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Mock Exercise for South Asian Regional Power Exchange (SARPEX)

MARKET RULES & DESIGN FOR PILOT MARKET

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OUTLINE

CONTEXT

1. DAY AHEAD MARKET (DAM) EXCHANGE IN BANGLADESH, BHUTAN, INDIA & NEPAL (BBIN)
2. BBIN MARKET DESIGN IMPERATIVES

SARPEX PILOT

1. SOUTH ASIAN REGIONAL POWER EXCHANGE (SARPEX) PILOT
2. BID SUBMISSION & AGGREGATION
3. PROPOSED MARKET CLEARING MECHANISM - PRICE & VOLUME DETERMINATION
    i. STEP-WISE & PIECE-WISE ALGORITHMS - COMPARISON
4. CURVE NON-CONVERGENCE, CONGESTION & SETTLEMENT OPTIONS
5. PROPOSED MODE OF OPERATION
    i. UNIFIED MODE
    ii. SEQUENTIAL MODE
    iii. UNIFIED AND SEQUENTIAL MODE COMPARISON

SARPEX MARKET DESIGN CONSIDERATIONS

1. GRID OPERATION – BID AREAS AND TRANSMISSION CAPACITY ALLOCATION
2. PROPOSED OPERATIONAL RULES
    i. ILLUSTRATIVE MEMBER COUNTRY TRANSMISSION CHARGES AND LOSSES
3. PROPOSED OPERATING TIMELINES
4. CURRENCY

ANNEXURE

DAY AHEAD MARKET (DAM) EXCHANGE IN BANGLADESH, BHUTAN, INDIA & NEPAL (BBIN)

Cross Border Electricity Trade (CBET) is currently only in the form of Bilateral Contracts - the following limitations however exist:

- No explicit co-ordination
- Prices not market-determined
- Ineffective real-time balancing
- Expensive on account of Contract Customization

Alternate/Complementary Trading Mechanism

DAM Exchange allows for:

- ✓ Market-determined prices
- ✓ Price transparency, efficient price signals and competition
- ✓ Greater flexibility since trades are on a short-term requirements and production capability basis
- ✓ Enhanced grid stability through real-time balancing and better coordination between all operating markets and dispatch schedules
- ✓ Assured transaction security on account of explicitly stated contingency plans in case of non-delivery and non-payment
- ✓ Economic dispatch

South Asian Power Exchange (SARPEX) is proposed for DAM to enable closer to real-time balancing and Social Welfare Maximization (SWM)

BBIN MARKET DESIGN IMPERATIVES

Current Scenario:

- India has two Power Exchanges i.e. IEX and PXIL, operational for the last 10 years
- Bangladesh, Nepal and Bhutan have also expressed their desire to trade by way of a Power Exchanges

Electricity Law, Policy and Regulatory Constraints:

- Existing regulations governing the BBIN's Power Sector can be streamlined to introduce Power Exchanges
- A basic framework in the form of either guidelines or an agreement may be used, until a formal legal and regulatory framework is in place

Demand-side and Supply-side Constraints:

- Three additional buy or sell side bids are anticipated post BBN's inclusion
- The magnitude of power supply / demand or number of players is not expected to be significant in the near-term.

Thickness and Liquidity:

- Thickness and liquidity anticipated to be limited in initial years
- The Exchange based cross-border trades elsewhere have also developed with limited number of transactions. For e.g. Nord Pool
- Over time, trades get a fillip with implementation of formal institutional frameworks and maturity of markets

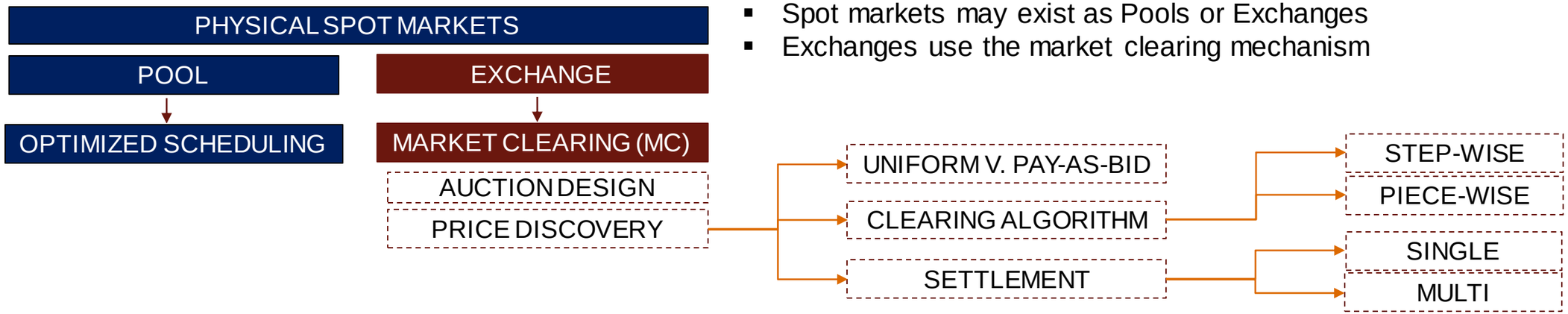
Products:

- Transactions on Exchange may be initiated with the primary products such as the DAM spot. Initially, a designated agency from the Indian side may enable setting up transactions with BBN on Exchanges.

- **SWM and efficiency are also factored in while determining SARPEX's pricing and matching mechanisms**
- **However the Pilot SARPEX assumes no grid constraints and so produces an unconstrained solution**

SARPEX PILOT:
MARKET RULES & DESIGN

SOUTH ASIAN REGION POWER EXCHANGE (SARPEX)



- Spot markets may exist as Pools or Exchanges
- Exchanges use the market clearing mechanism

MC mechanism arrives at a Market Clearing Price (MCP) & Volume (MCV).

BID AGGREGATION → **CLEARING ALGORITHM** → **SETTLEMENT**

Takeaways:

- Double Sided Closed Bids (DSCB) is proposed as part of the auction design
- SARPEX being an exchange will use the Market Clearing mechanism to determine MCP AND MCV
- Price discovered through Uniform Pricing as opposed to PAB mechanism since it maximizes SW

BID SUBMISSION & AGGREGATION

BID SUBMISSION

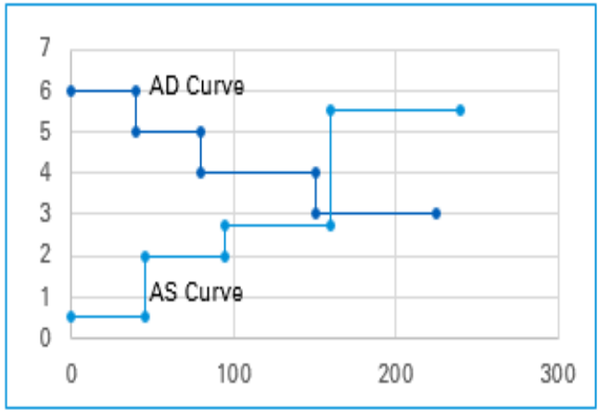
- DSCB bids (buy and sell), as described below are submitted for each 15-minute time interval in a day
- All bidders trade with the Exchange i.e. SARPEX is the counter-party to all agreements to buy and sell on the Exchange.

BID AGGREGATION

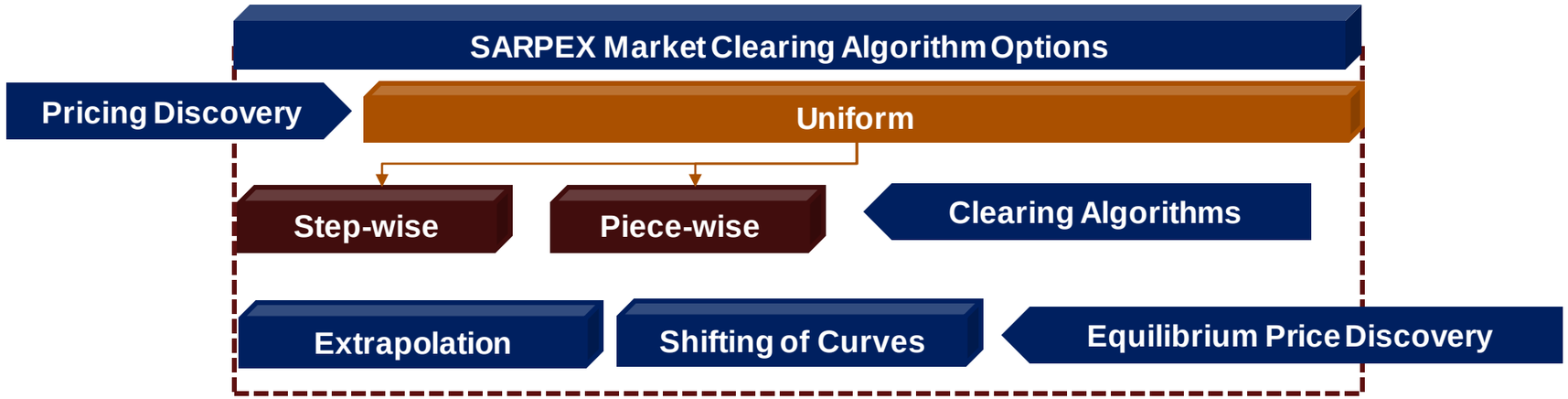
Sample Bids for a time period

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



PROPOSED MARKET CLEARING MECHANISM - PRICE & VOLUME DETERMINATION

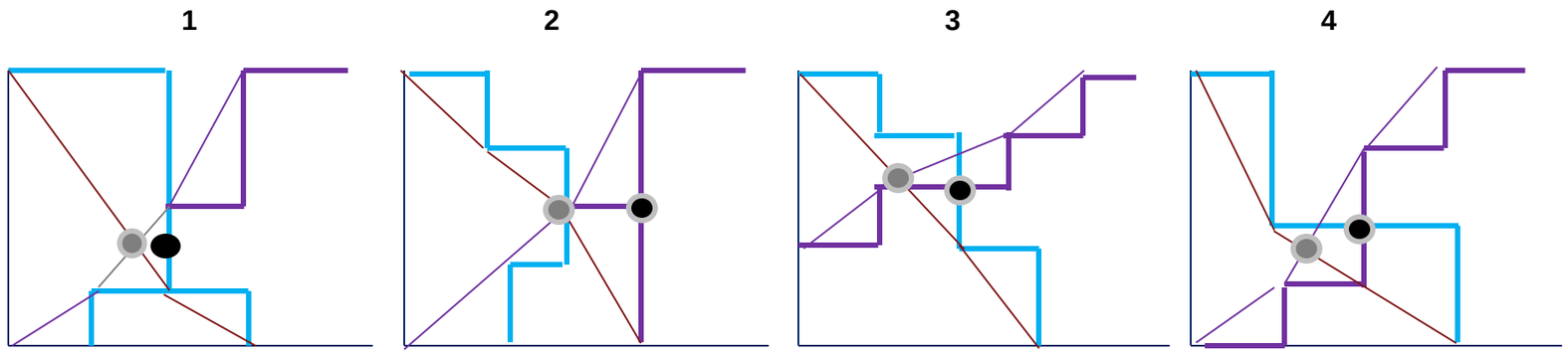


- Clearing algorithms match bids based on demand-supply equilibrium to arrive at a Market Clearing Price & Volume (MCP & MCV)
- Step-wise and Piece wise are two predominantly used market clearing algorithms

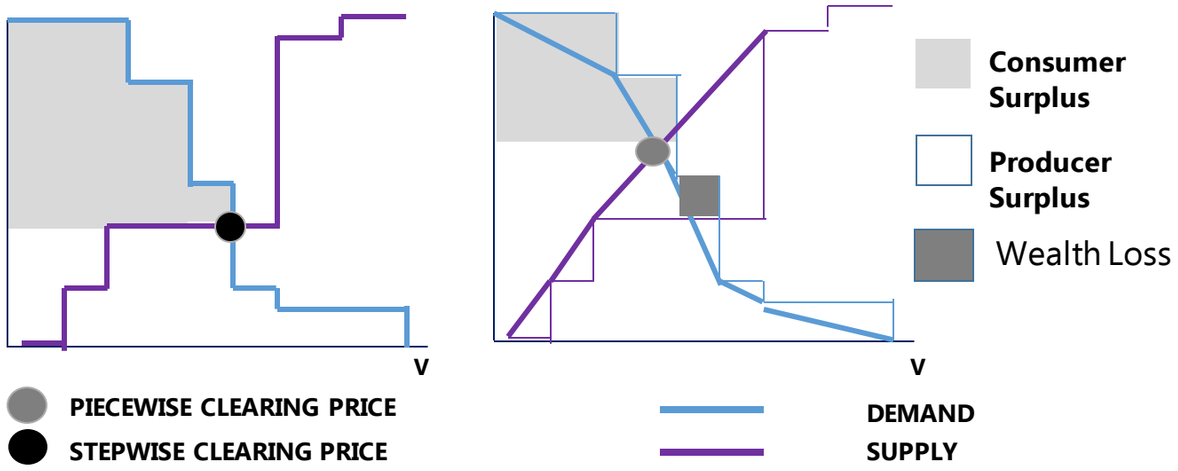
Criteria	Step-wise Approach	Piece-wise Approach
Curve Construction	Simple aggregation	Linear interpolation
Price Determination	Curve intersection point	Curve intersection point
Resulting Price	Single or multiple prices	Single Price
Volume Determination	Curve Intersection	Cleared volume determination not clearly outlined. Clearing price and bids compared to arrive at volume traded.

STEP-WISE & PIECE-WISE APPROACHES COMPARISON

COMPARISON BETWEEN PIECE-WISE & STEP-WISE – PRICE & VOLUME DETERMINATION

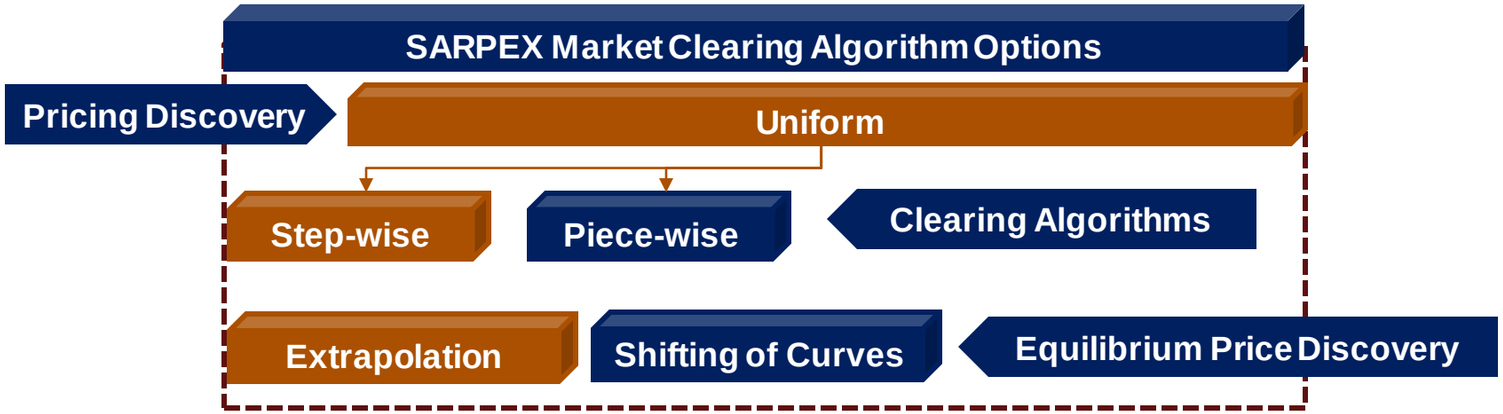


COMPARISON BETWEEN PIECE-WISE & STEP-WISE – WEALTH DISTRIBUTION



COMPARISON TABLE IN ANNEXURE

CURVE NON-CONVERGENCE, CONGESTION & SETTLEMENT OPTIONS



NON-CONVERGENCE: EXTRAPOLATION METHOD

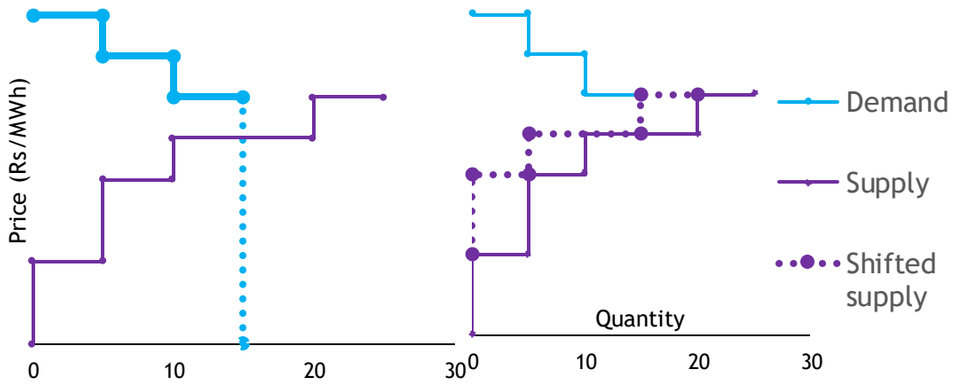
- Extrapolation and Shifting of Curves explored to address this issue
- The first method extrapolates one of the non-intersecting curves while the second method shifts one of the curves to arrive at a MCP/MCV

FURTHER EXPLANATION

CONGESTION (SARPEX Pilot assumes no such constraints)

- Market Splitting preferred to address this challenge
- In the event of congestion prices may vary between areas

CASE OF NON-CONVERGENCE DUE TO OVERSUPPLY



EXTRAPOLATION SHIFTING OF CURVES

SETTLEMENT SYSTEM

- Single settlement uses day-ahead bids to schedule but determines prices based on real-time dispatch, unlike multi-settlement which schedules and settles bids on the same day. **Multi-settlement is the preferred method of settlement**

PROPOSED MODES OF OPERATION

OPTION 1 – UNIFIED MODE

The bids from the Indian participants and BBN countries' participants would be cleared simultaneously.

OPTION 2 – SEQUENTIAL MODE (RESIDUAL MODE)

The bids from the Indian participants and BBN countries will be cleared in a sequential manner.

Both modes of operation are discussed on the basis of the structure, conduct and performance paradigms

Structure

Refers to the organization and structure of the DAM. The choice of trading arrangements – exchange over pool, and the auction design – DSCB, form part of the structure.

Conduct

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 on social welfare maximization and wealth distribution

UNIFIED MODE

Structure:

- BBN introduced as new bidding areas
- Trading on a 15-minute intervals
- DSCB Auction model
- Price discovery through Uniform Market Clearing Price mechanism

Conduct:

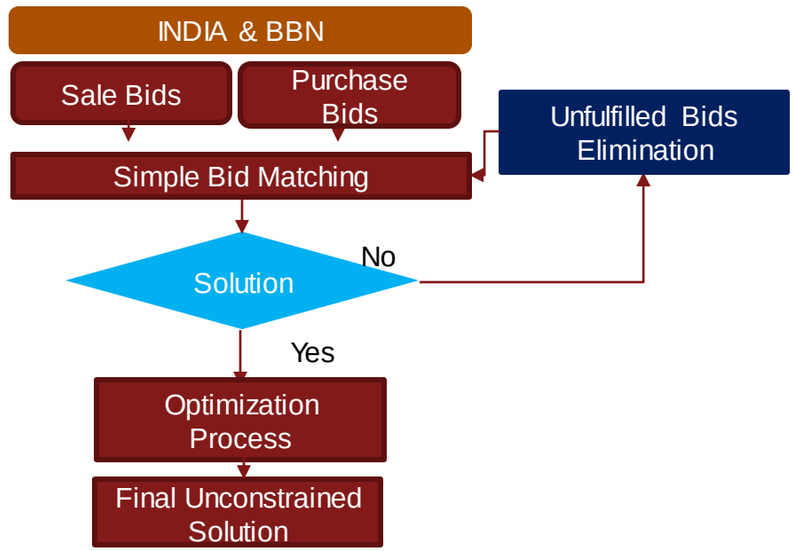
- Uniform Pricing
- Step-wise algorithm
- Extrapolation method in case of non-convergence of curves

Performance:

- The total SW of the Indian and BBN's market changes
- There may be a redistribution of the SW in terms of consumer surplus and producer surpluses for India and BBN

SARPEX's CLEARING ALGORITHM

UNIFIED MODE – 15 MINUTE DAM INTERVAL



THE PILOT SARPEX ASSUMES NO GRID CONSTRAINTS

SEQUENTIAL (RESIDUAL) MODE

Structure:

- *Same as Unified Mode*

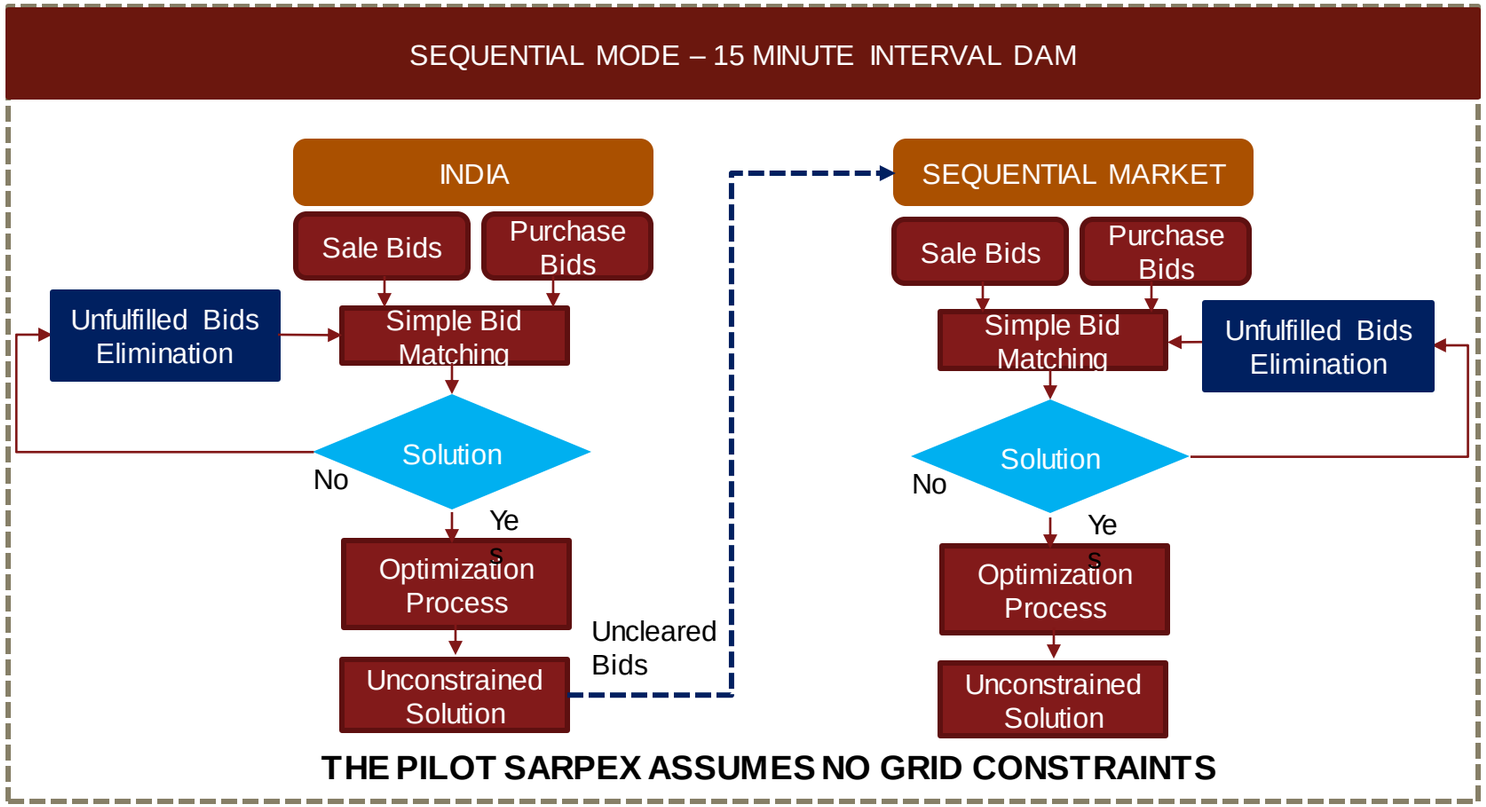
Conduct:

- Price discovery same as in Unified Mode.
- Exchange's simulation engine modified to initiate another round of iteration
- Price discovery occurs in two steps, one for each market

Performance:

- SWM and its distribution needs to be applied to both markets
- Minimal Impact on the Indian Market

SARPEX's CLEARING ALGORITHM



UNIFIED AND SEQUENTIAL MODE COMPARISON

UNIFIED MODE	SEQUENTIAL MODE
▪ Level of price impact on Indian market will be ascertained through pilot market simulations	▪ Impact on Indian market may be reduced.
▪ Efficient resource utilization	▪ Resource allocation may be lower
▪ Efficient price discovery and single pricing signals	▪ Bid-ask spread increase and lowering of liquidity ▪ Multiple price signals for the market participants
▪ Business Rules and Bye-laws extension to accommodate BBN	▪ The Business Rules, Bye-laws modifications to accommodate BBN.
▪ Minimal modifications to the standard trading software to accommodate new bid areas	▪ Software modifications required to add bid areas and produce a sequential solution

The extent of impact on BBIN welfare is contingent on several factors and would be evaluated through detailed modeling and market simulations through Pilot Market Runs for both modes of operation

SARPEX OPERATIONAL CONSIDERATIONS

GRID OPERATION – BID AREAS AND TRANSMISSION CAPACITY ALLOCATION

Bid Area Formation:

- Bid areas determine the price paid/charged in a specific geographical location in keeping with grid constraints and congestion.
- When bid areas are formed purely based on congestion considerations they are called congestion zones.
- Key considerations in Bid area formation
  - *Physical Considerations:* separate markets are formed in the congested areas which in turn necessitates the creation of separate bid areas or congestion zones for the Member Countries.
  - Other Considerations: Economic, political, geographical or technical in nature. For example: Indian generators JITPL and Sterlite are physically located in Eastern Region, but included in the Western Region bid area-W3, due to the transmission network topology

Transmission Allocation:

- Highest priority for transmission access is accorded to the long term PPAs
- Indian Exchanges are allocated only the residual transmission capacity

Bid Area Formation on SARPEX:

- 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.

"THE GRID CONSTRAINTS & TRANSMISSION CAPACITY ALLOCATION PROCEDURES DON'T APPLY TO PILOT MARKET "

PROPOSED OPERATIONAL RULES

Participation Pre-Requisites

- Provision for NOC in the absence of standardized OA regulations within BBIN
- As a long-term recommendation, formation of a Joint Association of System Operators to foster efficient electricity trade and congestion monitoring

Scheduling

- Existing bilateral delivery point retention
- International periphery as the delivery point i.e. interconnection of the cross-border transmission line and the inter-state transmission network of India
- Nodal Agencies for each member country to coordinate trading on Exchange

Deviation Settlement

- Retention of existing deviation settlement mechanisms of each member country
- Settlement paid by Nodal Agency, to the respective authorities, on behalf of all market participants.
- Settlement pro-rated in the case of multi Nodal Agency involvement.

Transmission Charges & Losses Treatment

- Existing transmission charges and losses related regulations retention
- Transmission charges and losses to be made through the nodal agency specifically to the Indian counterparts

THERE ARE NO CONSIDERATIONS SUCH AS PARTICIPATION PRE-REQUISITES, SCEDULING & DEVIATION SETTLEMENT FOR PILOT MARKET

ILLUSTRATIVE MEMBER COUNTRY TRANSMISSION CHARGES & LOSSES

Parameter	Buy Side		Sell Side		Comments
	Rs/kWh	*%*	*Rs/kWh*	*%*	
Bid Quantity (MW)	108		100		Quantity Bid at SARPEX
Price in SARPEX	2.50		2.50		Price discovered in SARPEX
PoC Withdrawal / Injection Losses		0.02		0.02	POC Charges & Losses applicable on Member Country for using the ISTS network of India
PoC Withdrawal / Injection Charges	0.20		0.20		
Cross Border Line Losses		0.02		0.02	Cross Border Transmission line connecting the delivery point in India with the Member Country
Cross Border Line Charges	0.10		0.10		
Member Country Losses		0.04		0.04	Member Country Transmission Charges & Losses for use of its internal transmission network
Member Country Charges (Rs/kWh)	0.20		0.20		
Operating Charges	0.03		0.03		Operating Charges of NLDC (0.01 Rs/kWh) and Transaction Fee for SARPEX (0.02 Rs/kWh)
Quantum Received / Injected @ Member Country Bus (MW)	100		108		Quantity Received / Injected by the Member Country
Landed/Received Price @ Member Country Bus	3.29		1.81		Landed Price to Member Country / Net back Price to Member Country Generator

Note: The transmission charges and losses etc. used in the above example don't reflect the actual rates and are only for illustration

ASSUMPTIONS FOR TRANSMISSION CHARGES AND LOSSES WILL BE DISCUSSED AND AGREED WITH MEMBER COUNTRIES DURING THE TRAINING ON BID FORMATION FOR PILOT MARKET

OPERATING TIMELINES FOR SARPEX

The choice between single and multi time zones needs to be made in keeping with the impact on Operating Timelines

Time zones observed in BBIN relative to UTC

Country	Time zone (In Hours)	IST Deviation (In Minutes)
India	UTC + 5:30	-
Bhutan	UTC + 6:00	+30 minutes
Bangladesh	UTC + 6:00	+30 minutes
Nepal	UTC + 5:45	+15 minutes

Mismatches in time-zones has implications on coordination of DAM operational activities.

Benefits of Single Time zone

- Efficiency
- Bottleneck Elimination
- Global Best Practice – Nord Pool, OMIE
- Consistency & Simplicity to avoid Mismatch

A single reference time zone and operating timeline is recommended for SARPEX.

OPERATIONAL CHALLENGES DUE TO MULTIPLE TIME ZONES IN SARPEX

Electricity Dispatch at the "day boundary" for three consecutive days D-2, D-1 and D

Slots	41	48	49	71	95	96	1	2	41	49	95	96	1	2	41	49	95	96
India	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	10:15	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	10:30	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	10:30	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

Coordination Issues

Day D-2 Day D-1 Day D

Dispatch periods at the "day boundary" i.e. Slot 95 and Slot 96 may lead to coordination issues. While these slots belong to Day "D-1" in India, they belong to Day "D" i.e. the next day in Bhutan, Bangladesh and Nepal

PROPOSED OPERATING TIMELINES

Key Activities in DAM on SARPEX

Bidding 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

Dispatch "D"

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

Pay-Outs "D+1"

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

*D - Current Day

INTERNATIONAL PRECEDENCE

All the operations and transactions could be aligned to a single Reference Time Zone of India in order to avoid any mismatch in the operational activities by following the individual country Time Zones

For the Pilot Market, the various activities of SARPEX will be as per the Indian Time Zone only.

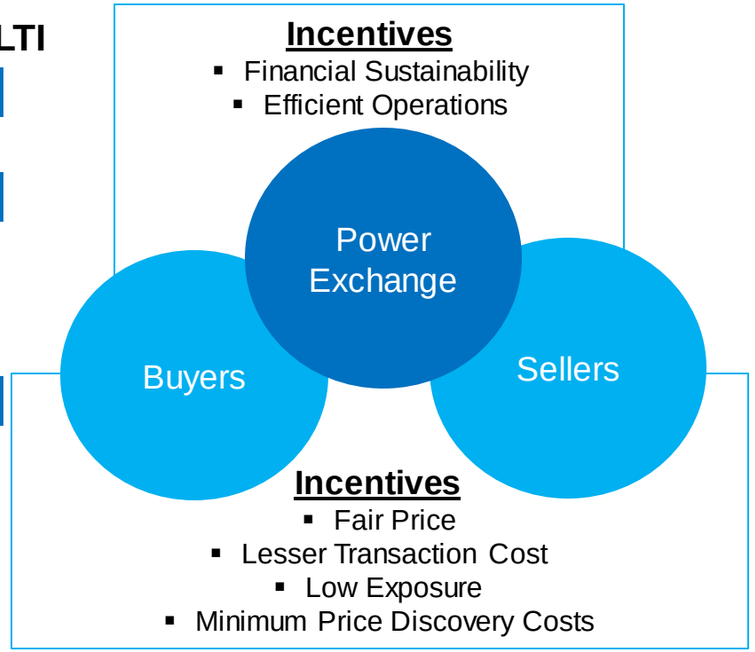
CURRENCY

KEY CONSIDERATIONS – SINGLE V. MULTI

Stakeholder's Preference
- Volumes traded based on currency

Physical Market Structure
- Market Efficiencies
- Consumer Distribution
- Nature of Products

Financial Market
- Currency Liquidity
- Market Liquidity
- Infra Development
- Trade Balances



SINGLE CURRENCY ALLOWS FOR:
- Clear, non-discriminatory, transparent information dissemination
- Liquidity and price stability
- Exchange's financial exposure reduced
- Lower transaction costs due to fewer intermediaries

Examples: Nord Pool, OMIE, APX, EPEX

APPROPRIATE APPROACH FOR SARPEX

Currency Scenario: Trade Agreements and Treaties between BBIN recommend the use of a mutually agreeable currency

Option 1 - Single Currency
- Banks take on fluctuation exposure
- Ease of pricing – lowers chance of currency arbitrage through power exchange

Option 2 – Currency Service
- Exchange takes on fluctuation exposure
- Convenience to Buyers and Sellers
- Enhanced market infrastructure to enable efficient and timely operations

ANNEXURE

INTERNATIONAL PRECEDENCE – EXCHANGES & POOLS

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:

- Transmission system linking Denmark, Norway, Sweden and Finland provides
- 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

- 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.

Market Clearing and Congestion Management: Nord Pool operates on self-scheduling and market clearing principles. The spot price set every hour.

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

- California Independent System Operator (CAISO) was originally designed to operate in conjunction with the PX, a day-ahead energy market that ceased to operate in January 2001.
- Collusion of a shortage of resources, poorly designed market and inaction by regulators or “regulatory failure” resulted in PX’s failure.
- 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.

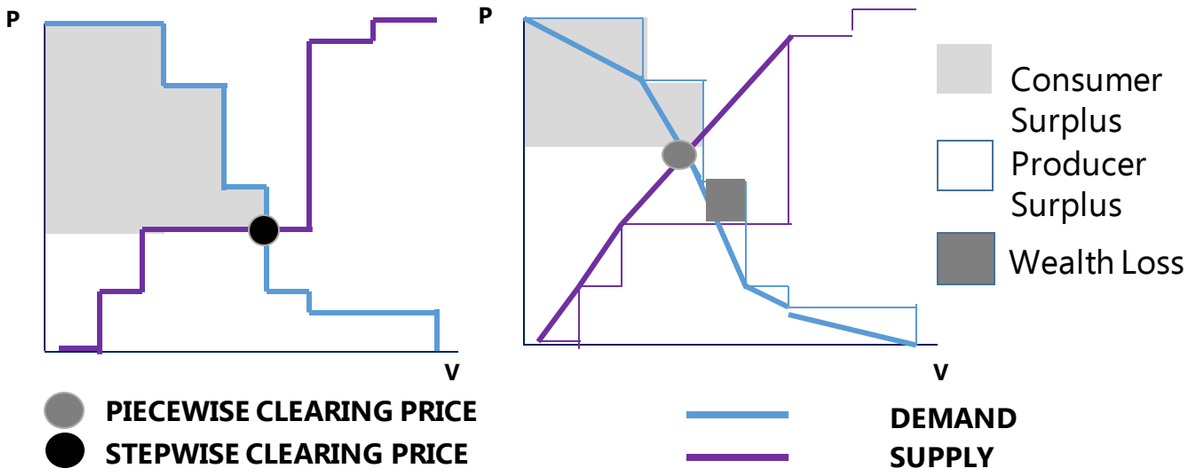
BELPEX & Nord Pool – Market coupling precedence

- The Belpex market zone is implicitly coupled with other market zones via the Belpex DAM.
- Scheduling allocation to maintain grid stability:
  - 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 TSOs

STEP-WISE & PIECE-WISE COMPARISON

Performance based Comparison between Piece-wise and Step-wise Approaches

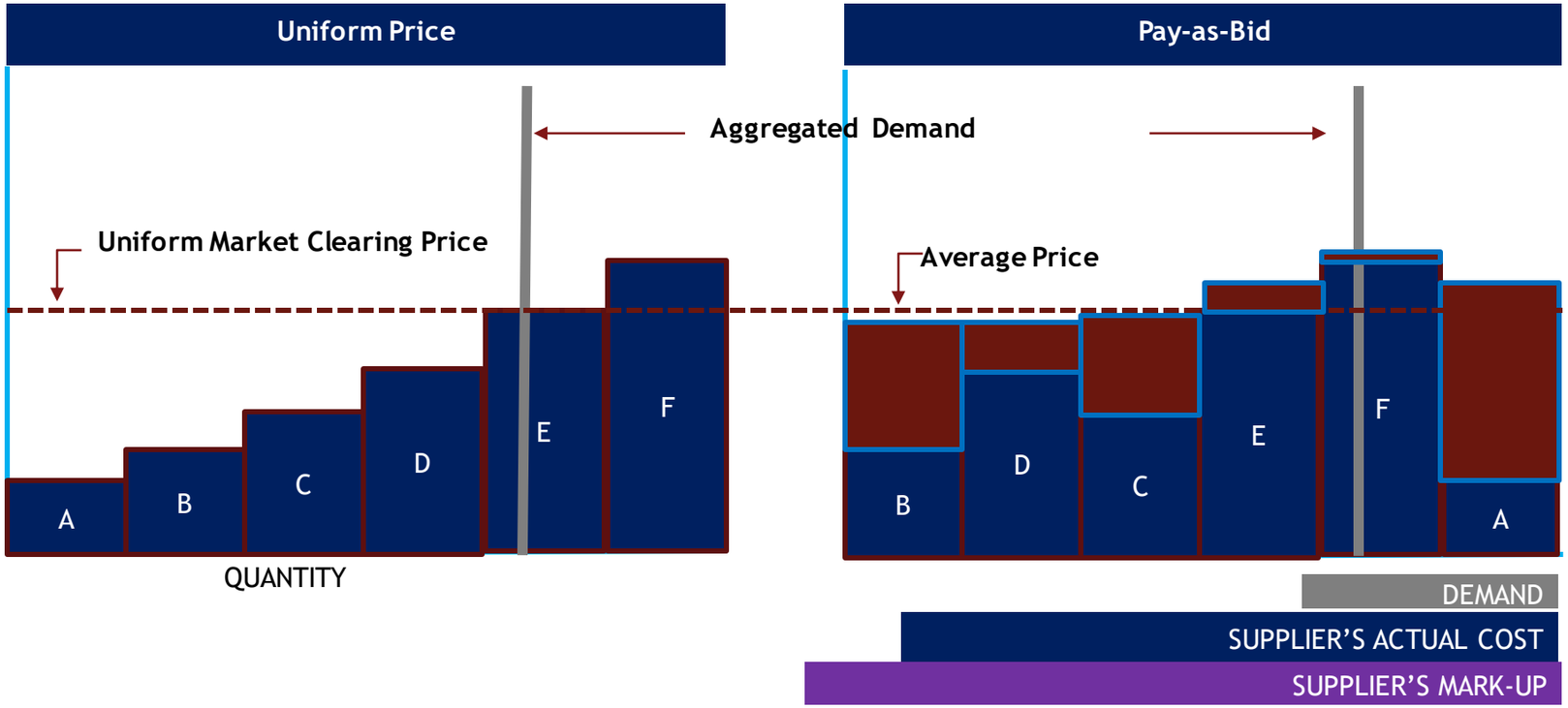
Criteria	Price Determination	Volume Determination
Wealth Distribution	▪ Piece-wise approach typically relates to disproportionate wealth distribution between buyers and sellers as compared to Step-wise	▪ Step-wise approach maximizes volume cleared based on social welfare. This allows for unbiased wealth 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



BACK

UNIFORM VERSUS PAY-AS-BID

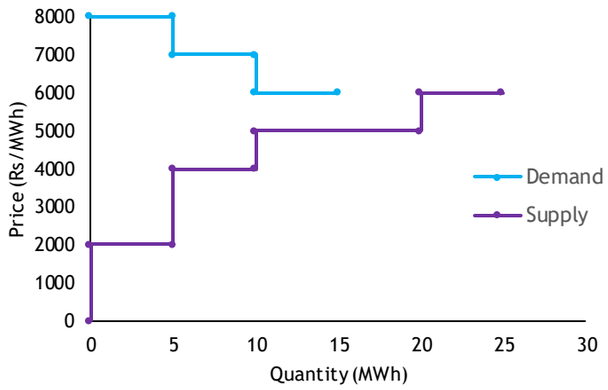
CHOICE OF UNIFORM OVER PAY-AS-BID (PAB)



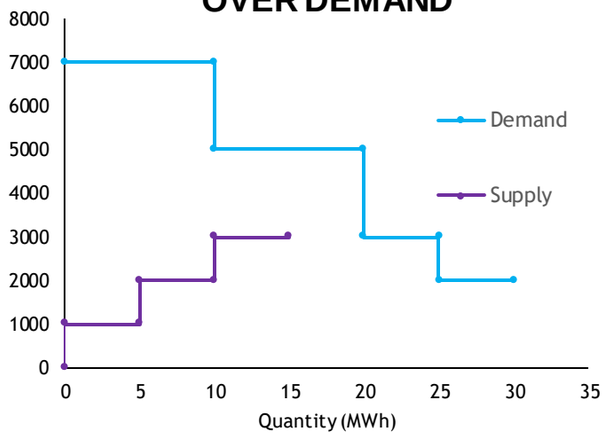
EXTRAPOLATION & SHIFTING OF CURVES

- Non Convergence may occur on two accounts:
  - Over Demand
  - Over Supply
- Methods such as Extrapolation or Shifting of Curves may be used to address this

OVER SUPPLY



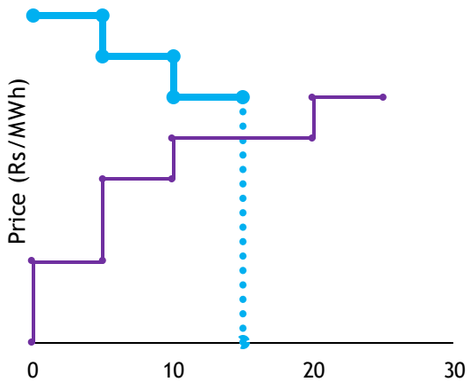
OVER DEMAND



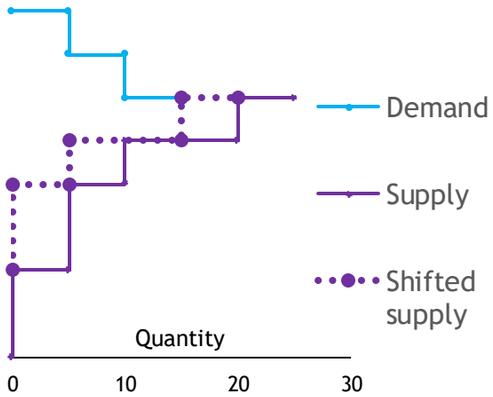
CASE OF NON-CONVERGENCE DUE TO OVERSUPPLY

Extrapolation:

- The demand or supply curve is extrapolated to find the equilibrium point
- The point of intersection is considered the MCP and MCV



EXTRAPOLATION



SHIFTING OF CURVES

Shifting of Curves:

- The demand or supply curve is shifted up or down to find the equilibrium point
- The point of intersection is considered the MCP and MCV

BACK

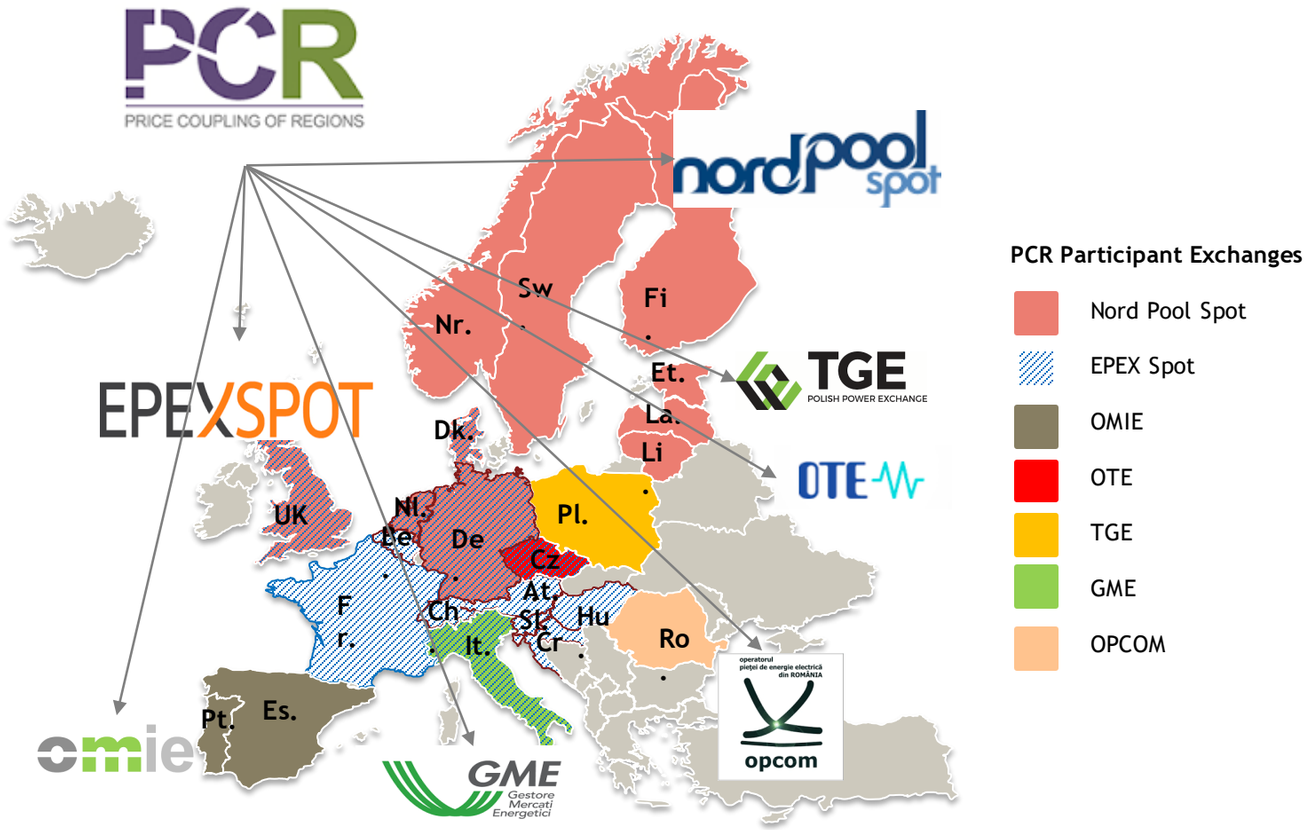
EXISTING INTERCONNECTIONS BETWEEN THE SARPEX's MEMBER COUNTRIES

As on date, the following interconnections exist

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 400 kV exist between these countries. A 400 kV DC line from Punatsangchu-I HEP (in Bhutan) to Alipurduar (in India) has been in operation.
India & 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 400 kV D/C Surjyamaninagar (Bangladesh) transmission line has been commissioned in March 2016. (India) to Comilla

PRECEDENCE FROM OTHER EXCHANGES - HARMONIZING THE TIME-ZONES

- Europe operates in four time zones - Western European Time (WET), Central European Time (CET), Eastern European Time (EET) and Further-Eastern European Time (FEET)
- Nord Pool Spot, has participants from the regions with CET and EET **but follows the CET**
- Similarly, OMIE has participants from CET and WET, **but is aligned to CET,** since the major Exchanges in Europe are all referenced to CET
- Similarly, the Price Coupling for Regions (PCR) has participants from almost every time zone of Europe and **is referenced to CET**



Referencing to a Single Time Zone is critical for effective integration of Exchanges

Source: https://www.epexspot.com/en/membership/who_are_our_members; http://www.Nord Poolspot.com/About-us/ ; http://www.free-powerpoint-slides.com/powerpoint-maps.php
Note: This diagram not necessarily depicts all the countries covered by a PX

BACK

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