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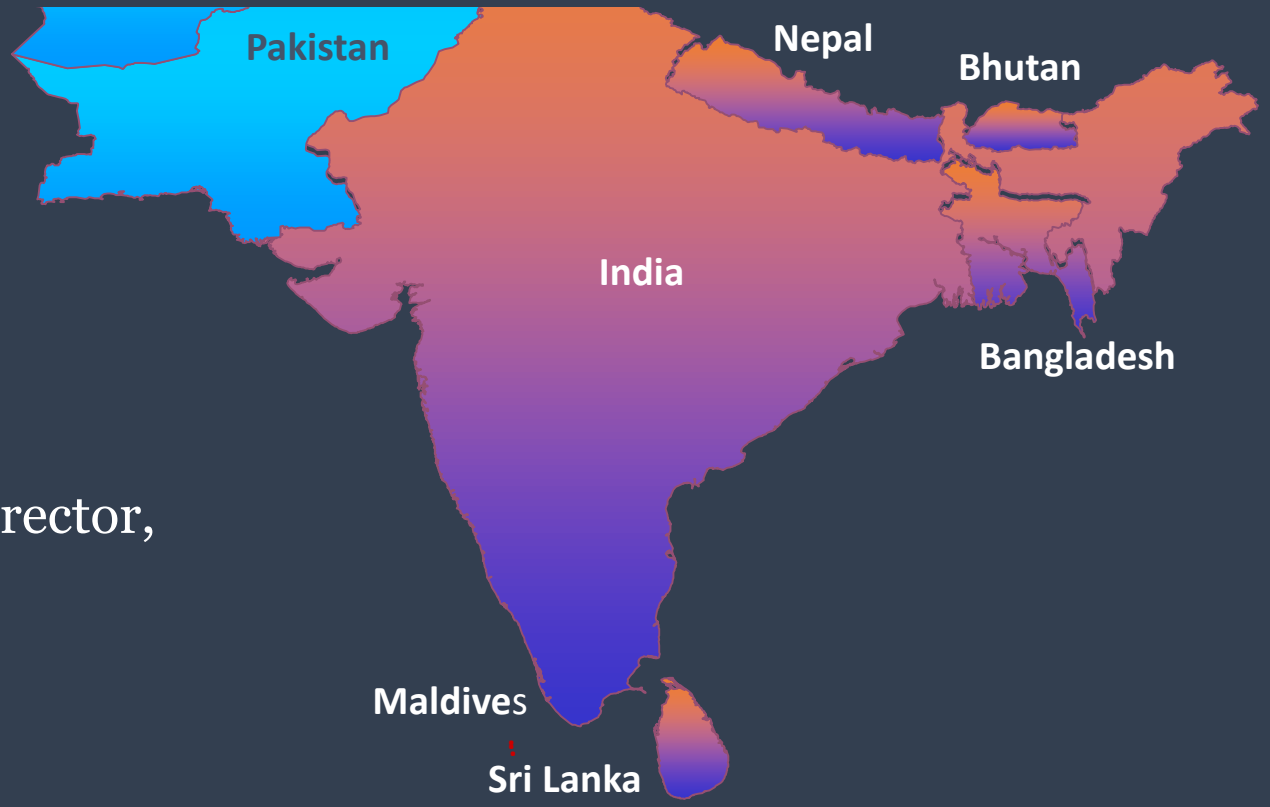
Key Considerations for Running Mock Exercise



Presented by:
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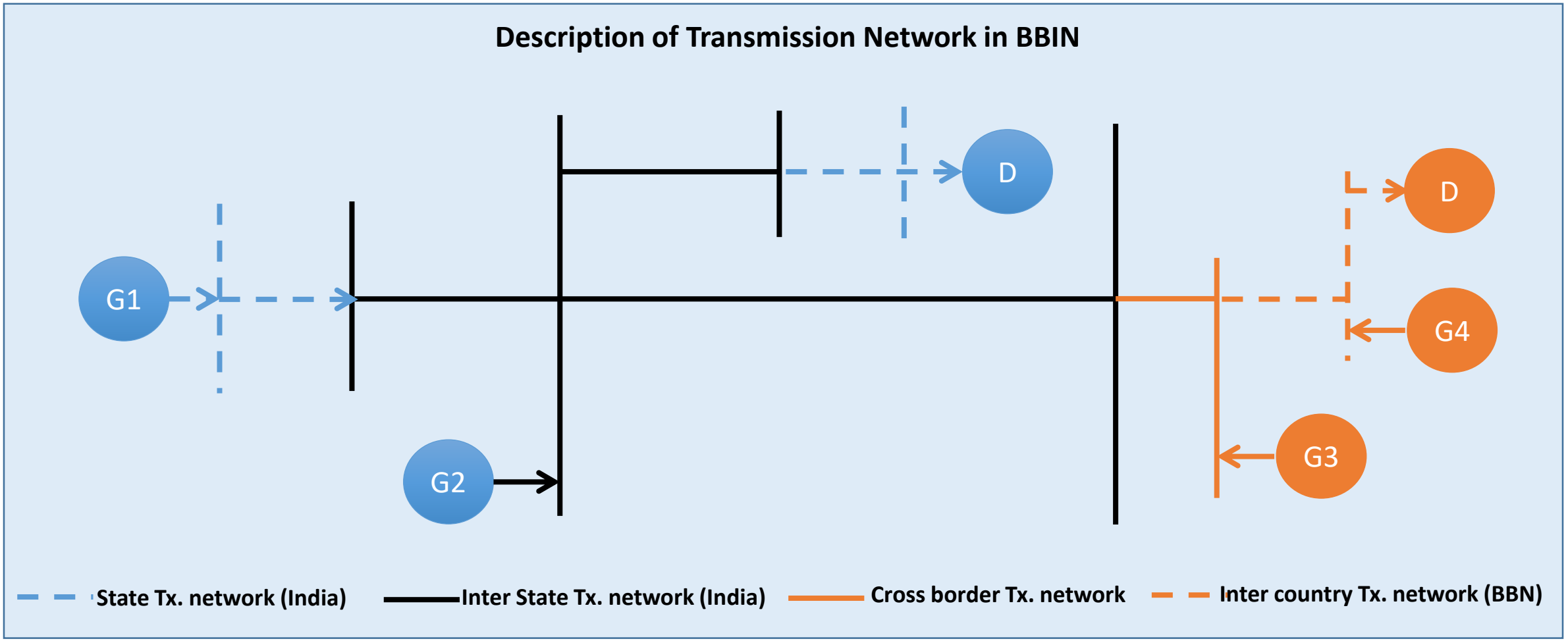
KPMG

Outline

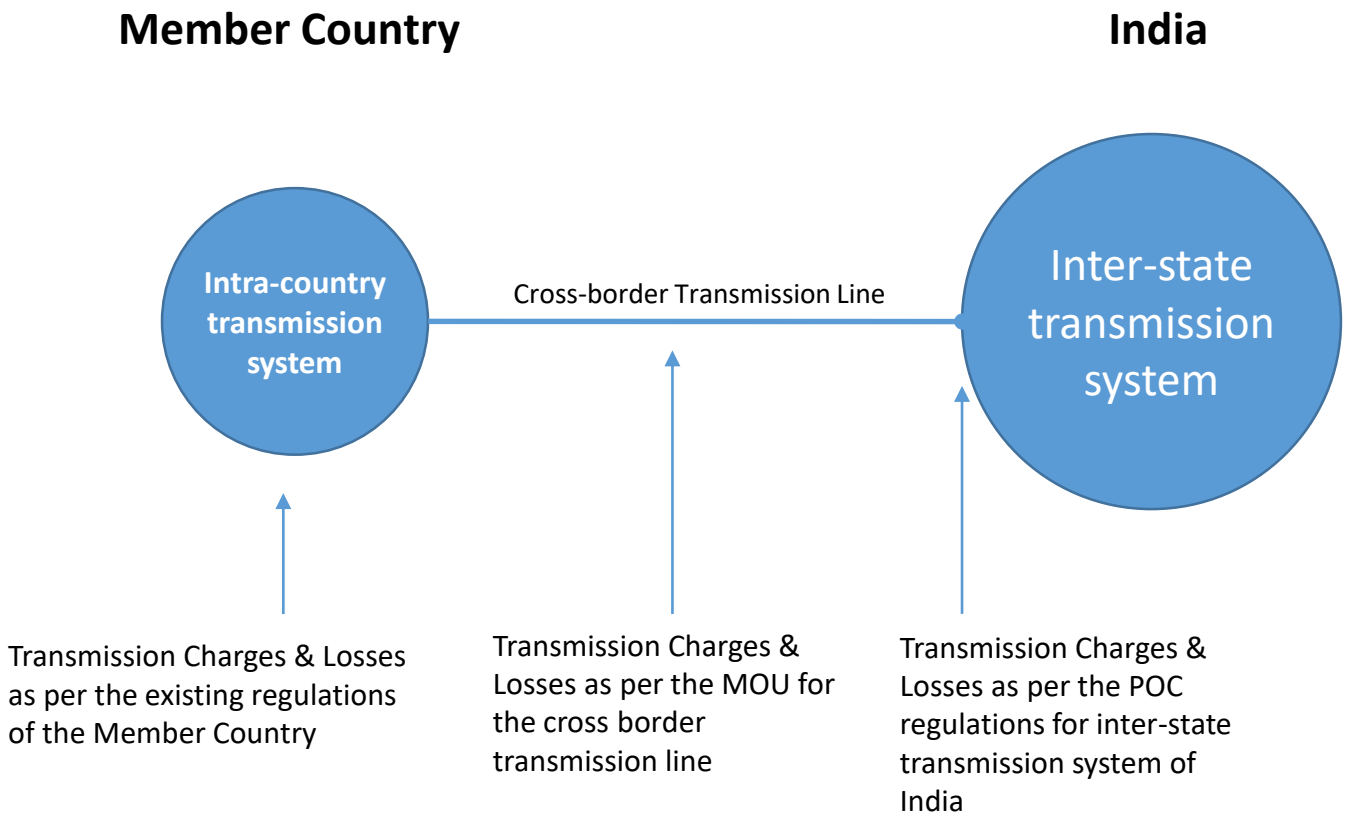
- Overview of Transmission Charges and Losses
  - Treatment of Transmission Charges and losses in the Mock exercise
  - Transmission Charges and Losses for BBN
  - Examples: Bhutan, Nepal and Bangladesh
- Overview of Transmission Congestion in Power Exchanges
  - Price Discovery in case of Transmission Congestion in India
  - Transmission Congestion within India
  - Price Discovery in case of Transmission Congestion in SARPEX
- Key Assumptions for SARPEX Mock Exercise
- Running of Matching Engine and generation of Results

Transmission Charges and Losses

Overview of Transmission Charges and Losses



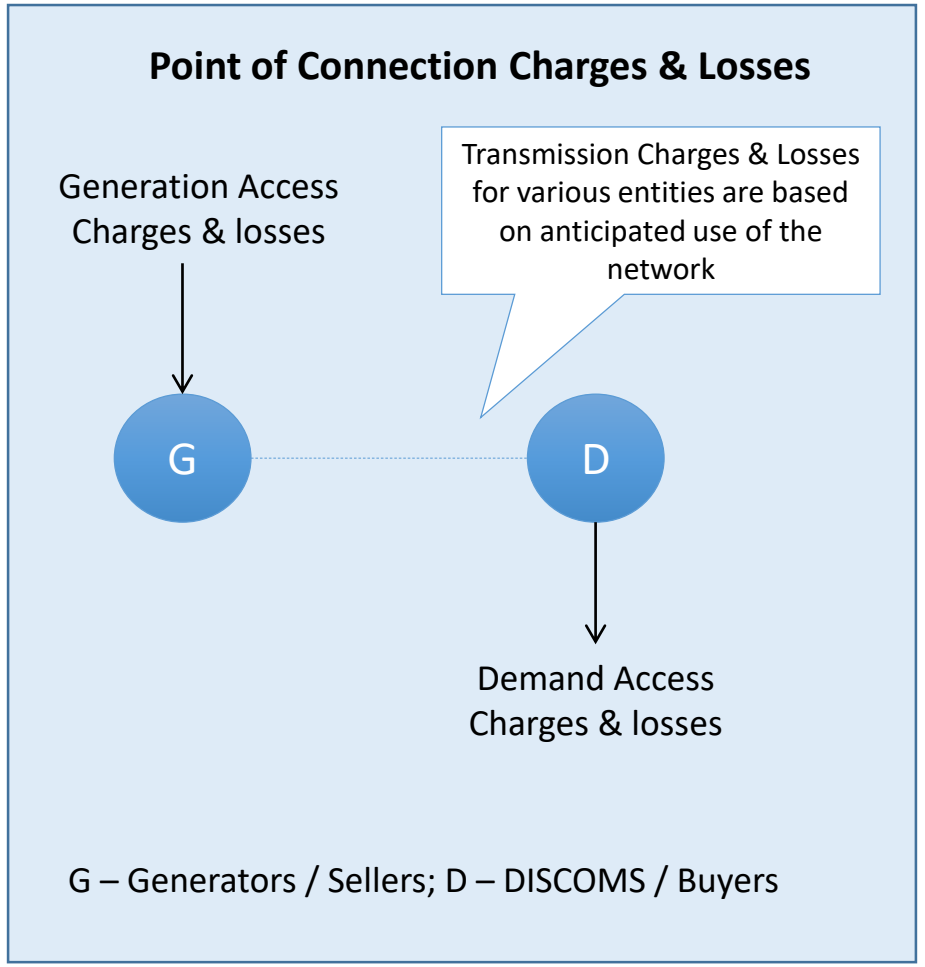
Transmission charges and loss allocation in SARPEX



- Both Buyers and Sellers to absorb losses
  - Buyers: Inject more than contracted power (Contracted Power + Losses)
  - Sellers: Draw less than contracted power (Contracted Power – losses)

POC Charges and Losses for the Inter-state Transmission Charges System

- Inter State Transmission Charges in India are categorized as the following:
  - POC Injection Charges
  - POC Withdrawal Charges
- Applicable on a Rs/MWh basis
- Both sellers and buyers of electricity pay as per their respective schedules for injection or withdrawal
- Similarly, Transmission losses are categorized as
  - POC injection losses
  - POC Withdrawal losses
  - Both are settled in kind i.e. the sellers inject more than their schedules and the buyers off-take less than their schedule to compensate for the losses



Treatment of Transmission Charges & Losses in the Mock Exercise

BBN: The impact of Transmission Charges & Losses has been reflected in the Bid Price by modifying the buy and sell bids.

- *Buy Bid is reduced by Transmission Charges & Losses*
- *Sell Bid is increased by Transmission Charges & Losses*

BUY BIDS

Modified Bid Price = Bid Price – (Transmission Charges) /(1 - % Losses)

SELL BIDS

Modified Bid Price = (Bid Price/(1- % Losses)) + Transmission Charges

Indian Participants: No modification was required for Indian Participants, since the were extracted from Aggregate Demand-Supply curves of IEX, where the Indian bidders had already subsumed these in their bids

Average Transmission Charges and Losses assumed for BBN in Mock Exercise

#	Country	Transmission Charges (Rs/kWh)	Transmission Losses (%)	Comments
1	**Bangladesh**	0.117	0.3%	• The cross-border transmission network for India-Bangladesh has already been included in the POC computations • Withdrawal Charges and Losses are published for Bangladesh on a quarterly basis
2	**Nepal**	0.301	4.1%	• The cross-border transmission network for India-Nepal has not been included in POC and therefore the transmission charges of Bihar and Cross-border line are assumed for Nepal • The normative transmission charges & losses were computed for Muzafarpur Dhalkebar transmission line
	- Bihar Withdrawal	0.257	1.6%	
	- Muzzafarpur Dhalkebar Line	0.044	2.5%	
3	**Bhutan**	0.089	1.1%	• The cross-border transmission network for India-Bhutan has already been included in the POC computations and Injection Charges are published on a quarterly basis

Source: NLDC India, CERC and KPMG Analysis

The bids submitted by BBN were adjusted based on the above charges and losses to reflect the true cost of power purchased or sold on the Exchange

Example 1 from Mock Exercise: Modification of Sell Bids from Bhutan

Bid Price

a. **Bid Price:** 2.50 Rs/kWh, Bid Quantum : 100 MW, Market Clearing Price: 2.55 Rs/kWh

b. **Transmission Charge**: 0.089 Rs/kWh, Transmission Losses: 1.1%

Bid Price after adjusting for Transmission Charges and Losses

a. **Modified Bid Price:** {2.50/ (1-0.011)} + 0.089 = 2.61 Rs/MWh

b. **Modified Sell Bid Price** > MCP implying zero cleared sell volume

Example 2 from Mock Exercise: Modification of Sell Bids from Bhutan

Bid Price

a. **Bid Price:** 2.00 Rs/kWh, Bid Quantum: 100 MW, Market Clearing Price: 2.11 Rs/kWh

b. **Transmission Charge:** 0.089 Rs/kWh, Transmission Losses: 1.1%

Bid Price after adjusting for Transmission Charges and Losses

a. **Modified Bid Price:** {2.00/(1-0.011)} + 0.089 = 2.11 Rs/MWh

b. **Modified Bid Price** = MCP

c. **Cleared sell Volume** = Zero as there were other competing bids that got priority based on Q and T

Example 3 from Mock Exercise: Buy Bid from Nepal

Bid Price

a. **Bid Price:** 2.50 Rs/kWh, Bid Quantum: 50 MW, Market Clearing Price: 2.25 Rs/kWh

b. **Transmission Charge:** 0.3013 Rs/kWh, Transmission Losses: 4.05%

Bid Price after adjusting for Transmission Charges and Losses

a. **Modified Bid Price:** {2.50 – (0.3013/(1- 0.045)} = 2.18 Rs/MWh

b. **Modified Buy Bid Price** < MCP

c. **Cleared Buy Volume** = Zero

Example 4 from Mock Exercise: Buy Bid from Bangladesh

Bid Price

a. **Bid Price:** 2.00 Rs/kWh, Bid Quantum: 200 MW, Market Clearing Price: 2.0 Rs/kWh

b. **Transmission Charge:** 0.117 Rs/kWh, Transmission Losses: 0.3%

Bid Price after adjusting for Transmission Charges and Losses

a. **Modified Bid Price:** {2.00 – (0.117)/(1- 0.003)} = 1.88 Rs/MWh

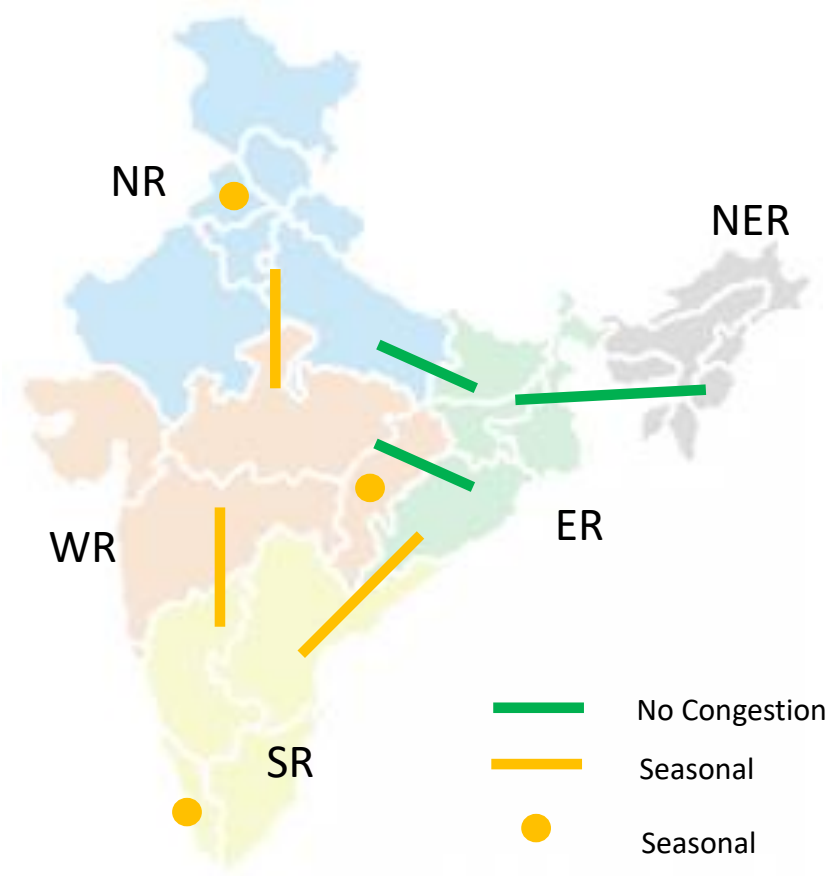
b. **Modified Buy Bid Price** < MCP

c. **Cleared Buy Volume** = Zero

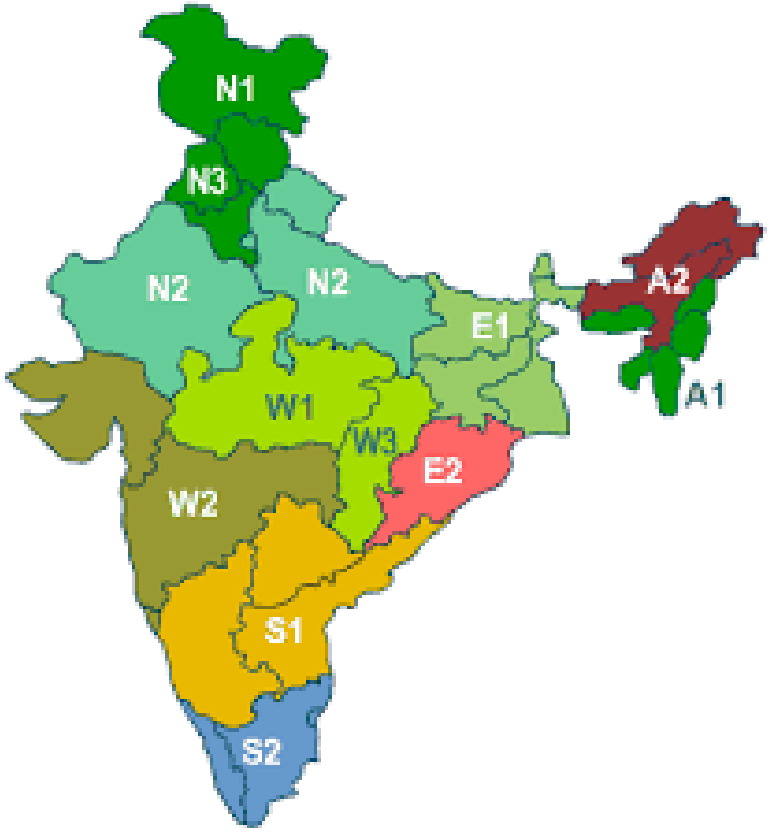
Transmission Congestion and Market Splitting

Major Transmission Corridors and Congestion in India

Congestion in inter-regional corridors



Bid Areas in Power Exchange



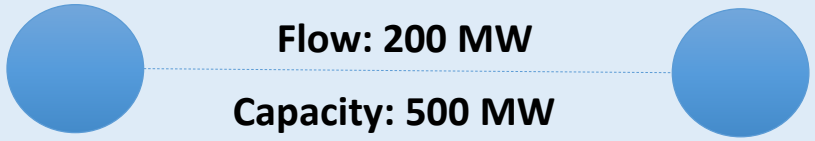
*Since 24 Jan, 2017, New Bid Area "S3" for Kerala and reconfiguration of Meghalaya in "A2" Bid Area has been demarcated

Price Formulation in case of Transmission Congestion

No Transmission Congestion

Area 1 **Area 2**

MCP: 2.0 Rs/kWh
MCV: 1000 MW



Buy Bids:
- B1: 200 MW @ 4.0 Rs/kWh
Sell Bids:
- S1: 100 MW @ 3.5 Rs/kWh

MCV for S1 = 0
MCV for S2 = 100 MW

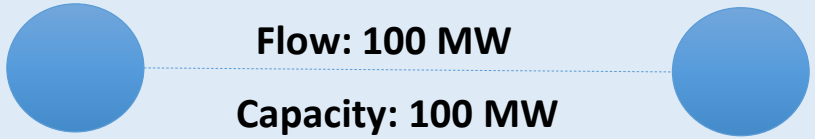
Buy Bids:
- B2: 800 MW @ 2.5 Rs/kWh
-Sell Bids:
- S2: 1000 MW @ 2.5 Rs/kWh

Limited Transmission Capacity

Area 1 **Area 2**

MCP: 3.5 Rs/kWh
MCV: 200 MW

MCP: 2.5 Rs/kWh
MCV: 800 MW



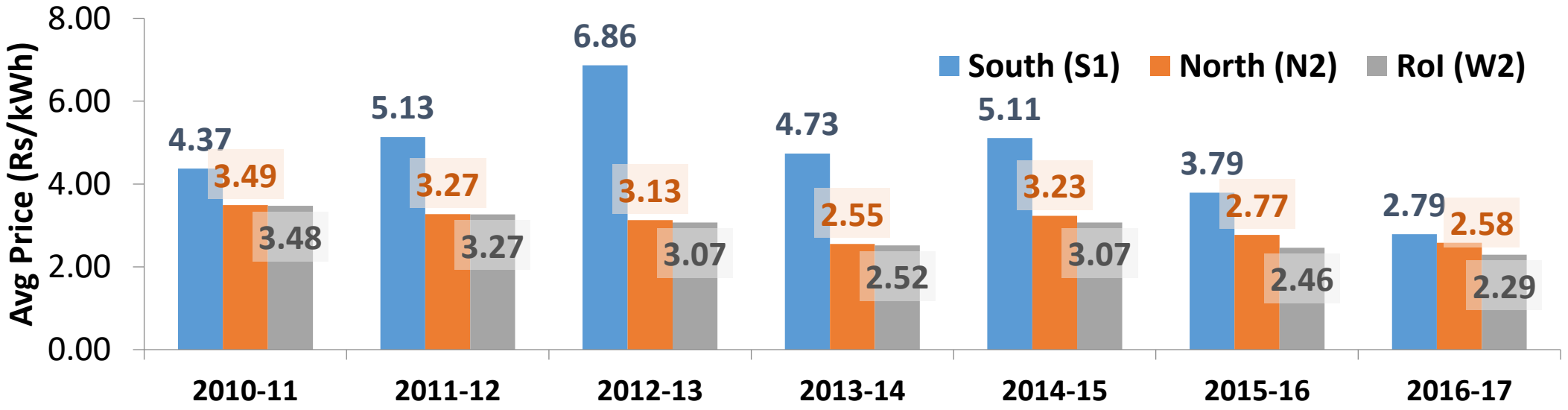
Buy Bids:
- B1: 200 MW @ 4.0 Rs/kWh
Sell Bids:
- S1: 200 MW @ 3.5 Rs/kWh

MCV for S1 = 100 MW
MCV for S2 = 900 MW
Required Capacity for No Transmission Congestion: 200 MW

Buy Bids:
- B1: 800 MW @ 2.5 Rs/kWh
-Sell Bids:
- S1: 1000 MW @ 2.5 Rs/kWh

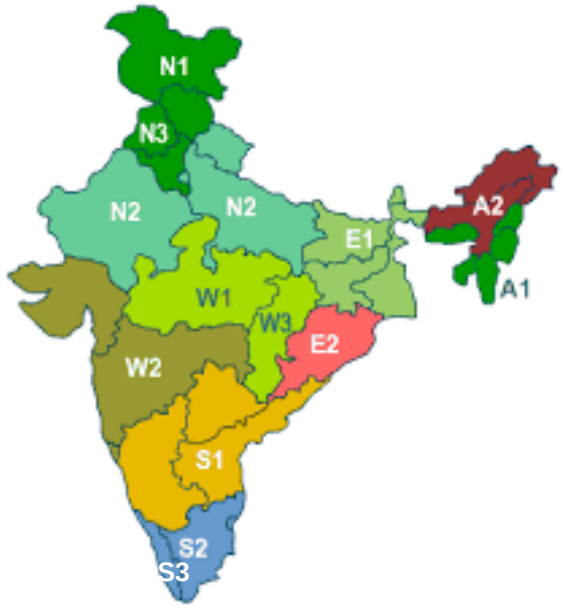
Congestion in the Indian Energy Exchange (IEX)

Year	Market Clearing Volume (MU)	Scheduled volume (MU)	Curtailed Volume (MU)	Curtailment (%)
FY11-12	15,561	13,799	**1,762**	11%
FY12-13	26,143	22,375	**3,768**	14%
FY13-14	34,230	28,925	**5,306**	15%
FY14-15	31,227	28,131	**3,096**	10%
FY15-16	36,210	34,067	**2,144**	6%
FY 16-17	41,310	39,783	**1,527**	3.7%

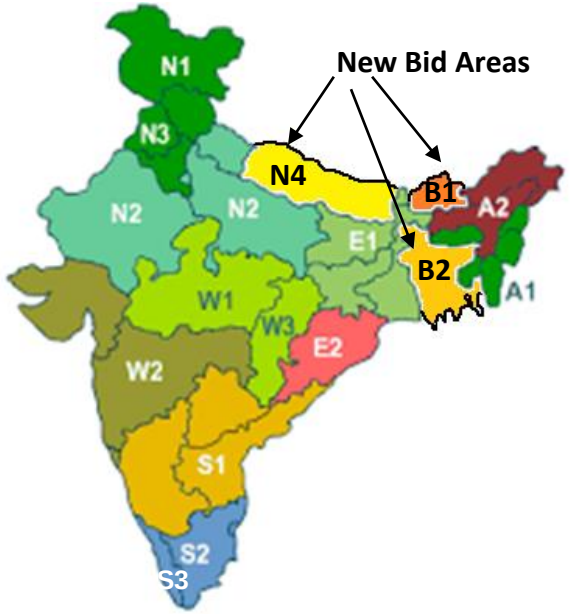


Congestion Mechanism in SARPEX (Applicable for either mode of congestion)

Bid Areas in India



Additional Areas for each New Country



The principles for Transmission Congestion of SARPEX Bid Areas will likely be similar to that followed by the Bid Areas in India

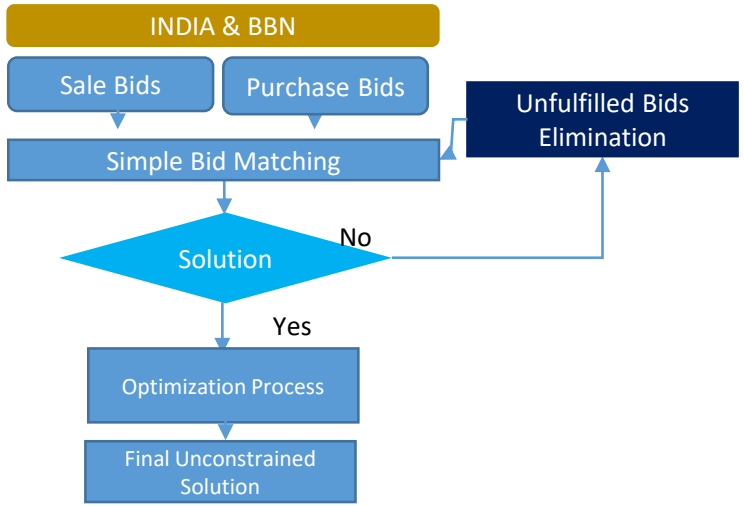
Key Assumptions for SARPEX Mock Exercise

Proposed Modes of Operation for Mock Exercise

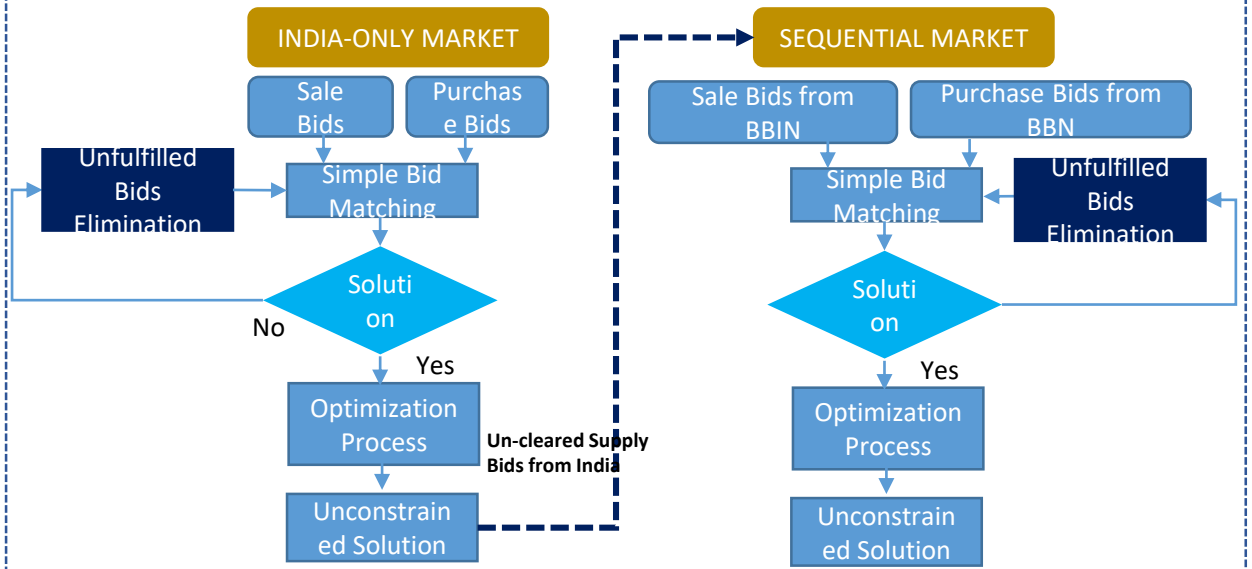
UNIFIED MODE: The bids from the Indian participants and BBN countries' participants would be cleared simultaneously

SEQUENTIAL MODE (RESIDUAL MODE): The bids from the Indian participants and BBN countries will be cleared in a sequential manner

UNIFIED MODE – 15 MINUTE DAM INTERVAL



SEQUENTIAL MODE – 15 MINUTE INTERVAL DAM



Key Assumptions of SARPEX Mock Exercise

1. The mock exercise is based on the Unconstrained Market Clearing Principle. However, the availability of inter-country transmission lines has been duly taken into consideration in the preparation of bids for BBN

2. Both buy and sell side bids of the Indian participants are taken in the Unified Mode in order to obtain a single uniform MCP and MCV. However, for Residual Mode, only the uncleared sell bids from India have been considered, since there are negligible chances for Indian buy bids to be cleared due to transmission congestion and lower bid prices

3. Assumes Transmission charges and losses as applicable under the current bilateral trade with BBN. For the ease of implementation, both transmission charges and losses are adjusted in the bid price of the participants.

4. The grid operating charges and exchange transaction are not assumed in the Mock Exercise, since there charges are very small (~0.03 Rs/kWh). However, in practice, all the participants on the exchange have to bear these charges.

Key Assumptions while preparing bids for Bangladesh

1. Bangladesh bid quantum was constrained at 250 MW as the upper limit. This limit was decided keeping in view the 250 MW medium term contract between Bangladesh and PTC. It was reasonable to assume that this power could be traded through SARPEX in the future

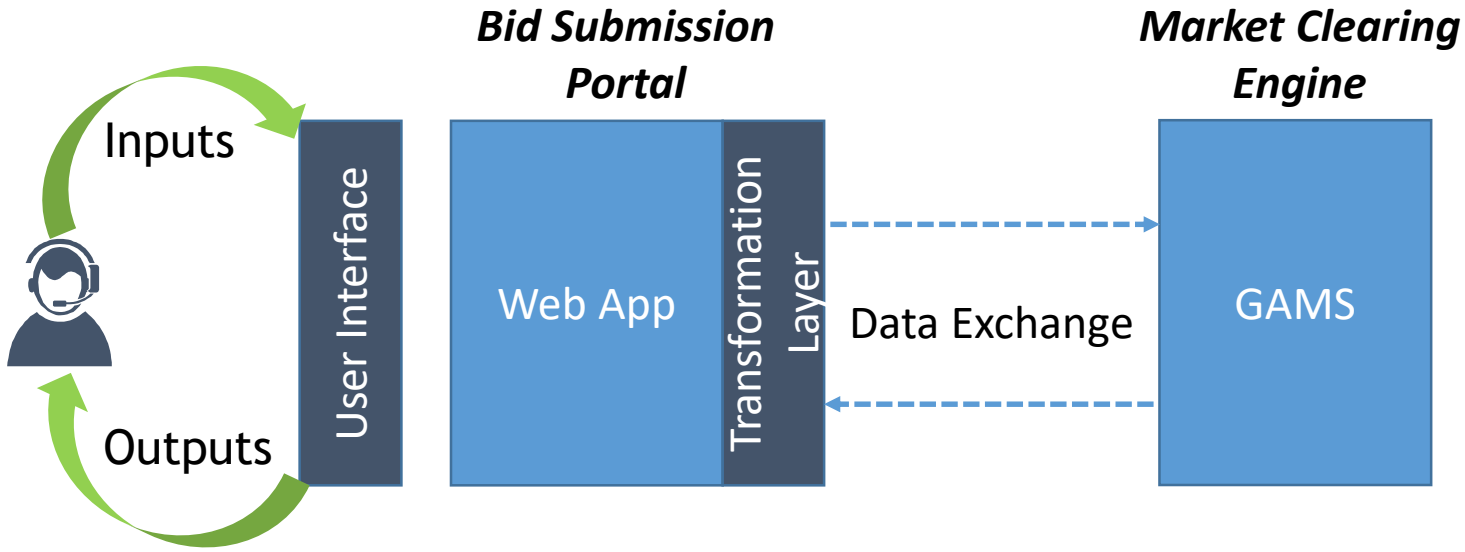
2. It was assumed that Bangladesh would replace all of its costly generation (Rs 10 and above) through the Exchange up-to the limit of 250 MW. In peak hours, the upper limit of 250 MW was found to be always binding.

3. 250 MW purchase bid was split as - 150 MW at Rs 6/KWh and 100 MW at Rs 10/KWh. (The total purchase bid at Rs 10/KWh was 250 MW). The split was made because with repeated learning, Bangladesh may want to revise down their bid price down to Rs 5 or Rs 6.

4. If in any block, the costly generation (above Rs 10) for Bangladesh was found to be less than 250 MW, the corresponding quantum was reduced from the bid placed at Rs 10 KW/h..

Running of Matching Engine and Generation of Results

Application Workflow for the SARPEX Mock Exercise



Illustrative Orderbook

Order Nature – Block or Normal

Order Type – Buy or Sell

Limit Price

Bid Quantity in MW, positive for buy and negative for sell

Client ID	Region	Time Slot	Order Nature	Order Type	Price (Rs./kWh)	Quantity (MW)	Date
ABC12345	India	T18	Normal	Buy	3.5	30	1/5/2017
ABC12345	India	T73	Normal	Buy	3.5	30	1/5/2017
ABC12345	India	T91	Normal	Buy	3.5	30	1/5/2017
ABC12345	India	T90	Normal	Sell	3.5	-40	1/5/2017
ABC12345	India	T4	Normal	Sell	3.5	-40	1/5/2017
ABC12345	India	T6	Normal	Sell	3.5	-40	1/5/2017

Unique ID assigned to Bidders

Bid Region – Nepal/ Bhutan/ Bangladesh

Delivery Time Slot – T1 to T96

Delivery Date

Key Outcomes from the Model

General Variables

a. Total Regional Surplus

b. Market Clearing Price

c. Market Clearing Volume

Country Specific Variables

a. Surplus – Both Producer and Consumer

b. Cleared Buy/Sell Volumes

c. Total Cost/ Revenue

QUESTIONS AND ANSWERS

THANK YOU

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