



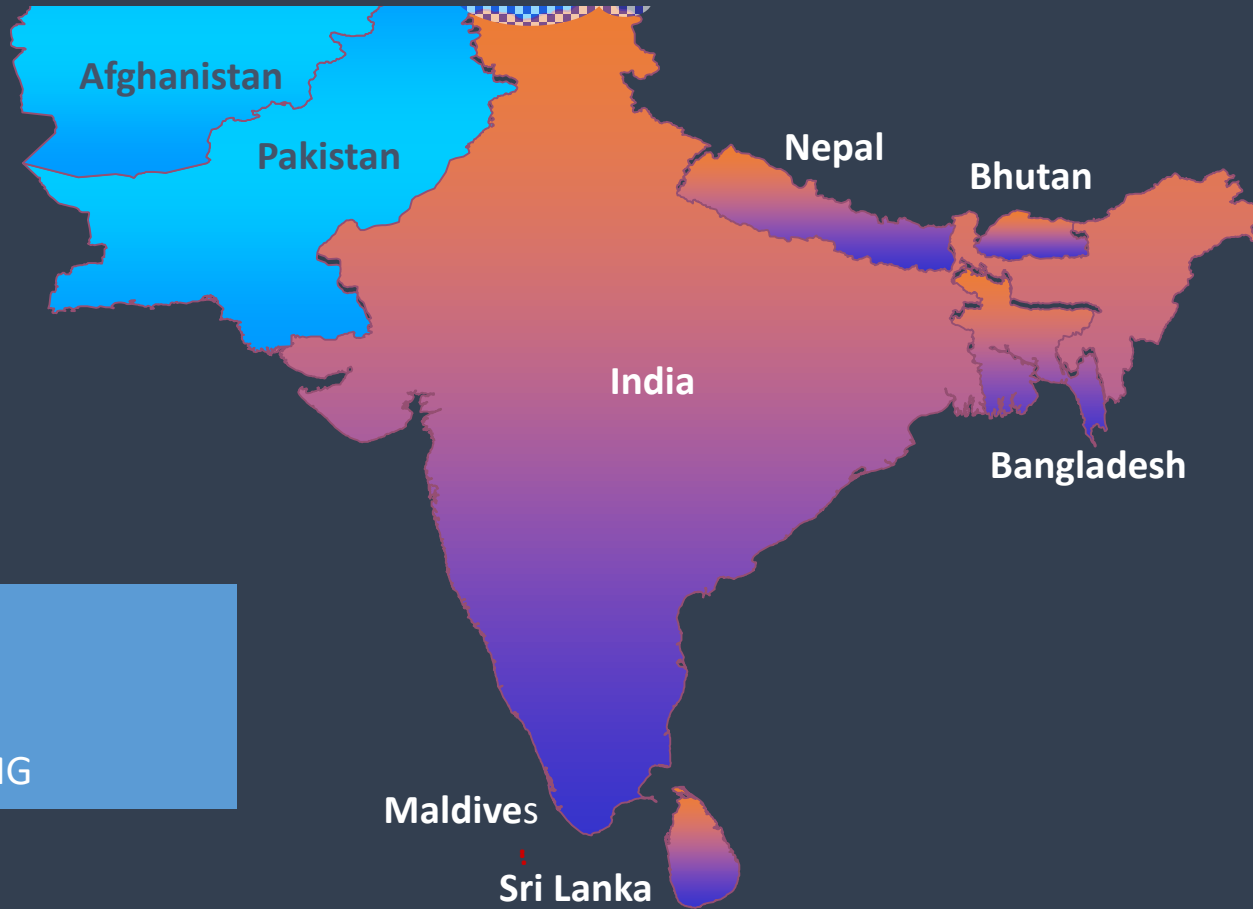
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Integrated Research and
IRADe Action for Development

SARPEX Mock Exercise Results for selected 71 days



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Methodology for Sampling and Extrapolation of Results

Sampling of Days from FY'16

The following variables were identified to be crucial in determining a sample that covers all probable demand-supply scenario on SARPEX

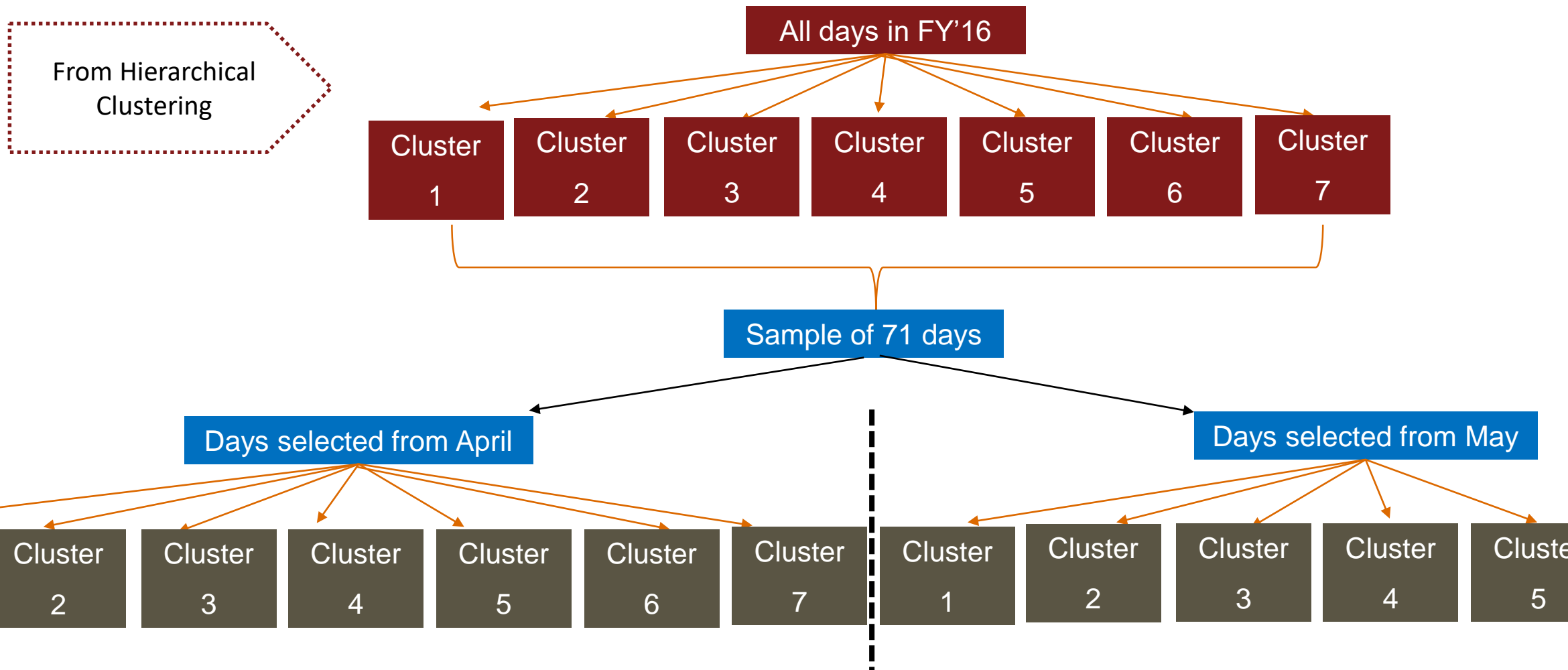
S. No	Data	General data/ Country Specific				
		India	Bhutan	Nepal	Bangladesh	Generic
1	Average to Peak Load	✓	✓	✓	✓	
2	Unconstrained Market Clearing Price on the Exchange	✓				
3	Relative Demand Supply Gap on the Exchange	✓				
4	Day of the Month					✓
5	Month of the Year					✓
6	Special Day/Holiday	✓	✓	✓	✓	

Using the above variables, all the days from FY'16 were divided into distinct clusters, using Hierarchical clustering technique

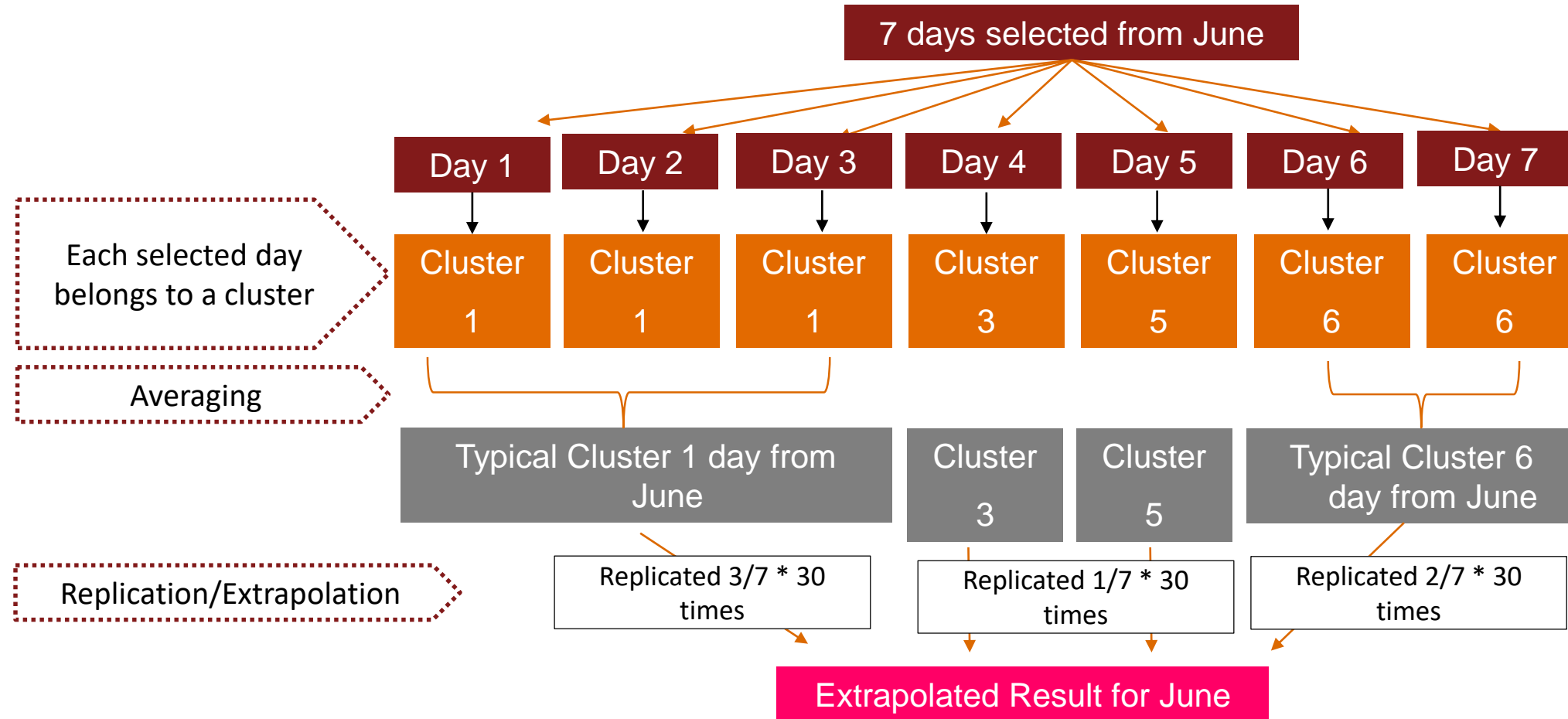
After clustering, random days from each cluster were chosen, depending upon the overall size of the cluster

In effect, a sample of 71 days, that is representative of the entire year (FY'16) was chosen for the study

Sampling of Days from FY'16

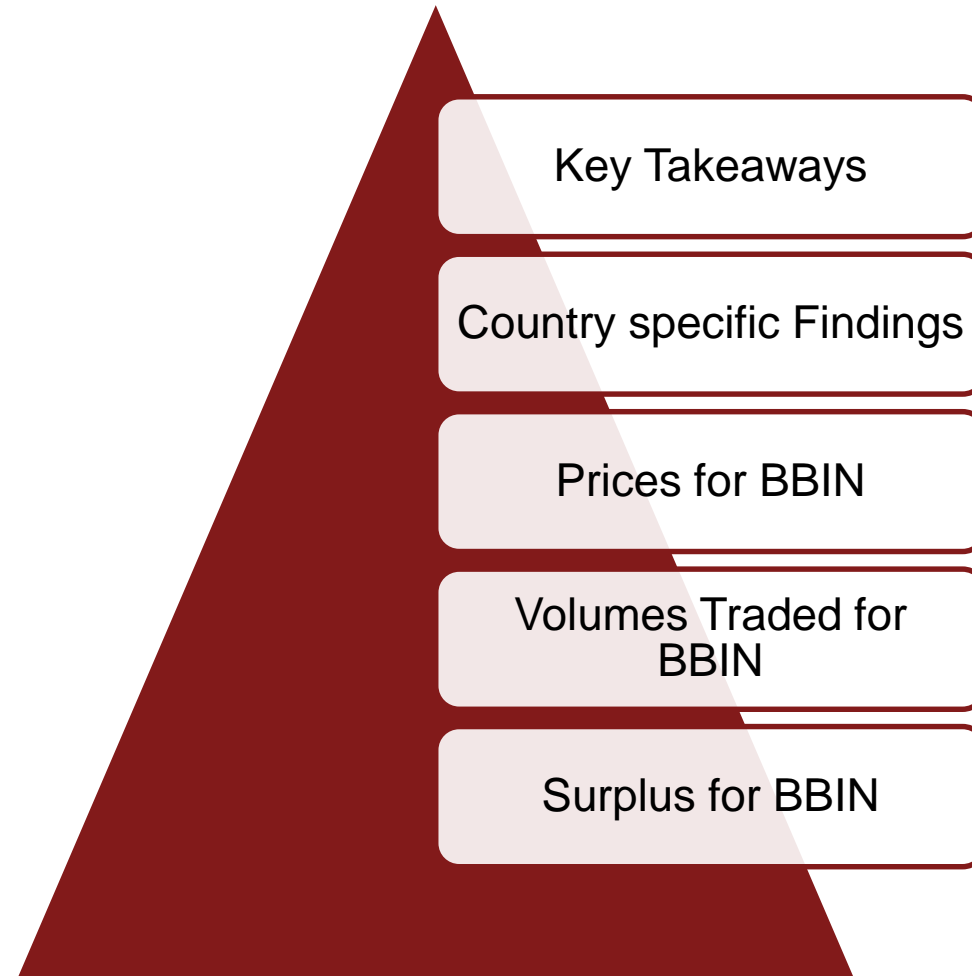


Extrapolation of Results from selected 71 days



Extrapolated Results for BBIN

Representation of Results



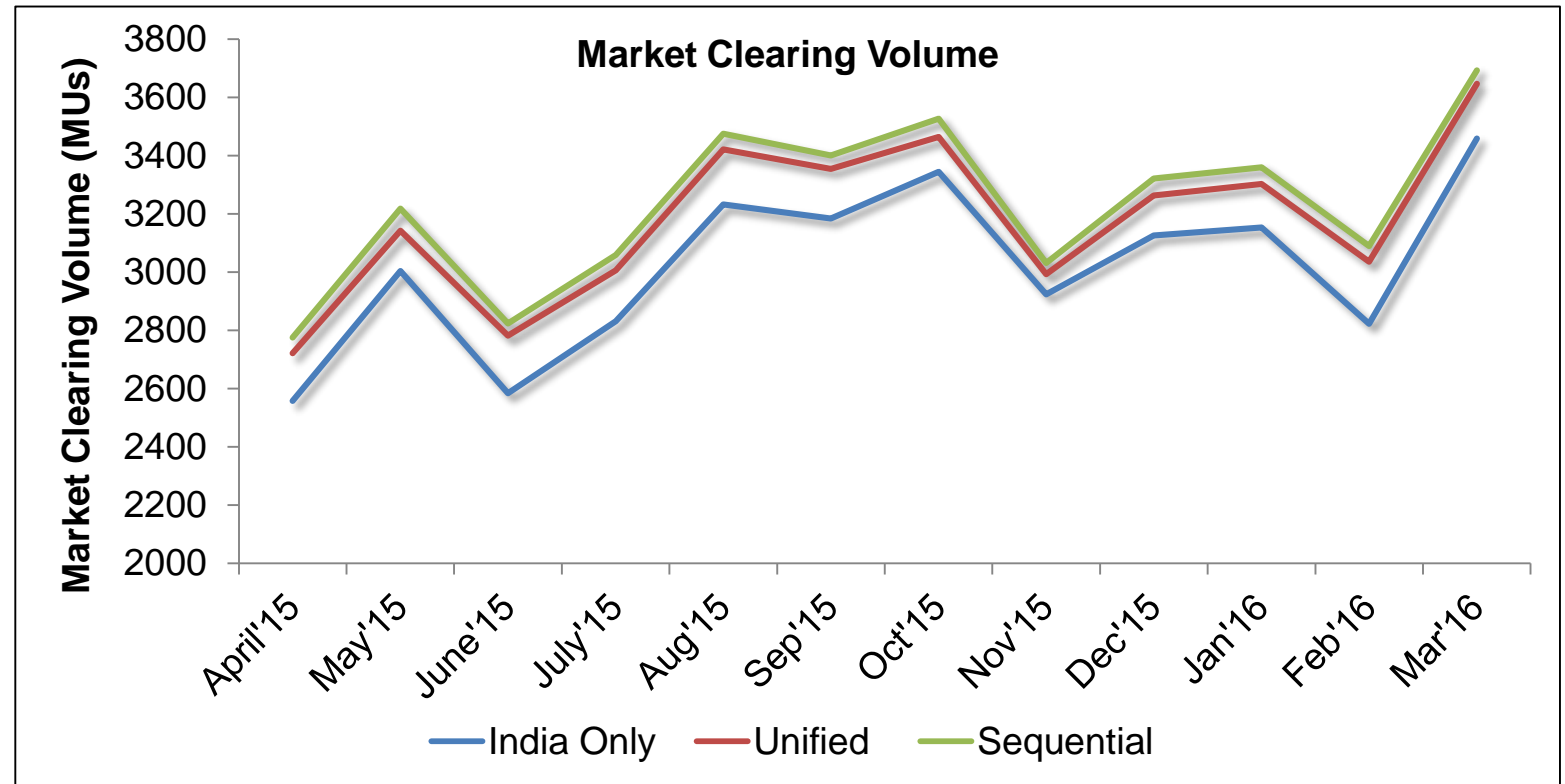
Total Surplus in the 3 Modes for FY'16

Surplus (Rs Billion)	
India Only	313.53
Unified	323.63
Sequential	323.24

The two modes of Operation for SARPEX are practically the same. The difference of 0.12%, as observed, is negligible given that the Mock Exercise only simulates the possible behavior of all bidders in the DAM on SARPEX through inputs that are accurate to a reasonable degree of accuracy

Total Market Clearing Volume in the 3 Modes for FY'16

	Total Market Clearing Volume (in MUs)
India-Only	36219
Unified	38127 (1908*)
Sequential	38768 (2549*)

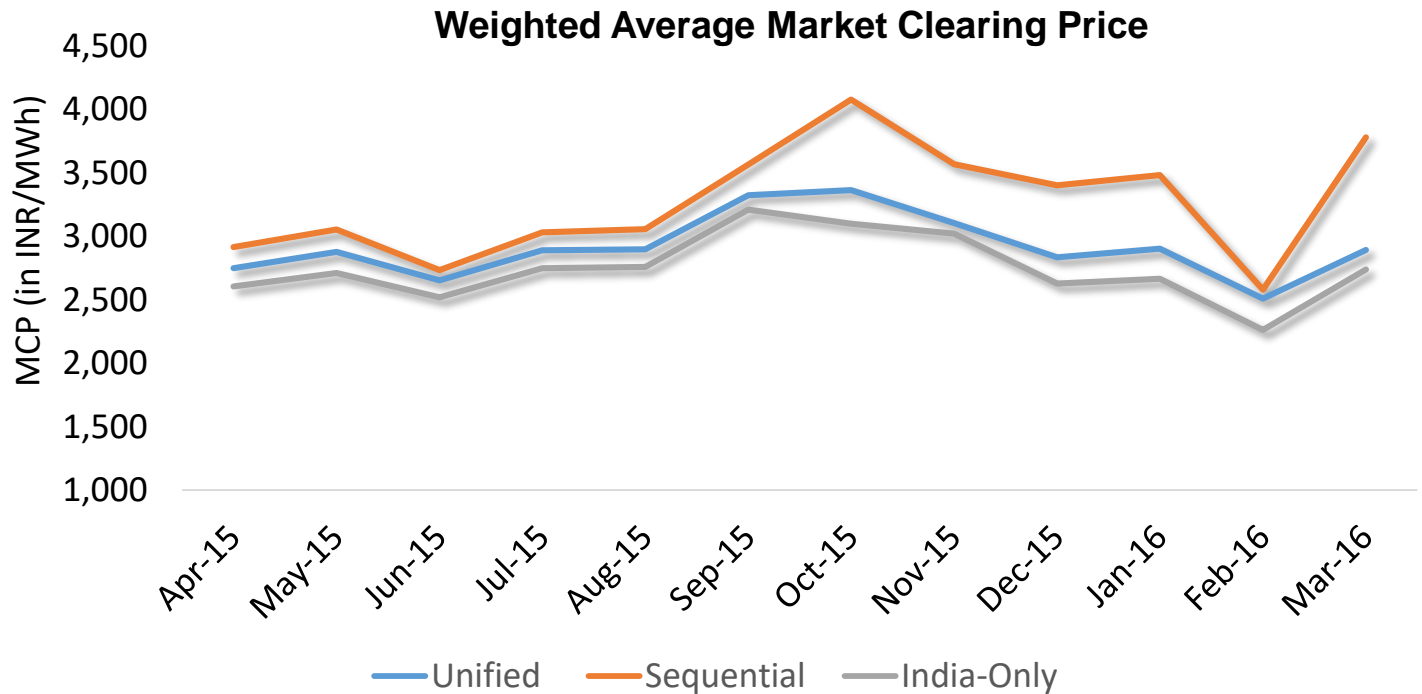


The figures for Unified and Sequential Mode include the existing DAM operations in India, referred as India-Only Mode

** The figures for in the bracket represent the change in MCV over India-Only Mode. The MCV in case of sequential mode is significantly higher*

Weighted Average Market Clearing Price in the 3 Modes for FY'16

	Weighted Average Market Clearing Price (in Rs/MWh)
India-Only	2745
Unified	2910
Sequential	3269



The market clearing volume for the respective mode is used as weight for computing the above figures

Monthly Weighted Average Market Clearing Price on SARPEX for FY'16

Month	Weighted Average MCP (in Rs/MWh)		
	Unified Mode	Sequential Mode	India-Only
April	2,751	2,916	2,606
May	2,878	3,056	2,712
June	2,655	2,735	2,520
July	2,892	3,032	2,750
August	2,898	3,059	2,760
September	3,324	3,567	3,211
October	3,367	4,079	3,101
November	3,106	3,571	3,024
December	2,836	3,403	2,630
January	2,903	3,484	2,667
February	2,510	2,581	2,262
March	2,751	3,783	2,740
Average	2,910	3,269	2,745

The monthly market clearing volume for the respective mode is used as weight for computing the above figures.

Comparison of Monthly Weighted Average MCP across 3 Modes

Month	Increment in Weighted Average MCP (in Rs/MWh, % Increment)		
	Increment in Weighted Average MCP Unified Mode over India-Only (% Increment)	Increment in Weighted Average MCP Sequential Mode over India-Only Mode (% Increment)	Increment in Weighted Average Sequential Mode over Unified Mode (% Increment)
April	145 (6%)	310 (12%)	165 (6%)
May	166 (6%)	344 (13%)	179 (6%)
June	135 (5%)	215 (9%)	80 (3%)
July	142 (5%)	281 (10%)	139 (5%)
August	138 (5%)	299 (11%)	161 (6%)
September	113 (4%)	356 (11%)	243 (7%)
October	265 (9%)	978 (32%)	713 (21%)
November	82 (3%)	547 (18%)	465 (15%)
December	206 (8%)	772 (29%)	567 (20%)
January	236 (9%)	817 (31%)	581 (20%)
February	248 (11%)	319 (14%)	71 (3%)
March	155 (6%)	1,043 (38%)	888 (31%)
Average	169 (6%)	523 (19%)	354 (12%)

The MCP in Unified and Sequential Mode increases in the winter months when supply from Bhutan is relatively very low

Distribution of Prices in Unified and Sequential Mode

Month	Mode	<2000	2000-2500	2500- 3000	3000- 3500	3500- 4000	4000- 4500	4500- 5000	>5000
April	Unified	4%	33%	32%	24%	6%	1%	0%	0%
	Sequential	6%	28%	24%	33%	6%	1%	0%	2%
May	Unified	1%	28%	33%	24%	12%	2%	0%	0%
	Sequential	1%	23%	22%	28%	20%	5%	0%	1%
June	Unified	2%	53%	26%	10%	4%	4%	1%	0%
	Sequential	1%	49%	29%	9%	6%	4%	1%	1%
July	Unified	1%	28%	40%	19%	5%	6%	1%	0%
	Sequential	0%	25%	39%	19%	7%	4%	1%	5%
August	Unified	2%	31%	29%	21%	5%	8%	2%	2%
	Sequential	2%	28%	27%	21%	8%	6%	2%	6%
Sep	Unified	0%	5%	25%	42%	13%	10%	5%	0%
	Sequential	0%	5%	30%	33%	8%	6%	3%	15%
Oct	Unified	4%	4%	21%	38%	20%	6%	4%	3%
	Sequential	5%	3%	17%	41%	10%	2%	2%	20%
Nov	Unified	11%	12%	19%	44%	5%	4%	5%	0%
	Sequential	8%	15%	15%	22%	28%	1%	0%	11%
Dec	Unified	21%	18%	18%	19%	16%	4%	4%	0%
	Sequential	18%	21%	14%	15%	14%	3%	1%	14%
Jan	Unified	20%	10%	24%	20%	16%	9%	1%	0%
	Sequential	17%	13%	20%	13%	14%	8%	4%	11%
Feb	Unified	15%	26%	53%	6%	0%	0%	0%	0%
	Sequential	14%	23%	52%	10%	1%	0%	0%	0%
Mar	Unified	0%	18%	53%	15%	8%	4%	2%	0%
	Sequential	0%	14%	53%	7%	7%	2%	0%	18%

Country Specific Findings

Surplus accrued to each nation (including the surplus of Indian DAM) on SARPEX for FY'16

	Regional Surplus (Rs Billion)	Surplus Gain to Bangladesh (Rs Billion)	Surplus Gain to Nepal (Rs Billion)	Surplus Gain to Bhutan (Rs Billion)	Surplus Gain to India (Rs Billion)
Unified	323.63	8.85	0.7	0.3	313.78
Sequential	323.24	8.23	0.63	0.42	313.96

Additional Surplus accrued to each nation on SARPEX (over the surplus of Indian DAM) for FY'16

	Regional Surplus (Rs Billion)	Surplus Gain to Bangladesh (Rs Billion)	Surplus Gain to Nepal (Rs Billion)	Surplus Gain to Bhutan (Rs Billion)	Surplus Gain to India (Rs Billion)
Unified	10.1	8.85	0.7	0.3	0.25
Sequential	9.71	8.23	0.63	0.42	0.43

Volumes (unconstrained) bought by each nation on SARPEX for FY'16

	India (in MUs)	Bangladesh (in MUs)	Nepal (in MUs)	Bhutan (in MUs)
India-Only	36219	-	-	-
Unified	35396 (-822*)	2011	719	0.09
Sequential	36219 (0*)	1920	630	0.04

The figures for Unified and Sequential Mode include the existing DAM operations in India.

** The figure in the bracket represents the change in purchase volume over India-Only Mode*

Volumes (unconstrained) sold by each nation on SARPEX for FY'16

	India (in MUs)	Bangladesh (in MUs)	Nepal (in MUs)	Bhutan (in MUs)
India-Only	36219	-	-	-
Unified	37715 (1496*)	-	10	412
Sequential	38342 (2123*)	-	10	427

The figures for Unified and Sequential Mode include the existing DAM operations in India.

** The figure in the bracket represents the change in purchase volume over India-Only Mode*

Weighted Average Buy Price for each nation

	India (in Rs/MWh)	Bangladesh (in Rs/MWh)	Nepal (in Rs/MWh)	Bhutan (in Rs/MWh)
India-Only	2745	-	-	-
Unified	2919	2938	2893	3751
Sequential	2745	3099	2881	3438

- *The prices represent the Unconstrained MCP , weights have been computed using the cleared buy volume of each nation*
 - *Bhutan is predominant seller on the Exchange*

Weighted Average Sell price for each nation

	India (in Rs/MWh)	Bangladesh (in Rs/MWh)	Nepal (in Rs/MWh)	Bhutan (in Rs/MWh)
India-Only	2745	-	-	-
Unified	2918	-	2000	2983
Sequential	2965 (2768*)	-	3000	3339

The prices in the sequential mode represents the weighted average price accrued to sellers from the sale of power in the residual market

** The figure in the bracket represent the weighted average price to Indian sellers from the sale of power in domestic as well as residual market*

Total Cost incurred by buyers from each nation in FY'16

	India (in Rs Billion)	Bangladesh (in Rs Billion)	Nepal (in Rs Billion)	Bhutan (in Rs Billion)
India-Only	99.4	-	-	-
Unified	103.32	5.90	2.08	0.0003
Sequential	99.4	5.95	1.81	0.0001

The figures for Unified and Sequential Mode include the existing DAM operations in India.

Total Revenue earned by sellers from each nation in FY'16

	India (in Rs Billion)	Bangladesh (in Rs Billion)	Nepal (in Rs Billion)	Bhutan (in Rs Billion)
India-Only	99.4	-	-	-
Unified	110.05	-	0.02	1.22
Sequential	105.71	-	0.03	1.42

The figures for Sequential Mode include the revenue from the sale of power in domestic (India Only) and residual market (BBN)

Recommended Market Rules and Design for SARPEX

It was agreed upon in the previous TF-3 Meeting that the following market rules and design is recommended for SARPEX

Design Aspect	Assumption for SARPEX
Market Type	Energy
Auction Type	First Price Auction
Bidding Format	Double Sided
Market clearing Algorithm	Step-wise
Pricing Rules	Uniform
Matching Rules	Single
Time Zone	IST
Currency	INR

Key Takeaways from SARPEX Mock Exercise...(1/2)

- ❖ All nations gain significantly from the trade in the DAM on SARPEX. Total (Regional Surplus is higher in Unified Mode (INR 323.63 Billion) by INR 0.39 Billion in comparison to the Sequential Mode (INR 323.24 Billion) for FY'16
- ❖ The difference of 0.12% in the regional surplus between the two modes is insignificant in comparison to the gain accrued to each nation and the overall regional surplus
- ❖ The two modes of Operation for SARPEX are practically the same. given that the Mock Exercise only simulates the possible behavior of all bidders in the DAM on SARPEX through inputs that are accurate to a reasonable degree of accuracy
- ❖ The revenue accrued to each nation from the trade is accounts to INR 8.85 Billion, 0.7 Billion, 0.3 Billion and 0.25 Billion for Bangladesh, Nepal, Bhutan and India respectively in Unified Mode for FY'16
- ❖ The revenue accrued to each nation in the Sequential Mode accounts to INR 8.23 Billion, 0.63 Billion, 0.42 Billion and INR 0.43 Billion for Bangladesh, Nepal, Bhutan and India respectively for FY'16
- ❖ Clearly, the DAM on a regional exchange is desirable and improves the socio-economic welfare of all participating nations

Key Takeaways from SARPEX Mock Exercise...(2/2)

- ❖ In Unified Mode, the volumes bought by Bangladesh, Nepal, Bhutan and India in FY'16 is 2011 MUs, 719 MUs, 0.09 MUs and 35396 MUs respectively. The corresponding figure for each nation is 1920 MUs, 630 MUs, 0.04 MUs and 36219 MUs in Sequential Mode (*These figures include the volumes from India DAM*)
- ❖ The volumes sold by Nepal, Bhutan and India in Unified Mode for FY'16 is 10 MUs, 412 MUs and 37715 MUs respectively. The corresponding figure for each nation is 100 MUs, 427 MUs and 38342 MUs in Sequential Mode (*These figures include the volumes from India DAM*)
- ❖ Over India-Only Mode, the purchase volume for India declines by 822 MUs in Unified Mode and remains unchanged in Sequential Mode. On the other hand, the sell quantum increases by 1496 MUs and 2123 MUs in Unified and Sequential Mode respectively
- ❖ The weighted average market clearing price is INR 2910/MWh and INR 3269/MWh in Unified and Residual Mode respectively. The price in the latter mode is higher by an average of 12% for FY'16. In both the modes, the price is below INR 4000/MWh in more than 80% of the cases
- ❖ The monthly trends of price observed in both the modes exactly mimics the trends on Indian Exchanges as India plays the role of a dominant player in the SA regional market

Discussion on Results

- ❖ The SARPEX Mock Exercise Project finds that based on the demand-supply and transmission conditions that prevailed in BBIN in FY'16, the DAM operation of SARPEX would benefit all the participating nations, resulting in the overall regional surplus of INR 323 Billion in a year, in both the modes
- ❖ The Surplus Gain in a year to BBIN is far higher than the YTC of the transmission line indicating that relatively small investments in transmission lines may yield surprisingly huge dividends in terms of increased economic gains and social welfare.
- ❖ With regards to the mode of operation for SARPEX, in Sequential Mode, all nations are better off without adversely impacting any nation from its current state.
- ❖ For Bhutan, Bangladesh and Nepal, the access to DAM on SARPEX, regardless of the mode of operation, not only helps in management of day-ahead contingencies in demand and supply; these countries also reap benefits of being able to buy/sell power at a price less than/greater to their marginal willingness. Thus the choice of mode of operation for SARPEX doesn't have a big bearing for BBIN
- ❖ For India, the consumer surplus falls in Unified Mode as the new market entrants with higher willingness to pay disturb the existing market equilibrium for Indian buyers. However, this problem is completely nullified in the Sequential Mode as by the virtue of its design, it doesn't impact the existing DAM for Indian participants.
- ❖ As more volumes are brought into the DAM on SARPEX with strengthening of inter-country transmission, the regional surplus in the Sequential Mode would increase. Therefore, it serves as a good starting point for the development of day-ahead cross border trade between these countries.



THANK YOU

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