CENTRAL ELECTRICITY REGULATORY COMMISSION
NEW DELHI

Petition No. 1/SM/2024

Coram:
Shri Jishnu Barua, Chairperson
Shri Arun Goyal, Member
Shri P.K. Singh, Member

Date of Order: 6th February 2024

IN THE MATTER OF:

Directions by the Commission for Implementing a Shadow Pilot on Power System and Cost Optimization through Market Coupling.

ORDER

The Commission notified the CERC (Power Market) Regulations, 2021 (hereinafter referred to as 'PMR 2021') on 15.2.2021, with the objective of creating a comprehensive market structure and enabling the transaction, execution, and contracting of various types of products in the power market. Subsequent to the implementation of various provisions of PMR 2021, the volume of transactions and the number of products and market segments have increased in all the power exchanges.

2. The PMR 2021, *inter-alia*, provides enabling provisions for the implementation of market coupling among the power exchanges, which are yet to be brought into effect by the Commission. Part-5 of the PMR 2021 (i.e., Regulations 37 to 39) provides 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. The Commission understands that the objectives of market coupling in the Indian context, including the discovery of a uniform market clearing price, optimal use of transmission infrastructure and maximization of economic surplus are different from those of other countries, where coupling broadly entails the integration of two or more electricity markets or different geographies. The need for and implementation of market coupling in India has been a major subject of discussion in both policy and regulatory spheres.

4. The Ministry of Power (MoP), vide its letter dated 2.6.2023, emphasized the importance of market coupling for the overall development of the power market. The Report of the Group on Development of Electricity Market in India, 2023, constituted by the MoP, also underscores the need to evaluate the feasibility of price coupling by CERC/MoP in order to ensure a uniform price discovery for the implementation of reforms like MBED.

5. Moreover, the Commission, in the matter of transmission corridor allocation on a pro-rata basis by an order in Petition 158/MP/2013, constituted an Expert Group to find an acceptable solution that may also achieve social welfare maximization. The Expert Group, comprising members from bodies such as 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.

6. With due regard to the recommendations of the expert committee(s) and the provisions in PMR 2021, the Commission vide a Public Notice dated 21st August 2023, issued a Staff Paper on Market Coupling. The Staff Paper attempted to initiate the discussion with the market participants and other stakeholders on various issues and challenges involved in the implementation of coupling amongst the power exchanges. The key points for discussion raised in the staff paper were:

i. Does the current market scenario form a compelling case for Market Coupling?

ii. Effect of coupling on technological innovation and competition

iii. **Operational Aspects:**
   a. Who shall be the Market Coupling Operator?
   b. Which Algorithm should be adopted for a coupled market?
   c. How will the Clearing & Settlement be carried out?
   d. In which market segments coupling should be introduced first?
   e. Changes in the Settlement Process

7. The Commission received an overwhelming response on the Staff Paper, with a total of 127 stakeholders submitting their comments and suggestions. The list of stakeholders is available on the Commission's website.

8. The Commission has examined the comments and suggestions received on the staff paper. The Commission notes that stakeholders have provided a mixed view on most of the issues raised in the staff paper. Those in favour of market coupling have advocated its benefits mainly in terms of improved competition, increased volumes, lower transaction costs, ease of operation, better services, check on monopoly, better transmission corridor allocation, integration of cross-border power markets, and that it will pave the way for reforms, like MBED, SCUC, and the introduction of financial derivatives. On the other hand, the stakeholders arguing against market coupling pointed out the disruption that may be caused by market coupling, the role of power exchanges getting diminished as a bid collecting agency, the dampening effect on innovation & technology investments, the adverse effect on

competition, no improvement in transmission infrastructure utilization, the addition of another layer in the form of Market Coupling Operator (MCO) and the resultant increase in transaction costs, adverse impact on smaller traders' businesses, violation of power exchange licence conditions, etc. Besides, some of the stakeholders, like PXIL and the World Bank, shared the results of the simulations done to support the need for market coupling under the prevailing market conditions.

9. After carefully examining the suggestions received from the stakeholders, the Commission felt the need for more evidence-based results to decide on the potential benefits that coupling may accrue to the market participants and the power system as a whole. Accordingly, the staff of the Commission carried out several simulations using bid data from power exchanges to study the impact of market coupling on volume, prices, and economic surplus, as stipulated in PMR 2021. For the purpose of the analysis, bid data from IEX and PXIL for the Real-Time Market (RTM) for 40 days in 2022-23 was considered where bids, including cleared and uncleared bids, were available on both trading platforms. The analysis for the Day-Ahead Market (DAM) pertains to the months of January, February, and March 2023. A brief summary of the results is as under:

i. The coupling of power exchanges enables the clearing of some uncleared buy and sell offers. For example, in RTM, there were times when supply and/or demand bids were received on one exchange but could not be cleared. When the bids of the two exchanges were coupled, the cheaper sell offers on the said exchange were cleared and replaced the high-price sell offers of the other exchange. Additionally, some high value buy offers were also cleared after coupling. This led to an increase in the economic surplus.
ii. In the instances where coupled MCP was below the uncoupled MCP on the dominant power exchange, the overall consumer surplus increased. The maximum increase in volume in RTM was approximately 250 MW. In most instances, the economic surplus increased by less than 1% in RTM.
iii. In DAM, the coupling of power exchanges led to an increase in economic surplus by less than 0.013%. However, in certain time blocks, an increase of up to 3% was also observed. The maximum increase in volume was approximately 230 MW (3% of that time block), and the maximum decrease in

volume was 100 MW (2% of that time block). The total increase in volume for the months of January, February, and March 2023 was ~9 MUs (0.08% increase). The average MCP also increased by 0.3 paisa/kWh (0.06%), and volatility was reduced by 0.050 paisa/kWh (0.02%). The number of times the MCP touched the price cap was observed to remain the same over the analysis horizon.

10. Based on the results of simulations for coupling in DAM and RTM, it emerges that there is a possibility of uncleared bids (buy and sell) getting cleared in a coupled scenario. However, the overall gains in terms of increase in volume and economic surplus may not be significant. The peak time blocks witnessed an increase in economic surplus in a coupled scenario, but over a longer time horizon, the gains remained insignificant. Further, the impact on MCP and volatility varies across different time durations depending on the elasticity of demand and supply curves. The Commission finds these results broadly in conformity with the largely accepted view that under the prevailing market structure, where one dominant power exchange holds about 99% market share in DAM and RTM, merely coupling bids of all the power exchanges will not yield substantial improvement in market outcome.

11. Notwithstanding the results of the simulations, the exercise undertaken, and the comments of the stakeholders revealed some insights that the Commission felt were worth taking forward. The insights were in the form of - the need to increase the depth of the market, the scope for further optimization of system cost, and the need to enhance power system reliability and flexibility through appropriate market design. The Commission feels it imperative to bring in more participation in the market, which would not only improve supply availability and encourage competition amongst suppliers but also facilitate a platform for optimizing the resources. While the coupling of bids in the present market structure marginally contributes towards this, other alternatives need to be explored in pursuit of increasing market depth, system and cost optimization and grid reliability.

12. The current power market is visibly a demand-driven market, as we have witnessed in the recent past. Thus, to increase the depth, commensurate supply has to be necessarily brought in to fully utilize the efficiency gains of the market platform.

Resource adequacy framework is being evolved to ensure the adequacy of supply to meet demand in all time horizons reliably and at the least cost. But this will take time, and as such, the Commission feels it is expedient to explore all options to optimally utilize the existing capacity. Currently, most of the generation is tied up in long-term purchase agreements. While the efforts to bring these contracts to the market are underway through various policy and regulatory measures – for instance, by requiring the generators to bid their un-requisitioned surplus (URS) into the market, defining transmission allocation principles accordingly - there still remains last mile scope for optimization after all trading options for a specific time block/duration have been exhausted.

13. Security Constrained Economic Dispatch (SCED) is one such optimization tool. But SCED seeks to optimize the generation, keeping the demand schedule as constant. There are instances when some supply still remains unutilized after meeting all the demand under SCED. In parallel, we have demand and supply in power exchanges which remain uncleared. The question is whether there is a possibility of harnessing this uncleared demand and supply, or for that matter, optimizing the dispatch of generation by combining these two market segments? If yes, will this increase the depth of the market and enhance the reliability of the power system? The Commission examines these aspects in subsequent paragraphs.

14. One of the suggestions that has come on the Staff Paper is to couple RTM with SCED for efficient dispatch and cost optimization. The Commission notes that RTM was introduced on the power exchanges from 1.6.2020, with the primary objective of providing buyers & sellers with a platform to trade closer to real-time in order to manage their energy imbalances which are known only closer to actual delivery. All grid-connected entities are eligible to sell electricity in RTM, subject to submission of No Objection Certificate (NoC)/ Standing clearance issued by RLDC/SLDC. It has also been observed that not only generators but even DISCOMs participate as sellers in RTM for the optimization of their portfolio.

15. SCED, on the other hand, has been implemented as a pilot from 1.4.2019 as per the Commission’s directions to Grid Controller of India Limited (Grid-India), vide

suo-motu Order dated 31st January 2019. The SCED is being implemented with the objective of reducing the system cost via optimization of the schedule of the participating generating stations. The model dispatches the generators based on their variable cost, i.e., the cheapest available generator to its full capacity, followed by the next higher variable cost generator, honouring the technical capabilities, and so on, until the entire requisition is met. This results in incremental/ decremental changes in the existing schedule of the generators, which is settled through a national pool. The Commission has extended the implementation of the Pilot on SCED from time to time, and finally formalized the arrangement through the Indian Electricity Grid Code (IEGC), 2023.

16. The Commission observes that at present, primarily the generators whose tariff is determined or adopted by the Commission participate in SCED, whereas in RTM, the sellers constitute the regulated generators, IPPs and merchant power plants, open access consumers and DISCOMs. The former (SCED) is a regulated cost-based optimization measure, whereas RTM is an auction/price-based market segment. On the face of it, these two market segments (SCED and RTM) may look heterogeneous, but the fact remains that the ultimate objective of both is system and cost optimization. Further, both methodologies operate at the centralized level. Therefore, the Commission feels it expedient to explore whether coupling RTM with SCED would increase the depth of the market and enhance power system cost optimization without adversely affecting the SCED savings.

17. In view of the above and considering the stakeholders' suggestions, the staff of the Commission carried out a sample simulation exercise, utilizing the actual data from RTM and SCED to assess the benefits of such an optimization model. The exercise revealed the following insight:

a) For a specific day, the time block wise bids of RTM (both cleared and uncleared bids) were coupled with the demand and supply under SCED of the same day. For this purpose, the SCED demand (i.e., the schedule of the beneficiaries) was taken as must clear (vertical demand curve), and the power exchange demand was stacked alongside it to draw an aggregate demand curve. On the supply side, the SCED generators and power

exchange sellers were stacked in merit order of their variable cost (for SCED generators) and bid price (for the power exchange sellers) to draw an aggregate supply curve. The intersection of aggregate demand and aggregate supply curves yielded the coupled MCP.

b) On coupling, volume movement was seen in both the directions, i.e., from SCED sellers to power exchange buyers and from power exchange sellers to the SCED buyers.

c) Movement of volume from the SCED to the power exchange was seen in time blocks when the variable cost (VC) of the SCED generator was lower than the sell bid of RTM. In other words, the low cost SCED generators partly or fully replaced the high cost RTM suppliers. This led to a reduction in MCP in a coupled scenario, but the coupled MCP still remained higher than the variable cost of the SCED generators that replaced the RTM sell volume, resulting in an increment to the SCED savings pool. This was because the SCED generators supporting the power exchange (i.e., the volume transferred from SCED to power exchange) continued to be paid their variable cost, while the non-SCED buyers (i.e. the buyers in the power exchange) in this arrangement paid the MCP that was determined after coupling. The gap between the coupled MCP and the VC for these SCED generators was an additional inflow into the SCED savings pool.

d) Conversely, the movement of volume from the power exchange to the SCED was seen in time blocks when the sell bid of the RTM was lower than the variable cost (VC) of the SCED generator. In other words, the low cost RTM suppliers partly replaced the high cost SCED generators, subject to ramping constraints and minimum turndown level of the SCED generators. This led to an increase in MCP under the coupled scenario. But even in such a scenario, SCED savings witnessed an increment. This was because the high cost SCED generators, which were decremented due to their being replaced by low cost RTM suppliers, paid back to the SCED pool their variable cost equivalent to the quantum of such decrement. In this scenario, the RTM sellers which replaced the SCED sellers' volume were paid from the SCED savings pool at the rate of the coupled MCP but given that the VC of the decremented SCED sellers were higher than the coupled MCP, the gap

between the VC of such SCED sellers and the coupled MCP resulted in additional flow into the SCED savings pool.

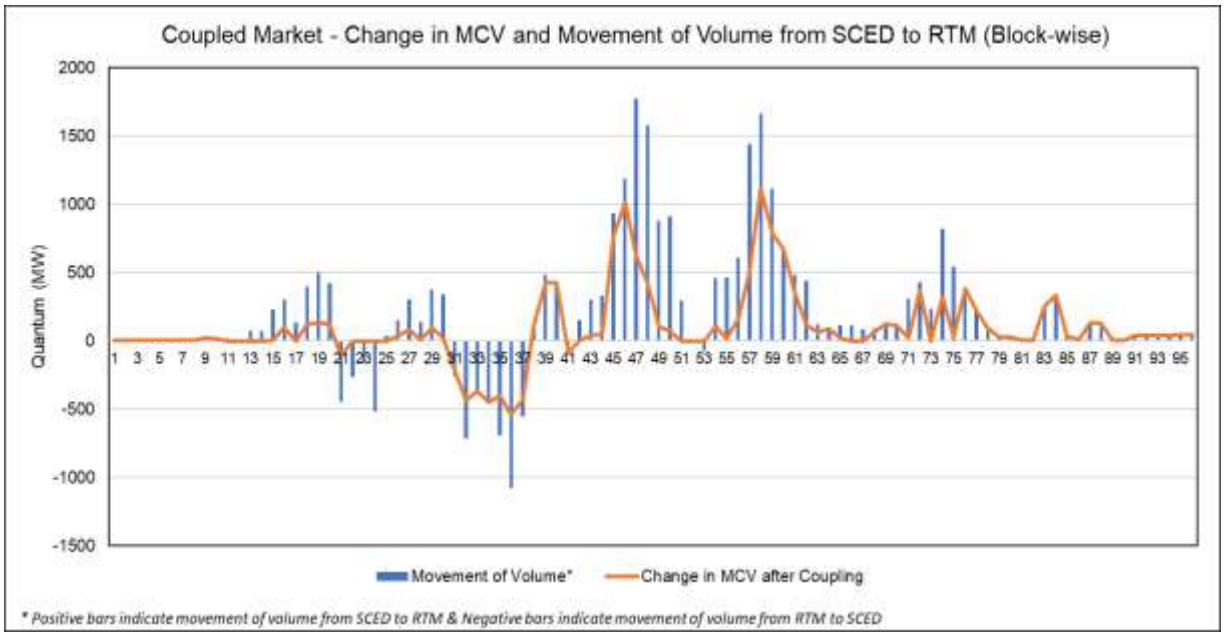
18. On a specific date of analysis, it was noted that the savings pool accumulated a total of approximately Rs. 85 lakhs, considering both credit and debit from the pool for the entire day over and above the estimated savings from SCED (Rs. 1.43 crore). Seen over a day, the instances of power exchange sellers replacing the SCED generators were less than the instances of the SCED generators replacing the power exchange sellers, as is evident from Figure 1.

19. The findings from the simulations revealed that the maximum increase in cleared volume was approx. 1100 MW. Additionally, the price variation range reduced by 5%, the price cap hits declined by approximately 10%, and the average coupled MCP was lower than the average MCP of the dominant exchange by Rs. 0.422/kWh.

20. Besides the economic benefits of coupling RTM and SCED, the simulation revealed some of the potential benefits in terms of power system reliability, as discussed below:

a) The simulation results showed a reduction in ramping-related infeasibility by 3%. **When price caps were hit, and the SCED** generators were ramp-constrained, the power exchanges helped lower the coupled prices.
b) On an average, electricity generated by SCED generators was cheaper than what was supplied on the power exchange. Therefore, these generators served the demand **that** otherwise remained unmet on the power exchange. This allowed the power plants to operate at higher PLFs, which in turn reduced their operation at lower efficiency levels (high heat rate). Operation at higher PLFs reduces maintenance expenses and enhances reliability.
c) When the cheaper power exchange supply served SCED demand, there could be conditions that result in higher availability of spinning reserves. In such cases, when the power exchange supply replaced the SCED supply, some of the SCED plants were either partially or completely relieved, thereby making them available to provide reserves.

Figure 1: Movement of volume between RTM and SCED



d) The simulation results showed a reduction of cycling instructions to generators, thereby leading to lower wear and tear and, hence, improved reliability.

e) The simulation results also made a case for better congestion management.

21. The Commission has examined the results of the simulations done by its staff and finds merit in implementing an optimization model through the coupling of RTM with SCED. The Commission understands that the current ambit of RTM and SCED is different, but both have the common objective of optimization of the power system. The Commission also observes that the generation capacities available in the day-ahead and real-time are currently fragmented between the three exchanges and the generators available in the SCED mechanism. Thus, there is potential to further harness the existing generation assets to better serve the demand. Based on the simulation results presented by the staff, the Commission is of the view that the proposed coupling of RTM with SCED may enable harnessing of the unutilized generation, serving the unmet demand and resulting in significant cost optimization. This would help increase the depth of the market while ensuring system reliability, as noted in the simulation results.

22. From the analysis and simulations done by the staff on RTM, RTM with SCED, and DAM, the Commission finds that there are apparent benefits (though marginal) in coupling RTM; RTM with SCED; DAM, as discussed in the preceding paragraphs. The Commission, however, also takes cognizance of the fact that the proposed coupling of RTM, RTM with SCED, and DAM is a novel concept. Therefore, following a guarded approach, the Commission has decided to implement the proposed model in a shadow pilot. The Commission believes that this exercise is essential to determining the operational, market, and regulatory impacts on the existing system.

23. Accordingly, the Commission hereby directs that Grid-India shall implement on a shadow pilot basis (a) coupling of the Real-Time Market of the three power exchanges (b) separately coupling of the Real-Time Market at the three power exchanges along with SCED, and (c) coupling of DAM of the three power exchanges. The operational aspects of the proposed Shadow Pilot shall be as follows.

Shadow Pilot on Power System & Cost Optimization through Market Coupling

a) Grid-India shall run a shadow pilot model, honouring the procedures/ practices followed for RTM, SCED and DAM after market hours.

b) The results of the shadow pilot run shall not have any effect on the price & volume discovery in the actual RTM and DAM and on the final schedule & settlement for any entity during the trial period.

c) Grid-India shall frame a procedure in consultation with the power exchanges for the shadow pilot. The procedure shall contain the operational aspects including, but not limited to, the sharing of bids by the power exchanges, uniform market price discovery (including mathematical formulation), indicative revisions in schedules, accounting, etc.

d) All the power exchanges shall share all the actual bids (Quantum & Price offer) received in the RTM and DAM for each session (both buy and sell bids) with Grid-India after the market hours on each day. Power exchanges and Grid-India shall ensure proper and reliable communication links.

e) Grid-India shall develop the necessary software as required for running the shadow pilot within two months from the date of this Order.

f) Grid-India shall aggregate the bids received from the power exchanges for running the shadow pilot (i) for coupling of Real Time Market; (ii) for coupling of the Real Time Market at power exchanges along with the DC of Generators in SCED considering technical constraints (on the supply side) and the requisition by the SCED beneficiaries (on the demand side); and (iii) for coupling of DAM of the three power exchanges, and run the algorithm. Grid-India shall ensure that the SCED demand is met under all the circumstances.

g) There shall be no difference in the principle of sharing benefits/ savings. Indicative savings from the shadow pilot run shall be recorded by Grid-India.

h) The shadow pilot shall be implemented for a period of four months after the development of the necessary software at Grid-India.

i) Grid-India shall also apprise the Commission regarding the experience gained while running the shadow pilot in the form of a monthly report during these four months and submit a feedback report at the end of the four-month period. The monthly report shall cover the details of bid volume, clearing volume & clearing price obtained by Grid-India block-wise; as well as observations (along with empirical data) on aspects including, but not limited to, economic surplus, comparison of price discovery & cleared volume in shadow pilot, any cases of uncleared bids getting cleared in the shadow pilot, any displacement of bids offered at the power exchanges, changes in schedule on account of shadow pilot, savings obtained on optimization through shadow pilot, etc. The feedback report shall also be published by Grid-India on its website for stakeholder awareness.

j) Grid-India shall also maintain the relevant data during the operation of the shadow pilot, including, but not limited to, installed capacity, declared capacity, schedule & revisions in schedule, variable cost, quantum offered in RTM and DAM, requisition by states/ beneficiaries, etc.

24. While the above shadow pilot is focused on the optimization of the power system and cost in RTM/SCED and DAM, the Commission feels that the depth of the market may further increase with the running of DAM along with Security

Constrained Unit Commitment (SCUC). Though SCUC has already been provided for in the IEGC 2023, it is yet to be implemented. On approval of the procedure of the SCUC by the Commission, it is expected that the SCUC shall be rolled out shortly. The primary objective of SCUC is to ensure the availability of adequate reserves in the system by bringing the off-bar generating stations on bar or by preventing the on-bar generating stations from going off-bar. The Grid-India is mandated in the IEGC to carry out SCUC three days in advance and update the requirement on a day ahead basis. Once SCUC is triggered based on system conditions, some additional capacity would be available in the system which, after accounting for the quantum of reserves required, could be harnessed for optimum utilization for meeting energy needs. Coupling of DAM and SCUC might create scope for such optimization on similar lines as RTM and SCED, while at the same time providing insight for co-optimization of energy and ancillary services. The Commission would, therefore, also like to explore the possibility of coupling DAM and SCUC once the SCUC is operationalized.

25. In light of the above, and with due consideration of the objectives of Market Coupling as specified in Regulation 37 of the PMR 2021 and with a view to exploring the scope of optimization of schedule and dispatch of electricity as enshrined in sections 26 and 28 of the Electricity Act, 2003 and in the Preamble to the IEGC, the Commission directs Grid-India as under:

(i) Develop, within two months from the date of this Order, the necessary software as required for running the shadow pilot for coupling of RTM of the three power exchanges as well as coupling of RTM & SCED, and for coupling of DAM of the three power exchanges. The software so developed should be scalable for running the shadow pilot for coupling of DAM and SCUC, as and when decided by the Commission.

(ii) Implement the shadow pilot of coupling (a) RTM of the three power exchanges (b) RTM and SCED and (c) DAM of the three power exchanges, for a period of four months after the development of the necessary software, based on the directions contained in paragraph 23 of this Order.

(iii) Share the operational experience of running a shadow pilot in the form of a monthly report during the period of four months and a feedback report at the end of the four-month period.

(iv) Suggest the feasibility of coupling of the DAM and SCUC within two months from the date of this order.

26. Based on the insights gained while running the shadow pilot, the Commission shall further decide upon the need for creating the necessary regulatory framework for market coupling.

27. The Commission also directs all the power exchanges to share the necessary data and other information required by Grid-India for running the shadow pilot, as detailed in this Order.

28. Petition No. 1/SM/2024 is disposed of in terms of the above directions.

Sd/-	Sd/-	Sd/-
(P.K. Singh)	(Arun Goyal)	(Jishnu Barua)
Member	Member	Chairperson