios
  - No transmission optimization (only the existing/planned transmission links)

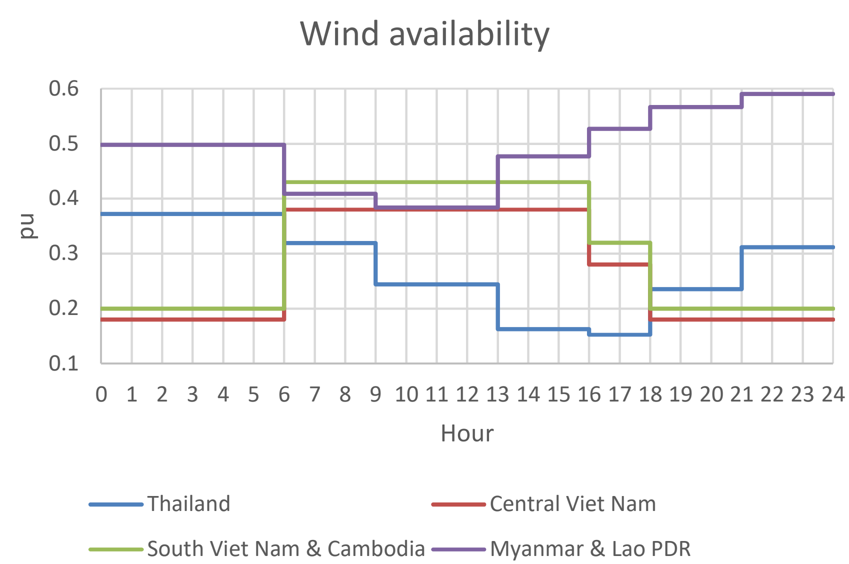
# OPTGEN™/SDDP™ Study model – Representation of load

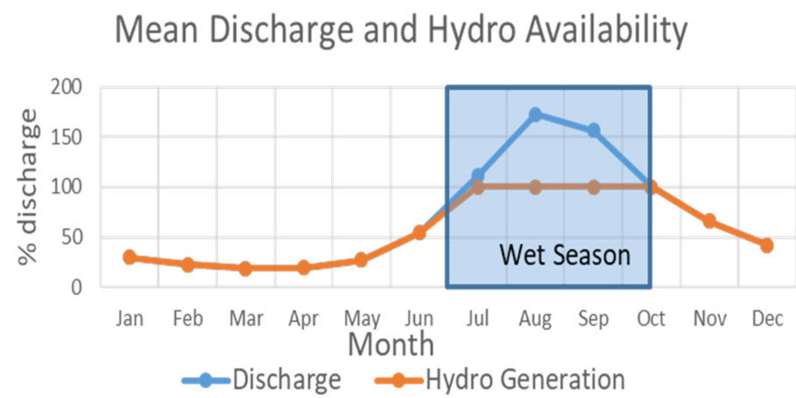
- The discretized daily load curve was modeled using 7 load “blocks”



# OPTGEN™/SDDP™ Study model – Availability of Renewable based generation



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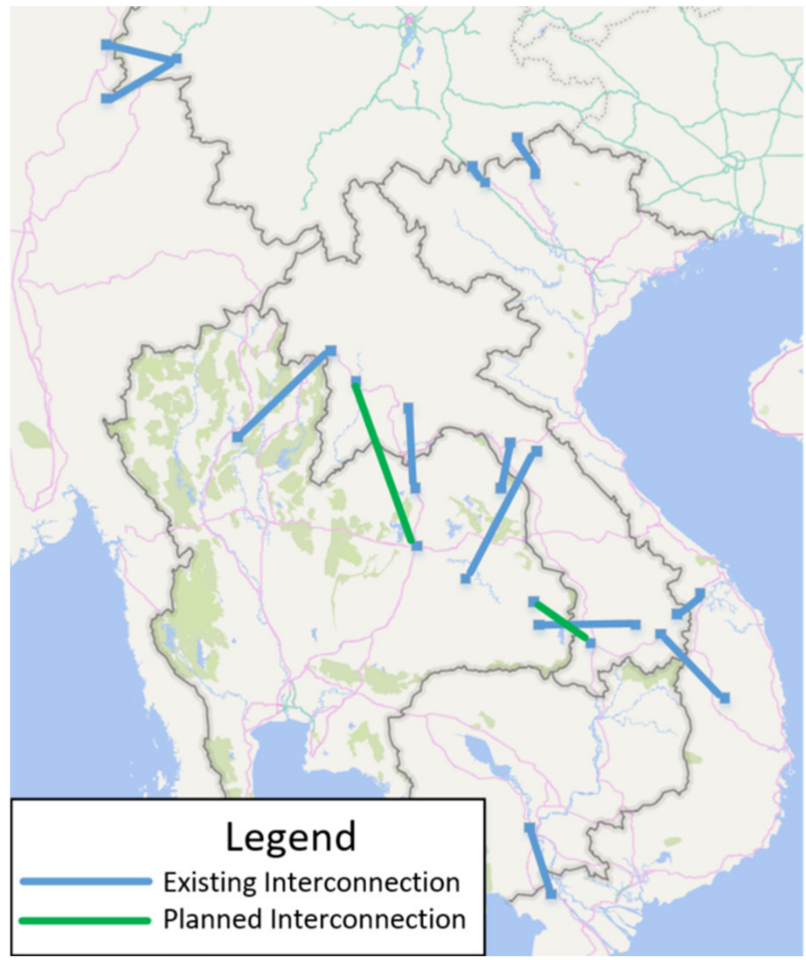
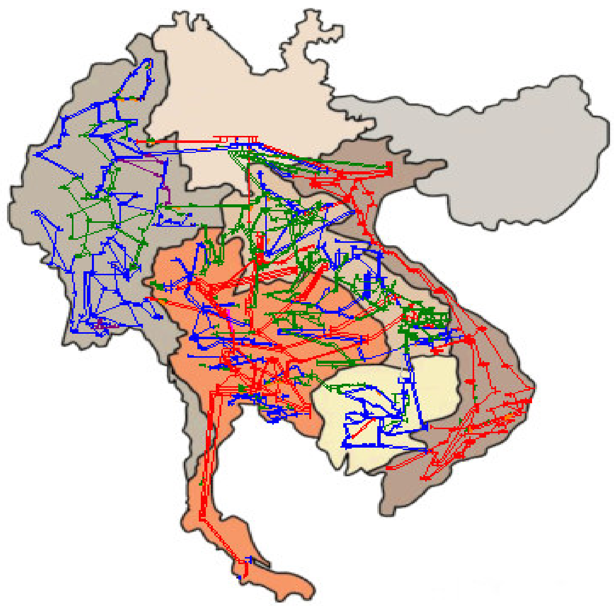
# OPTGEN™/SDDP™ Study model – Lines

- Existing Cross-border transmission lines
- Planned Cross-border transmission lines
- Only 220 kV and above



# PSS®E Study model

- Complete 500 kV and the relevant 230/220 kV and 110/115 kV networks.
- Detailed analysis including AC load flow based reliability studies
- Base scenario and selected scenarios are studied
- Study year - 2030



**Detailed bulk transmission model**

# Selected Results

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# Cost Benefit Summary

| Medium Demand Growth Scenarios Cost Savings (B$) | | | | |
|---|---|---|---|---|
| Economic factor | Technological/Policy factor | | | |
| | Base | Solar-battery storage | Nuclear | High cross-border power trade |
| Base | 18 | 18 | 18 | 27 |
| VRE cost reduced | 20 | 20 | | 29 |
| High fossil fuel price | -10 | | -10 | 0 |
| Low gas price | 31 | | | |

| Color code |
|---|
| >20 B$ |
| 10-20 B$ |
| <10 B$ |

| High Demand Growth Scenarios Cost Savings (B$) | | | | |
|---|---|---|---|---|
| Economic factor | Technological/Policy factor | | | |
| | Base | Solar-battery storage | Nuclear | High cross-border power trade |
| Base | 25 | 24 | 25 | 37 |
| VRE cost reduced | 26 | 27 | | 39 |
| High fossil fuel price | -8 | | -6 | 6 |
| Low gas price | 39 | | | |

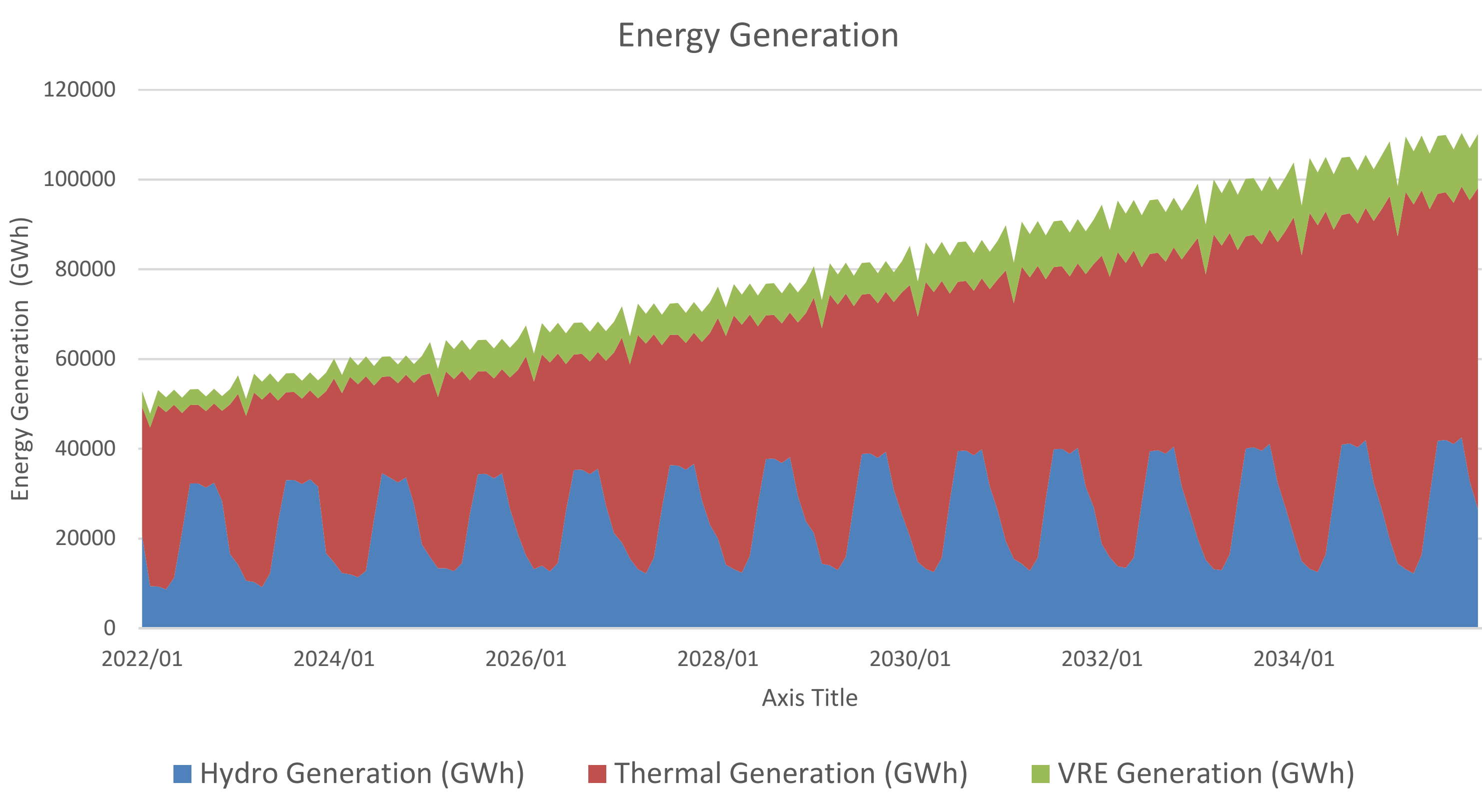
| Color code |
|---|
| >30 B$ |
| 10-30 B$ |
| <10 B$ |

| Low Demand Growth Scenarios Cost Savings (B$) | | | | |
|---|---|---|---|---|
| Economic factor | Technological/Policy factor | | | |
| | Base | Solar-battery storage | Nuclear | High cross-border power trade |
| Base | 18 | 18 | 18 | 28 |
| VRE cost reduced | 19 | 19 | | 29 |
| High fossil fuel price | -7 | | -7 | 4 |
| Low gas price | 28 | | | |

| Color code |
|---|
| >20 B$ |
| 10-20 B$ |
| <10 B$ |

# Annual Progression of Energy Usage

**Base study scenario – Medium load growth**



# Summary of regional transmission plans

| Year | From | To | Connection Points | Type | Capacity | CAPEX (2022 NPV M$) |
|---|---|---|---|---|---|---|
| - | China | Vietnam | Xinqiao (Guman) - Lao Cai | 220 kV | 500 | - |
| - | China | Vietnam | Maguan (Malutang) - Ha Giang | 220 kV | 250 | - |
| - | Myanmar | China | Shweli 1 HPP - Dehong | 220 kV | 500 | - |
| - | Myanmar | China | Dapein 1 HPP - Dehong | 500 kV | 1500 | - |
| - | Lao PDR | Thailand | Nam Theun 2 HPP - Roi Et 2 | 500 kV | 3000 | - |
| - | Lao PDR | Thailand | Houay Ho HPP - Ubon 2 | 230 kV | 500 | - |
| - | Lao PDR | Thailand | Theun Hinboun HPP - Thakhek - Nakhon 2 | 230 kV | 500 | - |
| - | Lao PDR | Thailand | Nam Ngum 2 - Na Bong - Udon 3 | 500 kV | 3000 | - |
| - | Lao PDR | Thailand | Hongsa TPP - Nan - Mae Moh 3 | 500 kV | 3000 | - |
| - | Vietnam | Cambodia | Chau Doc - Takeo - Phnom Penh | 230 KV | 500 | - |
| - | Lao PDR | Vietnam | Xekaman 3 HPP - Thanh My | 220 kV | 500 | - |
| - | Lao PDR | Vietnam | Xekaman 1 HPP (Hatxan) - Pleiku | 220 kV | 500 | - |
| - | Lao PDR | Thailand | Xayaburi HPP - Tha Li - Kon Kaen 4 | 500 kV | 3000 | - |
| - | Lao PDR | Thailand | Pakse - Ubon 3 | 500 kV | 3000 | - |
| 2022 | Myanmar | Thailand | Yangon area - Mae Moh | 500 kV | 1500 | 153 |
| 2022 | Myanmar | Thailand | Mawlamyine - Tha Tako | 500 kV | 1500 | 136 |
| 2023 | China | Thailand | Gan Lan Ba - Tha Wung via Lao PDR-N | 600 kV DC | 3000 | 1056.7 |
| 2024 | Myanmar | Thailand | Mae Khot TPP - Mae Chan | 230 kV | 250 | 47.5 |
| 2024 | Lao PDR | China | Luang Prabang - Yunnan | 500 kV | 1500 | 116.9 |
| 2024 | Myanmar | China | Mandalay - Yunnan | 500 kV | 1500 | 116.9 |
| 2025 | Lao PDR | Cambodia | Ban Soc/Ban Hatxan - Tay Ninh via Stung Treng | 500 kV | 1500 | 58.3 |
| 2025 | Cambodia | Vietnam | Ban Soc/Ban Hatxan - Tay Ninh via Stung Treng | 500 kV | 1500 | 58.3 |
| 2027 | Lao PDR | Vietnam | Savannakhet - Ha Tihn | 500 kV | 1500 | 49.2 |
| 2028 | Lao PDR | Vietnam | Xekaman 4 HPP - Ban Soc/Ban Hatxan - Pleiku | 500 kV | 3000 | 52 |
| 2028 | China | Vietnam | Yunnan - Hiep Hoa | 500 kV DC | 3000 | 480.7 |
| 2029 | Lao PDR | Vietnam | Nam Mo HPP - Ban Ve | 220 kV | 500 | 54.9 |
| 2029 | Lao PDR | Vietnam | Luang Prabang HPP - Xam Nau (Lao PDR-N) - Nho Quan | 500 kV | 3000 | 108.3 |
| 2030 | Thailand | Cambodia | Wangnoi - Banteay Mean Chey – Siem Reap - Kampong Cham | 500 kV | 3000 | 106.8 |
| 2030 | Cambodia | Vietnam | Kampong Cham - Tay Ninh | 500 kV | 3000 | 31.4 |

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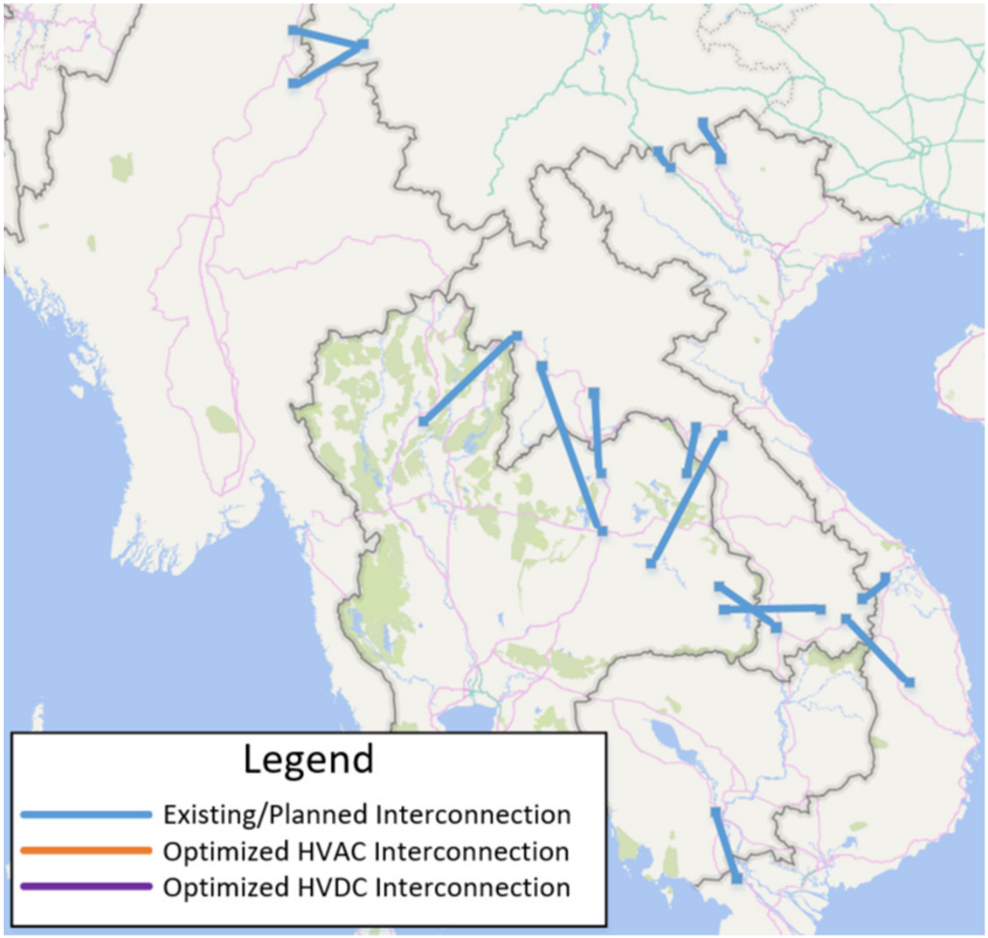
# Summary of regional transmission plans

Base Scenario



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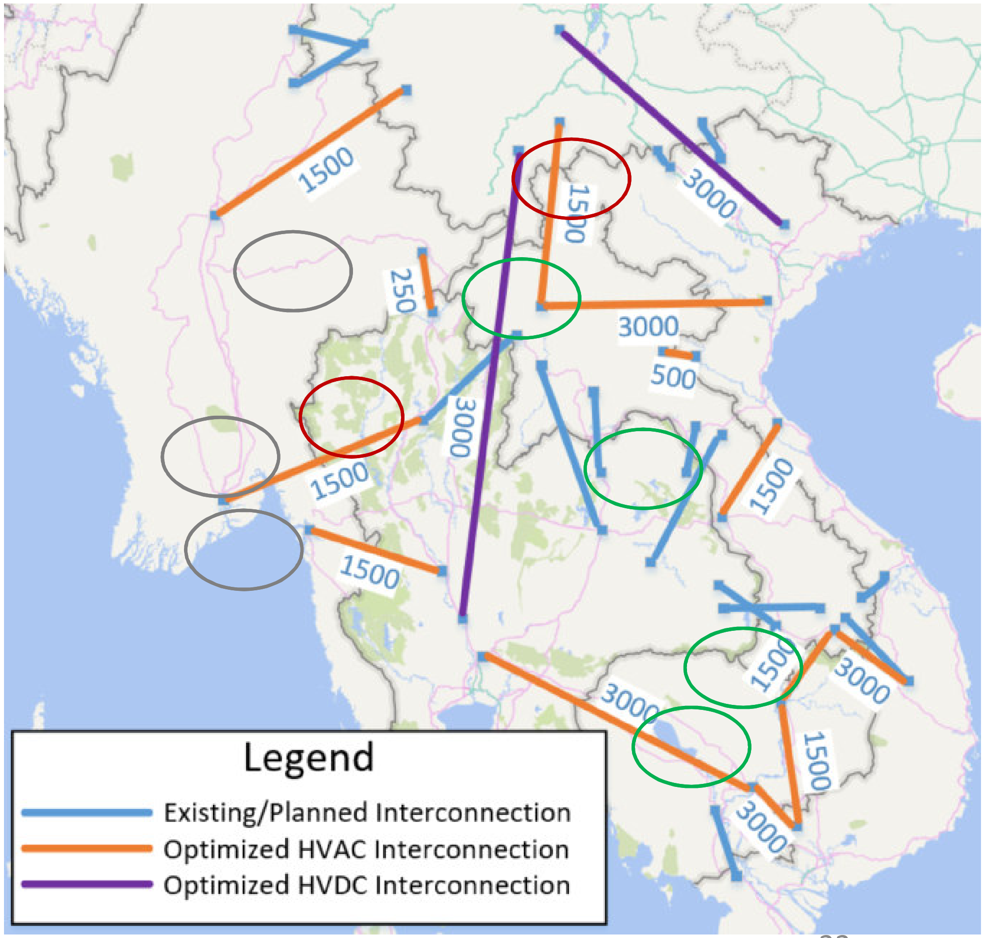
# Summary of regional transmission plans

Base Scenario (Medium Load Growth)

- Four interconnections are built between Laos and Viet Nam
- HVDC lines are built from China to Thailand and from China to Viet Nam
- Three interconnections are built between Thailand and Myanmar



# Conclusions and Key Study Outcomes

- Regional generation planning scenarios were identified for the period from year **2022 to year 2035**.
- Cross-border power transmission plans to facilitate generation plans were obtained for year **2022 to 2030**.
- Main future directions identified in the study for further analysis
  - Base scenario – Transmission optimized
  - Aggressive cross border power trade – Generation and added transmission
  - Reduced VRE cost – Overall impact studied
- Base scenario
  - **18 $ Billion** total cost benefit
  - High cross-border transmission development in **Myanmar – Thailand** and Laos- Viet Nam interfaces

# Key Study Outcomes

- Aggressive cross-border power trade scenario
  - 27 $ Billion total cost benefit
- Reduced VRE cost scenario
  - 20 $ Billion total cost benefit
- Regional transmission plan
  - Most of the candidate interconnections are optimized before 2030
  - These interconnections are largely beneficial to lower the total cost (CAPEX+OPEX) the GMS region

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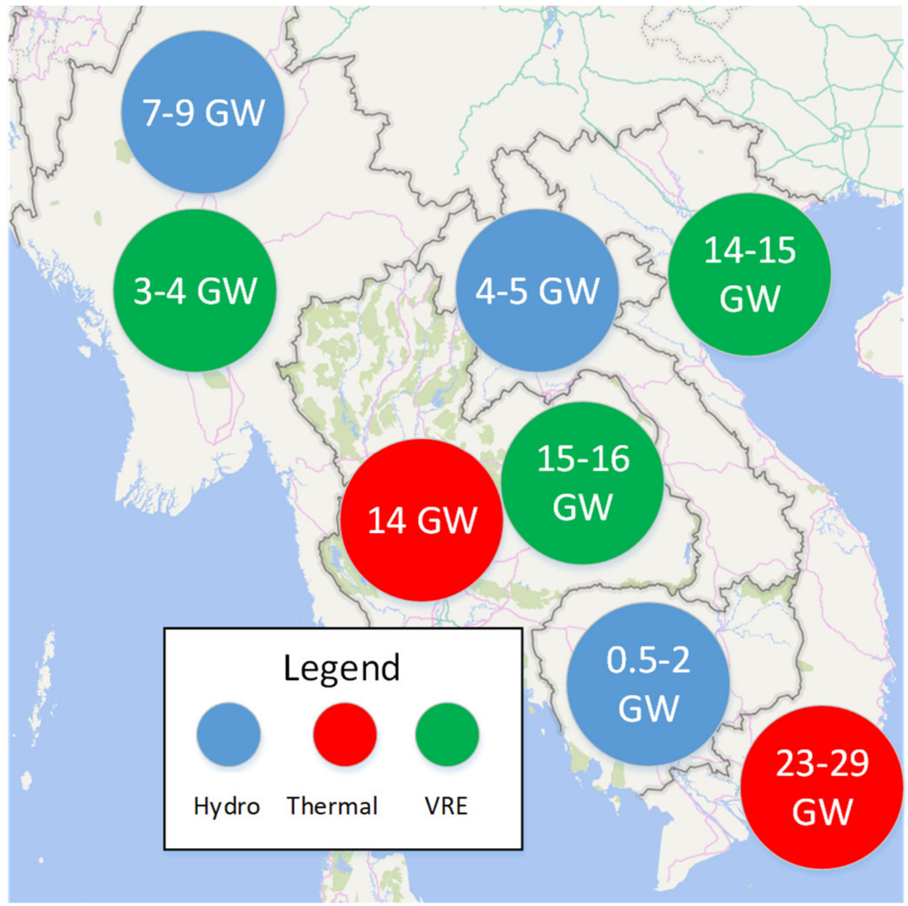
# Key Study Outcomes

Optimized generation developments

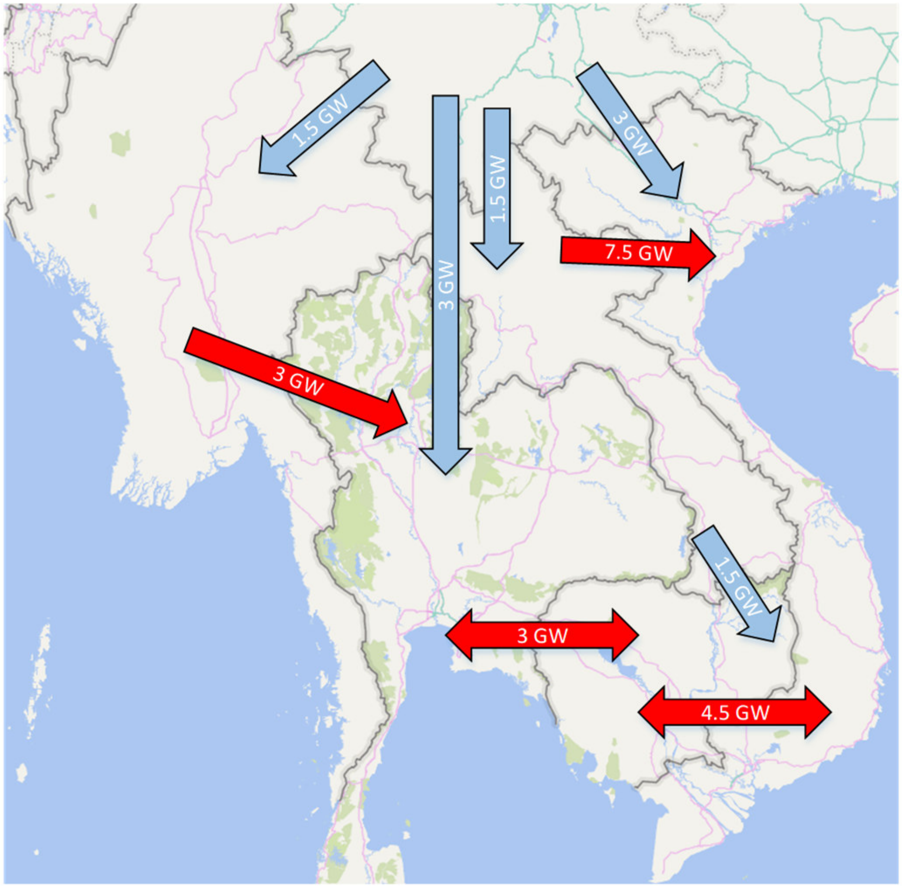
- Large hydro in Myanmar and Lao PDR
- Large thermal and VRE in Thailand, Viet Nam



# Key Study Outcomes

Optimized cross-border developments

- Highly impacting interconnections
  - Myanmar – Thailand interconnections (developed early in the study period)
  - Lao PDR – Viet Nam interconnections
  - Thailand – Cambodia – Viet Nam interconnections
- Other optimized interconnections
  - Lao PDR – Cambodia
  - China to Myanmar, Thailand, Laos & Viet Nam ( Generally near the end of the period)



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# Finalizing the study

- Update the study results **based on feedback**
- Finalize detailed analysis
- **Final report**

# Thank you

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