Discussion Paper

on

Re-designing Real Time Electricity Markets in India

No RA-14026(11)/2/2018-CERC

Prepared by Staff of

Central Electricity Regulatory Commission
3rd and 4th Floor, Chanderlok Building,
36, Janpath, New Delhi-110001
Website: www.cercind.gov.in

July, 2018

Disclaimer

The issues presented in this discussion paper do not represent the views of the Central Electricity Regulatory Commission, its Chairman, or Individual Members, and are not binding on the Commission. The views are essentially of staff of CERC and are circulated with prime aim of initiating discussions on various aspects of re-designing real time electricity market and soliciting inputs of the stakeholders in this regard.

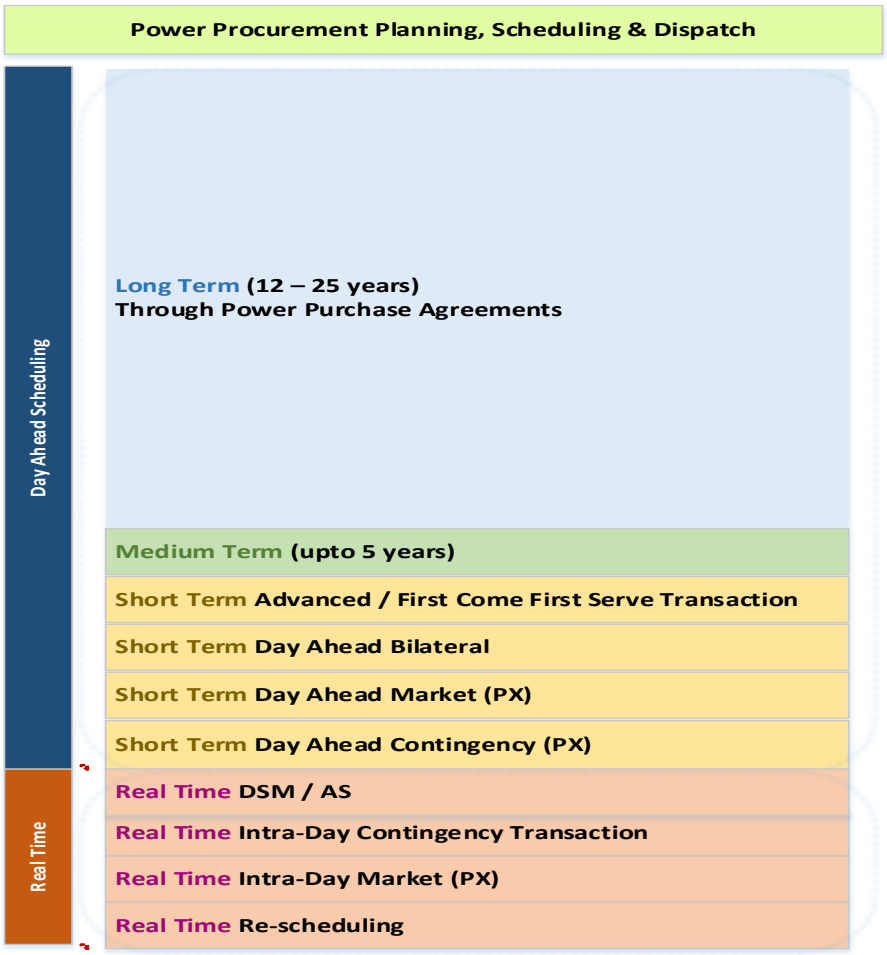
Contents

1. Current Market Operation in India

1.1 Generation and transmission assets are created much ahead in time for the distribution companies (Discoms) to plan their power procurement. Electricity market design needs to ensure that the objectives of system operation (to maintain system security) and power market operation (to serve power at the most efficient cost) are aligned. Pursuit to align these twin objectives is central to market reforms in power sector across geographies. Power procurement planning (in long-term, medium-term and short-term time horizons); dispatch of energy in day ahead and real time horizon; and handling of last mile system imbalances are essential ingredients to market operation and system operation.

1.2 In India, the duration for which power procurement planning occurs is shown in the figure below.

Figure 1 Power Procurement Planning in India



Source: Based on the data from the MMC Report of CERC (2016-17)

1.3 The Long-term contracts are entered through Power Purchase Agreements (PPAs) for duration up to 25 years. The Long Term Contracts constitute 90% and form the largest share of power procurement portfolio of the discoms and the remaining part is met through Medium Term and Short Term contracts.

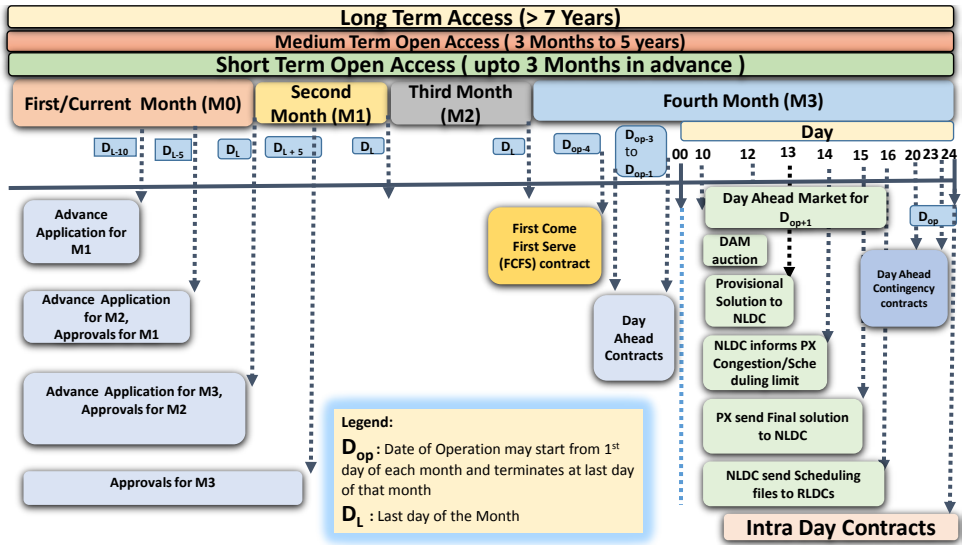
1.4 Most of the contracts in India are physical contracts and on a day-ahead basis, the discoms self-schedule based on such contracts. This implies that a day in advance, the discoms specify the quantum of power required to be scheduled from a generating station with which they have entered into a contract, without declaring the price of power under such long-term bilateral contracts. Almost 90% of the day ahead scheduling is based on this principle of self-scheduling[1]. The remaining 10%, are traded through traders, direct bilateral between the discoms and through power exchanges. There is another window of scheduling through Day ahead Contingency market segment of the power exchanges but its share is almost negligible at present.

1.5 After the day ahead scheduling as explained above, intra-day energy requirement as well as system imbalances are generally managed through Deviation Settlement Mechanism (DSM) and Ancillary Services (AS) Mechanism. In addition, the power exchanges also operate intra-day energy market (based on continuous trade) but it is not liquid enough as of now. Another option to manage the real time energy imbalances is by way of revision of schedule (four time blocks) before the actual dispatch. The generators can revise schedule themselves; so can the discoms, closer to real time (four time blocks/hour ahead) to manage their real time imbalances, and there is no financial liability for such revision. This is often termed as the right to recall[2]. The timeline of transmission access, and the scheduling and dispatch on day ahead and real time is depicted below in Figure 2.

1.6 Essentially, beginning a few days before the actual delivery, discoms plan procurement of power given their expectations about time-block wise chronological demand, generation from various sources especially wind, solar and run of the river. There could be surprises as the time approaches the day of actual dispatch and hence such planning is executed repeatedly till electricity is delivered reliably. This is the essence of power procurement planning and scheduling and dispatch of power

across seams of time. The processes as described above, especially of real time energy imbalance management in India have, however, thrown certain challenges and are being discussed in the subsequent section.

Figure 2 Transmission Access and Scheduling Prices in India



Source: Based on Regulations of CERC

2. Issues around real time energy imbalance system

2.1 At present real time energy imbalance is managed in India by means of – (i) Deviation Settlement Mechanism[3] (DSM) and Ancillary Services[4] (AS) Mechanism; (ii) intra-day bilateral contingency transactions (iii) Intra-day market segment of the power exchanges; and (iv) Re-scheduling / Revision of Schedule four time blocks ahead (Right to recall).

2.2 The DSM is meant to handle the last mile system imbalances. The frequency linked deviation prices and the allowable permissible band of deviation render the DSM to be a decentralized mechanism of managing grid frequency. The discoms and the generators tended to use DSM as an avenue for real time energy procurement and sale. The Commission has over the period been taking measures to discourage the market participants from using DSM as a trading platform. Recently, the Commission has proposed amendments to DSM Regulations seeking to link deviation price vector to day ahead average clearing price of the power

exchange(s) and also proposing mandatory zero crossing (deviation sign change) in six time blocks and consequent penalty for failure to do so[5].

2.3 In 2015/2016, the Commission introduced Ancillary Services (AS) mechanism, providing for the first time a centralized instrument (unlike the DSM which is a decentralized tool) of managing grid frequency. This enabled the system operator (POSOCO, operating the National Load Disptach Centre) to stack the un-requisitioned/un-dispatched surplus of the CERC regulated generators in merit order and use them as reserves for frequency control in real time. The generators called upon to provide such ancillary support are paid their fixed and variable charges plus a mark-up of INR 0.50/kWh. The payment to the generators is made from the DSM surplus pool. The implementation experience of AS, as reported by the POSOCO, however, reveals a number of challenges in the existing design[6]. For instance, it was reported that "***On 25th June-16, before 18:00 Hrs there was a falling trend in the demand met just prior to the evening peak hours and hence, regulation Down was implemented from 17:30 Hrs to 18: 15 Hrs (Figure – 26). Maximum regulation down implemented was 603 MW. From 18:15 Hrs the All India demand met started ramping up. To have sufficient generation in grid for meeting the demand as per trend of load, Regulation Up was implemented from 18:45 Hrs to 24:00 Hrs During this period Kahalgaon-II was given Regulation Up for (maximum 178MW).***"

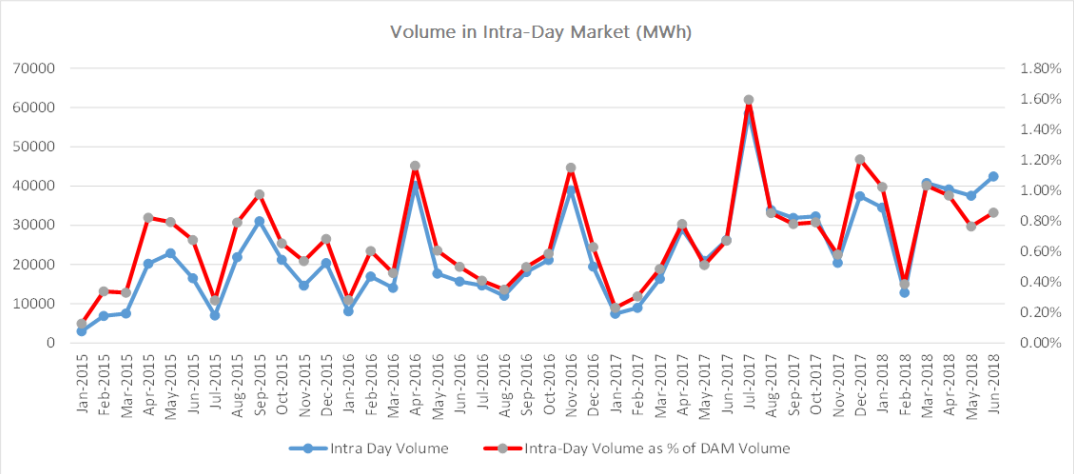
2.4 There are also some other instances reported when the ancillary services have been used for a still longer period. Use of regulation down or up services for such a long duration induces passive dependence of the discoms on this mechanism for their real time energy need. Such passivity is further accentuated as the AS costs are not "directly" incident on the utilities that were responsible for causing deviation. When demand is increasing in real time, the states whose demand is increasing should ideally buy power in the Intraday Market. Ancillary services or DSM/UI cannot and should not act as substitute for energy trade at intra-day time horizon.

2.5 POSOCO has also emphasized the need for intraday portfolio optimization. ***"It is emphasized that all the RRAS instructions highlighted above should not be construed as a substitute for proper load and wind/solar forecasting at***

state level and scheduling resources appropriately. The need for DISCOMs to fully capitalize on the 24 x 7 electricity market for intra-state transactions cannot be over emphasized." The Commission is already working on the next generation reforms in the Ancillary Services mechanism.

2.6 From the above discussion, it transpires that DSM and AS are not meant for real time energy management. Intra-day market in the power exchange was specifically introduced to address the need for meeting energy requirements closer to real time. However, the performance of this segment of the market has not been encouraging so far. This is illustrated in the figure below.

Figure 3 Intra-day Market Operation in Power Exchanges

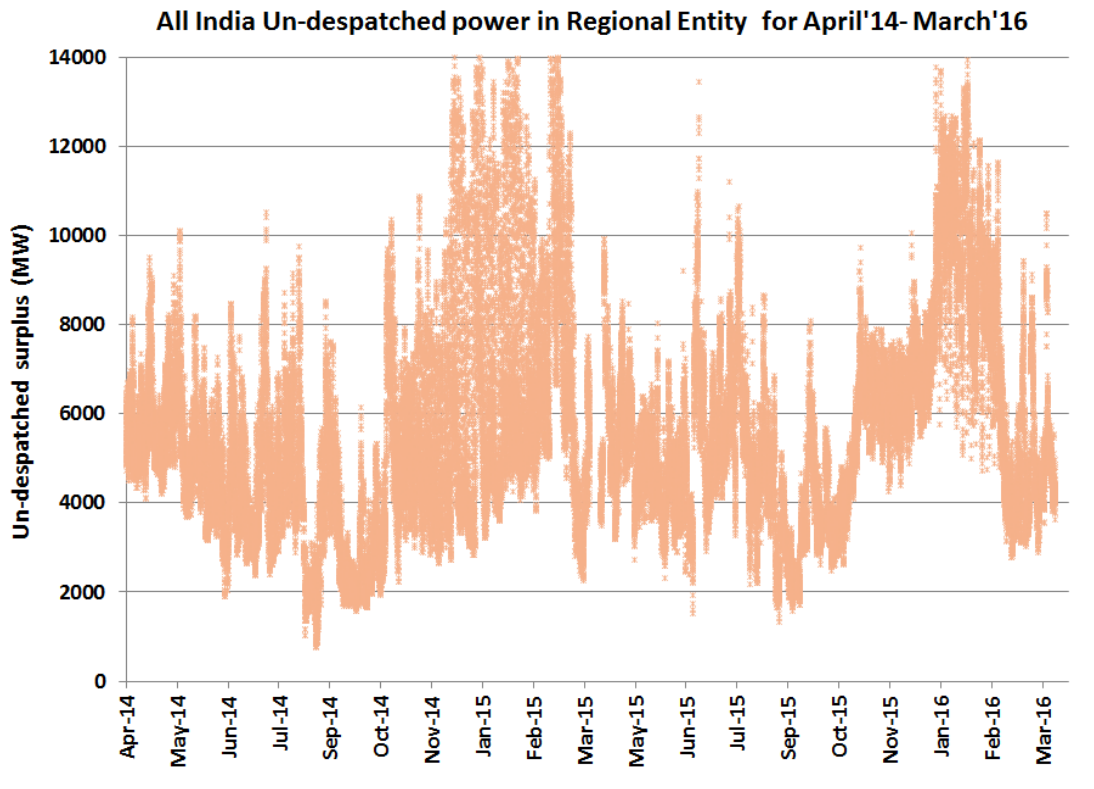


Source: MMC Report (January, 2015 to June, 2018), CERC

2.7 It is observed that the volume traded under the segment of intra-day market has remained static over the period and at a very miniscule level of less than 1%. A number of factors are cited to be responsible for such low response to this market segment - e.g., inertia of discoms and absence of delegation of decision making power at operators' level etc. On the design aspect, the price discovery methodology viz., continuous trading based on pay as you bid principle (as against the auction based on uniform clearing price) is also believed to be restricting the growth of this market. Yet another reason cited is absence of gate closure (- a system where the gate for schedule revision closes at a fixed time before the actual delivery, and the system operator takes over and schedules ancillary services). This brings us to the discussion on the next element of intra-day market segment viz., re-scheduling / provision for revision of schedule or the right to recall.

2.8 This provision of right to recall is meant to provide flexibility to the generators to adjust their output and the discoms to meet their contingent demand closer to real time. But the fallout is that sanctity and firmness of schedule is affected in the process. Seen from the generator's point of view, any generation capacity which remains un-utilised on day-ahead horizon cannot participate in the intra-day market as the original beneficiaries (discoms) have the right to recall such contracted generation at any time. Given that the discoms commit to bear the fixed cost for such plants, they claim to have inherent right to recall and any such request is to be honoured from the fourth time block ahead. While the rationale is appreciated, it remains a fact that this often leads to sub-optimal utilisation of generation resources and also limits liquidity for the intra-day market. The un-requisition surplus remaining available and un-dispatched over the period (please see the figure below) bears out this point.

Figure 4 Un-dispatched surplus power during April 2014- March 2016



Source: POSOCO Report on RRAS implementation- Half year Analysis (Nov-16)

2.9 Further, the Tariff Policy, 2016 also specifies that the load serving entity shall declare its un-requisitioned generating capacity to the generators at least 24 hours

before 00.00hrs of the day of dispatch. The Policy also provides for sharing of gains realized from sale of such un-requisitioned capacity in the ratio of 50:50 between the generator and the distribution utility. The relevant extract of the Tariff Policy is provided below.

> ***"6.2 Tariff Structuring and Associated Issues***
>
> *(1)*
>
> *……*
>
> *Power stations are required to be available and ready to dispatch at all times. Notwithstanding any provision contained in the Power Purchase Agreement (PPA), in order to ensure better utilization of un-requisitioned generating capacity of generating stations, based on regulated tariff under Section 62 of the Electricity Act 2003,* ***the procurer shall communicate, at least twenty four hours before 00.00 hours of the day when the power and quantum thereof is not requisitioned by it*** *enabling the generating stations to sell the same in the market in consonance with laid down policy of Central Government in this regard. The developer and the procurers signing the PPA would share the gains realized from sale, if any, of such un-requisitioned power in market in the ratio of 50:50, if not already provided in the PPA. Such gain will be calculated as the difference between selling price of such power and fuel charge. It should, however, be ensured that such merchant sale does not result in adverse impact on the original beneficiary(ies) including in the form of higher average energy charge vis-à-vis the energy charge payable without the merchant sale. For the projects under section 63 of the Act, the methodology for such sale may be decided by the Appropriate Commission on mutually agreed terms between procurer and generator or unless already specified in the PPA." (emphasis added)*

However, absence of gate closure stands in the way of implementation of the above provision in true sense.

2.10 Apart from the issues highlighted above, it has also transpired that the intra-day market in its present form is not adequate to address the emerging needs of time, as is being discussed in the next section.

3. Emerging Scenario and Need for market reforms

3.1 India has set a target of 175 GW of renewable energy (RE) capacity addition by 2022. RE is variable and uncertain and large scale integration of such RE throws multiple technological and commercial challenges. While RE achieved grid parity, in India, the share of installed capacity of renewable energy out of the overall capacity, has increased from 9% in 2010 to 20% by 2018.[7]

3.2 Increasing penetration of renewable energy has the potential of adversely impacting system operations and planning processes unless complemented by a market re-design which aids their integration. Real-time wind and solar availability is weather-dependent, uncertain, and variable. Another problem associated with the use of renewable resources is that they can increase the ramp in the net load profile (i.e., demand less renewable output). This effect of renewable generation can increase the need for flexible dispatchable resources that can ramp their output up and down quickly. This can also result in 'over-generation' situations, in which the system must curtail the output of renewable generators to maintain load balance.[8]

3.3 On the demand side, power systems are also undergoing important demand-side changes. These include:

- Growing adoption of distributed energy resources by end customers including roof top solar, RE sources connected at distribution and sub-transmission voltage levels. These resources are largely 'uncontrollable' by system operators even at the state level. In addition to the issues of being weather-dependent, uncertain, and variable that utility owned and operated renewable resources do, distributed renewable generators raise an additional 'visibility' issue. Discoms seldom have separate meters to monitor and are rarely able to forecast their real-time output.
- Novel uses of electricity (e.g., for electric vehicles, battery charging), can also increase demand uncertainty.
- On the brighter side, distributed energy resources and novel uses of electricity may also lead to greater demand-side flexibility in some power systems, which can mitigate some of the challenges associated with renewable integration.

3.4 The market models and structures are largely required to coordinate the supply and demand sides of the system and to keep pace with the same. However, owing to constraints thrown up by substantial growth in RE generation along with issues related to its integration, over-dependence on DSM / UI by the utilities, excessive reliance on ancillary services for longer durations etc., the system does not appear to absorb the shocks, thereby necessitating changes in the electricity market design..

4. Market Design Options

4.1 In this section we explore market design options under two broad heads, viz. International experience and India specific experience.

International Experience

4.2 Two alternative market designs which are followed in developed power markets are as follows[9]**:**

- An integrated market in which the system operator centrally optimizes the scheduling and dispatch of resources, and
- An exchange-based market in which energy companies trade day-ahead and throughout the day at prices that clear the market.

4.3 Integrated markets (where system operation as well as market operation is managed together by the system operator) are typically a characteristic of all US wholesale electricity markets, which operate day-ahead forward market and real-time imbalance market. Most European and the Australian markets follow largely exchange based market operation designs (where market operation is carried out at the exchange and system operation is handled by the system operator). Key difference between an integrated market and an exchange based market is in terms of how the unit commitment and dispatch processes take place and the extent to which the decisions are centrally coordinated. The exchange based designs rely on individual generating firms to manage the constraints on the operation of their generating units and to internalize operating costs such as start-up and no-load

costs, while in the system operator based integrated model these optimisations are done by the system operator**.**

4.4 Both the integrated markets and exchange based markets rely on day-ahead and real-time markets. The day-ahead market typically clears at about midday on the day before the operating day in question. In both these markets market players use forecasts of demand and supply conditions on the operating day to provide market participants with day-ahead schedules and corresponding prices.[9]

4.5 The real-time market clears much closer to the actual operating period. The primary purpose of the real-time market is to allow for changes in production and consumption schedules, to accommodate differences between day-ahead forecasts of system conditions and actual conditions that are observed in real time. During the initial years of multi-settlement electricity markets, real time markets cleared hour-ahead. Advances in computational capabilities over time have enabled many markets to evolve towards fifteen- or five-minute-ahead real-time markets.

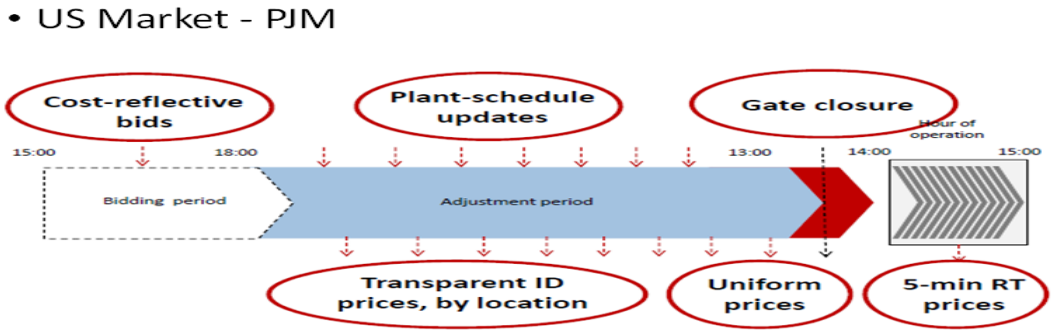
4.6 In the exchange based markets, while day-ahead markets are typically settled through auctions (for each hour/discrete time block), intra-day markets are settled using continuous trading mechanisms where orders are matched as soon as they arrive in the market orders book subject to their price and volume constraints. Continuous trading implements a pay-as-bid matching algorithm. In uniform pricing as followed in the integrated markets of US, auction participants receive the market clearing price so that the optimal strategy in competitive environments is to bid at marginal cost. In comparison, the pay-as-bid scheme used for continuous trading implies that market participants have to anticipate the clearing price and accordingly mark up their bids.

4.7 In December 2014, EPEX (power exchange in Europe) introduced an additional auction for 15 minute time slots at the beginning of the intraday trading session at 3 pm. The 3 pm auction is a uniform price auction for the 96 quarters for following day. Neuhoff et. Al[10]. have studied whether implementation of the Intraday 15 Minute Call Auction increased the efficiency in the German electricity intraday market and found that the trade volume was higher and the variation of the price

difference was lower after implementation of the new auction. Key findings of the research and a note on the intra-day continuous trade in Europe are detailed at Annexure-I.

4.8 Another important feature of advanced markets is the concept of Gate Closure. This is common in Europe as well as US markets. This implies that at some point before real-time, contracts (schedules) are frozen/finalized for the Delivery/Settlement Period. The point of time that the freeze/finalization occurs for a Delivery/Settlement Period is called Gate Closure. After Gate Closure, forward looking data for the Delivery/Settlement Period, such as physical information to the System Operator and contract (schedules) volumes, cannot be changed and the system operator takes over the responsibility for balancing the system. This is considered essential for the sake of ensuring reliability[11]. An illustration of gate closure (as in US/PJM Market) is depicted below:-

Figure 5 Gate Closure in PJM



Source: EPEX Spot- European Power Market Summit, 2016

India specific Experience

4.9 In India over the period various options to manage intra-day energy imbalance have been explored. The Forum of Regulators (FoR), through its Standing Technical Committee[12], examined the challenges facing the electricity market along with the options available for changes in market design through appropriate regulatory interventions. The Forum discussed the following seven different options for Intra-day/Hour Ahead transactions:

i. Banking: When there is higher generation in one State, it could bank its power with another State / utility and get the same quantum of energy back when it has

high demand. This does not involve any price transaction. This is, however, an adhoc arrangement of meeting intra-day energy imbalance. Further, this option is bilateral in nature and is opaque to other cheaper options. The true marginal cost of meeting the demand is not known in this mechanism, and gain or loss arising out of the transaction cannot be ascertained.

ii. Power Exchange (Day Ahead Market (DAM) price as reference) : As against settlement in kind (in energy terms), this option uses, the Day Ahead price on the power exchange as the reference price for intra-day bilateral settlement. This is an improvement over the banking arrangement as energy settlement is done based on price. However, it still remains bilateral, Also the liquidity of power remains an issue, as chances of availability of generation source in real time with marginal cost equivalent to or less than DAM price are very remote.

iii. Pool based on Regulator determined Variable Cost (VC) and transaction/trade on payment of variable cost: In this option, the generation resources in a region remaining undispatched on day ahead horizon could be pooled together by the RLDCs and stacked in merit order, for utilization to meet energy imbalance in real time in the region. If dispatched in real time, the resource could be paid based on its cost as approved by the Regulator. This provides greater visibility of all available options in real time and helps to make an informed purchase decision. However, in this option, the power is still transacted on its cost and does not capture its value. As variable cost of merchant plants is not determined by the regulator, such plants cannot participate in such transactions.

iv. Pool based on Regulator determined VC and transaction/trade on payment of Marginal Cost: This option is an improvement over the third option as it captures the value of electricity (as payment is made on the variable cost of the generator on the margin, and not as per its cost). But it still remains “administered” in nature. Again, as the tariffs of merchant plants are not determined by regulator, these plants cannot participate in the transaction. There was a realization that this option or for that matter the earlier three options are administered and regional in nature. The surplus and deficit scenario within a region might not be matching to meet the energy imbalance requirement of all the players in the region. Need for a national level market based product was therefore reiterated. The next three options are an outcome of such need.

v. Pool based on auction for intra-day for the rest of the day: This option provides for a national level market platform for discovering price based on auction at intra-day. The intra-day transaction, in this case is 'for rest of the day'. This implies that any time during the day of operation, one can use this platform for meeting its real time energy need for the rest of the day. This is definitely an improvement over the administered mechanism discussed earlier. But, 'transaction cleared for the rest of the day' ignores the definitive time boundary (gate closure) for system imbalance handling.

vi. Pool based on auction for intra-day on hourly basis: This option seeks to address the shortcoming of option-v, as discussed above. It provides for a market platform for hourly auction. In other words the intra-day market in this case could be operated every hour during the day for clearing volumes and price. The market participants would get opportunity to balance their energy portfolio continuously during the day. After the auction for any specific hour is completed and the transactions cleared, the schedules for that particular hour are frozen. No more schedule revision is allowed for that hour (gate closure). Deviation, if any, during that hour is managed by the respective market participants using their own resources (such as by varying intra-state generation) and/or by the System Operator using Ancillary Services.

vii. Pool based on auction for intra-day on intra-hour basis i.e for 15 min. block-wise: This option is an improvement over the sixth option by facilitating auction for intra-day on intra-hour basis i.e. 15 minute block time. This is closest to the real-time operation. Gate closure element is a pre-requisite.

4.10 The Forum of Regulators deliberated upon all the above options and recommended implementation of option 6, i.e. Pool based auction for intra-day on hourly basis. In order to operationlize this option, appropriate regulatory interventions through amendments to the existing electricity market framework, are required to be considered.

4.11 To summarise, the following options for real time market design emerge based on international and national experience: (i) US type integrated system and market operation with auction based on uniform clearing price and gate closure; (ii)

Europe type exchange based continuous trade with pay as you bid principle and gate closure; (ii) various options tried/contemplated in India, viz., banking, administered bilateral/multi-lateral transactions, market based intra-day auctions.

4.12 India having adopted the exchange based model cannot suddenly move to the integrated approach of market and system operation. The costs will far outweigh the benefits. But while retaining the exchange based model India can certainly move from continuous trade to auction based model in the intra-day segment for ensuring greater efficiency in price discovery and increasing the depth of the market. This is also in line with the current thinking in Europe. Lastly, the concept of gate closure can also be introduced for guaranteeing firmness and sanctity of schedules in intra-day trades. The recommendations of the Forum of Regulators are also on these lines. The next section discusses this in detail.

5. Suggested intra-day/real time market design for India

5.1 Discussion in the previous sections reveals the following position in so far as intra-day load generation management is concerned.

Table 1 Intra-day Load Generation Management

Market Operation – Framework			
Categories of Market	**Day Ahead Market (DAM)**	**Real Time Market (RTM)**	**System Imbalance/Ancillary Services Market**
Purpose	Energy Trade	Energy Trade	Inadvertent deviation management
Market Operation – India			
Current	DA (self-scheduling + Power Exchange (PX))	Deviation settlement Mechanism (DSM) + Ancillary Services (AS) + Intra-Day (PX) + Re-Scheduling (4 time blocks prior to dispatch)+ Intra-day contingency	
Desirable	DA (self-scheduling + PX)	Real Time Market (Hourly), with gate closure	DSM + AS

The current framework manages real time energy imbalances as well as inadvertent system imbalances primarily through DSM / AS mechanism, and partly through re-scheduling and intra-day market in the power exchanges. This has thrown up challenges that call for changes in market design. The recommendation that has evolved is for drawing a line of demarcation between 'energy trade' and 'system imbalance' handling. There is definitely a case for co-optimization of the two segments, but this should not imply mixing up the two and managing them jointly through a mechanism (of DSM / AS) which is meant for handling only system imbalances. Further, because of the provision of rescheduling, it becomes difficult to maintain firmness of day-ahead schedule. Hence, the need for a clearly identified real time / intra-day energy market with improved processes in the form of auction and gate closure.

5.2 In India we have followed the European model of exchange based market model. As a corollary, for the intra-day segment of the market as well, the exchanges have followed continuous trade based pay as bid model as against the auction based uniform pricing model.

5.3 However, as we observed in the previous section, continuous trade based on pay as you bid model suffers from inadequacies and even in Europe there is re-think on this design. The intra-day market segment in India also therefore needs to move to the next phase of reforms from continuous trade to auction based on uniform pricing mechanism. We have already witnessed its success in the day ahead segment. The discoms (which are predominantly public utilities) have posed faith in this system where they quote a price and are cleared either at that price or at lower than that price. Another important change suggested is in the form of introduction of the concept of gate closure. The real time market redesign suggested for India, therefore, seeks to encompass two elements viz., change over from continuous trade to uniform auction in the intra-day market of the power exchange and introduction of the concept of gate closure, as depicted below.

5.4 Key features of the existing intra-day electricity markets in the power exchanges are:

- Region specific 20 hourly intra-day contracts for delivery on the same day.

- The contracts are available for trading from 00:30 hrs to 20:00 hrs on a daily basis through continuous trading process.
- Since, under the extant processes, the difference between the trading end time and commencement of the delivery period is required to be three hours, the delivery period commences at 04:00 hrs. Similarly, the last intraday trade for the hour 23:00-24:00 ends at 20:00 hrs.

5.5 **Proposed Real-time Market design:** It is proposed to re-design the intraday market mechanisms as follows:-

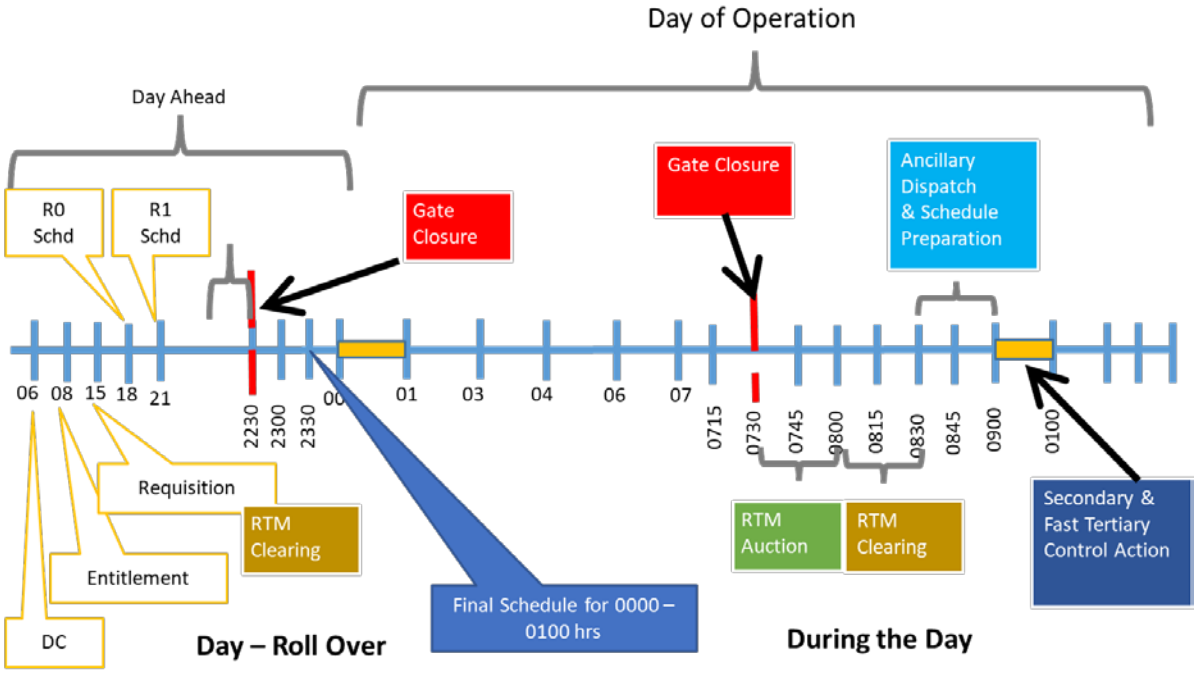
- ❖ The markets shall be based on double sided closed auctions with uniform market clearing price.
- ❖ The real time market shall be conducted once in every hour for delivery in four fifteen minute blocks in each hour. Such faster transaction/settlement requires automation, and the Commission has already initiated action on this (through amendments in regulations to implement National Open Access Registry).
- ❖ Timelines for Real Time Markets (RTM): RTM will involve double sided closed auctions with Uniform Market Clearing Price, with following timelines:-

Table 2 Timeline for Proposed Real Time Market

RTM Auction Start Time	RTM Auction End Time	RTM Clearing Interval	Communication with RLDC/SLDC and Schedule Preparation	Delivery Period (Delivery on the Same Day, MCP and MCV will be discovered for each 15 minute block)
22:30 Hrs (of the previous day)	23:00 Hrs (of the previous day)	23:00 Hrs – 23:30 Hrs (of the previous day)	23:30 Hrs – 24:00 Hrs	00:00:00 - 01:00:00
23:30 Hrs (of the previous day)	00:00 Hrs (of the delivery day)	00:00 Hrs - 00:30 Hrs	00:30 Hrs – 01:00 Hrs	01:00:00 – 02:00:00
…				
07:30 Hrs	08:00 Hrs	08:00 Hrs - 08:30 Hrs)	08:30 Hrs – 09:00 Hrs	09:00:00 – 10:00:00
…				
21:30Hrs	22:00Hrs	22:00 Hrs – 22:30 Hrs	22:30 Hrs – 23:00 Hrs	23:00:00 – 00:00:00

Pictorially, the above schedule is reflected as:-

Figure 6 Schematic of Proposed Real Time Market



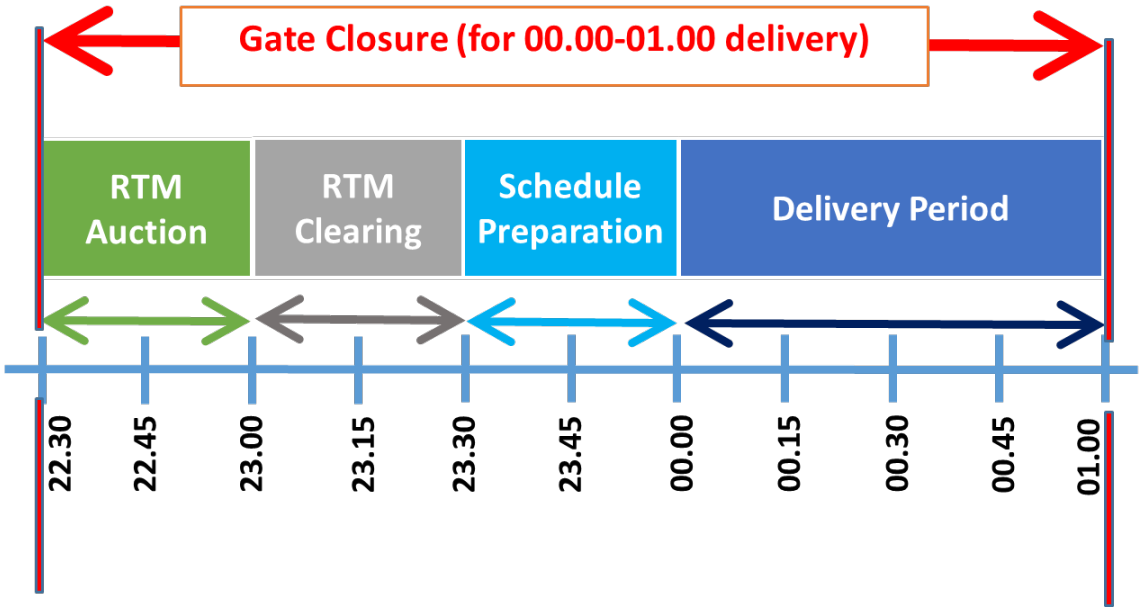
Source: CERC Staff

As it is evident, the energy trade for the first hour (00.00 Hrs. to 01.00 Hrs.) of the day starts at 22.30 Hrs. of the previous day and is repeated every hour thereafter.

5.6 For operationalizing real time markets, the schedules decided at the end of RTM clearing have to be both financially and physically binding. For this, the concept of Gate Closure is to be introduced. For each fifteen minute block in one hour, those with demand for electricity or discoms or traders will assess in advance what the demand will be. They'll then place their bids in the RTM for that volume of electricity. Similarly generators / traders will place their offers. To ensure firmness of such bids and offers, the gate for schedule revision will close before the start of the auction, as depicted below in Figure 7.

In this illustration, the gate for schedule revision for the hourly trade for 00.00 – 01.00 Hrs closes at 22.30 Hrs of the previous day. The auction is conducted for the delivery period 00.00 – 01.00 Hrs. This process is continued every hour thereafter. The gap between gate closure and delivery period will be reduced gradually as automation of the process improves.

Figure 7 Concept of Gate Closure



Source: CERC Staff

5.7 **Settlement in the proposed Real Time Market:** All day-ahead schedules (as a matter of principle) are "firm financial commitments". Firm-financial commitment means that a supplier (generator or trader) receives revenue from day-ahead schedules regardless of real-time output of its generation unit.

- If a supplier is scheduled 40 MWh on day ahead at a price of INR 2500 / MWh, it receives INR 1,00,000 for sales. Any shortfall or surplus from day-ahead generation schedule shall be rebalanced in real-time market (unlike in the existing system where such deviations are settled through DSM). If a supplier produces only 30 MWh in real time, it must purchase 10 MWh (to match day-ahead commitment) from real-time market at real-time price. This "purchase" by the generator is not for sale to the discom – this must be construed as generator making up for shortfall from its day-ahead commitment (day ahead schedule).
- Same logic applies to a discom / buying entity. If it is scheduled (day ahead) to draw 100 MWh for INR 4000/MWh (contract price) it pays INR 4,00,000 regardless of real-time consumption. If the discom / buying entity consumes 110 MWh, it must buy additional 10 MWh in real-time market at real-time price.

- If the load-serving entity consumes 90 MWh, it sells 10 MWh not consumed in real-time market at real-time price
- Real Time Markets must, therefore, be such that they allow generators / discoms to correct their positions in the real time markets, but with financial commitment for each such transaction.
- RTM is an energy only market and as such the play in this market is around the variable or marginal cost. The fixed cost liability will be borne / settled as per the existing contract. In the event of such generator earning revenue over and above the regulated variable cost, the gain shall be shared in the ratio of 50: 50 with the beneficiary as per the stipulation in the tariff policy.
- Illustrations of various scenarios to explain the concept of RTM have been provided in the box below.

Box 1: Scenarios for settlement in proposed RTM

Scenario 1: Case with significant intermittent resources

- Suppose a thermal unit is scheduled 100 MWh at price of INR 5000/MWh in day-ahead and wind resource is scheduled 80 MWh in day-ahead at same price
- In real-time, significantly less wind is produced than was scheduled
- Wind produces 50 MWh, so must purchase 30 MWh from real-time market at INR 9000/MWh
- Thermal unit must maintain supply and demand balance, which explains high real-time price - Sells 30 MWh at real-time of INR 9000/MWh
- Average price paid to thermal and intermittent units
  - INR 5923.08 / MWh= (100 MWh*INR 5000/MWh + 30 MWh* INR 9000/MWh)/130 MWh)
  - INR 2600/MWh = (80 MWh* INR 5000/MWh – 30 MWh*INR 9000/MWh)/50 MWh
- Dispatchable unit rewarded with higher average price than non-dispatchable intermittent unit

Scenario 2: Case of unexpectedly high intermittent resource output

- Wind resource is scheduled 50 MWh in day-ahead market and thermal unit is

scheduled 130 MWh. Both have a contract price of INR 5000/MWh

- Intermittent resource produces 80 MWh, which implies that it sells 30 MWh in real-time market at INR 2000/MWh
    - Low real-time price because of unexpectedly large wind output
- Thermal resource buys back 30 MWh in real-time at INR 2000/MWh
- Average prices paid to thermal and intermittent units
    - INR 5900 / MWh = (130 MWh*INR 5000/MWh – 30 MWh*INR2000/MWh)/100/MWh
    - INR 3875 / MWh = (50 MWh *INR5000/MWh + 30 MWh*INR2000/MWh) /80 MWh
- In this case, dispatchable unit is rewarded with higher average price than intermittent unit because it can reduce its output

Scenario 3: Case of generators and discoms tied up in a long term PPA:

- If a discom does not requisition / schedule power on day-ahead and until the gate closure, from a generator (with whom it has entered into a long term contract and has committed to pay fixed cost), such generator can sell the un-requisitioned surplus in the Real Time Market.
- The net revenue earned by such generator, over and above its variable cost, shall be shared with the discom in the ratio of 50:50. However, the fixed cost liability in respect of such generator shall continue to be borne by the discom as per the existing contract.
- Before the Gate Closure for any hourly transactions, the discom itself could also choose to sell in the RTM, the un-requisitioned power from the generator, and earn the entire revenue accruing from the sale of such power.
- In case, the discom has not, on day–ahead / until the gate closure, requisitioned / scheduled power from the generator and the generator has already sold such un-requisitioned power in the RTM, and the discom needs power closer to real time, then the discom, instead of schedule revision or exercising right to recall the generator, need to go to the RTM to meet its contingency requirement.

5.8 **Transmission Corridor Allocation and Congestion Management :**

Given the shorter duration of transaction in the Real Time Market, it would be desirable that POSOCO declares in advance the transmission corridor margin available for real-time transaction. Accordingly, Power exchanges shall factor in the said margin available while clearing the market in Real time. The congestion management shall be handled as per the existing practice including by way of market splitting.

5.9 **Treatment of Deviation from Real Time Schedule:** The real-time market is financially and physically binding. [13] Resources (Generators / DISCOMs / Traders / OA Consumers) must follow dispatch instructions. Failure to follow will attract charges under Deviation Settlement Mechanism (which eventually need be indexed to RTM prices as the next step to linking DSM price vector to DAM price).

5.10 **Mitigation of Abuse of Market Power or dominant position**

- The Commission shall monitor competitive constraints[14] to ascertain if:
    - Any player has a dominant position on the export end of a transmission constraint
    - Any player has a dominant position on the import end of a constraint
    - Any player has the ability to individually cause a constraint and alter market prices (i.e. is pivotal)
- The constraints may be defined *inter alia* in terms of market concentration (measured in terms of HHI, or Pivotal Supplier Index)
- In case the constraints are violated, the Commission may take appropriate actions under the provisions of the Electricity Act, 2003.

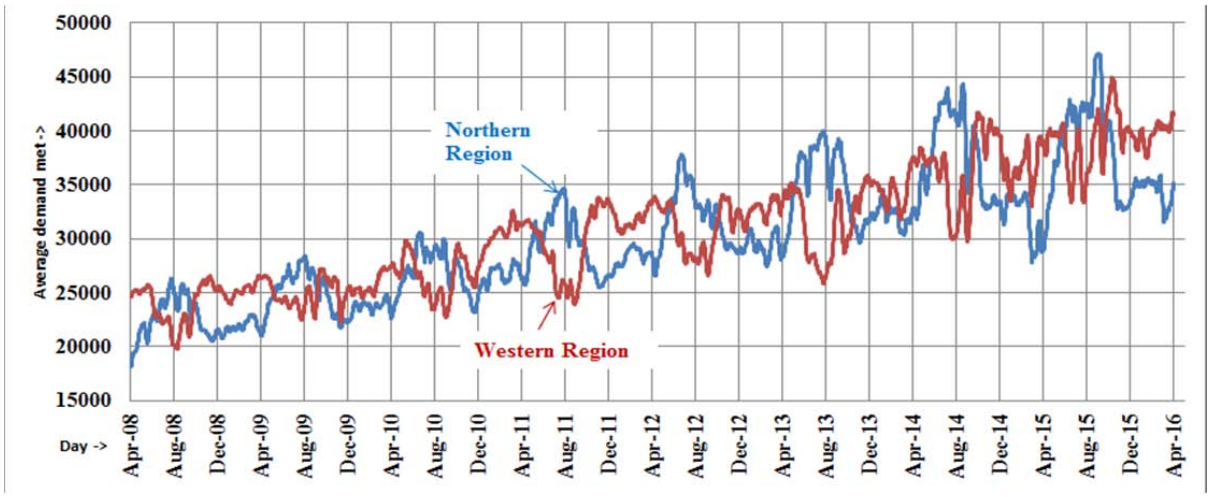
6. Benefits of Real Time Markets for the DISCOMs

6.1 Many states operate costly generators to meet demand during system peak hours (within the states) and run these plants at technical minimum during the rest of the day. This results in overall high cost of system operation. Though existing intraday markets provide opportunities to the states to replace such costly generators with cheaper resources in other states, such transactions are rarely observed. It has been estimated that if each state were to replace its costly

generation with cheaper resources available (in Real Time) in other states, the total daily power purchase cost of the country would reduce substantially. Lack of such trades in the extant setup is primarily due to poor liquidity in intraday markets. It is expected that liquidity in the proposed RTM will increase because of the design change in the form of auction and gate closure. The discoms have developed confidence over the period in the auction method of DAM. Further, strong deterrent against deviation (already initiated by way of amendment to CERC DSM Regulations) would drive the market participants towards organized markets which eventually would increase depth of RTM. Greater awareness and capacity building will definitely ease and quicken the process.

6.2 India has unique characteristics of variation in demand pattern in different region due to its climatic, and socio–cultural diversity. The following figure 8 shows when the maximum demand met in Northern region (July to August) coincides with minimum demand met in Western Region and vice versa[15]. This diversity in the demand pattern can be utilised effectively with national level organised market given the fact that electricity is more difficult and expensive to store. With National level organised market, possibility of resource optimization across regions to take advantage of cheap resources would increase significantly.

Figure 8 Average Demand Met in Northern and Western Region



Source: POSOCO report on 'Electricity Demand Pattern Analysis (2016)'

6.3 Currently discoms have the right to recall 4 time blocks ahead of actual despatch. Once the real time market with gate closure is introduced, the flexibility to

revise schedule will undergo change. While the gap between gate closure and delivery period will be reduced with automation of the process, such change should not be construed as disadvantageous to the discoms. Rather this framework is expected to benefit the discoms on the following counts:-

(i) The discoms would have access to larger pool of generation resources to meet their contingent requirement in real time as against the existing bilateral resources (under the right to recall) to meet contingencies;

(ii) Prices discovered in such real time market are likely to be more efficient than the cost of procurement of power from the bilateral arrangement under the right to recall;

(iii) In the event the generation resources (with which the discoms have contracts) sell the un-requisitioned surplus in the real time energy market, the net gains shall be shared with the discoms in the ratio of 50:50;

(iv) Alternatively, the discoms themselves can sell the surplus power from their contracted generation sources in the real time market and earn the revenue in full.

7. Way forward: Given the constraints in existing market operation and system operation and the challenges facing energy imbalance in real time, it is high time the country brought about changes in the market design in the real time segment as suggested above.

- X -

Annexure-I

Intra-day Continuous Trade in Europe

In the exchange based markets as in Europe, while day-ahead markets are typically settled through auctions (for each hour/discrete time block), intra-day markets are settled using continuous trading mechanisms where orders are matched as soon as they arrive in the market orders book subject to their price and volume constraints. Continuous trading implements a pay-as-bid matching algorithm. In uniform pricing as followed in the integrated markets of US, auction participants receive the market clearing price so that the optimal strategy in competitive environments is to bid at marginal cost. In comparison, the pay-as-bid scheme used for continuous trading implies that market participants have to anticipate the clearing price and accordingly mark up their bids.

Neuhoff et. al. have studied whether implementation of the Intraday 15 Minute Call Auction at EPEX increased the efficiency in the German electricity intraday market. Key findings of the research are as under.

- With the intraday auction much higher volumes (within a certain price range) are offered to the market.
- The authors attribute the increased depth to the following rationale: “In a uniform price auction, market participants can offer all available capacity at marginal costs and the uniform clearing price ensures remuneration at the value the capacity is required by the system. In contrast, in a continuous auction, market participants have to anticipate/negotiate the market clearing price and incorporate accordingly a mark-up in their offers in order to capture the value of generation assets to the system. However, this value to the system may change, for example if scarcity increases with the failure of a power station. Therefore, market participants only submit limited order for a fraction of their available capacity so that they can submit additional limited orders with adjust mark-ups should the supply-demand balance change.” (Emphasis added)
- The total trade volume for 15 minute intervals was higher after the implementation of the new auction.

- Authors also observe that the variance of the price was lower for observations after the implementation of the auction compared to similar observations before the implementation. Thus Neuhoff et. al. conclude that the new auction at 3 pm sets a strong price signal and reduces the variance of the price".

The prices discovered in Uniform Price Auctions serve as a better reference for derivative products as compared to average index price (computed by EPEX based on volume weighted price of all trades during the last three hours before gate closure). This is because actual sale/buy transactions are "discrete" and hence if the prices discovered in these discrete transactions are different from the index price, a basis risk is introduced. Using the EPEX data, Neuhoffet. al. conclude that "*However, as can be seen the basis risk is significant. In 5% of the transactions the basis risk is more than 86 €/MWh. Altogether, this indicates that the cap futures referenced to an index based on continuous trading only offers limited capacity to hedge against price risks. In contrast, if a similar option contract would have been referenced to a uniform price auction, then it hedges market participants trading in this auction without basis risk."*(Emphasis Added).

Auctions allow block bids and complex bids. It has been observed that the number of matched block bids is significantly lower than the number of matched blocks in the auction. This is because in continuous trading such matching becomes intractable for instantaneous immediate execution. Auctions allow for longer computation times and thereby ensure better execution/matching of blocks. This allows bringing full flexibility to the market.

Market results can further be made more efficient and full flexibility realized if the format of multi-part bids for generators is introduced. Quoting Budishet. al., Cramton reports that "*Continuous trading is unworkable in electricity markets, because combinatorial optimization is required to establish the feasibility of trade and this requires significant computation time (on the order of minutes). Thus, continuous trading results in unacceptable backlogs in order processing. A more sensible approach is intraday auctions, say every 15 minutes that would allow sufficient time for computation.*" Budish et. al. advocate for replacement of continuous trading by

frequent batch auctions. Appropriate frequency of intra-day auctions remains an important design question.

Implications for allocation of Transmission: Transmission capacity in intraday is allocated on a first come first serve basis in the present bilateral trading and exchange based continuous trading – both in India and Europe. Thus, the potential scarcity value of transmission capacity is captured by the first mover reserving the capacity explicitly or by the best offer on the exchange screen. The first come first serve rule on the explicit allocation, therefore, favours rapid traders instead of efficient ones.

Technically correct representation of the transmission network has huge implications for market efficiency. Practical experience in the US markets demonstrates that ignoring the transmission network or misrepresenting it (i.e., through a zonal model) creates inefficiencies, gives poor pricing properties, causes cross subsidies, and raises incentive issues. Given the advances in computational capabilities, tractability of problems is not an issue.

References:

1. Report on Short-term Power Market in India: 2016-17
2. Central Electricity Regulatory Commission (Indian Electricity Grid Code) Regulations, 2010.
3. Deviation Settlement Mechanism and Related Matters Regulations, 2014
4. Ancillary Services Operations Regulations 2015
5. Draft Central Electricity Regulatory Commission (Deviation Settlement Mechanism and related matters) (Fourth Amendment) Regulations, 2018.
6. Report on "RRAS Implementation in Indian Grid – Half Year Analysis and Feedback", November, 2016
7. Ministry of New and Renewable Energy, 2017 – year end review
8. National Load Dispatch Centre (NLDC), SCADA data, 2016-17
9. Wilson, R. (2002), 'Architecture of Power Markets', Econometrica, 70(4), 1299–340
10. Neuhoff, K., Ritter, N., Salah-Abou-El-Enien, A., and Vassilopoulos, P. (2016), 'Intraday Markets for Power: Discretizing the Continuous Trading?', Discussion Paper, DIW Berlin
11. Budish, E., Cramton, P., and Shim, J. (2015), 'The High-frequency Trading Arms Race: Frequent Batch Auctions as a Market Design Response', Quarterly Journal of Economics, 130(4), 1547–621, November.
12. First Report of FOR Technical Committee on Implementation of framework for Renewables at the State Level – Covering the proceedings from December, 2015 – November, 2017
13. AJ Conejo, R Sioshansi - International Journal of Electrical Power & Energy, Rethinking restructured electricity market design: lesson learnt and future needs - Elsevier 2018
14. Peterson, P., Biewald, B., Johnston, L., Gonin, E., and Wallach, J. (2001). Best Practices in Market Monitoring. Synapse Energy Economics
15. POSOCO report on 'Electricity Demand Pattern Analysis (2016)'