Staff Paper

on

Market Coupling

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Disclaimer

The issues presented in this discussion paper do not represent the views of the Central Electricity Regulatory Commission, its Chairperson, or its individual Members and are not binding on the Commission. The views are essentially those of the staff of CERC and are circulated with the aim of initiating discussions on various aspects of market coupling in the Indian power market and soliciting inputs from the stakeholders in this regard.

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1. Background

1.1. In accordance with the provisions of Section 178 read with Section 66 of the Electricity Act, 2003 (EA 2003), the Central Electricity Regulatory Commission (CERC) has framed various regulations for the development of the power sector in the country. One of the key regulations is the Power Market Regulations, which provide an enabling framework for the development of the power market. The CERC notified the CERC (Power Market) Regulations, 2010, on 21.1.2010. Thereafter, in view of the developments in the power sector, including growth in overall power generation, growth in demand, increase in the volume of electricity transacted on the power exchanges, etc., the CERC notified the CERC (Power Market) Regulations, 2021 (PMR 2021) on 15.2.2021, by repealing the earlier regulations. The main objective of these regulations is to help in creating a comprehensive market structure and enable the transaction, execution, and contracting of various types of products in the power market. At present, there are more than 50 inter-state trading licensees and three power exchanges, namely the Indian Energy Exchange Ltd. (IEX), the Power Exchange of India Ltd. (PXIL) and the Hindustan Power Exchange Ltd. (HPX), operating under the framework of PMR 2021. Various contracts are available for trading on these exchanges to meet the short-term needs of market participants.

1.2. The idea of a multi-exchange model in the power sector was originally conceived with a view to encouraging competition amongst the exchanges and catering to the growing and varying requirements of market participants. A voluntary approach has been followed for participation in various contracts in the power exchanges. Over the years, the volume of transactions in the power exchanges has increased manifold, and similarly, the number of products and market segments has expanded in all the power exchanges. Recently, the cross-border trade of electricity has also commenced in the Day-Ahead Market (DAM) of IEX. Though the transactions through power exchanges constitute only about 7% of the total electricity generation, the volume transacted and the number of participants registered with the power exchanges has grown significantly.

1.3. However, the multiple power exchange model has often resulted in scenarios such as different prices being discovered on different power exchanges. Table-

1 provides the month-wise difference in the weighted average price of electricity transacted in the DAM on the three power exchanges.

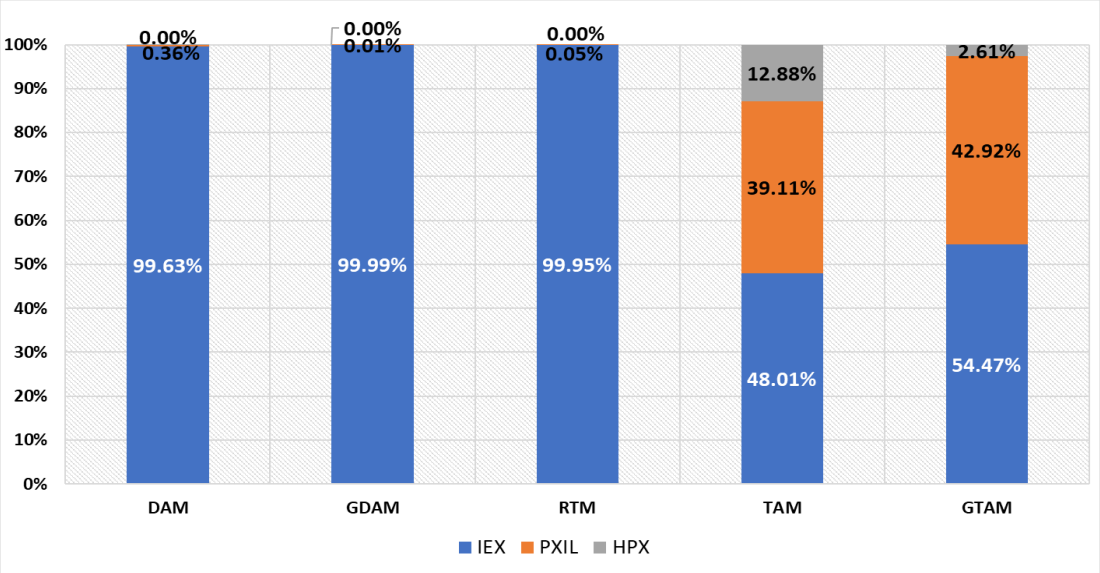
Table 1: Price of electricity transacted in DAM at Power Exchanges (Rs./kWh)

Month	IEX	PXIL	HPX
Jul-22	5.50	5.03	6.51
Aug-22	5.43	7.29	-
Sep-22	5.87	7.44	-
Oct-22	3.96	4.40	-
Nov-22	4.80	-	-
Dec-22	5.58	-	-
Jan-23	6.36	11.33	-
Feb-23	6.64	-	-
Mar-23	5.44	-	-

1.4. While the present market structure has been designed to maximize efficiency gains, the power exchanges with lower volumes often point to the intrinsic nature of the collective transactions segment (DAM and RTM), which leads to a concentration of liquidity in one power exchange, due to which the benefits of competitive efficiency do not percolate to the market participants. In the case of collective transactions such as DAM and RTM, which are based on a double-sided closed auction, the decision of an electricity buyer/seller is influenced by the certainty of getting his bids/offer cleared, which depends on the level of liquidity in an exchange. Thus, the liquidity on one exchange helps attract more liquidity over time. As such, these concerns do not arise in the case of other market segments, like the Term Ahead Market (TAM) and Day-ahead Contingency contracts which are based on continuous transactions.

1.5. The share of volume traded in different exchanges under different market segments is as under:

Figure 1: Share of Volume Traded in Power Exchanges, 2022-23



1.6. Considering the fact that collective transactions account for more than 70% of the electricity transacted through power exchanges, and the share of only one exchange has been increasing, the power exchanges with lower liquidity have been advocating for market coupling. The Commission provided enabling provisions in PMR 2021 to introduce market coupling among the power exchanges to enable uniform price discovery. These provisions related to market coupling are yet to be brought into effect and form the basis for discussion in this paper. The paper, in the subsequent sections, discusses the regulatory provisions for market coupling, international experience, the objectives of market coupling in India, the issues and challenges in the implementation of market coupling, and the key points for discussion.

2. Present Regulatory Provisions

Part-5 of the CERC Power Market Regulations 2021 (i.e. Regulations 37 to 39) provides the enabling provisions for market coupling among the power exchanges as under:

Definition of Market Coupling

"*Market Coupling" means the process whereby collected bids from all the Power Exchanges are matched, after taking into account all bid types, to discover the uniform market clearing price for the Day Ahead Market or Real-time Market or any other market as notified by the Commission, subject to market splitting"*

Objectives of Market Coupling

"37. Objectives of Market Coupling
(1) Discovery of uniform market clearing price for the Day Ahead Market or Real-time Market or any other market as notified by the Commission;
(2) Optimal use of transmission infrastructure;
(3) Maximisation of economic surplus, after taking into account all bid types and thereby creating simultaneous buyer-seller surplus."

Definition of Market Coupling Operator

"*Market Coupling Operator" means an entity as notified by the Commission for operation and management of Market Coupling."*

Designation of Market Coupling Operator

"*38. Designation of Market Coupling Operator*
Subject to provisions of these regulations, the Commission shall designate a Market Coupling Operator who shall be responsible for operation and management of Market Coupling"

3. International Experience

3.1. Evolution of Market Coupling in the European Market

3.1.1. The beginning of market coupling in Europe goes back to 2006 when the first transnational merger took place. Belgium, France, and the Netherlands coupled their day-ahead markets in order to make optimum use of cross-border electricity capacities and increase market liquidity.

3.1.2. Germany and Luxembourg joined the Trilateral Market Coupling (TMC) in 2010 and completed the Market Coupling of Western Europe (CWE). To date, this is the largest merger of European electricity exchanges and transmission system operators (TSOs), which are also organized in ENTSO-E.

3.1.3. The "Pentalateral Energy Forum" - consisting of the energy ministers of the five participating states is still the higher authority within this framework and strives for better integration of the Central West European (CWE) electricity

markets. It also adopts, among other things, rules on cross-border security of supply.

3.1.4. In 2007, a bilateral market coupling was realized between Portugal and Spain (SWE). This merger allowed the Portuguese and Spanish day-ahead markets to grow into an integrated market called the Iberian Electricity Market (MIBEL) with the joint electricity exchange OMIE.

3.1.5. At the same time, Scandinavia was connected to the Western European electricity market by submarine cables: electricity has been flowing between Germany and Denmark since 2007 and between the Netherlands and Norway since 2011.

3.1.6. In 2013, Austria joined the CWE Group and began to link its market with the other Western European electricity markets. In addition, the Pentalateral Energy Forum decided to accept Austria as a full member and Switzerland as an observer.

3.1.7. With the help of the Price Coupling of Regions (PCR) system introduced in 2010, the European countries implemented a nationwide market coupling of a total of 15 European countries in 2014, including the Baltic States, Great Britain, and Poland, in addition to the CWE and the Scandinavian countries. The SWE states joined this market coupling of northwestern European states (NWE), thus enlarging the unit area around Portugal and Spain.

3.1.8. The major change was introduced in 2015, with Italy coupling its market with France, Austria and Slovenia. July 2016 saw the successful coupling of the markets of Austria and Slovenia. This means that this area in Europe, also known as Multi Regional Coupling (MRC), comprised 19 European countries. In 2016, Bulgaria and Croatia also joined MRC in isolation mode, which was later coupled. At 85%, these countries cover the majority of European electricity consumption.

3.1.9. In 2018, the Single Electricity Market on the island of Ireland was coupled with the MRC, and the German-Austrian zone was split into two separate bidding zones. In 2020, Greece got coupled with MRC. In 2021, 4M MC (4 Markets

Market Coupling, covering Czech Republic, Hungary, Romania, and Slovakia) and the MRC coupled via the borders PL-DE, PL-CZ, PL-SK, CZ-DE, CZ-AT, HU-AT, and BG-RO.

Figure 2: Power Markets in European Union

3.1.10. The following projects have mainly contributed to the evolution of market coupling in Europe:

- **North-Western Europe (NWE)**: NWE Price Coupling was a project initiated by the Transmission System Operators and power exchanges of the countries in North-Western Europe. The 17 partners of this project comprised APX, Belpex, EPEX SPOT, and Nord Pool Spot from the power exchanges' side; 50Hertz, Amprion, Creos, Elia, Energinet.dk, Fingrid, National Grid, RTE, Statnett, Svenska Kraftnät, TenneT TSO B.V. (Netherlands), TenneT TSO GmbH (Germany), and TransnetBW from the TSO side. The cooperation was dedicated to the price coupling of the day-ahead wholesale electricity markets in this region, increasing the efficient allocation of interconnection capacities of the involved countries, and optimising the overall social welfare. A single algorithm, calculating simultaneously the electricity market prices, net positions, and flows on interconnectors between bidding zones, was used based on implicit auctions and facilitated through the Price Coupling of Regions solution.

- **Price Coupling of Regions (PCR)**: PCR was the initiative of seven European power exchanges (APX, Belpex, EPEX SPOT, GME, Nord Pool Spot, OMIE, and OTE) to develop a single price coupling solution to be used to calculate electricity prices across Europe and allocate cross-border capacity on a day-ahead basis. This was crucial to achieving the overall EU target of a harmonised European electricity market. The integrated European electricity market was expected to increase liquidity, efficiency, and social welfare. PCR was open to other European power exchanges wishing to join.

- **South-Western Europe (SWE)**: SWE Price Coupling Project was a joint project between the French, Spanish, and Portuguese TSOs, RTE, REE, REN, and the power exchanges OMIE in Spain and Portugal and EPEX SPOT operating the French market. This project aimed to define the pre-coupling, post-coupling, and exceptional situations and processes that were necessary to allow the implementation of price coupling between the NWE region and the Iberian day-ahead markets.

3.1.11. The **Capacity Allocation and Congestion Management (CACM)**[1] Regulation of 24th July 2015, is a key legislation for the single market in electricity. The Regulation entered into force on 14th August 2015. It sets out minimum harmonised rules for the ultimate single day-ahead and intraday market coupling. This Regulation defines binding requirements for Transmission System Operators (TSOs), Nominated Electricity Market Operators (NEMOs), Regulatory Authorities for implementation and functioning of integrated electricity market in the day-ahead and intraday timeframe.

3.1.12. **Operators facilitating the Market Coupling in the European market**

- **Nominated Electricity Market Operator** (NEMO) is a market operator designated by the competent authority of the European Union Member

[1] https://www.acer.europa.eu/Recommendations_annex/ACER%20Recommendation%2002-2021%20on%20CACM%20-%20Annex%201%20-%20CACM%20Regulation.pdf

State to participate in single day-ahead coupling and single intraday coupling, as required under CACM. The following NEMOs are presently participating in the coupled European power market: BSP, CROPEX, SEMOpx (EirGrid and SONI), EPEX, EXAA, GME, HEnEx, HUPX, IBEX, Nasdaq, Nord Pool, OMIE, OKTE, OPCOM, OTE, and TGE.

- **Market Coupling Operator** (MCO) matches orders from a single day-ahead market and a single intraday market. The MCO function is performed for different bidding zones and simultaneously allocates cross-zonal capacities. The cross-zonal capacity in the EU energy market is defined as the capability of the interconnected system to accommodate energy transfer between bidding zones. Pursuant to CACM, all NEMOs developed the MCO Plan that set out how NEMOs will jointly set up and perform the MCO functions. NEMOs are currently in charge of performing the role of MCO based on the rotational scheme.

- **Transmission System Operator** (TSO) is a natural or a legal person responsible for operating, ensuring the maintenance of, and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity. The following TSOs are presently participating in the coupled European power market: 50Hertz Transmission, ADMIE, Amprion, APG, AST, ČEPS, Creos, EirGrid, Elering, ELES, ELIA, Energinet, ESO, Fingrid, HOPS, Litgrid, MAVIR, PSE, REE, REN, RTE, SEPS, SONI, Statnett, Svenska Kraftnät, TenneT DE, TenneT NL, Terna, Transelectrica, and TransnetBW.

3.1.13. **Outcome of Market Coupling in the European Market**

- A major outcome of market integration is that, at a regional and ultimately Union level, demand is met securely by the most economic resources.

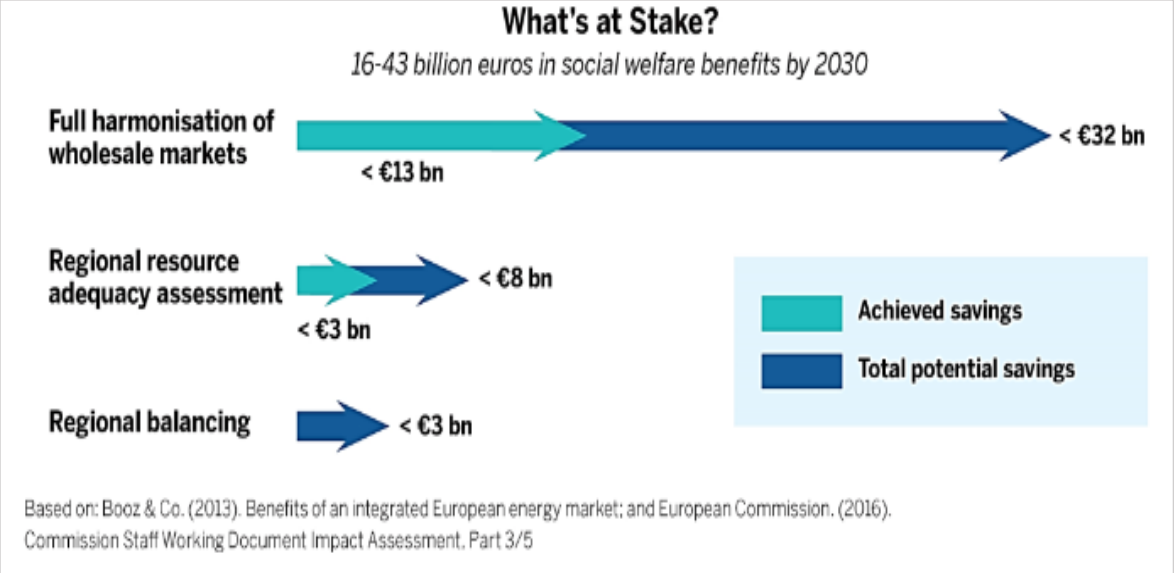
- A more coordinated and economical approach to resource adequacy – where some Member States are forecasting capacity deficits in the years ahead, others are forecasting surpluses. Market integration helps

implicitly utilize cross-border generating resources, so most Member States are in a healthy resource adequacy situation.

- Balancing energy over wider areas allows geographic and technical diversity to be exploited, reducing balancing volumes. Integration of RE has reduced aggregated imbalances, as despite being intermittent in nature, the correlation between the output of individual installations drops rapidly with distance.

- The potential increase in social welfare from fully integrating Europe's electricity markets could lie in the range of €16 billion to €43 billion[2] annually by 2030 (Figure-3).

Figure 3: Benefits of Fully Integrating Europe's Electricity Market

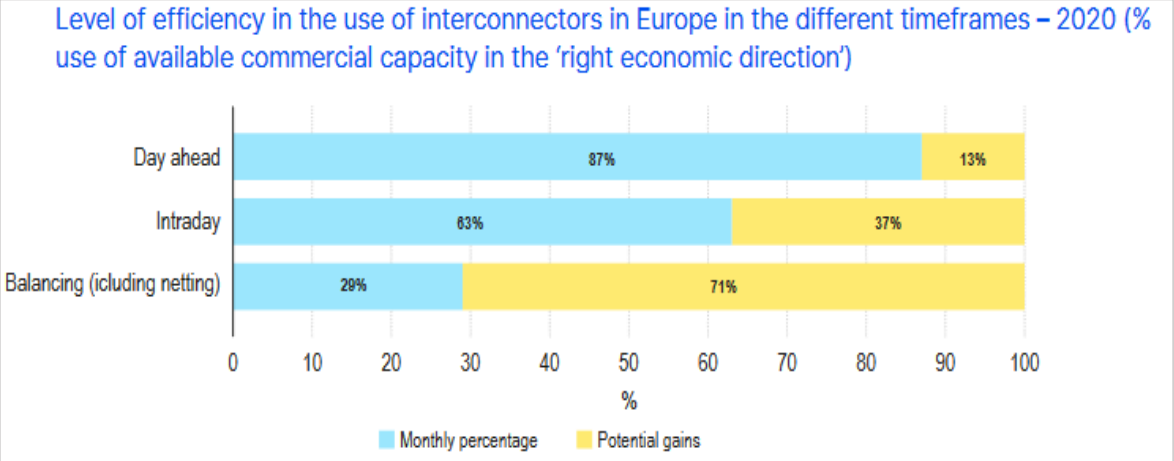


- Figure-4 below shows the level of efficiency in the use of interconnectors across the different market timeframes in 2020, which mirrors the level of progress of the various market integration projects across Europe. Due to market coupling, the integration of day-ahead markets, which are the main reference points for trading electricity close to real-time, has progressed significantly over the last decade. Consequently, the level of efficiency in the use of cross-zonal capacity (87 %) in day-ahead markets was the

[2] Realizing the benefits of European market integration, Regulatory Assistance Project, May 2018

highest across all short-term timeframes in 2020.[3] However, the indicator here is based on the interconnector capacity available, i.e. coupled borders. There remain several non-coupled borders, due to which there is an insufficient amount of capacity available for cross-zonal trade and, thus, greater potential to be achieved.

Figure 4: Level of Efficiency in use of Interconnectors in Europe



3.2. Germany – from Multiple Exchanges to Single Exchange

3.2.1. The German market is Europe's major electricity market. Prior to 2000, electricity was traded only on a bilateral basis. In June 2000, the first German power exchange - Leipzig Power Exchange (LPX), was launched in Leipzig with auction trading for individual hours and block contracts. The European Energy Exchange (EEX) was launched in Frankfurt in August 2000 with a day-head market for individual hour and block contracts settled in auctions and continuous trading, respectively[4]. Thus, there existed a multi-power exchange model in Germany.

3.2.2. However, the market was simply not large enough for two German power exchanges, and it was not much longer before the two exchanges – LPX and EEX, announced their merger in October 2001. Both exchanges were merged in July 2002 and formed the European Energy Exchange AG (EEX) with headquarters in Leipzig. While market shares of the exchange spot markets

[3] ACER/CEER Annual Report on the Results of Monitoring the Internal Electricity Markets in 2020
[4] Power exchange spot market trading in Europe: theoretical considerations and empirical evidence OSCOGEN, March 2002

were low in the beginning (2.7 TWh from June to December 2000), they increased steadily over time (15.6 TWh in 2001, 26.6 TWh in 2002)[5]. In 2003, the exchange's hourly spot auction had a share of nearly 10 per cent (48 TWh) of total German net consumption.

3.2.3. In 2008, European Power Exchange (EPEX SPOT), based in Paris, was created by the merger of the power spot markets of the energy exchanges Powernext (French exchange) and European Energy Exchange AG (EEX). A total of 621.5 TWh was traded on EPEX SPOT in 2021 (2020: 614.8 TWh). This represents a new all-time high, breaking the record of the previous year. 498.2 TWh were traded on the Day-Ahead segment and 123.3 TWh on the EPEX Intraday. The German/Luxemburg Intraday market saw a major boost in 2021 and reached 69,933.1 GWh, beating the record of the previous year (2020: 63,627.0 GWh) [6].

4. Market Coupling in the Indian Context

4.1. Globally, market coupling has been introduced to integrate two or more electricity markets or different geographies. However, in the Indian context, the objectives of market coupling, as stipulated in the Power Market Regulations 2021 ('PMR 2021'), include the discovery of a uniform market clearing price, optimal use of transmission infrastructure, and maximisation of economic surplus.

4.2. The key benefits of market coupling in the Indian context, as advocated by some stakeholders, are as follows:

4.2.1. **Discovery of a uniform market clearing price** – Presently, different prices are discovered on all three operational power exchanges for a particular time block of collective transactions. A uniform market clearing price discovered by the market coupling process would become the single reference price for the market. Moreover, as the Deviation Settlement Mechanism (DSM) charges are currently indexed to the clearing price of DAM, a single price from market

[5] Market Power in the German Wholesale Electricity Market, Institute of Energy Economics at the University of Cologne, May 2004

[6] https://www.eex-group.com/en/newsroom/detail?tx_news_pi1%5Baction%5D=detail&tx_news_pi1%5Bcontroller%5D=News&tx_news_pi1%5Bnews%5D=4177&cHash=97dd7520461e5186532c01766bce4750

coupling would minimize the scope for any arbitrage between deviation settlement and the market. Likewise, the introduction of financial products in the electricity market would benefit from a single, uniform price discovery.

4.2.2. **Optimal use of transmission infrastructure** - Allocation of transmission corridors amongst the power exchanges have not been optimal owing to the skewed market share of various power exchanges. In view of this, under a constrained scenario, the Commission had provided for the reservation of transmission corridors for the smaller power exchange (PXIL). However, it was noted that the reserved corridor remained underutilized. During the period from 01.01.2017 to 31.03.2022, the percentage of congested time blocks where the reserved margin got cleared was about 0.54%, which shows that the congestion remained insignificant. Accordingly, the Commission, vide its Order dated 09.05.2022, modified the allocation principle in the event of congestion (to be in the ratio of the initial market clearing volume of the respective power exchange).

Under the coupled market scenario, the market coupling operator would merge the bids from all the power exchanges and then clear them implicitly in one go. Therefore, in the coupled scenario, transmission infrastructure is expected to be used in an optimal manner, and no reservation on the transmission corridor would be required for any of the exchanges.

4.2.3. **Maximisation of economic surplus** - It has been envisaged that market coupling would lead to the maximization of economic surplus. In the case of coupled collective transactions on the power exchange, the market clearing price discovered through the matching of aggregate buy and sell bids would result in the creation of a surplus for the buyers and sellers of electricity, the summation of which is referred to as the “economic surplus”. This surplus refers to the difference between the bidding price of accepted bids and the clearing price per unit of electricity multiplied by the total volume of electricity in the cleared bids. An illustration of market coupling and maximization of the economic surplus is given in Annexure I.

4.2.4. **Improvement in Liquidity and Prices** - In the coupled scenario, when the sell and buy bids from all the exchanges are merged, more volumes would be cleared, and hence there would be more liquidity in the market. With this, merging bids and offers would also lead to price efficiency, and, therefore, MCP may be discovered at the lower end. This may also encourage the entry of new participants in the market.

4.3. The apprehensions/challenges of market coupling highlighted by some stakeholders are as follows:

4.3.1. **Diminished Role of Power Exchanges** – With market coupling and transfer of the clearing and settlement functions to clearing corporations, power exchanges will lose most of their functions. The role of a power exchange will be reduced to just collecting bids and transferring them to the market coupling operator.

4.3.2. **Dampen innovation & technology investments** – The coupling of power exchanges would centralise the bid matching platform. This would not leave any incentives or room for the power exchanges to innovate products or invest in technology. A centralized algorithm, by design, would not be able to accommodate complex bid structures, keeping in view the compatibility of different power exchanges. As a result, the market may have to forego certain innovative products that could have improved participation.

4.3.3. **Reduce Competition** – With no incentive to innovate & a reduced role, the competition amongst the power exchanges would get affected, which is considered necessary for product innovation and efficient price discovery. The competition will be based only on their transaction fees, but overall it will hamper product development and innovation in bid structures. The exchanges will also not engage in market making by engaging with and persuading buyers and sellers to participate in their respective platforms for efficient price discovery.

4.3.4. **Discourage investments** – The reduced role of power exchanges would also significantly affect their business and existing investments. This will also make the power exchange business unattractive for new entrants.

4.3.5. **No improvement in Transmission utilization** – As the exchange market is only 7% of the total generation, the objective of optimal utilization of transmission infrastructure by coupling the small share market does not seem to be relevant in the current market scenario. The current approach of transmission corridor allocation amongst the power exchanges on a pro-rata basis by the System Operator does not leave any further scope for improving the utilization of transmission corridors for the exchange market.

4.4. Expert Committee Recommendations

4.4.1. The matter of market coupling was first discussed during the meeting of the 14th Central Advisory Committee (CAC) held on 20.9.2010. The CAC discussed the issue of transmission corridor allocation on a pro-rata basis, and it was noted that pro-rata allocation of the transmission corridor between the exchanges is not an optimum solution, and there is a need to study the feasibility and appropriateness of adopting the market coupling method. On this matter, Petition 158/MP/2013 was also filed by PXIL. After deliberating different aspects of transmission corridor allocation in the context of the transactions on both power exchanges, the Commission, vide order dated 30.4.2015, decided that the issue needs to be examined by an Expert Group to find out an acceptable solution that will also achieve social welfare maximization.

4.4.2. The Expert Group, comprising members from CEA, POSOCO, CERC, Power Exchanges, and other subject experts from academia, noted in its report that merging the bids (integrated market clearing or market coupling) of the two power exchanges would give the most optimal solution with social welfare maximization irrespective of congestion. This would require changes in the market design and amendments to the Regulations.

4.5. Recommendations of the Group on the Development of the Electricity Market in India

4.5.1. The Report of the **Group on Development of Electricity Market in India 2023,** constituted by the Ministry of Power (MoP), inter-alia, made the

following suggestions regarding the implementation of market coupling in India:

……."5.3. The key learnings, derived by the Group, which could be applied in Indian context from the international studies on Day Ahead markets, are being summarized below:

…

ii. De-centralized markets such as the ones in Europe provide for degrees of self-dispatch / bilateral operations. However, to ensure social welfare maximization, bids and offers in the power exchanges across all the bidding areas / zones are combined through the Price Coupling of projects. Price coupling ensures that bids and offers are combined to discover a single uniform market clearing price for a zone / bidding area.

……."

4.5.2. Besides, the Report underscores the need to evaluate the feasibility of price coupling by CERC/MoP, to ensure uniform price discovery for implementation of reforms like MBED. The MoP also considers market coupling as an enabler for the overall development of the power market, as conveyed vide its letter dated 2.6.2023.

5. Points for Discussion

5.1. The enabling provisions for Market Coupling have already been provided by the Commission in the CERC (Power Market) Regulations 2021. Yet, it is imperative to study the readiness of the market and gauge the prerequisites for a smooth transition towards market coupling. With this in mind, in the following section, we discuss some of the key issues in the implementation of market coupling and pose some questions for stakeholders' comments on designing the framework for the implementation of market coupling.

5.2. **Does the current Indian power market scenario form a compelling case for market coupling?**

5.2.1. The participation in the power exchanges is voluntary at present. Buyers and Sellers have the option to trade electricity through power exchanges using the variety of contracts available on these exchanges. The electricity transacted through power exchange constitutes around 7% of the total generation in India.

5.2.2. Most of the generation capacities are tied up in long-term power purchase agreements (PPAs). At about 87%, long-term transactions dominate the share of total electricity transactions in the country. However, while a DISCOM contracts capacity on a long-term basis, it schedules the power mostly on a day-ahead time horizon. In such a scenario, the contracts available on the power exchanges (especially DAM & RTM) provide an opportunity for the DISCOM to "correct" its position by either buying more quantity (if it perceives that the demand will increase) or selling (directly, being a deemed trader, or through a separate trader) excess contracted quantity (if it perceives that the demand will decrease).

5.2.3. Within the overall transactions through power exchanges, the share of collective transactions in DAM and RTM accounts for more than 70% of the total transactions. On examining the recent monthly data on volume transacted through the power exchanges, it is observed that the monthly volume in DAM at PXIL was very low, and HPX registered transactions in DAM only on two days in July 2022 since its inception. At the block level, there have been many instances of zero volume at PXIL and HPX. A similar trend has been observed in the Real-Time Market (RTM). That means IEX accounts for almost 99% of the share in the collective transactions segment.

Table 2: Volume of electricity transacted in DAM at Power Exchanges (MU)

Month	IEX	PXIL	HPX
Jul-22	3516.65	31.78	1.43
Aug-22	3528.70	10.12	-
Sep-22	4049.64	12.89	-
Oct-22	4325.01	3.01	-
Nov-22	5083.85	-	-
Dec-22	4977.44	-	-
Jan-23	4947.96	0.12	-
Feb-23	4658.76	-	-
Mar-23	4718.38	-	-

5.2.4. Given the existing market share of power exchanges in the collective transaction segment, it seems that while the implementation of market coupling may not cause any major change in terms of price discovery, the bids could be divided among the exchanges, which at present are concentrated in one exchange. International evidence suggests that in countries where multiple exchanges exist, for instance, in Norway, where there are Nord Pool and EPEX, the bids are sent to the Coupling Operator by the exchanges for rate discovery.

5.2.5. Under such a scenario, what significant benefits can be derived in terms of uniform price discovery, and which model suits best for India?

5.3. **Effect of coupling on technological innovation and competition**

5.1.1. One school of thought could argue that price coupling would result in less incentive for product innovation and that the role of exchanges would be reduced to that of a bid-collecting agency. Further innovation, ease of transaction, technology solutions, dissemination of information, analytical tools, high-quality service will all be lost if the coupling of exchanges is centralised. The centralized algorithm, by design, may not be able to accommodate complex bid structures, keeping in view the compatibility of different power exchanges. As a result, the market may have to forego certain innovative products that could have improved participation.

5.3.1. The other school would point to the gains coupling could offer in terms of increased liquidity, efficiency, and competition among exchanges on the basis of the services they offer. Further, the increase in competition between the exchanges could result in a lowering of transaction fees, which would reduce the overall cost to the participants and may further increase the volume transacted.

5.3.2. Therefore, given the underlying economic principle of maximizing social welfare and optimal corridor utilization, which argument fits better in the Indian context?

Practical aspects involved in the implementation of Market Coupling

5.4. *Who shall be the Market Coupling Operator?*

As per the PMR 2021, a Market Coupling Operator (MCO) is to be designated by the Commission. The various aspects related to these options are discussed below:

a. **Power Exchanges to perform the function of Market Coupling Operator:** The power exchanges, i.e. market operators in the Indian Power Market, just like the procedure followed in the European Market, may be made in charge of performing the role of the MCO on a rotational basis. If this scheme is adopted, the various aspects to be considered, but not limited to, would be:

- ***Procedure for carrying out MCO Functions***

  The Power Exchanges would be required to jointly design the plan to perform the MCO functions, subject to consultation with the system operator and approval of the Commission. The Power Exchanges shall have to ensure that one single algorithm is utilized each time for price discovery.

- ***Cooperation between Power Exchanges***
  - For the exchange of information and related activities, a contractual arrangement will have to be explored to ensure smooth and fair operation between the exchanges and to avoid any conflicts.
  - Technical infrastructure for the transfer of bid information needs to be in place.

- ***Integrity of the Market Result***
  - The result so obtained should be repeatable and auditable.
  - All the power exchanges should provide acceptance of the result derived by the designated power exchange (acting as MCO), and there should be no possibility for any power exchange to contest the accepted result.
  - Power Exchange may be given the opportunity to compute the result in parallel and validate it. In case a power exchange exercises this option, the complete input file may be made

available in an anonymized manner to ensure transparency and integrity in operations.

- To ensure the integrity of market results, the Commission shall conduct periodic audits and analyses of bid data as part of market monitoring and surveillance.

- Commercial aspects of performing MCO functions, including transaction fees, shall be subject to the fulfilment of regulatory provisions and approval of the Commission.

b. **Third-Party Market Coupling Operator/ Super-Exchange:** While the power exchanges have the expertise to run the algorithms and handle different market scenarios, having a third-party MCO shall ensure more objective operation and will not have any conflict of interest. The third party could be the system operator or an explicitly formed entity. A sample information flow in the case of a third-party MCO is used is provided in Annexure-II.

Recently, the Commission has appointed Grid-India as the Nodal Agency for TRAS procurement through the market. The segment was introduced w.e.f 1st June 2023. As the nodal agency, Grid-India receives sell bid information from the power exchanges, enters the buy bid itself, runs the price discovery engine, and publishes the result to the power exchanges and market participants. All these activities broadly cover the functions to be performed by the MCO. Learnings from this segment would also help in deciding whether to appoint the system operator as the MCO.

The various aspects to be considered in appointing a third-party MCO are as under:

- ***Technological competence and Data Security***

  The entity shall have to ensure:

  - One single set of input data. A common format to be designed and adopted.
  - Develop technical infrastructure for transferring of information from power exchanges to this entity and vice versa.

- Along with a robust technical infrastructure, the entity should ensure a high level of data security.
- One single algorithm to be run based on the Commission's direction regarding the algorithm to be used. If desired, the Commission can direct an IT audit of the technology/ algorithm.
- One single set of results that is repeatable and auditable.

- **Regulated Entity**
  - The entity should be regulated by the Commission as it is designated to handle large volumes of data. The Commission, if it desires, can direct an audit of such an entity.
- Commercial aspects of performing MCO functions shall be regulated by the Commission.

5.4.1. Given these requirements, what should be the ideal institutional/ structural design for market coupling and the extent of autonomy of various parties in such a design?

5.5. ***Which Algorithm should be adopted for a coupled market?***

5.5.1. The three power exchanges operating in India at present utilize distinct algorithms for matching of bids and price discovery. All the exchanges have heavily invested in their respective market engines. Further, the algorithm of exchange is designed to accept the various types of bids offered by the particular power exchange. At present, there are differences in the bid types and the bidding interface offered by each exchange.

5.5.2. Given these realities,

- Would it be advisable to select a suitable algorithm out of the three existing algorithms, or should a new algorithm be designed jointly by the exchanges/ by the market coupling operator, like the PCR EUPHEMIA (acronym of Pan-European Hybrid Electricity Market Integration Algorithm) being used to calculate day-ahead electricity prices across Europe.

- To be able to match the bids received on the three exchanges, uniformity of bid types & relevant parameters is required. Would

standardizing/ harmonising the bid types in DAM & RTM across the exchanges address the issue? If so, which bid types would be suitable for the various buyers and sellers?

5.6. ***How will the clearing & settlement be carried out?***

5.6.1. Presently, the power exchanges clear and settle the transactions with the nodal agencies on behalf of their clients. The exchanges also manage the pay-in and pay-out of the clients/members. All the exchanges charge a transaction fee in lieu of that.

5.6.2. The PMR 2021 provides that the power exchanges shall carry out the Clearing and Settlement of transactions in accordance with the Payment and Settlement Systems Act, 2007 (PSSA 2007) within one year. The Regulations also provide that till such time the power exchanges carry out Clearing and Settlement in terms of the proviso above, the power exchanges shall constitute a Settlement Guarantee Fund (SGF) Management Committee and shall invest the proceeds of SGF in safe investments and ensure that the principal amount is not at risk. The Commission further extended this time period by another year.

5.6.3. In the coupled market scenario, the mechanisms for clearing and settlement may diverge. Till such time a separate Clearing Corporation is introduced, situations requiring cross-settlements between the exchanges are likely to occur.

5.6.4. Thus, in the scenario of a coupled market,

- While the power exchanges will be the counterparty to the market participants, would the Market Coupling Operator act as a counterparty to the power exchanges with regard to settlement rights and obligations?

- Would it be advisable to allow the Market Coupling Operator to charge transaction fees from the power exchanges, which in turn charge related transaction fees from the market participants?

- What should the grievance handling framework be?

5.7. ***Changes in the settlement process***

5.7.1. Traders are already collecting bids from clients, submitting bids to exchanges, and doing the clearing and settlement. In fact, security maintained by traders is approximately double the cost of power purchased, i.e. maintain a weekly average margin equivalent to power purchased while maintaining a sufficient margin for net cleared volume for tomorrow. Under such a scenario, should traders be allowed to submit their bids directly to the market coupler to reduce the cost of power for trader clients, as the clients are presently paying margins to the trader and also bearing fees and margins of exchange?

5.8. ***In which market segment should the coupling be introduced first?***

5.8.1. The market segments at present available on the power exchanges can be broadly categorized into collective and continuous transactions. The collective transactions (i.e. DAM and RTM) utilize uniform market clearing, wherein the aggregate demand and supply offers determine the cleared volume and price. In the recent past, it was observed that due to unprecedented high demand, the prices in these segments went abnormally high, warranting a regulatory intervention. The table below depicts the buy-to-sell ratio in DAM and RTM during the recent months in three power exchanges. Had there been commensurate supply in the market, the prices would not have gone exorbitantly high. Thus, it is important to have the counter-supply bids for the demand bids to clear and vice-versa.

Table 3: Buy to Sell Bid ratio in DAM at Power Exchanges

Month	IEX	PXIL	HPX
Jul-22	0.86	0.58	3.29
Aug-22	0.80	0.32	0.00
Sep-22	0.91	0.52	0.00
Oct-22	0.61	0.75	0.00
Nov-22	0.91	1.65	0.00
Dec-22	0.94	0.21	0.00
Jan-23	1.03	0.15	0.00
Feb-23	1.29	0.11	0.00
Mar-23	1.10	0.07	0.00

Table 4: Buy to Sell Bid ratio in RTM at Power Exchanges

Month	IEX	PXIL	HPX
Jul-22	0.94	0.40	0.00
Aug-22	1.05	0.95	0.00
Sep-22	0.96	0.92	0.00
Oct-22	0.83	0.00	0.00
Nov-22	0.77	0.00	0.00
Dec-22	0.98	0.00	0.00
Jan-23	1.16	0.38	0.00
Feb-23	1.48	0.00	0.00
Mar-23	1.01	0.00	0.00

5.8.2. It has been observed that while one exchange has witnessed measurable bids on both the demand and supply sides, the other two exchanges have not recorded similar bid volumes. Due to this, either most volume gets cleared on one exchange only, where counter supply/demand bids are available for matching, or else the prices discovered across the exchanges vary significantly. Further, it has also been observed that on one of the low-volume exchanges, even if both buy and sell bids were available, no volume got cleared. Reasons for this could be either the price offers did not converge or the supply & demand bids were available in different blocks of the day.

5.8.3. Further, it is argued that innovation in the bid types has been relatively limited by the power exchanges in the collective transaction segment, which otherwise would have incentivized more participation. The presence of multiple exchanges has not served the purpose of competition and innovation in this segment, as originally conceived by the Commission.

5.8.4. It has also been contended by the stakeholders that the argument that the market is skewed due to design inefficiencies does not hold good, as behavioural aspects assume significance in collective transactions because a participant prefers to trade where the liquidity is higher, which shall ensure him both commensurate supply and a better price.

5.8.5. In the case of continuous transactions, the buy bids and the sell bids are matched on a continuous basis with price-time priority. The participant behaviour here is different when compared to the collective transactions due to features like continuous matching. In this segment, all three exchanges seem to enjoy a

good market share. The exchanges have introduced innovative products/ contracts/ bid types in this segment on their respective platforms, which provides a variety of avenues for the participants. This has made the segment attractive across the exchanges.

5.8.6. Considering the above, is it imperative that market coupling be introduced in collective transactions segment to begin with?

6. Comments solicited

6.1. In view of the above discussions, the comments of the stakeholders are invited on the issues and questions highlighted in section 5 of this Discussion Paper.

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Annexure I

Illustration on Market Coupling and maximisation of economic surplus

Power Exchange 1 – Bids received

Buyer 1	Price	0	2000	2001	2500	2501	3000	3001	20000				
	Qty	35	35	15	15	6	6	0	0				
Buyer 2	Price	0	2000	2001	2500	2501	3000	3001	20000				
	Qty	20	20	10	10	4	4	0	0				
Seller 1	Price	0	1000	1001	2200	2201	2600	2601	3000	3001	3400	3401	20000
	Qty	0	0	36	36	120	120	180	180	210	210	300	300
Seller 2	Price	0	1000	1001	2200	2201	2600	2601	3000	3001	3400	3401	20000
	Qty	0	0	24	24	80	80	120	120	140	140	200	200

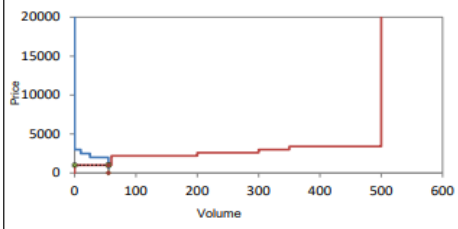
Price in Rs./MWh and Quantity in MW

Power Exchange 2 – Bids received

Buyer 1	Price	0	3000	3001	3500	3501	4000	4001	20000				
	Qty	64	64	30	30	12	12	0	0				
Buyer 2	Price	0	3000	3001	3500	3501	4000	4001	20000				
	Qty	36	36	20	20	8	8	0	0				
Seller 1	Price	0	1500	1501	2700	2701	3100	3101	3500	3501	3900	3901	20000
	Qty	0	0	18	18	60	60	90	90	105	105	150	150
Seller 2	Price	0	1500	1501	2700	2701	3100	3101	3500	3501	3900	3901	20000
	Qty	0	0	12	12	40	40	60	60	70	70	100	100

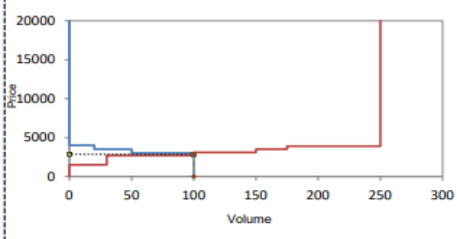
Price in Rs./MWh and Quantity in MW

Price Discovery in Power Exchange 1



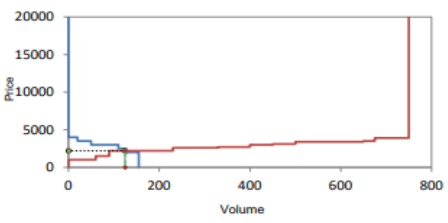
MCP (Rs./MWh)	1,000.92
MCV (MW)	55
Buyer Surplus	72,476.9
Seller Surplus	27.5
Total Surplus	72,504.4

Price Discovery in Power Exchange 2



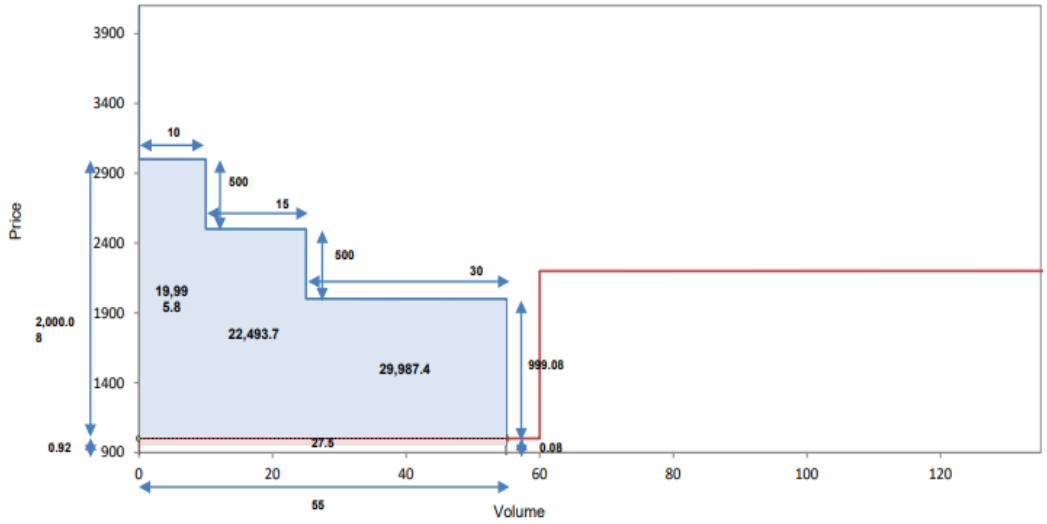
MCP (Rs./MWh)	2,850.50
MCV (MW)	100
Buyer Surplus	50,000
Seller Surplus	51,000
Total Surplus	1,01,000

Price Discovery after merging bids of Power Exchange 1 and 2



MCP (Rs./MWh)	2,200.25
MCV (MW)	125
Buyer Surplus	1,27,531.25
Seller Surplus	92,995
Total Surplus	2,20,526.25

Calculation of the surplus region: Power Exchange 1

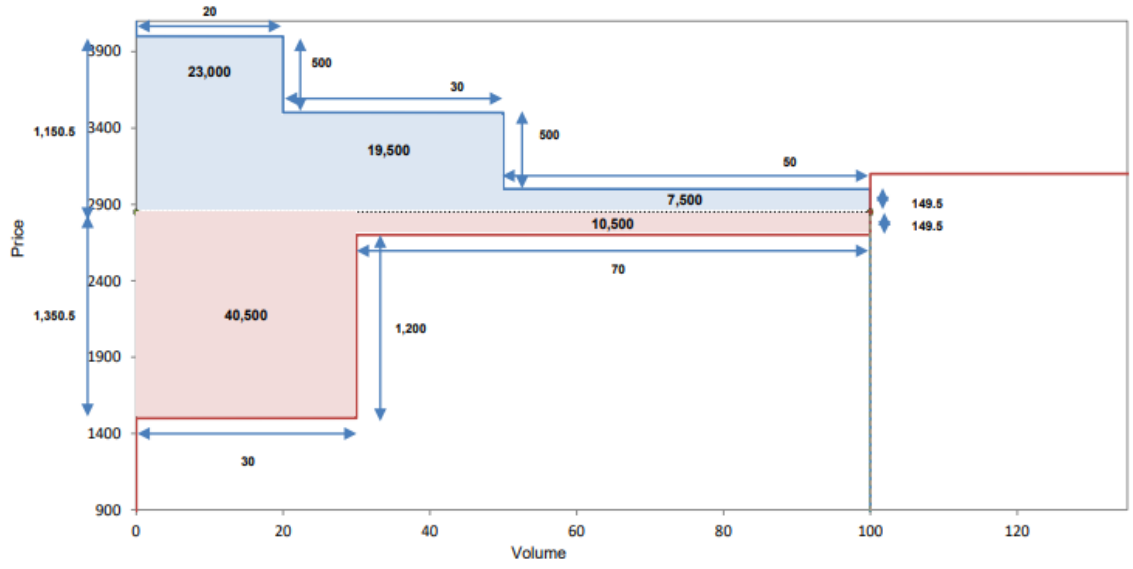


The area in blue comprises the buyer surplus, which is the summation of three regions: 19,995.8 + 22,493.7 + 29,987.4 = 72,476.9.

The area in red comprises the seller surplus, which is a single region: 27.5.

The **total of buyer and seller surplus** is the **overall economic surplus**. This is the summation of the red and blue regions: 72,476.9 + 27.5 i.e. 72,504.4.

Calculation of the surplus region: Power Exchange 2

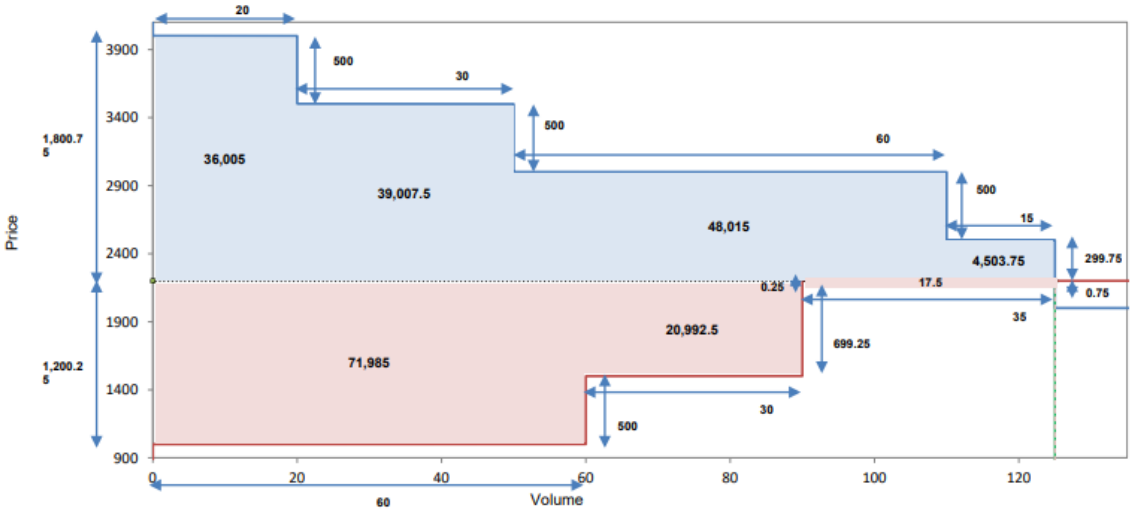


The area in blue comprises the buyer surplus, which is the summation of three regions: 23,000 + 19,500 + 7,500 = 50,000.

The area in red comprises the seller surplus, which is the summation of two regions: 40,500 + 10,500 = 51,000.

The **total of buyer and seller surplus** is the **overall economic surplus**. This is the summation of the red and blue regions: 50,000 + 51,000 = 1,01,000.

Calculation of the surplus region after merging bids of Power Exchange 1 and 2



The area in blue comprises the buyer surplus, which is the summation of four regions: 36,005 + 39,007.5 + 48,105 + 4,503.75 = 1,27,531.25.

The area in red comprises the seller surplus, which is the summation of three regions: 71,985 + 20,992.5 + 17.5 = 92,995.

The **total of buyer and seller surplus** is the **overall economic surplus**. This is the summation of the red and blue regions: 1,27,531.25 + 92,995 = 2,20,526.25.

Source: Based on the analysis undertaken during formulation of Power market Regulation 2021

Annexure II

Information Flow in case of market coupling

The figure below depicts the possible flow of information in market coupling.