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South Asian Regional Power Exchange (SARPEX) Market Design & Rules

South Asia Regional Initiative for Energy Integration Initiative

Task Force-3 Report

Prepared by:

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Contents

List of Figures

List of Tables

Abbreviations

BBIN	Bangladesh, Bhutan, India and Nepal
BBN	Bangladesh, Bhutan and Nepal
BEA	Bhutan Electricity Authority
BPDB	Bangladesh Power Development Board
CERC	Central Electricity Regulatory Commission, India
IEX	Indian Energy Exchange
CEA	Central Electricity Authority
MCP	Market Clearing Price
MCV	Market Clearing Volume
NEA	Nepal Electricity Authority
MOP	Ministry of Power
DAM	Day-Ahead Market
PMR	Power Market Regulation
CBET	Cross Border Electricity Trade
SAARC	South Asia Association of Regional Cooperation
SAR	South Asian Region
POSOCO	Power System Operation Corporation Limited
SAC	South Asian Countries
SW	Social Welfare

Preface

In the South Asian Region (SAR), 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 on bilateral basis 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 trade, further efficiencies could be achieved by enabling trade on Day Ahead Market (DAM) basis through a Regional Power Exchange.

The Government of India, has issued the CBET guidelines to facilitate cross-border trade and to promote transparency and predictability in regulatory approach. The guidelines allow trades through Power Exchange under several categories viz. 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 initiation of a DAM.

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 view of the CBET guidelines, a roadmap for South Asian Regional Power Exchange (SARPEX) 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. 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.

For conducting the Mock Exercise, core teams were nominated from the concerned authorities of BBN for bidding on the Mock Platform. The objective was to promote participation of each country in the Mock Exercise for their learning and development. This report on "South Asian Regional Power Exchange (SARPEX) – Market Design and Rules"details out the various aspects and recommendations related to power market design such as market clearing, congestion management, settlement system, bid aggregation and submission, modes of operation etc. It also covers power market rules aspects such as Operational Rules, Operating Timeline, and Business Rules etc. for DAM operation in South Asian region.

I thank all the members of Task Force-3 (South Asia Regional Electricity Market), Market Advisory Committee (MAC) andthe SARI/EI Project Secretariat 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.

Jyoti Parikh

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Executive Director

Integrated Research and Action for Development

Acknowledgements

The Preparation of this Report "South Asian Regional Power Exchange (SARPEX) Market Design & Rules" 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.

1 Introduction

> *Power Exchanges are the market places for electricity trading and play an important role for the market development as they provide liquidity, reduce transaction costs and increase price transparency. Additionally, Power Exchanges provide key risk mitigation tools which market participants can use to hedge their exposure. The participants are electricity producers and consumers or non-physical traders.*

-(Scheepers et al., 2003)

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 governments. Though the ongoing bilateral contracts have helped these countries in establishing trades, better 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. The overall supply in the country is inadequate to meet the demand and reliance on imports from India remains elevated. Further, Bhutan, which is endowed with high hydro potential of 24 GW, has tapped only six per cent of its potential so far due to limited demand base in the country and absence of long term PPAs for exports. On the other hand, the power generation mix of Bangladesh is heavily reliant on natural gas with marginal costs over INR 12/kWh. Lastly, the exports from India are picking up, a fact acknowledged by Ministry of Power in one of its recent press release. According to Central Electricity Authority (CEA), the nodal agency for CBET in India, India has turned around from a net importer of electricity to a net exporter of electricity in FY- 2017.[1] Exports to Nepal and Bangladesh from India have increased 2.5 and 2.8 times respectively in last three years. Over the last decade, India has added huge generation capacity both on conventional and renewables side. This lends scope for further power exports from the country given its huge asset base and demand supply complementarities within the region.

So far, CBET between BBIN takes place predominantly either in the form of bilateral contracts which are in the form of long, medium and short-term PPAs.[2] However, bilateral trading arrangement also has its limitations as listed below:

- Ineffective in balancing the day-to-day variations in demand since they don't allow for near to real-time demand and supply changes.
- While flexible, since it can be customized to specific trading arrangements, it is an expensive process as it involves negotiating and writing contracts.
- The price is usually a negotiated, and not determined by market forces.
- It doesn't explicitly coordinate all concerned markets i.e. reserve market, ancillary market etc.

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

[2] Indicative list of CBET Bilateral agreements in *Annexure I*

The inter-governmental bilateral trade's success in BBIN, coupled with the prevailing demand-supply scenarios within BBIN nations, gives rise to the need for an alternative trading arrangement that is complementary to the existing bilateral market.

1.1 Bridging the gap through Day Ahead Market

A DAM is a short-term market that operates a day in advance of the actual physical delivery of power and such a market is already operating in India through Power Exchanges. DAM is beneficial since it offers significant benefits to both producers and consumers through transparency in price discovery and management of demand supply closer to the real time grid operation.

In the context of BBIN, there are seemingly immense opportunities for DAM due to the daily, monthly and seasonal complementarities in demand supply conditions within the region. 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 daily complementarities between the countries as Fridays are the official weekly holidays in Bangladesh compared to Sundays in India, Bhutan and Nepal. Similarly, on a seasonal basis, the demand in Bangladesh is higher in May as compared to other countries while Nepal and Bhutan have higher hydro generation in the same month. The development of a Regional Power Exchange would enable the countries to share their resources more optimally, as:

- Prices on Power Exchanges are determined by market forces i.e. demand and supply, and using algorithms that maximize total welfare
- It allows for price transparency, efficient price signals and competition that benefit both buyers and sellers
- Compared with long-term bilateral contracts, spot markets provide both consumers and generators with greater flexibility in their trading decisions. Buyers and sellers may adjust their trades, as per their short-term requirements and production capabilities respectively, reducing reliance on long-term forecasts and electricity commitments
- Enhances grid stability through real-time balancing, since it coordinates between all operating markets and schedules dispatch accordingly
- Assured power supply since most power exchanges have explicitly stated contingency plans in case of non-delivery and non-payment
- Allows for economic dispatch, which determines the optimal supply to meet the system load, at the lowest possible cost, subject to transmission and operational constraints

Thus, it would be critical to move beyond the bilateral agreements and enhance the cross border electricity trading. Recently, multiple stakeholders across the borders have advocated for a Regional Power Exchange as it is felt across all quarters that DAM is crucial for achieving the efficiencies.

1.2 Recent Developments

One of the recent developments envisaging the need for cross-border electricity cooperation is the "Guidelines on Cross Border Trade of Electricity" issued by Ministry of Power (MoP), Government of India (GoI), in consultation with the Ministry of External Affairs (MoEA). The objectives of these guidelines are the following:

- 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

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.

1.3 Perceived Challenges

The implementation of Regional Power Exchange has been delayed on account of multiple factors. Some of these are related to provisions regarding the institutional, legal, policy and regulatory framework. The recent guidelines by MoP on CBET are in the direction of addressing these concerns and providing 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 to be designed from 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.

2 Key Objectives of Cross Border Power Exchange

It is worthy to note that the benefits of a short-term DAM, as discussed in the context of achieving cost-effectiveness and transparency,are by the virtue of its design and implementation. In an overall CBET Market design, the role of spot market in the short-term trading of electricity is illustrated in the figure below. In such a framework, the benefits of a short-term DAM in the context of achieving cost-effectiveness and transparency are by the virtue of its rules, design and implementation

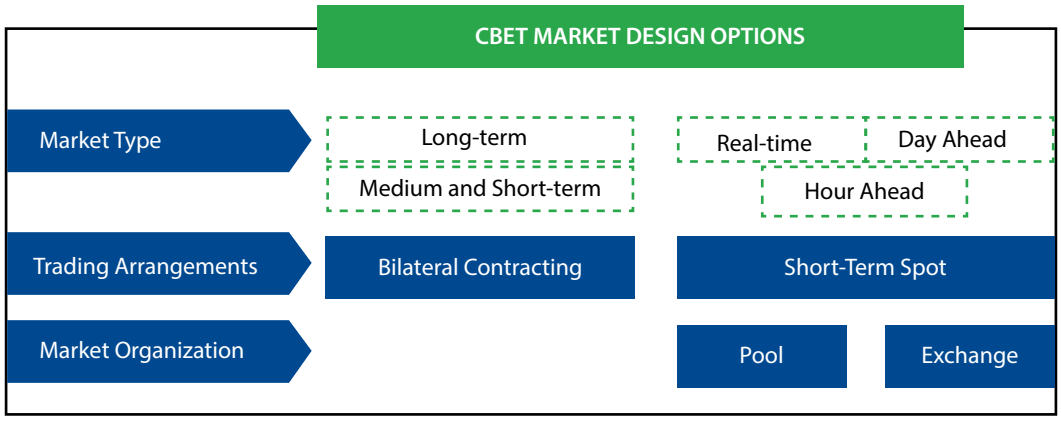


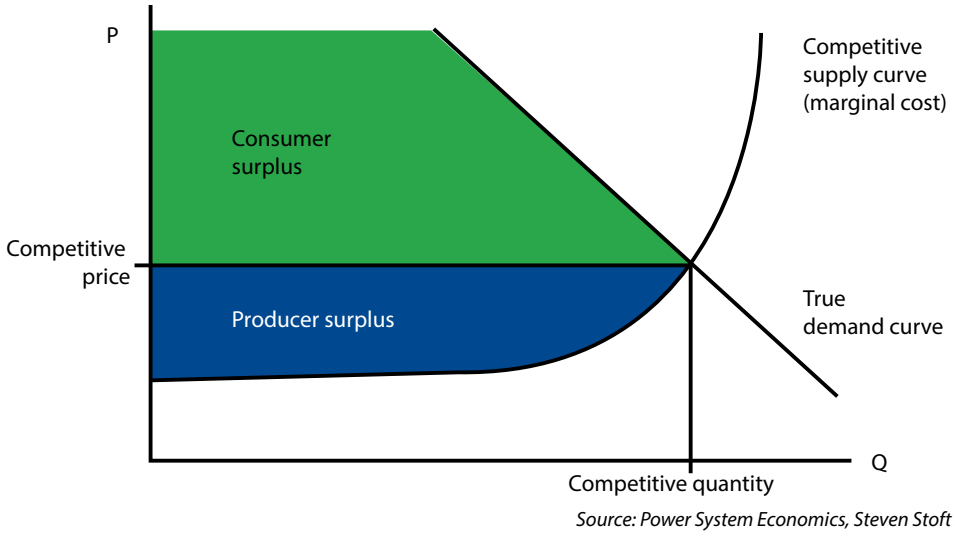
Figure 1: Fundamental CBET Market Design

Spot markets are physical trading arrangements that may be organized as Pools or Exchanges. Spot markets may deal in the real-time, hour ahead and DAM markets.

This section evaluates the merits of a DAM Power Exchange and evaluates its ability to achieve the key objectives of Electricity Markets discussed below:

i. Social Welfare Maximization (SWM) & Efficiency:

Social welfare is the sum of consumer and producer surplus. Social Welfare Maximization (SWM) is the difference between the willingness to pay off the bidders minus the cost of the offers.



Source: Power System Economics, Steven Stoft 2002

Figure 2: Diagrammatic Representation of Total Welfare, Consumer and Producer Welfare

SWM and efficiency are inter-related objectives. Efficiency aims to maximize total surplus, which is the sum of consumer surplus and producer surplus. An efficient price is a price that maximizes trade; this is where demand and supply intersect. Additionally, efficiency[3] requires the output to be:

- Produced at the lowest marginal cost in the right quantity &
- Consumed by those most willing to pay

Among other objectives are fairness, *revenue maximization and collusion redux*. Multiple objectives may co-exist in the same auction/market design basis prioritization. In the case of BBIN, SWM is proposed to be the guiding objective.

SUMMARY

In conclusion, a South Asian Power Exchange (SARPEX) is proposed for Bangladesh, Bhutan India and Nepal's Day Ahead Market to maximize social welfare and will enable closer to real-time balancing.

[3] In the short-run efficiency is a function of well-behaved costs, honest information disclosure and robust information dissemination. Further, the Efficient Market Hypothesis speaks to the importance information in a competitive market. Long-run efficiency, on the other hand, requires free-entry of new competitors as well.

3 SARPEX Mock Exercise

The main objective of the SARPEX Mock Exercise was to explore the desirability and feasibility of a Regional Power Exchange in the South Asia, develop the draft market rules and design for the regional market as well as build the capacity of the participating nations in working on an exchange platform. The results of mock exercise are expected to facilitate and enable policy makers in each country better understand the benefits and challenges of the regional exchange, which is critical for any decision-making.

In the view of the spirit of the CBET guidelines discussed above, a roadmap for SARPEX was laid down earlier covering the various aspects of integrating CBET between BBIN with the DAM on Indian domestic Power Exchanges. 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.

In order to establish the desirability of SARPEX, the mock exercise quantified the benefits for each country as well as the region. The benefits were assessed through the economic surplus accrued to participants in each country. The participants are either consumers (buyers) or producers (sellers) of electricity and thus the surplus gains to these are termed as consumer and producer surplus respectively, as discussed above.

Some of the key objectives of SARPEX mock exercise are listed below:

- To explore the desirability and feasibility of a Regional Power Exchange in the South Asia. This includes assessment of the following keys metrics:
- Quantification of benefits to individual countries and the region as a whole under market structures finalized for running of 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 nations in working on an exchange platform

On the basis of the findings of the SARPEX mock exercise and the literature review of various design aspects, market rules and design features are discussed and recommended for SARPEX in the following sections.

4 Recommended Market Design for SARPEX

A key aspect of a good market design is to address market limitations or failures, making the choice of design contingent on the market constraints which tend to prevail on both the demand and supply side. Further, in the case of SARPEX, the product types and anticipated regulatory and market structure also serve as market boundaries.

Current Scenario of Power Exchanges in BBIN:

- India has two Power Exchanges i.e. IEX and PXIL, which are neutral electronic platforms that allow electronic bidding from across the country and undertake price discovery through Double Sided Close Bidding (DSCB) mechanism. The price discovery happens for every 15-minute block in the day.
- Bangladesh, Nepal and Bhutan are in the process of evolving their institutional and infrastructural framework to improve the power supply position in their respective countries.

All three countries have also expressed their desire to trade power through exchange.

Electricity Law, Policy and Regulatory Constraints

- Existing regulations governing the Indian Power Sector are inadequate to deal with the cross-border trading since cross-border trades were not contemplated under the Electricity Act, 2003. However, the CERC does have practical experience in issuing the guidelines and regulations for power exchanges, as seen in the case of two operational exchanges.
- In the case of Bangladesh, Nepal and Bhutan, the concepts of electricity deregulation, multi-buyer and multi-seller model, imbalance or deviation settlement and open access etc. are still evolving. Since, initially the number of players from BBN are expected tobe limited, the countries may be considered as one entity in the Exchange or just one bid area**.**

A basic framework for SARPEX can be put in place in the form of either guidelines or an agreement between BBIN, until a formal legal and regulatory framework is in place.

Demand-side and Supply-side Constraints

- The Indian market is underpinned by a legislative framework which is based on the principles of competition and efficiency. Open Access allows multiple buyers and sellers to place bids for sale or purchase of power through exchange.
- At this stage, the power sector in Bangladesh, Bhutan and Nepal currently do not have provisions in their respective electricity Acts for Open Access. Thus, the number of buy or sell side bids from these countries are limited.

Only three additional buy side bids are anticipated post BBN's inclusion on the Exchange as opposed to the multiple players permitted to place demand bids by India's Open Access Regulations.4

On the supply side, while multiple power suppliers could be anticipated due to inclusion of BBN's IPPs, the magnitude of power supply and number of players is not expected to be significant in the near-term.

Contd...

[4] So long as they are authorized by the competent authority

Thickness and Liquidity

- India has sufficient liquidity as the Open Access Regulations are well defined both at the state and inter-sate levels through a regulatory framework and an enabling operational system for its implementation. The multi-buyer multi-seller model is vibrant in India as is evident from the very large number of participants and transactions taking place on exchanges.
- Bangladesh, Nepal and Bhutan all have a single buyer model and the corresponding utilities i.e. BPDB, NEA and BPS would trade on the Exchange. Deepening of reforms in the electricity sectors of the respective countries is not expected in the near future. Thus, there may be concerns related to efficiency; since the players from BBN are only numbered. In this context, the framework needs to be defined taking cognizance of the possibilities of single buyer model and emerging IPPs etc. Additionally, it is also pertinent to assess whether BBN would lead to shift of volumes from DAM in India to BBN or will it bring in additional volumes and new participants as the market evolves going forward.

The exchange based cross-border trades elsewhere have also faced demand and supply side constraints initially and have developed with limited number of transactions. However, with time and learning, the trades get a fillip with implementation of formal institutional frameworks and maturity of markets.

Product Types

- In the case of Indian Exchanges, several products such as the Day-ahead contracts, Intra-day contracts, Term-Ahead contracts etc. are being traded.
- Bangladesh, Bhutan and Nepal as of now primarily use only bilateral contracts for power trade and are in the process of strengthening their grids and amending their legal and regulatory framework for cross-border sale and purchases.

Thus, the transactions on exchange may be initiated with the primary products such as the DAM spot. Moreover, a single agency from the Indian side may be designated for settling up these transactions with/ between BBN.

In addition to the above listed market constraints of BBIN's power markets, the proposed market design for SARPEX factors in the objectives of Social Welfare Maximization and efficiency while determining pricing and matching mechanisms on SARPEX.

4.1 Market Clearing

Power exchanges use the market clearing mechanism to determine an efficient price and volume to clear the market. This mechanism uses an algorithm that aggregates bids and arrives at a Market Clearing Price (MCP) and Market Clearing Volume (MCV). Market clearing typically involves the following steps:

- A supply bid is an offer to supply energy at any price at or above the bid price, and a demand bid is an offer to take energy at any price at or below the bid price
- The MCP is the one that equates supply and demand
- No system optimization is involved, and it is each supplier's responsibility to schedule its own plants optimally to provide the energy sold[5]
- Settlements are made at the MCP in each market

[5] Clearing is superior to the Optimized Scheduling used by Pools, since the latter assumes that the costs suppliers bid are actual costs when in reality this may not be the case. This drawback allows for market manipulation and reduces buyer's surplus which in turn affects the social welfare since he is a price taker. This is another reason behind choosing an Exchange over a Pool for electricity trade within BBIN.

Thus, keeping in view the input bids from BBIN and the protocol followed in the cross border exchanges, it is recommended that the equilibrium price and volume for SARPEX be determined using market clearing mechanism.

4.2 Price discovery-Uniform pricing

In a uniform price auction, the sellers have an incentive to bid their marginal cost of generation or the forgone opportunity to sell in another market, since irrespective of what they bid a uniform price will be paid to all. This fosters the need of a seller to lower his costs so that he can make the most profit and qualify in the auction to supply electricity. Similarly, the buyers bid their marginal utility based on the financial constraints or willingness-to-pay. The underlying assumption in this case is that suppliers/buyers will be unable to affect the eventual market clearing price, owing to the large number of participants, leaving no incentive to bid above the marginal cost. Another option for price discovery is Pay-as-Bid (PAB) or discriminatory pricing where each participant pays as per the bid. While the winners are determined as per the market clearing price, the price paid by the buyer depends on the seller's bid.

In keeping with this,uniform pricing is recommended over PAB as in the case of latter, sellers bid their best-guess of the market clearing price with a goal to maximize revenues, they try to pick an offer price that balances their chance of winning by being at or below the offer price of the last bidder whose supplies are needed to meet demand against the decreased profits from bidding a lower offer price. Consequently, the plants with the lowest bids may not reflect the plants with the lowest marginal costs thereby impeding efficiency and the primary objective of social welfare maximization.

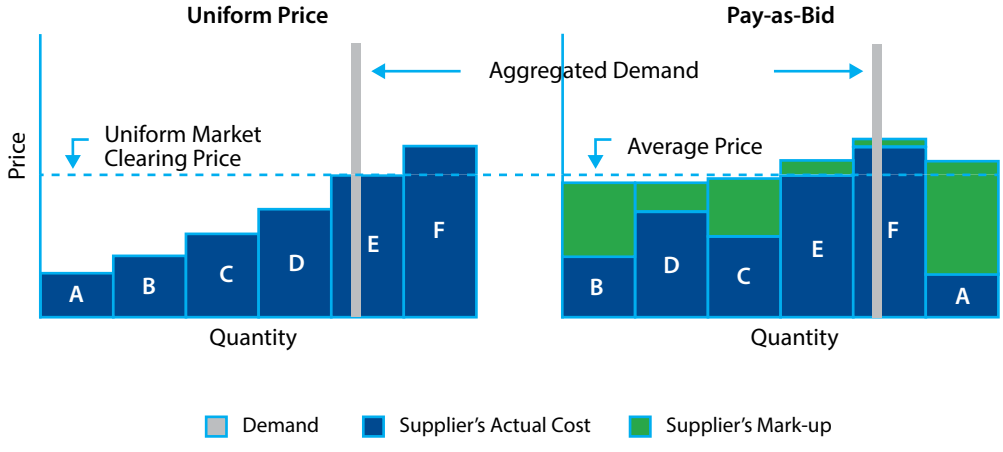


Figure 3: Uniform and Pay as Bid (PAB) design

In the figure above, the market clearing price in a uniform-price auction and the average price from a PAB auction are equal, however in reality the market clearing price under a PAB auction is generally greater than that under a uniform price auction.

It is critical to note that efficiency in an electricity market requires economic dispatch i.e. the plants/units with lowest operating costs are lined up ahead of those with a higher operating cost in the dispatch order. Thus, when there are sufficiently large number of market participants, the price discovery through uniform pricing mechanism tends to be both efficient and fair.

Thus, uniform pricing is more efficient since it reduces collusive and revenue maximizing behavior. Further, the demand curve on a power exchange may also be downward-sloping in which such a case the quantity supplied would be lower under the PAB mechanism than the Uniform Pricing one.

Lastly, since the players from BBN do not have a prior knowledge about the market dynamics of Indian DAM, uniform pricing is rendered as the obvious choice keeping in view the interest of all nations.

4.3 Auction design - Double-sided Closed Bid Auction (DSCB)

A Double-sided Closed-Bid auction is recommended for SARPEX, where both buyers and seller bid and given the sealed nature of the bid, each bidder is only aware of his bid. This type of an auction and bid aims to deter market collusion since the winners are determined based on their own bids. Typically the following bids are deemed winners:

- Supply bids below the market clearing price – fostering low supply costs
- Buy bids above the market clearing price - fostering allocation based on the greatest willingness-to-pay
- Both the aforementioned conditions aid in achieving the objectives of maximized social welfare, efficiency and fairness.

4.4 Bid Submission

In the mock exercise, discreet DSB bids were submitted at 15-minute intervals by each nation to buy or sell electricity in the DAM and the same is recommended for SARPEX.

Worldwide, it is a common practice in established exchanges for participants to submit flat bids to the exchange. In a flat bid system, submitting offers to sell requires a trader to indicate the prices and the volume increments he wants to sell at those prices. Submitting bids to buy requires a trader to indicate the prices and the volume increments he wants to buy at those prices. These offers and bids are later aggregated to construct demand and supply curves that are instrumental in market clearing price determination.

Thus, submission of flat bids is recommended for SARPEX in keeping with precedence and global best practices.

4.5 Bid Aggregation – Demand and Supply Curves

It is recommended that the Aggregate Demand (AD) and Aggregate Supply (AS) curves are obtained by stacking buy bids and sell bids, placed every 15 minutes for SARPEX, as also practiced in the mock exercise. The intersection point of the curves so obtained, is called the equilibrium price. The equilibrium price, also known as the Market Clearing Price (MCP), ensures welfare accrued to the participants i.e. buyers and sellers, is maximized. 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 remaining bids are fully curtailed.

Sample Bids for a time period

Bids		Offers	
Price	Quantity	Price	Quantity
6	40	0.5	45
5	40	2.0	50
4	70	2.75	65
3	75	5.5	80

AD-AS Curves

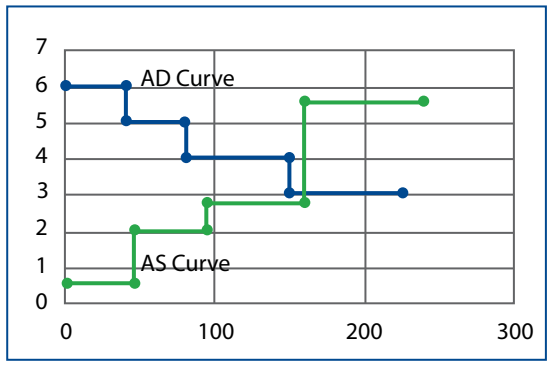


Figure 4: Demand and Supply Bids

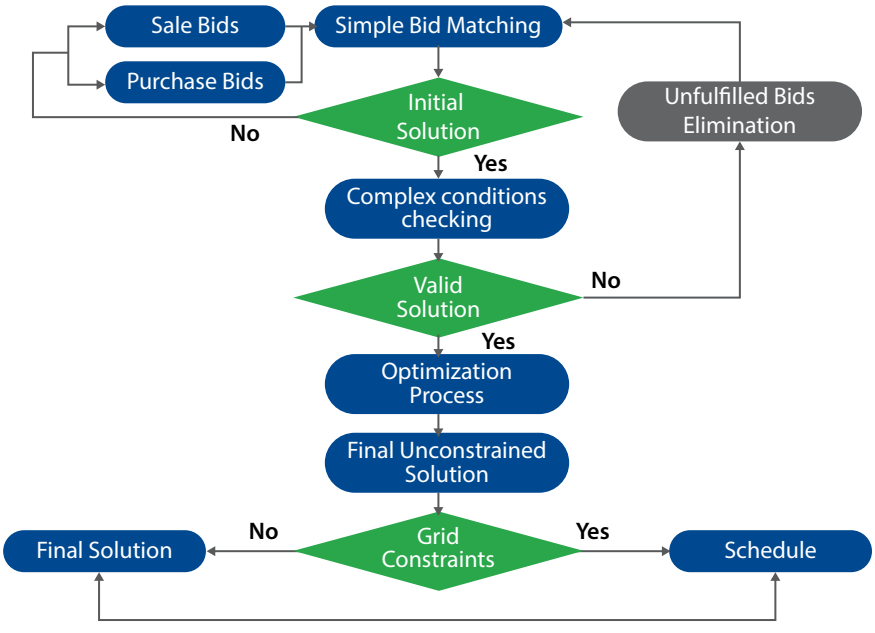
4.6 Price and Volume Determination

Clearing a single market involves setting the price and consequently matching demand and supply at that price. The aforementioned simple aggregation of flat bids (step-wise curve) may not allow for a well-defined price solution. A clearing algorithm is then used to determine the MCP by aggregating the buy and sell side bids during a specified time interval. Two predominantly used algorithms – step-wise approach and piece-wise approach are compared below to determine an appropriate approach to clear bids on the SARPEX.

Market Clearing Algorithm

A clearing algorithm produces a feasible outcome subject to certain market constraints and boundaries. An efficient price is one that clears the maximum volume, however prevalent market constraints do not always allow this. As seen in the flow chart below, clearing algorithms match bids based on simple demand-supply equilibrium. In some power exchanges however additional layers of conditions (over and above price and quantity) may be added to make it a complex bid. The algorithm first matches the primary conditions resulting in a uniform clearing price or a second round of bidding (non-intersecting aggregated demand and supply curves).[6] Finally, once a valid unconstrained solution is arrived at, an optimization process begins that maximizes the markets objectives and the grid constraints are applied to arrive at a constrained solution. SARPEX-specific decision trees have been constructed in keeping with the South Asian markets' constraints in section 4.

Generic Auction Algorithm Decision Tree



Source: Role of Physical Power Exchange in the Electricity Market, Penados 2008

Figure 5: Generic Market Clearing Algorithm Decision Tree

Two predominantly used algorithms i.e. step-wise and piece-wise approaches, are discussed below:

1. Step-wise Approach:

Price determination

Step-wise curves use simple aggregation of bids and offers to construct the demand and supply curves used to determine price. This however results in multiple price levels as can be seen in Figure 7. In the step-wise clearing approach additional rules have to be set up for price determination in case of multiple price levels at the intersection of the two stepwise linear curves.

[6] For SARPEX, however, alternative remedial approaches i.e. shifting of curves and extrapolation, are recommended instead of this step.

Volume determination

The market is cleared at the intersection of the stepwise linear curves, maximizing total cleared volume. This volume however is subject to certain market constraints that may require the supply to be curtailed based on the quantity demanded.

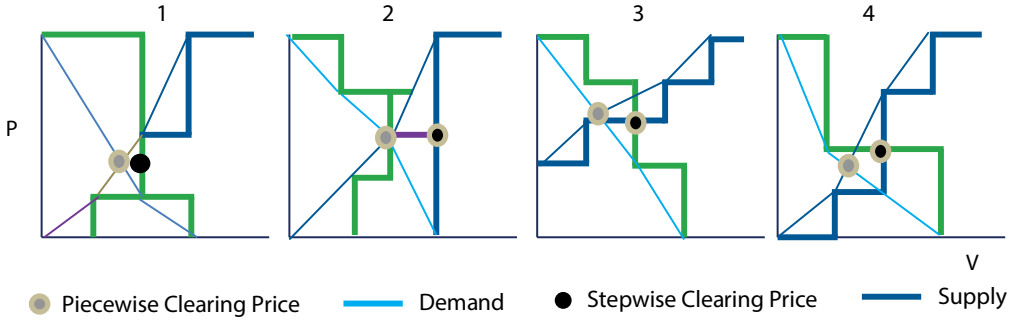
2. Piece-wise Approach:

Price determination

This approach uses linear interpolation instead of simple aggregation to get piecewise linear curves. This constitutes the piecewise clearing approach. In the piecewise clearing approach linear interpolation of volumes between submitted price steps, results in two curves that are piecewise linear. However, these curves do not have vertical and horizontal pieces. Piecewise linear curves always intersect at a unique point as seen in Figure 7.

Volume Determination

Cleared volume determination is not clearly outlined in the piecewise approach, except that traded volume is established by comparing the clearing price with the participants' bid forms. If the total cleared volume is determined like the clearing price, at intersection of the piecewise linear curves, the matching rules of the piecewise approach can lead to a further loss of wealth for participants.



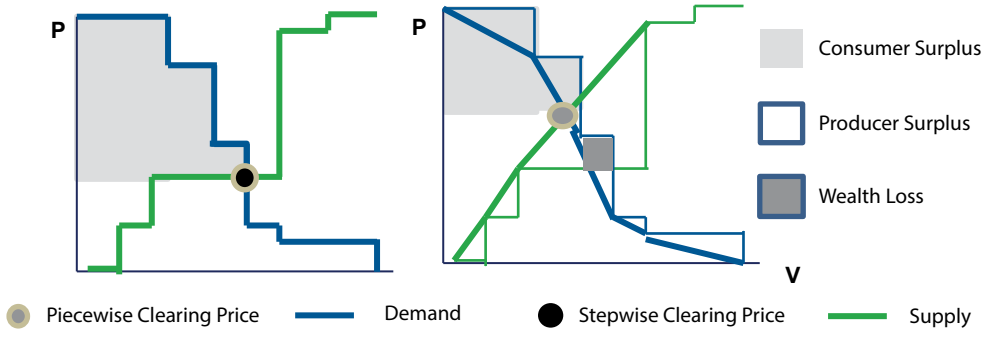
Source: Implementation Aspects of Power Exchanges by Meeus, Purchala and Belmans, Katholieke Universiteit Leuven

Figure 6: Intersection Cases of two Stepwise and piecewise Curves

Only in one of the four intersection cases piecewise and stepwise clearing always yield the same efficient price. Moreover, the market clearing price in piecewise algorithms may not be actually bid by any of the participants.

Comparative Analysis basis in Wealth Creation and Distribution:

Wealth distribution and maximization differ depending upon the algorithm used. Piece-wise and step-wise algorithms yield different prices and this consequently leads to varying levels of wealth distribution between the buyers and sellers of electricity. Further, if the clearing price is not an efficient price, the pricing rules do not maximize wealth for participants as seen in Figure 8. It has been shown in the 2 intersection cases below that the prices often differ resulting in a different distribution of wealth among sellers and buyers.



Source: Implementation Aspects of Power Exchanges by Meeus, Purchala and Belmans, Katholieke Universiteit Leuven

Figure 7: Non-intersection due to Over Supply and Over Demand Conditions

Recommended Approach for SARPEX

- In keeping with the above, tep-wise approach is recommended for SARPEX for price and volume determination as – 1) It maximizes volume cleared based on social welfare and thus allows for unbiased wealth distribution over piece-wise approach; 2) Piece-wise approach tends to clear a greater or lesser than efficient volume at an unfair price to either the buyer or seller while the step-wise approach maximizes both buyers' and sellers' wealth. The same is summarized in the table below:

Table 1: Comparison between Stepwise and Piecewise 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

4.6.1.1 Non-Intersecting Curves and Equilibrium Point Discovery Methods:

The AD and AS curves, in certain cases, may not intersect at all to result in an equilibrium point. The instances leading to such situations may arise in case the supply is more compared with the demand (over supply conditions)or if demand is more compared with the supply (over demand conditions). Both the cases are represented in the form of AD and AS curves as shown in the Figure 8 below.

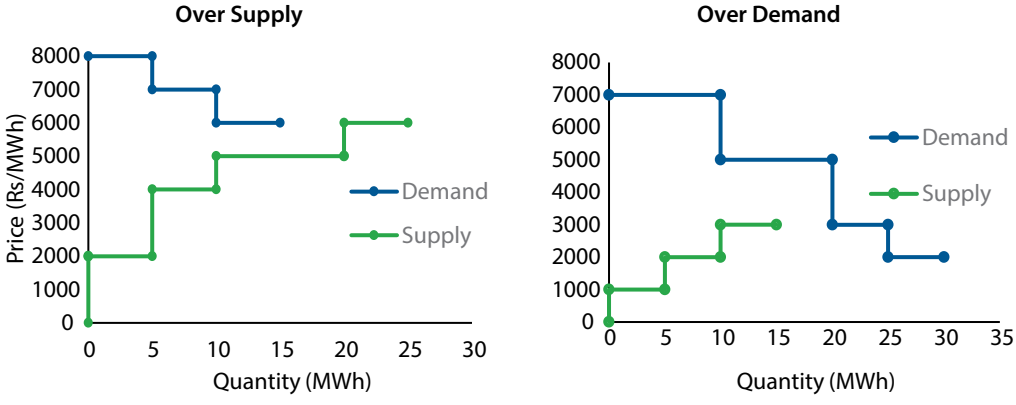


Figure 8: Over Supply- Extrapolation of Demand curve to discover MCP

Methods to address non-convergence Issues

When AD and AS curves fail to meet naturally, the equilibrium point and the corresponding MCP and MCV are not evident. To address this issue and arrive at a unique equilibrium point, either of the two methods may be employed – ***Extrapolation*** and ***Curve Shifting***

1) Extrapolation

This method extrapolates one of the non-intersecting curves to provide an intersection point. This point is treated as the point of equilibrium or the MCP and the corresponding volume is cleared as MCV. The extrapolation is typically carried out on either the AD or the AS curve depending upon scenario i.e. over demand or oversupply.

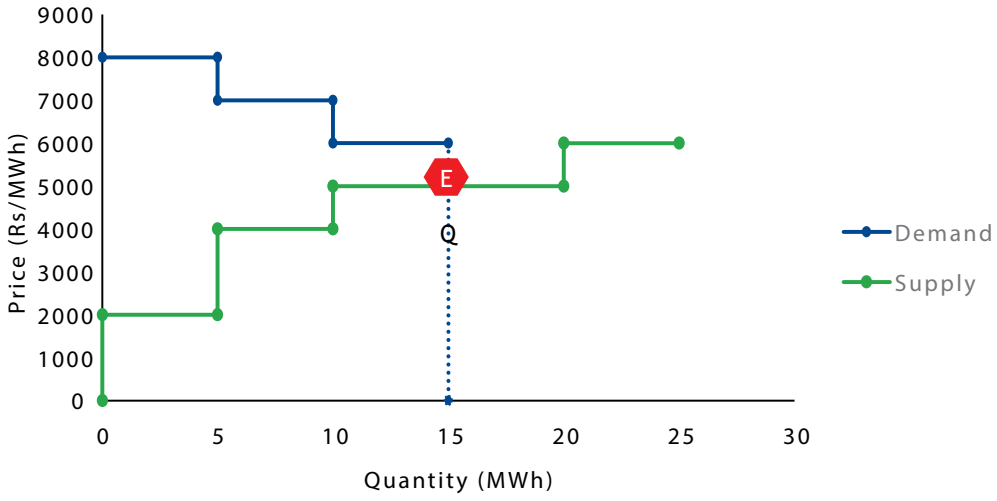


Figure 9: Over demand - Extrapolation of Supply curve to discover MCP

In Figure 9 depicts an oversupply scenario where aggregate demand is lesser than aggregate supply. The AD is then extrapolated (as shown by the dotted line) to intersect the AS curve at the point P, i.e. the equilibrium point. The MCP and MCV are thus equal to 5,000 Rs/MWh and 15 MWh respectively.

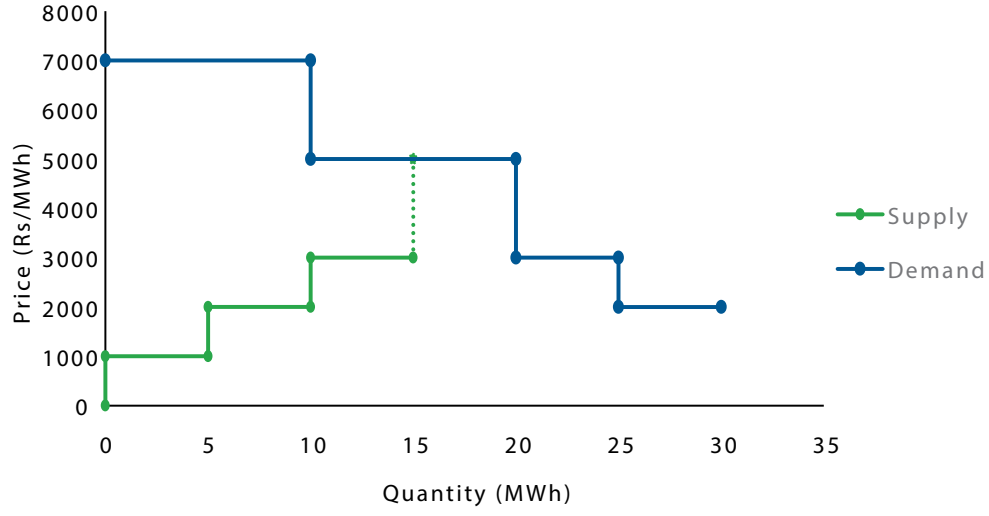


Figure 10: Over demand - Extrapolation of Supply curve to discover MCP

Similarly Figure 10 above, the AS curve is falling short and is therefore extrapolated (as shown by the dotted line) to intersect the AD curve at point P2, the equilibrium point. The MCP and MCV are thus equal to 5,000 Rs/MWh and 15 MWh respectively.

There may be cases where multiple bidders and suppliers bid the same price. In these cases the cleared volume is allocated on a prorata basis. This is explained in further detail in the Annexure III for each scenario – over-supply and over-demand.

2) Shifting of Curve

This is an alternative method that shifts either the demand or supply curve, depending on the scenario, to generate the point of equilibrium and determine the MCP and MCV.

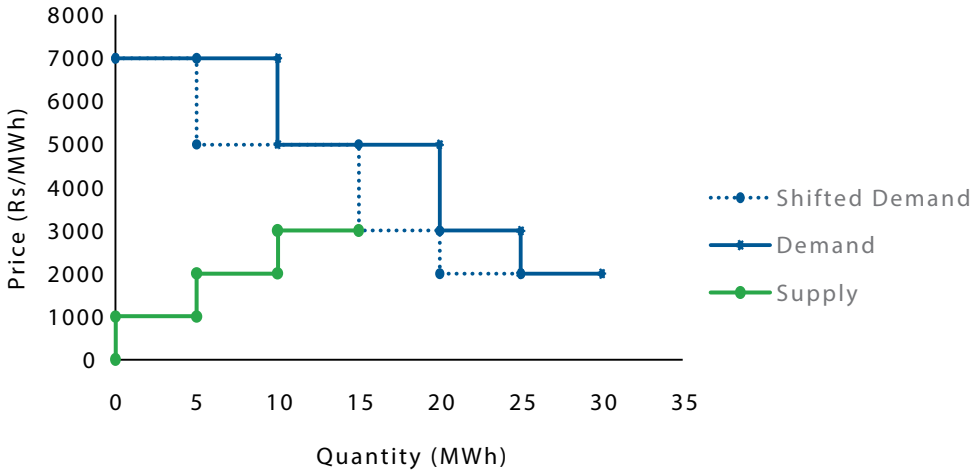


Figure 11: Over Supply Scenario: Shifting the Supply curve to left

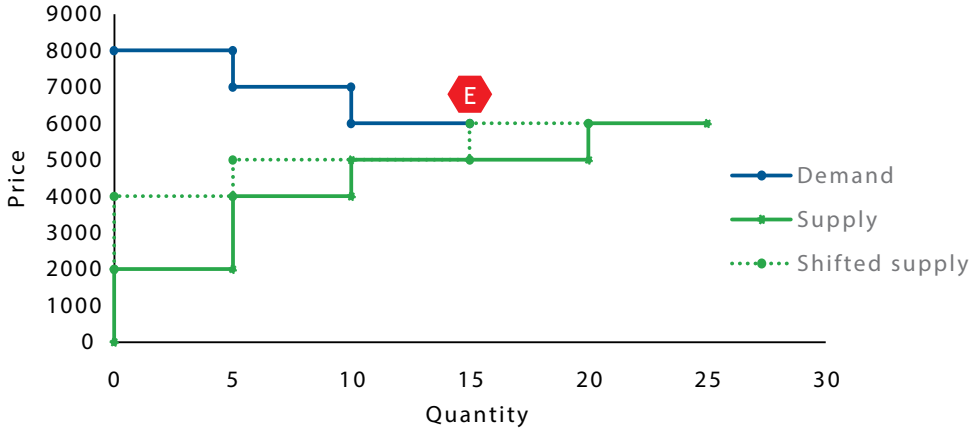


Figure 12: Over Demand - Shifting of Demand curve leftward to discover MCP

In case of oversupply, the AS curve is shifted in parallel so that it meets the AD curve at point E as shown in the Figure 12. E is the equilibrium point which determines the MCP and MCV. The dotted line shows the shift in the AS curve in order to close the gap between over supply and under demand. The MCP and MCV determined in the Figure is equal to 6000 Rs/MWh and 15 MWh respectively.

In case of over demand, the AD curve is shifted parallelly to meet the AS curve at point E as shown in the Figure 12. E is the equilibrium point which determines the MCP and MCV. The dotted line shows the shift in the AD curve in order to close the gap between the over demand and under supply. The MCP and MCV determined in the Figure 12 is equal to 3000 Rs/MWh and 15 MWh respectively.

Recommended Approach for SARPEX

The Extrapolation method is recommended over the Shifting of Curve method since it results in greater SW as compared to the latter which results in a Dead Weight Loss.[7] Both the methods have been evaluated on the basis of SWM and discussed in *Annexure IV*.

In keeping with the objective of SWM and increased participation for SARPEX, the Extrapolation method is recommended to clear the market in case of non-intersecting curves.

4.7 Congestion Management

While the mock exercise did not explicitly take into account the congestion, this section discusses the various methods to account for the same.

When transmission lines get overloaded the some transaction may not be allowed. An effective congestion management mechanism therefor plays an important role as it enables efficiency and social welfare maximization by effectively catering to demand. Congestion management mechanisms aim to prioritize the transactions and commit to schedules that do not overload the network. It is precautionary and remedial in nature and involves the following steps:

- Keeps the transmission system within limits.
- In case of overload due to unscheduled flows the SO takes remedial action

Congestion management methods may be split into market and non-market methods:

Criteria	Price Determination
1. Type of contract	1. Explicit Auctioning of network capacity
2. First come first serve	2. Nodal pricing
3. Pro - rata methods	3. Zonal pricing
4. Curtailment	4. Price area congestion management
	5. Re - dispatch
	6. Counter trace

Source: NPTEL

In Indian DAM, price area congestion management through market splitting algorithm is used to arrive at an appropriate price and volume in a particular geographical area. It involves splitting the exchange into geographical bid areas with limited capacities of exchange. The system is split into areas at predicted congestion bottlenecks. If no congestion occurs during market settlements, the market will settle at one price., which will be the same as if no price areas existed.

In order to cause the least disruption to Indian DAM, price area congestion management is recommended for congestion management on SARPEX.

4.8 Settlement Systems

Settlement systems are crucial to the functioning of power exchanges. A settlement system determines the price at which the bid volume is cleared in addition to laying down the rules pertaining to scheduling, congestion management and other grid related issues. A good settlement system insulates the real-time markets and preserves their incentives. Settlement systems are typically single or multi systems.

4.8.1 Single-settlement System:

This system uses the day-ahead bids to schedule but determines prices ex post, based on real-time dispatch. A single-settlement system consists of the elements mentioned in Figure 13.

[7] Welfare society does not benefit from

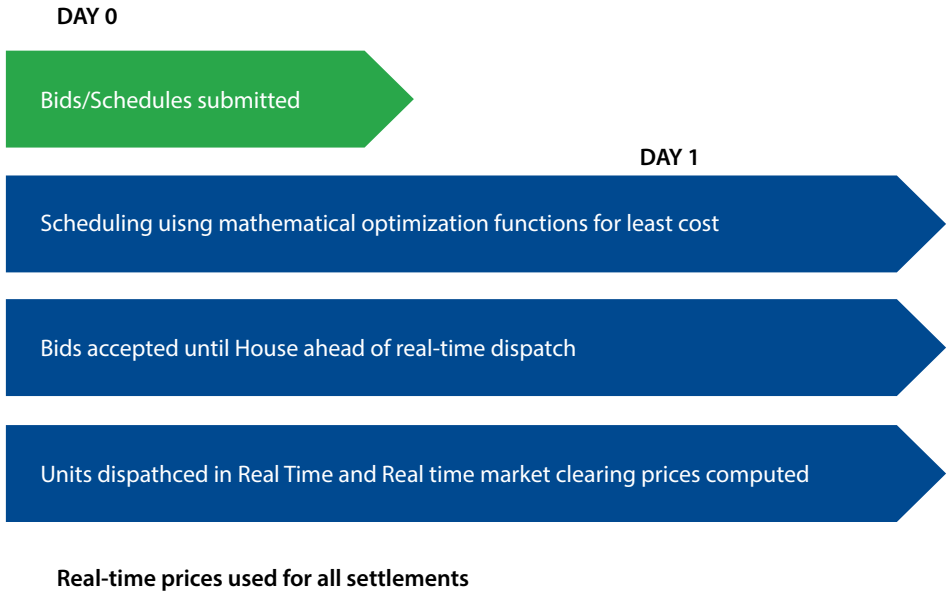


Figure 13: Diagrammatic representation of steps involved in single-settlement

4.8.2 Multi-settlement System:

Multi-settlement systems use day-ahead bids to schedule and settle day-ahead transactions. Only deviations from the day-ahead schedule are priced ex post. The price for energy applies uniformly to all transactions in that market; deviation prices are later charged in a subsequent market.

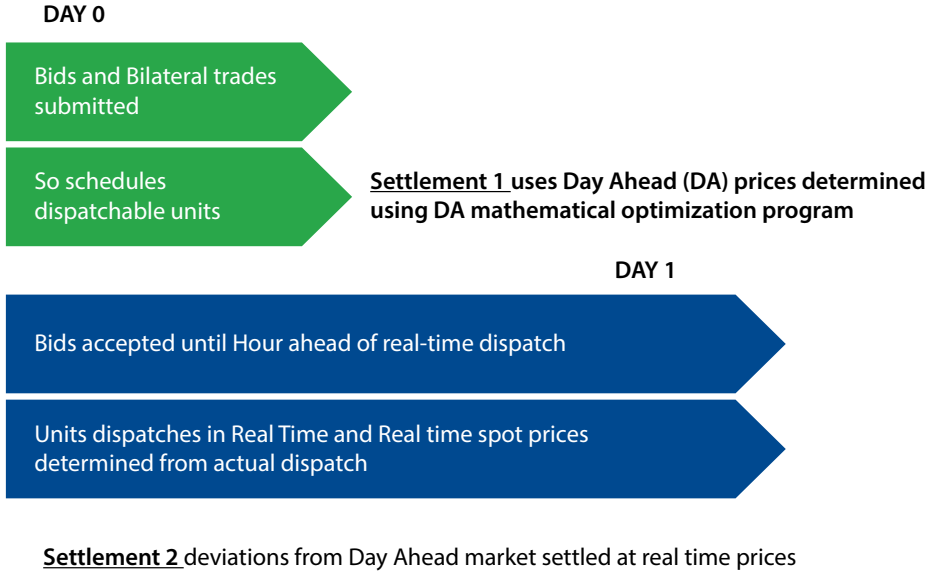


Figure 14: Diagrammatic representation of steps involved in multi-settlement

In keeping with the current rules and procedure applicable for the bilateral trade in BBIN and various other factors, a multi-settlement system is recommended for SARPEX.

SUMMARY

The following table tabulates the recommended features for SARPEX's market architecture and auction design:

SUMMARY

The following table tabulates the recommended features for SARPEX's market architecture and auction design:

Design Aspect	Options			
Price Discovery	**Uniform**	**Pay as Bid**		
	✓			
Auction Design	**Single-sided**	**Double-sided**	**Closed**	**Open**
		✓	✓	
Bid Aggregation	**Simple**	**Algorithm**		
		✓		
Market Clearing Algorithm			**Step-wise**	**Piece-wise**
			✓	
Equilibrium Point Discovery Method	**Extrapolation**	**Shifting of Curves**		
	✓			
Congestion Management	**Market Splitting**	**Network Capacity Auction**	**Zonal/Nodal Pricing**	**Others**
	✓			
Settlement Systems	**Single**	**Multi**		
		✓		

5 Proposed Modes of Operation for SARPEX

In order to assess the feasibility and desirability of DAM in South Asian Region, a set of draft market rules were earlier used for the purpose of mock exercise. These rules were drafted on the basis of inputs from the market advisory committee with experts from South African Power Pool (SAPP), Nord Pool, Energinet, Denmark and BBIN Power Markets Refer *Annexure-2*. The report recommended two modes of operation for conducting the mock exercise. After the completion of the mock exercise, the Market Rules and Design were reviewed. The recommended rules now being presented are based on this process.

This section presents a detailed discussion on the two modes of operation that were evaluated in the mock exercise in keeping with the key market objectives and constraints of SARPEX:

1. **Unified Mode:** The bids from the Indian participants and BBN countries' participants are cleared simultaneously.
2. **Sequential Mode:** The bids from the Indian participants and BBN countries are cleared in a sequential manner.

Both modes of operation are discussed on the basis of the Structure, Conduct and Performance (SCP) paradigm.[8] The analytical framework provides a means to study the relations amongst market structure, market conduct and market performance.

- **Structure:** refers to the organization and structure of the DAM. The choice of trading arrangements – exchange over pool, and the auction design, form a part of the structure. The structure under both modes is assumed to be the same in the mock exercise.
- **Conduct:** conduct alludes to market mechanisms that determine price and volume cleared. This also includes the rules and regulations that guide the market.
- **Performance:** aims to understand the impact of each mode of operation on social welfare distribution and maximization.

The SARPEX Mock Exercise simulates DAM on Power Exchange where bids placed in 15-minute intervals are cleared at a uniform price. The step-wise algorithm and uniform pricing mechanism are used for price discovery and matching.

5.1 Unified Mode

In this case, the bids from both the Indian participants and BBN are cleared simultaneously on the Exchange. In other words, in Unified Mode, a single Unconstrained Market Clearing Price is observed for both India and BBN. In doing so, the key features of the DAM as prevalent in the Indian Exchanges today remain unaltered for Indian entities.

5.1.1 Structure

The following represents the key features for the SARPEX market design for Unified mode of operation. The key structural elements remain the same under sequential mode as well:

[8] Structure, Conduct and Performance paradigm (SCP) is used as an analytical framework, to make relations amongst market structure, market conduct and market performance. It was developed in 1959 by Joe S. Bain Jr., who described it in his book "Industrial Organization". The SCP paradigm is considered a pillar of industrial organization theory, and it has been since its conception a starting point when analysing markets and industries, not only in Economics, but also in the fields of business management and controlling. (Source Policonomics)

- Trading on a 15-minute intervals
- Double Sided Sealed Bids (DSB) Auction model
- Price discovery through Uniform Market Clearing Price mechanism
- Grid Operational Procedures as prevalent today for cross-border bilateral trades

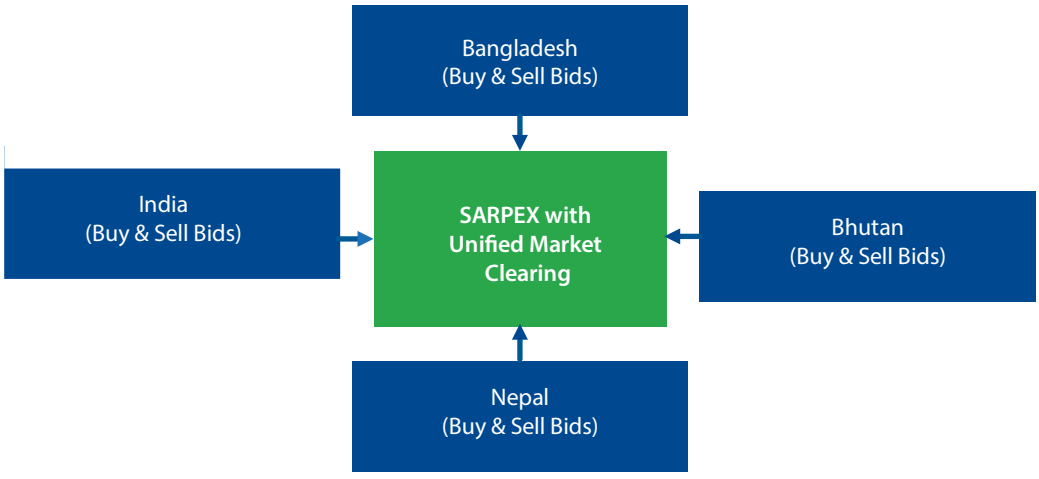


Figure 15: Unified Market Clearing Mode for BBN

5.1.2 Conduct

The unified mode doesn't alter the price discovery or matching mechanisms for SARPEX, which are the same as those used by Indian Exchanges.

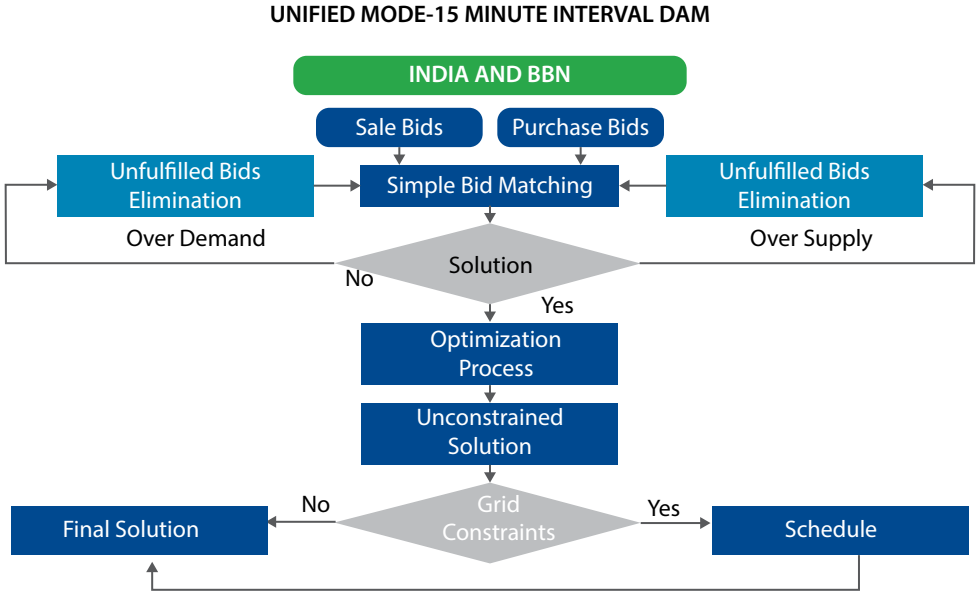


Figure 16: Market Clearing Decision Tree for Unified Mode

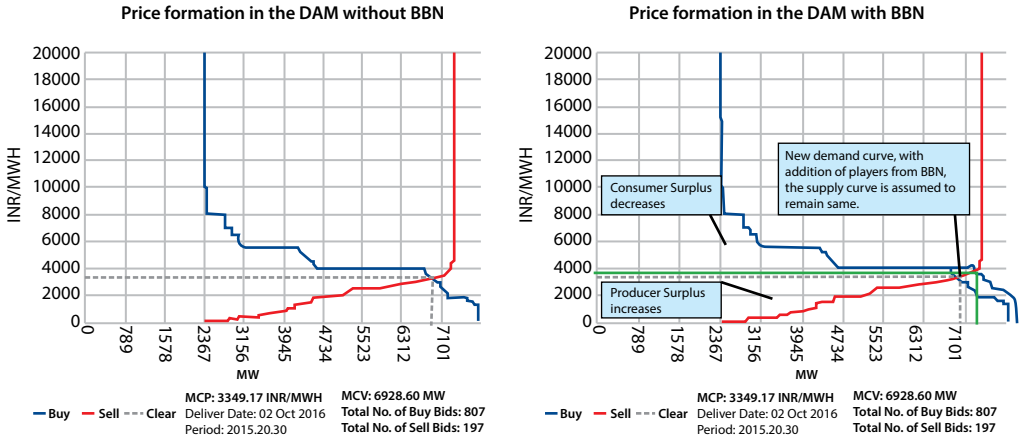
5.1.3 Performance

Social Welfare Maximization in the Unified Mode

In unified mode, the bids are cleared through the Uniform Price Clearing mechanism. Since under this pricing mechanism, the bidders may have a strong incentive to bid at their marginal costs, and hence, the outcome maximizes the overall Social Welfare of the entire market (India and BBN).

However, it was observed from the mock exercise results that the addition of BBN mostly increases the MCP as compared to the MCP observed in the current Indian DAM. This happens because the incremental buy bids from BBN (mainly Bangladesh) are greater in quantum than the incremental sell volume from Bhutan and are placed at a higher price than the latter. A few broad outcomes, identified in SARPEX mock exercise are discussed below.

- The total SW of the market (Indian and BBN) increases with inclusion of BBN with Indian DAM. The total SW of all entities (BBIN) also increases.
- There is a redistribution of the SW in terms of consumer surplus and producer surpluses - The consumer surplus of India falls relative to the current Indian DAM operations, while the producer surplus increases. For BBN, an incremental consumer or producer surplus is generated with the access to DAM.
- Since the addition of BBN bids leads to a greater increase in the buy side bids of exchange, the prices in India would increase. This results in higher producer surplus and a corresponding reduction in consumer surplus for the Indian market.

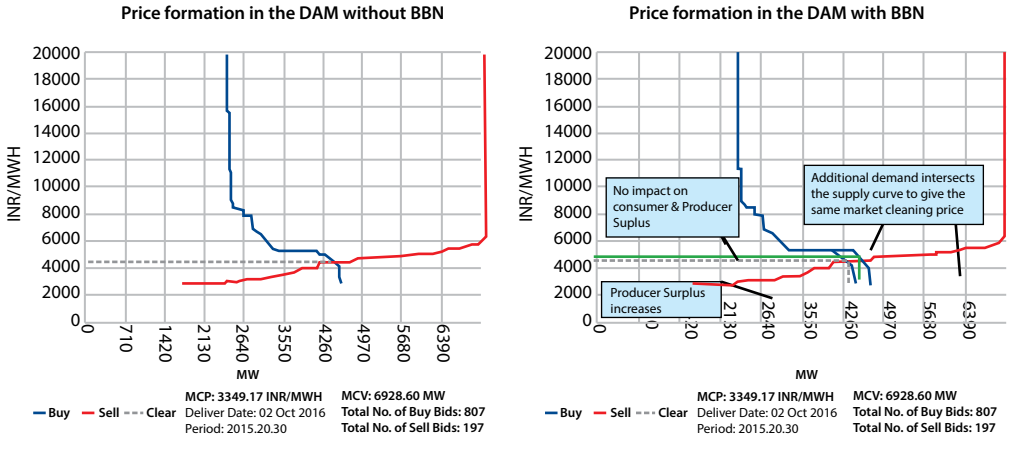


The black dotted line represents the market clearing price in absence of any participants from BBN

The green dotted line represents the market clearing price, as a result of new demand curve due to participation of BBn and with existing supply curve.

Figure 17: Change in MCP pre and post inclusion of BBN with India

In some cases/blocks of times, when there is sufficient liquidity in the Indian market, the supply curve becomes relatively flatter and less responsive to power prices. An increase in demand due to buy side bids from BBN in such cases not disturb the market clearing price, and hence there is not any significant change in the consumer and producer surpluses of the Indian participants.



The black dotted line represents the market clearing price in absence of any participants from BBN

The green line represents the market clearing price, as a result of new demand from BBN with existing supply curve.

Figure 18: Change in MCP pre and post inclusion of BBN with India

5.2 Sequential Mode

In this case, the exchanges for DAM are run in a sequential manner consisting of two auctions - one results in the discovery of the market clearing prices and volumes for India and the second one for BBN. The first auction comprises of market clearing solution for the Indian participants only and does not take into account the bids from BBN. The market is cleared as per the prevailing Uniform Market Clearing mechanism. Thereafter, a subsequent market is formed to initiate the second auction comprising of the bids from BBN and all the un-cleared bids taken "as is" from the first auction. The market in this case is cleared as per Uniform Market Clearing Price mechanism and the price for BBN is determined. Thus, overall two simulations are run in the sequential mode, one for computing the prices for India from the buy and sell side bids of the Indian participants only and the second one for BBN for computing prices and volumes from the un-cleared bids of India and the buy sell bids from BBN.

5.2.1 Structure

The key structural elements of SARPEX remain the same under sequential mode.

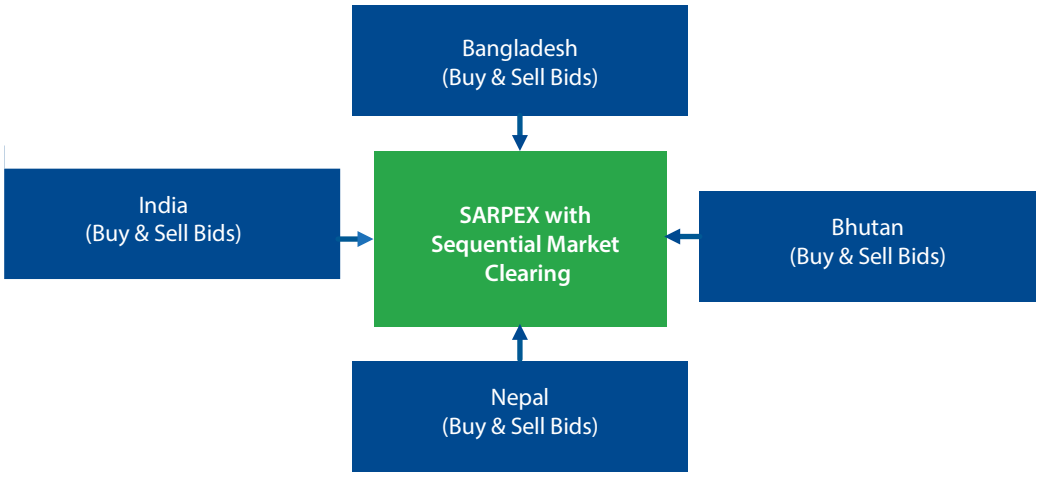


Figure 19: Sequential Market Clearing Mode for BBN

5.2.2 Conduct

All the rules, procedures, price discovery mechanism etc. remain exactly the same as that for the Unified Mode.

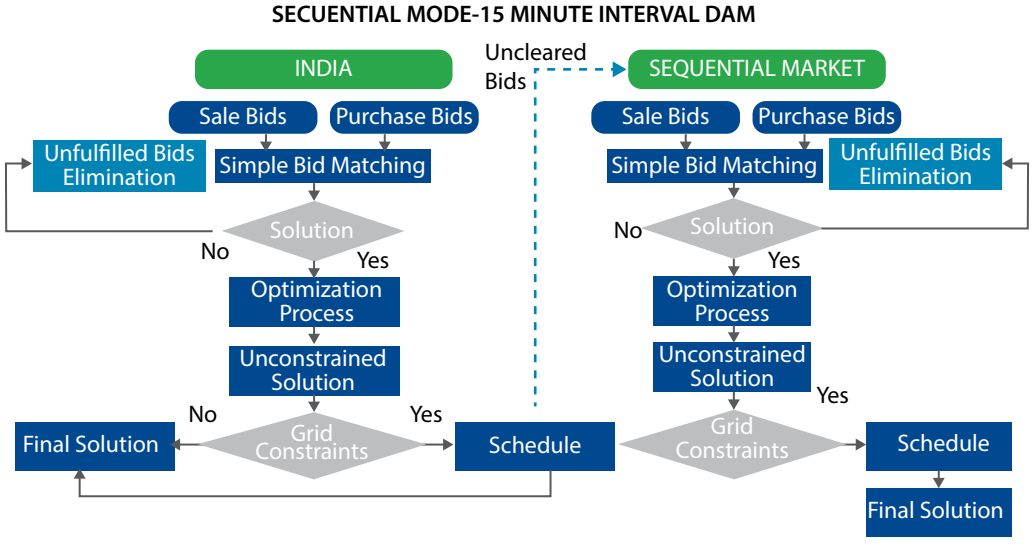


Figure 20: Market Clearing Decision Tree for Sequential Mode

While in the SARPEX mock exercise there were no events of strategic bidding by the players from BBN, it is important to note that the analysis for India was based on the past bids from FY'16. With the integration of BBN in Indian DAM in sequential mode, it is probable that Indian sell side bidders may resort to speculation and divide their volumes between the two auctions based on their conjecturing of the price signals or incentives in the two auctions.

5.2.3 Performance

In Sequential Mode, the price is discovered separately for India and the market formed by the un-cleared bids of the Indian participants and the bids from BBN. Hence, the principle of SWM and its distribution needs to be applied accordingly to the two markets.

In the Indian DAM, since the mechanism of price formation continues to be Uniform Market Clearing, the outcome in Sequential Mode results in same levels and distribution of SW as earlier considering the Indian bidders continue to behave as if there was no second chance for market clearing. Though there is an apprehension that the Indian sell side bidders may have an incentive to shift from the first auction of DAM to the second India-BBN auction due to the perceived higher payoffs in case of latter, the SARPEX mock exercise ignores this possibility.

5.3 Comparison between Unified and Sequential Mode

Both the market clearing modes not only improve the overall welfare of all participating countries, but the overall welfare of the BBIN also increases. Though, the overall regional surplus is slightly higher in the Unified as compared to the Sequential Mode, the mock exercise results indicated that in Sequential Mode all nations were better off without adversely impacting any nation.

The prices in the Sequential Mode are slightly greater than in the Unified Mode. The difference across the two modes arises because the price-setting marginal buyer and seller change from one mode of operation to the other. In 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 Sequential Mode, the prices observed in the first auction are the same as those realized on IEX. However, in the sequential auction between Indian suppliers and participants from BBN, the marginal buyer could either be from Bangladesh or Nepal depending upon the availability of the overall sell quantum.

Further, with regards to the overall traded volumes, it is found that in Unified Mode, the bids from Bangladesh and Nepal displace the bids of low cost Indian buyers. In case of Sequential Mode, the market clearing volume remain unaltered for the India participants while additional volumes from BBN are cleared in the sequential market – thereby contributing to more trade volumes. As a result, the overall volumes in Sequential Mode are higher than the volumes in Unified Mode.

Table 2: Qualitative Comparison of Unified and Sequential Mode

Unified Mode	Sequential Mode
▪ The prices in the Unified Mode are usually observed to be higher than the prices in Indian DAM. The level of increase varies across different seasons during the year and is observed to be higher during winters when the hydro supply from Bhutan is constrained.	▪ The prices in the Sequential Mode are usually observed to be higher than the prices in Unified Mode and Indian DAM. The level of increase varies across different seasons during the year and is observed to be higher during winters when the hydro supply from Bhutan is constrained.
▪ Unified Mode results in efficient resource utilization and maximizes the overall regional surplus for BBIN.	▪ The overall regional surplus in Unified Mode is slightly greater than the surplus in Sequential Mode due to a smaller market size and hence reduced liquidity. The difference in the surplus in the two modes is however not significant.
▪ Maximum volumes are traded in the DAM in Unified Mode	▪ The overall market clearing volumes are slightly lower in Sequential Mode as new entrants from BBN out-bid few Indian buyers in blocks where the overall increment in purchase volumes is greater than increment in sell volumes.
▪ Unified Mode results in efficient discovery of price and single pricing signals for all market participants.	▪ Unified Mode results in efficient discovery of price but different pricing signals for India and BBN.
▪ Minimal modifications to the standard trading software applications will accommodate the new bid areas and clearing and settlement mechanisms for the new participants.	▪ Exchanges would need to significant software modification required to add bid areas and produce a sequential solution for this model of operation. This may also be more time consuming.
▪ This will result in a sense of belongingness among all the participating countries, which is not the case in the other option.	▪ It is steady and calibrated pathway for development of the DAM market in the region.

A quantitative comparison between Unified and Sequential Mode based on the results of the mock exercise in terms of impact on prices, volumes, consumer surplus, producer surplus and social welfare is presented in the Report "Comparison between Unified and Sequential Mode for SARPEX". Both the modes of market operation clearly indicate the benefits of market integration for producers and consumers in all the countries, the final decision around the choice of appropriate mode would depend on the Governments of BBIN.

SUMMARY

Both the modes of operation for SARPEX viz., Unified and Sequential have their relative qualitative and quantitative merits, the final decision on the appropriate mode of operation would depend on the Governments of BBIN.

6 Recommended Grid Operations for SARPEX

6.1 Bid Area Formation

Bid area formation is contingent on the prevalent economic, social, technical and network topological factors. When bid areas are formed purely based on congestion considerations they are called congestion zones. Physical interconnections enable point-to-point electricity delivery and consequently form part of the requisite infrastructure that needs to be developed to ensure systemic and efficient delivery of power. The extent of physical interconnectivity is one of the key determinants of congestion. As on date, the following interconnections exist between the Member Countries of SARPEX:

- **India & Nepal:** A 400 kV DC line exists from Dhalkebar (Nepal) to Muzaffarpur (India) in addition to some 11, 33 and 132 kV links that are not-operational owing to high transmission losses.
- **India & Bhutan:** Interconnections up to 400kV exist between these countries. A 400 kV DC line from Punatsangchu-I HEP (in Bhutan) to Alipurduar (in India) has been in operation.
- **India and Bangladesh:** Interconnections between these countries exist at Bahrampur (India) – Bheramara (Bangladesh) through a 400 kV DC line and 500 MW HVDC back-to-back link at Bheramara. Further, a 400kV D/C Surjyamani nagar (India) to Comilla (Bangladesh) transmission line has been commissioned in March 2016.

Bid areas determine the price paid/charged in a specific geographical location in keeping with grid constraints and transmission line congestion. While the Exchange is anticipated to clear the market using the uniform pricing mechanism, the clearing algorithm also considers grid constraints. This section explores the key considerations in the bid area formation.

Key Considerations for Bid Area Formation in SARPEX:

Physical Considerations:

Congestion on the DAM is anticipated in keeping with the growing demand for electricity and CBET within BBIN. As transactions grow between the Member Countries, some physical interconnections are likely to get congested, resulting in restricted electricity flow.[9] In the event of such congestion, separate markets are formed in the congested areas which in turn necessitate the creation of separate bid areas or congestion zones for the member countries. India, for example, was originally divided into four regions namely Northern, Southern, Eastern and Western Regions. However, as a result of increased trade volume and experiential growth in managing regional congestion these areas were further spilt into various congestion zones that led to the formation of N3 and W3.A tabulated description of the existing bid areas in India has been provided in *Annexure V*. [10]

Other Considerations:

Considerations other than congestion may also guide the creation of bid areas. These considerations could be economic, political, geographical or technical in nature. For example, electricity generators in India such as JITPL and Sterlite, physically located in Eastern Region, were included in the Western Region bid area-W3, due to the transmission topology of the electricity grids within India.

[9] The level of restriction on the flow of power is determined by the existing capacity of these lines, unless new inter-connection links are formed between the Member Countries in the future.

[10] These zones are still treated to be "approximate zones" from the perspective of congestion. For example, large states like Uttar Pradesh, Maharashtra could be split further, thereby enabling further enhancement in transactions on the exchange.

Recommended Approach for SARPEX

In view of the above, separate bid areas for Nepal, Bhutan and Bangladesh, are proposed in addition to the existing bid areas for India. As observed in the case of India, market splitting may not be always desirable among SARPEX member countries. However, creation of separate bid areas for the member countries of SARPEX may be desired for the following reasons:

- Perceived Congestion in the cross border transmission lines
- Management of differences in the sovereign laws, power sector structure (bundled/unbundled), tariffs, grid operation related processes and procedures
- Settlement of Deviation Imbalances
- Alignment of time differences
- Settlement of currency related issues

Further, it is also proposed that the congestion revenues, on account of congestion along any international interconnection, be collected and credited to the Joint Country Power Development Fund.[11] This is in keeping with the need to assess the roles and responsibilities for managing and utilizing the congestion revenues among member countries arising due to transmission constraints, as the trade volumes grow in the future. The revenue so collected may be utilized for capacity expansion after both countries agree to expand inter-linkage capacity.

6.2 Transmission Capacity Allocation

Typically, the buyers and sellers in an electricity market optimize their procurement/sales portfolio through diversified purchases/sales from various market types i.e. long term, medium term, short term bilateral and short term DAMs. In most countries, long term, medium term and short term bilateral contracts are conceived as "secure" markets. One of the underlying reasons for this is the priority accorded to these transactions in the allocation of the transmission capacity between each pair of injection and withdrawal points. In some markets, transmission rights are contested; while in others, the priority order is defined by the regulator.

In BBIN, the highest priority for transmission access is accorded to the long term PPAs, followed by medium term and short term bilateral contracts in all the member countries. The Exchanges are currently operational only in India, and the residual transmission capacity is allocated to them, after accounting for transmission requirements of all the above mentioned transactions.

Recommended Approach for SARPEX

Since any deviation from the existing procedures for allocation of transmission capacities may be a long drawn process, each member country's existing mechanism for transmission capacity allocation is proposed to be retained for corridor allocation to SARPEX. Thus, the priority and capacity allocated to SARPEX is proposed to constitute the residual capacity left after accommodating all the long term, medium and short term bilateral contracts.

SUMMARY

Bid Area Formation:

- Formation of separate bid areas for BBN is proposed
- Joint Country Power Development Fund proposed to be set-up for management of the congestion revenues

Transmission Capacity Allocation:

- Each member country's transmission corridor allocation methodology is proposed to be retained, and transmission capacity allocated to SARPEX is the residual capacity after accounting for the long term, medium term and short term transactions.

[11] Referring to countries on both sides of the interconnection

7 Recommended Operational Rules for SARPEX

Grid operating norms and procedures enable seamless functioning of any formal electricity market. Further, well-constructed procedural rules promote efficiency and tend not to inconvenience existing markets. The subsequent sections discuss the operating procedures for DAM in SARPEX:

1. Pre-requisites for Participation
2. Scheduling Processes
3. Deviation Settlement Mechanism
4. Transmission Charges and Losses

7.1 Participation pre-requisites

Provision for No Objection Certification (NOC):

Non-discriminatory access to the respective transmission systems of the member countries increases the opportunities for power trading. OA[12] has the added benefit of allowing multiple and diverse power supply contracts that utilize the prevalent load and time diversity to foster efficient resource allocation.

In SARPEX, all trades are proposed to be executed at the inter-regional periphery of the Indian grid while the operational control of the transmission system of member countries falls within the jurisdiction of the respective countries. A "No Objection Certification"(NOC) is therefore required from interested participants in each member country for allowing access up to the inter-regional periphery of the Indian grid.

Joint Association of System Operators:

Once the unconstrained clearing volumes/prices are declared by the exchange, the trades between various bid areas are clearedas per the available transmission capacities. In India, the available transmission capacity is estimated by the system operator i.e. NLDC. However, for SARPEX, a Joint Association of System Operators is proposed to declare available transmission capacity along the cross border transmission corridors. Till such time as the association is formed, the role of coordination for available transmission capacity between country-specific system operators may be performed by the "Nodal Agency" as defined in the later section of this document.

Open Access Harmonization:

In keeping with the objective of efficiency, all the Member Countries need to harmonize their OA regulations and where regulations already exist they must be extended to include member countries. Bhutan and Bangladesh need to notify regulations on OA, including specific provisions on CBET as per their respective electricity laws while Nepal needs to establish OA provisions for both domestic and cross-border interconnections. India needs to extend its OA beyond its national boundaries and incorporate provisions on cross-border transactions as the current cross border bilateral trading is approved by the regulator on a case-to-case basis outside any regulatory framework.

[12] In power markets, "Open Access (OA)" means the non-discriminatory provision for the use of transmission lines or distribution system or associated facilities with such lines or system by any licensee or consumer or a person engaged in generation in accordance with the regulations specified by the Appropriate Commission.

7.2 Scheduling

SARPEX's operational rules aim to preserve the sovereignty and efficiency of each member country's electricity market. In keeping with this, the following scheduling related rules have been proposed:

Recommendation 1: Defining International Peripheries

Physical nodes for international inter-connection need to be specified for the cross border participants in order to schedule supply or off-take electricity. These points may be referred as the international periphery. Defining such nodes is critical to the efficient functioning of SARPEX. Unlike in case of bilateral contracts, where delivery points are mutually agreed upon, exchanges work on the principle of collective transactions[13], where delivery points are pre-determined. This enables a level playing field for buy and sell transactions and results in a single unconstrained market clearing price for the entire market.

Recommendation 2: Retaining Bilateral Trade Delivery Points:

Currently, all the cross border transmission interconnections exist only between India and the respective member countries.[14] There are no direct interconnections between the member countries themselves. Further, no such interconnections are given in the plans.

The following diagram shows an illustration of the prevailing bilateral contract for export of power from India to Nepal. Under this agreement, the delivery point of the trade is defined to be the 400 kV Muzaffarpur substation; while the injection point is the inter-connection of the generating plant with the Central Transmission Utility (CTU), also known as the Regional Periphery.[15]

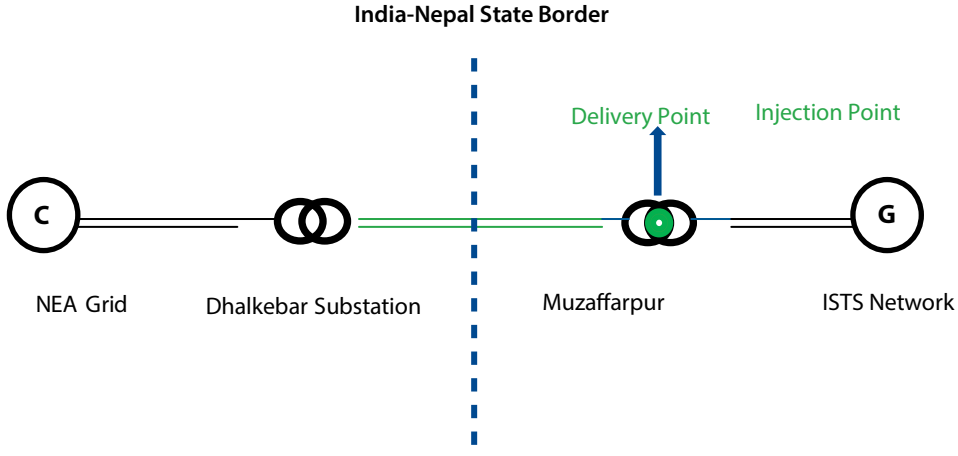


Figure 21: Bilateral Trade between India and Nepal

[13] Collective Transaction means a set of transactions discovered in Power Exchange through anonymous, simultaneous competitive bidding by buyers and sellers.

[14] Under existing bilateral trade agreements, the transactions between India and Bangladesh are scheduled at 400 kV Bahrampur substation in India; the power imports from Bhutan are scheduled at Alipurduar substation in Jalpaiguri (West Bengal); while the delivery points for all transactions between India and Nepal is chosen to be at Muzaffarpur in Bihar, India.

[15] Regional Periphery or CTU interface shall mean the point where (i) the power from the power station switch yard bus shall be injected into the interstate transmission system,or (ii) the dedicated transmission line of the power station shall connect to the interstate transmission system,or (iii) the intrastate transmission system of the state shall connect to the interstate transmission system for the purpose of transmitting power from the power station.

In order to cause least disruption to the existing cross border trading mechanisms between the member countries, it is proposed that the delivery points as defined under the bilateral agreements to remain same for SARPEX. Thus, the buy and sell side bids on SARPEX may be scheduled at point of interconnection of the cross border transmission line with the regional periphery of the Indian grid. This point may be referred as international periphery. For instance, in the above example, the delivery point for all the buy or sell side transactions on SARPEX, may be 400 kV Muzaffarpur substation.

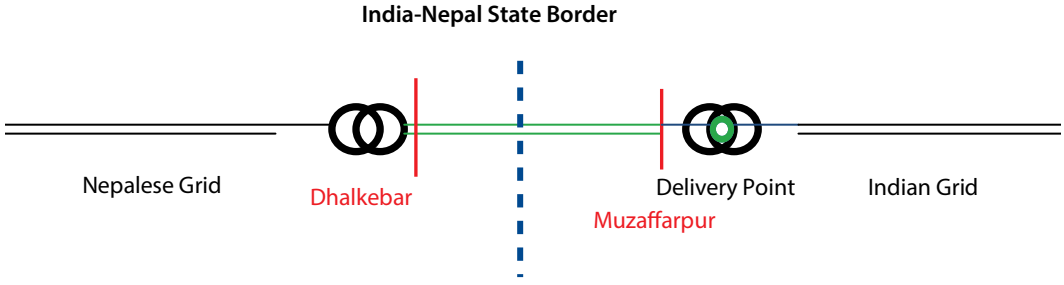


Figure 22: Cross Border trade on SARPEX between India-Nepal

However, it is possible that the member countries have more than one interconnection point within India. For example, Bangladesh is connected to Indian grid in West Bengal (Eastern Region) as well as in Tripura (North-Eastern Region). Similarly, interconnections with Nepal also exist in Uttaranchal (Northern Region) in addition to Bihar (Eastern region).

Recommendation 3: Appointment of a Nodal Agency

Under the aforementioned configuration and in keeping with the underlying procedural harmony between the member countries, there is a need to introduce an agency (or agencies) for coordinating the power flows on both sides of international periphery. The agency may be referred as the "Nodal Agency" and will need to be registered under the jurisdiction of the respective member countries. The Agency's responsibilities at a minimum may include the following:

- The nodal agency will furnish the schedule of drawl and injection to the concerned authorities on both the sides of international periphery.
- In case of multiple interconnections of the member countries with India, the nodal agency will be responsible for scheduling separately at each interconnection.

For Example, the Nodal Agency operating between India and Bangladesh shall provide the schedules of all trading on SARPEX for both the interconnection points that fall under the Control Area[16] of Eastern Region Load Dispatch Centre (ERLDC) and North-Eastern Region Load Dispatch Centre (NERLDC) to Power Grid Company of Bangladesh and NLDC, India respectively.

7.3 Deviation Settlement

Deviation is the mismatch in scheduled and actual injection/drawl of power to/from the grid. Inadvertent deviations from schedule may pose a threat to the grid stability and security. An appropriate penalty mechanism needs to be in place to reduce any deviations.[17] In most countries, the charges for the imbalance are paid through deviation

[16] A control area is an electrical system bounded by interconnections (tie lines), metering and telemetry which controls its generation and/or load to maintain its interchange schedule with other control areas whenever required to do so and contributes to frequency regulation of the synchronously operating system.

[17] After the nodal agency has scheduled power deliveries at each node of inter-connection, in real time operation, the actual flow may differ from the schedule due to various unforeseen reasons. Further, the settlement of physical imbalances is also required to ensure contractual commitment along with grid stability.

settlement for all the time blocks for over-drawl by the buyer and under-injection by the seller. The same is receivable for under-drawl by the buyer and over-injection by the seller based on the grid frequency. However, different countries adopt various deviation settlement mechanisms.

Currently, in cross border bilateral trades between India and the other member countries, there is no standard mechanism to undertake Deviation Settlement and accounting as well as no designated entity for monitoring the same. Member countries typically agree to settle deviations as per their respective MOUs for specific contracts.

Recommended Approach for SARPEX:

- In keeping with the above, retaining the existing deviation settlement mechanisms[18] of each Member Country is proposed for SARPEX where the settlement will be paid by the nodal agency, to the respective authorities, on behalf of all the market participants.
- The nodal agency will furnish the actual injection of each participant to the concerned authorities on both the sides of international periphery on 15-minute block basis, along with the actual ex-bus generation/drawl by each participant.
- The agency will also ensure that telemetering data at the generator-transformer bus/buyer-transformer bus shall be made available and proper protection coordination is implemented with the system operators of the member countries. For example,in the case of India and Bhutan,the Nodal Agency will provide the actual drawl/injection of the each participant at international periphery. It will also provide actual ex-bus generation/drawl by all the participants in India and Bhutan on account of DAM on SARPEX.
- The Nodal Agency shall be held responsible for overall deviations at International Periphery.[19] This includes metering and energy accounting for all the SARPEX participants to identify quantum of deviation on account of each generator/demand-entity.
- Deviation settlement may be pro-rated in the case of multi Nodal Agency involvement.[20] For example,consider a generator scheduled for 100 MW through nodal agency A under a long-term agreement and 50 MW on the exchange through agency B. If the actual injection of the generator is 120 MW, the deviation levied on the two agencies will be determined proportionally, i.e. agency A and agency B will be responsible for a deviation of 20 MW and 10 MW respectively.

7.4 Treatment of Transmission Charges and Losses

Since all the power deliveries on SARPEX are proposed to be scheduled at international periphery, the transmission charges and losses up to the delivery point may be charged to either the buyers or sellers.

Currently, all the member countries have their own mechanisms for estimation and application of transmission charges and losses on the entities using the grid. In the case of cross border bilateral contracts, the charges are levied in accordance with the MOU terms. The POC injection and drawl charges and losses at various interconnection points

[18] In India, CERC has defined the Deviation Settlement Mechanism and related matters Regulations, 2014 for determining Unscheduled Interchange (UI) charges. These regulations are applicable to sellers and buyers involved in the transactions facilitated through short-term open access or medium-term open access or long-term access in inter-state transactions. However, the regulations do not explicitly include the mechanism for commercial settlement in import and export of power with the neighboring countries. For Bangladesh, Bhutan and Nepal, Deviation Settlement Mechanism is yet to be explicitly defined through enactment of separate regulations/orders/provisions.

[19] The power flowing through the interconnecting lines may also include the contracted power under long/medium term open access, in addition to the exchange-based transactions and different nodal agencies may (or may not) be involved in these transactions.

[20] In case the same generating station is scheduled to sell through both bilateral and exchange-based transactions through different nodal agencies, deviation of the nodal agencies from their respective schedule at international periphery shall be determined pro rata basis.

of cross-border transmission lines in the Indian grid are already in place. Likewise, the transmission charges and losses for the cross border transmission line are also in place under the prevailing cross border bilateral agreements. Hence, it is proposed that the transmission charges and losses be according to the existing regulations in the member countries.

Recommended Approach for SARPEX:

- Transmission charges on a per MWh basisas per the Point of Connection (POC) regulations and characterized by injection charges or withdrawal chargesmay be applicable respectively to the sellers or buyers for their scheduled injection or withdrawal at the international periphery.
- Similarly, the transmission losses may be applied at delivery point and categorized by POC injection losses and withdrawal losses. The sellers are required to inject more and the buyers are required to off-take less to compensate for the transmission losses at the delivery point.
- The transmission charges and losses for the cross border interconnecting line and the Member country transmission network may be as per the applicable regulations and defined rates.
- All the payments related to transmission charges be made through the nodal agency to the concerned authorities on both the sides of international periphery. Examples of transmission charges under various scenarios are discussed in Annexure VI.

Also, in case of injection/drawl by member countries through multiple interconnection points in the same region, the POC charges and losses for the use of ISTS network of India would be charged at the applicable rate irrespective of the number of points of actual injection or drawl. However, in case of multiple interconnection points in different regions, such as India-Bangladesh connectivity in E1 (West Bengal) and A1 (Tripura), the transmission charges and losses may be different and would be charged depending upon the schedules at the each interconnection point. The following table shows the representative transmission losses of member countries:

Table 3: Illustrative Transmission Charges and Loss Calculation for a Member Country Buy Type Transactions on SARPEX

Parameter	Value		Comments
	Rs/kWh	%	
Bid Quantity (MW)	108		Quantity Bid at SARPEX
Price in SARPEX	2.50		Price discovered in SARPEX
PoC Withdrawal Losses		0.02	POC Charges & Losses applicable on Member Country for using the ISTS network of India
PoC Withdrawal Charges	0.20		
Cross Border Line Losses		0.02	Cross Border Transmission line connecting the delivery point in India with Nepal/Bhutan/Bangladesh
Cross Border Line Charges	0.10		
Member Country Losses		0.04	Member Country Transmission Charges & Losses for use of its internal transmission network
Member Country Charges (Rs/kWh)	0.20		
Operating Charges	0.03		Operating Charges of NLDC (0.01 Rs/kWh) and Transaction Fee for SARPEX (0.02 Rs/kWh)
Quantum Received @ Member Country Bus (MW)	100		Quantity Received by the Member Country
Landed Price @ Member Country Bus	3.29		Landed Price to Member Country

Table 4: Illustrative Transmission Charges and Loss Calculation for a Member Country Sell Type Transactions on SARPEX

Parameter	Value		Comments
	Rs/kWh	%	
Bid Quantity (MW)	100		Quantity Bid at SARPEX
Price in SARPEX	2.50		Price discovered in SARPEX
PoC Injection Losses		0.02	POC Charges & Losses applicable on Member Country for using the ISTS network of India
PoC Injection Charges	0.20		
Cross Border Line Losses		0.02	Cross Border Transmission line connecting the delivery point in India with Nepal/Bhutan/ Bangladesh
Cross Border Line Charges	0.10		
Member Country Losses		0.04	Member Country Transmission Charges & Losses for use of its internal transmission network
Member Country Charges	0.20		
Operating Charges	0.03		Operating Charges of NLDC (0.01 Rs/kWh) and Transaction Fee for SARPEX (0.02 Rs/kWh)
Quantum Injected @ Member Country Bus (MW)	108		Quantity Injected by the Member Country Generator
Price Received @ Member Country Bus	1.81		Net back Price to Member Country Generator

Note: The Transmission Charges and Losses assumed in the above calculations are representative only.

SUMMARY

Participation pre-requisites:

Provision for NOC in the absence of OA regulations and formation of Joint Association of System Operators is recommended to foster efficient electricity trade and monitor congestion effectively. In the long-term OA regulation harmonization is recommended.

Recommendation for Scheduling:

With a view of maintaining the sovereignty of each participating country's power systems, international periphery definition is proposed along with existing bi-lateral delivery point retention. Further,nodal agencies are proposed for each participating country to coordinate electricity flow on both sides of international periphery

Recommendation for Deviation settlement:

The deviation settlement mechanism is proposed for each member country,where the settlement will be paid by the nodal agency, to the respective authorities, on behalf of all market participants. Deviation settlement will be pro-rated in the case of multi Nodal Agency involvement.

Recommendation for Transmission charges and losses treatment:

Existing regulations applicable in the member countries with regard to transmission charge and loss settlement are proposed. The payments of the transmission charges and losses shall be made through the nodal agency to the concerned authorities on both sides of international periphery.

8 Recommended Operating Timelines for SARPEX

Varying time zones need to be considered while determining operating timelines on an exchange. Bidding and clearing activities on power exchanges are typically harmonized with the time differences in each of the participating countries. The timelines for each operational activity in a DAM exchange is specified in a chronological sequence. This is critical for a seamless information exchange and coordination between the various players involved in an exchange. Any aberrations in the timelines may result in the failure of the trades or the collapse of the entire trading system. The section explains a typical trading cycle and the role of each participant.

8.1 Trading Cycle in a DAM

Typically, the activities for execution of one trading cycle in a DAM are spread across three days as described below:

- **Day "D-1" (Bidding):** For all the bidding and scheduling activities
- **Day "D" (Dispatch):** For all dispatching and clearing
- **Day "D+1" (Pay Outs):** For all the "Pay-Outs"

Major activities and the associated timelines are discussed in detail below day-wise:

1) **Day "D-1" (Bidding):** The key operations performed on Day "D-1" include:
   a) **Bidding Window:** Time at which bidders place their bids in the exchange. Opening and closing hours (10:00-12:00) are usually fixed by the exchange.
   b) **Gate Closure Time:** The time at which the last set of bids are accepted by the exchange for the calculation of MCP and MCV (usually set 12:00).
   c) **Unconstrained Solution:** The time at which the exchange computes UMCP and UMCV and sends the same to the LDC or SO (completed by 13:00).
   d) **Corridor Availability:** LDC reverts back with transmission system availability and congested transmission corridors (by 14:00).
   e) **Constrained Solution:** After accounting for the constraints for power flows from LDC, the exchange computes the ACP and ACV and short lists the final set of bidders for the following day. The information is shared with LDC or System Operator for scheduling (completed by 15:00 hours.).
   f) **Pay-in:** Selected buyer's margins are blocked against their bids and their buy orders confirmed.
   g) **Schedule Confirmation:** The LDC declares and confirms the final dispatch schedule (by 17:30 hours.).
   h) **Final Scheduling:** All the participating LDCs incorporate the final dispatch schedule into their daily schedules.

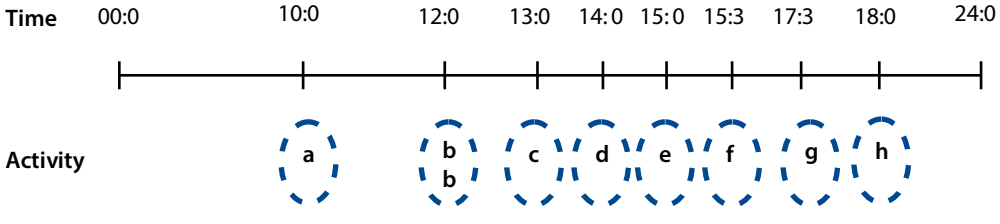


Figure 23: Timelines for each activity of Day D-1

2) **Day "D" (Dispatch):** The key operations performed on Day "D" include:

   a) **Dispatches:** All confirmed dispatches (on Day D-1) are physically delivered in their respective 15-minute time-slots (96 dispatches) during the course of 24 hours.

Figure 24: Operating Timelines of DAM as per the individual country Time Zones for Day "D+1"

3) **Day "D+1" (Pay-Outs):** The key operations performed on Day "D+1" include:

   a) **Pay-Out:** Sellers with successful dispatches confirmed by the exchange as per the schedules given out by LDC are paid against their dispatched volumes. The payment is made by the exchange into their settlement accounts.

8.2 Implications of Multi Time Zones on Operating Timelines

In a DAM,where all the players observe a single time zone, operating timelines are relatively simpler on account of time zone mismatching. On the other hand, a DAM with participants who operate in different time zones need to synchronize the operating timelines accordingly. For instance, the table below shows the time zones in BBIN countries relative to the Coordinated Universal Time[21] (UTC) and deviations from the IST.

Table 5: Time zones observed 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

This mismatch in time zones of BBIN countries has a direct implication for coordination of operational activity of the DAM. The key implications on the operating timelines are discussed below.

1. Bidding and Pay-in

The figure below highlights the mismatch observed in the timings on Days D-1. Opening time, closing time, pay-in time and other activities are impacted as a result of this. A Buyer in Nepal would expect its settlement account to be debited against its cleared bid by 15:30 hours in Nepal thereby confirming its purchase contract. Whereas as per IST the time would be 15:15 hours, with 15 minutes remaining to debit pay-in amounts from the Buyer's settlement account. Thus, a discord in the time zones results in an overall lack of clarity about the execution of activities of DAM.

[21] 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.

Table 6: Operating Timelines of DAM as per individual country Time zones for Day "D-1"

India	9:30	9:45	10:00	10:15	11:45	12:00	12:15	13:00	13:45	14:00	14:15	15:00	15:15	15:30	17:30	17:45	18:00	23:30	23:45
Nepal	9:45	10:00	10:15	10:30	12:00	12:15	12:30	13:15	14:00	14:15	14:30	15:15	15:30	15:45	17:45	18:00	18:15	23:45	0:00
Bhutan	10:00	10:15	10:30	10:45	12:15	12:30	12:45	13:30	14:15	14:30	14:45	15:30	15:45	16:00	18:00	18:15	18:30	0:00	0:15
Bangladesh	10:00	10:15	10:30	10:45	12:15	12:30	12:45	13:30	14:15	14:30	14:45	15:30	15:45	16:00	18:00	18:15	18:30	0:00	0:15

Bid Start Time | Gate Closure | NLDC checks | Pay-in | Scheduling

2. *Delivery*

Delivery of power in a DAM is for 96 blocks of 15-minute time-interval for 24-hours of a day as per the bids cleared on the previous day. The complications arising in delivery of contracts, due to differences in time zones are shown in the table below. The table shows a few dispatch slots for three consecutive days D-2, D-1 and D highlighted in different colors and indicated in the legend. As is evident from the table, the schedules or the dispatch periods at the "day boundary" i.e. Slot 95 and Slot 96, when one day ends and another begins are critical. Consider the Slots 95 and 96 highlighted in a dotted redbox. While these slots belong to Day D-1 in India as per IST, they belong to Day D, which is the next day, in Bhutan, Bangladesh and Nepal thereby leading to a mismatch and making them critical.

Table 7: Operating Timelines of DAM as per the individual country Time Zones for Day "D"

Slot	40	41	48	49	71	95	96	1	2	41	49	95	96	1	2	41	49	95	96
India	9:45	10:00	11:45	12:00	17:30	23:30	23:45	00:00	00:15	10:00	12:00	23:30	23:45	00:00	00:15	10:00	12:00	23:30	23:45
Nepal	10:00	10:15	12:00	12:15	17:45	23:45	00:00	00:15	00:30	10:15	12:15	23:45	00:00	00:15	00:30	10:15	12:15	23:45	00:00
Bhutan	10:15	10:30	12:15	12:30	18:00	00:00	00:15	00:30	00:45	10:30	12:30	00:00	00:15	00:30	00:45	10:30	12:30	00:00	00:15
Bangladesh	10:15	10:30	12:15	12:30	18:00	00:00	00:15	00:30	00:45	10:30	12:30	00:00	00:15	00:30	00:45	10:30	12:30	00:00	00:15

Critical Slots

Legend: Day D-2 | Day D-1 | Day D | Day D+1

Consider a Bidder in Nepal who wants to purchase power in the First Slot (00:00 – 00:15) of Day D (highlighted green) and for which it will expect to place the bid on the previous Day D-1 (highlighted orange). In India this first slot of Nepal has a very different connotation. Since IST is 15 minutes behind Nepal's Standard Time according to IST this First Slot of Nepal falls into Last Slot of the previous day as per IST. The deliveries for this block as per IST would thus mean dispatch from India at 23:45 hours in the Last Slot – 96 – of Day D-1, the bidding for which would have already been closed a day earlier i.e. on Day D-2.

3. *Pay-out*

The Table below shows the timing of pay-outs made by the exchange to the sellers on Day D+1 in the BBIN countries.

Table 8: Operating Timelines of DAM as per the individual country Time Zones for Day "D+1"

India	9:30	9:45	10:00	10:15	11:45	12:00	12:15	13:00	13:45	14:00	14:15	15:00	15:15	15:30	17:30	17:45	18:00	23:30	23:45
Nepal	9:45	10:00	10:15	10:30	12:00	12:15	12:30	13:15	14:00	14:15	14:30	15:15	15:30	15:45	17:45	18:00	18:15	23:45	0:00
Bhutan	10:00	10:15	10:30	10:45	12:15	12:30	12:45	13:30	14:15	14:30	14:45	15:30	15:45	16:00	18:00	18:15	18:30	0:00	0:15
Bangladesh	10:00	10:15	10:30	10:45	12:15	12:30	12:45	13:30	14:15	14:30	14:45	15:30	15:45	16:00	18:00	18:15	18:30	0:00	0:15

Pay out

The time for pay-outs as per the exchange rules is 14:00 hours (IST) on Day D+1. By 14:00 hours, pay-outs would be made in India but the seller settlement accounts in Nepal would be credited at 14:15 hours as per Nepal's standard time and 14:30 hours in Bhutan and Bangladesh as per their local standard times, resulting in a variation in the pay-out time with a change in country.

Thus, it is imperative that the various activities of a DAM are streamlined with reference to a single time zone. It is common practice for coupled exchanges operating in different time zones to follow the time zone of the established exchanges in the region. The Exchanges in other time zones align their activities with reference time zone.

Case Study

Europe operates primarily in four time zones i.e. Western European Time (WET), Central European Time (CET), Eastern European Time (EET) and Further-Eastern European Time (FEET). NordPool Spot, a major exchange has participants from the regions with CET and EET time zones. However, it follows the CET as the reference and all the activities associated with DAM from other time zones are referenced with respect to it. Similarly, OMIE has participants from two different time zones i.e. CET and WET, but the DAM is aligned to CET, since the major exchanges in Europe all referenced to CET. Similarly, the Price Coupling for Regions (PCR) has participants from almost every time zone which is present in Europe. For effective implementation of PCR, all the activities are referenced to CET.

8.3 Advantages of aligning SARPEX to a Single Time Zone

Referencing all the Exchanges to a Single Time Zone is a convenient and reliable solution as is evident from the global practices discussed above. The key advantages of aligning SARPEX to a single time zone include:

- Efficiency through streamlined activities and seamless integration
- Day-to-day bottleneck elimination
- Consistent and simple operational timelines to avoid mismatch
- Globally accepted method since major exchanges i.e. NordPool and OMIE follow the same philosophy to deal with participants from different time zones.

Recommended approach for SARPEX

It is clear from the preceding discussion that single reference time zones and SO activity coordination are critical to the operations of an exchange in a multi country context. The IST is recommended as the reference time zone on account of the electricity trade volume anticipated and prior experience in operationalizing Power Exchanges. Further, the System Operators in BBN may coordinate with the India's NLDC and exchanges to further streamline trading activities.

The suggested timeline for a DAM trading cycle on SARPEX is shown below.

Day D-1

Activity	Description	Time	Time zone
a	Bid Start Time	10:00	IST
b	Gate Closure Time	12:00	IST
c	Unconstrained Solution	13:00	IST
d	Corridor Availability	14:00	IST
e	Constrained Solution	15:00	IST
f	Pay-in	15:30	IST
g	Schedule Confirmation	17:30	IST
h	Final Scheduling	18:00	IST

Day D

Activity	Description	Time	Time zone
a	Dispatch Start Time End Time	00:00 23:45	IST IST

Day D+1

Activity	Description	Time	Time zone
a	Pay-out	14:00	IST

It is to be noted here that these timelines hold true for BBN countries as well, should BBN countries choose to align their trading activities to IST.

The key activities for Sequential Mode of Operation will be as follows:

- **Bid Invitation:** BBIN's bids accepted between 10:00-12:00 hours IST
- **Unconstrained Solution:** The unconstrained solution for all the bids will be declared at 13:00 hours IST. The UCMCP and UCMCV is first determined for the primary market and then for the sequential market. The bids that qualify in either iteration are provisionally chosen for margin requirement check.
- **Corridor Availability:** Corridor availability check to be done by the LDCs together for the bids received from BBIN countries.
- **Constrained Solution:** Once the congestion is declared by LDCs, constrained solution for all the bids received from BBIN will be declared at 15:00 hours IST. The algorithm will be run initially for the primary market and then for the sequential market to arrive at an Area Clearing Price and Area Clearing Volume for each market.

SUMMARY

- A single reference time zone is recommended for SARPEX as it promotes efficiency, consistency and bottleneck elimination
- IST is recommended as the preferred reference time zone for SARPEX's for DAM

9 Recommended Business Rules for SARPEX

SARPEX, like other exchanges around the world, needs to be governed by a certain set of rules and laws. These laws and rules are meant to facilitate the trading process on the exchange in a streamlined manner and to avert any disruptions. These rules and laws are formulated keeping in mind the benefit of all stakeholders involved and are decided upon by the mutual consent of all stakeholders viz.: electricity market regulators, market participants, exchange management and all others associated with the exchange, and are binding on the behalf of all the aforementioned stakeholders.

This section deals with the basic framework of laws and business rules for SARPEX, whose purpose is to manage the exchange, monitor and regulate the activities of its members and stakeholders and all other members associated with the exchange in any form. The laws and rules on the following are imperative for the exchange's governance:

- Bidding Platform
- Membership
- Settlement Guarantee Fund
- Clearing and Settling
- Margins and Deposits
- Trading Margin and Blocking Funds

9.1 Bidding platform

The bidding platform is a trading system consists of three major elements which work in tandem for execution of trading sessions on the exchange.

1. The user
2. The workstation and
3. Connectivity with exchange

These key elements of the Bidding Platform are highlighted sequentially in the Figure

25 below and discussed in detail in the section that follow.

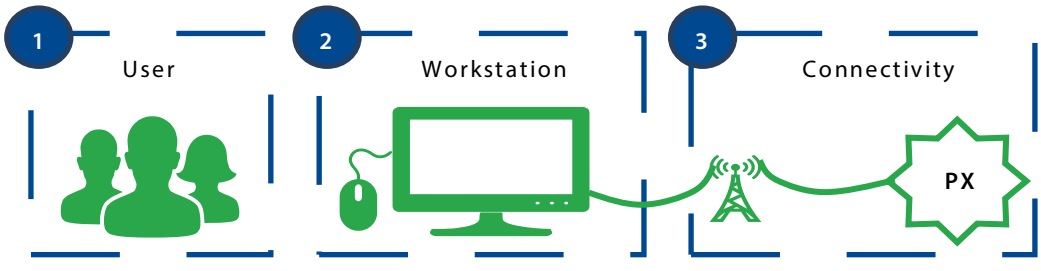


Figure 25: Key elements of a Bidding Platform

9.2 Membership

"Membership of the Exchange" entitles the members to trade and clear electricity on the exchange through sale or purchase, on their behalf as well as for their clients who are non-members, subject to the kind of Membership held.

This section broadly deals with: Qualification criteria, membership types, membership fee and documentation:

1. Qualification criteria

Anyone, individual or a firm, who is an electricity generator, trader or consumer can participate on the exchange.

The member may be an individual, partnership firm or a company registered under Companies Act, 1956

In view of pruning the risks associated with trading, some exchanges also have additional criteria of qualification,for example, IEX puts forth the criteria of minimum net worth of the firm for becoming a member.

For technical requirements of qualification, the member must have

- Standing clearance from SLDC
- Possess availability based tariff meter

2. Membership Types

A Member can associate with the exchange through three categories of memberships. These three categories differ in their rights. The membership types and their corresponding rights are discussed below:

- Type 1 – Member is entitled to trade and clear electricity contracts for self as well as for its clients. These are usually traders holding a trading license issued by appropriate authority
- Type 2 – Member in entitled to trade and clear electricity for self only. These are usually grid connected entities like generators, discoms or users.
- Type 3 – Member provides advice and support services but cannot trade or clear transactions on the exchange. These are the members who usually don't have either a trading license or are grid connected.

3. Membership Fee

Membership fee is usually a composite amount which is split across various cost heads. These costs may vary based on the type of Membership. The major cost heads are mentioned below:

- Interest Free Security Deposit – This forms a part of the Settlement Guarantee Fund and is submitted along with the membership application.[22] The deposit typically has a lock-in period and is reimbursable on surrender of membership.
- Annual Subscription Fees - Paid annually to renew membership subscription
- Processing Fees - Paid to screen and process membership applications
- Admission Fees - One-time fee payable to secure admission to the exchange
- Transaction Fees - Charged based on volume traded at a fixed rate of Rs/MWh
- Portfolio Subscription Fees - Paid while adding portfolio/s to the existing one
- Additional Deposit – Paid over and above the initial margin to settle daily contracts.

4. Documentation

Documentation implies production of relevant documents by the entity seeking membership of the exchange to:

- Act as a proof of agreement binding the exchange and the member
- Verify the information declared by the member and ensure its credibility

[22] The purpose is to give initial exposure to the Members depending upon the terms of the contract.

Either a member or a client of a member may associate with the exchange. The documentation required for both types of association is different as listed in the table below:

Table 9: Mandatory Documents Comparison for Members and Clients of Members

Members	Clients of Members
1. Membership Application Form	1. Client Registration Form
2. Bio Data	2. Member-Client Agreement
3. Board Resolution and Shareholding Pattern (in case of Firms)	3. Risk Disclosure Agreement
4. Net Worth Certificate (if necessary)	4. Undertaking by Client of a Member
5. Membership Undertaking	5. Re - dispatch
6. Settlement Bank Account Details	6. Counter trace
7. Address Proof	
8. Undertaking from all Partners (In case of Partnership Firm)	

9.3 Settlement Guarantee Fund

The exchange acts as a central counter party, responsible for payment security to all the stakeholders involved in trading operations on the exchange. This limits the participants' exposure to payment default. With a view of minimizing the exchange's exposure to default risk, a Settlement Guarantee Fund (SGF) is proposed to be. The sole purpose of this fund is payment risk management across all segments of the exchange. The following are some general features of the fund:

- The SGF generally has a minimum prescribed corpus, which first takes into account the deposits from members. Any shortfall in the corpus amount is made up for by the exchange.[23]
- All members contribute a fixed amount as prescribed by the exchange in the form of Initial Security Deposit which acts as the source of funds for the SGF
- The mode of payment is as specified by the exchange
- This amount held in the SGF is subject to a lock in period. This amount is reimbursed when membership is surrendered
- Suitable adjustments are made against the obligations and liabilities on the reimbursed amount

The funds serve to finance its own creation and maintenance. In addition to which it aids in bridging the clearing obligation shortfalls, loss or liability of the exchange arising out of clearing and paying the exchange's insurance cover which the exchange may take. The funds in SGF are also used to reimburse members surrendering their membership.

9.4 Clearing and Settlement

The Clearing and Settlement process is meant to settle the financial obligations of the members. It is a very robust process involving a number of elements working in tandem to execute the process which is entirely done electronically. The process and its elements have been discussed in detail below:

1) Clearing House – The exchange sets up a clearing house, which may or may not be a separate entity from the exchange. The clearing house is designated the responsibility to clear and settle all the trades approved by the exchange.
2) Clearing Account or Settlement Account – Every member has to open a clearing account in the exchange approved banks to effect all the financial transactions related to trading on the exchange like but not limited to margin payments, pay-in, pay-out, etc.

[23] In India, the power regulations mandate the establishment of the SGF. As per the power regulations, this amount can be invested in financial instruments but in a diversified manner, which implies funds have to be allocated across both liquid and illiquid instruments with a minimum 50% floor restriction mandating investments in highly liquid assets.

Like every Member, even the exchange operates its clearing account in the same banks. Exchange manages all the financial transactions like but not limited to receiving funds from sellers and disbursing funds to buyers through its clearing account.

3) Clearing Banks – These are the exchange Approved banks in which the members can open their clearing accounts. The exchange also holds its clearing account in these banks.

Each member has to authorize the clearing banks to allow debits and credits into their accounts by the clearing house. Thus, all the financial transactions between the exchange and its members are authorized by the clearing house and effected through their clearing accounts on their behalf at the instructions of clearing house through electronic transfers made by the clearing bank between the clearing accounts.

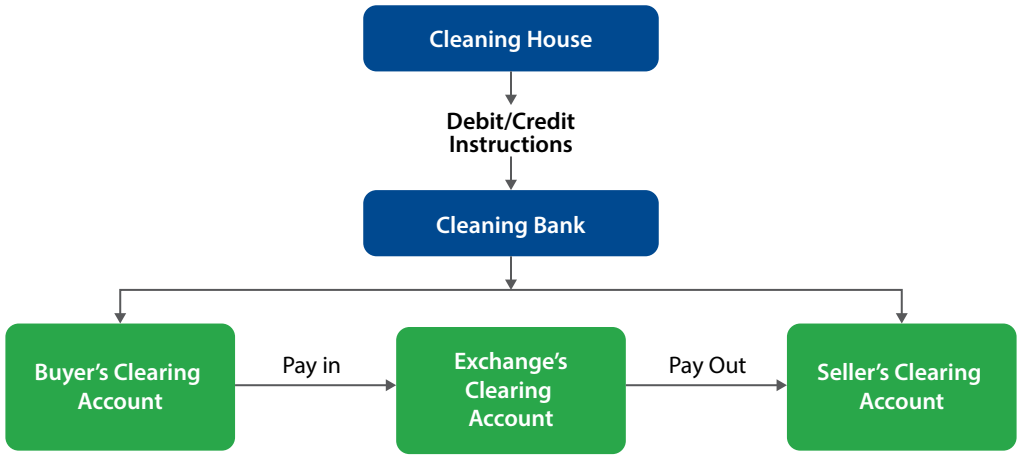


Figure 26: Representation of Clearing & Settlement process in Exchange

9.5 Margins and Deposits

9.5.1 Types of Deposits

The exchange's participants make deposits for various purposes which are binding. The types of deposits are discussed below:

1) Initial Security Deposit – The initial deposit paid by the members or their clients to participate on the exchange. This also acts as the participants' initial margin and is used to provide initial exposure to facilitate the trading process. This amount will also be used to settle contracts in case of defaults.

2) Additional Security Deposit – The exchange will compute the minimum margin each bidder needs to hold in his/her settlement account before placing a bid. This margin is computed on a daily basis and is contingent on the size of the bid and decided on by the exchange i.e. the margin can be set at par, on average or above the bid value. In case of insufficient margins the Bidder brings in additional funds to place its bid and failure to do so disqualifies the bidder form placing his bid. An additional deposit may also be demanded by the exchange in case it foresees an abnormal price increment.

3) Special Margin – Any enhanced risk may prompt the Exchange to levy additional margins to cover the risk exposure

9.5.2 Refund of Deposits

Members or their clients can seek refund of their deposits subject to terms and conditions as specified by the exchange. In the case of Initial deposit, members or clients of members may seek such a refund on surrendering their membership post a stipulated lock-in period. Additional deposits are refundable at any point of time upon intimation in a format specified by the exchange.

9.6 Trading Margin and Blocking of Funds

- Trading on the Exchange is done though a Settlement Account maintained by the participant at an Exchange-approved bank (clearing bank)
- All the payments and monetary transactions between the exchange and the bidder are processed by the clearing bank
- Trading margin is the requisite amount of money held by the bidder in its settlement account to place a bid. This margin is prescribed by the exchange and aims to avert payment defaults. It is necessary because if the margin requirement is not fulfilled and the settlement account has insufficient funds then the bidder may not be permitted to place its bid.

After gate closure i.e. bidding window closes, during the trading process the funds in the clearing accounts of the bidders are blocked for trading till the obligations of each of the bidders are met. The clearing accounts at this point will have a minimum amount equal to the trading margin which will be blocked during the trading process. No withdrawal is permitted from the clearing accounts during this period, even if the account has funds in excess of what is required. Once the bid is cleared, the participant need to either maintain a balance equal to the bid value or deposit additional funds as may be the requirement. In case the bidder fails to maintain this balance,the transaction stands null and void even if it qualifies the MCP. To avoid the disqualification it is advisable to keep sufficient margins and an additional balance to account for trade value variations.

SUMMARY

This section outlines the proposed Rules and Bye-laws for SARPEX under the following 4 sections:

Bidding Platform

The three major features – User, Workstation and Connectivity are discussed in relation to operating guidelines and the rules that govern participation on the exchange

Membership

Membership is discussed in terms of qualification requisites, membership types, fees and documentation

Settlement Guarantee Fund

The need and operations of a Settlement Guarantee Fund are discussed

Clearing and Settlement

The clearing and settlement process is also discussed with reference to key entities involved in the process

Margins and Deposits

Discussed in relation to types of deposits and conditions for refund (if any). And finally the importance of maintaining sufficient trading margins to avoid disqualification.

10 Recommended Currency for SARPEX

This section compares the benefits and limitations of using single and multiple currencies on SARPEX. The choice between single and multiple currencies have a bearing on market design, bidder participation and consequently liquidity as well. The ease with which participants can transact, translates into greater participation which in turn aids in increasing market competitiveness. Market competitiveness is a requisite for achieving an efficient market clearing price and volume. Further, it also improves market liquidity, which makes the Exchange an attractive option for potential participants to trade on.

A single currency is recommended for the following reasons:

- Maintains clear, non-discriminatory, transparent information dissemination
- Promotes liquidity and stability in prices and the economy by dealing in one strong currency
- Exchange rate fluctuation managed by local banks as opposed to the exchange reducing financial exposure
- Lower transaction costs owing to fewer intermediaries required to transact in a single currency environment

SARPEX Context

Key considerations while choosing between the two options broadly include:

- Participant's preference is related to the quantity of trade. That is the volumes traded should be significant enough to warrant a preference of one currency over another.
- Physical market structure also aids in determining the merits of a single and multiple currency system. The country-wise distribution of consumers and volumes traded impact not only the choice of a single or multiple currency systems but also the decision of which currency to use.
- Level of financial market development determines the feasibility of a multi-currency arrangement for the power exchange.

In keeping with figure below it is evident that only countries with significantly developed financial markets and equitable geographical distribution of bidders among participating countries warrant the multiple currency system. Also, while trading in multiple currencies could improve the exchange's attractiveness, it increases complexity and exposes the exchange to currency exchange fluctuations.

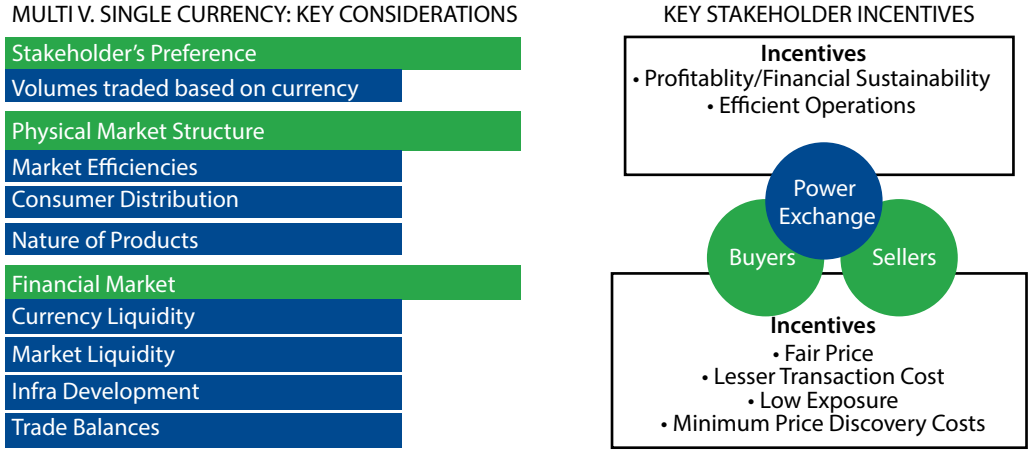


Figure 27: Key Considerations and Incentives for Choice of Currency

Participants Preference:

The four countries trading on the SARPEX – BBIN, significantly vary from one another in terms of electricity demand and supply. Further, Bangladesh is a net importer of electricity while Bhutan is a net exporter. Nepal and India both import and export electricity. The demand of a country like India is significantly greater than that of Bhutan or Nepal. In keeping with the above the volume traded is greater in the case of India than the other countries.

Physical Market Structure:

While BBIN have existing physical interconnections that are currently used for cross-border electricity trade, there is scope for improvement on this front. Grid integration and transmission line development is underway to improve market efficiencies in the region. In the context of information dissemination, the region is deficient in evolved means of communications and dedicated infrastructure for the same. In lieu of the existing stage of physical market development, some inefficiencies and complexities are anticipated, which make single currency a favored option. In terms of market distribution, consumer presence is skewed toward India at present owing to the presence of Open Access regulations.

Financial Market Development:

The financial markets are developed at different levels in these four countries. India's financial market infrastructure is relatively more developed, making the Indian currency widely accepted and consequently liquid. Further the anticipated transactions on SARPEX will likely be similar to existing regional exchanges i.e. IEX, PXIL as shown below:

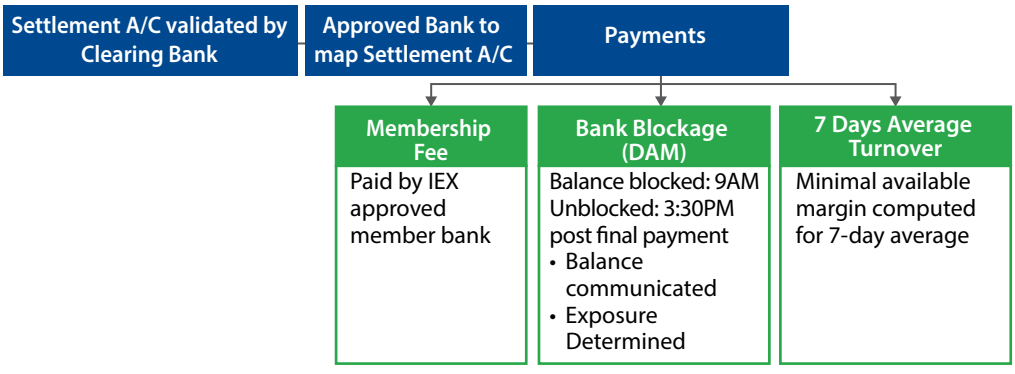


Figure 28: Indian DAM Exchange Transaction Mapping

While single currency is best suited, another option that can be explored is the currency service. A currency service (as in the case of Nord Pool) is offered to participants where each member country may trade in their own currency. The exchange takes on the exposure of fluctuation and treats this service as a value-added service which comes at a cost to those who may avail it. Further, a base currency is also declared which is the currency in which all trades are reflected.

Recommended Approach for SARPEX

Single Currency:

The demand and supply in the SARPEX is anticipated to come from Bangladesh, Bhutan, India and Nepal initially. The purchasing power parity between these four countries is not significantly different. Further, majority of the demand and supply is anticipated to come from the Indian sub-continent which skews the participants' geographical distribution in favor of India. Owing to the wide acceptability of the Indian currency in the global financial market, a single currency arrangement dealing in Indian Rupees (INR) is recommended as a viable option for SARPEX.

SUMMARY

The ultimate decision between single and multiple currency lies with the concerned authorities of the four countries. However, in keeping with the above, the following recommendations are made for SARPEX:

- The single currency arrangement is favored over the multiple currency for SARPEX since it is simple, lowers transaction costs and avoids exposure to exchange-rate fluctuation
- INR is the recommended currency for the single currency system seen as it is as a widely used currency which helps achieve the exchange's liquidity objective and foster participation.

11 Recommended Mechanism for Dispute Resolution for SARPEX

Dispute resolution is an important component of electricity market design. A neutral and efficient resolution mechanism inspires confidence and participation among bidders. This section discusses the prevalent dispute resolution mechanisms in BBIN and the need for an overarching regulation and framework to resolve disputes on SARPEX. The existing mechanisms pertain to either intra-country electricity trade disputes or disputes arising from bilateral trade. All power trading transactions on the proposed power exchange, SARPEX, are between the bidder and the exchange. Therefore, any disputes that may arise will be resolved between the exchange and bidder.

Current Scenario

India: IEX and PXIL

All transactions are governed by the concerned Indian law. The courts of New Delhi, India have the exclusive jurisdiction to determine any dispute in relation to or arising under or in connection with these Bye-Laws, the Rules and Business Rules.

Indian power exchanges i.e. IEX, PXIL, may bring proceedings in any other competent jurisdiction against a member to enforce the obligations of the member. In case of any dispute or difference in opinion originating from orders or transaction mismatch, the exchange's report is final, conclusive and binding on the members. Arbitration shall be in accordance with the provisions of the Arbitration &Conciliation Act, 1996

Bangladesh

The Bangladesh Electricity Committee (BERC) Act, 2003and subsequent amendment in 2005providefordispute settlement by the Commission. Also, the Arbitration Act 2001governsthearbitrationproceedings. Thecontractisopentointernationalarbitrationaswellasenforcementofforeignarbitralawardthroughlocalcourts.

Bhutan

Bhutan Sustainable Hydro power Development Policy, 2008 prescribes that dispute resolution be done through he matter may be resolved through disputere solution mechanism as specified in the Project Development Agreement (PDA) and Concession Agreement(CA)

Nepal

Nepal's dispute resolution mechanism is currently part of the bilateral contractual agreements it enters into with other countries. In the case of India-Nepal electricity trade the Umbrella Agreement, 2006 outlines the dispute settlement mechanism.

Precedence: Cross border trade between India and BBN

The recent power purchase agreement between India and Bangladesh follows Rules of Arbitration of Singapore International Arbitration Centre (SIAC Rules) for the purpose of arbitration. The other options such as international dispute resolution procedures like UNCITRAL and ICSID may also be explored. As per the Behrampur PPA (short-term PPA between India and Bangladesh), the binding law on all parties is the Law of England.

Recommended Approach for SARPEX

While developing a dispute resolution mechanism, the following must be considered:

- Existing laws and regulations, including electricity trade laws and regulations that already exist for cross border trade between BBIN as well as the prevalent local laws and regulations. SARPEX's dispute resolution will ideally need to take precedence over the local regulations for agreements on the exchange to be legally binding.
- Inter-country trade agreements and their specific dispute resolution mechanisms.
- Participant countries' willingness to participate and alter laws to include SARPEX's dispute resolution mechanism.
- Conflict of interest with existing dispute resolution mechanisms both in and between BBIN.

SUMMARY

International practices indicate that transparent, fair and commonly accepted legal frameworks are essential as they help mitigate risk and facilitate investor interest and confidence. In the case of SARPEX, it is recommended that all participating countries agree upon a common overarching dispute resolution mechanism which takes precedence over local power market regulations. Thus inspiring confidence through a transparent and unbiased market place.

Annexure 1

Agreements	Countries Involved
1. NTPC has a long-term PPA of 250MW with BPDB at 2.4 to 2.86 Rs/kWh -CERC determined tariff regulations.	India-Bangladesh
2. Medium-term PPA of 250MW from Adanito BPDB in the range of 4.26 to 5.0 Rs/kWh -similar to many medium term contracts in India. e.g. levelized tariff adopted in Bihar, AP, Telangana is 4.41, 4.32 & 4.15 Rs/kWh respectively.	India-Bangladesh
3. TC has sourced power competitively for its ST sales to Nepal at prices as low as 3.25 Rs/kWh in FY16. ST prices in the same period in Northern region were in the range of 3.0 to 3.40 Rs/kWh	India-Nepal
4. Daggachu HPP in Bhutan sold power to NPCL, ESIL, TPC Mumbai DISCOMS in the range of 1.99 to 3.0 Rs/kWh.	India-Bhutan
5. GMR has signed an MoU with Nepal and Bangladesh for Sale of power in in Bangladesh from its hydro plants in Nepal	India-Nepal-Bangladesh

Prices in each bilateral agreement vary on account of different price determination and discovery methods. In the case 1 and 2 commercial mechanisms for price discovery & convergence were used. In case 4, the price is relatively lower since short-term bilateral prices between India and Nepal had progressively reduced.

II. Power Exchange Market Design – Case Studies

(a) Nordic Electricity Market- Nord Pool: Example of a successful DAM with efficiency as a primary objective

The objective of Nord Pool financial market is to provide an efficient market, with excellent liquidity and a high level of security to offer a number of financial power contracts that can be used profitably by a variety of customer groups.

Infrastructure and Scheduling:

The existence of a transmission system linking Denmark, Norway, Sweden and Finland provides the basis for physical electricity exchanges organized on a national basis for these countries. The national transmission system operators (TSOs) are responsible for reliability and balance settlements. Nordel facilitates co-operation between these TSOs and deals with planning, operation and transmission pricing.

Products

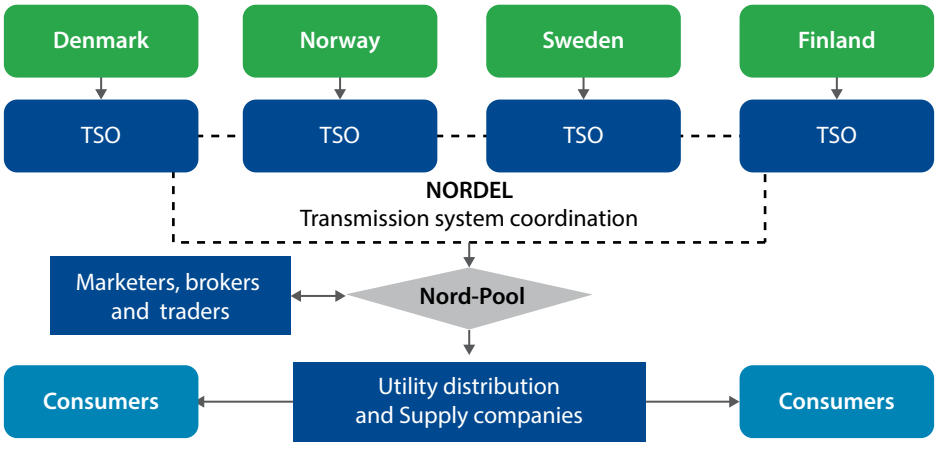


Figure 29: Nordic electricity market-major contractual relationships

Standardized physical and financial power contracts including clearing services. Elspot and Elbas are Nord Pool auction based spot market for trade in power contracts for physical delivery. Elspot trades in Day-ahead hourly power contracts are traded daily for physical delivery. Elbas trades in continuously adjusted hourly contracts, performed until one hour before the delivery hour. New contracts are opened after the day-ahead Elspot prices have been set. Bidding and Market Clearing Mechanism:

Market Clearing and Congestion Management

Exchanges such as California and Nord Pool operate on the principles of self-scheduling and market clearing as opposed to Optimized schedules. The spot price for the Nordic electricity market is set by Nord Pool every hour.

(b)California Electricity Market- CAISO and PX - Poor market design leading to bankruptcy

The competitive electric power market of California state began operation in 1998 with the California Independent System Operator (CAISO) along with the now bankrupt Power Exchange (PX) as the key operationally market facilitators. The CAISO was originally designed to operate in conjunction with the PX, a day-ahead energy market that ceased to operate in January 2001. The market took off smoothly, and the prices were seemingly just and reasonable until May 2000, when the first signs of market crisis emerged. California's electricity crisis was the result of the collusion of a shortage of resources, poorly designed market and inaction by regulators or "regulatory failure" [16]. Without PX day-ahead market, all short-term balancing of supply and demand has been pushed into the more volatile real-time market. This is the result of flaws in original design and inconsistencies between the ISO's forward and real-time markets.

(c) BELPEX & Nord Pool – Market coupling precedence

The Belpex market zone is implicitly coupled with other market zones via the Belpex DAM. The Belgian day-ahead market (Belpex DAM) is coupled with the Netherlands, Luxembourg, Great Britain, Germany/Austria, France, Norway, Sweden, Finland, Denmark, Estonia, Poland, Portugal, Spain, Latvia, Estonia and Lithuania.

Scheduling allocation to maintain grid stability – BELPEX: Open Access and Nominations

BELPEX DAM: *Implicit cross-border allocation:* a buyer or seller of electricity has automatically access to transmission capacity by submitting orders to the power exchange. Energy and transmission capacity are thus traded together. At the end of the day-ahead market, each Balance Responsible Party (BRP) submits a balanced portfolio to the TSO (i.e., so-called nominations). These nominations give the planned generation or consumption for every unit of the BRP. The nominations differ from the Belpex DAM market clearing in three aspects; nominations contain all planned generation or consumption (only part of it is traded on the Belpex), nominations are made on plant level whereas electricity is traded on BRP level on Belpex DAM, and nominations have a quarter-hourly time resolution whereas Belpex DAM has an hourly time resolution. In Belgium, a BRP has to submit its day-ahead portfolio to Elia by 2 p.m. day-ahead. This allows the BRP to account for all cross-border electricity traded and manage congestion and grid stability better.

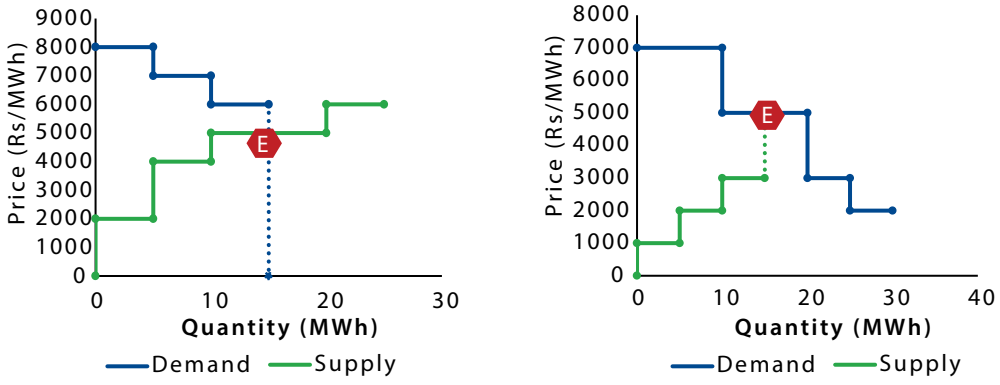
III. Non-intersecting Curves: Volume allocation using Extrapolation for Multiple Bids at the Same Price

Supply:

When more than one supplier places an equally priced bid at MCP, as shown in the adjoining graph, the volume is allocated on a pro-rated basis. The cleared volume at MCP (Rs. 5,000) is 5 MWh. Suppliers with equally priced bids will get a pro-rated volume allocation, which means both such suppliers will be allocated 2 and 3 MWh of volume respectively.

As in the case with the multiple suppliers bidding the same price, when more than one bidder places an equally priced bid. Volume is allocated on a pro-rated basis. This means at the price of Rs 5,000/MWh instead of one bidder placing a 10 MWh bid as is the case above, there can be more than one bidder placing bids at the same price point, say two

bidders placing bids of 4 and 6 MWh each, summing up to 10 MWh. The cleared volume at this price point still is 5 MWh. In such a case both the equally placed bidders will get a pro rata based volume allocation, which means both such bidders will be allocated 2 and 3 MWh of volume respectively.

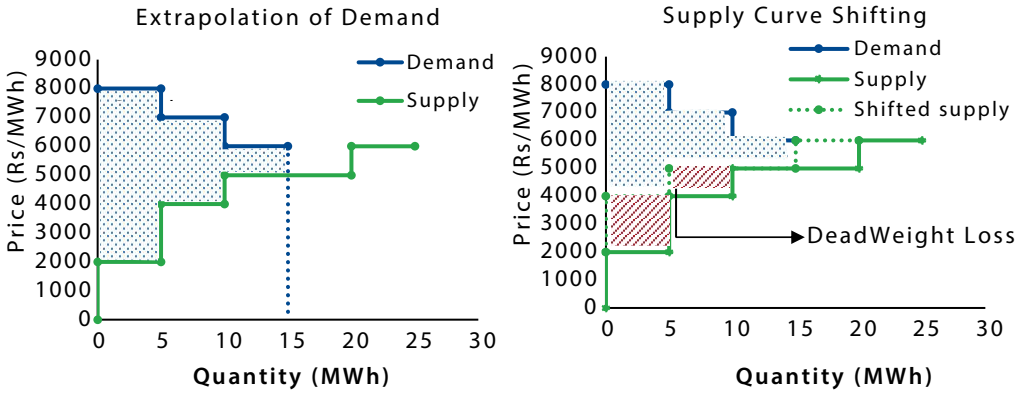


IV. Rational for choosing Extrapolation over Shifting of Curves

Extrapolation results in maximum social welfare while Shifting of Curve reduces Social Welfare and results in Dead Weight Loss (amount of welfare which the society cannot benefit from). This is true for oversupply and over demand scenarios.

Oversupply

The graph on the left depicts the case when the AD curve has been extrapolated to generate the point of equilibrium and thus arrive at the MCP and MCV. Here the shaded area represents the Total Welfare, which is the sum of Consumer Surplus and Producer Surplus. This area sums up to Rs 50,000 under the Extrapolation method and Rs 35,000 under the shifting of curves method. The area shaded in red represents the Welfare foregone, which is the Dead Weight Loss generated, equal to Rs 15,000.

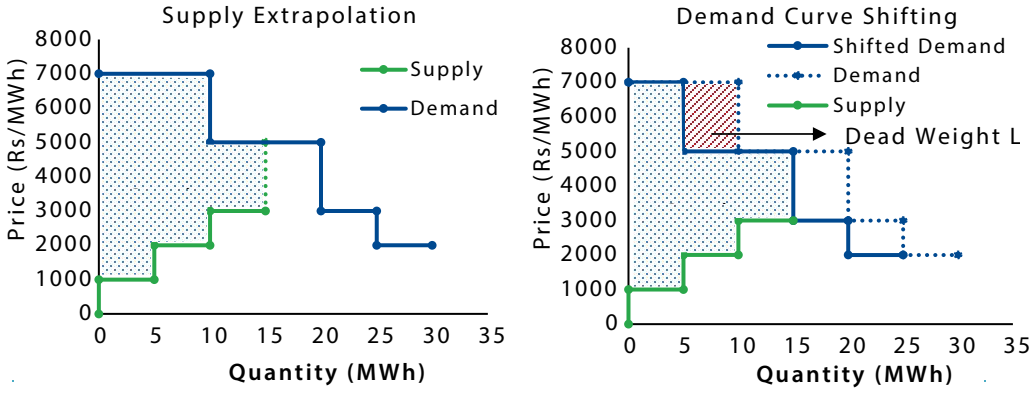


Over-supply: Social Welfare generated under each Method

Extrapolation of Demand curve (All values in Rs, MCV in MWh)					
MCP	MCV	Producer Surplus	Consumer Surplus	Total Surplus	Dead Weight Loss
5,000	15	20,000	30,000	50,000	0
Extrapolation of Demand curve (All values in Rs, MCV in MWh)					
6,000	15	20,000	15,000	35,000	15,000

Over demand

Total welfare using extrapolation sums up to Rs. 65,000 while shifting of curves method only yields Rs. 55,000. The resulting Dead Weight Loss generated, is equal to Rs 10,000.



Over-demand: social welfare generated under each method

Extrapolation of Demand curve (All values in Rs, MCV in MWh)					
MCP	MCV	Producer Surplus	Consumer Surplus	Total Surplus	Dead Weight Loss
5,000	15	45,000	20,000	65,000	0
Extrapolation of Demand curve (All values in Rs, MCV in MWh)					
3,000	15	15,000	40,000	55,000	10,000

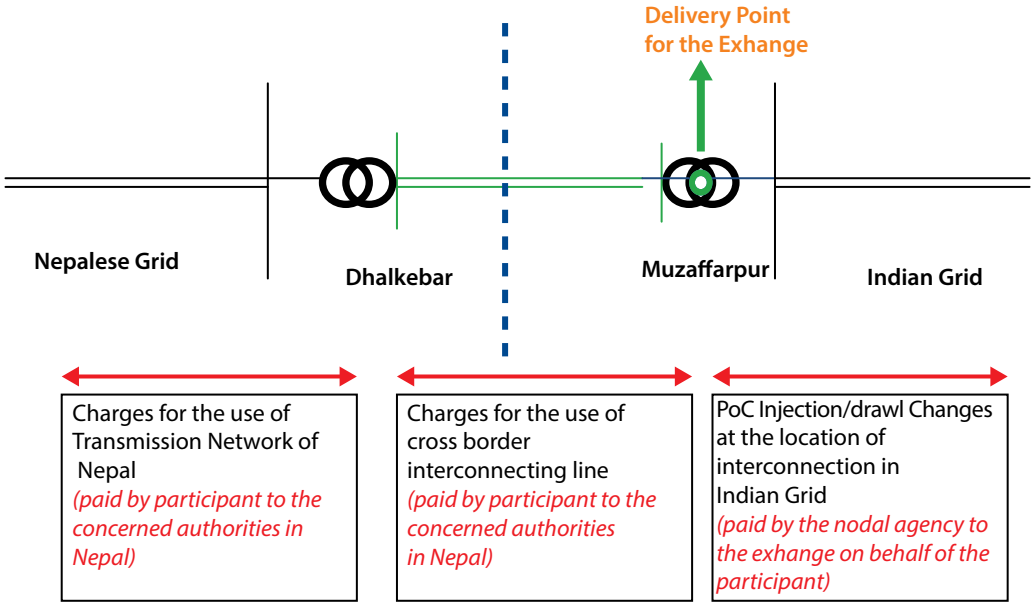
V. Existing Bid Areas in India

#	Bid Area	Region	States covered under Bid Area
1.	N1	North Region	Jammu and Kashmir, Himachal Pradesh, Chandigarh, Haryana
2.	N2	North Region	Uttar Pradesh, Uttaranchal, Rajasthan, Delhi
3.	N3	North Region	Punjab
4.	E1	East Region	West Bengal, Sikkim, Bihar, Jharkhand
5.	E2	East Region	Orissa
6.	W1	West Region	Madhya Pradesh
7.	W2	West Region	Maharashtra, Gujarat, Daman and Diu, Dadar and Nagar Haveli, North Goa
8.	W3	West Region	Chhattisgarh
9.	S1	South Region	Andhra Pradesh, Telangana, Karnataka, Pondicherry (Yanam), South Goa
10.	S2	South Region	Tamil Nadu, Kerala, Pondicherry (Puducherry), Pondicherry (Karaikal), Pondicherry (Mahe)
11.	A1	North East Region	Tripura, Meghalaya, Manipur, Mizoram, Nagaland
12.	A2	North East Region	Assam, Arunachal Pradesh

VI. Transmission charges and losses under various scenarios

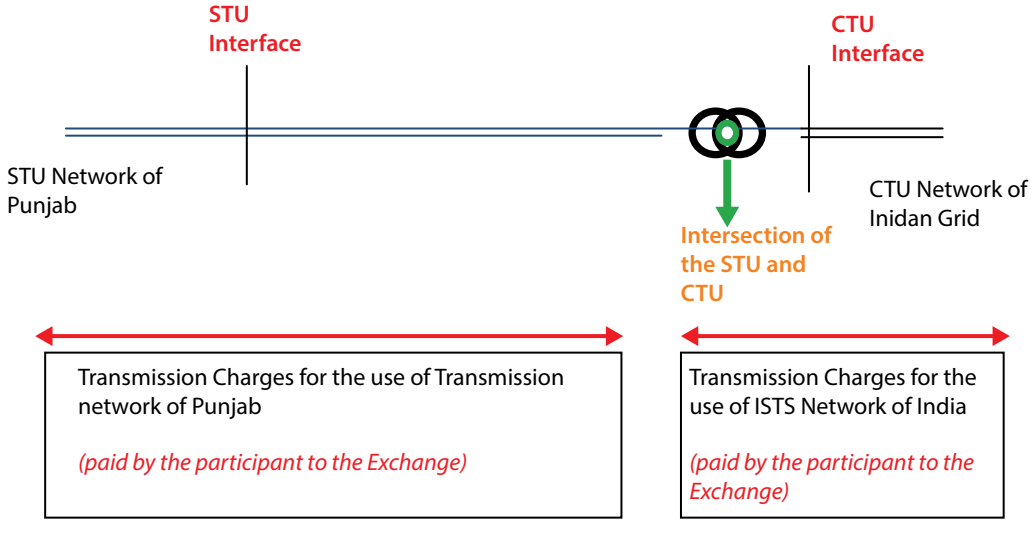
Example 1: Under all transactions on SARPEX, a generator/buyer located in Nepal shall pay all the transmission charges up-to the delivery point to the concerned authorities in Nepal and the POC injection/drawl charge into the Indian Grid (on the account of the participant) shall be paid by the nodal agency to the Exchange.

Transmission Charge Settlement for Participants from India and Nepal



Example 2: A generator/buyer embedded in the STU network of Punjab (India) shall pay the transmission charges for the use of intra-state and inter-state transmission network to the Exchange, as per the existing regulations of CERC.

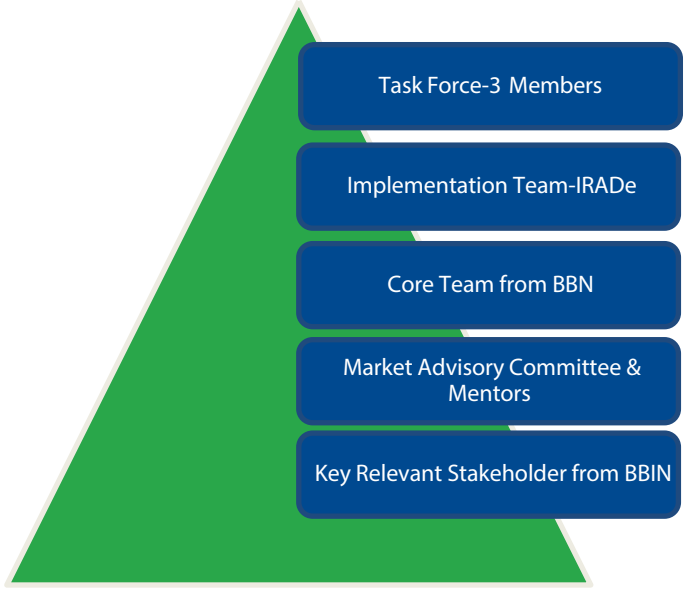
Transmission charge settlement for Indian Participants



Annexure 2: SARPEX Mock Exercise Team

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

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)

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 broad-based 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