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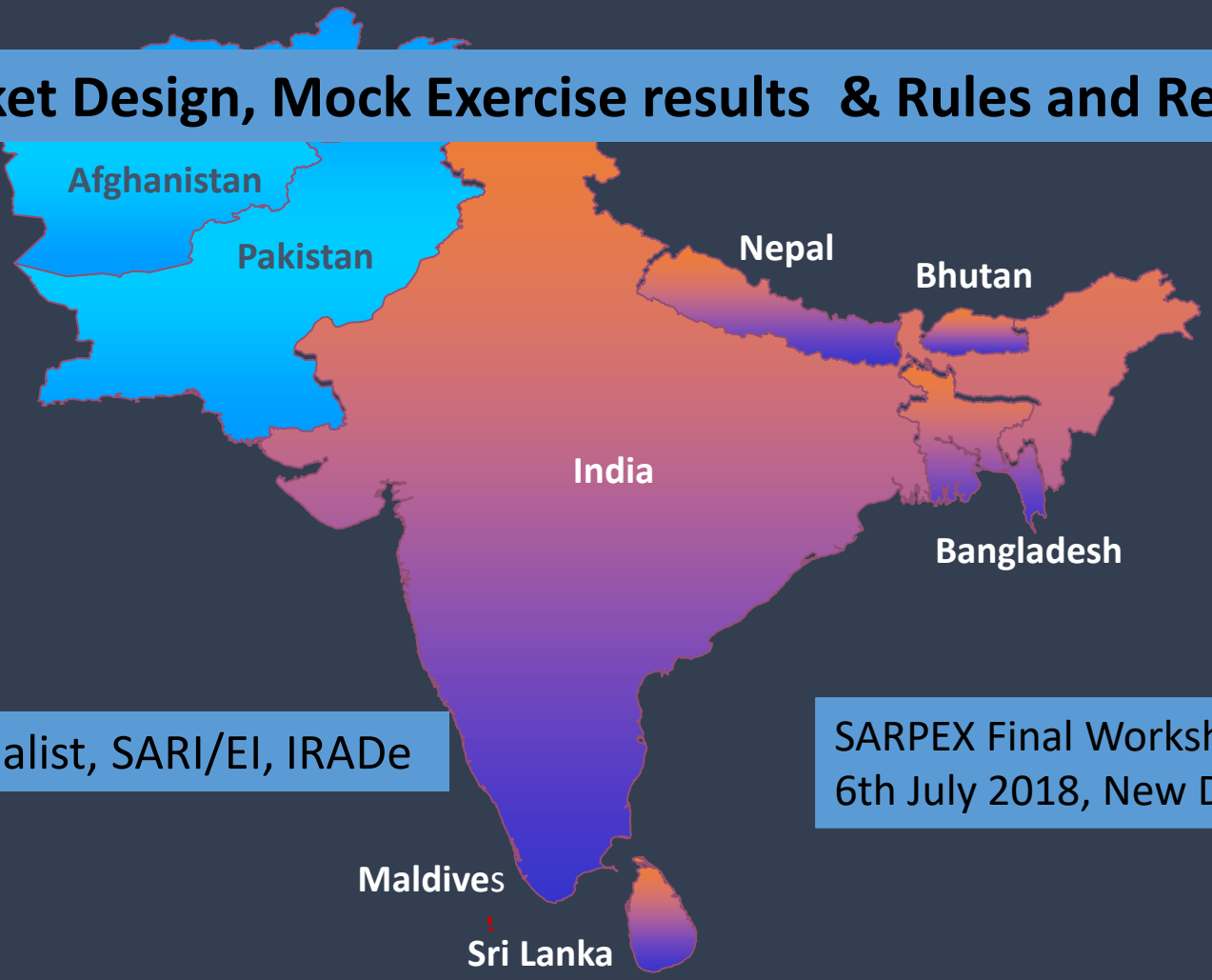
SARPEX: Market Design, Mock Exercise results & Rules and Recommendation



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SARPEX Final Workshop.
6th July 2018, New Delhi

Some Terminology relevant to the exercise

- Day ahead market (DAM): Bidding in the market is done on day n, for trades which are effective on day n+1.
- Unconstrained Market Price and volume (UMP & UMV) : The discovered market price and volume which do not take into account transmission constrains. **The price and volumes is the mock exercise are UMP and UMV however the maximum bid quantity was capped.**
- Constrained Market Price and volume (CMP & CMV) : The discovered market price and volume discovered after taking into account the transmission constrains.
- India Only Mode: Along with the Unified mode and the sequential mode, the results mention “India Only Mode”. This is nothing put the matching engine run with only the bids of India. This represents the Indian Domestic DAM. The results are useful for comparison purpose as we will see.
- Month-wise/Monthly Weighted Average Market Clearing Price - Average MCP typically observed in a month, weighted by the total volumes cleared in each block in that month. It is calculated by extrapolating the block-wise MCP of all selected days over the entire month
- Consumer Surplus: The gain to a buyer when he buys at a price(MCP) lower than his bid price.
- Producer Surplus: The gain to a seller when he sells at a price(MCP) higher than his bid price.

Capacity building of the Core Teams from BBN

- Core teams were nominated by the Government of Bangladesh, Bhutan and Nepal for participating in the mock exercised.
- After the nomination of core teams, the members from various participating nations were trained on the various skills required for placing a bid on the Pilot Exchange through a detailed workshop from 7th to 9th February 2017, held in Delhi. This was the first Capacity Building Workshop
- In the workshop, lecture notes/ study material/ videos/ were arranged to train the core teams of the member nations on various aspects relating to trade on Power exchanges.
- Hands on training for formulation of bids, uploading the bids, viewing the results were provided.
- Another capacity building workshop was done on 4th and 5th October 2017 to discuss the preliminary results of the SARPEX Mock Exercise and identify any discrepancy in the input data or the results

Conducting the SARPEX Mock Exercise 1/2

- The exercise covers the period from April'2015 to March'2016.
- 71 days have been selected in this one year period to cover all kind of demand situation and various other crucial factors (Sampling methodology) in the BBIN region.
- Core teams have been nominated by Bangladesh, Bhutan and Nepal who bid for all the dispatch periods of all these 71 days.
- Indian bids for these 71 days have been 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 transmission losses and charges have been factored in as in case of a regular day ahead market.

Brief about SARPEX Mock Exercise 2/2

- 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 was 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 be analyzed.
- Based on the above, a particular set of market rules and design was recommended for SARPEX.
- The web portal created for conducting the exercise has all information related to the mock exercise. The link to the web portal is http://mocksarpex.eu.ai

The Market Design and Rules for SARPEX 1/3

A. Modes of Operation

There are two options for mode of operation:

A. **Unified Mode –** All the bids including the bids including the bids of Bangladesh, Bhutan and Nepal (BBN) are cleared simultaneously in a single platform.

B. **Sequential Mode** - The Indian DAM is run as at present. Then the un-cleared bids of Indian Domestic exchanges are matched against the bids of the other nations in a separate platform.

B. Auction Design

The options are single or double sided and Closed or Open:

Recommended - Double sided Closed Bid Auction. This deters market collusion.

C. Price Discovery

There are two options for mode of operation:

A. **Uniform Market Clearing Price –** The Market Clearing price (MCP) is applicable to all trades.

B. **Pay as Bid (PAB)** - Each participant paying as per their bid. The price paid by buyer depends upon seller's price.

Recommended - Uniform Market Clearing Price

The Market Design and Rules for SARPEX 2/3

D. Market Clearing Algorithm

There are two options for market clearing:

A. **Step wise approach –** Uses simple aggregation of bids. Requires additional rules for price determination in case of multiple price levels at intersection point of two linear curves.

B. **Piece wise approach –** Uses linear interpolation to get piecewise linear curve. These curves always interact at a unique point.

Recommended – Step wise approach as it maximizes volumes based on social welfare and allows for unbiased distribution of wealth.

E. Methods to address non- convergence issues

There are two methods to address non convergence of curves issues:

A. **Extrapolation –** Uses extrapolation of one of the curves to provide an intersection point..

B. **Curve shifting –** Uses shifting of the entire demand or supply curve to generate point of intersection.

Recommended – Extrapolation approach as it maximizes social welfare.

F. Congestion Management

Recommended – Price Area Congestion Management as it cause least disruption to Indian DAM

The Market Design and Rules for SARPEX 3/3

G. Settlement Systems

There are two options for market clearing:

A. **Single settlement system –** In this case, the bids are accepted until hour before the real time dispatch and real time prices are used for all settlements.

B. **Multi settlement system –** In this case, the bids are submitted and cleared on a Day Ahead Basis and deviations are settled at real time prices.

Recommended – Multi settlement system as it is in line with the current rules and procedures for trade in BBIN.

H. Deviation Settlement

Recommended – The existing deviation settlement mechanism through Nodal agencies is proposed to be adopted for exchange based transactions also. As such the DSM can't be different for different transactions. In case of multi nodal agency involvement , settlement may be on a pro-rata basis.

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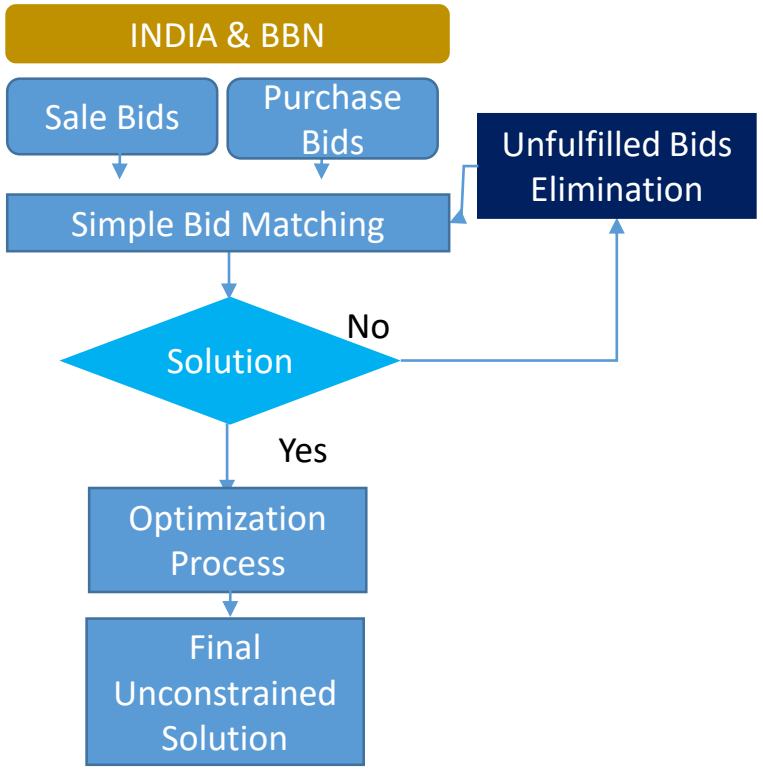
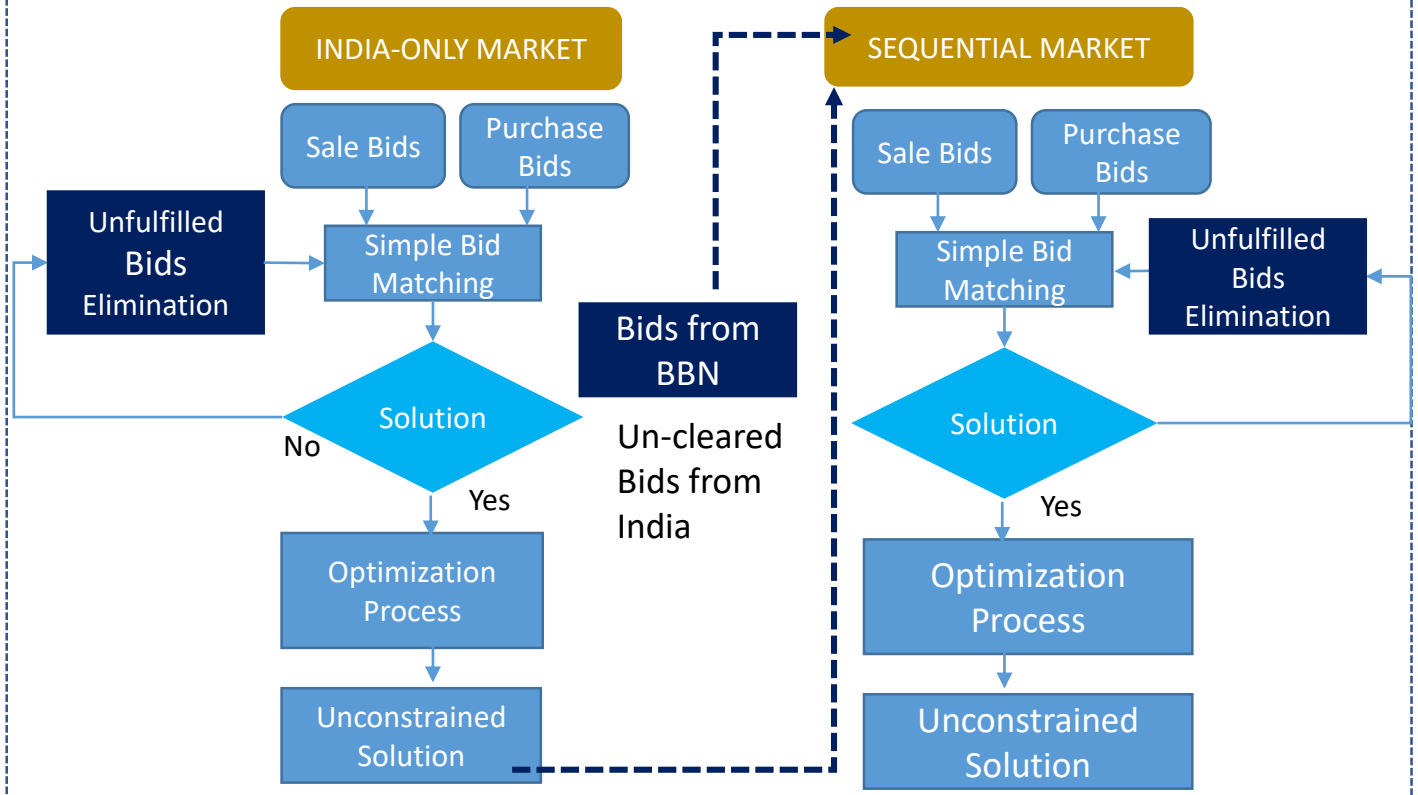
The Two Modes of Operation for SARPEX

UNIFIED MODE



SEQUENTIAL MODE



Systems and Procedures Related to Exchange based DAM for BBIN 1/3

A. Formation of Bid Areas

Separate Bid Areas for Nepal, Bhutan and Bangladesh, are proposed in addition to the existing bid areas for India. This is for the following reasons:-

- Perceived Congestion in the cross border transmission lines
- Management of differences in the Sovereign Laws, Power Sector Structure (Bundled/Unbundled), Tariffs, Grid operation related processes and procedures
- Settlement of Deviation Imbalances. Initially through Nodal agencies as being practiced currently.
- Alignment of time differences. It is also the globally accepted method in all Regional Exchanges.
- Settlement of currency related issues

B. Transmission Capacity allocation

- Each member country's transmission corridor allocation methodology is proposed to be retained, and Cross Border transmission capacity allocated to SARPEX is the residual capacity after accounting for the long term, medium term and short term transactions. **Reserving some capacity for CBTE DAM should be considered.**

Systems and Procedures Related to Exchange based DAM for BBIN 2/3

C. Participation pre-requisites:

• Provision for NOC is recommended for CBTE DAM participants. The operational control of the transmission system of Member Countries falls within the jurisdiction of the respective countries. An "No Objection Certification" (NOC) is therefore required from interested participants in each Member Country for allowing access up to the inter-regional periphery of the Indian Grid. The NOC is expected to be issued by the respective NLDCs in consultation with each other.

D. Coordination between NLDCs

- Once the unconstrained clearing volumes / prices are declared by the Exchange, the trades between various bid areas are cleared as per the available transmission capacities. In India, the available transmission capacity is estimated by the system operator i.e. NLDC. However for CBTE DAM, to declare available transmission capacity along the cross border transmission corridors India's NLDC shall have to coordinate with the NLDCs of BBN.

- Physical nodes for international inter-connection need to be specified for the cross border participants in order to schedule supply or off-take of electricity. Unlike in case of bilateral contracts, where delivery points are mutually agreed upon, Exchanges work on the principle of Collective Transactions, where delivery points are pre-determined. The concept of "Pooling Station" will help in simplifying this issue.

Systems and Procedures Related to Exchange based DAM for BBIN 3/3

E. Treatment of Transmission Charges and Losses

- Transmission charges on a per MWh basis as per the Point of Connection (POC) regulations and characterized by injection charges or withdrawal charges may be applicable respectively to the sellers or buyers for their scheduled injection or withdrawal at the International Periphery.
- The transmission losses may be applied at delivery point and categorized by POC injection losses and withdrawal losses. The sellers are required to inject more and the buyers are required to off-take less to compensate for the transmission losses at the delivery point
- The transmission charges and losses for the cross border interconnecting line and the Member country transmission network may be as per the applicable regulations and defined rates.

F. Multi Time Zones

- The time zones of BBIN Nations are within a 30 Mins slab. While Bhutan and Bangladesh are having +30 minutes deviation from IST, Nepal is having a +15 minutes deviation from IST. Nord Pool spot a major regional exchange has participants from EET and CET time zones but follows CET as a reference. It is recommended that IST may be followed for SARPEX operation.

Business Rules for SARPEX

These covers the following and details are detailed in the report

- Qualifying criteria
- Membership Types
- Membership fees
- Documentation
- Settlement Guarantee Fund (SGF)
- Clearing and settlement
- Margins and deposits
- Trading Margin and blocking of funds
- Recommended Currency – INR
- Dispute resolution – In line with the bilateral contract.

Extrapolated Results for BBIN

Total Yearly Surplus in the 3 Modes for FY'16

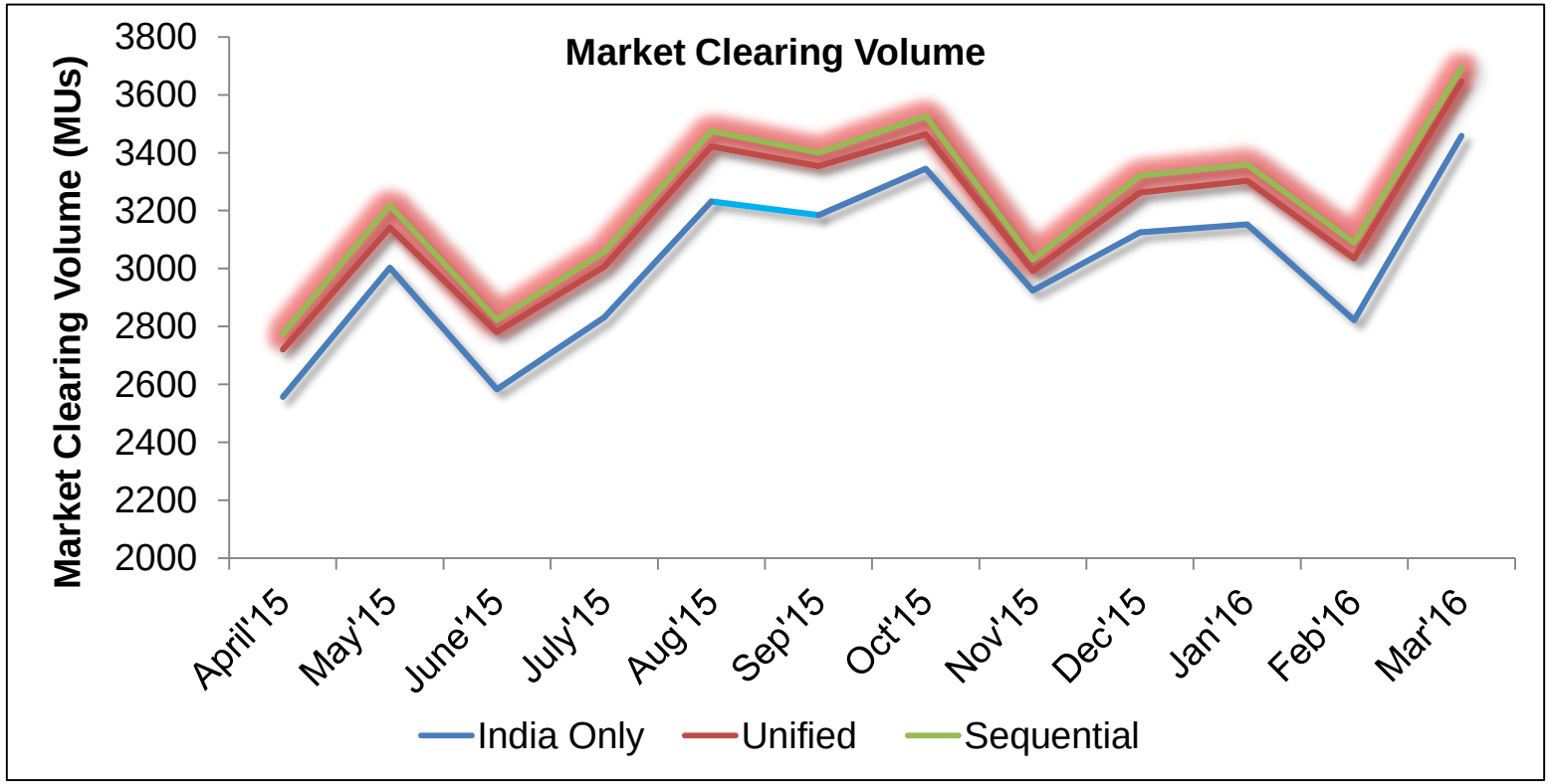
	Surplus (Rs Billion)
India Only	313.53
Unified	323.63
Sequential	323.24

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**

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

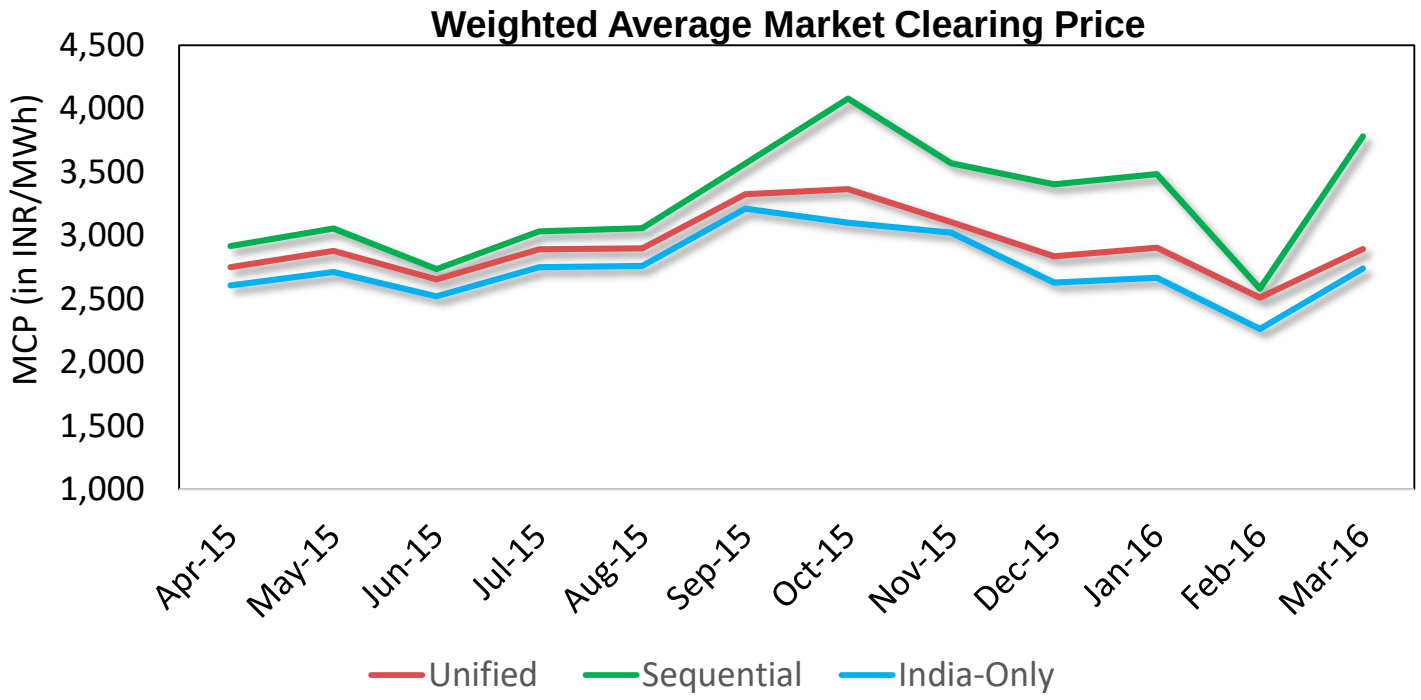


The figures for Unified and Sequential Mode include the existing DAM operations in India, referred as India-Only Mode

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

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

Country Specific Findings

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

	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

Bangladesh gained the highest Consumer Surplus of INR 8.85 Billion and INR 8.23 Billion in Unified and Sequential Mode respectively since the cost of electricity displaced by Exchange was highest at INR 10,000/MWh. This is much higher than those in the other Nations

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

MUs

	India	Bangladesh	Nepal	Bhutan	Total
India-Only	36219	-	-	-	36219
Unified	35406 (-812*)	2011	719	0.09	38136 (1997*)
Sequential	36219 (0*)	1920	630	0.04	38769 (2550*)

The volume bought by India actually reduces in the Unified mode. This is because the bids from Bangladesh and Nepal displace the bids of low cost Indian buyers

The additional volume over India only mode gives **the volume of the Cross Border DAM** which is 1997 Mus in case of Unified mode and 2550 Mus in case of sequential mode. **Roughly 6-7 Mus per day (Unconstrained Volume)**

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

In MUs

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

The volume sold by India is higher in Sequential mode by about 50%. This is because the bids from Bangladesh and Nepal DO NOT displace the bids of low cost Indian buyers as was the case in Unified mode

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 on SARPEX for FY'16

In Rs/MWhr

	India	Bangladesh	Nepal	Bhutan
India-Only	2745	-	-	-
Unified	2919	2938	2893	3751*
Sequential	2745	3099	2881	3438*

The Indian buyer will be adversely impacted in the Unified mode as the increased price will increase the cost of power purchase as these prices are applicable to all participants including Indian Buyers

- ***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. These generally will not impact the Indian buyer.

**** 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

INR Billion

	India	Bangladesh	Nepal	Bhutan
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.

It may be noted that though buy volume of India is less in unified mode, the cost incurred is high due to increase in the price..

Total Revenue earned by sellers from each nation in

	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)

It may be noted that the revenue earned by India is less in the sequential mode but this has to be viewed along with the high cost incurred figure in unified mode

Key conclusions particularly for India

1) The gain for entire BBIN Region is practically the same in both modes of operation. Slide 11
2) The surplus gain for the Region is slightly higher in the Unified mode but for India, it is much more high in case of the Sequential mode (By about 70%). Slide 15
3) The buy volume of India actually reduces in the unified mode. Slide -16
4) Indian buyer get less power at higher cost in the Unified mode. Slides 17 and 18
5) The sell volume of India increase in both the modes with higher increase in the residual mode. Slide -17
6) The Regional Volume is also higher in Sequential Mode. Slide 12
7) There is an increase in MCP in both the modes over the MCP discovered in the Indian Domestic Exchange . Slide 13
8) The increase in MCP is more in case of Residual mode but this do not effect the Indian Buyers. Slide 13
9) The increase in MCP will benefit Indian Sellers and the benefit is more in case of residual mode .

Conclusions and Recommendation

1) The findings of the SARPEX mock exercise provide enough empirical evidence that a regional electricity exchange based on Day-Ahead Market can massively improve the producer and consumer welfare in each country as well as the region as a whole.
2) The CBET DAM will also yield efficient price signals, transparency and major distributive benefits in terms of increased fuel diversity, diversified supply mix and decreased overall costs
3) It was also found that the adequate inter country transmission capacity is critical for ensuring higher surplus in the region.
4) The surplus gain to BBIN witnessed in FY2015-16 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
5) While both the market modes have their relative qualitative and quantitative merits, the final decision has to be taken by the Governments of BBIN countries for the next steps.

For more details please contact:-

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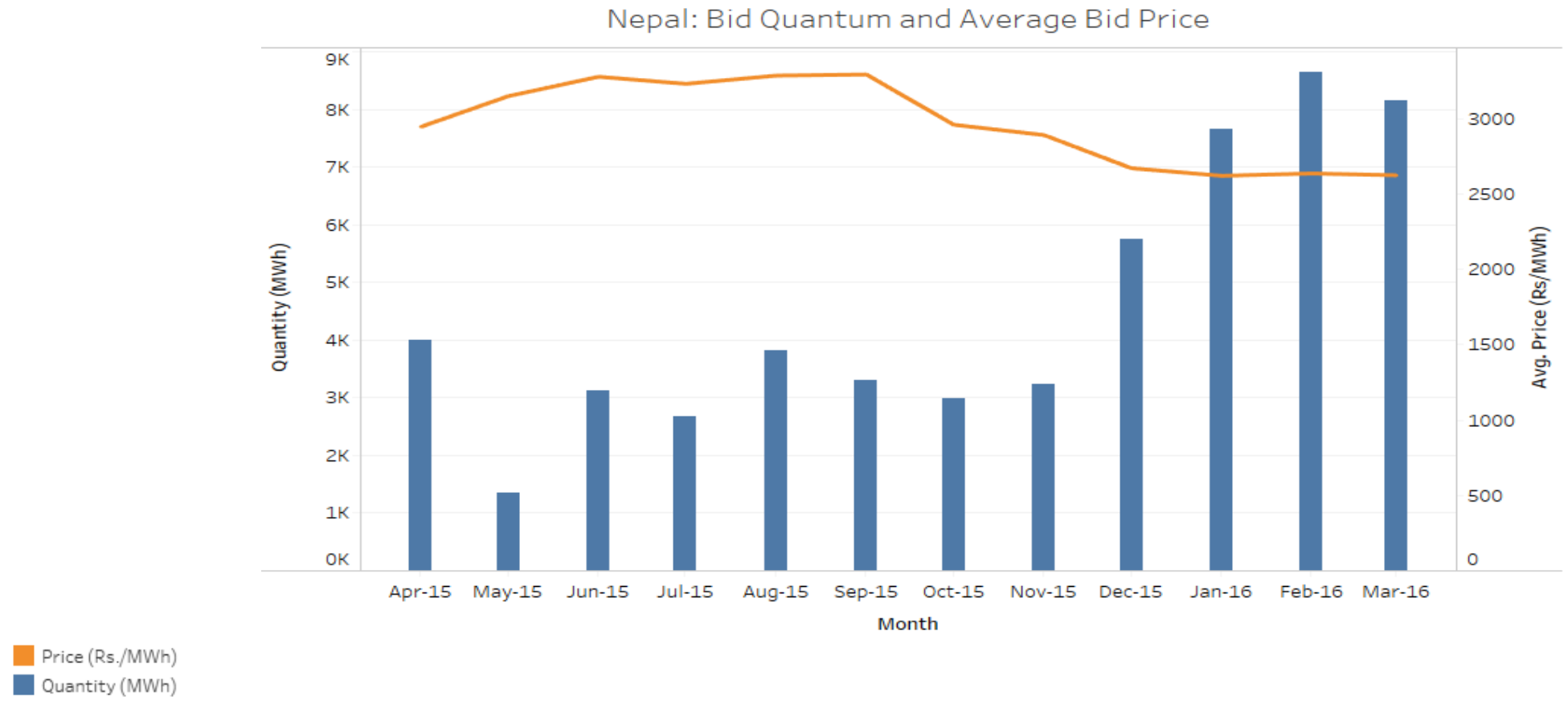
Annexure

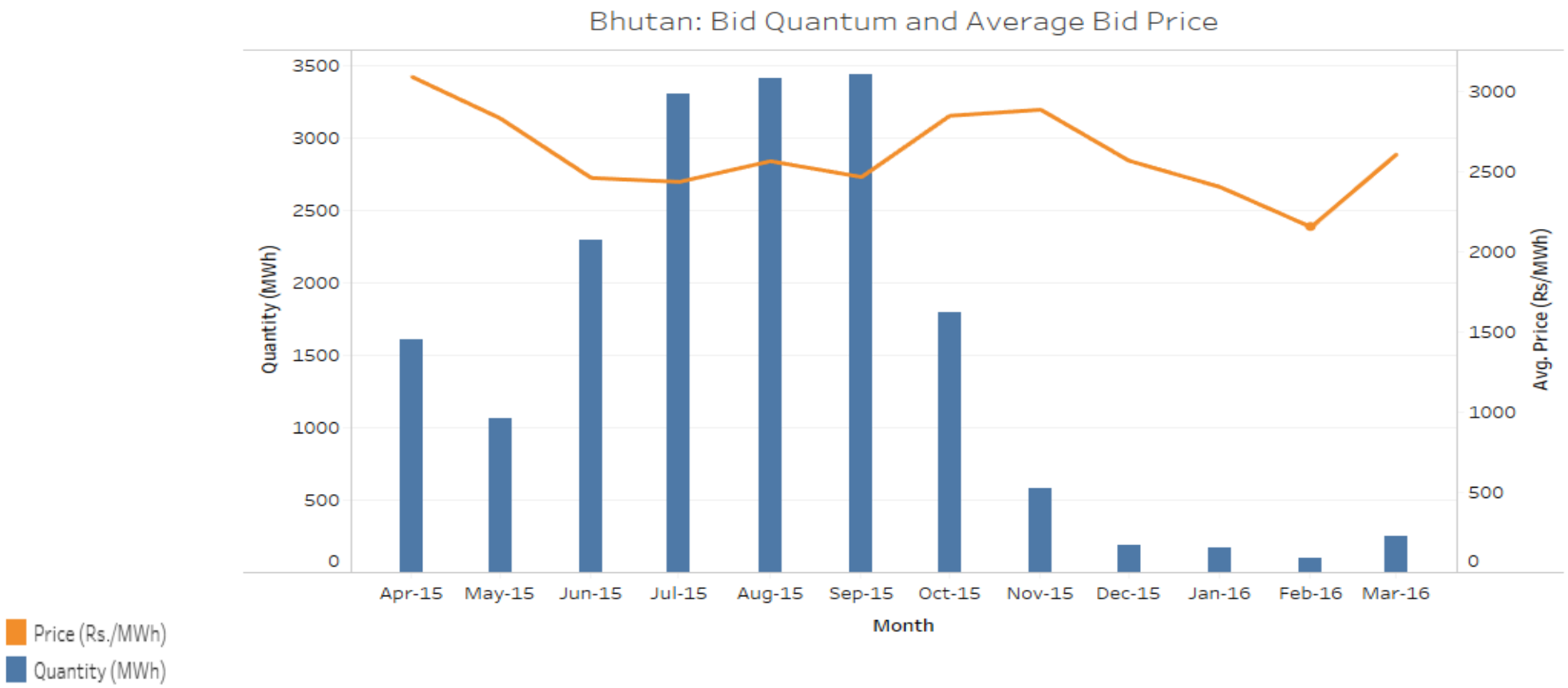
Purchase Bids from Nepal

Purchase bids from Nepal for a typical day in each month



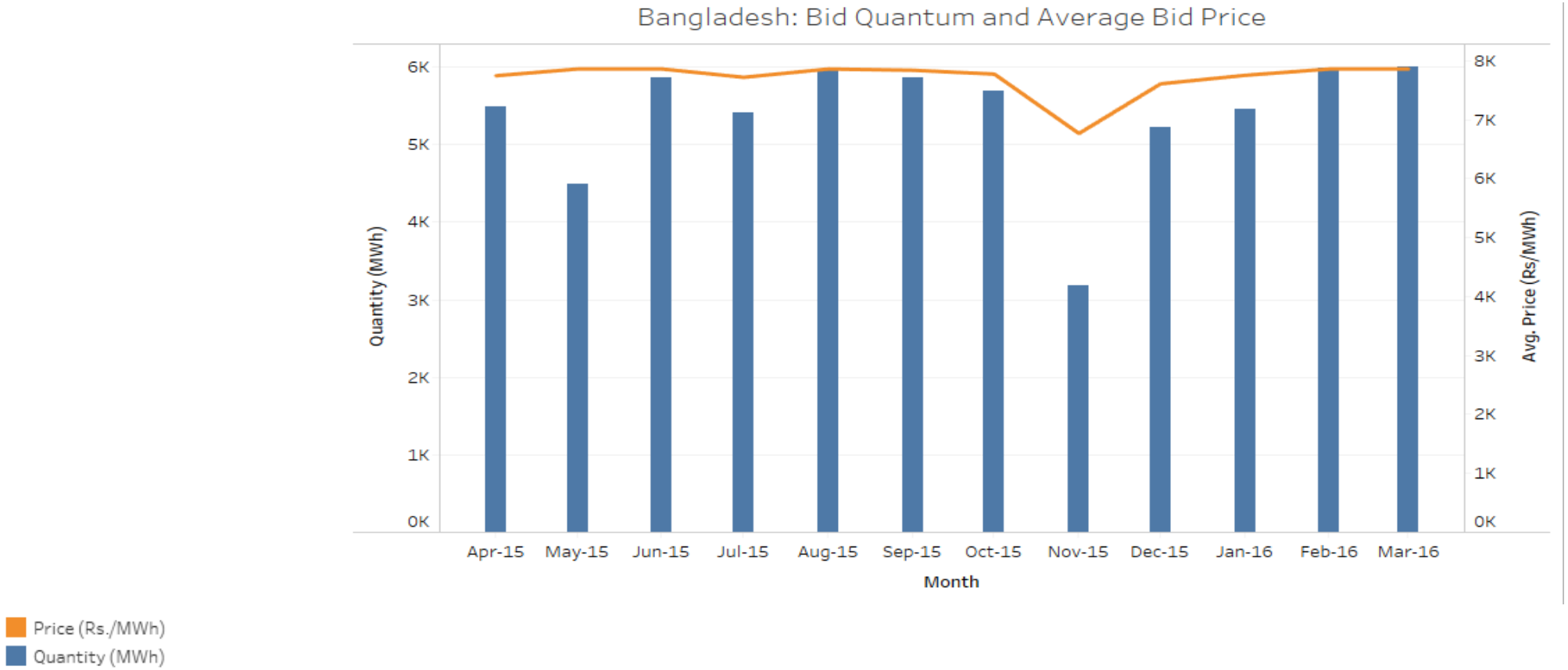
Sell Bids from Bhutan

Sell bids from Bhutan for a typical day in each month



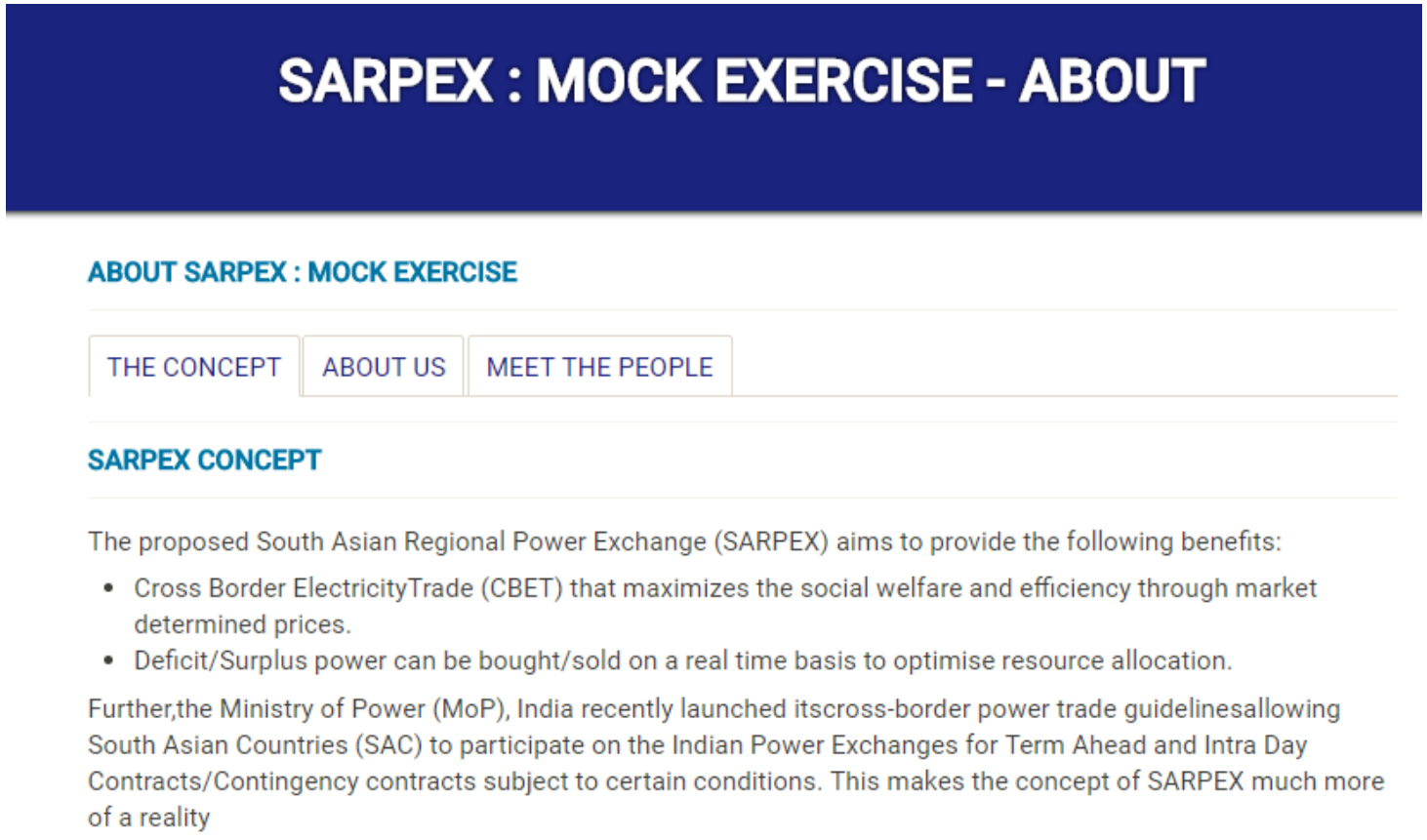
Purchase Bids from Bangladesh

Purchase bids from Bangladesh for a typical day in each month



SARPEX Web Portal and its Applications

SARPEX Web Portal -Home Page



SARPEX : MOCK EXERCISE - ABOUT

ABOUT SARPEX : MOCK EXERCISE

THE CONCEPT | ABOUT US | MEET THE PEOPLE

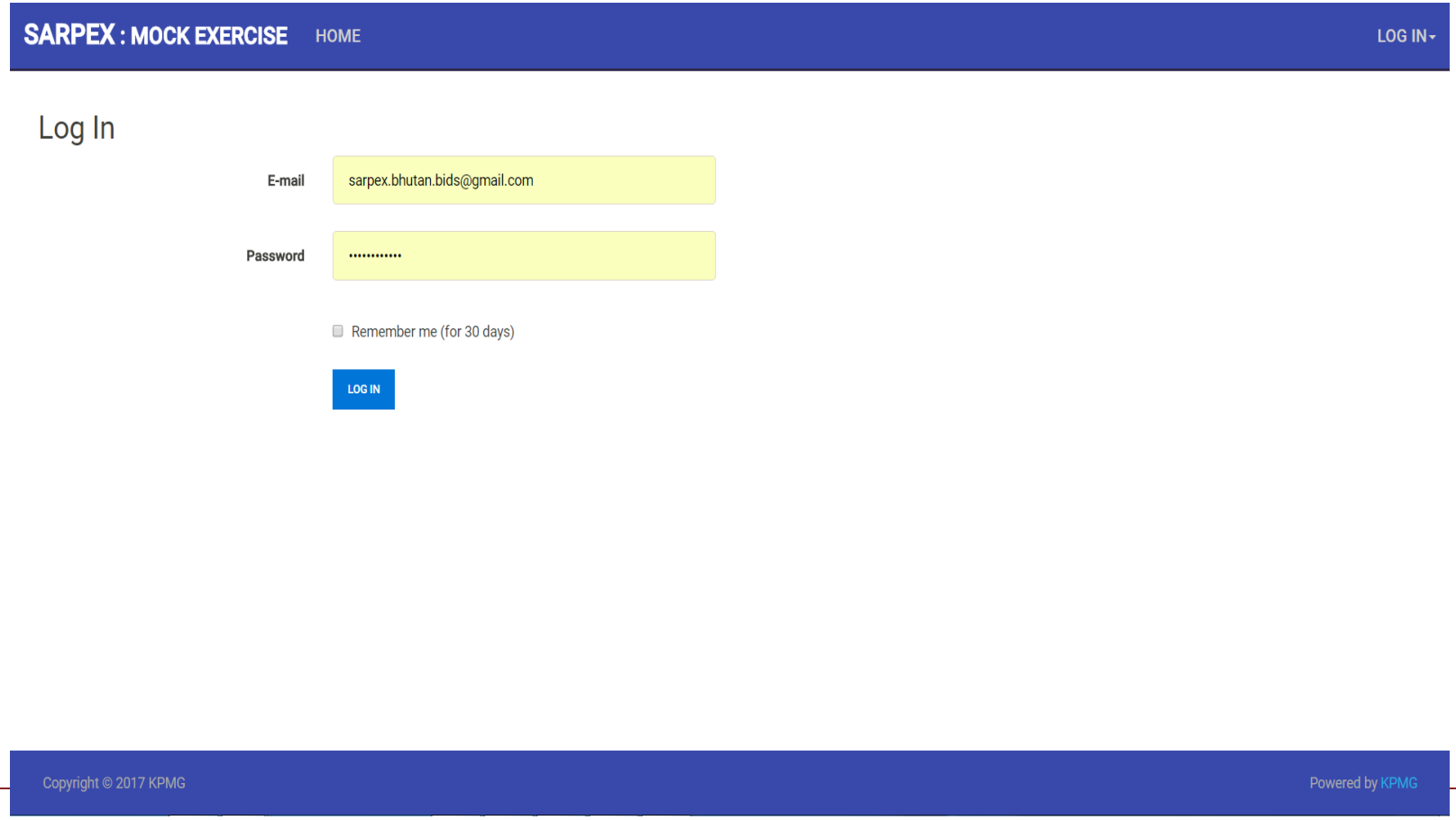
SARPEX CONCEPT

The proposed South Asian Regional Power Exchange (SARPEX) aims to provide the following benefits:

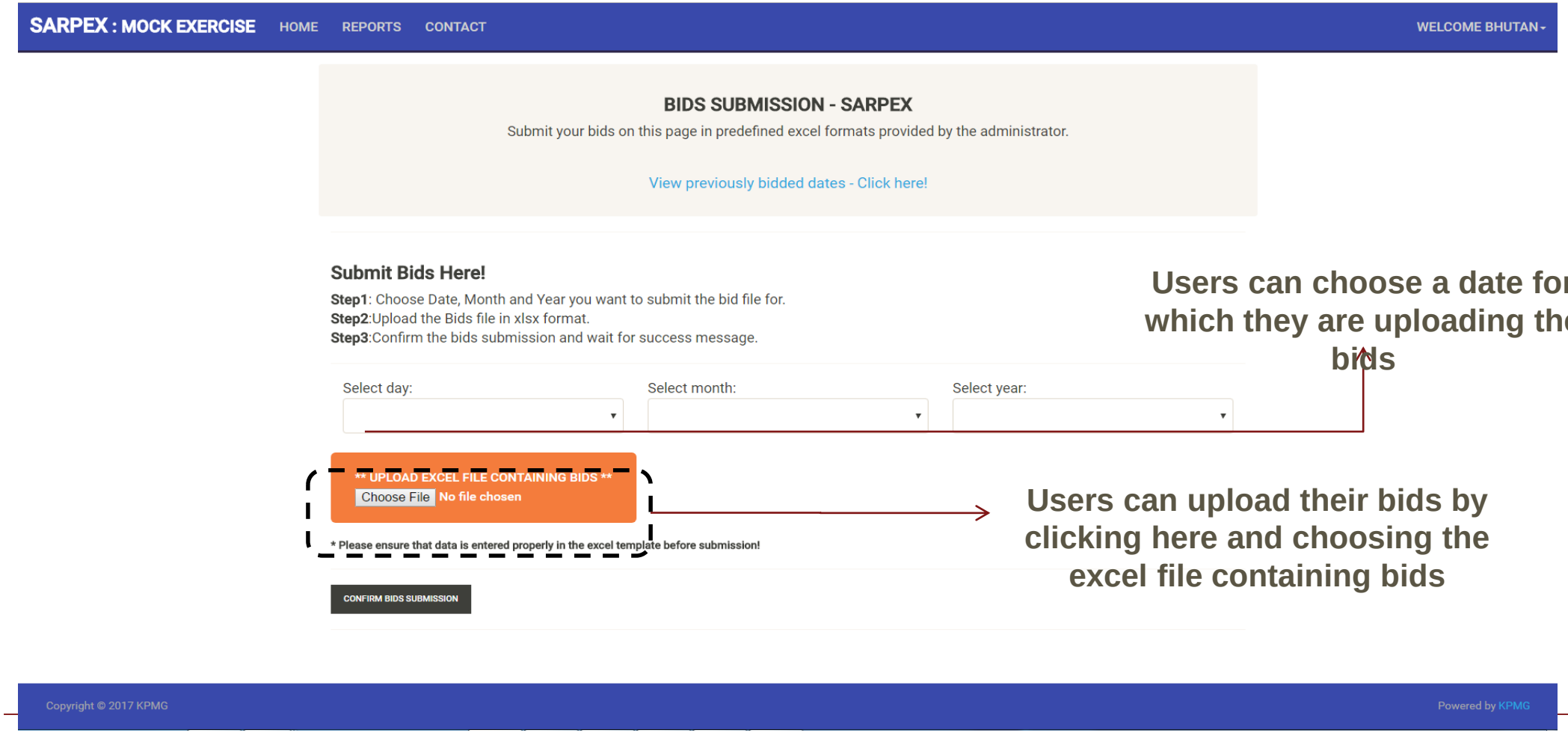
- Cross Border ElectricityTrade (CBET) that maximizes the social welfare and efficiency through market determined prices.
- Deficit/Surplus power can be bought/sold on a real time basis to optimise resource allocation.

Further,the Ministry of Power (MoP), India recently launched itscross-border power trade guidelinesallowing South Asian Countries (SAC) to participate on the Indian Power Exchanges for Term Ahead and Intra Day Contracts/Contingency contracts subject to certain conditions. This makes the concept of SARPEX much more of a reality

SARPEX Web Portal – Login Page



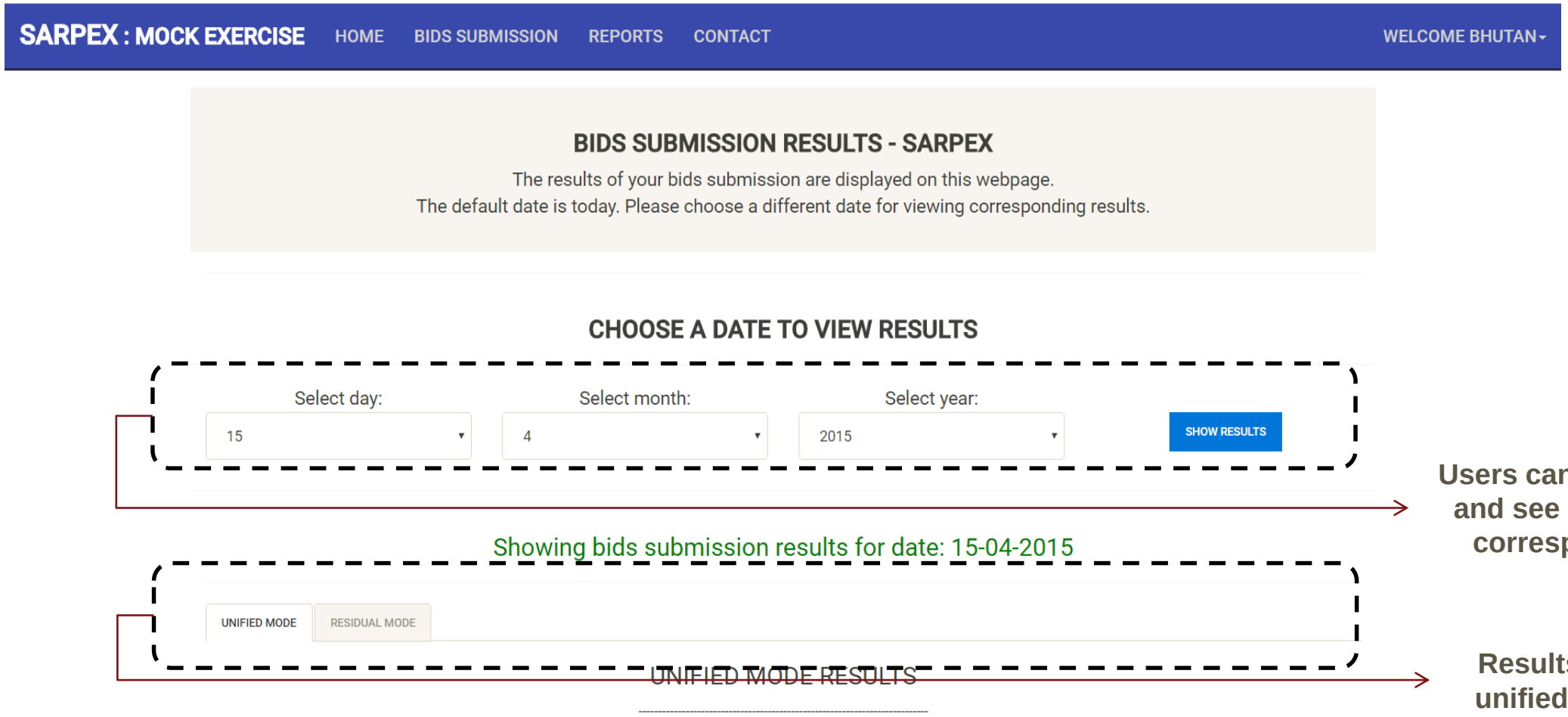
SARPEX Web Portal – Bid Submission Page



Users can choose a date for which they are uploading the bids

Users can upload their bids by clicking here and choosing the excel file containing bids

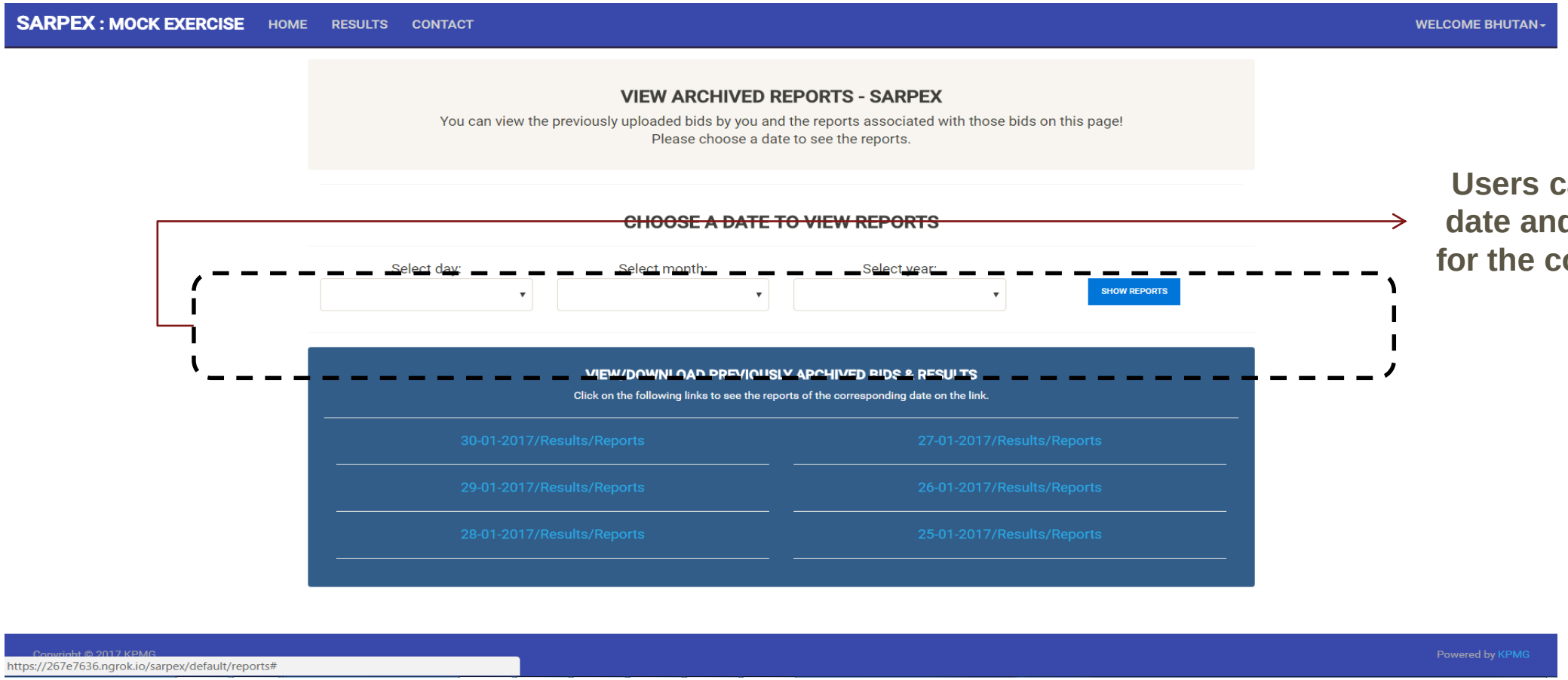
SARPEX Web Portal – Results Page



Users can choose a date and see results for the corresponding date

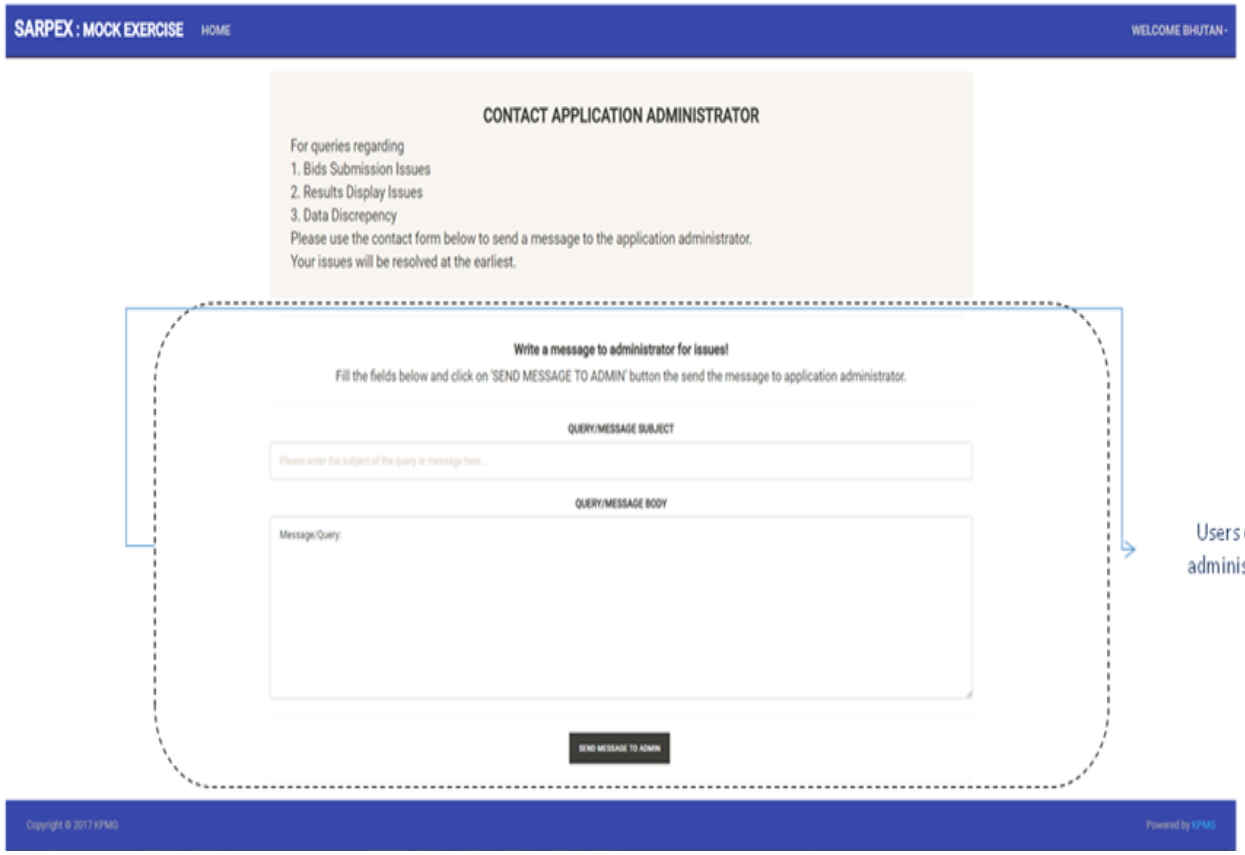
Results are shown for unified and Sequential Mode

SARPEX Web Portal – Archived Reports Page



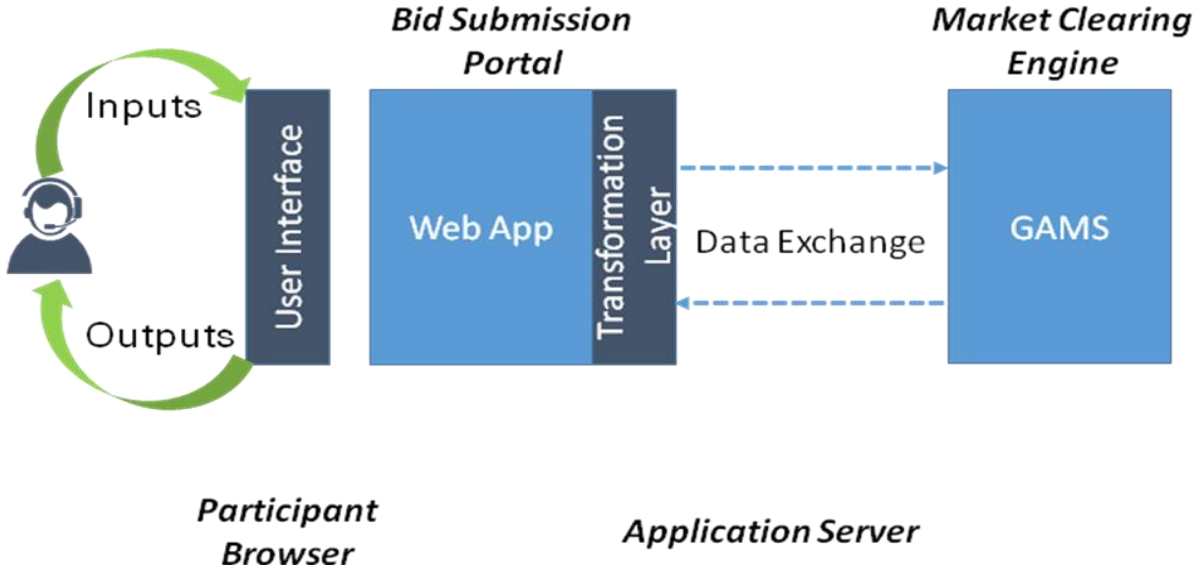
Users can choose a date and see reports for the corresponding date

SARPEX Web Portal – Contact Administrator Page



3. Bidding Platform Creation – SARPEX Web Portal

- 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 mimick the trade in the DAM on a Regional Power Exchange
- Link http://mocksarpex.eu.ai



Average Transmission Charges and Losses Figures for BBN

#	Country	Transmission Charges (Rs/kWh)	Transmission Losses (%)	Comments
1	Bangladesh	0.117	0.3%	The cross-border transmission network for India-Bangladesh has been included in the POC charges and transmission Withdrawal Charges and Losses are published 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 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