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South Asian Regional Power Exchange (SARPEX) Mock Exercise- Key Findings

South Asia Regional Initiative for Energy Integration (SARI/EI)

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ABBREVIATIONS

AD	Aggregate Demand
AS	Aggregate Supply
BBIN	Bangladesh, Bhutan, India and Nepal
BBN	Bangladesh, Bhutan and Nepal
BEA	Bhutan Electricity Authority
BPDB	Bangladesh Power Development Board
CBET	Cross Border Electricity Trade
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission, India
DA	Designated Authority
DAM	Day-Ahead Market
GoI	Government of India
IEX	Indian Energy Exchange
MCP	Market Clearing Price
MCV	Market Clearing Volume
MoEA	Ministry of External Affairs, India
MOP	Ministry of Power
NEA	Nepal Electricity Authority
PMR	Power Market Regulation
POSOCO	Power System Operation Corporation Limited
SAARC	South-Asian Association for Regional Countries
SAC	South Asian Countries
SAR	South Asian Region
SW	Social Welfare
YTC	Yearly Transmission Charge

LIST OF DEFINITIONS

Exchange	An Exchange is a platform on which buyers and sellers come together to transact. It is **not** the market but a **host** to the market. Its core function is to ensure fair and transparent transactions as well as efficient dissemination of price information to its stakeholders.
Power Exchange	A Power Exchange is a type of spot market for trading in electricity. It is similar to a Stock Exchange in that it uses demand and supply to determine the price of the product being traded on the exchange.
Day-Ahead Market	DAM is a short term market that operates a day in advance of the actual physical delivery of power through a Power Exchange.
Consumer Surplus	It is a measure of consumer welfare. It is the area under the demand curve that represents the difference between what a consumer is willing and able to pay and what consumer actually ends up paying.
Producer Surplus	It is a measure of producer welfare. It is the area under the demand curve that represents the difference between the price received by a producer and the price at which he is willing to supply.
Social Welfare	It is the sum of Consumer and Producer Surplus.
Demand Curve	It represents the price-quantity combinations that represent maximum quantity that would be purchased as each of those prices. A demand curve is almost always downward-sloping, reflecting the willingness of consumers to purchase more of the commodity at lower price levels.
Supply Curve	It represents the price-quantity combinations that represent maximum quantity that would be supplied as each of those prices. A supply curve is usually upward-sloping, reflecting the willingness of producers to sell more market with higher prices.
Market Clearing Price	It is the price at which quantity demanded is equal to quantity supplied. It is also known as the equilibrium price.
Market Clearing Volume	It is the equilibrium quantity at which demand equals supply.
Aggregate Demand	It represents the total quantity demanded by all consumers at different price levels. It is computed by summing the purchase bids of all consumers.
Aggregate Supply	It represents the total quantity that the producers are willing to supply at different price levels. It is computed by summing the supply bids of all producers.
First Price Auction	The auction where the winning bidder pays the amount that is equal to the bid price.

Uniform Price Auction	The auction where all the winning bidders pay the same price, regardless of their bid price. This price is generally the equilibrium or the market clearing price.
Double Sided Auction	It is the auction where both the buyers and sellers submit their bids that together determine the equilibrium price and quantity.
Step-wise Algorithm	It is the method of simple aggregation of individual bids and offers of buyers and sellers respectively to construct aggregate demand and supply curves.
Weighted Average Price	Average MCP observed over FY'16, weighted by the market clearing volume. It is calculated by extrapolating the block-wise MCP of selected 71 days over the entire year.
Month-wise/Monthly Weighted Average 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.
Month-wise/Monthly Weighted Average Buy Price	Average MCP typically observed in a month, weighted by the total volumes bought by a country in each block for that month. It is calculated by extrapolating the block-wise MCP of selected days over the entire month.
Month-wise/Monthly Weighted Average Sell Price	Average MCP typically observed in a month, weighted by the total volumes sold by a country in each block for that month. It is calculated by extrapolating the MCP of all selected days over the entire month.
Daily Average Price	The MCP observed for a typical day in each month. It is computed by averaging the Month-wise MCP over each block of time.

FOREWARD

The USAID South Asia Regional Initiative for Energy Integration (SARI/EI) program aims to enhance regional energy cooperation through cross-border electricity trade (CBET) by harmonizing policies, legislation and regulations, facilitating transmission interconnections and establishing a regional power market.

Currently, the majority of the power trade in the South Asian Region (SAR) is between four countries i.e. Bangladesh, Bhutan, India and Nepal (BBIN). This trade is driven by Power Purchase Agreements (PPAs) signed as part of special Memorandum of Understanding (MOU) between the various governments. While these bilateral contracts have been critical in establishing power trade in the region, greater efficiencies can be achieved by enabling trade on a Day Ahead Market (DAM) through a Regional Power Exchange.

One of the key initiatives conducted under the SARI/EI program was a mock exercise on a South Asian Regional Power Exchange (SARPEX). The purpose of the exercise was to assess the feasibility of a regional power exchange, develop market rules for the exchange and build the capacity of key stakeholders in Bhutan, Bangladesh and Nepal for working on an exchange platform.

This exercise established the feasibility of a regional exchange and answered some critical question such as the possible volume of trade in a regional exchange, impacts on domestic energy markets and benefits to each country participating in the exchange. The exercise also helped to highlight some of the key aspects related to the design of the power exchange such as market clearing, congestion management, settlement system, bid aggregation and submission, and modes of operation.

I would like to take this opportunity to thank the Task Force 3 members, the SARI/EI Project Secretariat at IRADe, and the SARI/EI Consultants M/s KMPG for the excellent work done for this mock exercise and for producing this very valuable report. I hope that the recommendations of this report will be very useful to energy stakeholders from the different South Asian countries, and will support the establishment of a regional power market in South Asia.

Thank you

Julia Kennedy
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Preface

In the South Asian Region (SAR) comprising of Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka, a major share of Cross Border Electricity Trade (CBET) has only been enabled between the four countries i.e. Bangladesh, Bhutan, India and Nepal (BBIN). The CBET between these countries has been primarily through Power Purchase Agreements (PPAs) signed as part of special MOUs (Memorandum of Understanding) between the various governments. Though the ongoing bilateral contracts have helped these countries in establishing trades, however, further efficiencies could be achieved by enabling trade on Day Ahead Market (DAM) basis through a Regional Power Exchange.

Currently, Nepal, apart from its hydro generation, meets its electricity demand through high cost imported diesel, but the overall supply in the country is still inadequate to meet the demand and reliance on imports from India remains elevated. Further, Bhutan is endowed with high hydro potential of 24 GW, however only 6 per cent of it has been tapped so far due to limited demand base in the country and securing long term PPAs for exports. On the other hand, the generation mix of Bangladesh is heavily based on natural gas with marginal costs over INR 12/kWh.

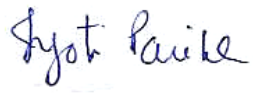
The Government of India, has issued the CBET guidelines in 2017 to facilitate cross-border trade and promote transparency and predictability in regulatory approach. The guidelines allow trades through Power Exchange under the categories i.e. Term Ahead Contracts, Intra Day Contracts/ Contingency Contracts as defined in the CERC Power Market Regulations. It is noteworthy that initiation of cross border transactions with above contracts through exchanges will serve as a launch pad for establishment of a DAM, which is where the bulk of trading takes place.

IRADe as the implementing partner of USAID's flagship program South Asia Regional Initiative for Energy Integration (SARI/EI) since 2012 had constituted a Task Force on South Asia Regional Electricity Market with representation from each of the South Asian countries. In the view of the CBET guidelines, a roadmap for South Asian Regional Power Exchange (SARPEX)- Day Ahead Market was laid down under the SARI/EI program covering the various aspects of initiating the CBET between BBIN (Bhutan, Bangladesh, India and Nepal) through day ahead market (DAM) on a Regional Power Exchange. Both the roadmap and the mock exercise were conceptualized and conducted under SARI/EI program to give a firm basis for establishing a DAM in the South Asian Region. This report is providing an answer of key questions related to volume of regional market, market price, total regional & country specific social welfare etc.

The Task Force-3 (South Asia Regional Electricity Market) was established under the program with representation from each of the South Asian countries. I would like to congratulate SARI/EI for the completion of the report on “South Asian Regional Power Exchange Mock Exercise – Key Findings” which is a product of combined efforts of Task Force-3, Core team members and SARI/EI Team. For conducting the Mock Exercise, core teams were nominated from the concerned authorities of BBN for bidding on the Mock Platform.

I take this opportunity to thank all the members of Task Force-3 (South Asia Regional Electricity Market), the SARI/EI Project Secretariat at IRADe, Core Team Members from Bangladesh, Bhutan and Nepal, Market Advisory Committee and the SARI/EI consultant M/s. KPMG for their time and preparing this quality report. I hope the findings of this report will be actively considered by the Governments of South Asian Countries.

Dr. Jyoti Parikh



Executive Director

Integrated Research and Action for Development

Executive Summary

The objective of the SARPEX mock exercise was to explore the feasibility and desirability of a regional power exchange for Bangladesh, Bhutan, Nepal and India (BBIN) by simulating a Day-Ahead Market (DAM) for these countries. Currently, these countries trade in electricity mostly on the basis of bilateral trade agreements at a fixed negotiated price. Day-Ahead Market (DAM)trade through a regional power exchange works in a dynamic buy and sell environment determined by the demand and supply position. It has the potential business advantages in terms of transparency in dynamic price discovery, efficient use of available power based on regional complementarities and economic efficiencies for both producer (seller) and consumer (buyer). The SARPEX mock exercise was conducted for demonstrating the benefits of a regional power exchange, evaluating and recommending the market design and rules for the regional electricity exchange and capacity building of the participating countries.

The mock exercise demonstrated how the regional power exchange based on DAM captures the demand and supply complementarities of the countries in the region for the effective utilization of the available power generation and dynamic and transparent buy and sell price for the entire region. These intra-day, intra-week, and seasonal complementarities can only be fully captured by a DAM.

The mock exercise was carried out for the Indian financial year April 2015 - March 2016 by extracting the actual aggregated bids from the Indian Energy Exchange (IEX) and actual bidding from Bangladesh, Bhutan and Nepal (BBN). A total of 71 days representing FY2015-16 were selected for conducting the simulations. The days were sampled based on a robust statistical methodology that factored in intra-day, inter-day, holidays, weekends, and seasonal demand and supply conditions of the respective countries.

Bidding was done for 96 blocks of 15 minutes duration over 24 hours for all 71 days against the trade volume and unit price. The extracted Indian bids and the BBN bids for the selected days were matched using a Market Clearing Software to determine Market Clearing Volumes (MCV), Market Clearing Prices (MCP) and the social welfare of the individual countries and the overall region. A web portal (http://mocksarpex.ga) was created for the exercise and used by the BBN participants for placing the bids and viewing the results.

The mock exercise was run in two modes of operation

(1) Unified Mode – the bids from India and BBN were cleared simultaneously at a single unconstrained MCP for BBIN.

(2) Sequential Mode – In the sequential mode bidding takes place in two stages. In the first stage Indian buyers and sellers bid for the domestic market as is the current practice. In the second stage, the un-cleared bids from India are cleared with the participants from BBN. In the sequential mode, MCP for the domestic and international market is naturally different. In view of the structure of the power sector in the BBIN region, this enables a level-playing field for all participating countries (see report *SARPEX Market Design and Rules)*.

Before the mock exercise, all participants from BBN were trained in various aspects of market clearing, determination of equilibrium price and volume, operational and business rules, currency, timelines, placing of bids etc. through capacity building workshop.

The results of the mock exercise show that Bangladesh and Nepal are the major buyers and India and Bhutan the major sellers. Bangladesh's buy quantum was 2,011 MUs and 1,920 MUs of power in the unified and sequential mode, respectively, for FY2015-16. Nepal too was a major buyer though it did sell some power (about 10 MUs) in the month of October. It bought 719 MUs and 630 MUs in the unified and sequential modes, respectively. Bhutan sold 412 MUs and 427 MUs in the unified and sequential mode, respectively.. India, the largest seller on SARPEX, sold 1496 MU and 2114 MUs in unified and sequential mode, respectively. This was over and above sales in India-only mode. At the same time, India's total buys reduced by 822 Mus in the Unified mode. In other words, a regional electricity exchange is likely to boost India's sell volumes without impacting the buy volumes in the sequential mode.

This report analyses the outcome of the mock SARPEX cross border electricity trade in terms of MCP and MCV and the associated social welfare for each country. On a DAM exchange, MCP and MCV are determined by the market dynamics of demand and supply, and the buyers' willingness to pay. Power deficit states of Bangladesh and Nepal cause increase in the demand and price, which though is variable in the span of a day and week, creates value for both the consumer (buyer) and producer (seller).

At 2015-16 values, the MCV cleared on SARPEX in the unified and sequential modes (with bids from BBN and existing Indian DAM) was 38,137 MUs and 38,769 MUs including the volumes of the Indian domestic DAM. The weighted average MCP of INR 2,910/MWh and INR 3,269/MWh is slightly higher than the price of Indian domestic DAM. The actual unconstrained MCV in DAM of the Indian domestic market for FY2015-16 was about 36,219 MUs at an average MCP of INR 2,744/MWh and a total surplus of INR 313.53 billion. Thus, the addition of BBN to the Indian domestic market resulted in an increase of 1,918 MUs (5.3%) and 2,550 MUs (7.0%) in the MCV for the unified and sequential modes, respectively, over the Indian domestic market.

The maximum volumes were observed in the months of September, October and March. During these months, Nepal and Bangladesh have a severe power deficit. While Nepal generates electricity with imported diesel, Bangladesh tides over with expensive gas-based power generation at the rate of more than INR 10/kWh. For the remaining months, the share of each country in the overall power bought or sold was fairly constant throughout the year.

The consumer and the producer surplus give a measure of the benefits to the participating nations. The total surplus was INR 323.63 billion under unified mode and INR 323.24 billion under sequential mode. The surplus under unified mode was marginally higher (these figures include the volume of the Indian DAM). The additional surplus wasINR10.10billion and INR9.71billion in the unified and sequential modes respectively out of which 0.25 billion and

INR 0.43 billion respectively wasaccrued to India. However, the MCP also increased slightly by INR 165/MWh and INR 513/MWh respectively in the two modes as compared to that of the Indian domestic market.

Table: Total Annual Regional Surplus, Market Clearing Volume and Weighted Average MCP

	Regional Surplus (in INR Billion)	MCV (in MUs)	Weighted Average MCP (in INR/MWh)
India-Only	313.53	36219	2745
Unified	323.63	38137	2910
Sequential	323.24	38769	3269

Bangladesh gained the highest consumer surplus (difference between the cost incurred in the domestic production and the cost of buy on the DAM exchange times the volume) of INR 8.85 billion and INR 8.23 billion in the unified and sequential modes, respectively, since it has the highest cost of electricity production in the region.

Table: Surplus Figures: in INR Billion

	Additional Surplus Gain to Region	Surplus Gain to Bangladesh	Surplus Gain to Nepal	Surplus Gain to Bhutan	Additional 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

If Bangladesh could replace its costly marginal power generation on SARPEX, it could save roughly INR 18 million in FY2015-16 which is much more than the surplus gain of roughly INR 8 billion shown in the table above. Similarly, Nepal observed a load shedding of 1,670 MUs during FY2015-16, which, if bought on the DAM on SARPEX, could have led to further benefit (in socio-economic terms).

In the case of Bhutan, the actual benefit to the country is greater than the producer surplus shown in Table 7 and 8 as the sell bids were placed in reference to the prices prevailing on IEX in FY2015-16 instead of the actual marginal cost of generation, which is relatively much lower. If they had followed the logic used by Bangladesh, their gains would have been much higher.

Lastly, in case of India, it may be noted that the bids used were extracted bids which the various Indian participants had placed in the Indian Domestic DAM. Secondly, unlike a single source of bidding, as in the case of BBN, Indian bids were the sum total of the bids from a large number of buyers and sellers on IEX.

One also has to take into account that the Indian buy bids, which were not cleared due to transmission constraints in the Indian grid, will not get cleared irrespective of the bidding from BBN. Similarly, as the MCP of the Indian domestic DAM is lower than the BBIN DAM, the un-cleared buy bids on the Indian Domestic DAM will also not be cleared on the BBIN DAM. It is seen that in the unified mode the Indian sell volume actually reduces as compared to Indian domestic DAM. This is because the cheaper power from Bhutan outbids the Indian sellers who have bid close to the MCP. However, this situation does not arise in the sequential mode. These facts need to be considered while interpreting the figures of Indian surplus.

Further, the surplus gain to BBIN in FY2015-16 was far higher than the yearly transmission charges (YTC) of the Cross Border Transmission Lines. Thus, it was evident that the investments in transmission lines could result in huge dividends in terms of increased economic gains and social welfare irrespective of the manner in which trade is happening, through DAM or PPA based.

In the light of these findings, a regional power exchange for BBIN countries, regardless of the operating mode, not only would help in the management of day-ahead demand and supply positions, but would also benefit the member countries in buying their marginal power requirements at a cost lower than their production cost or sell surplus power in a larger market.

This report provides vital information on Cross Border Trade of Electricity in the BBIN region in general and DAM based trade in particular. It serves to inform the BBIN governments in the decision making on CBET.

1 Background

In the South Asian Region (SAR) comprising Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka Cross Border Electricity Trade (CBET) exists only among Bangladesh, Bhutan, India and Nepal (BBIN region). The CBET between these countries is based on Power Purchase Agreements (PPAs) signed as part of special MOUs (Memorandum of Understanding) between the governments. Though the bilateral contracts have helped these countries establish electricity trades, further efficiencies can be achieved by enabling trade on Day Ahead Market (DAM) basis through a Regional Power Exchange. For example, in April, the peak load in Nepal occurs at 19:00 hrs compared to 21:00 to 22:00 hrs in India. Also, there are weekly and seasonal complementarities between the countries. Fridays are the official weekly holidays in Bangladesh, compared to Sundays in India, Bhutan and Nepal. Similarly, Bangladesh has a higher demand in May, while Nepal and Bhutan have a higher hydro generation in the same month.

Currently, apart from hydro-electricity, Nepal generates electricity from imported diesel. Its current overall generation is inadequate to meet its demand. Therefore, it has a high reliance on power imports from India. On the other hand, Bhutan is endowed with a large hydro potential of 24 GW, but only six percent of it is tapped so far due to limited demand. In Bangladesh, power generation is based on natural gas with marginal costs over INR 12/kWh.

In this BBIN regional power scenario exports from India are picking up, a fact acknowledged by Central Electricity Authority (CEA), the nodal agency for CBET in India. In FY-2017, India turned around from a net importer of electricity to a net exporter of electricity.[1]India's electricity exports to Nepal and Bangladesh have increased by 2.5 and 2.8 times respectively in the last three years.

Over the last decade, India has added significant generation capacity in conventional as well as renewable energy. This lends favorably to greater exports from the country given its huge asset base and the demand-supply complementarities within the region.

A DAM is a short-term market that operates a day in advance of the actual physical delivery of power. Such a market is already operating in India through Power Exchanges.DAM offers significant benefits to both producers and consumers through transparency in price discovery and management of demand and supply closer to the real-time grid operation. Thus, the development of a Regional Power Exchange for BBIN would enable the member-countries to share their resources more optimally.

[1]Press Information Bureau, Ministry of Power, Government of India

Multiple stakeholders across the borders have advocated a Regional Power Exchange over and above other mediums of trade as it results in a better price discovery and helps achieve efficiencies on day-ahead basis. Given that electricity cannot be stored and the electrical systems need to be balanced at all times, a regional exchange addresses these concerns apart from its other stated advantages

In view of the above, a roadmap was conceptualized for the BBIN region under the SARI/EI program covering various aspects of initiating CBET based on DAM on a regional power exchange, referred as SARPEX. The roadmap identified plausible regimes/draft market rules for SARPEX that paved way for quantified assessment of these market rules and design by each participating nation through a mock exercise simulating the DAM.

1.1 Recent Developments

In December 2016, the Ministry of Power (MoP), Government of India (GoI), in consultation with the Ministry of External Affairs (MoEA) issued *"Guidelines on Cross Border Trade of Electricity"* with the following objectives

- Facilitate cross border trade of electricity between India and its neighboring countries
- Promote transparency, consistency and predictability in regulatory approaches across jurisdictions and minimize perceptions of regulatory risks
- Meet the demand of the participating countries by utilizing the available resources in the region
- Reliable grid operation and transmission of electricity across the borders
- Evolve a dynamic and robust electricity infrastructure for cross border transactions

In February 2017, CERC released its draft regulations on Cross Border Trade of Electricity, in which one section was dedicated to electricity trade through Indian Power Exchanges(s) under the categories i.e. Term Ahead Contracts, Intra Day Contracts/ Contingency Contracts as defined in the CERC Power Market Regulations, 2010. Lastly, in December 2017, CEA released a draft conduct of Business Rules of the Designated Authority (DA) for facilitating CBET.

It is noteworthy that initiation of cross border transactions with above contracts through exchanges will serve as a launch pad for the establishment of a DAM, which is where the bulk of trading takes place.

The SARPEX mock exercise was the first attempt to quantify the benefits of initiating a DAM through Regional Power Exchange in BBIN. Actual bids were extracted from the Indian Energy Exchange (IEX) and simulated with the bids from BBN in a mock exercise to evaluate the benefits of a Regional Power Exchange.

1.2 Perceived Challenges

Initiation of a regional power exchange has been delayed on account of multiple factors. Some of these are related to the institutional, legal, policy and regulatory framework. The recent guidelines by the Ministry of Power, Government of India, on CBET addressed those concerns and provided a consistent regulatory framework to address the issues and risks. Further, robust structures and mechanisms for a DAM already exist in India and have been tested and fine-tuned since last several years of operation through the power market regulations, exchange bye-laws, balancing and settlement mechanisms etc. Therefore, the Regional Power Exchange need not be designed from the scratch. The next step that needs to be taken by the respective governments of BBIN is to initiate the Day Ahead and Intra-Day markets.

1.3 Structure of this Report

This report is structured as follows: Section 2 of this report discusses the key purpose of mock exercise. Sections 3 describes the approach and methodology used for collecting data, bid extraction and generating the results of the mock exercise. Section 4 highlights the key assumptions used in mock exercise. Section 5 discusses the bidding behavior of BBIN. Section 6 analyses and discusses the results of the mock exercise. Section 7 gives detailed country-specific findings. Section 8 analyses the impact of transmission on mock exercise. Lastly, Section 9 concludes the choice of the preferred market design for SARPEX based on the findings of the mock exercise.

2 Objective of the SARPEX Mock Exercise

In view of the CBET guidelines, discussed in the previous section, a roadmap for SARPEX was laid down under the SARI/EI program for simulating the CBET between BBIN through DAM on a Regional Power Exchange. Both the roadmap and the mock exercise were conceptualized and conducted under SARI/EI program to give a firm basis for establishing a DAM in the SAR. The key objectives of the SARPEX mock exercise were the following:

- To explore the desirability and feasibility of a Regional Power Exchange in South Asia. This includes assessment of the following keys metrics:
    - Quantification of the benefits to individual countries and the region as a whole under the market structures finalized for the pilot market
    - The energy bought/ sold by each country, net export/ import position of each country
    - Comparative analysis of different modes of operation for SARPEX
- To develop the draft market rules and design for SARPEX based on the above outcomes and quantitative and qualitative factors and discussions with key stakeholders
- To build the capacity of the participating countries in working on an exchange platform

3 Approach and Methodology

The approach and methodology adopted for the SARPEX mock exercise had following components:

1. Evaluation of the different market designs for SARPEX
2. Capacity building of the core team
3. Setting up infrastructure for running the pilot market
4. Selection of days for running the pilot market
5. Running of the pilot market
6. Extrapolation of the results

3.1 Evaluation of Different Market Designs

The key market design elements of the SARPEX are discussed in the report on Market Design and Rules for SARPEX. In the report, the following two modes of operation were chosen and evaluated for the SARPEX mock exercise:

1) *Unified Mode:* In this case, the bids from the Indian participants and BBN were cleared simultaneously to have a single unconstrained MCP for the entire region. In doing so, the key features of the DAM, as prevalent in the Indian Exchanges today, were kept unaltered for Indian entities.

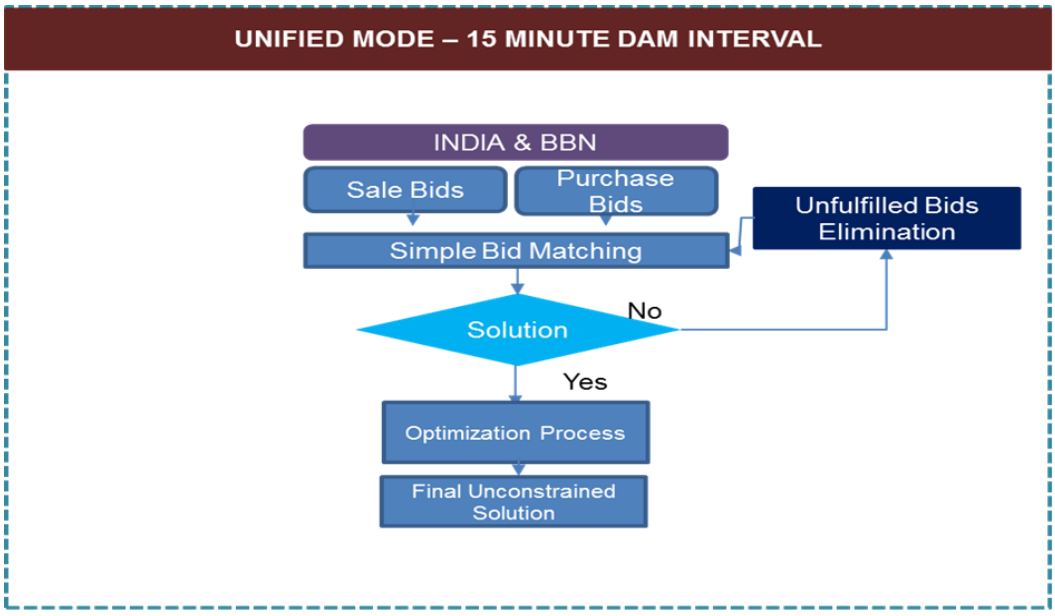


Figure 1: Market Clearing Decision Tree for SARPEX – Unified Mode

2) *Sequential Mode:* In this case, the bids from the Indian participants and BBN countries were cleared in a sequential manner ensuring the least disruption to the Indian domestic exchange. In the first stage, the MCP was determined for India and the un-cleared sell bids from India were aggregated with the buy and sell bids of BBN for determining the MCP of the second stage.

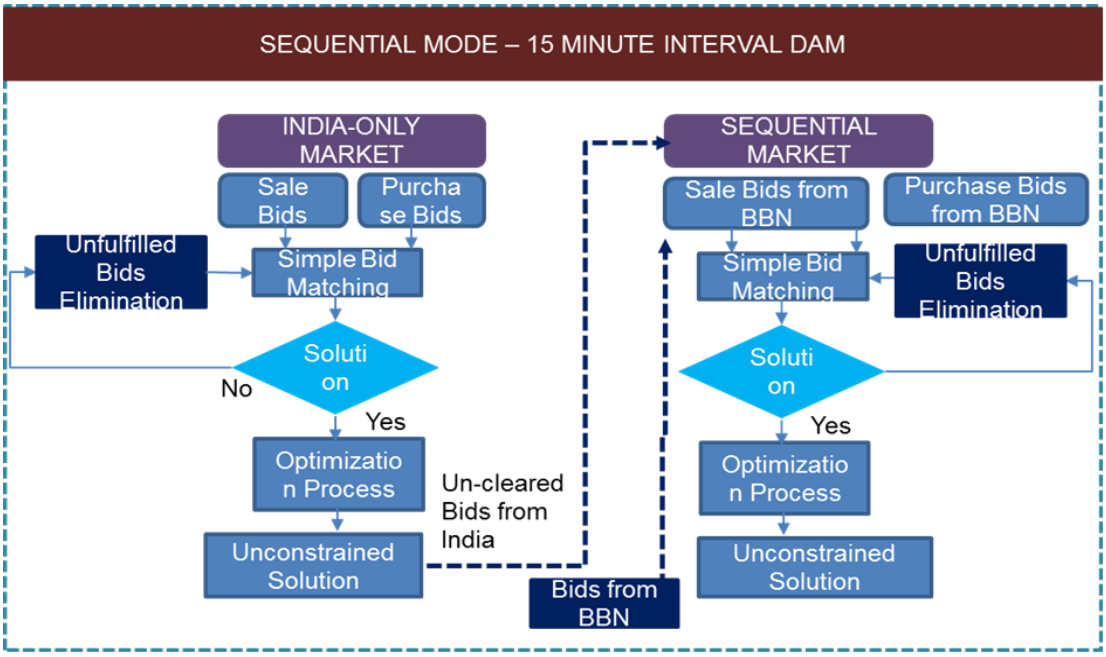


Figure 2: Market Clearing Decision Tree for SARPEX – Sequential Mode

The above modes of operation for SARPEX were initially conceived from *"The roadmap for SARPEX"*[2] and further refined through the following studies/ activities

- Study of the power market structure of BBIN, their supply demand characteristics, key challenges and major trends
- Study of the state of CBET in the SAR, its key enablers and barriers; review of the SAR studies/literature/reports/data on electricity laws, policy and regulation framework
- Study of the Cross Border Power Exchanges and review of the relevant documents on laws and bye-laws governing Cross Border Power Exchanges, market rules and design principles and products offered
- Study of the Market Rules and Design of Indian Power Exchanges
- Assessment of various market structures based on qualitative parameters like suitability to the SAR, fit with the existing structure of Indian Exchanges etc.
- Stakeholder consultation with regulators, distribution companies and system operators in BBIN. Among those consulted were Central Electricity Authority (CEA), Central Electricity Regulatory Commission (CERC), Indian Energy Exchange (IEX) and Power System Operation Corporation Limited(POSOCO) in India, Department of Hydropower and Power Systems and Ministry of Economic Affairs in Bhutan, Nepal Electricity Authority in Nepal, Bangladesh Power Development Board and Power Grid Company of Bangladesh and others.

[2]https://sari-energy.org/publications-list/sarpex-road-map/

- Consultations with a Market Advisory Committee representing power markets such as South African Power Pool (SAPP), Nord Pool, Energinet, Denmark, Indian power market.
- Consulting the Task Force-3 with the nominated members from all countries to take their technical inputs for a suitable market design and to incorporate their other suggestions

3.2 Capacity Building of the Core Teams

For conducting the mock exercise, core teams were nominated from the concerned authorities of BBN and were typically from departments like Ministry of Power and Energy, Power Trade Department, Load Dispatch Centre and/or Regulatory Commission etc. In order to ensure sufficient involvement of the core team members in the mock exercise, it was important to develop the necessary skills pertaining to trading on a power exchange. To facilitate this, the core teams were trained for various skills required for power trading on an exchange. A 2-day workshop was conducted in Delhi. Lectures, study material and PPTs were arranged to train the core teams of BBN on various aspects of trading on power exchanges. Tests were also conducted at the end of the workshop to ensure learning. The following modules were covered in the capacity building workshop:

- Module 1
  - Fundamentals of electricity markets
  - Overview of the draft market design for running of the pilot market
  - Price discovery mechanism in power exchanges
  - Clearing and settlement in power exchanges
  - Overview of CBET – current status in South Asia
- Module 2: This module focused on building the capacity in ‘decision making for bidding’
  - Information required for placing of bids on the pilot exchange, including but not limited to the demand-supply characteristics, transmission corridor availability, etc.
  - Impact of transmission on merit order dispatch
  - Impact of the policy and regulatory interventions on prices
  - Impact of the bidders’ strategic behavior (especially generators and traders with multi-locational facilities) on prices

        - The role of consumer price elasticity of demand in the process of price formation
    - Module 3: Since India is the biggest market in the region, it was also important for members to understand the dynamics of the Indian power markets. Hence this Module covered the following:
        - Transmission pricing mechanism in India at the center and state level and its impact on the bidding strategies of exchange
        - RLDC and SLDC charges in India
        - Congestion in the Indian Transmission Network
        - Deviation settlement mechanism in India
        - Long Term (including Case-I and Case-II processes)/ medium term and short term bilateral markets in India and the impact of these markets on the exchange prices of Indian markets
    - Module 4: Hands-on training for all activities related to the pilot market
        - Data requirements for forming the bids for the selected 60 days
        - Ascertaining price bids based on the data procured for both buy and sell
    - Module 5: In this Module, the members of the core team were trained in forming the bids and placing them using a software

Full details of the capacity building workshop can be accessed in a report titled ***"Capacity Building Under SARPEX Mock Exercise".***

3.3 Infrastructure for Running the Mock Exercise

To facilitate the uploading of bids by BBN, a web portal mimicking an exchange based platform was created, where the bidders could submit their bids and see the results. The users from each BBIN country were given the web-link and a password protected user login to maintain the confidentiality of the bids.

The web portal was designed in such a manner that after the bid submission, the web application interacted with the Market Clearing Engine software to generate and view the results. This provided the confidentiality of the bids and transparency of results.

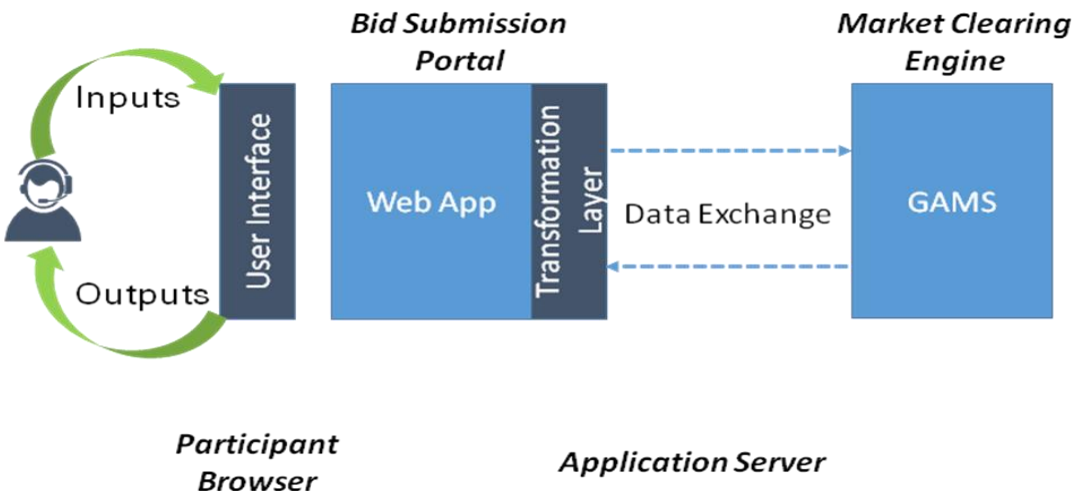


Figure 3: Design of the SARPEX Web Application

As shown in Figure 4, the inputs i.e. bids chosen by the user through the user interface interacts with the Web App, transforms the data into formats required by Market Clearing Engine developed in General Algebraic Modeling System[3] (GAMS). The user interface then displays the results or reports based on the output of the Market Clearing Engine.

The users login to the web application at ***http://mocksarpex.ga*** with their ids and passwords provided by the administrator.

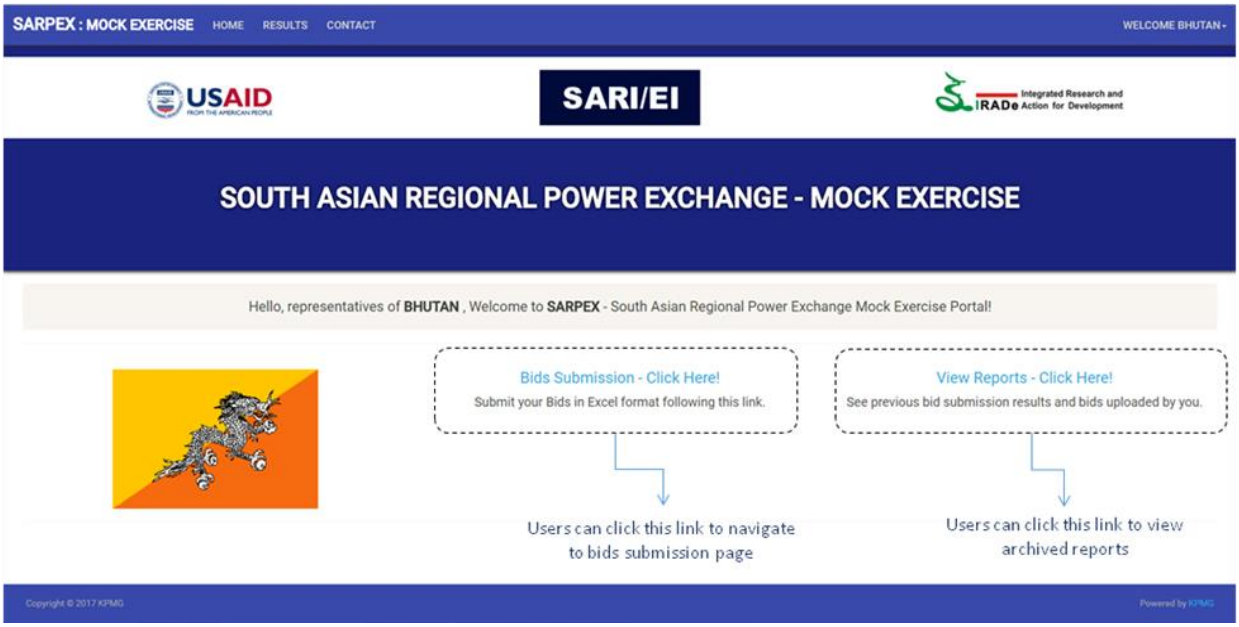


Figure 4: Snapshot of SARPEX Web Platform for Bid Submission

[3]The General Algebraic Modeling System (GAMS) by **GAMS Software GmbH** is a high-level modeling system for mathematical optimization and designed for solving linear, nonlinear, and mixed-integer optimization problems.

The Web App has seven user-specific web pages. The key pages are “Bids Submission” and the “See Results”. Other pages or links are “View Archived Reports”, “Contact Administrator” (users of the application can send the message in case of any issues or queries) and “Track user bid submissions” etc. The web app also has information about various events held as part of the SARPEX mock exercise. The detailed functionality of the SARPEX web portal is discussed in the annexure.

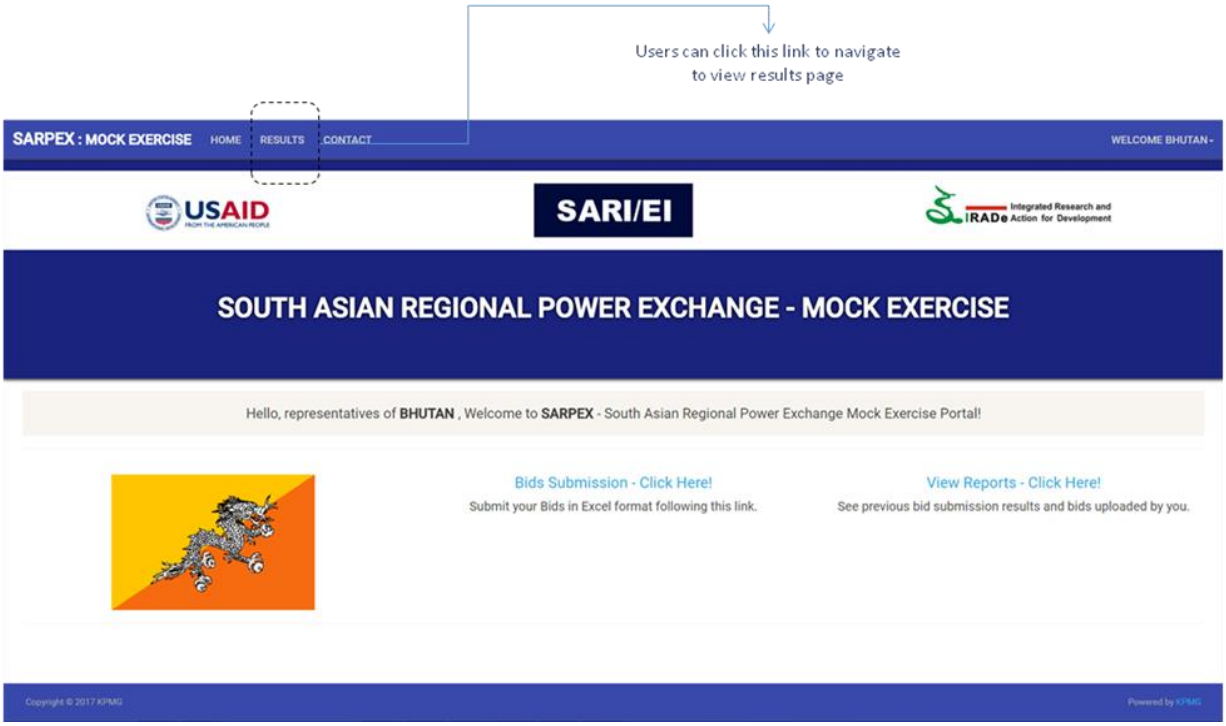


Figure 5: Snapshot of SARPEX Web Platform for Viewing Results

3.4 Selection of the Sample Days for Mock Exercise

As it was not practically possible to run the simulations for all the days of FY2015-2016, sample days representing the year were selected for simulating the DAM of a regional power exchange. The results from the sample days were then extended to cover the entire year.

The key criterion of the sampling methodology was to capture the demand and supply scenarios during the seasonal changes and holidays. Therefore, the selection of the sample days was done in keeping with the fluctuations of prices and volumes witnessed on IEX in conjunction with the daily load and generation variability in BBN during the course of the year. The sample selection technique took into account the following considerations:

- Day of the week (weekdays/weekends)
- Holidays/Special Days
- Time of the year (Seasonal component)

Apart from the above, factors such as variations in unconstrained MCP and MCV on the DAM of IEX and intra-day market were also considered. For example, the days with unnatural spike or drop in MCP indicated temporary shocks due to specific instances such as a generator or the line outages, weather-induced disturbances, higher hydro availability etc. Therefore, the selection of the days was done such that the variation in unconstrained MCP was captured covering both normal as well as days with abnormal behavior. Thus, the additional factors considered for sampling were the following:

- Average daily unconstrained MCP and MCV
- Block-wise deviation from daily average MCP
- The behavior of intraday contingency market

The sample days were selected using the Hierarchical Clustering [4]by grouping the data into clusters such that the objects lying within a cluster have similar characteristics defined through a set of variables. The key steps of the sampling methodology are shown in Figure 7.

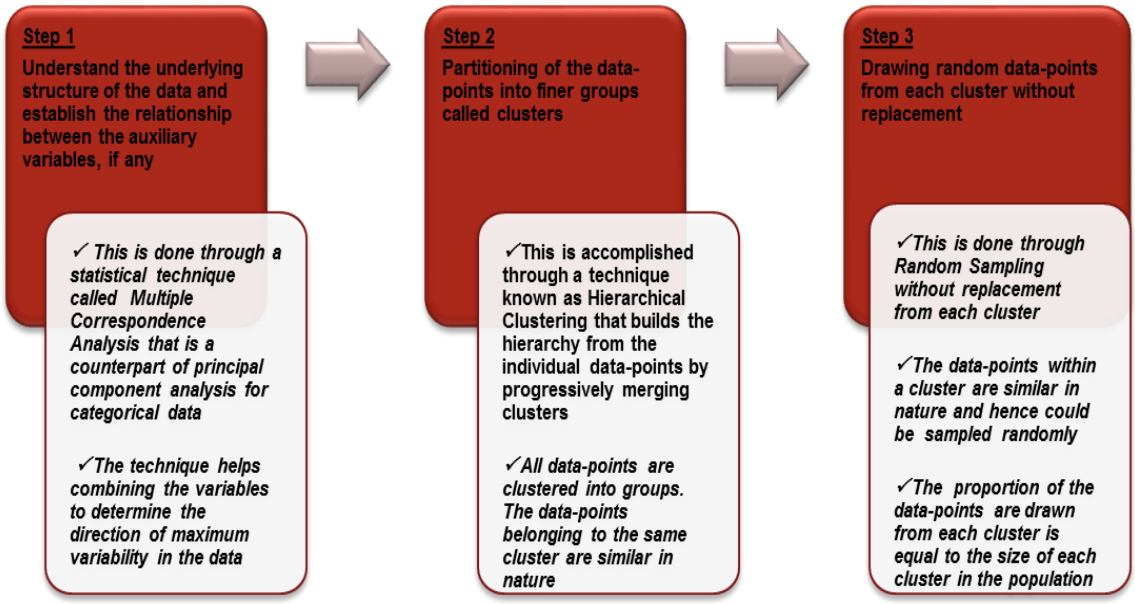


Figure 6: Sampling Methodology for selection of days from FY16

[4] In data mining, Hierarchical Clustering is a method of cluster analysis where data is represented in the form of a cluster tree such that each node of the cluster tree contains a group of similar data; Nodes group on the graph next to other, similar nodes. Clusters at one level join with clusters in the next level up, using a degree of similarity; The process carries on until all nodes are in the tree, which gives a visual snapshot of the data contained in the whole set.

The detailed framework of the sampling methodology was borrowed from a few academic publications[5].The data required for sampling was sourced from various sources. The daily demand and supply position and load profiles of all the member countries for the FY2016 were obtained from relevant authorities (Department of Hydropower and Power Systems for Bhutan, Nepal Electricity Authority for Nepal), while the same was available in the public domain for India and Bangladesh. The ratio of the average load to peak load was determined for all the days from the load profile. The daily data on the unconstrained MCP and total aggregate demand and supply volumes on Indian Power Exchanges were obtained from IEX.

Daily dummies were created for each day of the week and included to ensure the selection of balanced sample with an appropriate number of weekdays and weekends. Further, monthly dummies were also created so that the sample has appropriate number of days from each month of the year. Using the above methodology, a sample of 71 days was selected, as shown in Table 1.

Table 1: Characteristics of the 71 days selected from FY2015-16 for the SARPEX Mock Exercise

April	May	June	July	August	September
Sunday, April 5, 2015	Wednesday, May 13, 2015	Thursday, June 11, 2015	Thursday, June 11, 2015	Saturday, August 8, 2015	Sunday, September 13, 2015
Saturday, April 11, 2015	Friday, May 15, 2015	Sunday, June 14, 2015	Sunday, June 14, 2015	Sunday, August 9, 2015	Sunday, September 20, 2015
Monday, April 13, 2015	Saturday, May 16, 2015	Monday, June 15, 2015	Monday, June 15, 2015	Tuesday, August 11, 2015	Tuesday, September 22, 2015
Sunday, April 19, 2015	Tuesday, May 19, 2015	Sunday, June 21, 2015	Sunday, June 21, 2015	Wednesday, August 19, 2015	Wednesday, September 23, 2015
Wednesday, April 29, 2015		Friday, June 26, 2015	Friday, June 26, 2015	Thursday, August 20, 2015	Monday, September 28, 2015
			Saturday, June 27, 2015	Saturday, August 22, 2015	
			Tuesday, June 30, 2015	Sunday, August 23, 2015	
				Wednesday, August 26, 2015	
				Sunday, August 30, 2015	

[5]https://www.ripublication.com/irph/ijict_spl/14_ijictv3n11spl.pdf

http://jmlr.csail.mit.edu/papers/volume15/balcan14a/balcan14a.pdf

https://ieeexplore.ieee.org/document/7100308/

https://ieeexplore.ieee.org/document/4483087/

October	November	December	January	February	March
Tuesday, October 13, 2015	Friday, November 27, 2015	Thursday, December 10, 2015	Wednesday, January 6, 2016	Sunday, February 7, 2016	Saturday, March 5, 2016
Wednesday, October 14, 2015		Monday, December 14, 2015	Friday, January 8, 2016	Monday, February 8, 2016	Tuesday, March 8, 2016
Saturday, October 17, 2015		Tuesday, December 15, 2015	Saturday, January 9, 2016	Thursday, February 11, 2016	Monday, March 14, 2016
Thursday, October 22, 2015		Sunday, December 20, 2015	Monday, January 11, 2016	Sunday, February 14, 2016	Saturday, March 19, 2016
Tuesday, October 13, 2015		Wednesday, December 23, 2015	Thursday, January 14, 2016	Wednesday, February 24, 2016	Monday, March 21, 2016
		Thursday, December 24, 2015	Tuesday, January 19, 2016		
		Tuesday, December 29, 2015	Wednesday, January 20, 2016		
		Wednesday, December 30, 2015	Thursday, January 21, 2016		
			Friday, January 29, 2016		

In order to check the robustness of the sample, it was seen that the average load to peak load distribution for each nation in the sample was similar to the population characteristics and also the distribution of prices and demand-supply gap on the Exchange for FY2015-16.

3.5 Bids Submission

The nominated core team members in each country were entrusted with the task of preparing the buy/sell bids for the selected days after the capacity building training workshop.

3.5.1 Bids Preparation

The core team members developed the sale / purchase bids for 15-minute time block for each of the 71 days and subsequently uploaded them on the SARPEX web portal. The key factors considered by the core team in the formation of the bids were the following:

- Demand and supply gap to assess the power surplus/deficit in each block of time
- Variable cost of their own generators to access the cost of buying/selling power on SARPEX vis-à-vis own generation

The bidding behavior of each country, along with the bid price and quantum is discussed in the subsequent section.

3.5.1.1 Operating Timelines

The BBIN countries fall in different time zones (see Table 2). The table shows the time zones in BBIN countries relative to the Coordinated Universal Time[6] (UTC) and deviations from the IST. To harmonize the bidding, market clearing and delivery of power for 96 blocks of 15-minute time-interval for 24-hours a day across BBIN region, Indian Standard Time (IST) was adopted for the purpose of SARPEX working. Report titled *''SARPEX Market Design and Rules''* discusses the issue in detail.

Table 2: Operating time zones in BBIN relative to UTC

Country	Time zone	IST Deviation
India	UTC + 5:30 hours	-
Bhutan	UTC + 6:00 hours	+30 minutes
Bangladesh	UTC + 6:00 hours	+30 minutes
Nepal	UTC + 5:45 hours	+15 minutes

3.5.1.2 Currency

Another key consideration for the mock exercise was to choose between a single and multiple currencies. As detailed in the report on *"SARPEX Market Design and Rules"*, the Indian rupee was chosen as the currency for trading on the regional power exchange.

3.5.2 Extraction of Bids from India

In case of India, the bids for each of the 15-minute time block were extracted from the aggregate demand-supply curves, which are available in the public domain on the IEX website. Since DAM is already operational in India, the intent was to take the actual bids of Indian buyers and sellers so that the findings of the mock exercise are real and practical.

[6] The UTC is the global standard followed for time observed in different countries and is considered to be the absolute time. All other time zones are referenced to it.

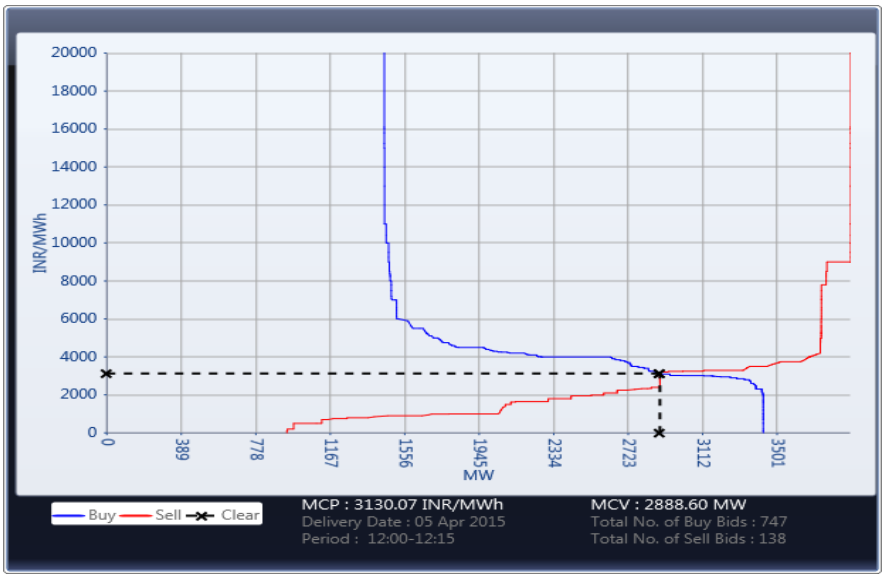


Figure 7: Typical AD-AS Curve extracted from IEX

The methodology of extraction of the bids from IEX is explained below:

a) Step 1: Each of the selected days was sent as an input to a python[7] script that extracted the aggregate demand and supply curves present on the IEX website in the graphical form. Running this script saved the graphs for each of the 96 blocks for each day in the form of an image.

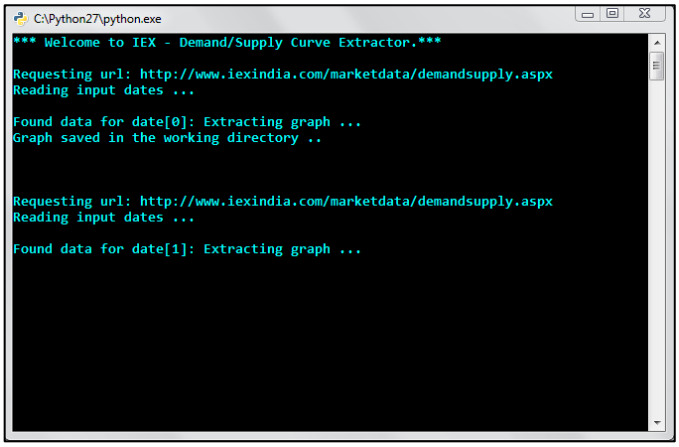


Figure 8: IEX Demand-Supply graph extractor application

b) Step 2: Once the graphs for all the 96 blocks for each of the selected day were extracted, these charts were fed into an image processing software called **'im2graph'**. The software identified the scanned images (pixels) from the graph using user-specified X-Y coordinates and converted them into discrete data-points, as shown in the Figure 10.

[7] Python is a programming language that has an open source license.

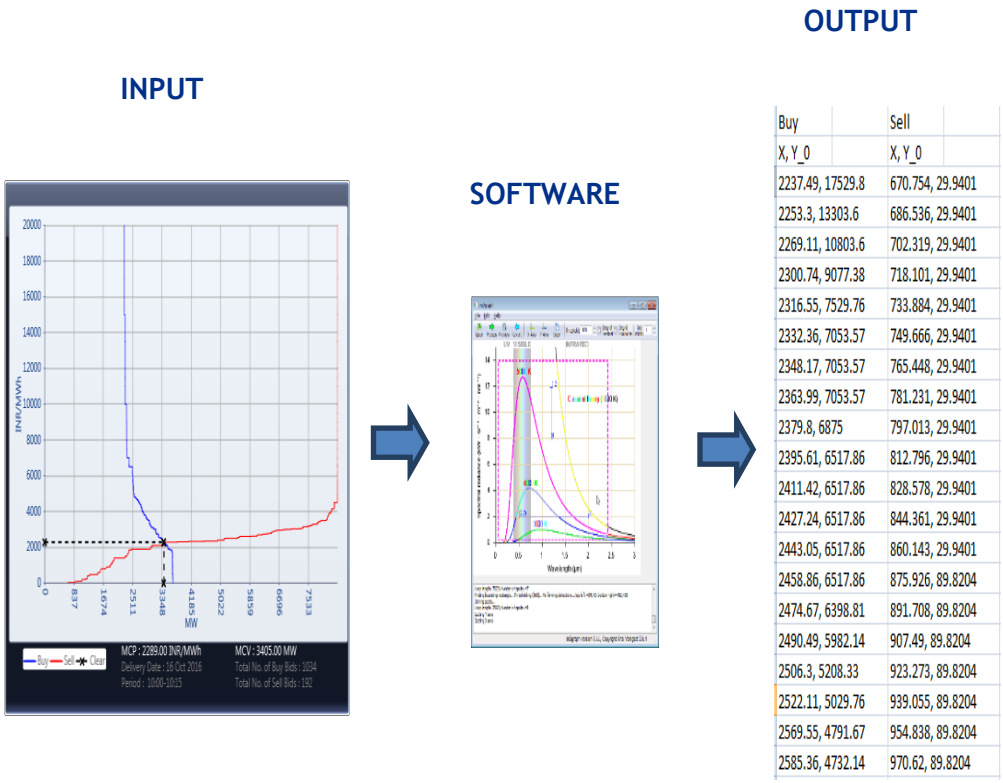


Figure 9: Image processing of the aggregate demand and -aggregate supply curves

c) Step 3: The bids extracted for India were then validated by running them through a market clearing algorithm (discussed in detail in the latter sections). The MCP and MCV obtained from the extracted data points were matched with the actuals published on IEX and data was manually corrected / re-extracted whenever required to ensure that the deviation with regard to actuals was minimal (in the range of 2-3%).

The bids submitted by BBN were also checked for the parameters such as bid price cap, the time block for which the bid was placed etc. and reconciled in consultation with the respective nodal officers from each country.

3.6 Running the Mock Exercise

The estimated Indian bids and bids sourced from other participating countries were aggregated to obtain an Aggregate Demand (AD) and Aggregate Supply (AS) curves and then matched using KPMG Proprietary Market Clearing Engine under the two market designs i.e. the unified and sequential mode to arrive at the Market Clearing Volume (MCV) and Market Clearing Price (MCP) for each dispatch period i.e. 15-minute block. The design of the market clearing engine was borrowed from a few academic papers.[8]

[8] https://arxiv.org/pdf/1712.00235.pdf

https://www.sciencedirect.com/science/article/abs/pii/S0377221713009120

3.6.1 Bid Aggregation

The bids obtained from all countries were aggregated using the Step-wise Approach, which is one of the common methods of aggregation. Two predominantly used algorithms for bid aggregation i.e. step-wise and piece-wise approaches were discussed in the report titled "*SARPEX Market Design and Rules".* The SARPEX mock exercise used the step-wise approach for price and volume determination for the reasons mentioned in Table3.

Table 3:Comparison between Step-wise and Piece-wise Approach

Criteria	Price Determination	Volume Determination
Wealth Distribution	▪ Piece-wise approach typically relates to disproportionate wealth distribution between buyers and sellers as compared to Step-wise	▪ Step-wise approach maximizes volume cleared based on social welfare. This allows for unbiased wealth distribution
Wealth Maximization	▪ Matching rules under the piece-wise method leads to loss of wealth and lower wealth maximization as compared to the step-wise approach	▪ Piece-wise approach tends to clear a greater or lesser than efficient volume at an unfair price to either the buyer or seller. ▪ The step-wise approach on the other hand maximizes both buyers' and sellers' wealth

3.6.2 Matching Engine for Price Discovery

In order to determine the MCP and MCV, the AD and AS curves were obtained by stacking buy bids and sell bids of all the countries. The MCP and MCP (equilibrium)were obtained through the matching engine by the way of intersection of AD and AS curves. Determination of equilibrium in this way maximizes the welfare accrued to the participants i.e. buyers and sellers. All sell offers below the MCP and all buy bids above the MCP are cleared completely. Bids and offers at the MCP may be partially cleared and the remaining bids are curtailed. This algorithm is known as Uniform Pricing Mechanism.

The MCP and MCV obtained from the mock exercise were used to quantify the benefits of the entire region as well as each country. The benefits were computed by assessing the economic surplus accrued to participants in each country. The participants were either the consumers (buyers) or producers (sellers) of electricity and thus the surplus gains to these are termed as consumer and producer surplus respectively, as shown in figure 10.

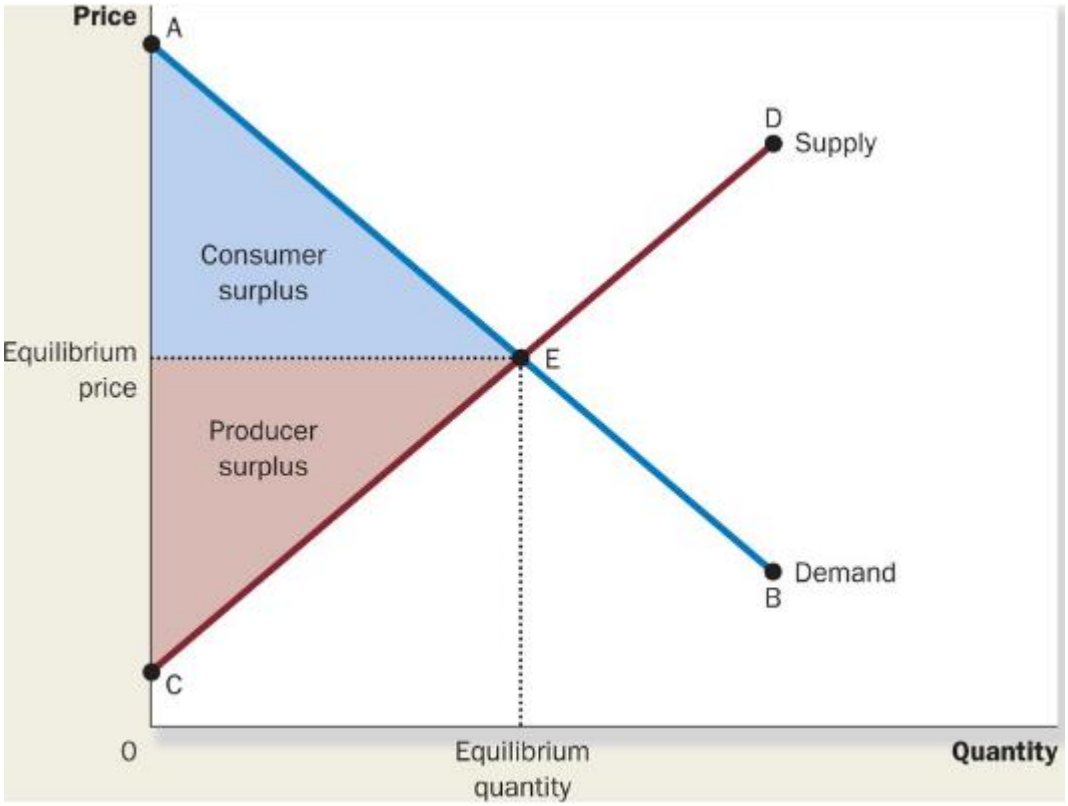


Figure 10: Diagrammatic representation of consumer and producer surplus

The key assumptions of the market design and rules chosen for SARPEX mock exercise are summarized in Table 4.

Table 4: Design features 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

The SARPEX Market Design and Rules as discussed above and implemented for the mock exercise were approved by the Task Force-3 (TF-3) Members.

In the TF-3 meeting held in Kathmandu in December 2016, some of the key aspects about the market design were discussed. The members had recommended the step-wise clearing algorithm for price discovery in the pilot market. They had noted that the mean error of roughly 2-3% in extracting the Indian bids was reasonable. The members had further recommended extrapolation method for treating the non-convergence of the buy and sale curve in the market clearing algorithms as well as the use of Indian time zone and Indian currency for the purpose

of the pilot market. The data sampling procedure was also discussed and agreed upon by the TF-3 members before the simulation of results.

3.7 Extrapolation of Results

The result obtained from the simulations of 71 days were extrapolated to cover all the days of FY2016 to assess the impact of SARPEX on each country, in terms of the key metrics discussed earlier. The methodology used for extrapolation is explained below.

The representative days for the mock exercise were selected using clustering. Thus, each of the selected days in the sample was associated with a particular cluster. The days of the same cluster had similar characteristics, regardless of the calendar month. Thus in order to aggregate the results at a monthly level, the results for the days falling within the same cluster were averaged to arrive at a 'typical characteristic day' for that cluster and such typical characteristic days of each cluster were then averaged over a month (weighted by their frequency)to arrive at the total (extrapolated) monthly figures.

The result, presented in the latter sections, extrapolated for the entire FY2015-16 shows the outcome of SARPEX for the FY2016.

The extrapolation methodology for a typical month has been explained graphically in the annexure II.

4 Assumptions for the Mock Exercise

This section discusses some of the key assumptions associated with the Mock Exercise:

1. The mock exercise was based on unconstrained market clearing principles i.e. determination of MCP and MCV without taking into account the impact of transmission congestion. However, the availability of transmission capacity between BBN and India was duly considered by BBN members in the formulation of their bids by assuming only the residual capacity i.e. the capacity available after accounting for the long term and medium term open access of each country with India. Thus, the transmission flows incident on exchange were restricted to 300 MW buy by Bangladesh, 350 MW buy by Nepal and265 MW sell by Bhutan. For detailed assumptions on available transmission capacity for power exchange, please refer section 8 of this report.
2. Both buy and sell bids of the Indian participants were taken in the unified mode in order to obtain a single uniform MCP and MCV. However, for the sequential mode, only the un-cleared sell bids from the first auction (i.e. India only) were included in the second auction. The reason for taking only the sell bids from India in the second auction are the following:
    a. The un-cleared buy bids from the first auction may have negligible chances of being cleared in the second auction for majority of time since the bids would have been placed at lower prices than the MCP of first auction.
    b. The buy-bids that were left un-cleared on Indian exchange due to transmission congestion would remain so even with the additional power flowing in from Bhutan or any other neighboring country. Therefore, inclusion of these buy-bids and their subsequent clearing in the residual market would present a misleading picture of additional buy-volume in India.
    c. The key objective of the sequential mode was to minimize impact on the MCP, MCV and exchange related grid operations in India. Thus, to avoid operational complexities to Indian buyers which may arise due to two auctions such as allocation of transmission corridors, multiple price signals or fall back for purchase through second auction etc. only the un-cleared sell bids were allowed to be passed into the second auction.
    d. Secondly, given the dominance of the sell bids in the Indian market for most parts of the year (barring a few instances such as fuel shortage or low hydro conditions) plus the reality of limited supply availability in BBN, it seems that allowing only the Indian sellers in the second auction would be a more equitable solution rather than allowing the Indian buyers to clash for price and volumes in the second auction.

3. The Transmission charges and losses as applicable under the current bilateral trade with BBN were assumed for the mock exercise.

Table 5: Average transmission charges andlosses assumed in the mock exercise

#	Country	Transmission Charges (INR/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 are estimated 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 plus 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

**Source: National Load Dispatch Centre, India*

For the ease of implementation, the above mentioned transmission charges and losses were adjusted in the bid price of the participants. The formula used for the price adjustment is given below:

a) **Modified Buy Bid Price = (Bid Price – Transmission Charges) *(1 - % Losses)**

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

4. The grid operating charges and exchange transaction fee were not assumed in the mock exercise, since these charges are very small (~0.03 INR/kWh). However, in practice, all the participants on the exchange have to bear these charges.

5 Bidding Behavior of the Countries

This section discusses the bidding behavior of BBN and highlights the months where each country chooses to buy or sell power, depending upon its demand supply position. The following observations are important in this regard:

- Nepal intends to buy power throughout the year. However, the maximum power is purchased in November to January (7-10 MUs per day) on account of low hydro availability within the country. During these months, the purchase bids were generally higher in the evening hours from 5 to 11 pm. For September to October, when the demand is relatively lower than the availability, Nepal sold power during the off-peak morning hours (i.e. 00:00 to 04:00 HRS).Figure 11 shows the monthly average buy bids (price and quantum) received from Nepal.

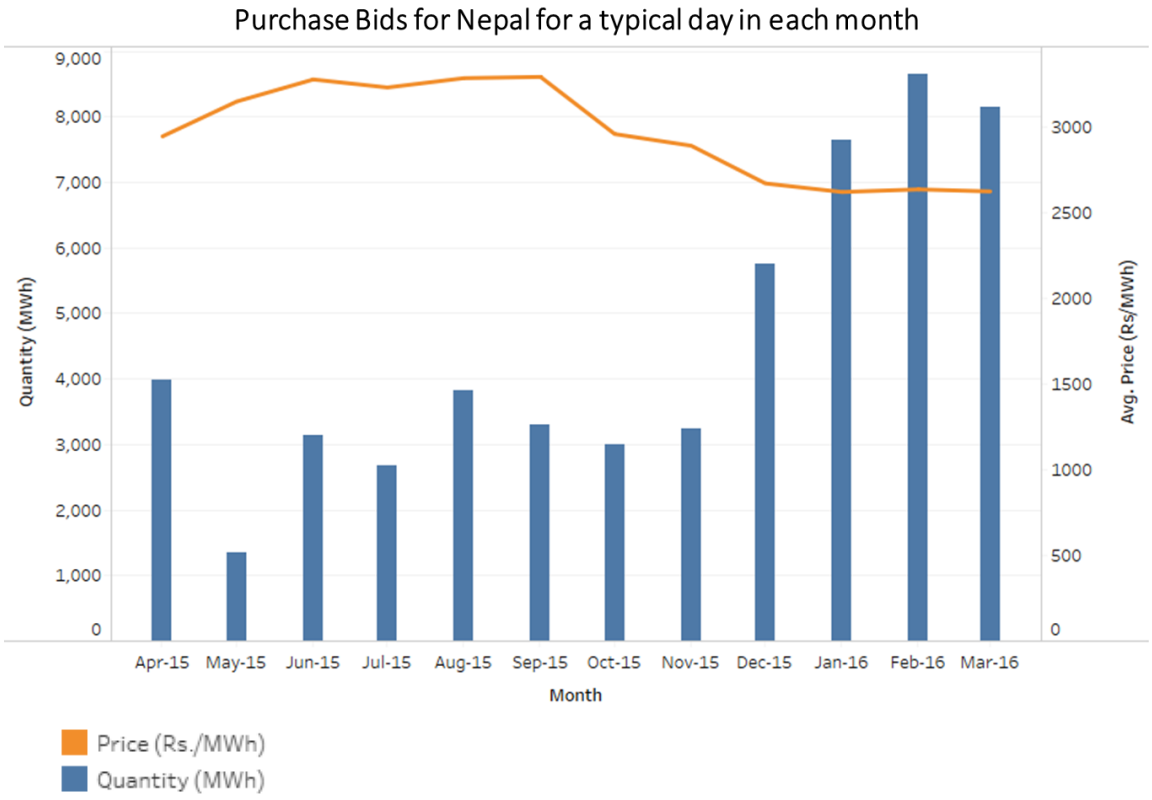


Figure 11: Average monthly purchase (Quantum and Price) bids from Nepal

- Bhutan, with hydro dominant supply profile, chose to sell power throughout the year, though the sell quantum reduced significantly during the winter months. Maximum surplus is available to Bhutan during the summer months due to higher hydro availability. During the peak winter months, when the rivers are frozen, Bhutan also purchased power, though the purchase quantum was relatively small (up to 0.07 MUs in a month). The average monthly sell bids (price and quantum) received from Bhutan are shown in Figure 12.

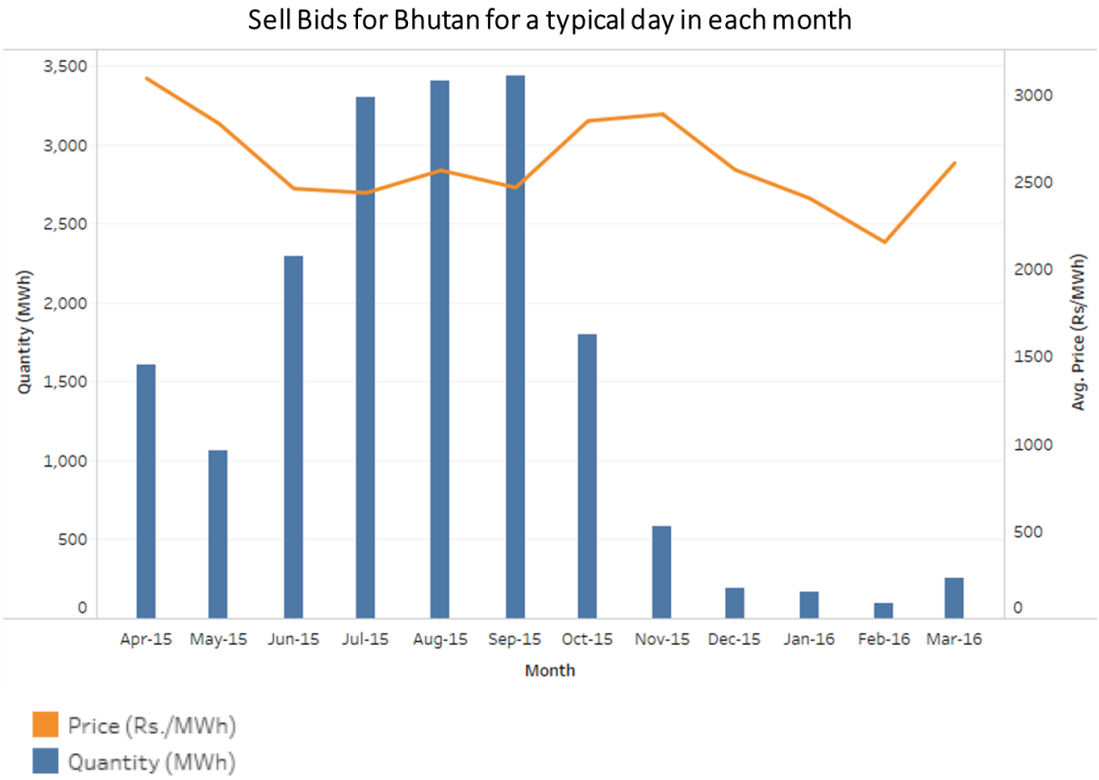


Figure 12: Average monthly sell (Quantum and Price) bids from Bhutan

- Bangladesh placed only the buy bids to manage its power deficit and replace its costly generation. Since, Bangladesh has high reliance on costly generators (~5 MUs being generated every day at marginal cost of above INR 10/unit), the buy bids from Bangladesh were more aggressive. The average monthly buy bids (price and quantum) received from Bangladesh are shown in Figure 13.

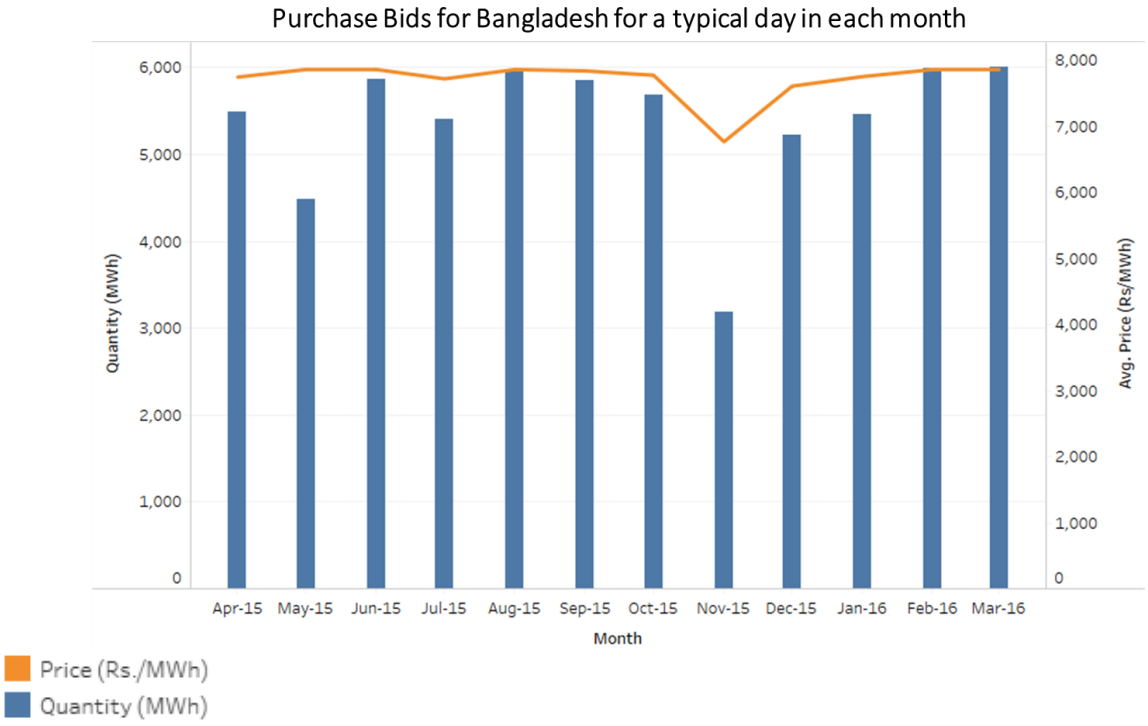


Figure 13: Average monthly purchase (Quantum and Price) bids from Bangladesh

- India, being the largest market in the BBIN region contributes a significant purchase and sale quantum on SARPEX. The maximum power in India was traded in the months of September to October accounting for over 18% of the total volumes traded in FY2015-16.Higher trade volumes in these months were mainly due to higher electricity demand as well as gradual decrease in the hydro-generation. The sell bids on the other hand were highest from January to March (~5,000 MUs per month).

Based on the above, the key conclusions on the bidding behavior of BBN can be summarized as below:

(a) The sell bids by Bhutan, in most cases, were guided by their expectations of higher prices on the exchange. This is “strategic” only to the extent that Bhutan, like all other sellers would not want to lower prices on the exchange. However, through a repeated play on exchange, Bhutan may learn that getting cleared at ‘a price” on the exchange is better than a high price sell offer and not getting cleared.

(b) Both Nepal and Bangladesh, like any rational buyer, would not want to place a bid which leads to an arbitrary increase in the market price. These players, too, bid a price which was higher than the price on the India only markets, but still lower than their marginal willingness to buy. In Nepal, during load shedding large commercial establishments (hotels etc.) use costly diesel generator sets. In Bangladesh, too, “quick rentals”, which are diesel based power plants, are used to meet electricity demand. The buy bids of Bangladesh were lower than the cost of power from these power plants.

(c) Finally, the seasonal variations in the buy and sell patterns of these countries reflect a response to the genuine demand and supply conditions.

Since, these countries were learning the process of bidding, they were able to keep their bids close to their marginal willingness to pay or their marginal costs (in case of sell). Beyond this, there was no evidence of any strategic bidding by any party.

6 Results of the Mock Exercise

This section discusses the results of the mock exercise based on the sale/purchase bids submitted by BBN, actual sale and purchase bids extracted from IEX and the underlying market design parameters as firmed up in the above sections. The results are discussed for both unified and sequential mode of operation and compared with the existing DAM in India. The results for the latter were obtained by generating the MCP and MCV using the Market Clearing Engine for the Indian market from the extracted bids of the IEX. These results are denoted as India-only mode in the report. The outcomes of the India-only mode almost matched with the results published by IEX.

The results of the mock exercise are structured as follows:

- Summary of the results showing the highlights of both the modes of operation, in terms of three key variables – Total (Producer and Consumer) Surplus Gain, MCP and MCP
- Detailed monthly results of the two operating modes for the above variables.

The section is divided into five sub-sections. Section 6.1 presents the overall annual summary of the two operating modes. Section 6.2 presents the surplus gain for BBIN in both the modes of operation and the share of each country in the overall regional surplus. Section 6.3 presents the overall volumes traded by each country in both modes. Section 6.4 presents the comparison of prices in unified and sequential mode. Section 6.5 presents the monthly variation in surplus, volumes traded and MCP in the two modes and the monthly trends in the demand and supply of the overall region.

6.1 Summary of Results

The mock exercise finds that the BBIN can make significant gains in both modes of operation. The total regional surplus for FY2016 was INR 323.63 billion and INR 323.24 billion in the unified and sequential modes, respectively. The surplus for the sequential mode subsumes the surplus generated from both the clearing stages i.e. Indian DAM (first stage) as well as India with BBN (second stage).

Table 6: Total Surplus (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 mainly accounts for consumer surplus
*Surplus gain to Bhutan mainly accounts for producer surplus
*Surplus gain to India accounts for both producer and consumer surplus

However, the total regional surplus and individual surplus to BBN differed across the two modes. As shown in Table 7 and Table 8, the surplus gain to India and Bhutan was higher in the sequential mode while Bangladesh and Nepal accrued higher surplus in unified mode. This is because Bangladesh and Nepal are predominantly buyers and prices in the sequential mode were higher than that in the unified mode (up to 20 to 35 paisa) in most cases. A higher purchase price and hence relatively lower cleared buy volumes results in a slight drop in surplus for the buying countries, though the differences are too small in terms of the overall gains to each country from participation in DAM on SARPEX.

Table 7: Surplus (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
		(87.6%)	(6.93%)	(2.97%)	(2.48%)
Sequential	9.71	8.23	0.63	0.42	0.43
		(81.4%)	(6.24%)	(4.16%)	(4.26%)

*Surplus gain to Bangladesh and Nepal mainly accounts for consumer surplus
*Surplus gain to Bhutan mainly accounts for producer surplus
*Surplus gain to India accounts for additional gain to the producers and consumers in India

The weighted average MCP was found to be INR 2,910/MWh and INR 3,269/MWh in the unified and sequential mode respectively. The price for the sequential mode was the price observed in the second stage where un-cleared-buy bids from India were matched with buy/sell bids from BBN. The MCP of the first stage of sequential mode was INR 2,745/MWh which is same as the MCP for the India-only mode.

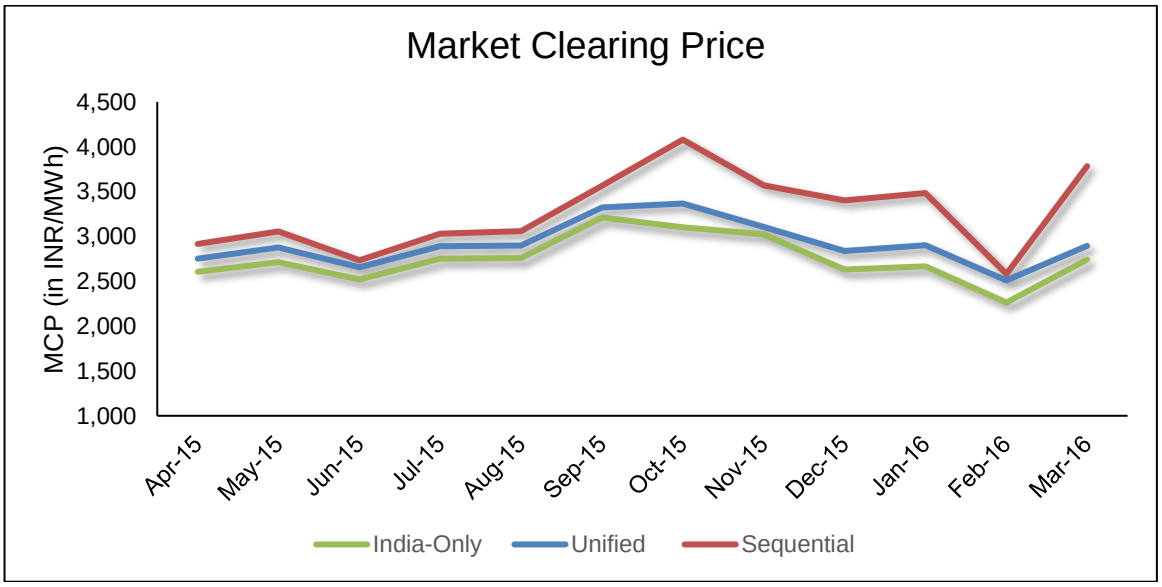


Figure 14: Weighted average MCP in unified, sequential and India-only modes

The price difference across the two modes arises because of the price-setting by the marginal buyer and seller change from one mode of operation to the other. In the case of unified mode, since the bids of all participants are cleared together, the marginal buyer is generally from India or Nepal, who bid at relatively lower prices than Bangladesh. On the other hand, in the sequential mode, the prices observed in the first stage are the same as those realized on IEX. However, in the second stage, the marginal buyer could either be Bangladesh or Nepal depending upon the availability of the overall sell quantum.

The mock exercise finds that whenever the low cost supply from Bhutan is constrained (example during winter's months) and the overall purchase quantum is higher than the sell bids, Bangladesh happens to be the marginal buyer in the sequential mode and hence the market gets cleared at a higher MCP.

Further, the mock exercise found that in the unified mode, the bids from Bangladesh and Nepal displace the bids of low cost Indian buyers as all bids are cleared simultaneously. Even on the sell side, a few Indian sellers are out-bid by low-cost sell bids from Bhutan, which reduces the overall cleared volumes for the region.

However, as the markets run in a sequential manner, the market clearing volume in the sequential mode remains unaltered for India while additional volumes from BBN are cleared, thus adding more volume. As a result, the overall volume cleared in the sequential mode is higher by approximately 1.6% of the unified mode.

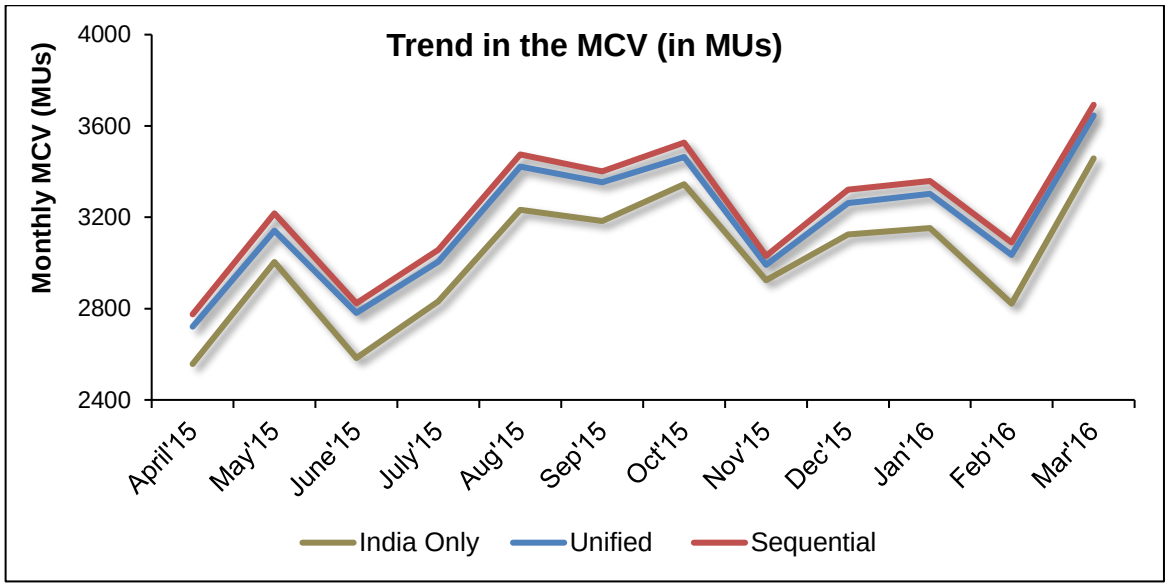


Figure 15: Monthly Total MCV in Unified, Sequential and India-Only mode

On aggregate, 38,137 MUs and 38,769 MUs were traded annually in the unified and sequential mode, respectively. The volumes presented for the sequential mode include the cleared volumes from both the stages. In the sequential mode, the volumes that were traded in the first stage are the same as volumes cleared in India-only mode (or on IEX) and account to ~36,219

MUs. A snapshot of volumes bought and sold by each country and total annual cost/revenue incurred for FY16 is presented in Table 8.

Table 8: Total annual volumes bought by each country in Unified and Sequential mode (in MUs)

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

For India, the volumesfor unified and sequential mode include the existing DAM operations in India
**The figure in bracket represent the change in purchase volume over India-only Mode*

Table 9: Total annual volumes sold by each country in the unified and sequential Mode (in MUs)

	India	Bangladesh	Nepal	Bhutan	Total
India-Only	36219	-	-	-	36219
Unified	37715 (1496*)	-	10	412	38137
Sequential	38333 (2114*)	-	10	427	38769

For India, the volumesfor the unified and sequential mode include the existing DAM operations in India
**The figures in the bracket represent the change in the sell volume of Indiaover india-only Mode*

Table 10: Total annual cost incurred by each country from purchase of power (in 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 figuresfor the unified and sequential mode include the existing DAM operations in India*

Table 11: Total Annual revenue earned by each country from sale of power (in INR Billion)

	India	Bangladesh	Nepal	Bhutan
India-Only	99.4	-	-	-
Unified	110.05	-	0.02	1.22
Sequential	105.71	-	0.03	1.42

Table 12: Total annual weighted average buy price (in Rs/MWh)

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

Table 13: Total annual weighted average sell price (in Rs/MWh)

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

The prices in the sequential mode represent the weighted average price accrued to sellers from the sale of power in the residual market (BBN) only
**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*

6.2 Surplus

As highlighted earlier, the regional exchange for BBIN led to a total surplus of INR 323.63 billion and INR 323.24 billion in the unified and sequential modes, respectively, for FY2015-16. This is inclusive of the overall surplus of INR 313.53 billion from India. Of the total regional surplus (including the surplus from India), the share of surplus accrued to BBIN was 2.74%, 0.09%, 96.95% and 0.22% respectively in the unified mode and 2.55%, 0.13%, 97.12% and 0.20% respectively in the sequential mode.

The share of India in the total surplus is the highest, it being the largest market in BBIN region. On excluding the surplus generated in India, the total additional surplus generated from SARPEX is as shown in Table 14 below.

Table 14: Incremental surplus in the unified and sequential mode for BBIN

	Increment in Annual Surplus over India-Only mode (in INR Billion)
Unified	10.1
Sequential	9.7

On excluding the surplus from India operations, the distribution of surplus inBBINwas89%, 3.1%, 0.6% and 7% in the unified mode and 86%, 4.4%, 2.4 .6% and6.6% in the sequential mode, respectively.

It is to be noted that the buy/sell bids of each country truly reflect its marginal willingness to buy and its marginal cost of selling. The surplus gain quantified in the previous sections reflect the benefit or the cost savings to each country from the trade in DAM on SARPEX. However, the actual gains of the trade to these countries may even be more.

For example, Bangladesh runs expensive diesel generators with a variable cost above INR 10/kWh, as illustrated in the data shared by the core team members. If Bangladesh could replace this costly generation on SARPEX, it would lead to cost savings of roughly INR 18 Million in FY16which is much more than the surplus gain of roughly INR 8 billion, as shown in Table 7 and 8. This is because a part of the costly generation of power in Bangladesh (costlier than INR 10/kWh) was replaced by bid at a much lower price (INR 6/MWh).

Similarly, Nepal observed a load shedding of 1,670 MUs during FY16 which, if bought on the DAM on SARPEX, could have led to further benefit (in socio-economic terms).

Lastly, in the case of Bhutan, the actual benefit to the country is greater than the producer surplus shown in Table 7 and 8 as the sell bids were placed in reference to the prices prevailing on IEX in FY2016 instead of the actual marginal cost of generators which is relatively much lower.

6.3 Trade Volume

The total trade on SARPEX in the unified and sequential modes for FY2015-16 was 38,127 MUs and 38,768 MUs, respectively. These volumes are inclusive of the volumes that were traded on IEX for FY2015-16 in India.

The maximum trade volume was observed in the months of September, October and March. This may be attributed to higher overall electricity demand in India, Nepal and Bangladesh during this time. Nepal faces severe power deficit during these months, while in Bangladesh also its reliance on expensive gas based generators is higher during these months.

For the remaining months, the share of each country in the overall power bought or sold remains fairly constant throughout the year. Of the total volumes bought on SARPEX(including the volumes from Indian DAM), the share of BBIN was roughly 5.29%, 0.001%, 92.81% and 1.90% respectively in the unified mode. The distribution of cleared buy volumes changed in the sequential mode to 4.98%, 0.00%, 93.38% and 1.65%, respectively.

The buy volumes for India reduced in the unified mode by 822 MUs, as new buyers (Nepal and Bangladesh) out-bid some of the Indian buyers. As a result, the total volumes bought by Nepal and Bangladesh in the unified mode were higher. However, in the sequential mode, the increase in the purchase volumes over India-only mode was equal to the volumes bought by Nepal and Bangladesh as there was no change in the purchase volumes for Indian participants.

Of the total volumes sold on SARPEX in FY2015-16, the share of Bhutan and India was roughly 98.2% and 1.08% respectively in the unified mode and 98.90% and 1.1% respectively in the sequential mode. The sell volumes for India increased in both the modes to cater to the additional demand from Bangladesh and Nepal.

Table 15: Incremental volume in the unified and sequential mode for BBIN over India-Only Mode

	Increment in Cleared Volume (in MUs) over India-Only
Unified	1918
Sequential	2550

6.4 Prices

The weighted average MCP on SARPEX was found to be approximately INR 2,745/MWh, INR 2,910/MWh and INR 3,269/MWh in India-Only, unified and sequential modes, respectively.

Table 16: Month-wise weighted average MCP in the unified, sequentialand India-Only mode

Month	Weighted Average MCP (INR/MWh)		
	Unified	Sequential	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	2,895	3,783	2,740
Average	**2,910**	**3,269**	**2,745**

**The market clearing volume in each mode is used as the weight in computing the average prices*

Prices in all the modes were observed to be higher in the month of September, October and March. The relative difference in the weighted average prices is shown in the Table 17.The prices are higher in the two modes relative to Indian-only mode due to high-priced purchase bids from Bangladesh. Further, during winter months (especially October, January and March), the prices in the unified and sequential mode are relatively higher than the India-only mode due to non-availability of low-cost hydro power from Bhutan. The effect of the same was prominent in the month of March where the MCP in the Sequential mode went up due to high price purchase bids from Bangladesh (over INR 9/MWh), coupled with negligible sell quantum from Bhutan.

Table 17: Month-wise comparison of MCP in the unified, sequential and India-Only mode

Month	Increment in Weighted Average MCP (in Rs/MWh, % Increment)		
	Increment in Unified mode over India-Only	Increment in Sequential mode over India-Only	Increment in Sequential mode over Unified
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 prices in the sequential mode are higher than that in the unified mode by an average of INR 354/MWh. The month-wise increment in prices in the sequential mode over the unified mode is depicted in Table 18. It can be seen that the difference in prices of the two modes also varies significantly across months from INR 71/MWh to 888/MWh. Also, for FY2015-16, the prices in 76% of the blocks lie within INR 2,000-INR 3,500/MWh in the unified mode, while the same holds true for 69% of the blocks in the sequential mode (refer Table 19).

Table 18: Distribution of MCP in the 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%	52%	7%	7%	2%	0%	18%

** The percentage has been computed for each dispatch period (15-minute time block) for all selected 71 days*

6.5 Monthly Variation in Surplus, Volume Traded and Prices

This section discusses the monthly trends of surplus, volumes and prices observed in the unified and sequential modes. The maximum volumes in both the modes are traded in the month of September, October and March, when the purchase volumes from India are higher owing to more demand either due to agriculture, seasonal changes or festivals. India, being a bigger market than BBN, impacts the overall trends on SARPEX. The overall regional surplus and the prices were also found to be higher during this time. The monthly trends in the surplus, prices and volume traded are given in Table19.

Table 19: Month-wise surplus, MCV and weighted average MCP in the unified and sequential mode

	Monthly Regional Surplus in Unified mode (INR Billion)	Monthly Regional Surplus in Sequential mode (INR Billion)	MCV in Unified mode (in MUs)	MCV in Sequential mode (in MUs)	Weighted Average MCP in Unified mode (INR/MWh)	Weighted Average MCP in Sequential mode (INR/MWh)
April'15	23.2	23.2	2720	2775	2,751	2,916
May'15	29.6	29.5	3141	3217	2,878	3,056
June'15	24.5	24.5	2781	2822	2,655	2,735
July'15	29.8	29.8	3006	3058	2,892	3,032
Aug'15	28.2	28.2	3421	3474	2,898	3,059
Sep'15	24.1	24.1	3353	3400	3,324	3,567
Oct'15	27.0	26.9	3464	3526	3,367	4,079
Nov'15	22.2	22.2	2992	3031	3,106	3,571
Dec'15	26.6	26.5	3262	3320	2,836	3,403
Jan'16	27.6	27.5	3302	3359	2,903	3,484
Feb'16	26.2	26.2	3035	3089	2,510	2,581
Mar'16	34.8	34.7	3646	3692	2,895	3,783
Average	**27**	**26.9**	**3177**	**3230**	**2,751**	**2,916**

One of the key revelations of the mock exercise was the abundant availability of power in the Indian DAM which was sufficient to cater to the additional demand of the neighboring countries. The following figure shows the un-cleared surplus from Indian DAM in FY2015-16 and the total purchase volumes cleared for Bangladesh and Nepal.

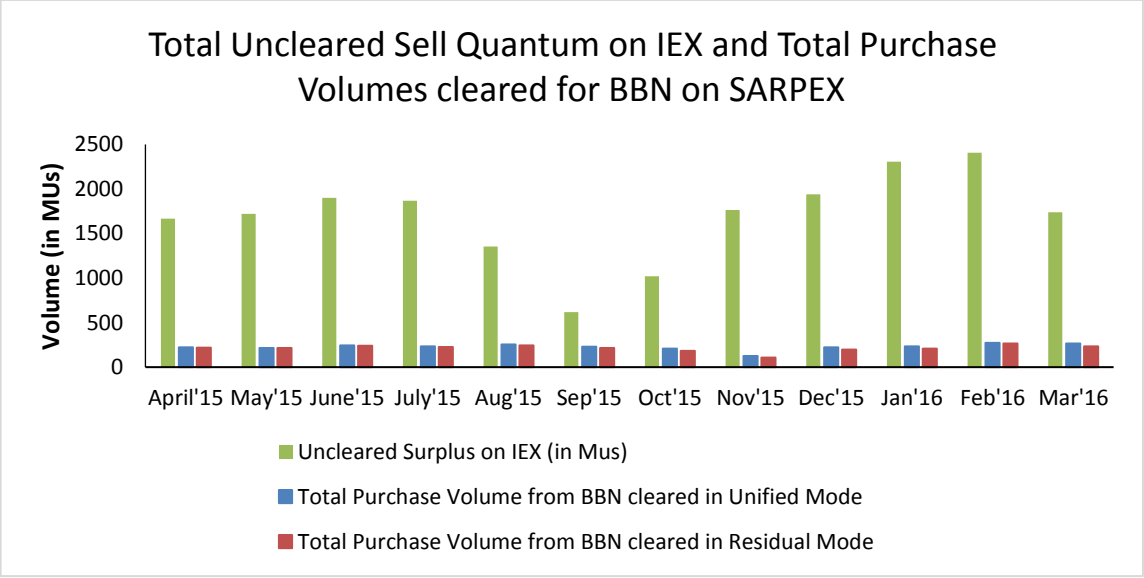


Figure 16: Monthly purchase volumes cleared on SARPEX and un-cleared surplus on IEX

It is noteworthy that in FY2015-16 India had a surplus of more than 250 MUs in each month, which is much greater than the combined power requirement from Nepal and Bangladesh. Though in the mock exercise the buy bids from both Bangladesh and Nepal were capped at 300-350 MW, the surplus that existed in the Indian DAM would still be greater if these transmission caps were relaxed.

Further, the overall sell quantum from Bhutan is very small relative to the combined demand of Nepal and Bangladesh. Most of the existing surplus generation from Bhutan is tied up in the long-term agreements and hence the quantum available for sale on the exchange is assumed to be only 265 MW. Any additional availability of power on SARPEX from Bhutan would only add to the pool of surplus power from India and hence the overall regional supply would still remain greater than the regional demand.

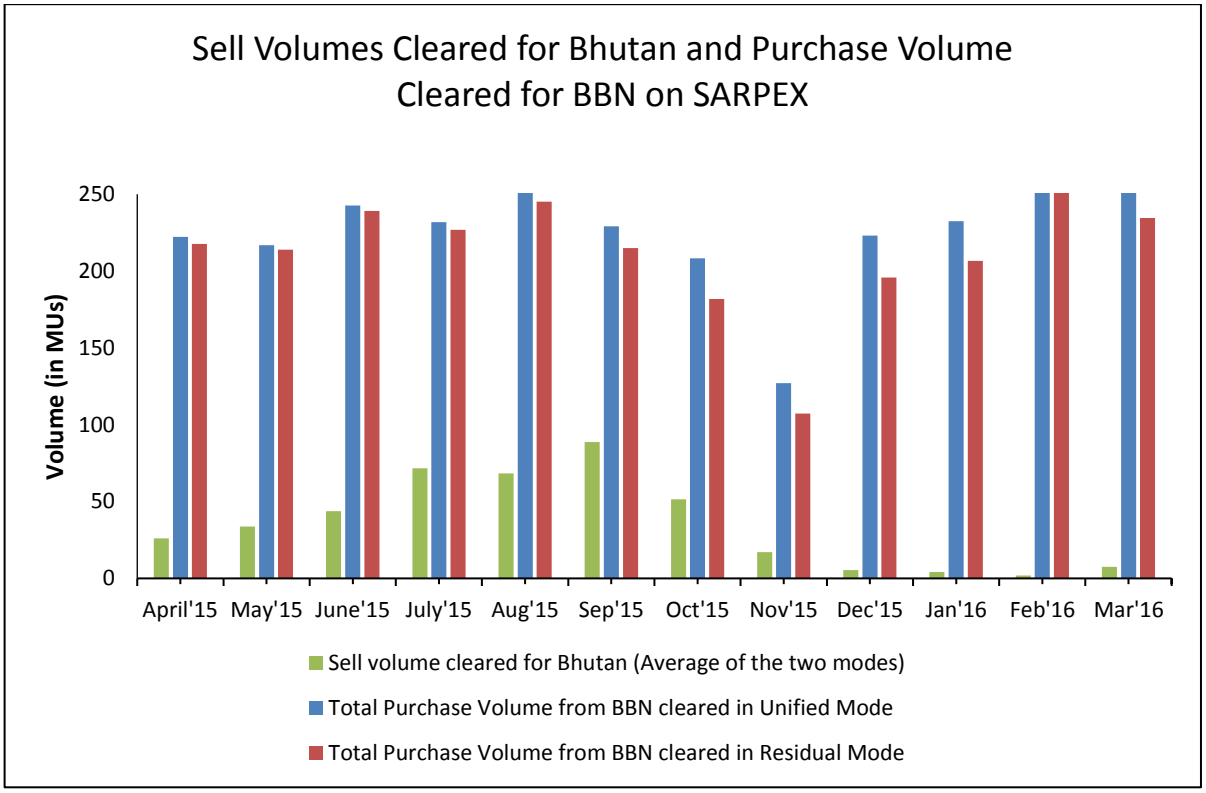


Figure 17: Monthly volumes cleared on SARPEX

7 Country Specific Findings

This section presents the country specific findings on surplus, volumes traded and weighted average sale or purchase prices for each country.

7.1 Bangladesh

The SARPEX leads to a consumer surplus [9]of roughly INR 8.85 billion and INR 8.23 billion for Bangladesh in the unified and sequential mode respectively in FY2016. Surplus is slightly higher in the unified mode as a result of higher volumes cleared for Bangladesh at relatively lower prices.

It is beneficial for Bangladesh to buy power throughout the year to replace its costly generation up to the limit of transmission capacity available, which was assumed to be roughly 300 MW in the mock exercise. Total of 2,011 MUs and 1,920 MUs of power was bought on the SARPEX in the unified and sequential mode respectively.

The weighted average price of buying power on SARPEX was roughly INR 2,938/MWh and INR 3,099/MWh in the unified and sequential mode respectively.

The month-wise break-up of the total surplus, volumes traded and weighted average buy price for Bangladesh in both the modes is shown in the Table 20.

Table 20: Month-wise total surplus, MCV and weighted average MCP for Bangladesh

	Monthly Surplus (in INR Million)		Quantum bought in a month (in MUs)		Weighted Average Buy Price(in INR/MWh)	
	Unified	Sequential	Unified	Sequential	Unified	Sequential
April'15	735.9	711.6	164	162	2782.01	2882.30
May'15	840.1	808.17	183	183	2863.47	3034.50
June'15	840.9	827.4	176	175	2632.20	2699.60
July'15	730.67	705.25	167	165	2913.27	3028.14
Aug'15	832.35	795.15	184	181	2926.02	3051.07
Sep'15	712.8	667.8	174	166	3321.13	3460.56
Oct'15	708.04	608.84	173	157	3395.76	3644.34
Nov'15	331.5	281.7	95	84	3173.28	3327.43
Dec'15	686.34	606.98	161	148	2911.41	3162.49
Jan'16	723.23	639.22	169	156	2970.20	3225.31
Feb'16	860.43	848.54	173	173	2498.58	2567.92
Mar'16	853.12	737.8	186	165	2874.14	3106.11
Average	738	687	167	160	2938	3099

[9] Refer to the list of definitions at the beginning of the report

Lastly, the average daily volume bought by Bangladesh in each month and the corresponding costs incurred by Bangladesh in the two modes is represented in the figures18 and 19.

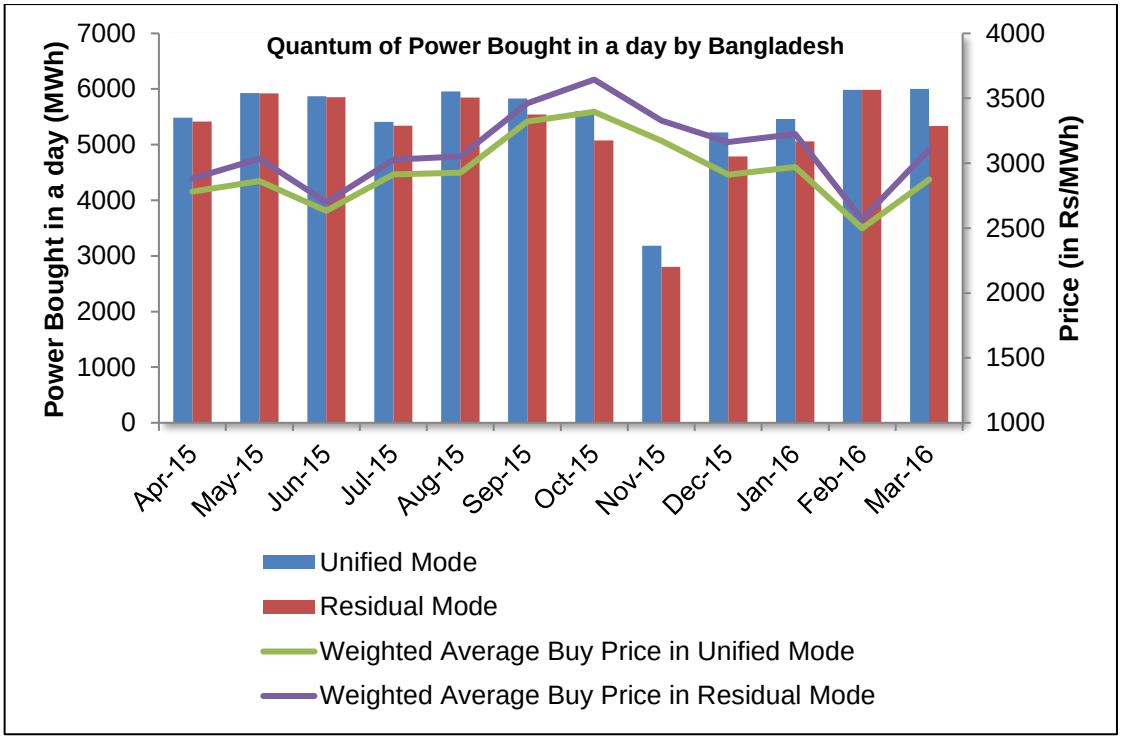


Figure 18:Month-wise averagedaily purchase volume for Bangladesh

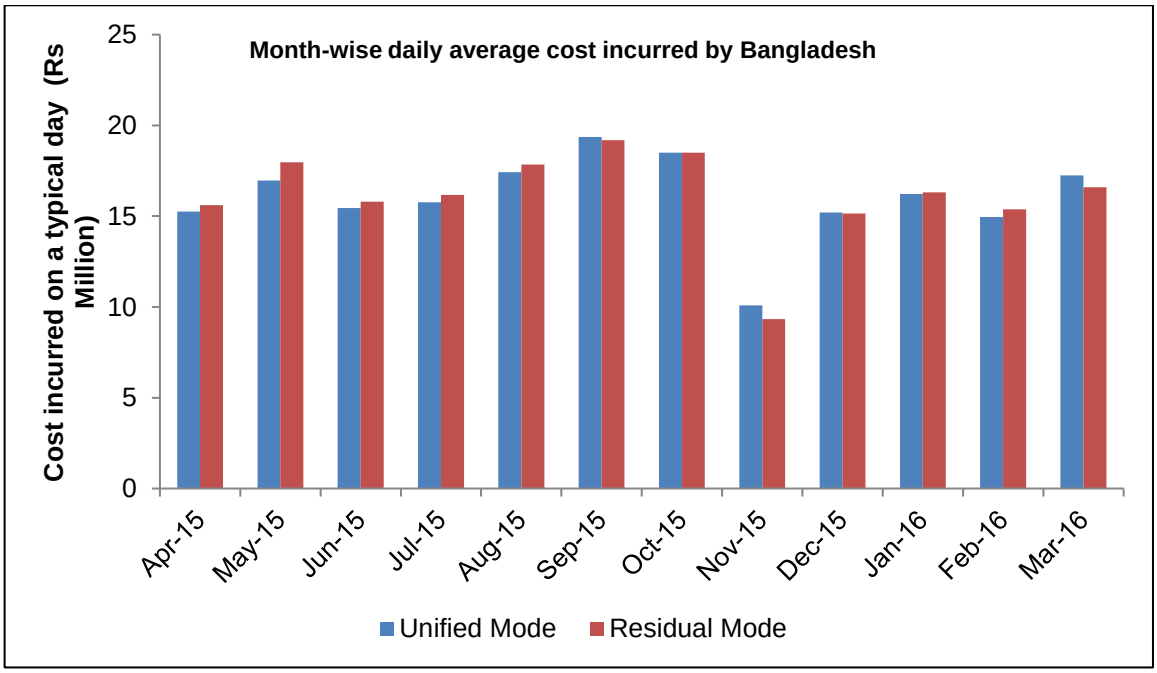


Figure 19: Month-wise daily average cost of buying power for Bangladesh

7.2 Nepal

The SARPEX leads to a total surplus of roughly INR 0.70 billion and INR 0.63 billion for Nepal in the unified and sequential mode respectively, which majorly constitutes the consumer surplus.

As a buyer, the consumer surplus for Nepal is slightly higher in the unified mode as a result of higher volume cleared at relatively lower prices. Nepal bought a total of 719 MUs of power in a year in the unified mode and 630 MUs in the sequential Mode.

Nepal also accrued producer surplus around October and sold roughly 10 MUs of power in a few off-peak blocks for INR 0.018 billion in the unified mode and INR 0.019 billion in the sequential mode.

The weighted average price of power bought by Nepal on SARPEX was roughly INR 2,938/MWh and INR 3,099/MWh in the unified and sequential mode, respectively (averaged over FY2015-16).

Month-wise break-up of the total surplus, volumes traded and weighted average buy price for Nepal in both the modes is given in Table 21.

Table 21: Month-wise total surplus, MCV and weighted average buy price for Nepal

	Monthly Surplus (in INR Million)		Quantum bought in a month (in MUs)		Weighted Average Buy Price (in INR/MWh)	
	Unified Mode	Sequential	Unified	Sequential	Unified	Sequential
April'15	73.8	68.1	57.78	55.23	2680.02	2727.54
May'15	45.26	42.16	33.07	30.44	2690.83	2715.22
June'15	86.4	82.8	66.6	63.63	2595.59	2608.82
July'15	75.64	70.99	64.07	61.22	2756.20	2791.87
Aug'15	79.98	75.64	71.73	63.79	2772.02	2712.00
Sep'15	45	47.4	54.3	48.69	3125.93	2992.66
Oct'15	26.04	18.91	34.41	24.49	3382.89	3274.02
Nov'15	21	16.8	31.68	23.22	3385.07	3308.09
Dec'15	45.57	33.17	61.31	47.30	2932.64	2920.33
Jan'16	44.02	32.86	63.24	49.78	3010.59	3028.52
Feb'16	84.68	77.43	100.83	93.35	2639.54	2715.71
Mar'16	79.67	70.68	80.10	69.06	2745.94	2787.17
Average	58.92	53.08	59.93	52.52	2893.11	2881.83

Lastly, the volumes bought by Nepal on a typical day in the month in the DAM and the corresponding expenditure incurred by Nepal in the two modes is represented in figures 20 and 21.

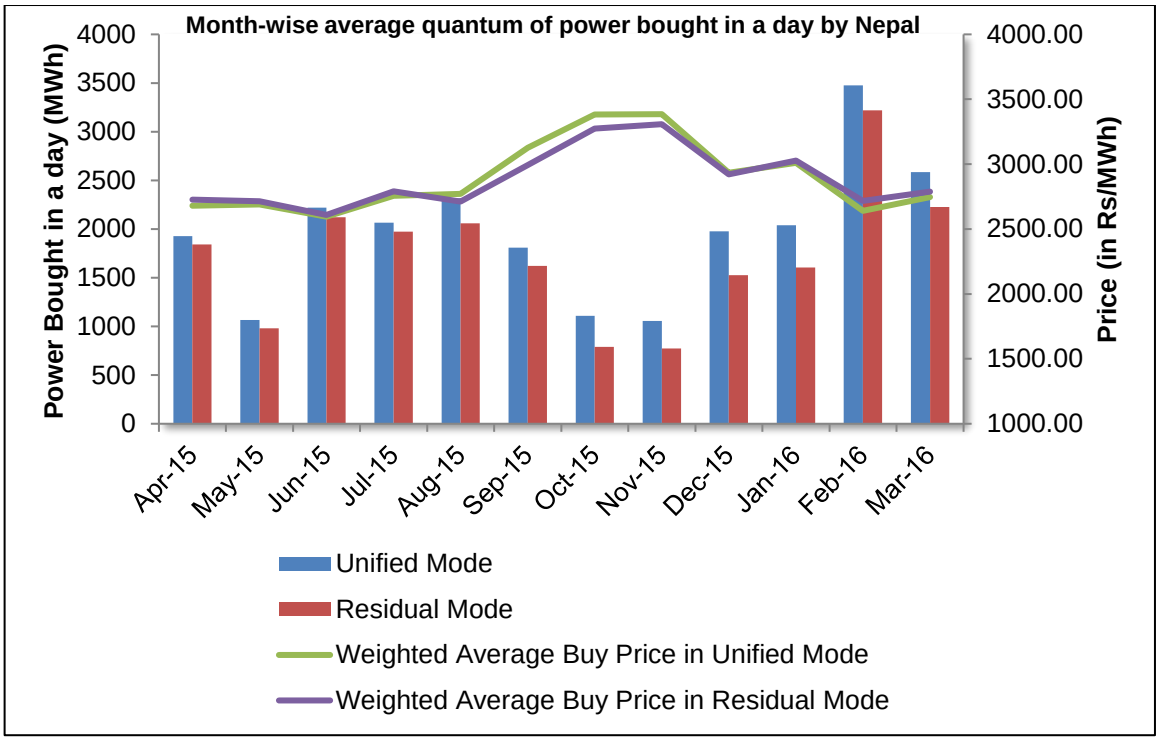


Figure 20: Month-wise cleared daily purchase volume for Nepal

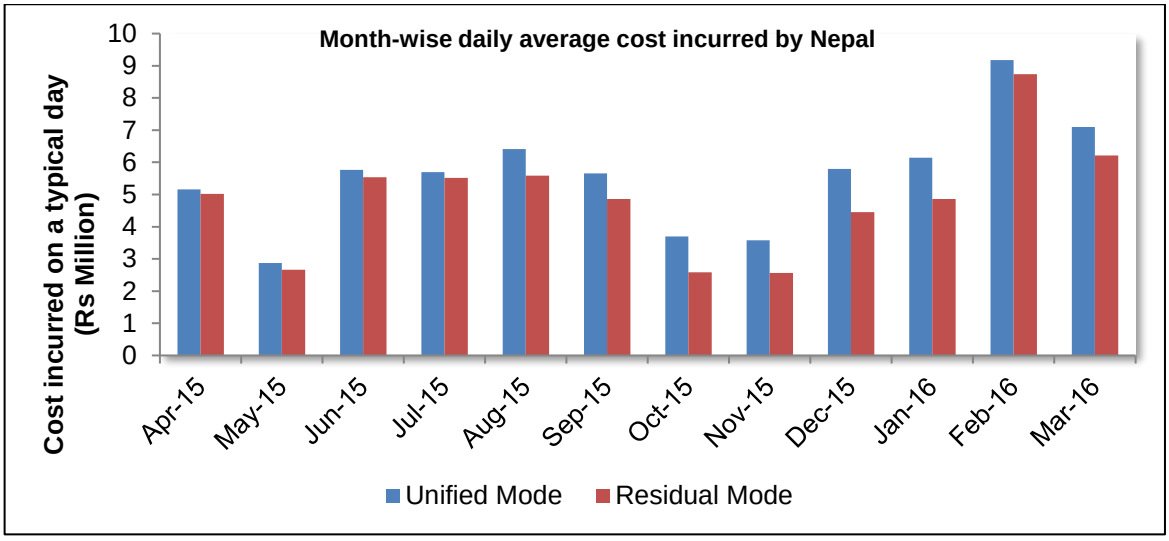


Figure 21: Month-wise daily average cost of power purchased by Nepal

7.3 India

The SARPEX shows a total surplus of INR 313.78 billion and INR 313.96 billion for India for FY2015-16 in the unified and sequential mode, respectively. In comparison to the unified mode, total surplus to India is higher in the sequential mode by roughly INR 175 million.

Of the total surplus of INR 313.78 billion accrued in unified mode, the consumer surplus and producer surplus was INR 238.08 billion and INR 75.70 billion, respectively. In the sequential mode, the consumer surplus was INR 243.6 billion while the producer surplus was roughly INR 70.36 billion. Among the two modes, the Indian consumers are better off in the sequential mode and the producers gain more in the unified mode. Month-wise break-up of the total surplus, consumer surplus and producer surplus for India in both the modes is presented in the Table 22.

Table 22: Month-wise total surplus, consumer surplus and producer surplus for India (including the existing DAM operations) in INR million

	Total Surplus		Consumer Surplus		Producer Surplus	
	Unified	Sequential	Unified	Sequential	Unified	Sequential
April'15	22418.1	22427.4	17726.1	18093.3	4691.70	4334.40
May'15	28626.95	28637.8	22324.03	22828.09	6302.92	5809.71
June'15	23571.3	23575.2	19098.9	19457.7	4472.40	4117.50
July'15	28910.29	28914.94	23648.97	23989.97	5261.32	4924.97
Aug'15	27225.13	27229.78	21159.05	21518.03	6066.08	5711.75
Sep'15	23264.1	23272.8	15858.6	16232.7	7405.50	7040.10
Oct'15	26899.94	26916.06	18729.58	19193.34	8170.36	7734.81
Nov'15	21833.4	21847.8	15244.5	15486.9	6588.90	6360.90
Dec'15	25877.25	25903.91	18770.5	19413.44	7106.44	6490.47
Jan'16	26782.76	26813.14	19753.51	20470.85	7028.94	6342.29
Feb'16	25246.24	25251.17	19658.23	20280.86	5588.30	4970.31
Mar'16	33824.72	33865.33	26675.19	27232.88	7149.53	6632.45
Average	26206.68	26221.28	19887.26	20349.84	6319.37	5872.47

**The FIGUREs for Unified and Sequentialmode include the existing DAM operations in India*

Further, India generated a surplus of INR 313.53 billion in FY2015-16 from India-only Mode. Of this, the consumer and producer surplus constitutes INR 243.06 billion INR 69.9 billion, respectively. An additional surplus of INR 0.25 billion and INR 0.43 billion gets accrued to India from inclusion of BBN. Monthly break-up of increment/decrement in surplus in the India-only mode is shown in Table 23.

Table 23: Month-wise changes in the total surplus, consumer surplus and producer surplus for India excluding the India-only mode(in INR Million)

	Increment in Total Surplus		Decrement in Consumer Surplus		Increment in Producer Surplus	
	Unified	Sequential	Unified	Sequential	Unified	Sequential
April'15	17.1	26.4	367.2	-	384	26.7
May'15	16.43	27.28	504.06	-	520.49	27.28
June'15	15	18.9	358.8	-	373.8	18.9
July'15	12.4	17.05	341	-	353.4	17.05
Aug'15	12.4	17.05	358.98	-	371.38	17.05
Sep'15	9.3	18	374.1	-	383.4	18
Oct'15	40.92	57.04	430.28	-	471.2	56.73
Nov'15	7.2	21.6	242.4	-	249.6	21.6
Dec'15	26.66	53.32	642.94	-	669.29	53.32
Jan'16	30.69	61.07	717.34	-	747.72	61.07
Feb'16	35.96	40.89	622.63	-	658.88	40.89
Mar'16	23.56	64.17	557.69	-	581.25	64.17
Average	20.64	35.23	459.79	-	480.37	35.23

In comparison to India-only mode, the consumer surplus in the unified mode decreases by INR 5.5 billion as a result of increase in prices and new buyers from Bangladesh and Nepal out-bidding the Indian participants. However, the consumer surplus in the sequential mode doesn't change at all since the Indian buyers get cleared in the first stage only. Thus, overall consumer surplus is lower for India in the unified mode compared to the sequential mode.

In comparison to India-only mode, the producer surplus in the unified mode increases by INR 5.7 billion due to higher bid prices from Bangladesh. The producer surplus in the sequential mode also increases by INR 0.42 billion as a result of power sale to new market entrants compared to India-only mode. However, overall producer surplus is higher for India in the unified mode compared to the sequential mode as all the producers are able to sell power at higher prices.

The total surplus for India increases in both the modes over its existing operations i.e. the India-only mode. However, the loss to consumers in the unified mode is completely offset by the gain to its producers. In case of the sequential mode, the producers gain without incurring any loss to the consumers. Though the Indian producers gain more in the unified mode, the overall surplus is maximized in the sequential mode for India.

In terms of MCV, roughly 35,396 MU and 36,219 MU are bought by India in the unified and sequential mode, respectively, while the MCV in India-only mode was around 36219 MUs inFY2015-16. Thus, total purchase volumes of Indian participants fall by 822 MUs in the unified mode due to out-bidding of Indian buyers by Bangladesh, whereas the purchase volumes remain unchanged in the sequential mode.

Further, the total volumes sold by India in SARPEX are close to 37,715 MUs and 38,333 MUs in the unified and sequential mode, respectively. A month-wise breakup of the volumes bought and sold by India in the two modes is shown in Table 24.

Table 24: Month-wise cleared purchase and sale volumes (in MUs) for India in the unified and sequential mode

	Monthly Buy Volumes for India (in MUs)		Monthly Sell Volumes for India (in MUs)	
	Unified	Sequential	Unified	Sequential
April'15	2498.43	2557.32	2696.3	2747.52
May'15	2924.78	3003.77	3109.1	3182.61
June'15	2538.48	2583.69	2739.3	2777.22
July'15	2774.25	2831.29	2935.8	2985.02
Aug'15	3165.19	3232.15	3355	3407.17
Sep'15	3124.56	3184.26	3263.6	3312
Oct'15	3255.93	3344.59	3413.4	3474.20
Nov'15	2864.91	2923.71	2975.3	3013.89
Dec'15	3039.27	3125.14	3257.1	3314.32
Jan'16	3070.42	3152.91	3298.8	3355.22
Feb'16	2760.59	2822.22	3033.2	3084.22
Mar'16	3379.96	3458.01	3638.6	3680.00
Average	**2949.73**	**3018.26**	**3142.96**	**3194.44**

**The figures for unified and sequential mode include the existing operations in India*

The total sell volumes in the IEX were greater than the purchase volumes by 13,413 MUs in FY2015-16.This reflected significant un-cleared volumes in India. However, under SARPEX, the surplus sell volumes reduce significantly as India sold additional 1,500 MUs and 3,000 MUs in the unified and sequential mode, respectively. Monthly break-up is given in Table 25.

*Table 25:**Month-wise increment/decrement in the cleared purchase and sale volumes for India over India-only mode (in MUs)***

	Decrement in Monthly Buy Volumes for India		Increment in Monthly Sell Volumes for India	
	Unified	Sequential	Unified	Sequential
April'15	58.9	-	139.0	190.2
May'15	79.0	-	105.3	178.8
June'15	45.2	-	155.6	193.5
July'15	57.0	-	104.5	153.7
Aug'15	67.0	-	122.9	175.0
Sep'15	59.7	-	79.3	127.7
Oct'15	88.7	-	68.8	129.6
Nov'15	58.8	-	51.5	90.2
Dec'15	85.9	-	132.0	190.2
Jan'16	82.5	-	145.9	202.3
Feb'16	61.6	-	210.9	265.0
Mar'16	78.1	-	180.6	227.0
Average	68.5	-	124.7	176.9

The weighted average MCP observed in FY2015-16 for India-only mode was around INR 2,745/MWh. The weighted average buy price for India rose to INR 2,919/MWh and INR 2,745 in the unified and sequential mode, respectively. The increase in the weighted average buy price can be attributed to the high priced buy bids from Bangladesh that lead to higher MCP.

On the sell side, the producers in India incur a weighted average sell price of INR 2,918/MWh in the unified mode. In the sequential mode, the weighted average sell price for Indian sellers is INR 2,965/MWh from the sale of power in residual market with buyers from BBN only.

The monthly break-up of weighted average buy and sell price in the two modes is presented in Table 26.

Table 26: Weighted average buy and sell price for India (in INR/MWh)

	Weighted Average Buy Price		Weighted Average Sell Price	
	Unified	Sequential	Unified	Sequential
April'15	2,750.82	2,609.87	2,749.78	2,818.88
May'15	2,880.88	2,713.03	2,876.97	2,953.09
June'15	2,658.33	2,520.01	2,652.27	2,613.99
July'15	2,894.24	2,772.32	2,887.11	2,817.91
Aug'15	2,898.99	2,790.06	2,890.43	2,756.55
Sep'15	3,327.65	3,210.86	3,321.38	3,091.75
Oct'15	3,390.21	3,102.45	3,389.44	3,332.69
Nov'15	3,100.34	3,023.88	3,106.21	3,309.07
Dec'15	2,830.15	2,632.31	2,836.40	3,104.59
Jan'16	2,897.41	2,677.33	2,903.44	3,176.35
Feb'16	2,505.94	2,283.37	2,509.99	2,620.35
Mar'16	2,899.42	2,739.94	2,894.78	2,980.66

**The figures for weighted average sale price for India in the sequential mode only incorpoartes the sale of power in the residual market (buyers from BBN only)*
The figures for weighted average buy price for India in the sequential mode only incorpoartes the sale of power in the domestic market (buyers from India only)

7.4 Bhutan

The producer surplus for Bhutan is roughly INR 0.30 billion and INR 0.42 billion in the unified and sequential mode, respectively. Since, Bhutan is predominantly a selling entity, the surplus is higher in sequential mode as a result of higher market clearing prices and higher sell volumes.

The maximum surplus with Bhutan was witnessed in the month of September, when the cleared sell volumes for Bhutan were higher. The hydro availability in the country decreases significantly in the winter months which consequently led to lower surplus in these months.

A total of 412 MUs and 427 MUs of power was sold by Bhutan in the unified and sequential mode, respectively, in FY2015-16. Bhutan also bought power during winter months to the tune of 0.09 and 0.04 MUs in the unified and sequential mode respectively, which is negligibly small as compared to the overall sell volumes on SARPEX.

The weighted average price of power sold by Bhutan was roughly INR 2,983/MWh and INR 3,339/MWh in the unified and sequential mode, respectively.

Month-wise break-up of the total surplus, volumes traded and weighted average sell price for Bhutan in both the modes is presented in the Table 27.

Table 27: Month-wise total surplus, cleared sell volumes and weighted average sell price for Bhutan in unified and sequential mode

	Monthly Surplus (in INR Million)		Quantum sold in a Month (in MUs)		Weighted Average Sell Price (in INR/MWh)	
	Unified	Sequential	Unified	Sequential	Unified	Sequential
April'15	9.66	11.64	24.51	27.54	2907.79	3009.91
May'15	53.134	60.202	32.49	35.12	2963.67	3172.21
June'15	14.25	19.17	41.85	45.69	2845.03	2935.85
July'15	52.204	65.72	70.31	73.09	3111.45	3272.35
Aug'15	50.034	67.115	66.50	70.12	3268.99	3477.71
Sep'15	88.29	105.93	90.18	87.24	3420.21	3739.49
Oct'15	30.163	69.998	50.72	52.23	3457.35	4245.76
Nov'15	2.64	9.6	16.80	17.19	3012.10	3397.65
Dec'15	1.209	3.441	5.43	5.54	2670.97	3085.15
Jan'16	2.046	3.999	4.06	4.27	2795.17	3250.97
Feb'16	0.812	0.957	1.86	1.97	2459.21	2519.82
Mar'16	1.55	9.61	7.51	7.50	2888.05	3968.82
Average	25.50	35.62	34.35	35.63	2983.33	3339.64

Lastly, the average volumes sold by Bhutan in each month and the corresponding revenue accrued to Bhutan in the two modes is presented in Figure 22 and 23.

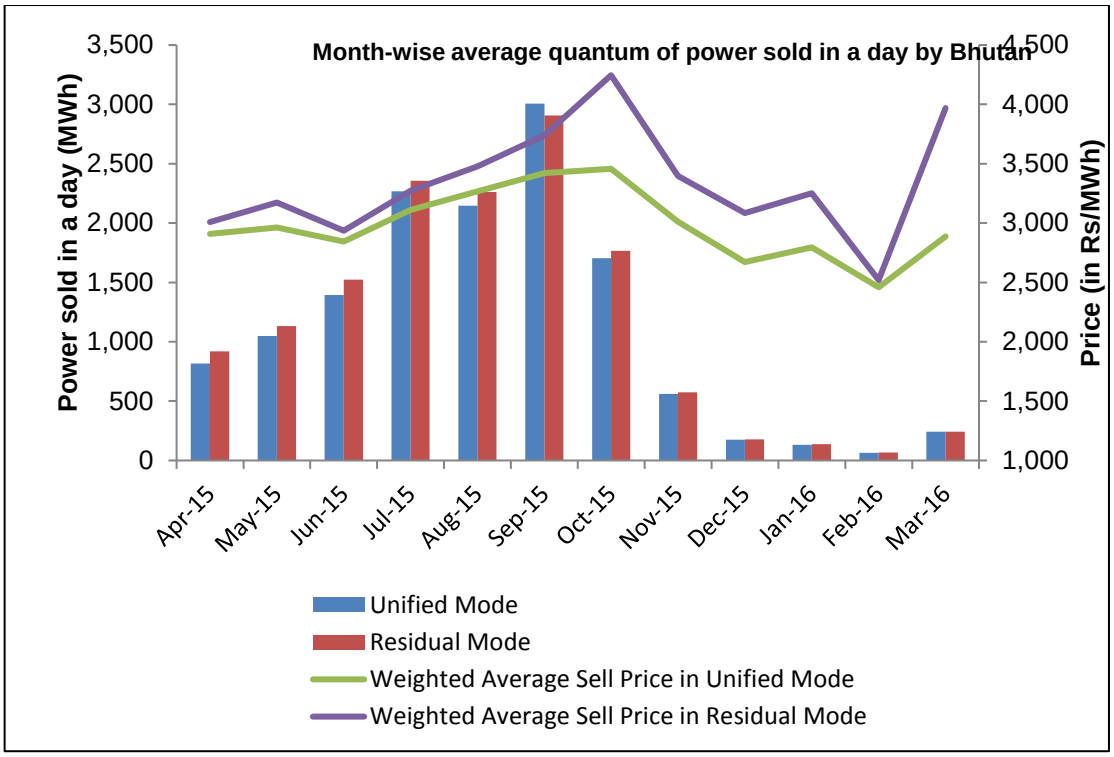


Figure 22: Month-wise cleared daily sell volume for Bhutan

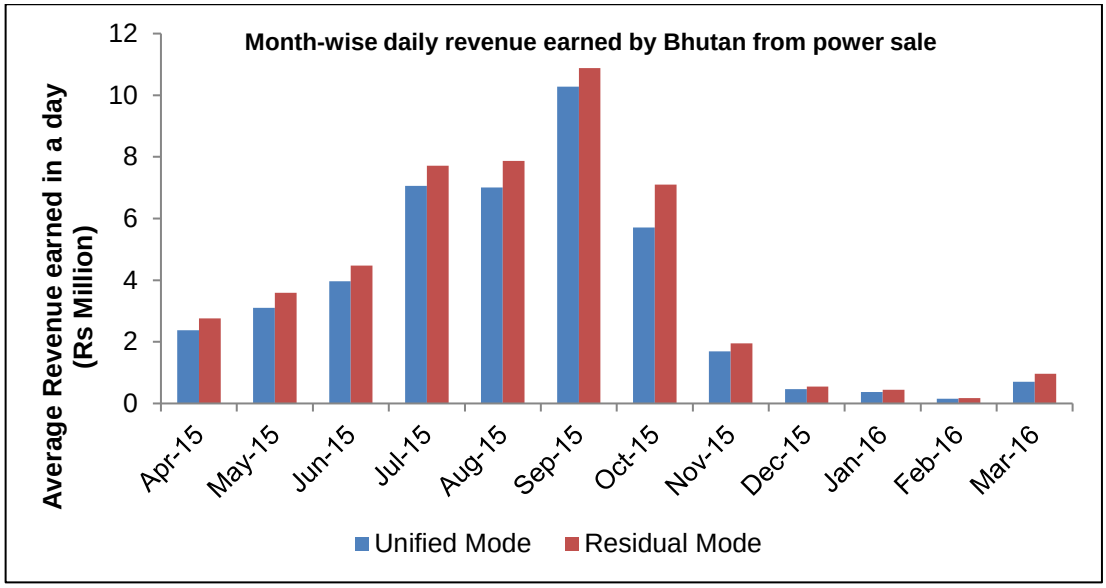


Figure 23: Month-wise daily average revenue earned by Bhutan from power sale

8 Impact of Transmission on SARPEX Mock Exercise

The results of the SARPEX mock exercise were based on the unconstrained market clearing mechanism, where the inter-country transmission capacity was explicitly considered in the formulation of the buy and sell bids by BBN countries. The bid quantum were restricted on the realistic assumptions around the current and foreseeable cross-border transmission capacity available between India and BBN.

Currently, India exports around 190 MW to Nepal over 12 cross border interconnections at 11kV, 33kV and 132kV level. The export of power to Nepal increased further by around 145 MW with the commissioning of Muzaffarpur (India) – Dhalkhebar (Nepal) 400kV line in 2016. Currently, this line is operated at 132 kV; once fully charged at the rated capacity, it can facilitate flow of another 650 MW between India and Nepal. Thus, the transmission capacity of 350 MWfor power exchange between India and Nepal assumed in the mock exercise is completely in line with the limit of 800 MW flow across the India-Nepal interconnection.

About 500 MW of power is traded between India and Bangladesh through two cross border interconnections between Baharampur (India) and Bheramara (Bangladesh) and between Surjyamani nagar (India) and South Comilla (Bangladesh). The total capacity of these lines is between 550-600 MW, out of which 250 MW is contracted through long-term (LT) and 250 MW is contracted through medium-term (MT) and short-term (ST) contracts. Thus the total quantum of 250 MW (MT and ST contracts) along with inherent margins of about 50 MW left in the transmission lines accounts for a residual capacity of 300 MW available for exchange. Further, additional transmission lines are planned between Bangladesh and India including the 765kV Katihar – Bornagar Double Circuit line, which will alleviate any potential transmission congestion.

The transmission between India and Bhutan is not a binding constraint currently and is planned to be further augmented with the commissioning of new power pooling /interconnection points in India at Alipurduar HVDC substation, West Bengal and Rangia HVDC/power pooling substation in Assam. While the transmission capacity was not a binding constraint, the surplus available to Bhutan that could be sold on power exchange was up to 265 MW, after accounting for the generation that is totally tied up in LT contracts.

This makes it obvious that an augmented transmission network between BBIN along with prudent buy and sell decisions through MT and ST access will allow for better utilization of the transmission corridors between the countries and further lead to a better social surplus at the regional level. This is shown by comparing the capital cost and yearly transmission charge (YTC)[10] computation of 400 kV and 220 kV double circuit lines with the surplus gain of BBN in Tables 28.

[10] Yearly Transmission Charge (YTC) is the total Annual Transmission Charges determined by CERC in accordance with the terms and conditions of tariff regulation or as adopted in case of Tariff Based Competitive Bidding

Table 28: Indicative Costs and YTC for a 400 and 220 kV Transmission Line

Description	Line Capacity (MW)	Indicative Cost (INR Million/ km)	Monthly Transmission Charges/km (INR)	YTC for a 200 km* line (INR Million)
400 kV Twin Moose D/C	~900	11.10	91,936	220.65
220 kV Twin Moose D/C	~500	4.40	36,443	87.46

Source: Power Grid Corporation of India (PGCIL), Central Electricity Regulatory Commission (CERC) Regulations on Computation of Transmission Charges, KPMG Analysis.

**Transmission line length between India and BBN is assumed to be 200 km*

Table 29: Country-wise surplus gain compared with YTC(INR Million)

Mode	Surplus Gain				Ratio				Ratio			
	(INR Million)				(Surplus Gain/YTC 400 kV)				(Surplus Gain/YTC 220 kV)			
	BD	NP	IN	BT	BD	NP	IN	BT	BD	NP	IN	BT
Unified	8,850	700	10,100	300	40.11	3.17	45.77	1.36	101.2	8	115.48	3.43
Sequential	8,230	630	9,710	420	37.3	2.86	44.01	1.9	94.1	7.2	111.02	4.8

Note: BD- Bangladesh, NP – Nepal, BT – Bhutan, IN- India

From the above analysis, it is clear that the surplus gain in a year to BBN is far higher than the YTC, indicating that relatively small investments in the transmission lines may yield surprisingly huge dividends in terms of increased economic gains and social welfare.

9 Conclusions from the SARPEX Mock Exercise

The SARPEX mock exercise for FY2015-16indicated that the initiation of a Day-Ahead Market based regional power exchange would result in an overall surplus of INR 323.63 billion and INR 323.24 billion in the unified and sequential mode respectively, compared to the overall surplus of INR 313.53 billion in the India-only mode. The additional surplus could in turn bring higher economic activity and associated increase in the economic welfare of the respective countries.

For example, Bangladesh replaced the expensive diesel generation having a variable cost of above INR 10/kWh with low cost supply from India and Bhutan leading to cost savings of ~INR 18 million. Similarly, Nepal obviated load shedding of 1,670 MUs for socio-economic benefits to the country. India and Bhutan gained additional revenues from the sale of power which could contribute to their respective gross domestic products.

The access to SARPEX, regardless of the mode of operation, not only helped BBN in the management of demand and supply balance on a day-ahead basis, but also allowed the countries to buy power at a price less than their willingness to pay or sell at a price greater than their marginal cost. The operating mode however slightly impacted the overall regional surplus, which was higher in the unified mode as compared to the sequential mode. But, the choice of operating mode didn't have any significant bearing on the total surplus in BBN.

The operating mode had a slight impact on India as the 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. However, the situation was completely nullified in the sequential mode as by virtue of its design, it didn't impact the existing operations of the Indian participants. However, in terms of the total surplus, India gained in both the unified and sequential mode as the un-cleared sell bids were cleared through purchase bids of Bangladesh and Nepal, thereby making it symbiotically beneficial to all the countries.

Further, it was also found that the adequate inter country transmission capacity is critical for ensuring higher surplus in the region. For instance, the gain in consumer surplus of Bangladesh and Nepal or the producer surplus of India and Bhutan are direct consequences of the available transmission capacity between the various countries. 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. Therefore, strengthening of inter-country transmission capacity could permit more volumes on SARPEX resulting in further increase in surplus due to a larger and efficient market size.

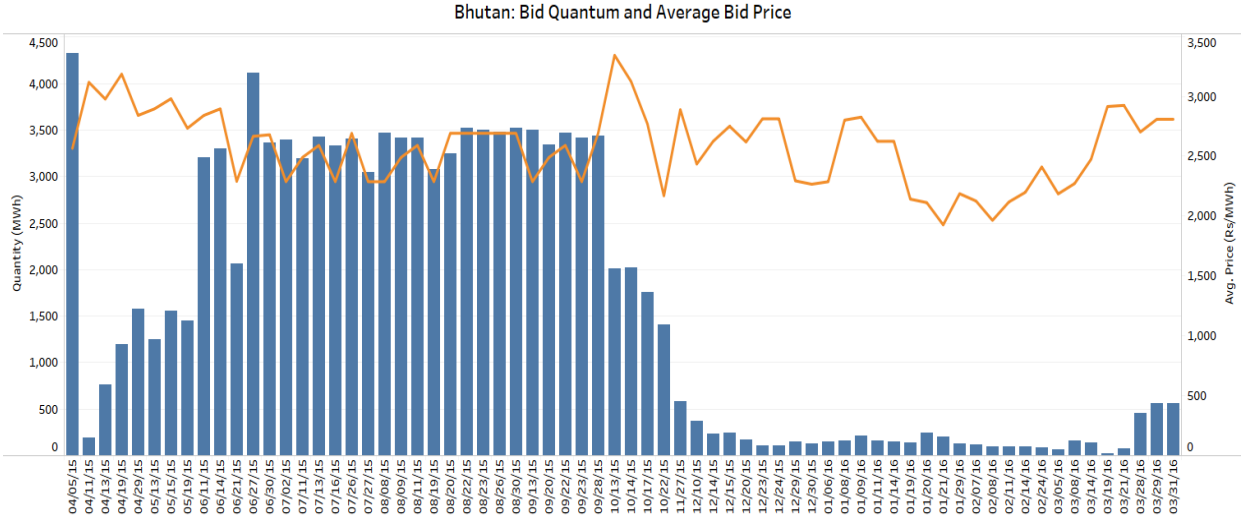
The findings of the SARPEX mock exercise provide enough empirical evidence that a regional electricity exchange based on Dar-Ahead Market can massively improve the producer and consumer welfare in each country as well as the region as a whole. Additionally, such an exchange will also yield efficient price signals, transparency and major distributive benefits in terms of increased fuel diversity, diversified supply mix and decreased overall costs. Therefore, initiation of a regional power exchange for BBIN, backed by an efficient market design in the form of either the unified or sequential mode is crucial for enhancing and sustaining cross border electricity trade between the countries.

As way forward, it is proposed that the results and other outcomes of the mock exercise should be shared with the decision-makers of all the participating nations. 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. Through this exercise, the stakeholders from all nations can clearly relate their bids with the outputs of the market clearing process and can take preparatory actions towards their future participation in the DAM. Alongside, the stakeholders should initiate discussions in their respective countries with respect to formulation of SARPEX.

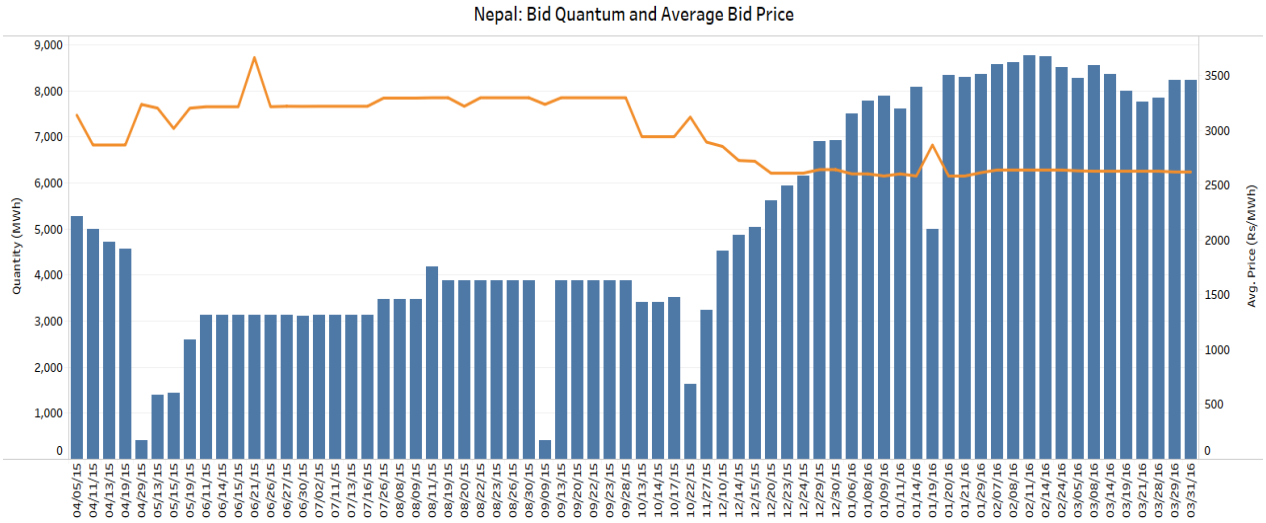
ANNEXURE-1

I. *Bids from BBIN for 71 days:*

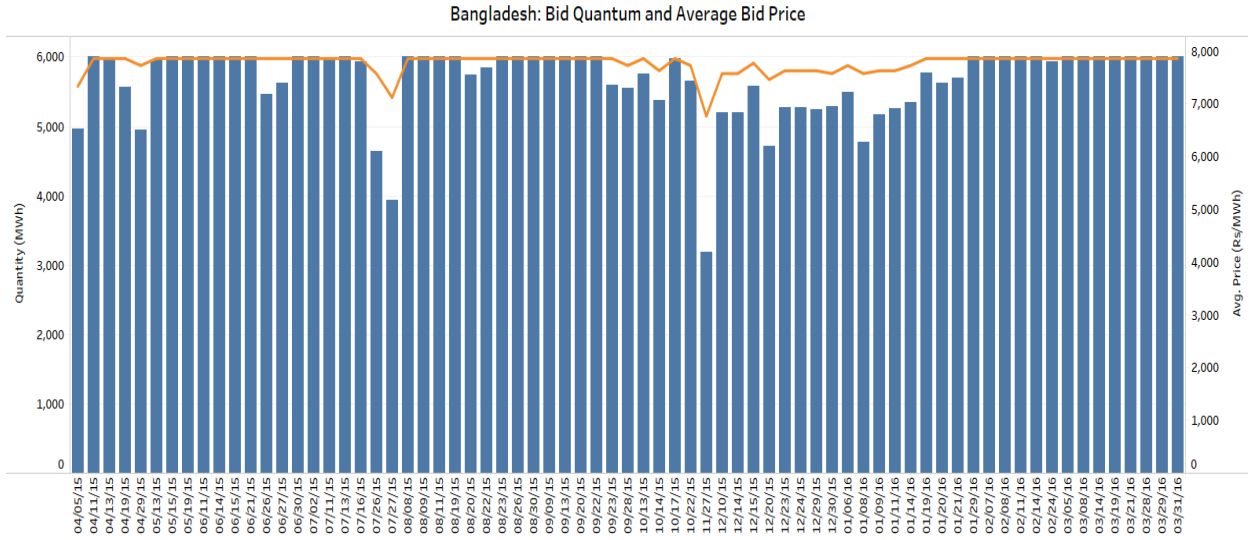
Sell Bids from Bhutan



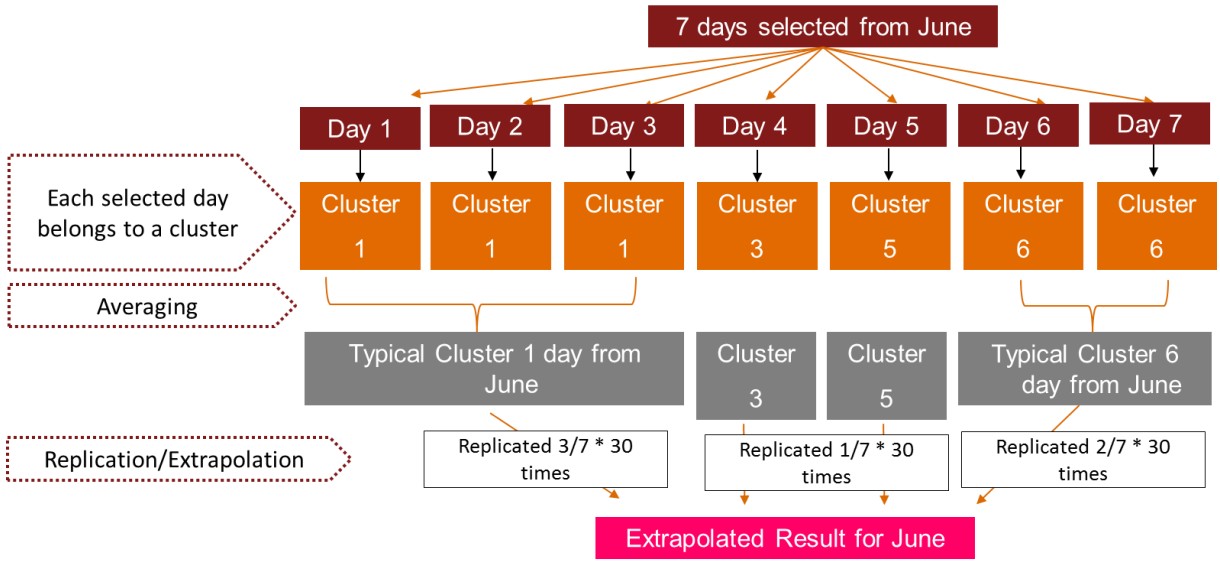
Buy Bids from Nepal



Buy Bids from Bangaldesh



II. *Graphical Illustration of Extrapolation Methodology:*



III. *SARPEX web Portal*

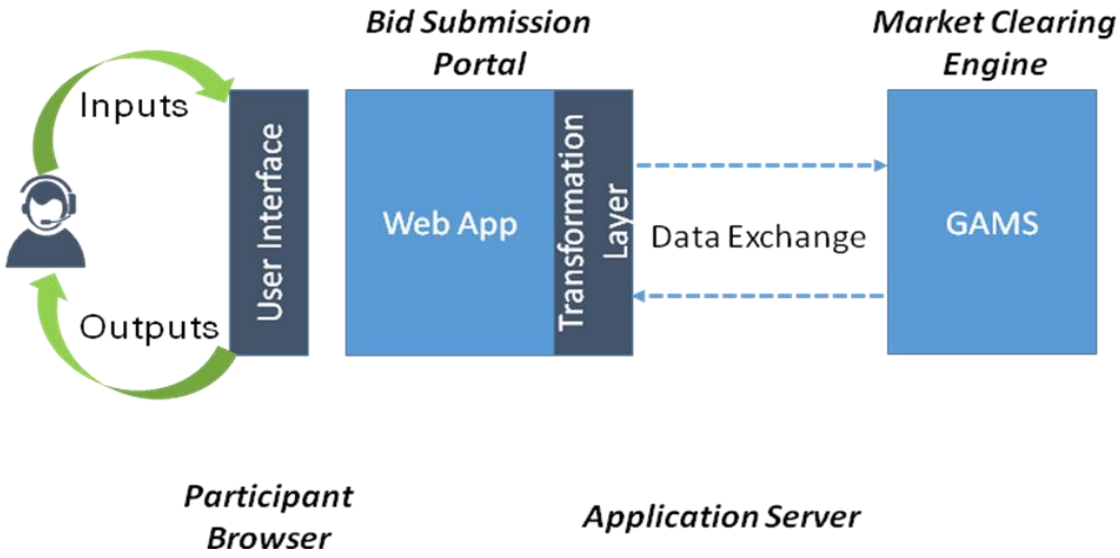
To facilitate the uploading of bids by BBN, a web portal, mimicking an exchange based platform was created where the bidders could submit their bids and see the results for their bid submission. The users from each country were provided with a web-link (***http://mocksarpex.ga)*** to access the portal and a password protected user login and access to maintain the confidentiality of the bids.

1. The Manual

This manual presents the application workflow and functionality of Pilot Market Web Portal where participating countries can place their bids and see results for their bids submission. The application is called **"SARPEX: Mock Exercise"**. You can access this application using a web browser such as Google Chrome. Users will be provided with a web link which can be accessed in a browser. The manual also provides information about the various Webpages displayed on the portal. The functionality of user-interactive forms is explained in detail.

2. Application Workflow

The "SARPEX: Mock Exercise" 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. Please note the “Web App”, “Web Portal” and “application” refers to "SARPEX: Mock Exercise" web application.



The users are exposed to user interface of the application via a web browser that allows the users to submit bids, view results, view reports and contact the application administrator etc.

The inputs chosen by the user through the user interface interacts with the Web App, Transforms the data into formats required by Model and the data exchange happens with General Algebraic Modeling System (GAMS). The user interface then displays the results or reports based on users' interaction with the application.

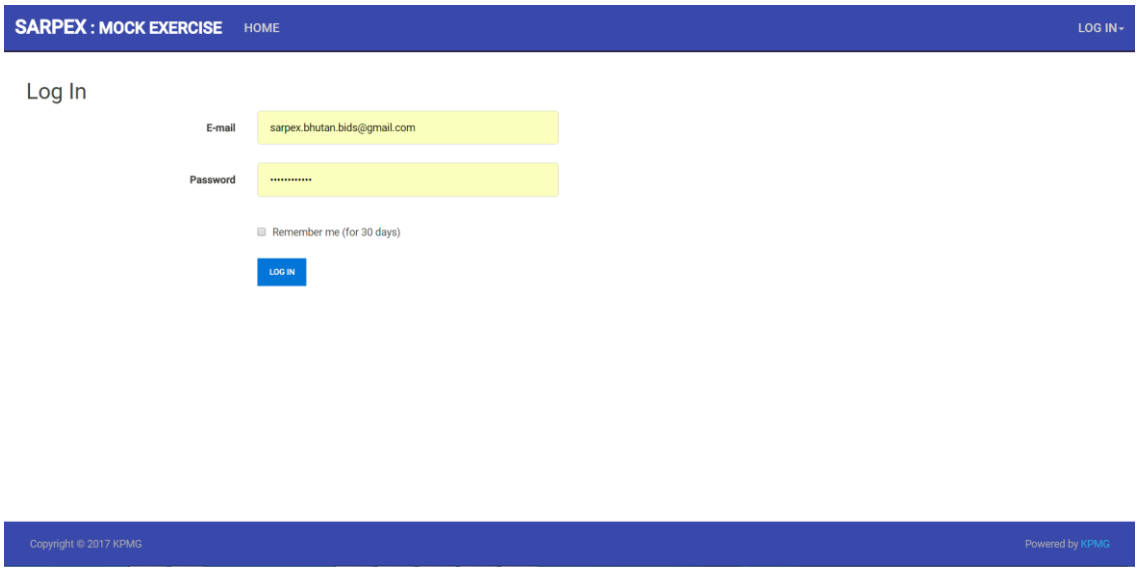
3. Functionality and WebPages

The Web App consists of seven user specific WebPages. Most important ones being the “Bids Submission Page” and the “See Results Page”. Other pages include functionalities to “View Archived Reports”, “Contact Administrator” of the application to send message in case of issues or any queries and a page to “Track user bid submissions”.

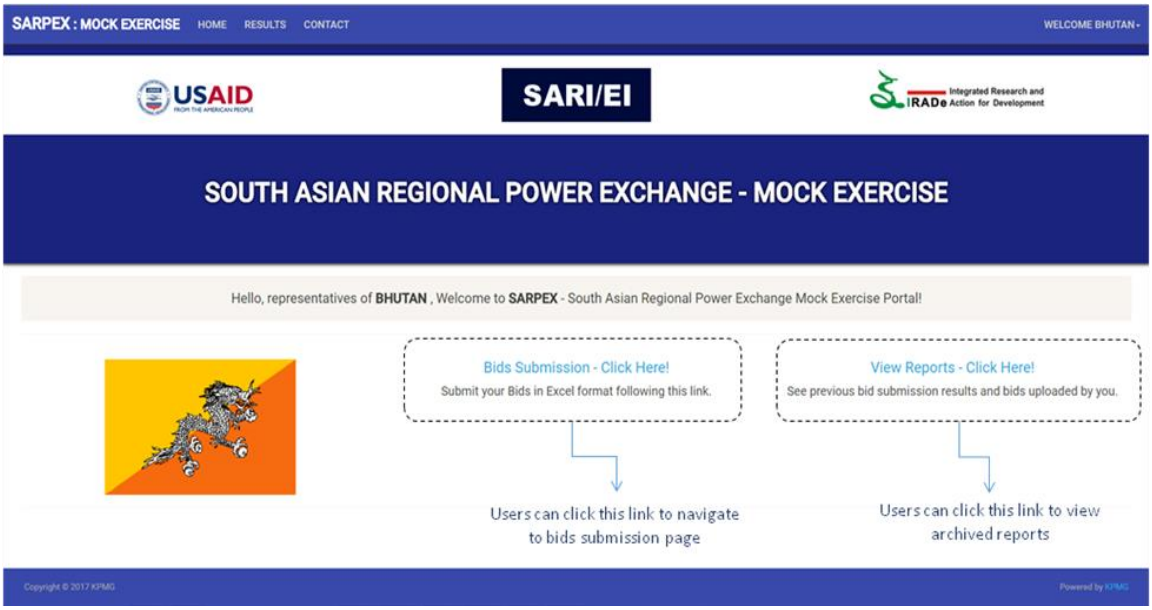
The users are required to login to the application with user ids and passwords provided by the administrator to access any of these functionalities. The next section explains steps to execute functionalities like Submitting Bids, Viewing Results, Viewing Reports, Contacting Admin and Tracking User uploaded Bids.

4. Logging into the Web Portal

Participating countries will be provided with a web link using which the users can interact with the application. Every user will be provided with one unique user id and password to login to the application. The following image shows the login page of the application.

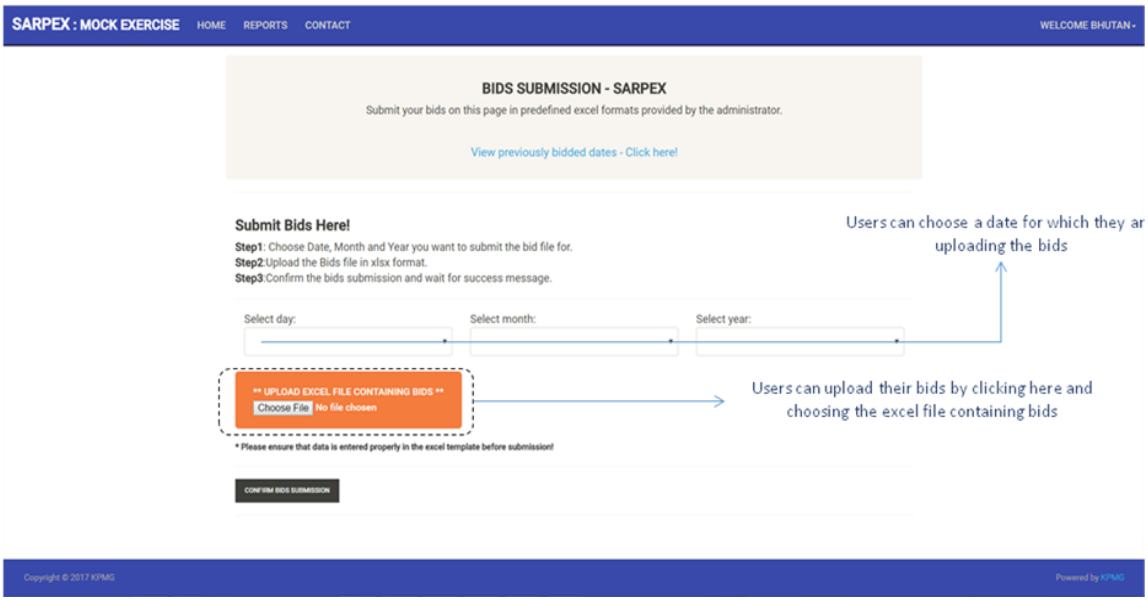


The users can login to the Web App using the user id and password provided. Entering a correct id and password will land to the application Home Page which can viewed in the following image.

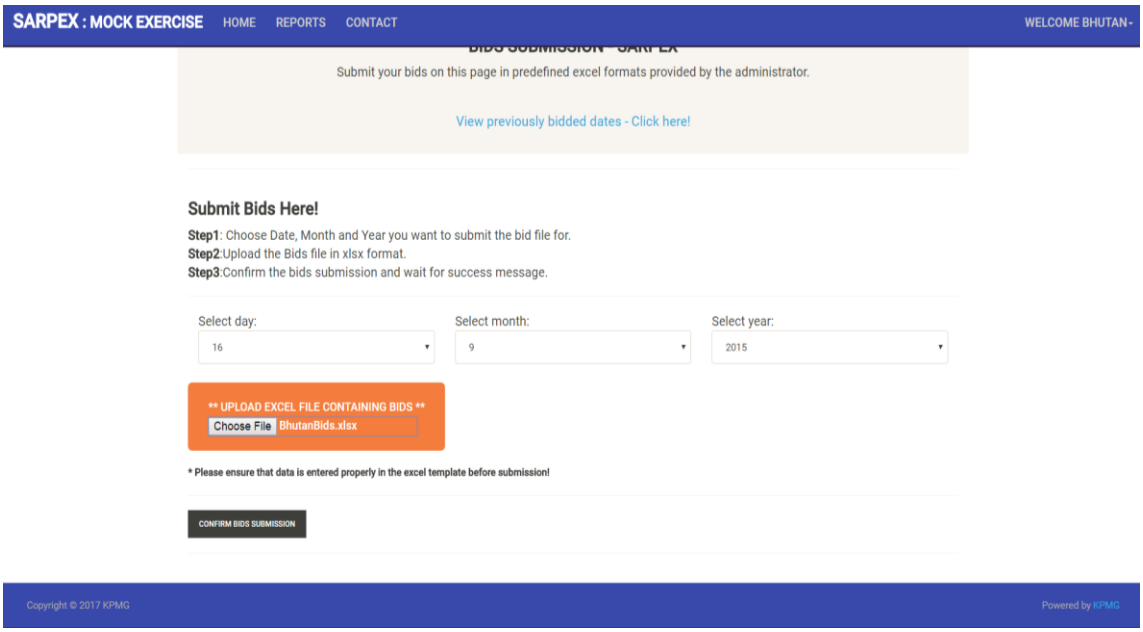


5. Submitting Bids

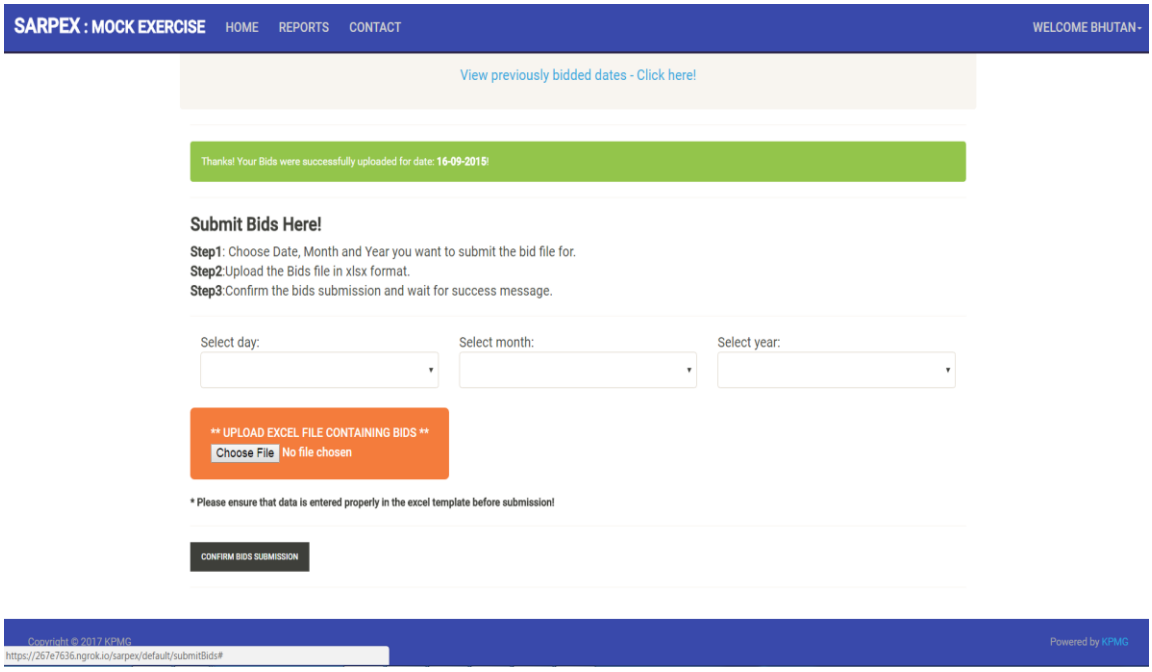
The Home Page displays a welcome message and two links listed in the webpage named as "Bids Submission - Click Here!" and "View Reports - Click Here!" - can be viewed in the image in previous section. Please click on the "Bids Submission - Click Here!" link to navigate to bids submission page that can be viewed in the following image.



Every user will be provided with a specific excel template that will be filled by the user and upload on the web portal using the form provided on Bids Submission Page. The user need to select a date for which the bids are being uploaded by them. Then by clicking the "Choose File" button users can navigate into their own directories and select the required excel template.

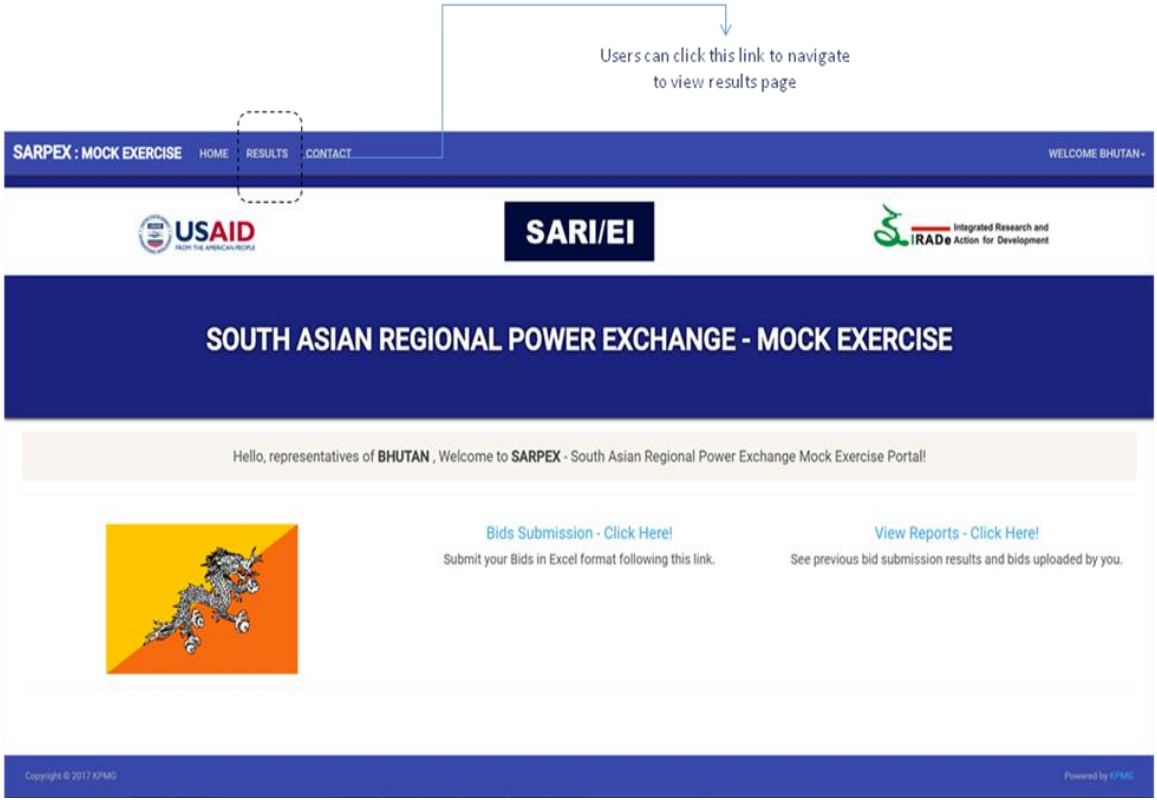


Following this users can click on the "CONFIRM BIDS SUBMISSION" button to submit their bids for the date chosen by the user. If the bids are successfully accepted the users will be displayed a success message or else an error message will be displayed on the screen which can be used to troubleshoot the process.

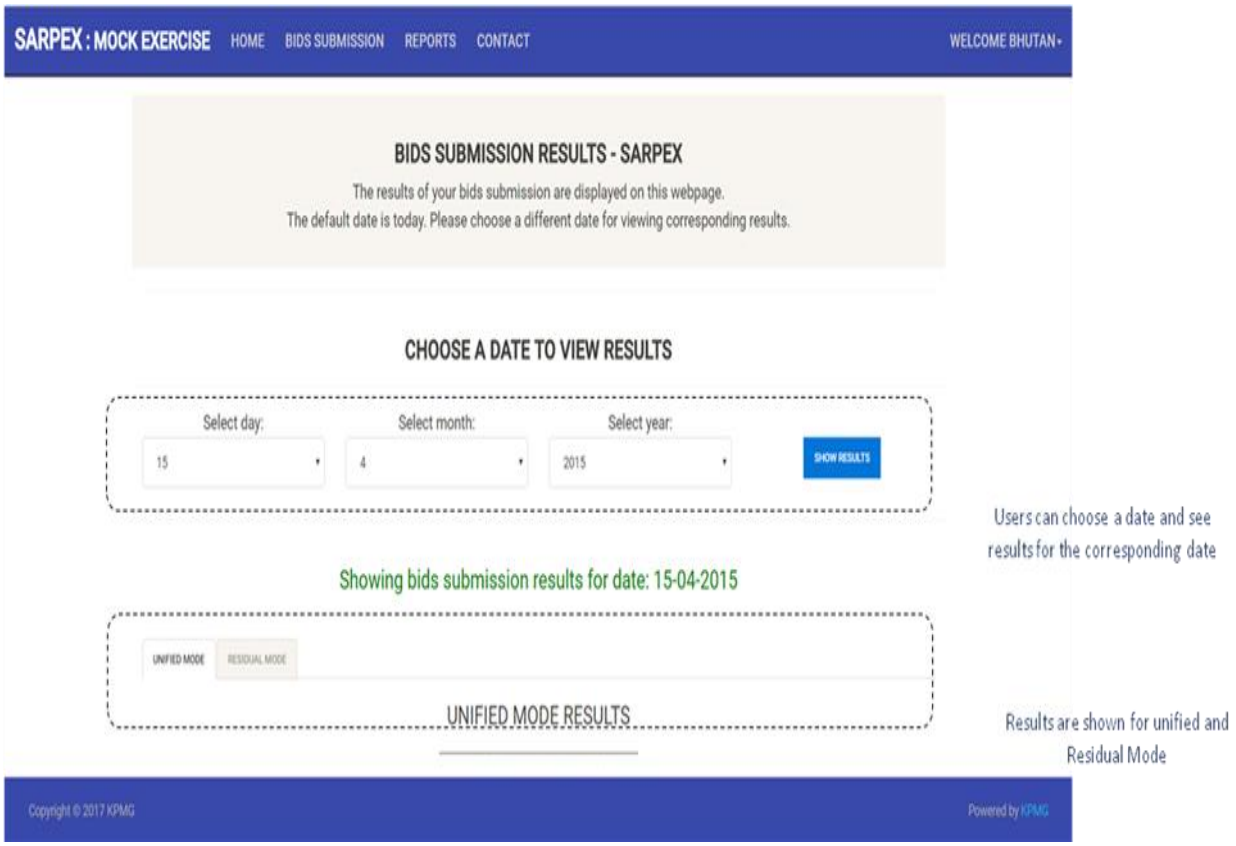


6. Viewing Results

Users can view bids submission results on the results webpage. This can be accessed by clicking the "RESULTS" link provided on the navigation bar at the top.



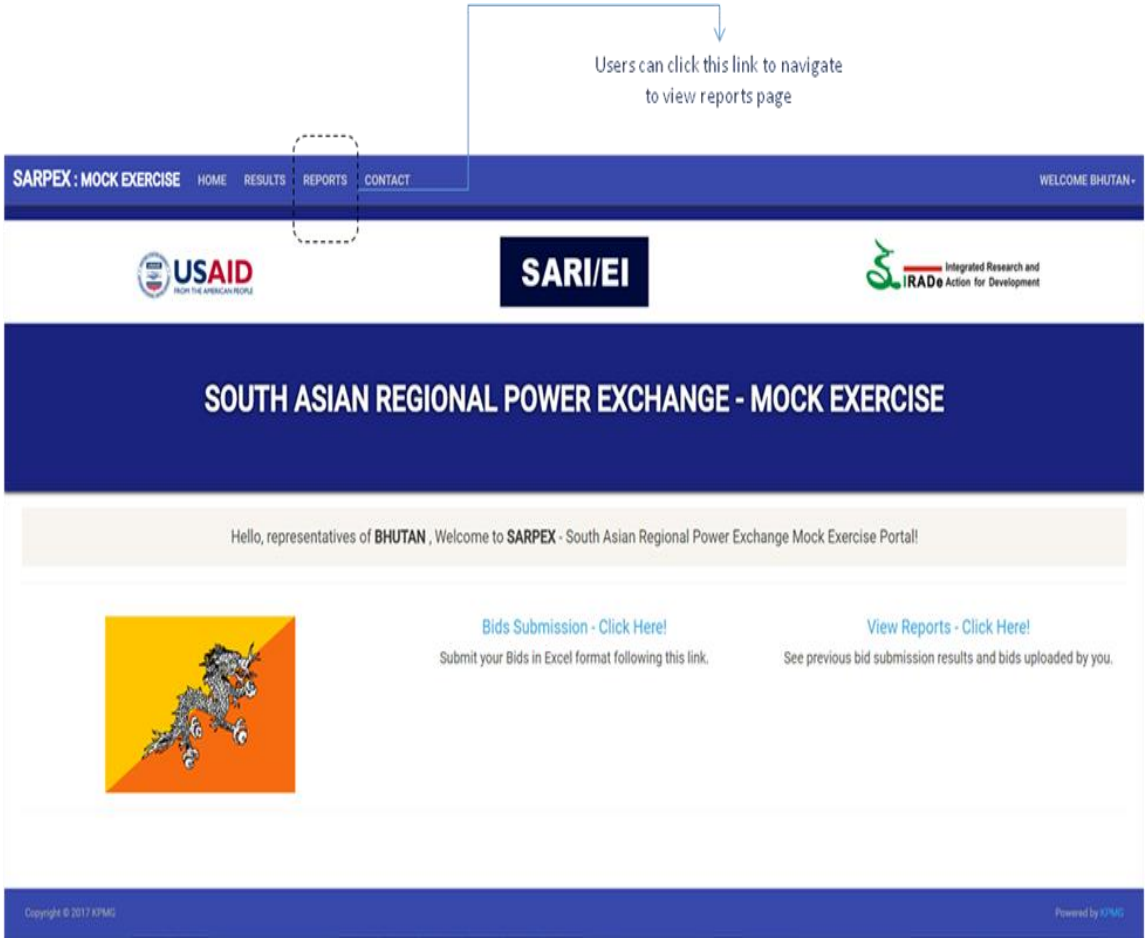
By clicking this link users will be navigated to the results page where the results will be shown. Users can choose a date and click on "SHOW RESULTS" button to see results for any date.



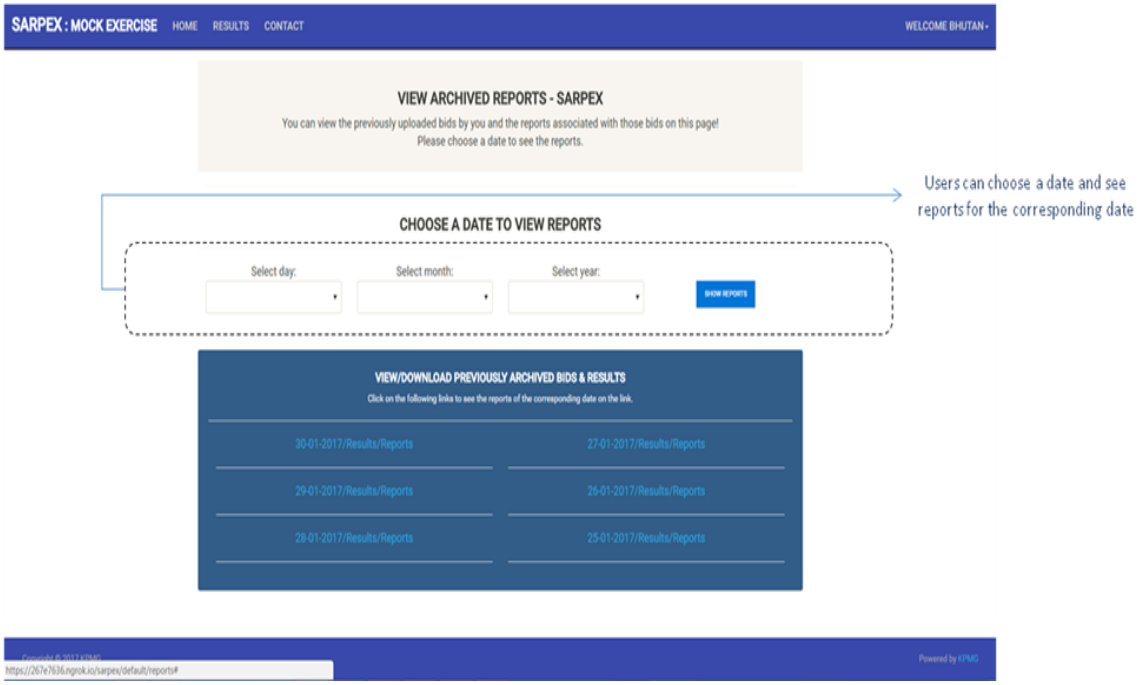
The results for unified and sequential mode are shown below the dates chooser form in separate tabs which users can click and view. These results are only visible if you have participated in the bids of the corresponding dates otherwise an error is displayed that the results are not available for the date.

7. Viewing Reports

Users can view bids submission results on the results webpage. This can be accessed by clicking the "REPORTS" link provided on the navigation bar at the top.



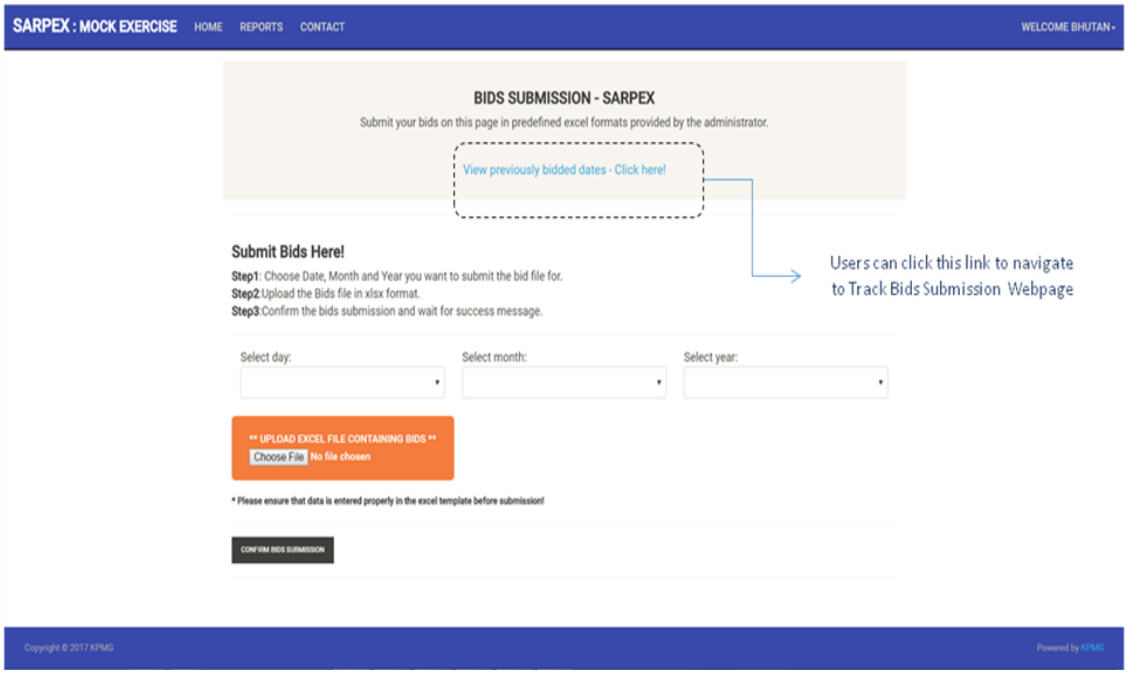
By clicking this link users will be navigated to the reports page where the reports will be listed for various dates for users. Users can click and navigate to download and view the reports.



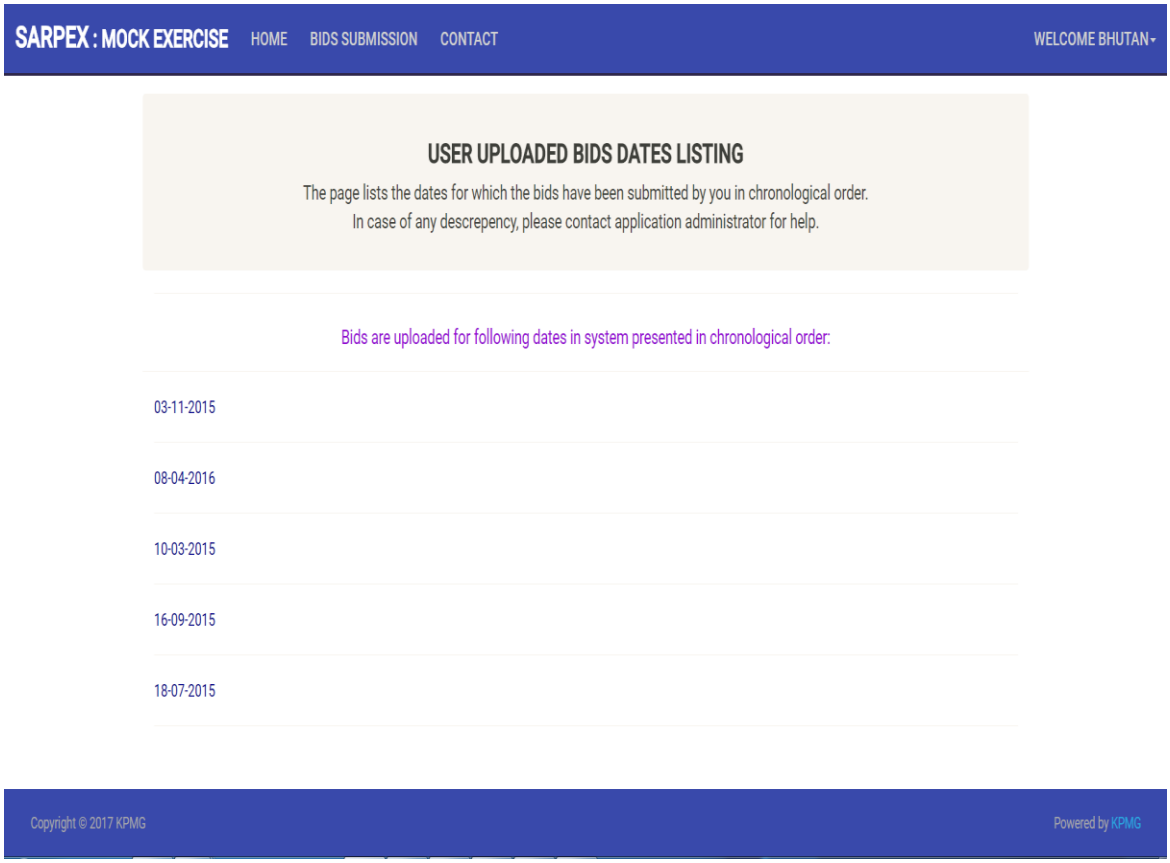
Alternatively, users can also choose a date to see reports. If reports are not available for a particular date then an error will be displayed to the user with relevant information.

8. Tracking Submitting Bids

Users can track their submissions by clicking on the link listed on the header of the webpage named as "View previously bidded dates - Click here!"

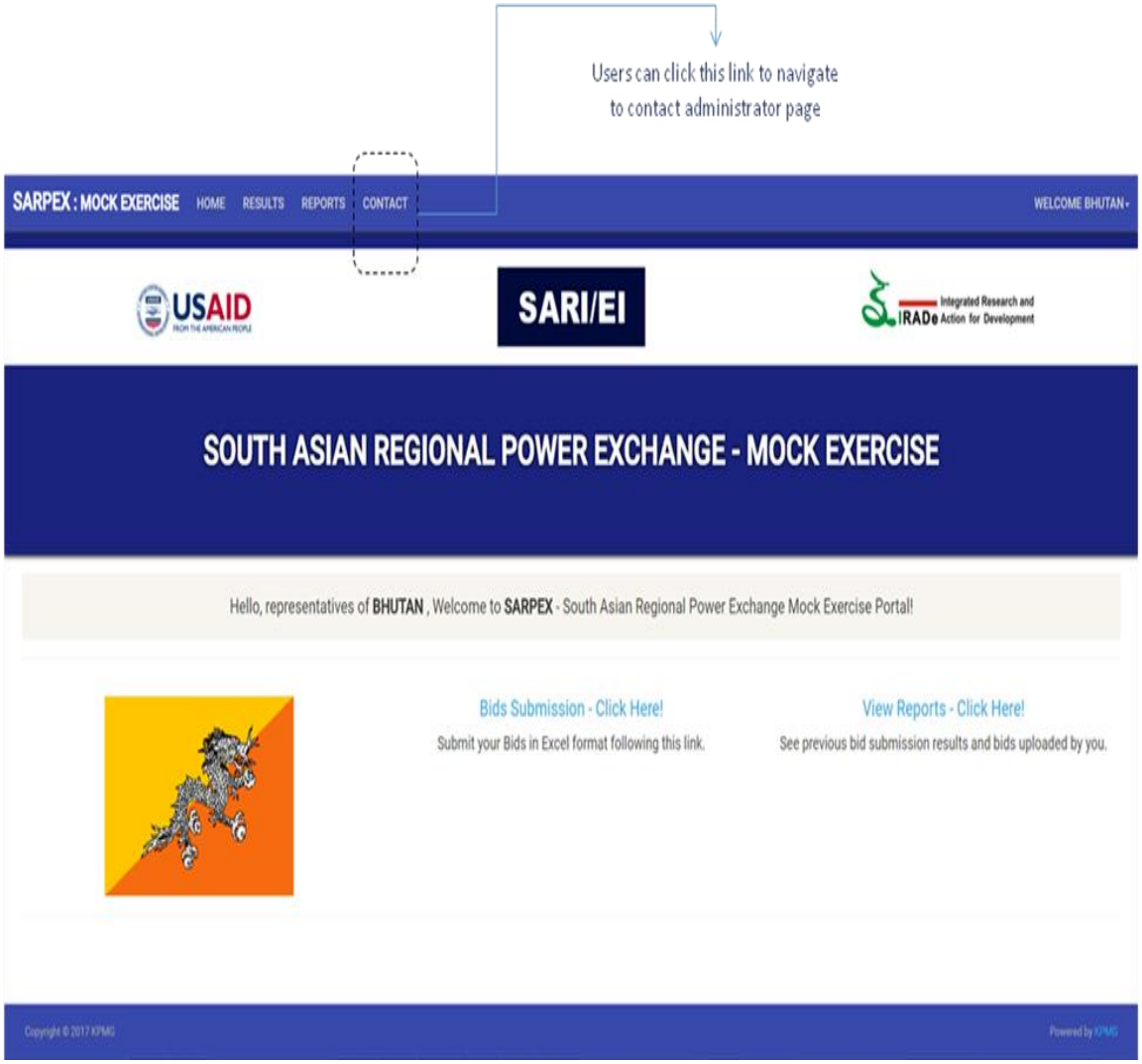


By clicking this link user will be navigated to the User Uploaded Bids Dates Listing webpage where a list of dates for which user has submitted their bids. This can be seen as in the following image.

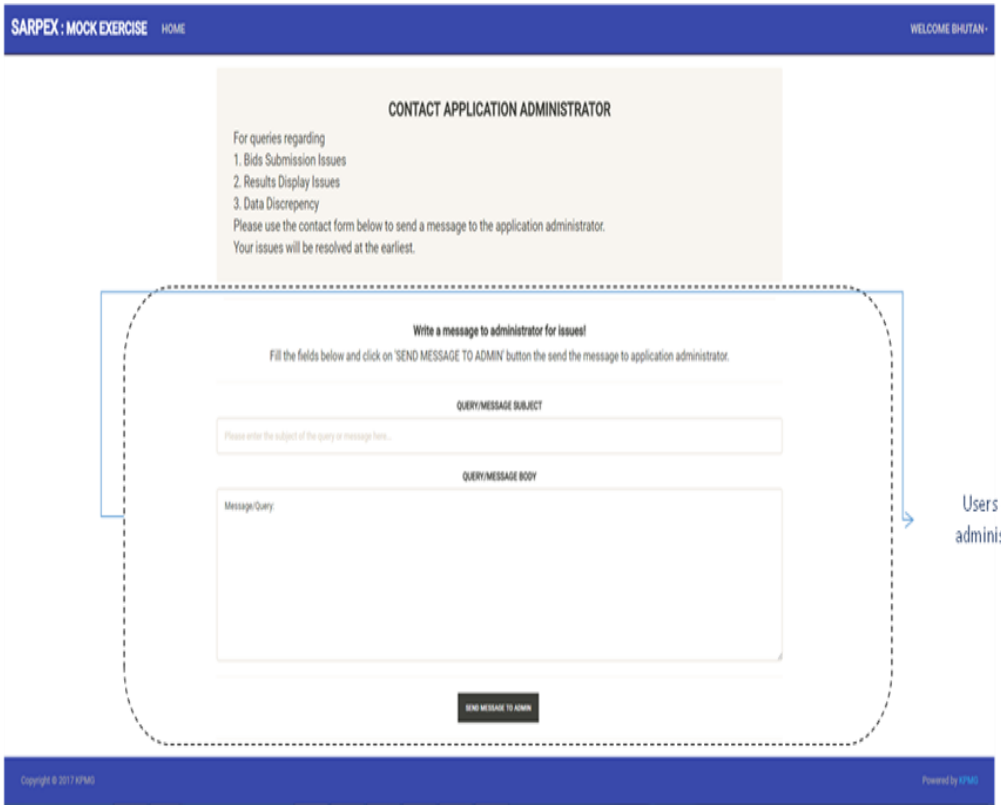


9. Contacting Administrator

Users can view bids submission results on the results webpage. This can be accessed by clicking the "REPORTS" link provided on the navigation bar at the top.



By clicking this link users will be navigated to the contact administrator page where the user can fill the form the send the message to administrator for queries or assistance.



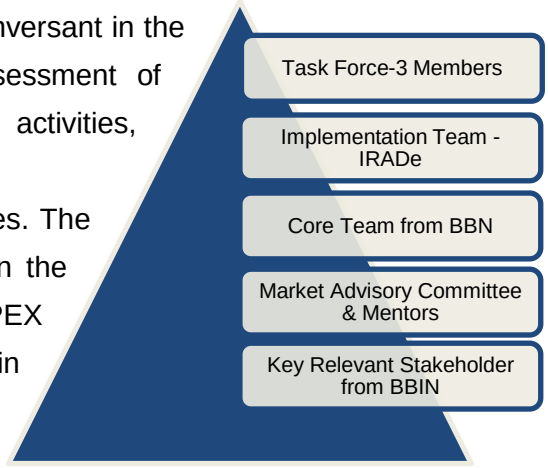
Users can contact app administrator for issues.

ANNEXURE-2: SARPEX MOCK EXERCISE TEAM MEMBERS AND THEIR ROLES

Market Advisory Committee- International Experience				
S.No	**Name**	**Country**	**Designation**	**Organisation**
1	Mr Anil Razdan	India	Ex- Secretary Power	Ministry of Power
2	Hans-Arild Bredesen	Norway	CEO	Nord Pool Consulting
3	Mr Peter Jogersen	Denmark	Vice President	Energinet, Denmark
4	Mr Musara Beta	South Africa	Chief Analysts	South African Power Pool
			Mentor	
S.No	**Name**	**Country**	**Designation**	**Organisation**
1	Dr. Kirit Parikh	India	Chairman	IRADe
2	Dr. Jyoti Parikh	India	Executive Director	IRADe
			Core Team Members - BBN for SARPEX	
S.No	**Name**	**Country**	**Designation**	**Organisation**
1	Mohammad Hossain,	Bangladesh	Director General	Power Cell
2	Shiekh Faezul Amin -	Bangladesh	Joint Secretary (Dev)	Power Division
3	Md Amzad Hossain	Bangladesh	Director (Commercial)	Power Cell
4	Golam Kibria	Bangladesh	Director IPP 1	Bangladesh Power Development Board (BPDB)
5	Md. Nuruzzaman	Bangladesh	Superintending Engineer (Plg)	Power Grid Corporation of Bangladesh (PGCB)
6	Mr Arun Kumar Saha	Bangladesh	Chief Engineer- Project Monitoring	Power Grid Corporation of Bangladesh (PGCB)
7	Mr. Karma Namgyel	Bhutan	Chief Engineer, Department of Hydropower and Power Systems	Ministry of Economic Affairs
8	Mr. Denkar	Bhutan	Engineer, Department of Hydropower and Power Systems	Ministry of Economic Affairs
9	Mr. Ugyen Chophel	Bhutan	Engineer, Department of Hydropower and Power Systems	Ministry of Economic Affairs
10	Mr. Nima Tshering	Bhutan	Bhutan Power System Operator (BPSO)	Bhutan Power Corporation (BPC)
11	Mr. Anil Rajbhandary	Nepal	Director	Nepal Electricity Authority
12	Mr. Nutan Prakash Sharma	Nepal	Senior Divisional Engineer	DoED, Nepal Electricity Authority (NEA)
13	Mr. Narendra Shrestha	Nepal	Assistant Manager	Load Dispatch Center, Nepal Electricity Authority (NEA)
14	Mr. Tej Krishna Shrestha	Nepal	Assistant Manager	Power Trade Department, Nepal Electricity Authority (NEA)

Core Team: Three core teams were nominated with members drawn from the governments of Nepal, Bhutan and Bangladesh. The team was well conversant in the respective countries power procurement/trading, assessment of demand and generation availability, load dispatch activities, transmission and distribution costs and tariffs etc.

The core team led the SARPEX mock exercise activities. The team members analysed the data and placed bids on the web portal for their respective country. The SARPEX implementation team gave them the required training in power exchange related areas and supported them execute their functions.



Market Advisory Committee & Mentor

The Market Advisory Committee (MAC) included experts who provided guidance to the team in conducting the mock exercise. The functions of the Market Advisory Committee (MAC) were

- To advise on the pilot market rules and design
- To monitor the pilot market activities and advice SARI/EI technical team as and when required.
- To facilitate stakeholder consultation and advocacy of the mock exercise in the participating nations.
- To give guidance to the core teams

Task Force-3 Members:

To initiate the action towards the formulation of South Asia regional electricity market, a Project Steering Committee was set up under the SARI/EI programme for guiding the three Task Forces. The three task forces (TF) provided the guidance for creating the enabling conditions for the development of regional electricity market.

Task Force 3 guided the activities of SARPEX and would finally give recommendations on all regional-market related activities including SARPEX.

Implementation Team:

The SARI/EI project secretariat members have conducted all activities related to the mock exercise and responsible for the following activities:

- Timely and efficient execution of the mock exercise.
- Preparation of all programmatic inputs
- Coordination with TF-3 members, Market Advisory Committee, Core Team and stakeholders from respective countries
- Presenting the exercise and its outcome at various forums
- Providing the enabling environment to core team member for the execution of mock exercise

Acknowledgements

The Preparation of this Report “South Asian Regional Power Exchange (SARPEX) Mock Exercise Key Findings” would not have been possible without the sparing valuable time, and support provided by various organizations.

We are thankful to the various organizations and individuals in Bangladesh, Bhutan, India, Nepal, and Sri Lanka for their support and guidance in running of the mock exercise and providing valuable suggestions for improvements. In India, we are thankful to Central Electricity Authority (CEA), Central Electricity Regulatory Commission (CERC), Power System Operation Corporation Limited (POSOCO), Power Trading Corporation (PTC), Indian Energy Exchange (IEX), Tata Power Trading Corporation Limited (TPTCL) and others. In Bangladesh, we are thankful to the Ministry of Power, Energy and Mineral Resources, Bangladesh Power Development Board (BPDB), Power Grid Corporation of Bangladesh (PGCB), Bangladesh Electricity Regulatory Commission (BERC) etc. In Bhutan, we express our sincere gratitude to Ministry of Economic Affairs (MoEA), Bhutan Electricity Authority (BEA), and Druk Green Power Corporation (DGPC) etc. In Nepal, we are to thank the Ministry of Energy, Water resources and Irrigation, Nepal Electricity Authority etc. In Sri Lanka, we express our gratitude to the Ministry of Power and Renewable Energy, Public Utilities Commission of Sri Lanka etc.

We are grateful to United Sates Agency for International Development (USAID) for its generous support. We would like to express our sincere thanks to Mr. Michael Satin, Regional Energy Director, USAID/India, Director, Clean Energy and Environment Office USAID/India and Ms. Monali Zeya Hazra, Regional Energy Manager and Clean Energy Specialist, USAID/India, Mr. Shankar Khagi, Environment and Energy Specialist, USAID/Nepal and Mr. Shayan Shafi, Energy Specialist, USAID Bangladesh for their valuable inputs and suggestions.

We sincerely thank our mentors Dr. Kirit Parikh, Chairman, IRADe and Dr. Jyoti Parikh, ED, IRADe for their valuable suggestions, encouragement and direction and Mr. V. K. Kharbanda, Project Director, SARI/EI, for ensuring all along that the exercise is conducted in the best possible manner.

We also like to thank Market Advisory Committee and Core team members from Bangladesh, Bhutan, and Nepal (Details provided in Annexure-2) for all their continuous efforts and time to make this mock exercise successful.

We also acknowledge and express our appreciation for all those individuals whose names cannot be penned here but who offered invaluable time and generous support throughout this exercise. We hope this document will serve as a valuable input for the initiation of Day Ahead Market in the South Asian Region.

About SARI/EI

Over the past decade, USAID's South Asia Regional Initiative/Energy (SARI/E) has been advocating energy cooperation in South Asia via regional energy integration and cross-border electricity trade in eight South Asian countries (Afghanistan, Bangladesh, Bhutan, India, Pakistan, Nepal, Sri Lanka and the Maldives). This fourth and the final phase, titled South Asia Regional Initiative for Energy Integration (SARI/EI), was launched in 2012 and is implemented in partnership with Integrated Research and Action for Development (IRADe) through a cooperative agreement with USAID. SARI/EI addresses policy, legal and regulatory issues related to cross-border electricity trade in the region, promote transmission interconnections and works toward establishing a regional market exchange for electricity.

About USAID

The United States Agency for International Development (USAID) is an independent government agency that provides economic, development, and humanitarian assistance around the world in support of the foreign policy goals of the United States. USAID's mission is to advance broadbased economic growth, democracy, and human progress in developing countries and emerging economies. To do so, it is partnering with governments and other actors, making innovative use of science, technology, and human capital to bring the most profound results to a greatest number of people.

About IRADe

IRADe is a fully autonomous advanced research institute, which aims to conduct research and policy analysis and connect various stakeholders including government, non-governmental organizations (NGOs), corporations, and academic and financial institutions. Its research covers many areas such as energy and power systems, urban development, climate change and environment, poverty alleviation and gender, food security and agriculture, as well as the policies that affect these areas.

For more information on the South Asia Regional Initiative for Energy Integration (SARI/EI) program, please visit the project website:

www.sari-energy.org