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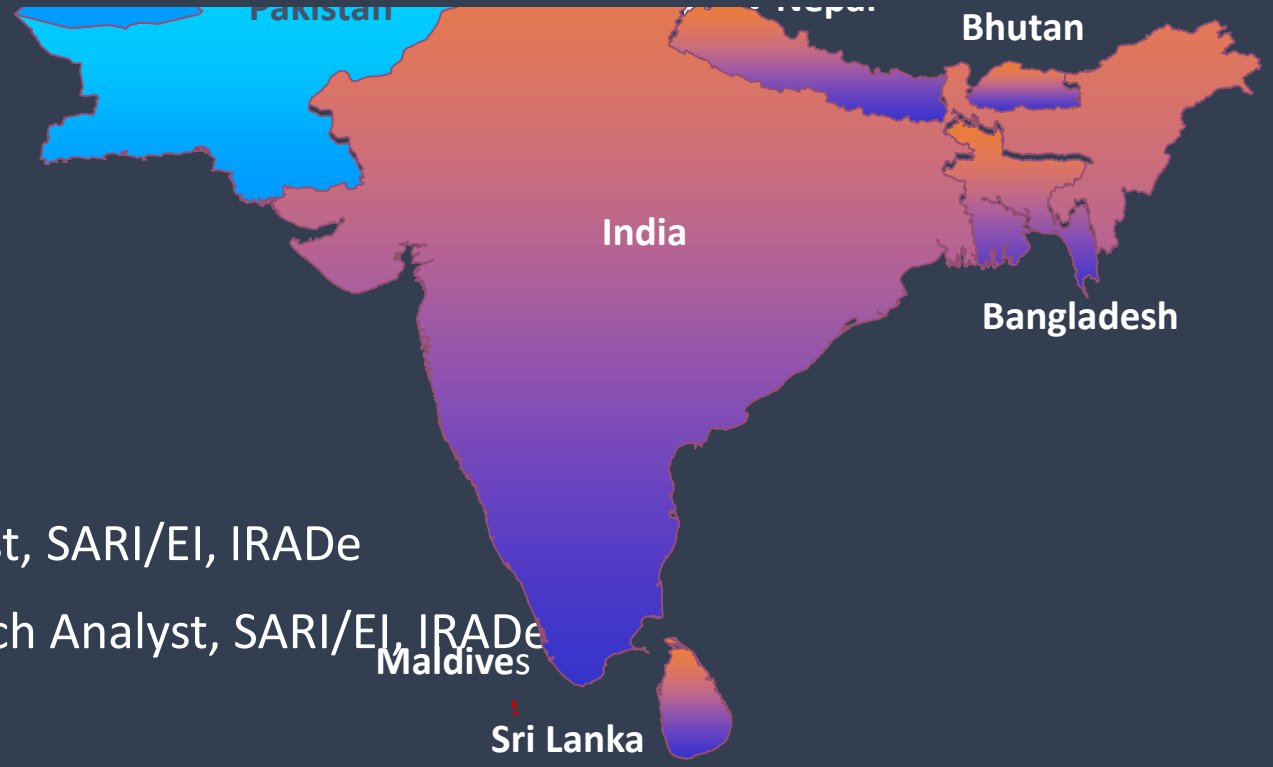
URJA VICHAR MANCH

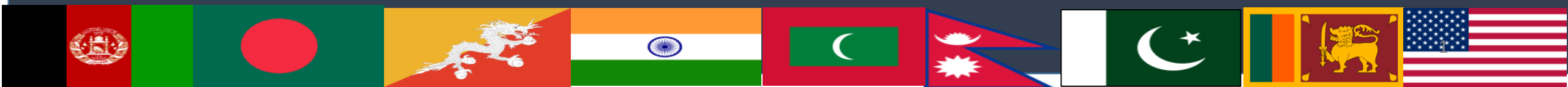
Wednesday, 30th May 2018, 3.00 PM. Shriram Hall, PHD House, New Delhi

South Asian Regional Power Exchange (SARPEX)Mock Exercise



Mr. S.K. Ray, Technical Specialist, SARI/EI, IRADe

Mr. Gaurav Jain, Senior Research Analyst, SARI/EI, IRADe

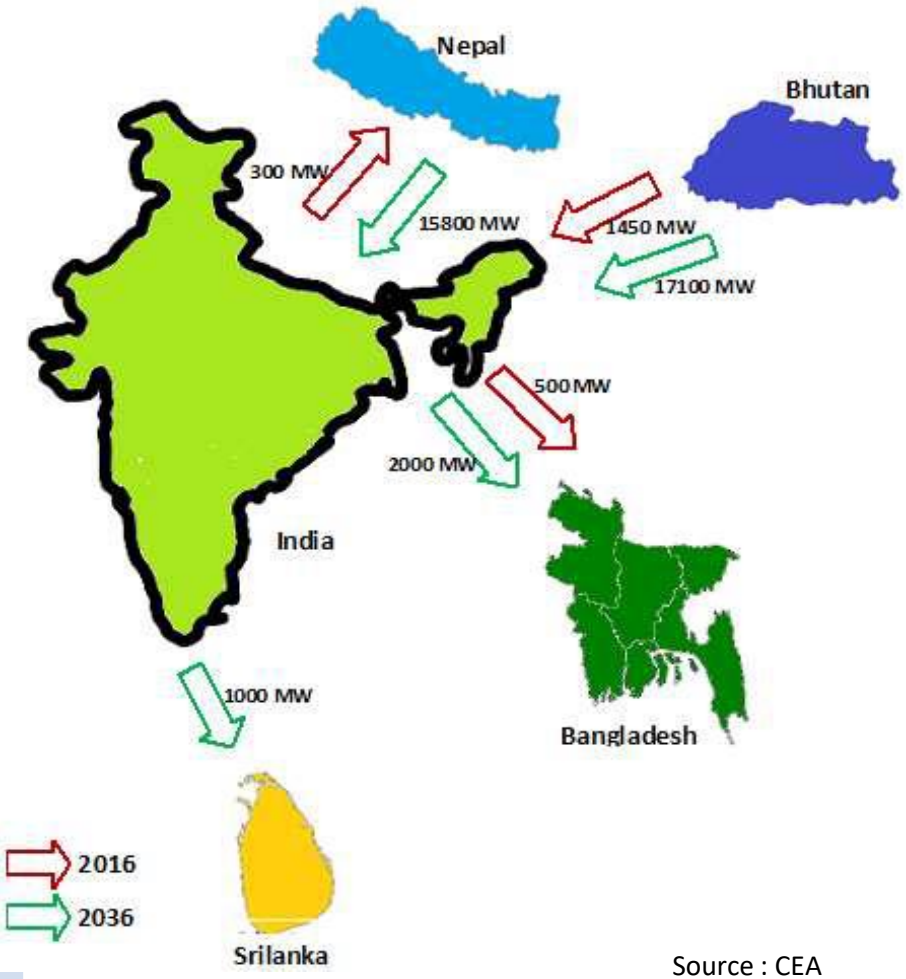


Content

- Existing Trade Scenario
- Recent guidelines, orders and agreements related to CBET
- Need of South Asian Regional Power Exchange
- Conducting the South Asian Regional Power Exchange(SARPEX)- Mock Exercise
- The SARPEX mock Exercise web portal
- Result of SARPEX- Mock Exercise
- Conclusions from the SARPEX Mock Exercise

Existing Power trade in South Asian countries

Country	Contracts quantum and duration	Type
Bhutan → India (1450 MW)	Contract with PTC for Chukka (336 MW), Kurichhu (60 MW) Hydro Projects (Long Term)	G to G
	Contract with PTC for Tala (1040 MW) Hydro Project (Long Term)	G to G
	Contract with TPTCL for Dagachhu (126 MW) Hydro Project (Long Term)	Commercial
India → Bangladesh (660 MW)	BPDB Long-term contract with NVVNL for 250 MW	G to G
	BPDB Medium-term contract with PTC for 250 MW	Commercial
	Tripura – Comilla 160 MW contract	G to G
India→ Nepal (420 MW)	NEA Bilateral contracts / Treaties to the tune of 420-440 MW	G to G
	NEA Past contracts with PTC (2011-2015) during December-April months for ~20-30 MW	Commercial



Source : CEA

Commercial Mechanisms of Price Discovery in Power Trading is well established now in all the BBIN countries

Aspiration Behind the Regional Integration

Technical and Operational Benefits:

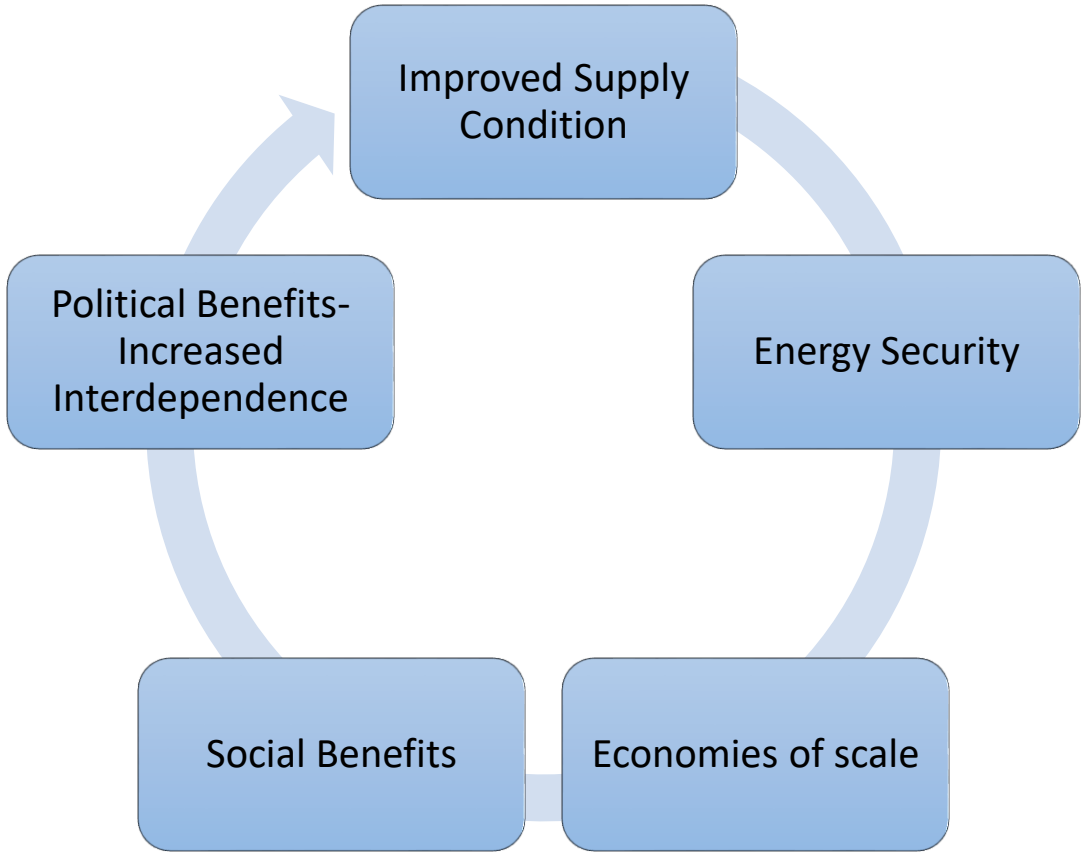
- Optimal Use of Regional Resources and System Operation
- Economies of scale in the development of regional resources
- Improved energy security and reliability of respective power systems
- Optimized transmission network
- Reduce environmental impact
- Reduce fossil fuel imports

Economic and Financial Benefits:

- Cost effective power system
- Better return to investors in generation assets
- Improvement in industrial productivity and competitiveness
- Less exposure to volatile international energy prices
- Economic Growth
- High export income

Environmental Benefits:

- Less Impact on Local and Global environment
- Reduce Adverse Impact of Indoor Air Pollution
- Improvement in Social Indicators
- Renewable Energy Development



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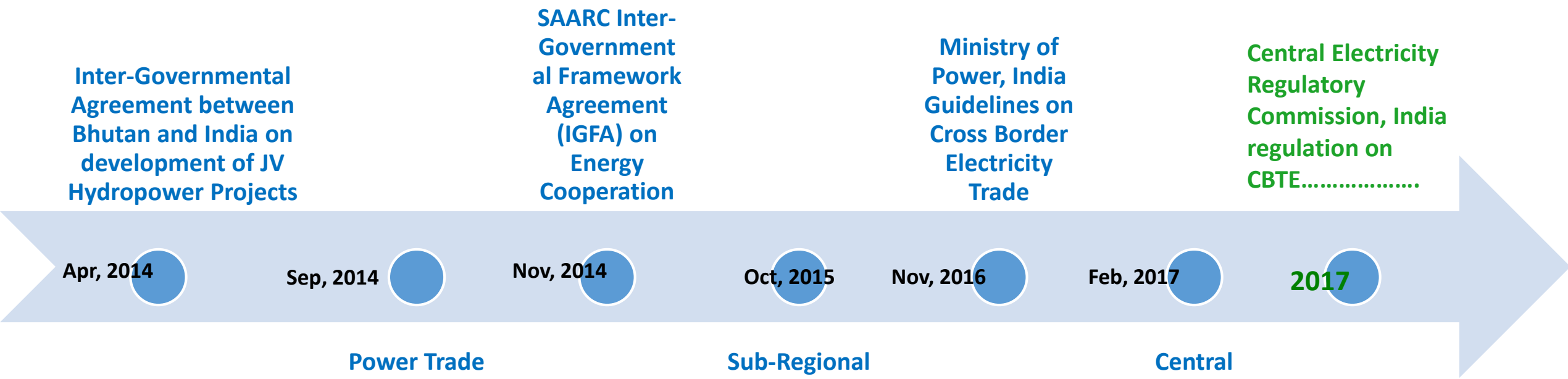
Exchange Based Trading for Cross Border Power Trade



Existing proposed provision: Trading through the Power Exchanges

- **The following products are proposed to be permitted as per the Indian Government Notification and CERC draft regulation.**
  - Term Ahead Contracts Intra Day Contracts or Contingency Contracts.
  - However, the Guidelines mentions that the same can subsequently be extended to other categories of contracts based on review by Ministry of Power in consultation with CERC. This includes the Day Ahead Market (DAM).
- **These are also subject to**
  - Approval from the Designated Authority.
  - The quantum of electricity that can be traded under cross border trade of electricity in Indian Power Exchange(s) shall be as prescribed from time to time by the Designated Authority

This is a very promising start and Exchange based operation has now been permitted. Also doors have been opened for the core Product of Power Exchanges i.e. the Day Ahead Market (DAM) Spot products to be offered through Exchanges

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Regional Complementarities- Monthly and Hourly

	January	February	March	April	May	June	July	August	September	October	November	December
Bangladesh												
India - North East												
Bhutan												
India - East												
Nepal												
India - North												
India - West												
Pakistan												
India - South												
				Low	Medium	High						

(Source: World Bank Reports, 2015)

Countries	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Bangladesh- April																								
Bhutan - April																								
India- April																								
Nepal- April																								
Pakistan-April																								
Sri Lanka- April																								

How this hourly complementarities of South Asian countries may be used for social welfare maximization of region??

Color Coding	Range	
	Min	Min+ (Max-Min)*20%
	Min+ (Max-Min)*20%	Min+ (Max-Min)*40%
	Min+ (Max-Min)*40%	Min+ (Max-Min)*60%
	Min+ (Max-Min)*60%	Min+ (Max-Min)*80%
	Min+ (Max-Min)*80%	Max

Regional Power Exchange- Mock Exercise

- A trading platform mimicking a regional Energy Exchange for the SA Region.

- **The mock exchange provided an answer to various key questions, related to feasibility and desirability and possible volume in the regional market, the impact of regional market on domestic energy markets.**

- The mock exercise results provided the desired inputs for the decision makers in selecting a suitable option for market design. This will also give clarity about the identity of the buyers and sellers in such a Regional Exchange.

- Additionally, the mock exercise also developed/provided:
  - Develop a draft set of market design and rules of a SA regional electricity market.
  - Prepare a detailed report based on the analysis of the pilot market data to ascertain the desirability and the feasibility of a SARPEX, and
  - To build the capacity of relevant officials from the SA countries on the functions of a power exchange which is critical irrespective to the option finally selected.

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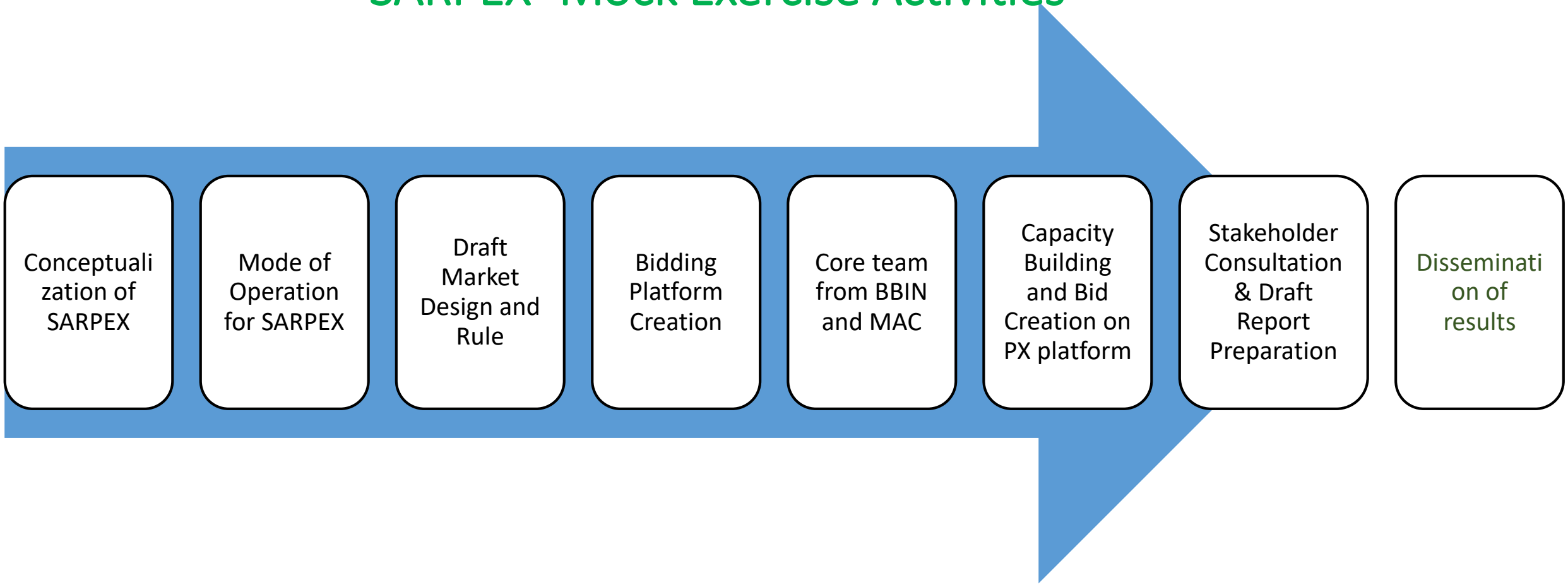
SARPEX- Mock Exercise Activities



Real-time balancing and social welfare maximization in the Region

- A cross border exchange will provide a fair, neutral and robust price discovery platform and create an orderly marketplace for all the buyers and sellers in BBIN
  - Market-determined prices - Price transparency, competition and efficient price signals
  - Greater flexibility since trades are on a short-term requirements and production capability basis – better suits the resource type of the countries
  - Allows for absolving the counterparty risk
  - Enhanced grid stability through real-time balancing and better coordination between all operating markets and dispatch schedules
  - Economic dispatch
- Apart from the other benefits of Exchange, it will not only supplement the existing bilateral trade in BBIN but also encourage more choice and investments in the sector

Conducting the SARPEX Mock Exercise

- The exercise covers the period from April'2015 to March'2016.
- 71 days were selected in this one year period to cover all kind of demand situation and various other crucial factors as per the approved Sampling methodology. Six different clusters were created on this basis.
- Core teams were nominated by Bangladesh, Bhutan and Nepal who will bid for all the dispatch periods of all these 71 days.
- Indian bids for these 71 days were extracted from information available in public domain.
- The mock trading platform was run to generate results for all these 71 days.
- The mock trading platform was run in two modes of operation, "Unified mode" and " Sequential or Residual Mode" as explained further in this presentation.
- The market rules and design for running of the mock exercise were approved in the Task Force-3 meeting for both the modes of operation.

Conducting the SARPEX Mock Exercise .. Continued

- The transmission losses and charges have been factored in as in case of a regular day ahead market.
- The figures of transmission losses and charges used for Bangladesh, Bhutan and Nepal are mentioned further in this presentation.
- The result of the matching engine yields the unconstrained solution.
- The result for the 71 days were extrapolated to get the result for the entire year for both the modes of operation.
- The consumer and producer surplus, quantum of power sold/bought, sale/buy price etc. for each participating Nations and the entire region was worked out in both the modes .
- The impact of the regional trading platform on the domestic market was analyzed.
- Based on the above, a particular set of market rules and design has been recommended for SARPEX.

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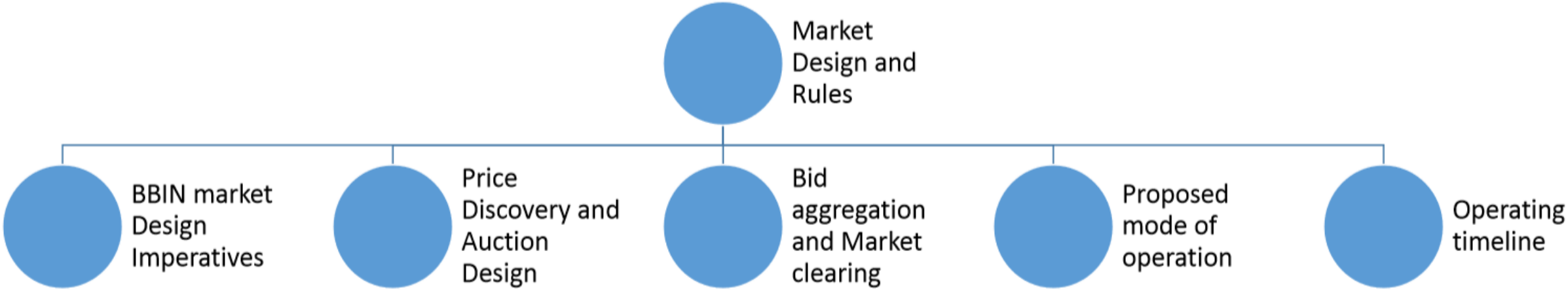
Market Design and Rule For SARPEX

- An efficient market design for Power Exchanges may optimizes the Social Welfare is fundamental to developing and sustaining integration of the SARPEX countries.

- Harmonisation of the market rules across the SARPEX countries through an appropriate market design will likely lead to efficient utilization of available resources and infrastructure.



Market Advisory Committee for deciding the Market Rules & Design for SARPEX

Market Advisory Committee

Name	Country	Designation	Organization
Mr Anil Razdan	India	Ex- Secretary Power	Ministry of Power
Mr. Hans-Arild Bredesen	Norway	CEO	Nord Pool Consulting
Mr Peter Jogersen	Denmark	Vice President	Energinet, Denmark
Mr Musara Beta	South Africa	Chief Analysts	South African Power Pool

Mentors

Name	Country	Designation	Organization
Dr. Kirit Parikh	India	Chairman	IRADe
Dr. Jyoti Parikh	India	Executive Director	IRADe

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Nominated of Core Team and TF-3 Members

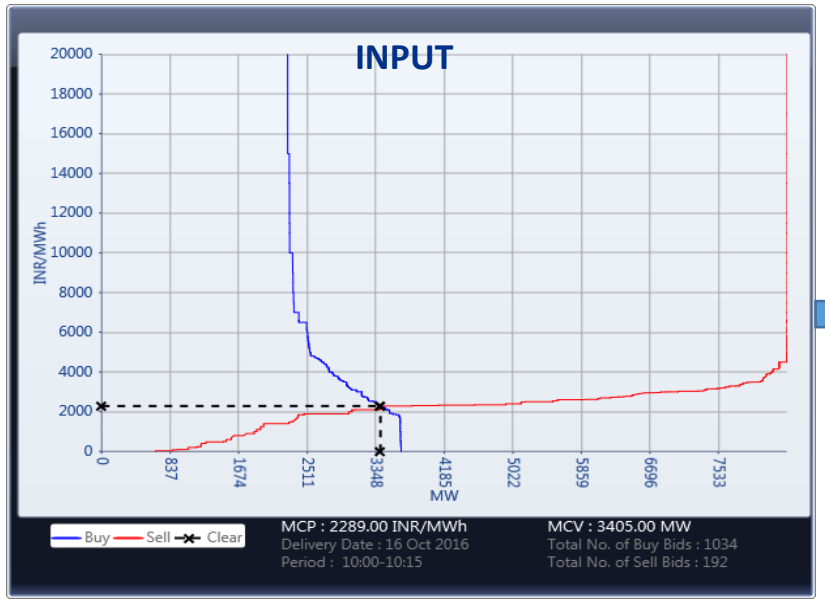
Core Team Member - BBN for SARPEX				
S.No	Name	Country	Designation	Organisation
1	Mr. Karma Namgyel	Bhutan	Chief Engineer,Department of Hydropower and Power Systems	Ministry of Economic Affairs
2	Mr. Denkar	Bhutan	Engineer,Department of Hydropower and Power Systems	Ministry of Economic Affairs
3	Mr. Ugyen Chophel	Bhutan	Engineer,Department of Hydropower and Power Systems	Ministry of Economic Affairs
4	Mr. Nima Tshering	Bhutan	Bhutan Power System Operator (BPSO)	Bhutan Power Coporation (BPC)
5	Mohammad Hossain,	Bangladesh	Director General	Power Cell
6	Shiekh Faezul Amin -	Bangladesh	JS (Dev)	Power Division
7	Golam Kibria	Bangladesh	Director IPP 1	BPDB
8	Md. Nuruzzaman	Bangladesh	SE (Plg)	PGCB
9	Mr. Anil Rajbhandary	Nepal	Director	Nepal Electricity Authority
10	Mr. Nutan Prakash Sharma	Nepal	Senior Devisional Engineer	DoED, NEA
11	Mr. Narendra Shrestha	Nepal	Assistant Manager	Load Dispatch Center, NEA
12	Mr. Tej Krishna Shrestha	Nepal	Assistant Manager	Power Trade Department, NEA

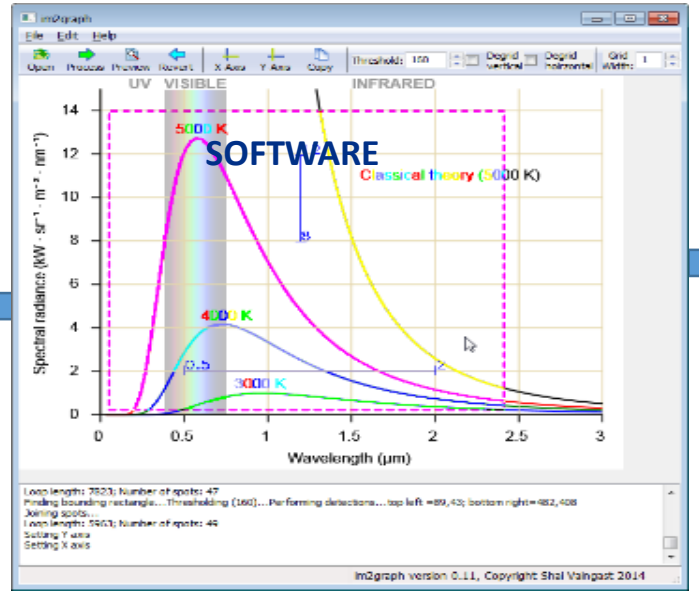
Task Force-3 Members- South Asian Countries				
S.No	Name	Country	Designation	Organisation
1	Mr. Md. Mizanur Rahman	Bangladesh	Member	Bangladesh Energy Regulatory Commission
2	Mr. Abid Latif Lodhi	Pakistan	CEO	Central Power Purchasing Agency (Guarantee) Limited
3	Mr. Sonam P.Wangdi	Bhutan	Director General- Department of hydropower and power system	Ministry of economic affairs
4	Mr. Harish Saran	India	Executive Director (Marketing)	Power trading Corporation India Limited
5	Mr. Rajesh K Mediratta	India	Director – Business Development	Indian Energy Exchange Limited
7	Mr.K.L.R.C. Wijayasinghe	Sri Lanka	Director (Power & Energy)	Ministry of Power & Energy

Extraction of Indian Bids

- The bids of the Indian participants were extracted from the images of the aggregate demand-supply curves/ charts available on IEX website using an “image-processing software” called “im2graph”
- The charts were fed into the software and the range for X-Y coordinates were specified and software then identified the scanned images (pixels) and converted them into discrete data-points

Process of Image Scanning and Data Extraction





OUTPUT

Buy	Sell
X, Y_0	X, Y_0
2237.49, 17529.8	670.754, 29.9401
2253.3, 13303.6	686.536, 29.9401
2269.11, 10803.6	702.319, 29.9401
2300.74, 9077.38	718.101, 29.9401
2316.55, 7529.76	733.884, 29.9401
2332.36, 7053.57	749.666, 29.9401
2348.17, 7053.57	765.448, 29.9401
2363.99, 7053.57	781.231, 29.9401
2379.8, 6875	797.013, 29.9401
2395.61, 6517.86	812.796, 29.9401
2411.42, 6517.86	828.578, 29.9401
2427.24, 6517.86	844.361, 29.9401
2443.05, 6517.86	860.143, 29.9401
2458.86, 6517.86	875.926, 89.8204
2474.67, 6398.81	891.708, 89.8204
2490.49, 5982.14	907.49, 89.8204
2506.3, 5208.33	923.273, 89.8204
2522.11, 5029.76	939.055, 89.8204
2569.55, 4791.67	954.838, 89.8204
2585.36, 4732.14	970.62, 89.8204

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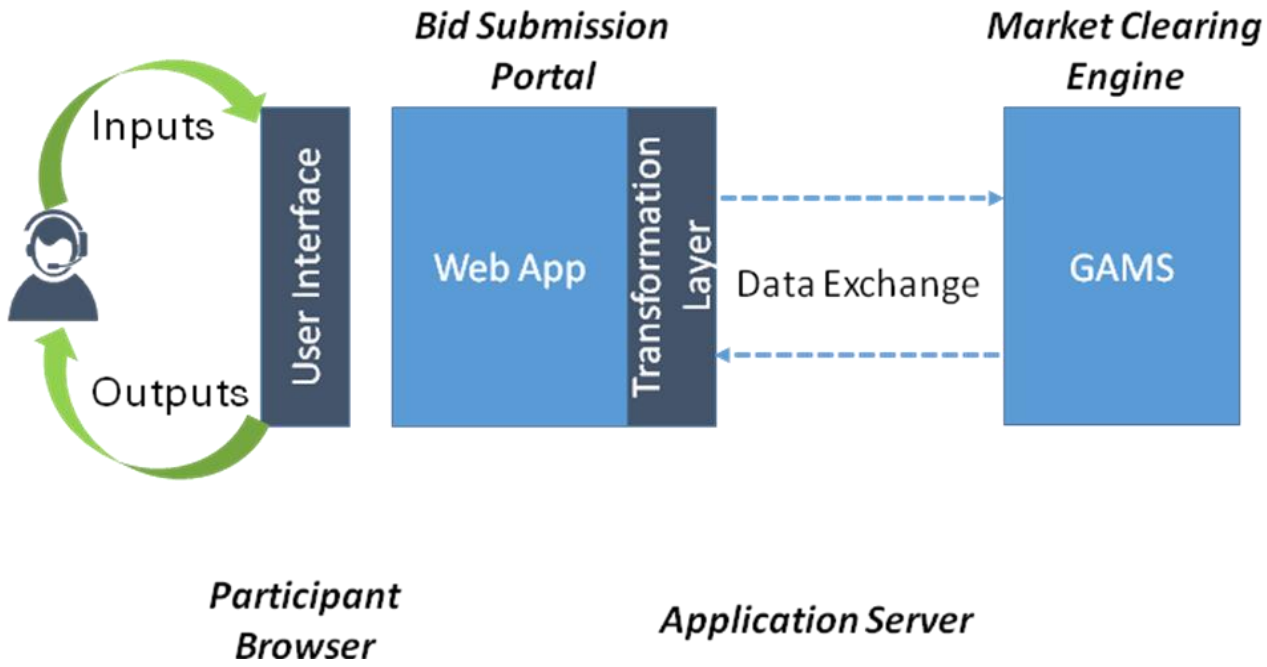
Average Transmission Charges and Losses Figures for BBN

#	Country	Transmission Charges (Rs/kWh)	Transmission Losses (%)	Comments
1	**Bangladesh**	**0.117**	**0.3%**	The transmission charges for injection or withdrawal of power by Bangladesh **from the Indian transmission network a**re published by NLDC and published on a quarterly basis as POC Injection or POC Withdrawal charges for Bangladesh
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**
	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 been included in the POC charges and only the transmission Injection Charges are published by NLDC for Bhutan**

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

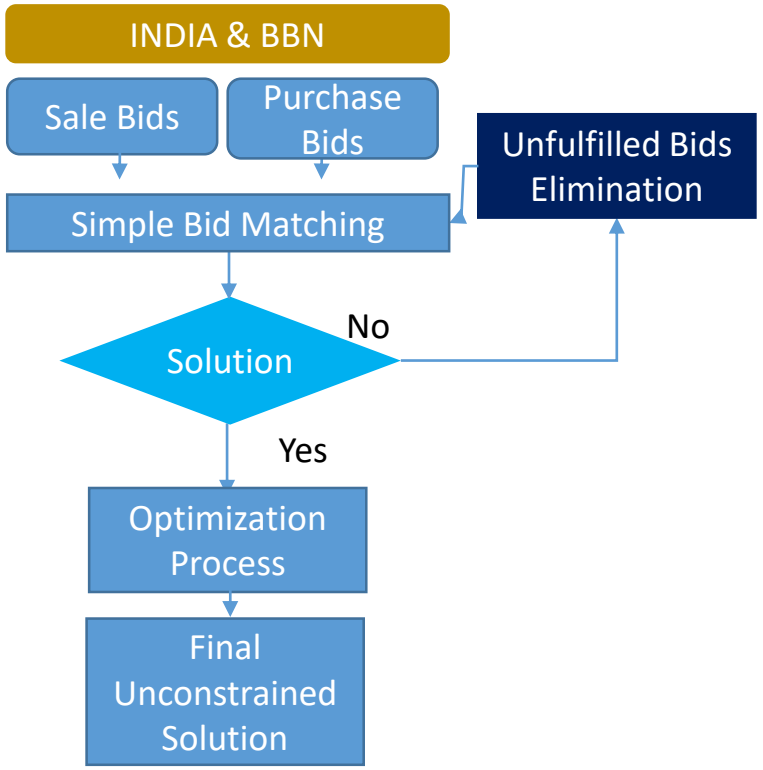
SARPEX Web Portal
Bidding Platform and Market Clearing Engine

- The portal is powered by a front-end web application which interacts with Market Clearing Engine at the back-end and allows users to see the results on the Web Portal.
- The web portal has been created to mimic the trade in the DAM on a Regional Power Exchange
- Link http://mocksarpex.ga

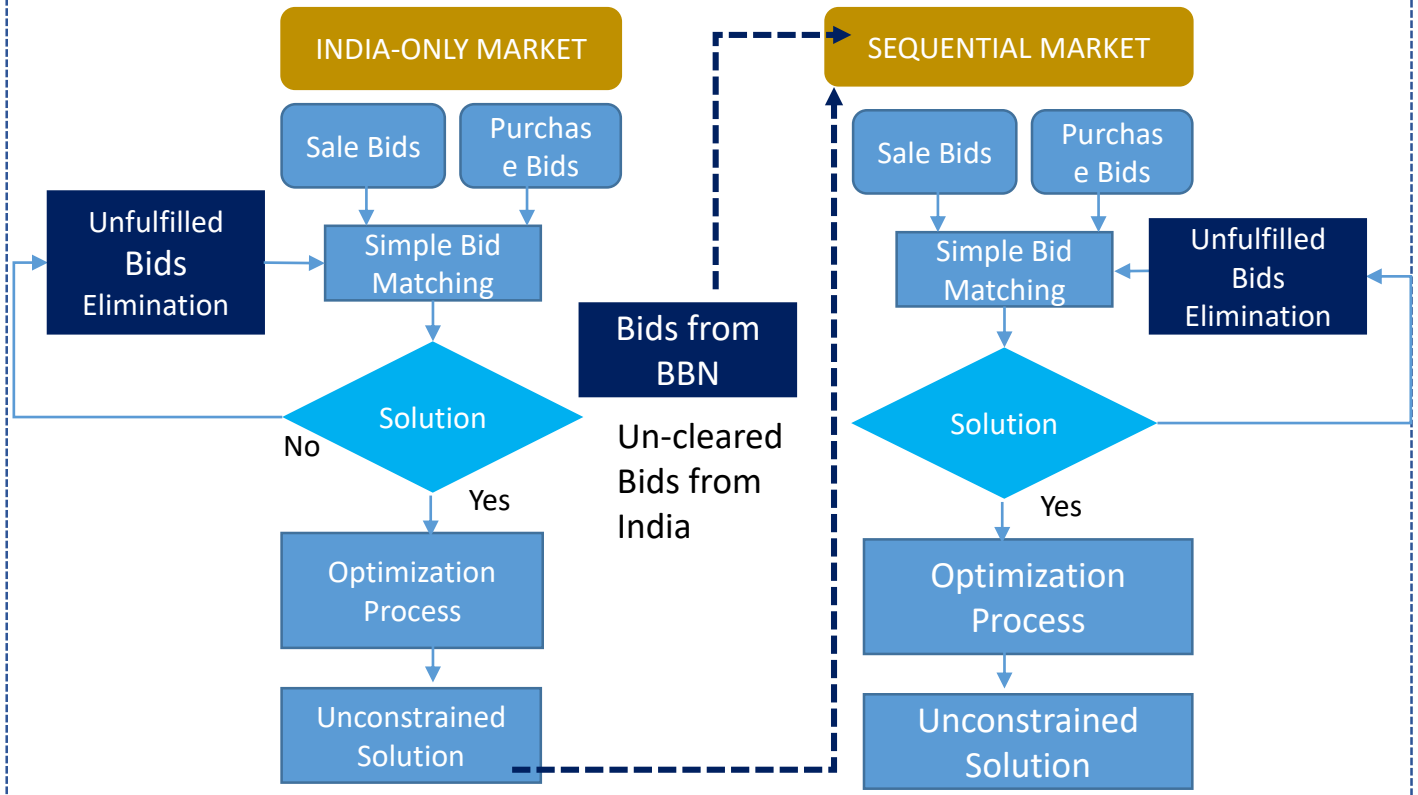


SARPEX's Clearing Algorithm

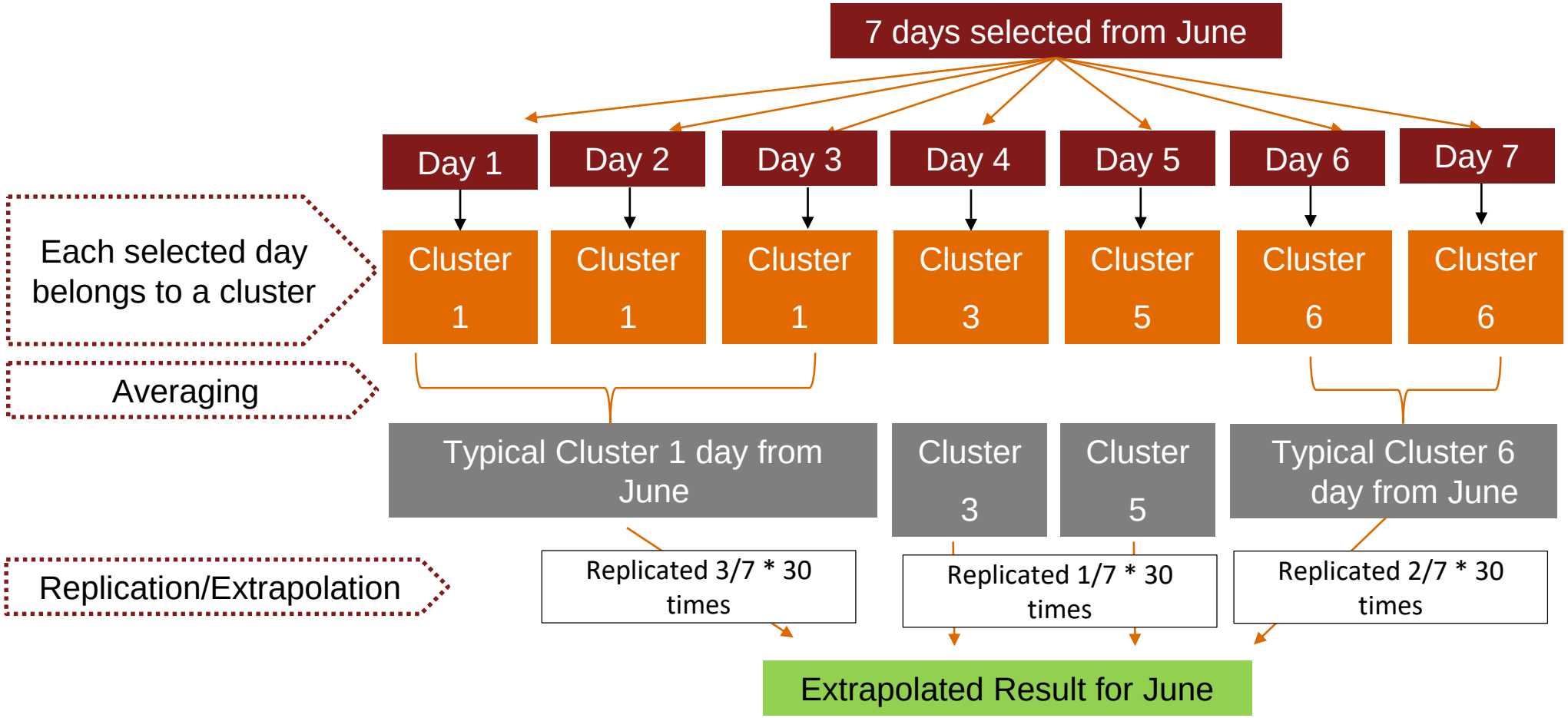
UNIFIED MODE – 15 MINUTE DAM INTERVAL



SEQUENTIAL MODE – 15 MINUTE INTERVAL DAM



Extrapolation of Market Results



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Total Yearly Surplus in the 3 Modes for FY'16

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

The surplus in the two modes of Operation for SARPEX are practically the same on a Regional basis.

The difference, 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**

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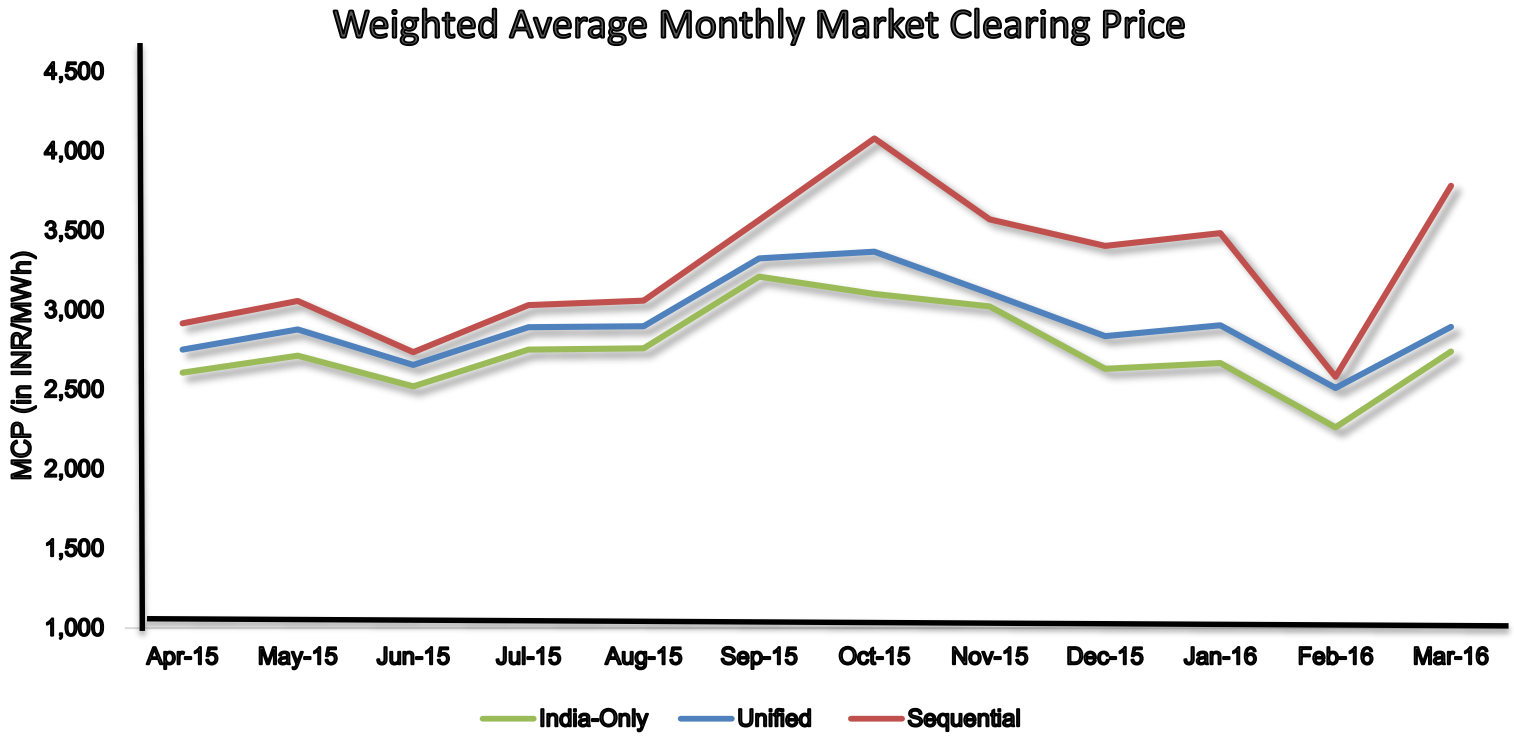
Weighted Average Market Clearing Price in the 3 Modes for FY'16

	Monthly 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

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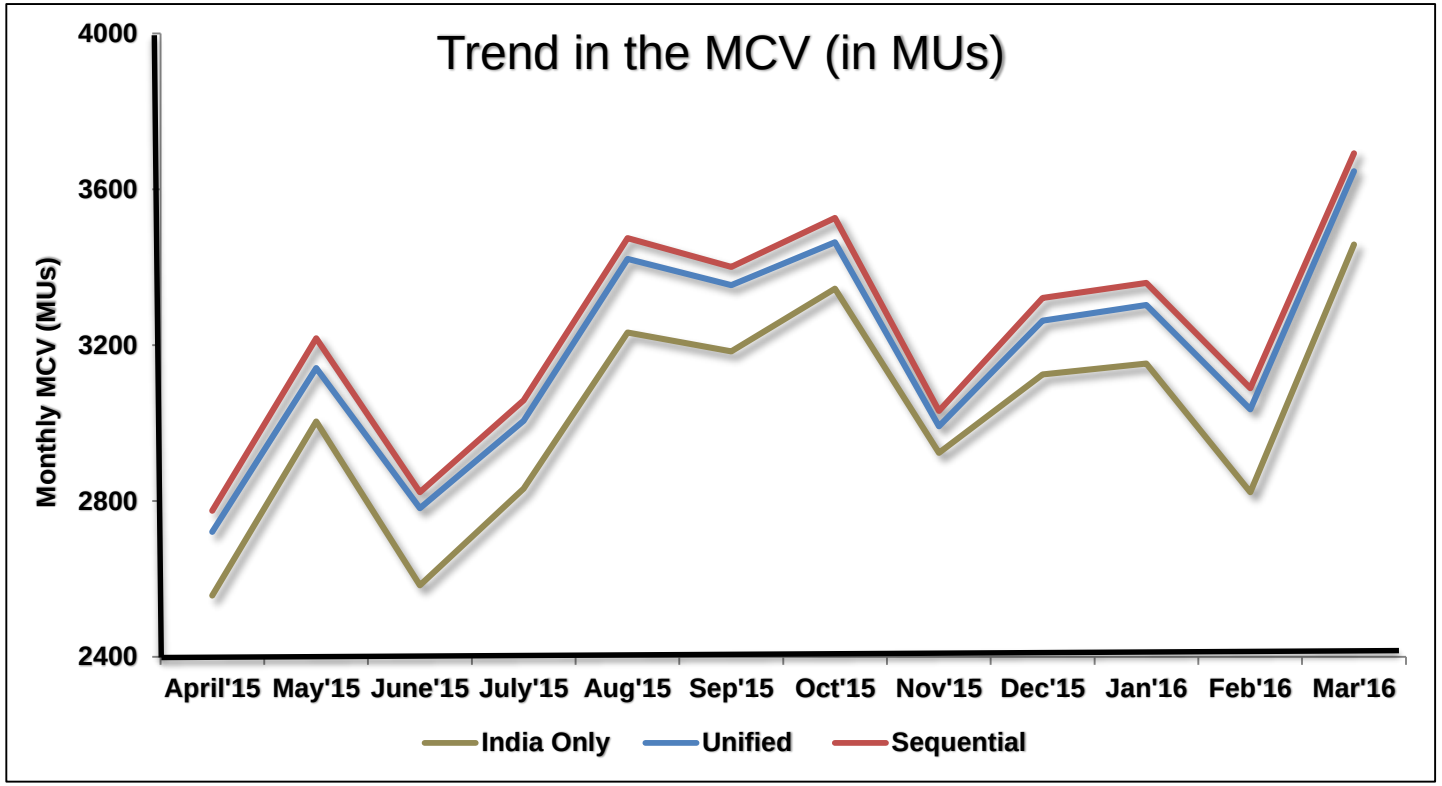
Total Market Clearing Volume in the 3 Modes for FY'16

	Total Yearly Market Clearing Volume (in MUs)	% Increment over India-Only Mode
India-Only	36219	-
Unified	38127 (1908*)	0.05
Sequential	38768 (2549*)	0.07



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. This is the actual additional volume generated by the DAM.*
- **The volume of the Cross Border DAM is 1908 Mus in case of Unified mode and is higher at 2549 Mus in case of sequential mode. Roughly 6-7 Mus per day (UCV)**

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Surplus Accrued to Each Nation (including Indian DAM) in Unified and Sequential mode (in INR Billion)

	Regional Surplus	Surplus Gain to Bangladesh	Surplus Gain to Nepal	Surplus Gain to Bhutan	Surplus Gain to India
India-Only	323.53				313.53
Unified	323.63	8.85	0.7	0.3	313.78
Sequential	323.24	8.23	0.63	0.42	313.96

Surplus gain to Bangladesh and Nepal is mainly accounts for Consumer Surplus
Surplus gain to Bhutan and India accounts for Producer Surplus

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Surplus Accrued to Each Nation (Excluding Indian DAM) in Unified and Sequential mode (in INR Billion)

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

All the Nations in the Regional Gain due to SARPEX
The gains to individual nations are very similar irrespective of the mode of operation.

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

	India	Bangladesh	Nepal	Bhutan	Total
India-Only	36219	-	-	-	36219
Unified	37715 (1496*)	-	10	412	38137
Sequential	38342 (2123*)	-	10	427	38779

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*

The figure for Nepal is low as Nepal at present is rarely in a position to sell Power. It is Expected that after 2020, the share of Nepal will increase at least up to 100 MUs

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

	India	Bangladesh	Nepal	Bhutan	Total
India-Only	36219	-	-	-	36219
Unified	35396 (-822*)	2011	719	0.09	38137 (1908*)
Sequential	36219 (0*)	1920	630	0.04	38769 (2549*)

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*

The Buy Volume of India actually reduces in the Unified Mode.

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Conclusions

- Introduction of DAM in SAR could immensely improve the producer and consumer welfare in each country as well as the region as a whole
- SARPEX could also yield efficient price signals, transparency and major distributive benefits in terms of increased fuel diversity, diversified supply mix and decreased overall costs
- Access to SARPEX regardless of the mode of operation not only helped BBIN in management of demand supply balance on a day ahead basis but also allowed the countries to buy/sell power at a price less than/greater than their marginal willingness
- Operating mode had an impact on India as its consumer surplus in Unified mode reduced as the new market entrants i.e. Bangladesh and Nepal with higher willingness to pay displaced some of the low cost Indian buyers
- The Surplus Gain to BBIN witnessed in FY16 was far higher than the annual transmission charges of the interconnecting transmission lines. Thus, any investments for enhancing the transmission capacity could result in huge dividends in terms of increased economic gains and social welfare.

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India Specific conclusions from SARPEX Mock Exercise

- India's total surplus is higher in the Sequential Mode as surplus power from India is traded in the regional power market at high price while the domestic Indian market remains unaffected .
- The sequential mode is providing the level playing fields for all the South Asian countries and also insulating the National domestic market from the Regional Market.
- In the **Unified mode** of operation the quantum of **power bought by India reduces** not only as compared to the Sequential mode but also as compared to the India Only mode.
- In the **Sequential mode** of operation the quantum of power **bought by India do not change** from the India only mode. This is because the MCP of sequential mode is higher than the MCP of both the modes and any buy bid of India not cleared in Indian Domestic market will not get cleared in SARPEX too.
- In the **both the mode** of operation the quantum of power sold by India increases as compared to the India Only mode but the **increase is higher in case of Sequential Mode by 50%** as compared to the Unified mode.
- The Weighted Average **Buy Price for India increases in Unified mode but not in Sequential Mode**.
- The **Weighted Average Sell Price for India increases in both the modes**. This increase in Unified mode impacts all Indian buyer also but in sequential mode, Indian sellers will still gain while the buyers will not be adversely impacted.

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THANK YOU

For more details please contact:-

1) S. K. Ray, Technical Specialist, IRADe skray@irade.org ,+91 9971792136
2) Gaurav Jain, Sr. Research Analyst IRADe gjain@irade.org , +91 9643380643