# पावर सिस्टम ऑपरेशन कॉर्पोरेशन लिमिटेड
(भारत सरकार का उद्यम)
# POWER SYSTEM OPERATION CORPORATION LIMITED
(A Govt. of India Enterprise)

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पोसोको/135 दिनांक: 9 सितम्बर 2019

सेवा में,

सचिव
केंद्रीय विद्युत विनियामक आयोग
तृतीय एवं चतुर्थ तल, चंद्रलोक भवन
36 जनपथ
नई दिल्ली-110001

**विषय:** Comments/Suggestions on draft amendments to the enabling provisions contained in: (i) Central Electricity Regulatory Commission (Indian Electricity Grid Code), 2010; (ii) Central Electricity Regulatory Commission (Power Market Regulation), 2010; (iii) Central Electricity Regulatory Commission (Open Access in inter-State Transmission) Regulations, 2008.

**संदर्भ:** CERC Public Notice RA- 14026(11)/2/2018/CERC dated 06.08.2019

महोदय,

With reference to above mentioned notice of the Hon'ble Commission, the views/suggestions on behalf of RLDCs/NLDC on draft amendments to the enabling provisions contained in: (i) Central Electricity Regulatory Commission (Indian Electricity Grid Code), 2010; (ii) Central Electricity Regulatory Commission (Power Market Regulation), 2010; (iii) Central Electricity Regulatory Commission (Open Access in inter-State Transmission) Regulations, 2008 are enclosed for kind perusal.

Delay in submission may be condoned.

सधन्यवाद,

भवदीय,

09/09/19

**(देबाशिस दे)**

**कार्यपालक निदेशक, रा. भा. प्रे. के.**

**संलग्नक:** उपरोक्त अनुसार

**Draft Open Access Regulations, Draft Power Market Regulations and Draft IEGC Regulations in the context of Introduction of Real Time Market (RTM)**
**Suggestions on behalf of the RLDCs & NLDC**

A discussion paper on 'Re-Designing the Real-Time Electricity Markets in India' was published by CERC on 25th July 2018. The Hon'ble Commission after due consideration of the proposal in the discussion paper and the comments received thereon proposed the Real-Time Market design as under:

a) Half hourly real time market
b) Price discovery mechanism: double sided closed auction with uniform price
c) Introduction of concept of gate closure with timeline in consonance with half hourly market
d) Buyers/sellers may place buy/sell bids for each fifteen-minute time block in the half hourly real time market
e) Generators with long term contract and participating in real time market Have to share the net gains with DISCOMs in the ratio of 50:50 in line with Tariff Policy, 2016
f) Failure in following dispatch instruction post RTM by the utilities would charges under Deviation Settlement Mechanism

To implement the Real Time Market, the amendments to Power Market regulations, Indian Electricity Grid Code (IEGC) Regulations, and Open Access in inter-state transmission regulations have been proposed. The proposed amendments are a welcome move towards creating a market platform for trade of energy closer to the delivery of power in real time. Earlier also, POSOCO has given feedback on the RTM Staff Paper and these are enclosed at **Annex-I** for ready reference. As Nodal Agency for collective transactions, National Load despatch Centre (NLDC) is closely associated with the implementation process and following aspects need to be suitably considered/factored.

**1. Ramping considerations in RTM (Collective transaction) schedule**

It may be appreciated that ramping of both generation and load is a major technical consideration to address the intermittent generation of renewable energy. Ramping is normally taken care of while scheduling of transactions by the RLDCs and individually, RRAS, FRAS and SCED all incorporate ramping as a constraint. However, ramping is not presently factored in the Power Exchange bidding/clearing and the bilateral market transactions. The trades cleared in the Power Exchange have an impact on scheduling and consequently, on real time operation. With RTM in place, multiple rounds of trades will happen and this will form a substantial portion of the schedule in real time.

In this context, it is pertinent to mention that the CERC appointed Committee on "Review of Block Bids at Power Exchanges" recommended ramping consideration in Collective transaction schedule. The same is quoted below:

*"d. It was also agreed that any change in Power Exchange Market design which has a material impact on the price discovery, volumes cleared and social welfare will need to be approved by*

*the Hon'ble Commission. Ramping requirements in system operation need to be taken care of and any step changes should be avoided as envisaged in the Grid Code. In future, detailed discussion on ramping restrictions on all segments of market could be taken up separately as need arises."*

Internationally, ramping is a constraint which is incorporated in market runs e.g., Nord Pool (https://www.nordpoolgroup.com/trading/Day-ahead-trading/Ramping/ ). The following mentioned on the Nord Pool website in this regard:

*"**Reasons for ramping restrictions***

*When imposing ramping restrictions, the Nordic transmission system operators have stated that frequent large changes in production and flow in the grid make it more difficult to control the frequency. The transmission system operators are therefore imposing ramping restrictions on HVDC connections in order to reduce risks that might threaten security of supply.*

*Without restricting the maximum change of flow per hour (ramping) on interconnectors, very large ancillary services and operational reserves would be needed to handle imbalances within operative hours."*

Hence, it is suggested that ramping in the bids in sequential blocks be limited to 1% in bidding stage itself in line with the provisions of CERC (Indian Electricity Grid Code) Regulations, 2010. As an example, the ramp between the bid quantum in any two consecutive time blocks shall not be more than ±1% both for generators to begin with. Ramping capability is expected to improve with the implementation of the relevant provisions in the CERC Terms and Conditions of Tariff Regulations 2019. Once this improves, the ramping limits allowed in the Power Exchange may be reviewed.

**2. Applicability of transmission charges, scheduling & operating charges and application fees**

The applicability of transmission charges, operating charges and application fees on the transactions to be cleared through real time market needs to be suitably incorporated in regulations. The real time market envisages running of the electricity market in collective mode 48 times per day.

(a) Application fee for the RTM application by the Power Exchanges may be considered as Rs. 5,000 as the consolidated application fee for all 48 runs. The Power Exchanges must deposit this in advance at the time they make the application for the DAM segment.

(b) Considering the fact that all transactions in real time market are for physical delivery and are financially binding for the participants, the applicability of transmission charges and losses is mandatory for each transaction. This would also help in bringing seriousness among the bidders and would avoid frivolous bidding.

(c) Operating charges need to be paid as per the trades and at the existing rates in the regulations.

Timeline for payment of transmission charges and operating charges shall be as per the prevailing norms i.e., next working day.

**3. Inter play of DAM and RTM for liquidity, robustness of price discovery and market manipulation**

Enough liquidity is also necessary to facilitate a robust price discovery and adequate safeguards must be built in to reduce the possibilities of market manipulation. While the day-ahead market can continue to run as it is, the design of RTM has to be such that it attracts participants from the OTC market, which has higher transaction costs, to the more organized platform, i.e., RTM. Presently, the prices are available for the day-ahead market operating in the Power Exchanges (IEX and PXIL). More than one prices are discovered in case of congestion and market splitting in the day-ahead market. With the RTM coming into picture two (2) prices (one for DAM and one for RTM) are going to be discovered. Interplay in the different market segments needs to be considered. Therefore**, it is suggested that only the participants who have purchased/sold power through day ahead collective transactions may be allowed to participate in real time market.** There can be cases where a market participant may not need to participate in the DAM but requires access to RTM to balance the portfolio. In such cases, these participants can place a 'zero' bid in the DAM to gain access to the RTM. This will not only bring liquidity to RTM but also reduce possibilities of market manipulation.

**4. Auction Design for RTM**

**(a) Price Discovery Mechanism**

The present proposal envisages the double sided closed auction for the RTM similar to the DAM segment with a uniform price. It is understood that a uniform price has been adopted from the viewpoint of the faith of the market participants in this mechanism. A robust price discovery requires a liquid market with large participation. The present DAM segment has grown over the last few years to achieve considerable degree of participation but whether it is liquid enough is a matter of debate. The participation in both DAM and RTM segment is 'voluntary' and thus, liquidity is a concern in the RTM segment. In absence of a fairly liquid market to support a robust price discovery, uniform pricing or pay-as-bid needs to be debated thoroughly while considering auction design. Pay-as-bid is generally the preferred mechanism in thin markets from a price discovery perspective.

**(b) Participation in RTM – Voluntary or Mandatory ?**

In the proposed market design for RTM, it is understood that participation shall be voluntary on the lines of participation in DAM, though this is not explicitly mentioned. RTM provides the last market opportunity to re-balance the portfolio by sale/purchase of the imbalances for all utilities.

In order to have utilities necessarily correct their position and balance their portfolio, it is suggested that mandatory participation for all regional entities may be considered. This would also bring liquidity and robustness of price in the RTM.

**5. Participation by Generators in the RTM**

(a) **Inter-state Generators:**

It is suggested all ISGS should be mandatorily asked to participate in the RTM. Those ISGS whose tariff is determined or adopted by the Central Commission should place their bids as per the variable charges respectively. The draft amendment already provides for sharing of net gain by these generators with their beneficiaries. Such a step will also bring liquidity to the system.

(b) **Intra-State Generators & Implementation of SAMAST:**

It is essential to have SAMAST implemented in the states in order to have participation by intra-state entities in the RTM and necessary thrust has to be given at all levels. Implementation of SAMAST will facilitate participation of state owned generators as well as intra-state IPPs in the RTM.

(c) **Renewable Energy Generators:**

It is expected that in future the RE generators may also participate in the RTM. It needs to be made clear that schedules for RE through the RTM cannot be revised and they shall be treated as firm and no revisions in RTM schedules can be done.

**6. Participation of generators in RTM for buying power**

In case of forced outage generator can buy power for the beneficiary to honor its commitment. It is suggested that instead of all generators, only the generator under forced outage may be allowed to buy power in Real Time Market. Power exchanges may ask such generators to submit a certificate declaring the reasons for forced outage and anticipated time of revival before allowing them to participate in RTM. This provision is extremely essential from a market manipulation perspective. Such a restriction should remain in place till financial products for hedging the risk are introduced in the Indian Electricity Market.

**7. Deviation Settlement Mechanism**

The Hon'ble Commission has already indicated in the 4$^{th}$ amendment to Deviation Settlement Mechanism Regulations to link the DSM prices with the RTM prices as and when it comes into effect. RTM has to be a liquid market so as to facilitate a robust price discovery and therefore, the price discovered in the RTM should not be considered for linking to the DSM prices till at a later stage when the market has stabilized further with enough liquidity and a robust RTM price.

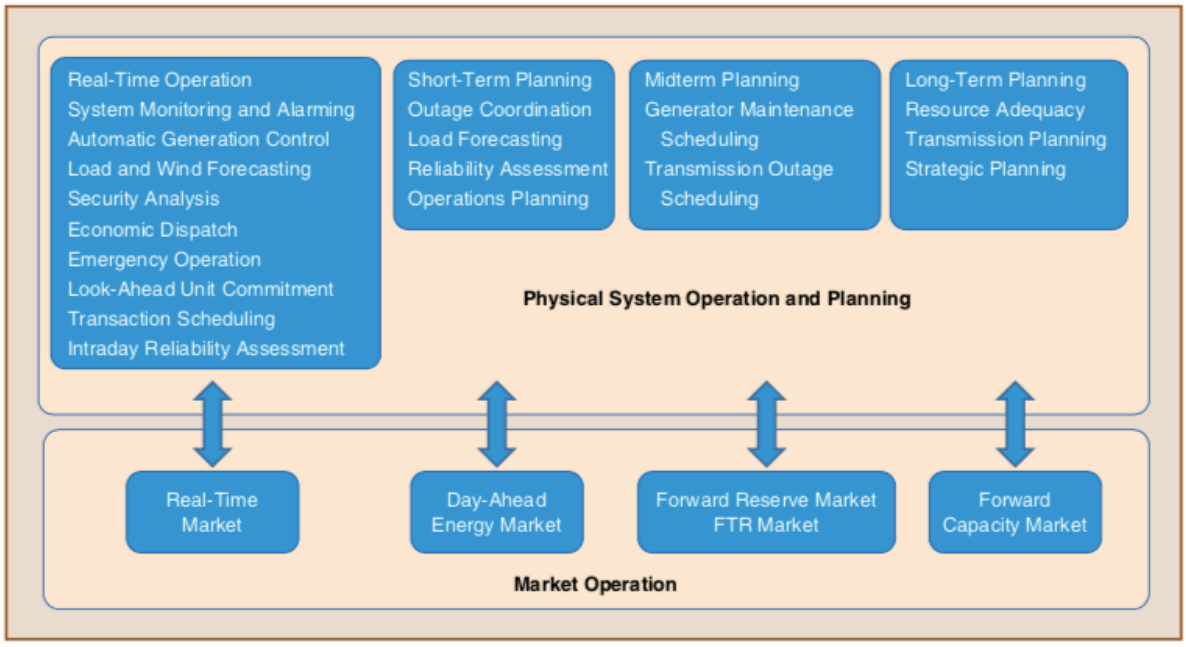
## 8. Implementation of Automatic Generation Control (AGC)

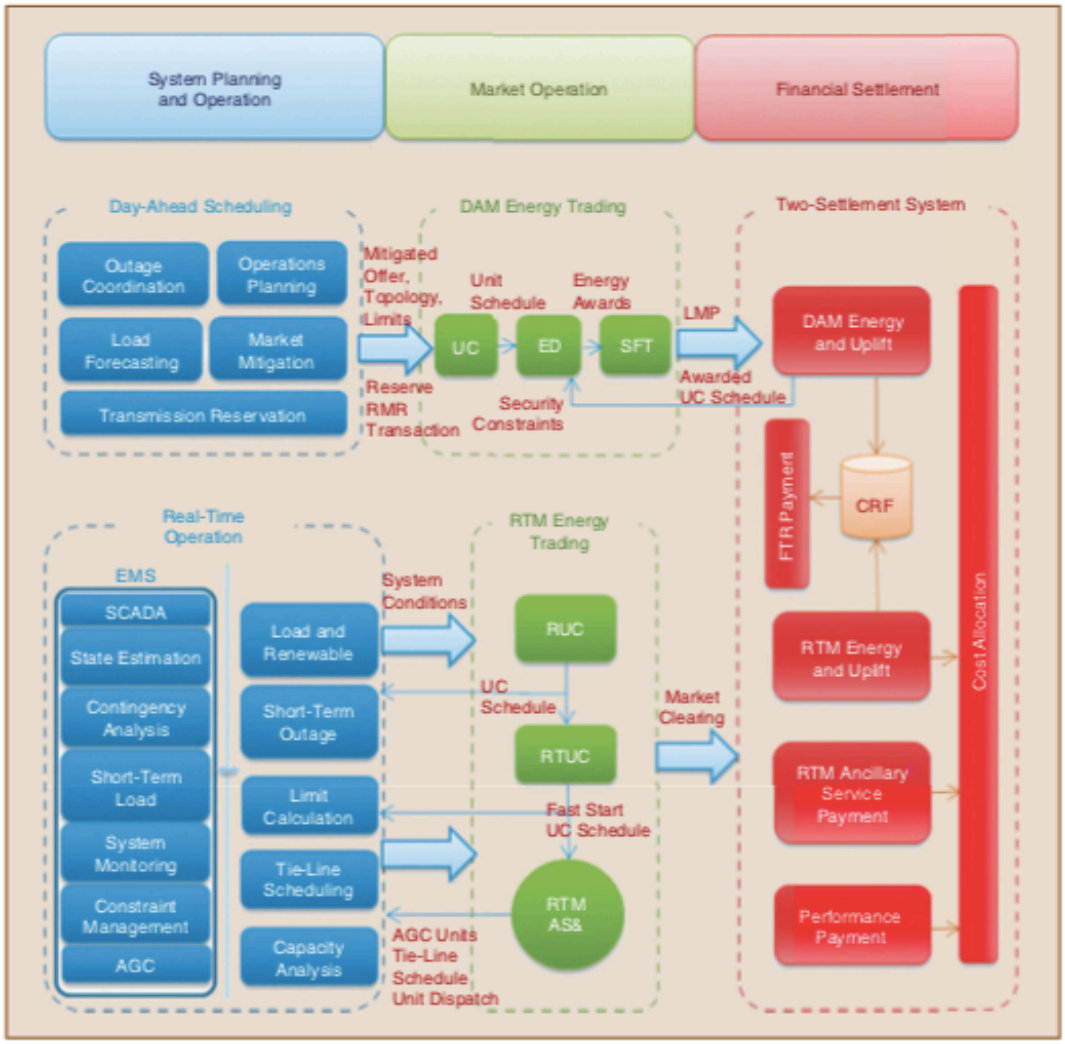
The backstop of RTM is AGC and DSM and the three are very closely linked. Any deviations/imbalances in real time after RTM are to be handled by AGC and DSM. In this regard, the following is mentioned in the book "Market Operations in Electric Power Systems – Forecasting, Scheduling and Risk Management" by Mohammad Shahidehpour, Hatim Yamin and Zuyi Li:

> *"In real time markets, in important responsibility of the ISO is to maintain the real-time balance of energy and supply. One of the. Indispensable tools for the task is the automatic generation control (AGC). AGC is offered in ancillary services markets for minimizing frequency deviations, which would lead to a balance of energy and supply, and for regulating tie-line flows, that would facilitate bilateral contracts from spanning over control areas"*

AGC is offered as a product in some of the markets internationally. However, in India, all inter-state generating stations have been mandated to provide AGC vide CERC Order in Petition No. 319/RC/2018 dated 28th August 2019. AGC implementation in the Indian Power System is extremely essential and needs to be done as per the CERC order.

Internationally, the Electricity Markets have the essential components such as AGC, congestion management, etc. as shown in figures below (Source: IEEE Power & Energy Magazine, Jan/Feb 2019 Volume 17, Number 1; pp 35-45)





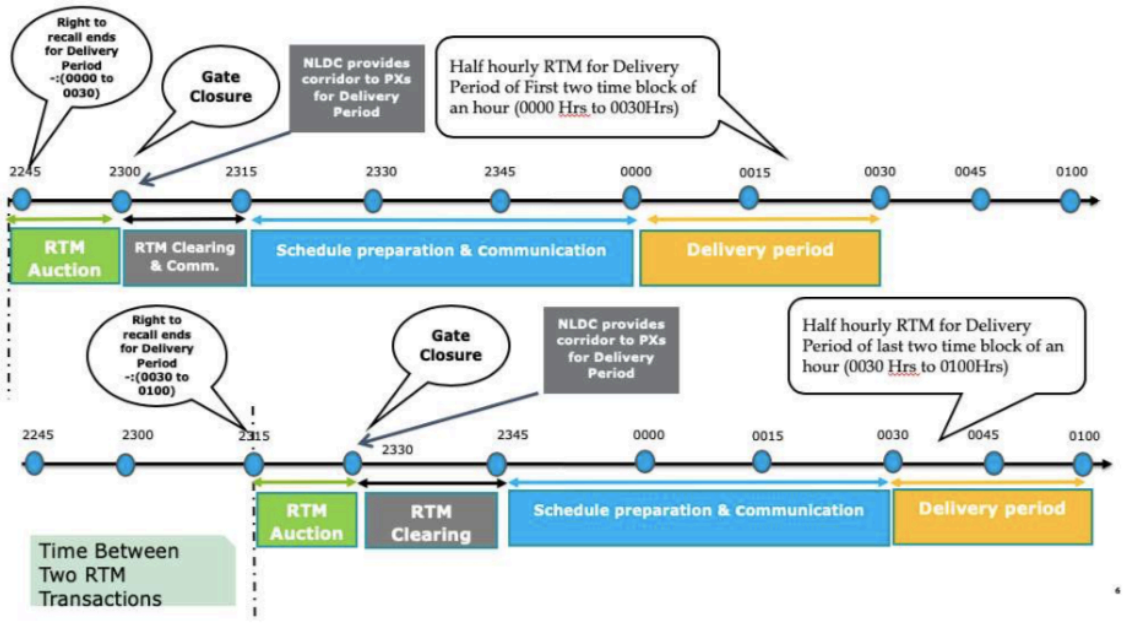

**9. Congestion management in real time**

There is a need for specifying the modalities for the transmission Congestion Management post operation of the RTM. This would have bearing on the transfer capability assessment by the system operator. As time lines for RTM are short and tight with the bidding window and market clearing window proposed to be 15/30 minutes respectively only, congestion management in real time assumes significant importance. The draft regulations propose that margins will be provided in advance to the Power Exchanges so as to avoid two step clearing (Provisional Market Solution and Final Market Solution) of the RTM market.

Further, added complexities are introduced with real-time curtailment and therefore the mechanism and priority to deal with real time curtailment may be specified clearly in the regulations. There could be a situation when a large number of participants may get affected due to real time curtailment and with the proposed timeline for real time market, communicating the information to all such affected parties would be a challenge.

## 10. Gate Closure

The pictorial depiction of the timelines for RTM and the gate closure has been provided in the RTM.




From the above figure it is seen that the bidding window opens at 2245 Hrs for delivery period of 0000 to 0030 hrs. Revisions in schedules (change in DC, recall of power, any other variations, etc.) upto 22:44:59 hours. Once the window for revision in schedules closes, the RTM window opens. Further, once the window for revision of schedules closes at 22:45, the RLDCs shall be working out the injection and drawl schedules which takes 2-3 minutes. In order to be able to bid in the RTM, the participants must clearly know where their portfolio stands e.g., a generator willing to participate in the RTM must know how much surplus power it has so that a sell bid can be placed for the requisite quantum. In the proposed scheme of things, there is no time allowed for running and finalizing the schedules prior to opening the RTM bidding/auction window and there can be information gaps. The RTM auction window is itself only 15 minutes and hence timelines are tight and market participants may face some difficulty. Allowing one more block of 15 minute may provide sufficient time to the participants.

Recently, a paper "Opening Markets, Designing Windows and Closing Gates: India's Power System Transition – Insights on Gate Closure" has been published (weblink https://www.nrel.gov/docs/fy19osti/72665.pdf ) where the subject of Gate Closure has been dealt with in detail both in the Indian context as well as international experience. The paper is enclosed for ready reference at **Annex-II** and may be referred. Quoting from the paper:

*"Available documentation indicates that decisions related to changing the length of the gate closure interval in the systems discussed above have been based primarily on qualitative rather than quantitative analysis. However, interest in quantitative analysis of gate closure options is growing; in an effort to inform current discussions regarding the harmonization of balancing*

*gate closure time in the European Union (discussed further in the "Harmonizing Gate Closure Across Borders: A Case Study from the European Union" text box), Petitet et al. (2019) recently developed a first-of-its-kind study comparing the operational costs of different gate closure intervals. The study found that 60-minute gate closure resulted in lower operational costs as compared to a 15-minute gate closure in the simulated system."*

Hence, it is not necessary that very short gate closure time necessarily reduces operational costs and thus, ease of operation, participation and implementation also need to be considered while designing gate closure. This becomes all the more relevant & contextual considering the fact that India has a coordinated multilateral scheduling model.

**11. No Objection Certificate for RTM Participation**

Regulatory provisions must ensure that the total quantum allowed for long term, medium term and short term open access including quantum to be traded under RTM is within the limit of the approved NOC quantum for the applied period. Presently, NOC is being issued for each transaction in bilateral segment and a separate NOC for DAM segment. The NOC for DAM segment of the Power Exchange transactions is also applicable for contingency category transactions. It is proposed that the NOC for DAM segment may also be used for the RTM with the added provision mandating that the participant must ensure compliance to the NOC. The requirement must be made further stringent by clearly mentioning that violation of NOC quantum shall have penal provisions such as withdrawal of NOC.

**12. Implementation of National open Access Registry (NOAR)**

National Open Access Registry (NOAR) was conceptualized with an aim to provide automation for faster operation and settlement of short term market. Initially, it was thought that Implementation of RTM would be subsequent to implementation of NOAR and RTM would be introduced after the implementation of NOAR. The Hon'ble Commission has already initiated action on this through amendments in regulations to implement National Open Access Registry. The Request for Application (RFA) documents for development and implementation of NOAR has been floated on the 4$^{th}$ September 2019. The project has an implementation period of 12 months from award.

**13. Upgradation of Information Technology (IT) infrastructure**

As per the draft regulations for implementing real time market, the time provided for communication amongst Power Exchanges, NLDC and RLDCs is very limited and accordingly, it requires more automation. It is pertinent to mention that in the envisaged RTM framework, there is sequential process of product clearing and despatch. Further, for carrying out inter-regional and cross border scheduling, a separate scheduling software is required to be installed at NLDC

and the installation process is being initiated by NLDC. Therefore, significant resources in terms of automation, communication and financial settlement are needed.

**14. Role of SCED in the RTM Regime**

SCED shall be running after the RTM has cleared. Ideally, if there is perfect information and perfect markets, then there would be hardly any margins left for SCED to optimise. However, considering the multilateral coordinated scheduling mechanism in India, there will still be some scope for optimisation through SCED. Sally Hunt and Graham Shuttleworth in their book "Competition and Choice in Electricity" mention the following (pp 160)

*"What is more, the despatcher would find it very difficult to operate the system, if traders are continually making minor adjustments to their inputs, in anticipation of possible imbalances. Such adjustments might undermine the least-cost nature of despatch. Instead, despatchers usually prefer to arrange any last minute rebalancing by controlling generator outputs on a least-cost basis."*

**15. Market Monitoring and Surveillance**

With further development of the electricity market in the country and introduction of new market segments, market information dissemination systems and market monitoring mechanisms need to be reviewed and strengthened. Information dissemination by the Power Exchanges needs to be reviewed and provisions for more elaborate information dissemination are needed e.g., social welfare, consumer surplus, producer surplus, etc. need to be incorporated. Multiplicity of prices and interplay between market segments are the areas which would require close monitoring. In this regard, the provisions under Part – 7 on Market Oversight of the Power Market Regulations 2010 are pertinent and relevant. These may be kept in view while designing the market information system and market monitoring mechanisms for RTM. There is a need for robust and pro-active market monitoring and surveillance mechanisms to be put in place for analysing bidding patterns, price discovery, market power, gaming etc. for smooth and dispute-free implementation.

**16. Information Dissemination, Workshops, Training and Mock Runs**

Introduction of RTM is a paradigm shift for the Indian Electricity Market and a significant effort is required in terms of information dissemination, workshops and training by all stakeholders.

**17. Harmonisation of new Time lines (7/8 time blocks) across all provisions for rescheduling**:

As per present IEGC clause 6.5.20, RLDCs can revise from 4$^{th}$ block for better system operation which could be difficult to fit in the above table. Suitable provision/clarification need to be incorporated. Similarly, all such clauses where there is a reference to revision from 4$^{th}$ time block need to be aligned & harmonized. A few such clauses from IEGC are given under:

- IEGC 6.5.16
- IEGC 6.5.20
- IEGC 6.5.23(iii)
- IEGC Annexure-1 – Complimentary Commercial Mechanism 4(ii)

In the interest of reliable and secure grid operation, Hon'ble Commission vide order dated 28th August 2019 directed that all the ISGS stations whose tariff is determined or adopted by CERC shall be Automatic Generation Control (AGC) enabled and the ancillary services including secondary control through AGC may be implemented as per the directions outlined in the order. The enforcement of primary response and secondary control through AGC would be of great importance in the interest of secure and reliable grid operation.

**Some other para wise observations with regard to draft regulations are enumerated below:**

**Draft CERC (Open Access in inter-State Transmission) (Sixth Amendment) Regulations, 2019.**

| Clause | As per Draft Regulations | Proposed |
|---|---|---|
| 2 (1) (g-a) | Intra-Day Transaction / Contingency Transaction" means the continuous transaction which occurs on day (T) after the closure of day ahead market window for delivery of power on the same day (T) except for the duration of the specified hour of delivery of the real-time market, or for the next day (T+1) and which are scheduled by Regional Load Despatch Centre or National Load Despatch Centre | Intra-Day Transaction / Contingency Transaction" means the continuous transaction which occurs on day (T) after the closure of day ahead market window for delivery of power on the same day (T) except for the duration of the specified ~~hour of delivery~~ **period of delivery (presently half an hour)** of the real-time market, or for the next day (T+1) and which are scheduled by Regional Load Despatch Centre or National Load Despatch Centre |

**Draft CERC (Power Market) (Second Amendment) Regulations, 2019.**

| Clause | As per Draft Regulations | Proposed |
|---|---|---|
| 2 (i) (o) | Intraday Contract / Contingency Contract means the contract where continuous transaction occurs on day (T) after the closure of day ahead transaction window and the delivery of power is on the same day (T) or next day (T+1) and which is scheduled by Regional Load Despatch Centre or National Load Despatch Centre | Clause 2(i)(o) Intraday Contract / Contingency Contract means the contract where continuous transaction occurs on day (T) after the closure of day ahead transaction window for delivery of power is on the same day (T) **except for the duration of the specified period of delivery of real time market** or next day (T+1) and which is scheduled by Regional Load Despatch Centre or National Load Despatch Centre |
| New Clause as 59 (x) | NA | For Real Time Market, Power Exchanges shall provide block wise, daily and monthly details of all transactions on its platform. |

**Draft CERC (Indian Electricity Grid Code) (Sixth Amendment) Regulations, 2019**

As mentioned at point 8 above, some of the clauses in the Principal regulations where there is a reference to revision from 4th time block need to be aligned & harmonized. Such clauses along with proposed regulations are mentioned below:

| Clause | As per Extant Regulations | Proposed |
|---|---|---|
| 6.5.16 | In the event of bottleneck in evacuation of power due to any constraint, outage, failure or limitation in the transmission system, associated switchyard and substations owned by the Central Transmission Utility or any other transmission licensee involved in inter-state transmission (as certified by the RLDC) necessitating reduction in generation, the RLDC shall revise the schedules which shall become effective from the 4th time block, counting the time block in which the bottleneck in evacuation of power has taken place to be the first one. Also, during the first, second and third time blocks of such an event, the scheduled generation of the ISGS shall be deemed to have been revised to be equal to actual generation, and the scheduled drawals of the beneficiaries shall be deemed to have been revised accordingly. | In the event of bottleneck in evacuation of power due to any constraint, outage, failure or limitation in the transmission system, associated switchyard and substations owned by the Central Transmission Utility or any other transmission licensee involved in inter-state transmission (as certified by the RLDC) necessitating reduction in generation, **the RLDC shall revise the schedules as: Any revision in schedule made in odd time blocks shall become effective from 7th time block and any revision in schedule made in even time blocks shall become effective from 8th time block**, counting the time block in which the bottleneck in evacuation of power has taken place to be the first one. **Also in this condition, for first, second, third, fourth, fifth and sixth time blocks, the scheduled generation of the ISGS shall be deemed to have been revised to be equal to actual generation if the event has occurred in odd time block and for even time blocks, the schedule will be equal to actual generation for first, second, third, fourth, fifth, sixth and seventh time blocks**, and the scheduled drawals of the beneficiaries shall be deemed to have been revised accordingly. |
| First para of 6.5.17 | In case of any grid disturbance, scheduled generation of all the ISGSs | In case of any grid disturbance, scheduled generation of all the **affected** ISGSs |

| | | |
|---|---|---|
| | supplying power under long term / medium term shall be deemed to have been revised to be equal to their actual generation and the scheduled drawals of the beneficiaries/buyers shall be deemed to have been revised accordingly for all the time blocks affected by the grid disturbance. Certification of grid disturbance and its duration shall be done by the RLDC. | supplying power under long term / medium term shall be deemed to have been revised to be equal to their actual generation and the scheduled drawals of the beneficiaries/buyers shall be deemed to have been revised accordingly for all the time blocks affected by the grid disturbance. **Further The generator is expected to revise the schedule from the time block and in the manner as specified in Regulation 6.5.18 counting the time block in which the grid supply to the affected station was restored as first block. Also in this condition, for first, second, third, fourth, fifth and sixth time blocks, the scheduled generation of the ISGS shall be deemed to have been revised to be equal to actual generation if the event has occurred in odd time block and for even time blocks, the schedule will be equal to actual generation for first, second, third, fourth, fifth, sixth and seventh time blocks, and the scheduled drawals of the beneficiaries shall be deemed to have been revised accordingly.** Certification of grid disturbance and its duration shall be done by the RLDC |
| 6.5.20 | If, at any point of time, the RLDC observes that there is need for revision of the schedules in the interest of better system operation, it may do so on its own, and in such cases, the revised schedules shall become effective from the 4th time block, counting the time block in which the revised schedule is issued by the RLDC to be the first one. | If, at any point of time, the RLDC observes that there is need for revision of the schedules in the interest of better system operation, it may do so on its own, and in such cases, the revised schedule ~~if made in odd time blocks shall become effective from the 4th time block~~ **shall become effective as: Any revision in schedule made in odd time blocks shall become effective from 7th time block and any** |

| | | |
|---|---|---|
| | | **revision in schedule made in even time blocks shall become effective from 8th time block**, counting the time block in which the revised schedule is issued by the RLDC to be the first one. |
| 6.5.23 (iii) | The schedules by wind and solar generators which are regional entities (excluding collective transactions) may be revised by giving advance notice to the concerned RLDC, as the case may be. Such revisions shall be effective from 4th time block, the first being the time-block in which notice was given. There may be one revision for each time slot of one and half hours starting from 00:00 hours of a particular day subject to maximum of 16 revisions during the day. | The schedules by wind and solar generators which are regional entities (excluding collective transactions) may be revised by giving advance notice to the concerned RLDC, as the case may be. Such revisions shall be effective from ~~4th time block, the first being the time-block in which notice was given~~ **the time block and in the manner as specified in Regulation 6.5.18**. There may be one revision for each time slot of one and half hours starting from 00:00 hours of a particular day subject to maximum of 16 revisions during the day. |
| Annexure-1 : 4 (ii) | The schedule by such wind and solar generators which are regional entities, supplying inter-state power under long-term access or medium-term open access or short-term open access may be revised by giving advance notice to RLDC. Such revisions shall be effective from 4thtime-block, the first being the time-block in which notice was given. There may be one revision for each time slot of one and half hours starting from 00:00 hours of a particular day subject to maximum of 16 revisions during the day." | The schedule by such wind and solar generators which are regional entities, supplying inter-state power under long-term access or medium-term open access or short-term open access may be revised by giving advance notice to RLDC. Such revisions shall be effective from ~~4thtime-block, the first being the time-block in which notice was given.~~ **the time block and in the manner as specified in Regulation 6.5.18**. There may be one revision for each time slot of one and half hours starting from 00:00 hours of a particular day subject to maximum of 16 revisions during the day." |
| 6.4.6 | The system of each regional entity shall be treated ……<br>…… | The system of each regional entity shall be treated …….<br>……<br>…… |

| | | |
|---|---|---|
| | ……. Inadvertent deviations, if any, from net drawal schedule shall be priced through the Deviation Settlement mechanism as specified by the Central Commission from time to time. Every regional entity shall ensure reversal of sign of deviation from schedule at least once after every twelve time blocks. | Inadvertent deviations, if any, from net drawal schedule shall be priced through the Deviation Settlement mechanism as specified by the Central Commission from time to time. ~~Every regional entity shall ensure reversal of sign of deviation from schedule at least once after every twelve time blocks.~~ **Every regional entity shall ensure reversal of sign of deviation as specified in the Deviation Settlement Mechanism regulations and its subsequent amendments thereof.** |

## Additional Inputs

**a) Regulation 6.4.6 of IEGC**

**Existing Regulation:**

**Quote:**

6. The system of each regional entity shall be treated ……..
……Inadvertent deviations, if any, from net drawal schedule shall be priced through the Deviation Settlement mechanism as specified by the Central Commission from time to time. ~~Every regional entity shall ensure reversal of sign of deviation from schedule at least once after every twelve time blocks~~

**Unquote:**

**Proposed modification**

The last sentence (strikethrough portion above) may be replaced as under:

***Every regional entity shall ensure reversal of sign of deviation as specified in the Deviation Settlement Mechanism regulations and its subsequent amendments thereof.***

**Rationale:** The provision for sign reversal stands amended in the DSM 5th amendment regulations.

b) The definition of Intra Day Transaction/contingency Transaction has been amended as follows:

*"(g a) "Intra Day Transaction /Contingency Transaction" means the continuous transaction which occurs on day (T) after the closure of day ahead market window for delivery of power on the same day (T)* ***except for the duration of the specified hour of delivery of the real-time market****, or for the next day (T+1) and which are scheduled by Regional Load Despatch Centre or National Load Despatch Centre.*

As per the procedure for scheduling of bilateral transaction in contingency category, the transaction shall be scheduled from the 6$^{th}$ time block, counting the block in which acceptance is accorded as the first time block i.e. the applicants can punch contingency transactions 1.5 hrs before the actual time of delivery. For example: the contingency transaction is punched exactly at 22:29 hrs for delivery of power from 00:00 hrs to 00:15 hrs and at 22:44 hrs for delivery of power from 00:15 hrs to 00:30 hrs, then the application needs to be approved by the nodal RLDC within 15 minutes and 1 minute respectively as the auction for RTM will start at 22:45 hrs. and information regarding approval/rejection of the application is to be communicated to concerned applicant before 22:45 hrs. Approval/rejection of such transactions and further communication to concerned applicant in such a short duration would be a challenge for the nodal RLDC.

This issue would be addressed by either increasing the time line specified for making a contingency application (from 1.5 hrs to 2 hrs) or by bringing necessary changes in the STOA software at RLDCs.

Annexure - I


# पावर सिस्टम ऑपरेशन कॉर्पोरेशन लिमिटेड
(भारत सरकार का उद्यम)
# POWER SYSTEM OPERATION CORPORATION LIMITED
(A Govt. of India Enterprise)

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CIN: U40105DL2009GOI188682

पोसोको/ के.वि.वि.आ/ **दिनांक :** 31st August, 2018

सेवा में,

सचिव,
केन्द्रीय विद्युत् विनियामक आयोग,
तृतीय और चतुर्थ तल, चंद्रलोक बिल्डिंग
36, जनपथ
नई दिल्ली-110001

**Subject:** Views/Suggestions on the discussion Paper on "Re -Designing Real Time Electricity Market in India"

**Ref.:** 1. CERC Public Notice RA-14026(11)/2/2018-CERC

महोदय,

With reference to the above-mentioned notice of the Honourable Commission, the views/suggestions of RLDCs/NLDC on the discussion Paper on "Re -Designing Real Time Electricity Market in India" are enclosed for your kind perusal.

सादर धन्यवाद,

भवदीय,

एस॰आर॰नरसिम्हन

संलग्न : यथोपरी

(एस॰आर॰नरसिम्हन)

कार्यकारी निदेशक,रा॰भा॰प्रे॰के॰

**Power System Operation Corporation Ltd.**
**New Delhi**

**Suggestions on Behalf of NLDC/RLDCs on the**
**CERC Discussion Paper on Re-Designing Real Time Electricity Markets in India**

At the outset, the CERC Discussion Paper on Re-Designing Real Time Electricity Markets in India is a welcome, very timely and forward-looking step by the Hon'ble Commission. Given the ambitious target of 175 GW for large scale grid integration of renewables, this paper suggests introduction of new and multiple market opportunities for the participants to balance their portfolio. This discussion paper seen along with the recent amendments in the CERC Short Term Open Access in Inter-State Transmission Regulations which purports to bring in the 'National Open Access Registry' is expected to take the Indian Electricity Market to the next level.

Suggestions on various aspects brought out in the CERC Discussion Paper are given as follows.

**1. Introduction of Gate Closure**

There is an urgent need for introduction of 'Gate Closure' in Indian Electricity Market. The following two aspects become important from a market design perspective in reference to 'gate closure'.

(a) How far ahead of the beginning of the despatch period does the gate need to close? The discussion paper proposes that the gate closes 90 minutes before the beginning of the despatch period.
(b) How long should the duration of the gate closure be? The discussion paper proposes that the gate should remain closed for 60 minutes duration.

IEGC provides for giving effect to revised schedules from the 4$^{th}$ time block considering the time block in which revision has been requested as the 1$^{st}$ time block. The following aspects are important in this regard:

(a) The above provision effectively closes the window only for 1-time block of 15-minutes making it difficult for any form of market to work.
(b) With coordinated multilateral scheduling process, the schedule modifications are being carried out continuously by the concerned RLDC as one or the other participant request keeps pouring in. For example, re-scheduling of un-despatched surplus on the request of one of the beneficiaries, tripping of power system elements, natural variations, revision in schedule of generators due to changes in requisition, revision in the schedule of beneficiaries due to change in DC of generators, transmission corridor availability etc. This also leads to uncertainty in terms of the available reserves for despatch under Ancillary Services (refer NLDC Feedback on Implementation of Ancillary Services).
(c) There is a need for making the schedules, which are nothing but contracts, financially binding for the participants while at the same time bringing in certainty of despatch.

Hence, there is a need for review of the current provisions with the objective of introducing gate closure.

While the market participants may argue that some degree of flexibility to re-balance portfolio that is available presently is being withdrawn with the introduction of gate closure, there also needs to be an appreciation for the fact that an alternate mechanism is being provided to re-balance their portfolio closer to the time of delivery. The alternate mechanism proposed is the Real Time Market (RTM) through Power Exchanges which provides access to a larger market & participating resources with a competitive price formation mechanism. Bidding of URS by ISGS in RTM would dissolve the existing limitation of URS scheduling only amongst co-beneficiaries of the same station. RTM would create an organized market for ISGS and intrastate generators.

Once the gate closes, the following activities are envisaged to be carried out during the gate closure period for the identified delivery period of one hour:

(a) RTM Auction period
(b) RTM Market Clearing & Scheduling
(c) Assessment of the requirement for despatch of Ancillary Services
(d) Communication of schedules by the RLDCs to the market participants and adequate time for the generators to ramp-up or ramp-down

From an implementation perspective, the proposed timelines for gate closure allow only 90 minutes ahead of the delivery period which is inadequate for all of the above activities. Further, this concept is being implemented for the first time in the country and there may be unforeseen implementation issues. For example, in the implementation of Ancillary Services, initially it was proposed to send the Ancillary Schedules directly to the participating generators from NLDC so as to obtain fast response. However, immediately after implementation, scheduling and ramping related difficulties were experienced and the schedules for ancillary services had to be routed through the RLDCs. Once we gain experience, the Hon'ble Commission can review the timelines based on the experience gained. In view of above, it is suggested that the gate closure should be 120 minutes ahead of the identified delivery period of one hour. An illustration is given below in Figure-1 for better clarity.

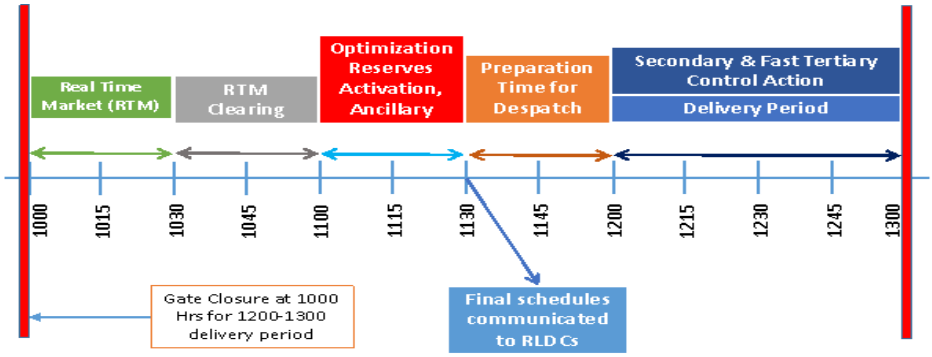



**Figure-1: Illustration of Suggested Gate Closure**

## 2. Existing Market Options and the Real Time Market

Various market options are presently available to the market participants through bilateral transactions (advance, first-come-first-serve, day-ahead bilateral and contingency) and collective transactions (day ahead market) through the Power Exchanges. The 'Term Ahead Market (TAM)' falls under the category of bilateral transactions. Under the present mechanism, window for only one product is open at any given point in time so as to facilitate electricity market administration in terms of margin determination and other activities. This is extremely important from an implementation perspective.

The Discussion Paper proposes to introduce a new market segment 'Real Time Market (RTM)' which is envisaged to run on every hour i.e., there shall be 24 market runs. Implementation of the RTM would require some modifications in the timelines of existing market products. While doing so, it may be ensured that window for only one product is open at any given point in time so as to facilitate electricity market administration.

Moreover, in order to process the multiple market transactions, a high degree of automation is required without which, implementation of RTM may be extremely difficult. The Hon'ble Commission has already taken steps to introduce the 'National Open Access Registry (NOAR)' and necessary draft amendments have already been notified.

## 3. Market Design Issues associated with the Real Time Market (RTM)

The Discussion Paper proposes a closed double-sided auction for the RTM with price formation taking place based on the principles of social welfare maximization. Following market design issues need to be addressed while implementing the RTM.

(a) Should participation in the RTM be voluntary or mandatory (say for example, is there a need for withdrawl of some existing market product e.g., contingency category transactions)? Should there be a linkage between the participation in the day-ahead market and the RTM? Participation in RTM can be made mandatory for at least some types of the participants such as generators.

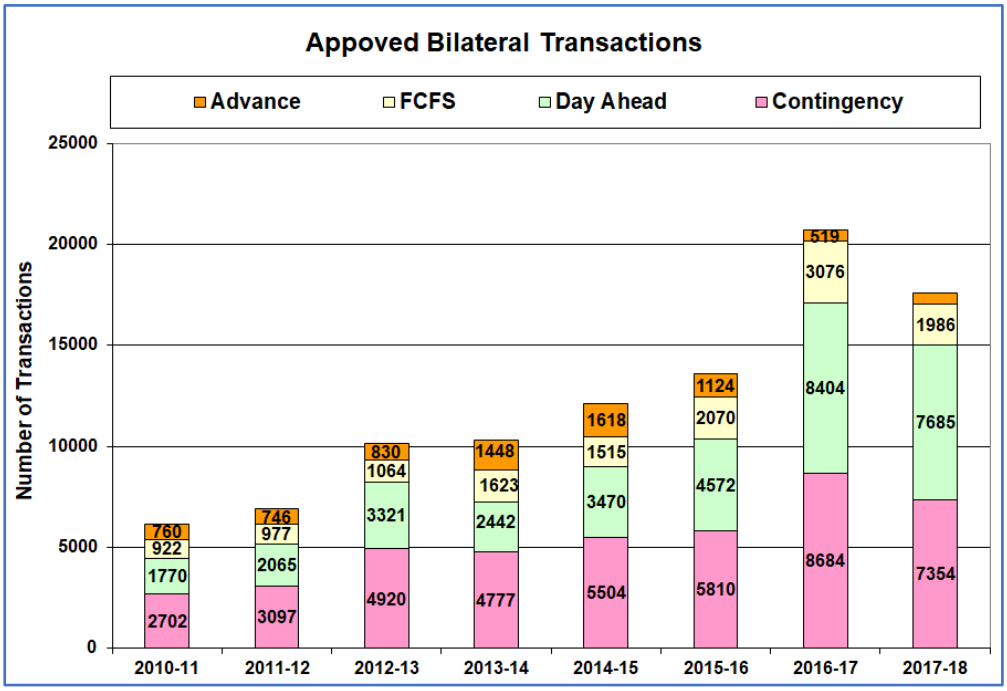
(b) RTM has to be a liquid market so as to facilitate a robust price discovery. The price discovered in the RTM can also be considered for linking to the DSM prices ultimately at a later date.

(c) Enough liquidity is also necessary to reduce the possibilities of market manipulation

(d) While the day-ahead market can continue to run as it is, the design of RTM has to be such that it attracts participants from the OTC market, which has higher transaction costs, to the more organized platform, i.e., RTM. The present volumes in the different products in the OTC market as shown in Figure-2 below which shows the kind of potential that exists for the RTM.

(e) Scheduling and Settlement also need attention and it needs to be clearly specified that all transactions are for physical delivery and financially binding for the participants.

(f) Presently, the prices are available for the day-ahead market operating in the Power Exchanges (IEX and PXIL). More than one prices are discovered in case of congestion and market splitting in the day-ahead market. With the RTM coming into picture two (2) prices (one for DAM and one for RTM) are going to be discovered. Interplay in the different market segments needs to be considered.



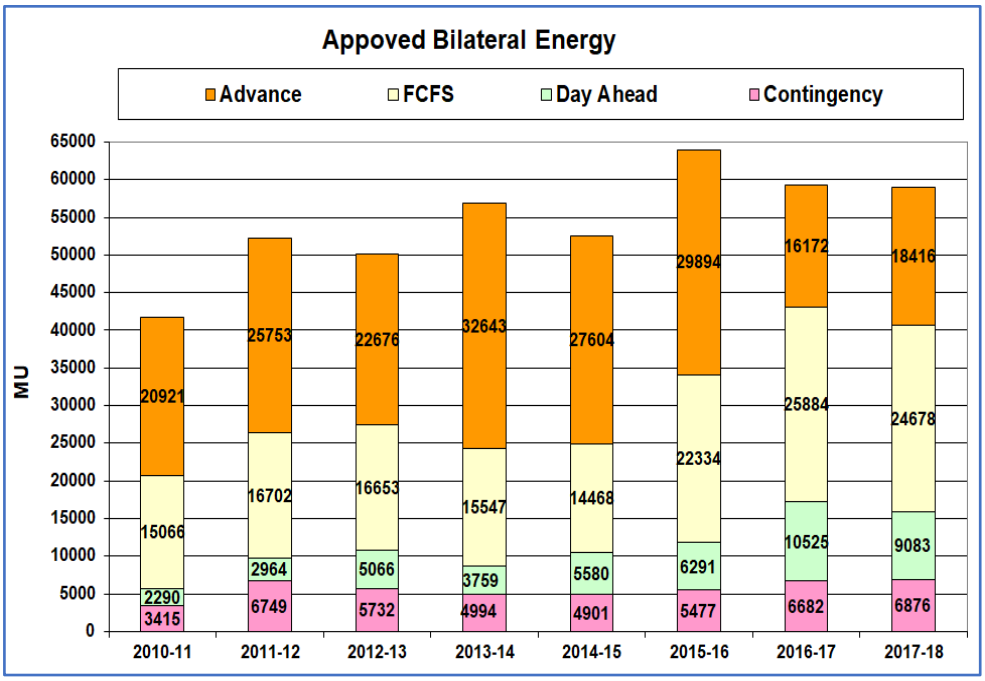




**Figure -2: Multi-year trend of trades in different segment, viz. Advance, FCFS, Day-ahead bilateral and contingency categories**

(g) Presently, a 15-minute scheduling, metering, accounting and settlement mechanisms are in place. Deliberations have begun for migrating to 5-minute from 15-minute scheduling, metering, accounting and settlement. Switching to 5-minute systems in the future (as also prevalent worldwide) may also be kept in view.

## 4. Congestion Management in the RTM

Transmission Congestion Management in the RTM is proposed using market splitting and shall be on similar lines as in the day-ahead market in the Power Exchange(s). The time lines

for RTM are short and tight with the bidding window and market clearing window proposed to be 30 minutes each only. The discussion paper (section 5.8) proposes that margins will be provided in advance to the Power Exchanges so as to avoid two step clearing (Provisional Market Solution and Final Market Solution) of the RTM market.

While it is appreciated that the objective is to facilitate faster processing of the RTM transactions, such a step will have a bearing on the price discovery in the RTM market segment. It is pertinent to mention that in the process of providing the transmission corridor margins in advance, we are implicitly declaring transmission as a 'scarce commodity' in economic terms. As soon as such a declaration is made in advance of the trading session, the behavior of market participants changes (even if it is found after clearing that there is no congestion) and aggressive bidding takes place thereby impacting the price discovery.

Implementation of National Open Access Registry (NOAR) is already being carried out and margins will be readily available for passing on to the Power Exchanges as soon the bidding session closes. Thus, the Power Exchanges can still clear the RTM in one iteration ensuring quick market clearing avoiding possible distortion in the price discovery on this account.

**5. Revision in Schedules by Generators**

Presently, IEGC Clause 6.5.19 provides that generators can revise schedules in case of unit tripping (unit size more than 100 MW). This provision hampers the development and prevents liquidity in organized market segments. In this regard, attention is also drawn to the POSOCO Suggestions on Draft Amendments to the Short Term Open Access Regulations dated 20th March 2009 (enclosed at Annex – I for ready reference), wherein the generic market design issues in allowing revisions have been mentioned. These are very relevant in the present context also. It is once again re-iterated that revisions in scheduled short-term transactions on account of generator unit tripping should be disallowed.

In the context of the above, it is further suggested that the generators may be allowed in the event of unit tripping to purchase power in the RTM to make up for their contractual liability.

**6. Deviation Settlement Mechanism**

The Hon'ble Commission has already notified the 4th Amendment to the Deviation Settlement Mechanism Regulations which propose linking the DSM rates to the daily average Area Clearing Price (ACP) market rates discovered in the day ahead market (DAM). This is a forward-looking step and needs to be quickly implemented. As we move further on with the implementation of RTM, the DSM rates may be linked to the market clearing price discovered in the RTM. It is pertinent to mention here that the DSM has played in important role in complementing grid security through a commercial mechanism.

**7. Market Information and Market Monitoring**

With further development of the electricity market in the country and introduction of new market segments, market information dissemination systems and market monitoring mechanisms need to be reviewed and strengthened. Information dissemination by the Power Exchanges needs to be reviewed and provisions for more elaborate information

dissemination are needed e.g., social welfare, consumer surplus, producer surplus, etc. need to be incorporated. Multiplicity of prices and interplay between market segments has already been mentioned as areas which would require close monitoring. In this regard, the provisions under Part – 7 on Market Oversight of the Power Market Regulations 2010 are pertinent and relevant. These may be kept in view while designing the market information system and market monitoring mechanisms for RTM. Market surveillance tools would be required to take care of market power in congested systems, provision of purchase by generators in case of unit tripping and so on.

**8. Demand Forecasting to ensure Resource Adequacy**

Electricity market design should complement reliability and resource adequacy is key towards ensuring reliability of supply. It is in this context that the provisions of Clauses 5.3 and 5.4 of the IEGC pertaining to demand estimation, forecasting and demand management, need to reiterated and enforced.

**9. Need for Automatic Controls in the Grid**

After the gate closes, RTM is cleared and ancillary has been dispatched for the designated delivery period, a contingency can still occur, say, for example a generator unit tripping. It is in this context that automatic controls in the grid such as Primary Response and Secondary Response through Automatic Generation Control (AGC) assume great importance in the interest of secure and reliable grid operation. It is hereby reiterated that Primary Frequency Control may be enforced and secondary control through AGC be rolled out for all ISGS.

**10. Reserves and Ancillary Services at the State Level**

While Ancillary Services has been successfully implemented at the inter-state level, similar mechanism for maintenance of reserves and ancillary services needs to be implemented at the intra-state level.

**11. Implementation of SAMAST at the State Level**

An important stepping stone for taking the electricity market to the next level is the implementation of (Scheduling Accounting Metering and Settlement of transaction) SAMAST also and this needs to be pursued.

**12. Pilot Project – Running Multiple iterations for Collective Transactions in Power Exchanges**

The RTM envisages running of the electricity market in collective mode 24 times per day. Implementation of the RTM is dependent upon the implementation of the National Open Access Registry (NOAR) and the NOAR implementation is still under process. In the meanwhile, in order to gain experience in running multiple iterations of the market in the Power Exchanges, it is proposed that a pilot may be carried out to run multiple iterations on a 6-hourly or 12 hourly basis. In this regard, POSOCO proposal for running an 'Evening Market' dated 18th May 2010 is also enclosed for ready reference (Annex-II). It is pertinent to mention here that by implementing such a pilot, deep insights will be obtained into

(a) Various market design issues such as liquidity, price discovery, interplay of prices, bidding by participants, etc.

(b) Implementation related aspects such as ramping up of the infrastructure, market clearing process etc.
(c) Capacity building requirements for all stakeholders i.e., market participants, system operators (NLDC/RLDCs/SLDCs) and the Power Exchanges

Hence, it is hereby proposed that the Hon'ble Commission may consider implementation of the above mentioned pilot.

Annex - I

पावर ग्रिड कारपोरेशन ऑफ इंडिया लिमिटेड
(भारत सरकार का उद्यम)
POWER GRID CORPORATION OF INDIA LIMITED
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पावरग्रिड

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संदर्भ संख्या /Ref. Number : **CSO/** **Dated: 20th March, 2009**

**To,**

**The Secretary,**
Central Electricity Regulatory Commission,
3rd & 4th Floor, Chanderlok Building,
36, Janpath, New Delhi- 110001

**Sub : Suggestions on proposed Amendments to Open Access in Inter-State Transmission 2008**

**Dear Sir,**

The Hon'ble Commission has proposed Amendments to the Open Access Regulations, 2008. In the proposed amendments, two major issues arise:

a) In case the SLDC has not refused concurrence or 'no objection' or standing clearance , as the case may be, within the specified period of 3 or 7 working days, as the case may be, of receipt of the application, concurrence or 'no objection' or standing clearance, as the case may be, shall be deemed to have been granted.
b) Allowing revision of the schedules on the day on which the transaction is scheduled or on the day-ahead basis.

Our detailed views on the above and other minor issues are enclosed herewith for the kind consideration of the Hon'ble Commission.

Thanking you,

**Yours faithfully,**

20/03/09

**(S.K.Soonee)**
**Executive Director(SO)**

Encl: A/a

**Comments on the Draft Amendment Regulations on Open Access in inter-State transmission system issued vide public notice dated 27th February, 2009**

CERC vide its public notice dated 27th February 2009 has invited comments/ suggestions/ objections on the draft Regulations by 20th March 2009. Most of the changes as proposed are bringing out more clarity on the subject. However, some of the changes as proposed in the draft regulation are against the spirit of CERC (Open Access) Regulations 2008 which evolved over time based on experience after the first set of regulations issued in January 2004 and amended in February 2005 and December 2006.

Comments on the Draft CERC Open Access, (Amendment) Regulations, 2009 are as follows:

1. **Clause (4) of the Regulations 8:**

   As per the proposed draft amendments, the last para of the Clause (4) of Regulation 8, states that:

   ***Quote***
   *"Provided that where the State Load Despatch Centre has not refused concurrence or 'no objection' or standing clearance, as the case may be, within the specified period of three (3) working days or seven (7) working days, as the case may be, of receipt of the application, concurrence or 'no objection' or standing clearance, as the case may be, shall be deemed to have been granted."*
   ***Unquote***

   As per the above proposed amendment, if a SLDC has not processed the application for issuance of "Standing clearance" or "No Objection" by an applicant, in the specified time frame the same shall deemed to have been granted. The above amendment may cause dispute in implementation of Open Access Regulations. Proper record of SLDC's consent is required on account of the following reasons:

   - SLDC is the apex body for system operation in the state
   - SLDCs are to be empowered and not to be bypassed
   - SLDC has to check for availability of adequate transmission margin so that there are no network constraints in real time operation
   - Energy transactions have to be accounted for and SLDC has to ensure that necessary infrastructure for energy accounting is available

   The issues that arise out of this proposed amendment are outlined below.

**(a) Empowerment of SLDC**

Regarding whether or not prior consent of SLDC is required was much deliberated during the hearing on draft CERC Open Access Regulations 2008. CERC vide para 8 of the "Statement of Reasons" dated 4th March 2008 on the CERC (Open Access) Regulations, 2008 has expressed its views as follows (emphasis supplied):

**Quote**

*8. In our view SLDC is the apex body to ensure integrated operation of the power system in the State as per the provision of the Act.* ***For the overall benefit of sector, it is necessary that SLDCs act impartially in the matters of system operation and take responsibility for their actions. The scheme proposed in the draft regulations is designed to propel SLDCs in this direction.*** *Therefore, this proposal has been retained in the final regulations.*

**Unquote**

The rapidly changing scenario in the power sector has resulted in changes in the role of LDC at all levels. Further, it is essential that the industry has a confidence on the competence of the System Operator and their conduct is above suspicion. This is all more important especially with the rapidly growing economy, unbundling of State Electricity Boards, increasing participation of Private Sector players, open access in transmission and distribution, power exchange and other market mechanisms. Therefore, the State Load Despatch Centres must be provided with an enabling environment to help them to deliver the desired result while performing their duties for ensuring integrate operation of the power system with in their State, non-discriminatory open access to all and bringing overall economy and efficiency in the State Power Sector.

**(b) Network Security**

Section 32(1) of the Electricity Act, 2003 provides that State Load Despatch Centre (SLDC) is the apex body to ensure integrated power system operation within that State. While granting "No Objection" or "Standing Clearance" for Open Access, it has to check for the congestion in the State network and carry out studies etc if required. In case an SLDC has not processed the application in time and it is presumed that there is no network constraint it would lead to more serious error.

In case sufficient transfer capability to accommodate the proposed open access transaction is not available and due to some or other reason the respective SLDC has not processed the application and open access has been granted based on deemed consent, it may endanger the security of the grid. In statistical term this shall lead to type II error (false negative).

Statisticians speak of two significant sorts of statistical error. The context is that there is a "null hypothesis" which corresponds to a presumed default "state of nature", e.g., that an individual is free of disease, that an accused is innocent, or that a potential

login candidate is not authorized. Corresponding to the null hypothesis is an "alternative hypothesis" which corresponds to the opposite situation, that is, that the individual has the disease, that the accused is guilty, or that the login candidate is an authorized user. The goal is to determine accurately if the null hypothesis can be discarded in favor of the alternative. A test of some sort is conducted (a blood test, a legal trial, a login attempt), and data is obtained. The result of the test may be negative (that is, it does not indicate disease, guilt, or authorized identity). On the other hand, it may be positive (that is, it may indicate disease, guilt, or identity). If the result of the test does not correspond with the actual state of nature, then an error has occurred, but if the result of the test corresponds with the actual state of nature, then a correct decision has been made. There are two kinds of error, classified as "Type I error" and "Type II error," depending upon which hypothesis has incorrectly been identified as the true state of nature.

In this case the "Null Hypothesis" is that there is there is existense of infrastructrue necessary for time block wise energy metering and accounting and availability of surplus transfer capability in the State network. Type –I, error means, that the hypothesis is true but consent is not accorded. Type-II error means, either there does not exist necessary infrastructure and/or surplus transfer capability is not there and approval is granted. In more common parlance, a Type I error can usually be interpreted as a false alarm or insufficient specificity. A Type II error could be similarly interpreted as an oversight, a lapse in attention or inadequate sensitivity. In this case, Type-II error is costlier than the Type-I error and therefore to reduce Type-I error one cannot increase the probability of the Type-II error.

(c ) **Dispute Free Implementation**

Further, if prior consent is not on record, then it may lead to many disputes and it will be very difficult to implement the CERC Open Access Regulation. The Hon'ble Commission vide para 11 (c) of its Order dated 07.03.2007 in Petition No. 24/2007, in the matter of "Refusal No 131 of 25.1.2007 by the Western Regional Load Despatch Centre of the open access application filed by Tata Power Trading Company Limited for transmission of 27 MW power through Eastern Regional Load Despatch Centre and Orissa State Load Despatch Centre from Nava Bharat Ventures Ltd, on the ground of "No consent from OPTCL", has placed its views on record as quoted below:

**Quote**

*11. Before parting, we would like to place on record our observation on certain issues which have come to light during the hearing of this petition.*

*(a) ……..*

*(b) ……..*

*(c) In case an inter-State open access involves buying/selling power from/to an entity embedded in the State grid, the concerned RLDC must obtain the prior consent of the concerned SLDC, since the open access transaction has to be duly accounted for in*

*the net drawal schedule of that State. If prior consent is not on record, there could be intractable disputes regarding scheduling, etc. later on.*
*(d)……*

**Unquote**

From, the observation of the Hon'ble Commission it is abundantly clear that the prior consent should be on record otherwise there could be intractable disputes regarding scheduling etc.

Therefore it is requested that the last para of the proposed modification i.e.; *"Provided that where…… …… shall be deemed to have been granted"* should be deleted.

**2. Clause (1) of Regulation 14**

Replace "notice the nodal agency:" with "notice to the nodal agency:" at the end of the first paragraph of the clause (1) of Regulations 14.

**3. Clause (2) and Clause (3) of Regulation 14**

As per the draft amendment, transmission charges are to be paid for notice period of two (2) days. If an applicant gives notice two days in advance, then as per the proposed amendment he will not have to pay any charges for exercising exit option. In most of the trades/ agreements, exit has some charges, either in the name of cancellation charges or any other name. It is a well settled issue that an exit option must have some charge/cost. How much shall be quantum of this charges would depend on the degree of seriousness required or impact such exit would have on either party. CERC OA Regulations, 2008 had specified minimum 5 days charges and now the intent of the Commission is to reduce these charges from 5 days to 2 days. In order to have clarity on the issue it is proposed that the clause (2) and clause (3) of the Regulation should be replaced with the following (similar to clause 2, 3 and 4 of Regulation 14 of CERC OA Regulations, 2008):

*(2) The applicant shall continue to be liable to pay transmission charges as per the schedules originally approved, if the period of curtailment or cancellation is upto two (2) days.*
*(3) If the period of curtailment or cancellation exceeds two(2) days, transmission charges for the period beyond two (2) days shall be payable in accordance with the curtailed schedule and for the first two (2) days in accordance with the original schedule.*
*(4) In case of cancellation, operating charges shall be payable for two (2) days or the period of cancellation in days, whichever is less.*

## 4. Regulations 14 (A) – Revision of Daily Schedule

The Draft Amendment of Open Access Regulations provides for a new regulation 14A which will entitle flexibility to cancel/curtail the scheduled bilateral transactions. In this context, it would be seen that long-term contracts have the provision for any number of schedule revisions in a day. The Regulations in respect of medium term access has not yet been released by the Honourable Commission. Revision in schedules on daily basis is a cause for concern.

The proposed amendment will seriously hamper the development of Short-Term Electricity Market in India on account of the following reasons cited below:

### i. "Contract" vs "Option"

If cancellation/curtailment of scheduled bilateral transaction is permitted than the bilateral contract shall no longer remain a "Contract" and will virtually convert into "Option" with "ZERO" or negligible premium. Seriousness of contracts or firmness of delivery would be lost. With such easy exit options, volumes might shift to advance bilateral contracts with possibility of inflated requests for transmission capacity and frequent revisions.

### ii. Pseudo Congestion : Blocking of Transfer Capability, Easy Exit Option

In the earlier Open Access Regulation (2004), there was a provision for daily scheduling of bilateral transactions. Market Players used to reserve/block the transmission corridors in advance as exit option was very easy. This had resulted in under utilization of the transmission corridors and many a time pseudo congestion was observed. The above anomaly was removed in CERC Open Access Regulations 2008. The issue of providing flexibility to stakeholders to revise the daily schedule was discussed in detail and the Hon'ble Commission in the Statement of Reasons for CERC Open Access Regulations 2008 has stated as quoted below (emphasis supplied):

**Quote**

***Flexibility to revise the schedule and exit option***

*4. Most of the stakeholders have observed that it is impractical to schedule a transaction too much in advance. Global Energy Limited has observed that the prohibition against revision and cancellation of schedules would put the generating companies to undue hardship, as they would be exposed to uncertain UI charges even on account of shutdown of generating units for genuine and unforeseeable reasons. Some stakeholders have stated that hydro generators should be allowed to revise the schedule as their generation is dependent of uncertain water flows. Similar reason has been advanced for*

*wind generation by GFL. Some stakeholders have suggested that period of advance scheduling should be reduced further for simplification and certainty.*

*5.* ***In the draft regulations, the proposal to fix the schedule for the entire period of transaction while approving the application of open access customer was intended to prevent blocking of the transmission capacity. For the same reason, no exit option was provided to the open access customers whose applications have been approved by the nodal agency.*** *This issue has been reconsidered in view of the comments/suggestions of the stakeholders and it has now been decided to grant a limited flexibility of revising or canceling previously approved schedules by giving 5 days notice. If the period of revision/cancellation is up to 5 days, the customer will pay transmission charges as per the originally approved schedule. If the period of revision or cancellation is more than 5 days, the customer will be liable to pay first 5 days transmission charges as per the originally approved schedule and for the remaining period as per the revised schedule. Operating charges shall be payable as per the original number of days during the period of scheduling, if the period of cancellation is up to 5 days. If the cancellation period is longer, operating charges for the period beyond five days shall be refunded.* ***Since, the revised provision will give some flexibility of revision/cancellation in case of contingencies, the provision in the draft proposing powers to the nodal agency to allow revision/cancellation in extraordinary circumstances has been omitted. The regulations provide full freedom to the applicants to apply over a period of three months. Those, who are comfortable only few days before or even a day before the date of actual transaction to commit to the transaction, can choose to do so. When viewed in this manner, there is no need to change regulations further.***

*6.* ***To recapitulate, one can apply for open access and scheduling three months in advance, two months in advance, one month in advance and one or more days in advance, depending on when he is able to commit to the schedule being applied for. Exit option is also available up to five days ahead of the day for which schedule is proposed to be curtailed or cancelled, but without refund of any transmission charges for first five days of curtailment/cancellation. We believe that the final regulations adequately address the concerns expressed by the stakeholders.***

**Unquote**

From the above mentioned extracts from Statement of Reasons, it is abundantly clear that the Hon'ble Commission has given due thought on the issue and after considering views of all stakeholders and experience gained over the years, the CERC Open Access Regulations 2008 was finalized. Insertion of the proposed new clause will tantamount to revision of own order of CERC without any new material evidence being brought to the notice of the Commission to incorporate such changes. In fact, in the proposed

amendment, the exit option has been relaxed further. The notice period has been reduced form 5 days to 2 days. This sufficiently takes care of the issue.

Therefore, provision for revision of schedule on daily basis will be a retrograde step knowing in advance the pitfalls involved.

**iii. Interplay between bilateral and balancing market**

Allowing cancellation/curtailment of schedule on Daily basis shall mean the Day-Ahead schedules are no longer financially binding. There is a possibility of inter-play between the bilateral market and the real-time balancing market. The Paper titled "ELECTRICITY MARKET DESIGN: THE GOOD, THE BAD AND THE UGLY", by Peter Cramton, University of Maryland examines the principles for market design as applied to Electricity Markets. As we move closer to real-time, the system becomes less responsive as options vanish. The supply curve becomes steeper. Hence, the vulnerability to gaming near real time is great, especially if a lot of value is riding on the real time prices. The author has strongly advocated that the day-ahead contracts should be financially binding. As per the Author the one solution to this issue is either forbidding changes, and the other better solution is to make the day-ahead schedule financially binding, as quoted below:

**Quote:**

*One solution to this problem is forbidding changes. This may be effective for bid changes, but outages are often necessary and it is difficult for the regulator to distinguish between legitimate outages and those intended to raise the price. Also, generators often have good reason to change bids in response to export opportunities, revised fuel prices, or other changes.*

*A better solution is to make the day-ahead schedule financially binding. This is called a multiple settlement system, sincere there are at least two sets of prices and quantities. Those in the day-ahead schedule and those at real time. Having the day-ahead bids financially binding does two things. First, it makes the bids credible, since successful bids involve a financial commitment. This is a general principle of market design. Bids should be financially binding. Second, a multiple settlement system mitigates incentives to manipulate the real-time price. Most of the pricing and allocation is done day-ahead. The real-time market is only to price deviations from the day-ahead plans. Those scheduled day-ahead have no incentive to manipulate the real-time price. Rather their incentive is to make adjustments to bids in response to changes in their economic situation.* **Unquote**

It is important to mention here the fundamental difference in the charges for the long term contracts and bilateral contracts. Long term contracts have a multiple settlement system (separate capacity and energy charges) whereas the

short term bilaterals have a single settlement system (energy charges only). Revisions are allowed for long term contracts and by design there is no incentive for gaming. Allowing revision of bilateral contracts would provide an opportunity for gaming besides bringing bilateral contracts at par with long term contracts by defective market design.

In this context, it is pertinent to quote Power System Economics by Steven Stoft, wherein it is stated that ***"All except the real time markets are financial markets in the sense that the delivery of power is optional and the seller's only real obligation is financial"***.

**iv. "No Show" : Past Experience**

Based on its operational experience, POWERGRID System Operation vide letter dated 15.07.2006 gave feedback to the Hon'ble Commission that a few of the Short-Term Open Customers are under-utilizing the transmission capacity, resulting in blocking of transmission capacity which could have been utilized by other prospective customers. The Hon'ble Commission examined the issue and subsequently issued an amendment in December 2006 to the Open Access Regulations whereby any transmission capacity available after catering to the requirements of long-term and short-term customers, as advised by the eligible entities by 3:00 PM of the day preceding the day for which schedules are being prepared, may be released for use of other perspective users. The utilization of transmission capacity increased significantly after the amendment of the Regulation. Moving further, the Honourable Commission in the 2008 Regulations further used the term 'scheduling of transactions' instead of 'reservation of transmission capacity' indicating higher firmness.

**v. Congestion Management**

Electricity markets can operate only with some level of certainty in respect of transmission capacity. This has been ensured through specifying 'window closing and opening times'. Thus while the PX window is 'open', the bilateral window is 'closed' and vice-versa.

While assessing the transfer capability for day-ahead transactions, counter-trades are accounted for optimum utilization of the transmission corridors. Collective Transactions through Power Exchange (PX) are scheduled based on the available margin after considering the net scheduled transaction. Cancellation / curtailment of scheduled bilateral transaction on day of operation or on day ahead basis will be known only after PX transactions are cleared at 1400 hours. This would lead to the following scenarios:

a) Sub-optimal utilization of transfer capability – more margin could have been allocated to the PX if the revision was known in advance.
b) Congestion in real time and grid security may get endangered—if the wrong set of transactions gets revised.

**vi. Ripple Effect**

If the schedule for bilateral transaction is allowed to be cancelled / curtailed on daily basis then the same will create a ripple effect in the whole market. For example, a State Utility has entered into a bilateral agreement for purchase of 'X' MW power from some generator. Because of some or other reason the generator is not able to deliver the contracted power and therefore revised the transaction. The State Utility may now have to revise its requisition from other generating stations from which it has not requisitioned its full entitlement. In case this State Utility has sold power to some other party, then it may like to cancel/curtail its scheduled bilateral transaction.

Accordingly, allowing cancellation/curtailment of scheduled bilateral transaction on daily basis will create a ripple effect.

**vii. Transfer of wealth**

Any cancellation/curtailment of schedule shall result in a shift of the liability for payment of Unscheduled Interchange (UI) charges from supplier to buyer and is in effect transfer of wealth from one party to other. By allowing cancellation/curtailment of scheduled bilateral transaction, the financial liability of the party who is not able to deliver as per contract is getting obviated.

**viii. Risk allocation of unsystematic risk of Private Goods**

In Electricity Market, risk mitigation is avoiding risk and bringing in more certainty and Risk Allocation describes who shares the cost of risk in case it actually happens. Presently a number of Short-term open access products are available to market participants and they can utilize the same for risk mitigation. A systematic risk affects the whole group and not individuals, but the Unsystematic risk affects only few. Unsystematic risks may be due to non performance of individuals. Cancellation/Curtailment of schedules shall tantamount to entering into the domain of risk allocation of unsystematic risks

of private goods. Normally this should be responsibility of the parties entering into the contract. In case of two part tariff for ISGS (long-term contracts), the risk is allocated to the party by way of capacity charges payment or reduction but such is not the case in short-term or energy only contracts.

**ix. Trading License Regulations,2009**

Even after the above aspects are considered and the Commission decides to accept revision in schedules, it would open the doors for innumerable disputes. Chapter IV, 7(i) of the Trading License Regulations 2009 by CERC states as under:

*'(i) The licensee shall ensure that appropriate agreement for purchase and sale of electricity are entered into by him with the sellers and the buyers prior to scheduling a transaction, and that the agreement shall specify the following, namely-*
*(i) the boundaries, that is to say, upper and lower MW limits of electricity to be purchased or sold,*
*(ii) modalities for scheduling,*
*(iii) persons authorized to specify the schedule, or to modify it after it has been intimated to the Regional Load Despatch Centre or the State Load Despatch Centre,*
*(iv) whether the buyer or the seller can unilaterally advise modification of the schedule, or whether the modification can only be advised jointly by the buyer and the seller,*
*(v) the liabilities of the parties (seller, buyer and licensee) in case the scheduled quantum (MW) and time of scheduling differs from the agreed terms, or in case of modification in schedule, and in the latter case, the party that will bear non-refundable part of short-term open access charges.*

In the Statement of Reasons dated 16th February 2009, the Honourable Commission in response to POWERGRID's suggestion had remarked as under:

*"31. PGCIL has pointed out that though modification of schedule for long-term (and medium-term) transactions are allowed, such freedom to allow scheduling advice by either or both would lead to confusion and should be avoided. Hence it has suggested that a provision may be made that only the applicant can advise modification of schedule to RLDCs, if required, after taking consent from the parties involved. We do not think that any modification on the lines suggested by PGCIL is necessary, since the clause is only to ensure that the party which can advise a schedule change is duly identified in the contract, and there is no dispute on this account later on."*

The Hon'ble Commission has ordered that SLDCs should only check whether the necessary infrastructure for metering and accounting is in place and there is surplus transfer capability to accommodate the transaction. If the above is to be accepted, it would involve subjectivity of SLDCs/RLDCs and every application has to be judged on merit. All this has the potential to create disputes, particularly when there could be 40-50 bilateral transactions on any

given day. More so since in any schedule revision there are three parties involved viz. the buyer, seller and the trader and each would have different objectives which are contradictory.

**In view of the above facts, RLDCs would earnestly request the Commission not to accept any request for schedule revision.**

**x. Un Requisitioned Surplus (URS) of Inter State Generating Stations (ISGS)**

In the background note for the meeting of the Central Advisory Committee (CAC) on 18th March 2009, the issue of revision in schedules for Open Access transactions has been mentioned. One of the main drivers appears to be the URS from ISGS as evident from the extracts below.

*"Flexibility of revision is also desirable to remove difficulties faced by the central generating companies with regard to un-requisitioned surplus capacity. When a beneficiary which is entitled to a capacity does not give requisition, such un-requisitioned capacity can be sold through open access. However, when original beneficiary wants it back, difficulty is faced because of not-so-flexible provision for revision of schedule for open access transaction."*

In this connection it is stated that the issue of Un Requisitioned Surplus (URS) is essentially a concept from the pre-Open Access era. After the introduction of Inter State Open Access in May 2004, any URS of ISGS has a status similar to any other latent generation capacity in the grid (captive or otherwise). The provisions of 'non-discriminatory' open access apply to all such latent embedded generators and a vividness bias caused on account of ISGS URS should not distort the Electricity Market Design. In order to overcome the problem caused by recall of URS by original beneficiary, the ISGS may obtain prior consent and enter into a no-recall understanding with the original beneficiary before selling the URS through Open Access.

ISGS need to take some amount of risk while scheduling their URS through Open Access and through their trading arms, if any. Change in Open Access rules sought on account of ISGS status might therefore not strictly be in order.

**xi. <u>Impact on Power Exchange:</u>**

The development of Electricity Market in India has received a major impetus with the introduction of Power Exchange(s) in the Country in 2008. Two Power Exchanges are functioning presently. Collective transactions through

Power Exchange are processed before Day Ahead transactions and they are accommodated in the margins available after approving Advance and First Come First Serve category bilateral transactions. Collective Transactions once approved by NLDC are '**deemed delivered**' subject to any real-time curtailment by the NLDC on account of transmission constraints.

**a) Revision of Collective Transactions through Power Exchange:**

As per the Procedure for Scheduling of Collective Transactions, the Power Exchanges send an unconstrained solution (provisional trade result) to NLDC at 1300 Hrs and NLDC, after checking for congestion (if any), reverts back by 1400 Hrs. The final trade results along with the Application for scheduling of Collective Transactions is submitted by the Power Exchanges at 1500 Hrs. The Power Exchange simultaneously checks for availability of funds in the member's accounts commensurate to the provisional trade result. In order to cover business risk, the rules of Power Exchange provide for rejection of bids in case of inadequate funds available in the member's account. Even this provision which inadvertently provides an easy exit option to the members of the Power Exchange and has been strongly opposed by NLDC (vide NLDC Comments on 'Application of Setting up Power Exchange by IEX' dated 21-April-2008).

As per the Procedure for Scheduling of Collective Transactions, the provisional trade results may be revised by the Power Exchange only in case of transmission congestion on the advice of NLDC. No revision is thus possible in the case of Collective Transactions through Power Exchange. In this context, it may be clarified here that **the Collective Transactions have never been revised till date**.

**b) Level Playing Field for Power Exchange vis-à-vis other Market Segments:**

Short Term Open Access Transactions provide for two categories namely, Bilateral and Collective (through Power Exchange). It has already been explained above that Collective Transactions cannot be revised. Allowing revision of bilateral transactions would clearly discriminate against the Collective Transactions through Power Exchange and level playing field would no longer exist. With an easy exit option available in the Bilateral Market at zero or a nominal cost, the volumes in short term market may shift out from the Power Exchanges to the Bilateral Market. The institution of Power Exchange which has only recently been added to the Indian Electricity Market may become unviable.

xii. **Promotion of Renewable Source of Energy Generation**

In the draft amendment, different treatment has been proposed if source of power is from Wind Generation Power Plants. Nodal RLDC while approving open access transactions, checks only for the following two things:

- Concurrence of respective SLDCs : To ensure proper recording of transaction for metering and accounting and available surplus transfer capability in the intra-State System
- Availability of Surplus transfer capability in the inter-State transmission system to accommodate the transaction

Nodal RLDCs does not go on merit of the case and is practically not possible for nodal RLDC to verify the same. Therefore, different treatment for different type of source of energy may result difficulties in implementation of the open access regulations.

One of the objectives of the Electricity Act, 2003 is promotion of efficient and environmentally benign policies and to meet this objective, harnessing of generation from renewable sources has to be attached top priority. Renewable energy sources in the country are non-uniformly distributed and some states are more endowed than others. The generation from the renewable energy source at one location is small when compared to the conventional energy sources. Further the output from these sources is inherently intermittent and hence non-firm. These characteristics make them difficult to dispatch. There are a number of other issues involved in promotion of Renewable Source of Energy Generation and Hon'ble Commission has taken a lot of initiatives to promote the Renewable Sources of Energy Generation. **Therefore, it is proposed this issue may be covered separately.**

**In view of the above, it is strongly suggested that the proposed new Regulation 14(A) should not be inserted in the CERC Open Access in inter-State Transmission System (Amendment) Regulation, 2009.**

5. **Clause (1) Regulation 16**

It is proposed that in the first sentence after *" In case of the bilateral transactions"* , *"for use of the inter-State transmission system,"* is to be inserted.

6. **Clause (2) Regulation 16**

It is proposed that in the first sentence after *" In case of the collective transactions"* , *"for use of the inter-State transmission system,"* is to be inserted.

7. **Clause (5) and Clause (6) of the Regulation 17**

   These clauses shall become ineffective if our proposal for deleting the Regulation 14(A) is accepted.

8. **Clause 6 of Regulation 20**

   In order to have clarity on the issue it is proposed that the para may be modified as quoted below:

   *"(6) Charges, other than those specified under regulation 16 and regulation 17 (such as standby charges, grid support charges, parallel operation charges) shall not be imposed by the State Utilities on the customers of inter-State open access."*

9. Regulation 27/27A:

   The title might read only 'Information System' and the term Regional Load Despatch Centre and State Load Despatch Centre may be removed.

XXXXXXXXXXXXX

Annex - II

पावर ग्रिड कारपोरेशन ऑफ इंडिया लिमिटेड
(भारत सरकार का उद्यम)
POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

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संदर्भ संख्या / Ref. No.
CSO/CERC/

केन्द्रीय कार्यालय / CORPORATE CENTRE
**Dated:** 18th May 2010

The Secretary,
Central Electricity Regulatory Commission,
3rd & 4th Floor, Chandralok Building
36, Janpath,
New Delhi – 110 001

**Subject:** Unmatched and Uncleared volume in Power Exchanges - Suggestion for Evening Market

Sir,

The opportunity lost due to Uncleared and Un-matched volume in the Power Exchanges is nearly four times the volume lost due transmission congestion.

Normally, congestion has been occurring seasonally, that too, only in few corridors in a particular direction and the available margins remain unutilized in the many other corridors.

The option of reservation of corridors for the Power Exchange trades would have many associated contentious issues like Transmission Rights besides issues like where, how much to reserve and in what direction, in which corridor etc besides subsequent under-utilization due to fragmentation.

Considering the above, a subsequent round of trading in the Power Exchange Market may be considered say, in the late evening to provide another opportunity for players to optimise their portfolio and take a more informed position in the market. This in all likelihood would lead to more cleared volume, better utilization of the other un-congested and under-utilized corridors, more social welfare maximization and consumer satisfaction.

The evening market should be totally independent of morning market and all the rules could continue to be same for the evening market too. There would be a change in the strategy of the players and the overall satisfaction is expected to improve. Though this may require realignment of the present timelines etc. and would increase the work volume at NLDC and Power Exchanges, the same is being proposed to cause more economy & efficiency, better utilization of the available infrastructure and take the market to the next trajectory.

The proposal could be implemented in a relatively short time frame and the details could be discussed with the Power Exchanges and experts. Hon'ble CERC may consider the proposal for further directions, please.

Thanking you,

Yours faithfully,

18/05/10.

**(S. K. Soonee)**
**Executive Director (SO & NLDC)**

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संदर्भ संख्या/Ref No.

**Dated: 26th July 2010**

**POSOCO/CERC/123**

To
Chief, Engineering
Central Electricity Regulatory Commission,
3rd & 4th Floor, Chandralok Building
36, Janpath
**NEW DELHI – 110 001**

**Subject:** Proposal for Evening Market in Power Exchanges

**Reference:**

1. Minutes of Meeting on Evening Markets in Power Exchanges vide CERC letter dated 9th July, 2010
2. Letter to CERC on suggestion for Evening Market dated 18th May,2010

Dear Sir,

Further to meeting held in CERC on 28th June, 2010 to discuss the feasibility of introduction of Evening Market in Power Exchanges, it transpired that Evening Market may in all likelihood lead to an increase in volumes and thus the model can be tried out on a pilot basis. As desired, the proposed timelines for Evening Market in Power Exchanges is enclosed at Annex – 1. The timelines for Morning Session in the Power Exchanges continue to be the same as per existing detailed procedure for Scheduling of Collective Transactions.

Further, the need for introducing bidding at 15 – minute interval in the Power Exchanges was proposed vide letter dated 26th March 2010 may also be considered for overall economy and efficiency.

Thanking you,

Yours faithfully,

28/7/2010

**(S. S. Barpanda)**
**Dy. General Manager**

**Enclosure:** as above

**CC:** **Secretary, CERC**
**MD, IEX / CEO, PXI**

Annex – I

## PROPOSED TIMELINE FOR THE MORNING AND EVEING MARKETS IN POWER EXCHANGES

| S.No. | Morning/ Evening Session | Processing of Application | Timeline |
|---|---|---|---|
| 1 | Morning session | Market participant to place bids at Power Exchange platform | 10:00-12:00 Hrs |
| 2 | Morning session | NLDC to indicate Power Exchanges the list of interfaces/control areas/regional Transmission system *(Common for Morning & Evening Session)* | 11:00 Hrs |
| 3 | Morning session | Power Exchange to send provisional unconstrained solution to NLDC and flow on TS as informed by NLDC | 13:00 Hrs |
| 4 | Morning session | NLDC to check for congestion. In case of congestion shall intimate PX regarding the period for congestion and available margins | 14:00 Hrs |
| 5 | Morning session | PX to send Scheduling Request to NLDC based on margin specified by NLDC/SLDCs | 15:00 Hrs |
| 6 | Morning session | NLDC to send details to RLDCs for scheduling | 16:00 Hrs |
| 7 | Morning session | RLDC to confirm its acceptance to NLDC | 17:00 Hrs |
| 8 | Morning session | NLDC to confirm acceptance. PX to send files to SLDCs for scheduling | 17:30 Hrs |
| 9 | Morning session | RLDCs/SLDCs to incorporate Collective Transactions in the Daily Schedule | 18:00 Hrs |
| 10 | Evening Session | Trading Session: Market participant to place bids in Power Exchange | 16:00-17:00 Hrs |
| 11 | Evening Session | Power Exchange to send provisional unconstrained solution to NLDC | 17:30 Hrs |
| 12 | Evening Session | NLDC to check for congestion. In case of congestion shall intimate PX regarding the period of congestion and available margins | 18:00 Hrs |
| 13 | Evening Session | PX to send Scheduling Request to NLDC based on margin specified by NLDC/SLDCs | 18:30 Hrs |
| 14 | Evening Session | NLDC to send details to RLDCs for scheduling | 19:30 Hrs |
| 15 | Evening Session | NLDC to confirm acceptance for Scheduling of Collective Transactions<br>PX to send files to SLDCs for scheduling | 21:00 Hrs |
| 16 | Evening Session | RLDCs/SLDCs to incorporate Collective Transactions in the Daily Schedule (Revision 1) | 23:00 Hrs |

Annexure -II

USAID FROM THE AMERICAN PEOPLE

GOVERNMENT OF INDIA
MINISTRY OF POWER

POSOCO

# OPENING MARKETS, DESIGNING WINDOWS, AND CLOSING GATES

## India's Power System Transition - Insights on Gate Closure

GREENING THE GRID PROGRAM
A Joint Initiative by USAID/India and Ministry of Power

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Prepared by

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FROM THE AMERICAN PEOPLE

GOVERNMENT OF INDIA
MINISTRY OF POWER

POSOCO

# OPENING MARKETS, DESIGNING WINDOWS, AND CLOSING GATES

## India's Power System Transition - Insights on Gate Closure


**Authors**

Jessica Katz and Jaquelin Cochran, *National Renewable Energy Laboratory (NREL)*

K.V.N. Pawan Kumar, S.C. Saxena, S.K. Soonee, S.R. Narasimhan and K.V.S. Baba, *Power System Operation Corporation Limited (POSOCO)*

(**Lead** authors Jessica Katz and KVN Pawan Kumar)

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**PI:** David Palchak, *NREL*

## ABSTRACT

This report explores the concept of gate closure, the time at which market participants must submit their final bids and offers for electricity. Gate closure is typically considered a minor feature of market design, but its implementation could be pivotal to how power markets will operate under high penetrations of renewable energy. This report analyzes global experiences with gate closure, and then reviews the unique benefits, challenges, and other considerations that will impact the implementation of gate closure in the Indian electricity market.

# List of Acronyms

| | |
|---|---|
| ACER | Agency for the Cooperation of Energy Regulators |
| AEMC | Australian Energy Market Commission |
| CERC | Central Electricity Regulatory Commission |
| DC | Declared Capacity |
| DOE | U.S. Department of Energy |
| ERCOT | Electric Reliability Council of Texas |
| EU | European Union |
| ISGS | interstate generating station |
| ISO | independent system operator |
| LTA | Long-Term Access |
| MTOA | Medium-Term Open Access |
| MW | megawatt |
| MWh | megawatt-hour |
| NEM | National Energy Market |
| NLDC | National Load Despatch Centre |
| NREL | National Renewable Energy Laboratory |
| NYISO | New York Independent System Operator |
| RRAS | Reserve Regulation Ancillary Services |
| RLDC | Regional Load Despatch Center |
| RTC | real-time commitment |
| SCADA | Supervisory Control and Data Acquisition |
| SCED | Security Constrained Economic Dispatch |
| SCUC | security-constrained unit commitment |
| SLDC | State Load Despatch Centre |
| STOA | Short-Term Open Access |
| TSO | transmission system operator |
| URS | Un-Requisitioned Surplus |
| WEM | Western Australia Wholesale Electricity Market |

# Table of Contents

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# 1 Introduction

Picture the last time you traveled via commercial airline. When you received your boarding pass, you may have observed a notation informing you the time at which the doors closed or boarding ended. This time was likely 15-30 minutes before the actual departure time for your flight. With all passengers on board and eager to reach their destination, why must the airplane wait to depart?

In fact, the short window of time between the completion of boarding and the plane's departure is crucial to ensuring a safe flight and orderly air traffic. After the aircraft's doors close and the flight deck crew completes its preflight checklist, the pilot contacts air traffic control for clearance to push back from the gate. Air traffic control is responsible for coordinating the sequence of departures for all flights. Although airline dispatchers usually request a particular routing from air traffic control more than an hour before takeoff, the final minutes before the aircraft leaves the gate provide an opportunity for air traffic control, the flight dispatcher, and the pilot to make last-minute adjustments based on updated weather conditions, runway usage, and airspace dynamics. During this time, the flight dispatcher also provides final information about passenger count, cargo loading, and aircraft and fuel weights, which the pilot and first officer use to adjust takeoff settings and speed (Collier and Smith 2017; Midkiff, Hansman, and Reynolds 2004).

Just as the airline industry allows time between final boarding and takeoff for operations that enable preflight planning and the safe release of each flight, many wholesale electricity markets employ a similar period of preparation time between the close of the bidding period and the dispatch of electricity. This period is known as gate closure**.**

This paper explores the concept of gate closure, including rationale, design features, and considerations for implementation. The paper then reviews the wide range in gate closure design, including in-depth descriptions in example markets. The paper concludes with an assessment of design considerations for gate closure in the India power sector, where gate closure is being considered for implementation with the adoption of real-time markets.

## 1.1 Gate Closure in Electricity Market Design

Indian power system stakeholders are deliberating a move toward creating electricity markets closer to real time. The value of real time market operations could be significant in respect to grid reliability and optimal operations, particularly with an increasing share of variable renewable energy in the generation mix. One element under consideration is a proposal to introduce gate closure in the Indian power system, which may have broad market implications and presents a number of important issues needing thorough examination, including:

- Purpose of gate closure in the electricity market
- The duration or period of the gate closure
- The nature of gate closure (i.e., day-ahead/intraday, rolling/fixed window)
- Time interval of rolling gate closure
- Impact on system security assessments and planning
- The layers of gate closures across various jurisdictional seams
- Ease of operations for stakeholders in generation, transmission, distribution, and trading
- Risk diversification and mitigation

- Impact on electricity market prices and volatility
- Impact on system costs (i.e., balancing and transaction costs).

This report first explores many of these issues in the global context, drawing from the experience of power systems in which gate closure has been considered, implemented, or revised. We then discuss the unique benefits, challenges, and other considerations that will impact the implementation of gate closure in the Indian electricity market.

## 1.2 What Is Gate Closure?

In a wholesale electricity market, gate closure refers to the time at which market participants must submit their final bids and offers for electricity.[1] Following gate closure, no further trades may take place unless certain circumstances apply. Gate closure is typically presented as a minor feature of market design. Yet, its implementation could be pivotal to how power markets will operate under increasing penetrations of renewable energy in the generation mix.

At some point before real time, contracts (i.e., dispatch schedules) must be finalized for a predetermined upcoming delivery or settlement period. Gate closure is the point at which the finalization occurs. After gate closure, forward-looking data, such as physical information and contract volumes for the predetermined delivery period, are frozen. The system operator takes over the responsibility for balancing supply and demand through available reserves or ancillary services, thereby ensuring reliability, security, and the economic optimization of power system operations.

Historically, vertically integrated utilities balanced supply and demand along a continuum. The system operators in the utilities set schedules day-ahead to allow slower ramping thermal plants to come online, and the operators could continue to adjust schedules based on physical capabilities of the plants against improved load forecasts and contingencies. In many power systems, these adjustments could continue up through delivery of power, the end point in this continuum.

The introduction of centralized platforms for markets, in which a market operator creates schedules and dispatch set points based on the marginal costs of delivering energy, presented an opportunity to improve competition among generation and reduce costs of operations. Yet, one aspect of this evolution has the potential to decrease efficiency—the interruption of seamless least-cost balancing up through delivery. With markets, the requirement for gate closure emerges. Market operators must fix and communicate the dispatch set points, the point that, in many jurisdictions, occurs one hour before the delivery of energy. Between gate closure and delivery, system operators rely on a separate set of resources, such as regulating reserves, to ensure readiness to maintain balance. Regulating reserves are not subject to the least-cost economic optimization that occurs within the real-time market. If the deployment of the reserves is co-optimized with energy markets, this inefficiency is minimized. Yet, the inherent division of energy from ancillary services creates potential opportunities for suboptimal dispatch compared to a seamless vertically integrated operation. Shortening the time interval between gate closure and dispatch allows more opportunity to balance supply and demand economically through the market, reducing the need for regulation reserves.

[1] In this paper, we refer to market participants as electricity buyers (e.g., scheduled loads or load-serving entities, such as distribution utilities) and sellers (e.g., generators).

## *Definitions: Time Horizons for Power System Operations*

Gate closure occurs within the broader context of power system operations, including unit commitment and dispatch:

***Unit commitment*** (also known as scheduling) is the practice of ensuring a generator is committed and available when needed. Unit commitment reflects the time period needed to start up a generator so that the plant is synchronized to the grid. Many system operators make decisions about which units to commit one day ahead to allow time for plants that have slower start-up times.

***Dispatch*** refers to the frequency with which power system operators change generation set points among available generators to deliver energy (e.g., hourly or subhourly).

***Gate closure*** is the time at which participants in a wholesale electricity market submit their final bids and offers. At this point, the power system operator uses the most recent actual data (operational and market) to begin the set point calculation and communication process. Gate closure can occur at a particular time (e.g., at 1000 on the day before delivery), or it can be defined with reference to each dispatch period (e.g., one hour before each dispatch period). Some systems use both approaches. For example, power systems with day-ahead and real-time markets may define both an initial and a final gate closure time (van der Veen and Hakvoort 2016):

- ***Initial gate closure time***: The time at which market participants must submit their initial bids and offers (or the time at which the load serving entity must provide its initial energy schedule) to the system operator. Initial gate closure frequently occurs the day before energy delivery and defines the unit commitment and dispatch schedule for the following day.
- ***Final gate closure time***: The time at which final bids and offers (or the energy schedule) must be submitted for the real-time market. Power systems that define both an initial and a final gate closure time may allow market participants to submit updates to their initial bids, offers, or schedules before the final gate closure time.

Figure 1 illustrates an example of how these processes might integrate with a power system with day-ahead unit commitment, 15-minute dispatch periods, and gate closure one hour in advance of delivery.

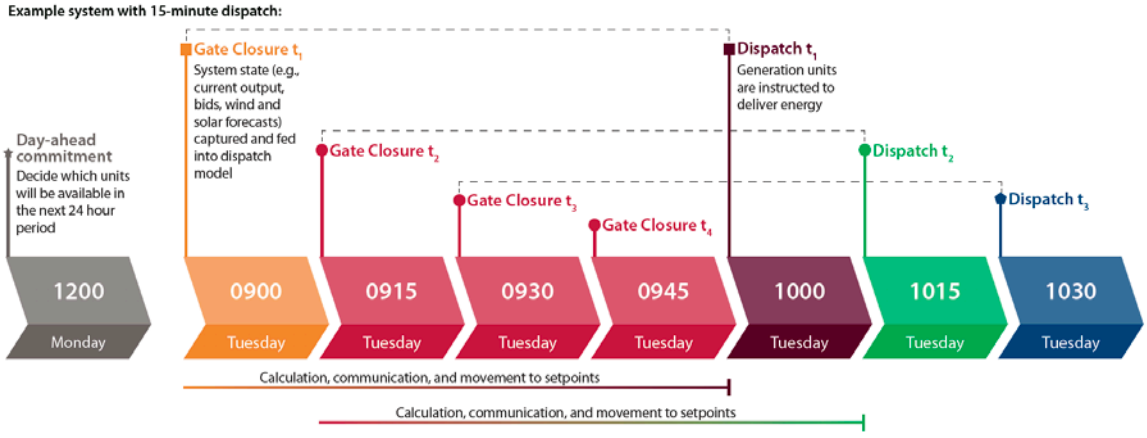


**Figure 1. Example of unit commitment, gate closure, and dispatch processes for a hypothetical power system**

In this illustrative case, dispatch occurs every 15 minutes, and gate closure occurs one hour prior to dispatch.

# 2 The Rationale for Gate Closure

Fundamentally, gate closure is a bid-scheduling tool. Its implementation is intended to benefit a variety of power sector stakeholders. Gate closure provides:

- Time for the system operator to compare the energy demand forecast with the schedules submitted by all generators in the system. The system operator uses this data to identify reliability issues, determine the need for ancillary services (including reserves), and take action accordingly (Elexon 2018).
- Generators and other balancing resources (e.g., demand response) a prescribed amount of time to finalize their physical outputs based on contracted volume, notify the system operator of their expected output, and reach their new specified dispatch setpoints.

Without gate closure in the real-time market, electricity markets have two general alternatives for scheduling generation: 1) committing units during the day-ahead schedule and not allowing rebidding by market participants following the close of the day-ahead market; or, 2) allowing generators to submit revisions to their day-ahead bids at any time until dispatch. The former approach potentially impacts the cost of system operations, because it prevents economic updates to schedules based on conditions nearer to real-time, with the likely results of increasing the forecasting error and requiring more reserves than would be needed if economic dispatch could occur closer to real-time (see the "The Importance of Gate Closure in Power Systems With Higher Levels of Variable Renewable Energy" text box).

The latter approach also has potential cost implications. For example, before 2015, the Australian Energy Market Commission (AEMC) found circumstantial and statistical evidence that some generators were engaging in deliberately late re-bidding behavior in certain regions of Australia's National Energy Market (NEM), in which market participants may rebid until dispatch (Australian Energy Market Commission 2015). AEMC linked late bidding with price volatility[2] and an increase in the price of forward contracts as market participants sought to pay a premium to hedge this volatility. While gate closure does not necessarily prevent deliberately late rebidding (it simply shifts the deadlines for late rebids earlier), it can help to address the resulting price spikes by giving demand-side resources (including demand response) and fast-start generation an opportunity to respond to the higher price.

[2] Price spikes could occur, for example, if a generator rebid at a high price capacity it had previously offered at a low price and did so too close to dispatch for other generators to respond with their own adjustments.

# 3 Defining the Length of Time Between Gate Closure and Dispatch

Perhaps the most crucial design decision in gate closure implementation is the length of time between gate closure and dispatch. Generally, a trade-off exists between balance planning accuracy (i.e., unit commitment or scheduling) and market efficiency, with the former being favored by a longer interval and the latter being favored by a shorter interval (ACER 2018c; Competition Economists Group 2014; van der Veen and Hakvoort 2016). System operators might prefer a longer window between gate closure and dispatch to ensure they have adequate time to balance supply and demand while maintaining an appropriate reserve margin. Conversely, market participants might prefer gate closure closer to dispatch so they can react to changing market or plant conditions and submit bids and offers that are more likely to reflect real-time circumstances. However, some generators may be more flexible than others in their ability to respond as time approaches real time; thus, short gate closure windows might favor fast-moving units over less flexible ones.

Some considerations might place a lower bound on a power system's desired gate closure interval. One major determinant of the length of the gate closure interval is a power system's generation mix. Longer gate closure intervals (e.g., several hours to day-ahead) may be necessary in systems that rely on slower-starting or slower-ramping thermal units as the marginal electricity supplier. On the other hand, shorter gate intervals are possible in power systems with a large capacity of fast-starting units. Facchini, Rubino, Caldarelli, and Di Liddo (2019) provide an example of how gate closure can change to reflect an evolving generation mix:

> In the United Kingdom, historically the [gate closure (GC)] has been calibrated on the time needed to the marginal provider to supply its service. For this reason, the UK moved the GC from 3.5 to 1 h before real time…because of the progressive substitution of the coal generation with other form of more flexible plants - Combined Cycle Gas Turbine (CCGT) - that allowed for the management of energy imbalances closer to real time. This reflects the different timing required to warm up and operate those two different types of plants: about 3 h for coal plants and 5 up to 30 min (depending on efficiency and on generation capacity) for gas fired plants.

Beyond the generation resource mix, the availability of greater computing power and improved modeling also influence the gate closure interval. The gate closure interval must be long enough to allow the system operator to run the security constrained unit commitment and dispatch models, then transmit dispatch instructions to generators. Historically, power system operators may have relied upon relatively long gate closure intervals to allow sufficient time to conduct power flow calculations and determine reserve requirements; with modern technologies, those calculations can be done faster.

Studies are just beginning to emerge regarding the impact of gate closure interval on electricity prices. In cases where no rules are in place to ensure bids are made in good faith, some studies have raised concerns that defining gate closure at a fixed time will enable generators to engage in late bidding, which can enable these generators to influence market price, as previously discussed (Competition Economists Group 2014); however, recent analysis provides evidence that the United Kingdom's 2002 decision to shorten the gate closure interval from 3.5 hours to 1 hour before dispatch had the effect of reducing short-term price volatility in the wholesale market (long-term price volatility has not been impacted) (Facchini et al. 2019). The authors of that report attribute this impact to the ability of shorter gate closure intervals to facilitate more accurate short-term forecasting of electricity demand.

Notably, global experience has demonstrated a general trend toward power systems shortening the interval between gate closure and dispatch. Power systems in Alberta, Singapore, and the United

Kingdom all shortened their gate closure intervals in the early 2000s (Competition Economists Group 2014; Facchini et al. 2019). The Western Australia Wholesale Electricity Market (WEM) is currently evaluating a rule change that would reduce the interval between gate closure and dispatch from 2 hours to 30 minutes (Economic Regulation Authority 2019). In its 2015 comments on the revised draft Network Code on Electricity Balancing, the European Agency for the Cooperation of Energy Regulators also recommended that gate closure be set "as close as possible to real time in order to ensure that the balancing energy bids reflect the real time value of balancing energy to the highest possible extent" (ACER 2015). Beyond enhancing market flexibility, reducing the interval between gate closure and dispatch has important benefits for renewable energy integration, as discussed in the "The Importance of Gate Closure in Power Systems With Higher Levels of Variable Renewable Energy" text box.

Available documentation indicates that decisions related to changing the length of the gate closure interval in the systems discussed above have been based primarily on qualitative rather than quantitative analysis. However, interest in quantitative analysis of gate closure options is growing; in an effort to inform current discussions regarding the harmonization of balancing gate closure time in the European Union (discussed further in the "Harmonizing Gate Closure Across Borders: A Case Study from the European Union" text box), Petitet et al. (2019) recently developed a first-of-its-kind study comparing the operational costs of different gate closure intervals. The study found that 60-minute gate closure resulted in lower operational costs as compared to a 15-minute gate closure in the simulated system.

### *Singapore's Rationale for Moving from 2-Hour to 65-Minute Gate Closure*

When Singapore's power system reduced its gate closure from 2 hours to 65 minutes, the market operator cited additional benefits of a short gate closure interval (Market Administration 2005). Reducing the gate closure interval would enable market participants to react to changing market or plant conditions closer to real time by offering more capacity of online generating units if prices were forecast to be high due to shortages in the market. This would in turn help moderate price spikes in supply-constrained situations (this would not be the case if offline units have to be brought online, as they generally take two hours to start up). Additional justifications for a shorter gate closure interval included: 1) encouraging more responsive bidding based on most recent market information; 2) reducing any given generator's risk by allowing it to correct sudden changes to its physical position closer to real time; and 3) reducing the need for a generator to justify offer variations.

## 3.1 Changes to Bids and Offers

Different power systems define different rules regarding the extent to which changes are allowed after gate closure. Most of these rules are driven by reliability considerations. Some power systems define acceptable operational reasons for schedule changes after gate closure (Competition Economists Group 2014). For example, Alberta allows repositioning of the asset to serve the stand-by operating reserves market or to manage physical or operational constraints. Other power systems (Electric Reliability Council of Texas [ERCOT], New Zealand, Singapore) allow changes for physical reasons, such as a forced outage.

### *The Importance of Gate Closure in Power Systems With Higher Levels of Variable Renewable Energy*

Around the world, several power systems with growing levels of variable renewable energy resources, such as solar and wind, have taken steps to decrease the amount of time between gate closure and dispatch within their power systems.

Gate closure can influence the ability of a power system to use renewable energy forecasts, which are an important tool for increasing power system flexibility and enabling efficient integration of variable renewable energy to the grid. Like electricity demand, solar and wind resources are variable (their output changes over all timescales) and uncertain (their output cannot be predicted with perfect accuracy). Solar and wind power forecasting can help mitigate these twin challenges. The accuracy of solar and wind power forecasts—as well as demand forecasts—depends on their time horizon, with forecast errors decreasing significantly closer to real-time dispatch (CIGRE 2006; Holttinen et al. 2016).The combination of frequent dispatch and short gate closure allows for more frequent generation schedule updates based on the best available forecasts. These frequent updates reduce uncertainty and also reduce the need for reserves and the cost of operating the power system. Studies of the Western Interconnection in the United States have shown that the need for regulation reserves decreases as the dispatch interval and renewable energy forecast lead time decrease, as illustrated in Figure 2 (King, Kirby, Milligan, and Beuning 2011). Reserve requirements decrease even further as the size of the balancing footprint increases, from individual balancing area authorities, to regional aggregations of balancing area authorities, to interconnection-wide.

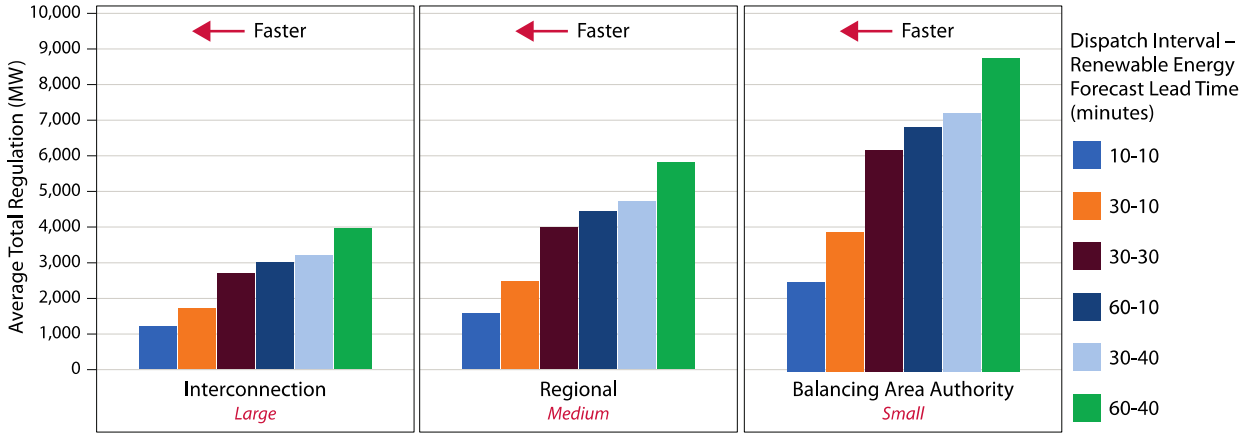


**Figure 2. The need for regulation reserves decreases as power system operations become "big" (i.e., the size of the balancing footprint increases) and "fast" (i.e., the dispatch interval and renewable energy forecast lead time decrease).**

Figure adapted from King, Kirby, Milligan, and Beuning 2011

Reducing the gate closure interval can also decrease the total reserve requirement. Several power systems around the world allow renewable energy generators to participate in electricity markets. In these systems, wind and solar generators offer their generation into the day-ahead and (if available) intraday markets, using the best-available generation forecasts to inform their bids. Because forecast accuracy improves as the horizon between the forecast and real time decreases, shortening the gate closure interval reduces forecast error. It also can reduce costs; a recent study of the power systems of Denmark, Finland, and Portugal provides evidence that reducing gate closure from day-ahead to two hours before dispatch has the potential to reduce imbalance costs associated with wind energy production by 30% and 50% in the Portuguese and Nordic markets, respectively (Holttinen et al. 2016).

Ideally, gate closure, forecasting horizon, and dispatch interval align within an electricity market to maximize the economic benefits of achieving fast operations. For example, 15-minute renewable energy forecasts—while very accurate—will provide the most value if the dispatch or gate closure interval is also 15 minutes, so the power system operator can use the most recent forecasts to inform decisions. That said, many power systems (especially those with growing levels of variable renewable energy) may benefit from an incremental approach in which the gate closure, dispatch interval, and the renewable energy forecasting horizon are shortened periodically to allow time for the entities involved in electricity markets to adjust their information infrastructure and institutional practices. The pace of change is also influenced by availability of data and experience conducting accurate forecasting. Singapore, the United Kingdom, and Western Australia are power systems that have, or are considering, shortening their gate closure intervals over time (Economic Regulation Authority 2019; ELEXON 2002; Market Administration 2005).

# 4 Gate Closure Around the World

Globally, gate closure takes as many forms as electricity markets themselves, and its implementation reflects the unique institutional structure, resource composition, and geography of each power system. Figure 3 shows the interval between gate closure and dispatch in several countries with wholesale energy markets. At the extremes, market participants in the Nord Pool market in Germany may trade until the moment of dispatch, while in the New England Independent System Operator's service area, gate closure occurs between 1600 and 1800 the day before dispatch. More commonly, gate closure ranges from five minutes to approximately two hours ahead of dispatch.

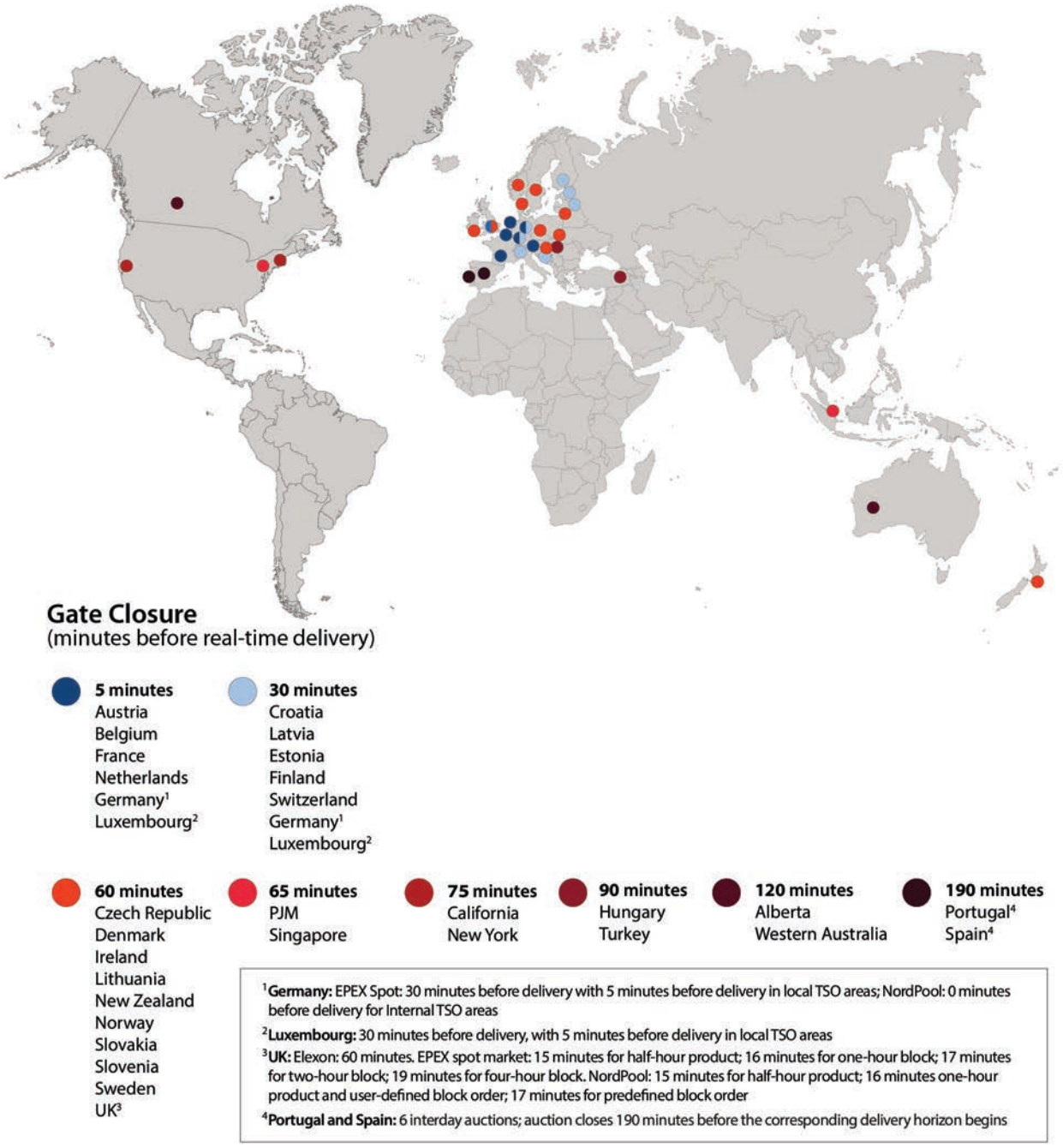


**Figure 3. Gate closure in electricity markets around the world**

See Appendix A for data sources.

Not all wholesale electricity markets implement gate closure. For example, to address the late rebidding behavior previously discussed, AEMC contemplated but ultimately dismissed the option of introducing gate closure into the NEM (AEMC 2015).[3] The Commission recognized that introducing gate closure would have the potential to result in positive outcomes; however, it ultimately decided against

[3] Australia has two energy markets: the NEM and the WEM. Unlike the NEM, the WEM has implemented gate closure (120 minutes in advance of dispatch).

implementing gate closure to allow the market its maximum flexibility to "reach efficient outcomes that reflect changing conditions" (ibid.).

### *Gate Closure in Germany*

In Germany, the implementation of an imbalance pricing system (which enacts a charge on market participants who deviate from their schedules) incentivizes market participants to balance as close as possible to real time. The relatively short gate closure times in Germany's markets reflect this feature of the system. For Nord Pool power exchange participants, the gate closure is effectively zero minutes. EPEX SPOT Market provides a power exchange with a 30-minute and 5-minute gate closure:

> Electricity traded for a delivery on the same or on the following day on single hours, 15-minute periods or on block of hours. Each hour, 15-minute periods or block of hours can be traded until 30 minutes before delivery begins; and until 5 minutes before delivery within the respective control zones. Starting at 3pm on the current day, all hours of the following day can be traded. Starting at 4pm on the current day, all 15-minute periods of the following day can be traded. (EPEX SPOT 2019)

To facilitate short gate closure, the transmission system operators in Germany conduct re-dispatching ex ante to avoid transmission constraints and keep sufficient spinning reserves.

### *Harmonizing Gate Closure Across Borders: A Case Study from the European Union*

Beyond its utilization within particular power systems, gate closure can also apply to power and energy trade across borders. The gate closure window for trades that take place between two or more markets need not be the same as the gate closure for transactions within each of the participating systems.

Recent experience from the European Union (EU) provides one example of how a group of power systems can define and implement gate closure to facilitate cross-border trade. In the EU, market participants in each bidding zone (which sometimes—but not always—are delineated by the national borders of the EU member states) submit orders for cross-zonal capacity allocations and are continuously matched with contracts to deliver this electricity. To coordinate and harmonize this process, the EU has established regulations that require intraday cross-zonal gate closure times to be set for each bidding zone border. The regulations specify that the chosen gate closure times must meet two objectives:

- "[Maximize] market participants' opportunities for adjusting their balances by trading in the intraday market as close as possible to real time; and,
- [Provide Transmission System Operators] and market participants with sufficient time for their scheduling and balancing processes in relation to network and operational security" (ACER 2018a).

To implement these regulations, the EU Agency for the Cooperation of Energy Regulators (ACER) recently adopted a decision to set the intraday cross-zonal gate closure time for all bidding zone borders to 60 minutes before the start of the relevant intraday market time unit (i.e., dispatch period) on the bidding zone border (ACER 2018b). The market time unit to which gate closure will ultimately be applied is the longer of the two market time units on either side of the border. For example, if one system dispatches every 15 minutes and its neighbor dispatches every 30 minutes, the intraday cross-zonal gate closure time will occur 60 minutes before each period in the 30-minute dispatch system. ACER's decision also allows one exception: the gate closure time will be 30 minutes across the Estonia-Finland border, as both Estonia and Finland conduct gate closure internally on a 30-minute basis.

ACER considers the 60-minute gate closure time conservative with respect to the amount of time needed by transmission system operators and market participants to schedule and balance their systems reliably (ACER 2018c); however, ACER acknowledges the conservative gate closure as being justified in lieu of uncertainty related to the implementation of concurrent electricity balancing regulations in the EU, which will, for example, harmonize the imbalance settlement period across the EU to 15 minutes by 2021. As the system operators and market participants gain experience with the integrated balancing market under these new regulations, ACER encourages the adoption of a gate closure closer to real-time, with the goal of improving market liquidity and reducing the need for more expensive balancing services.

# 5 From Gate Closure to Dispatch: Case Study from the New York Independent System Operator

In this section, we walk through a detailed example of the process used by the New York Independent System Operator (NYISO) between gate closure and dispatch in its real-time market. Gate closure in NYISO occurs 75 minutes prior to each operating hour. Figure 4 shows the operational time frame. This figure and the discussion that follows are adapted from NYISO's *Transmission and Dispatch Operations Manual* (NYISO 2018).

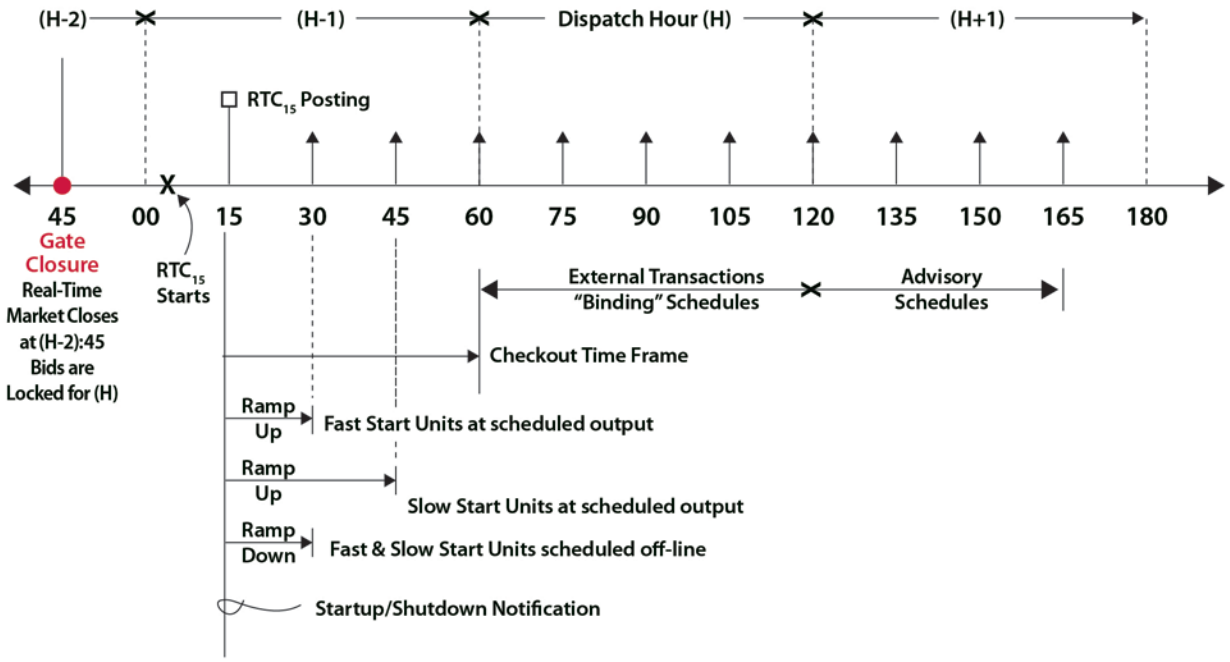


**Figure 4. Operational timeline for NYISO's real-time commitment (RTC) market**

Adapted from NYISO 2018

1. **Gate closure (75 minutes prior to the operating hour):** Bidding for the dispatch hour (H in Figure 4) closes. The system operator collects the accepted bids from the day-ahead market, as well as real-time supply offers, transactions, regulation bids, and constraints. In their supply offers, generating units provide information (including minimum run time, minimum down time, max starts and stops per day, response rate, duration, start-up time, minimum generation, and upper operating limit) that help to define the ability of particular units to respond within the gate closure period. In addition, suppliers must specify the unit operating mode of their units as fixed (i.e., their output cannot be changed from the in-hour schedule) or flexible, as well as whether they are independent system operator (ISO)-committed (economically-selected) or self-committed (price taker).

2. **Real-time commitment begins (60 minutes prior to the operating hour):** NYISO executes the real-time commitment ($RTC_{15}$), a multiperiod security-constrained unit commitment (SCUC) and dispatch process. $RTC_{15}$ co-optimizes to simultaneously solve for load, operating reserves, and regulation service on a least-as-bid production cost basis over the following 165-minute optimization period (10 points separated by 15-minute intervals). NYISO:

    - Updates the power system grid model based on the latest transmission outage schedules (including forced outages)

- Updates the load forecast based on the latest load information
- Accepts any updated reserve requirements
- Accepts the day-ahead schedules and firm transaction schedules, as well as the hour-ahead generation bids and firm transaction bids
- Accepts the telemetered phase shifter and tap settings from Supervisory Control and Data Acquisition (SCADA) with adjustments made for known schedule change.

Each $RTC_{15}$ run produces the following outputs:

- Binding unit commitment and de-commitment instructions for periods beginning at 15 minutes (for resources that can respond in 10 minutes) and 30 minutes (for resources that can respond in 30 minutes) after the scheduled posting time of each $RTC_{15}$ run. For example, units that submit a 30-minute startup time will receive a binding startup notification from the RTC that posts its results 30 minutes before the scheduled start of the units.
- Advisory commitment guidance for the remainder of the optimization period
- Binding schedules for External Transaction schedules to begin at the start of each quarter hour
- Calculated transmission losses as part of the power flow solution for each time interval for each load zone.

During $RTC_{15}$, NYISO also conducts the Supplemental Resource Analysis, a process used to commit additional resources outside of SCUC and RTC to ensure sufficient resources are available to meet forecasted load and reserve requirements.

3. **Posting of real-time results (45 minutes prior to the operating hour):** accepted bids, offers, transactions, regulation bids, and constraints are publicly posted into the Market Information System, which is the interface between NYISO and market participants. This posting serves as a notification for suppliers to start or shut down their units. The posted information includes:
    - Revised generator schedules for the next hour
    - Revised firm transaction schedules for the next hour
    - Market participant actions
4. **Reserve pick-up (approximately 10 minutes prior to the operating hour):** NYISO monitors the area control error and load trends and identifies and mitigates deficiencies in generation or transmission security violations. NYISO or the transmission owner may request out-of-merit generation; for example, for security, during communication failures, or if $RTC_{15}$ did not successfully run.

# 6 Gate Closure for India's Electricity Market

With its unique characteristics and behavior, the Indian electricity market is one of the most dynamic electricity markets in the world. A coordinated multilateral scheduling and dispatch model has been in place since 2001. This approach encourages competition and at the same time maintains necessary coordination to ensure reliability. Power system operation is optimized through cooperation of agents in a multilateral trade structure. In the Indian power system, reliability assessments are carried out by the system operator on transmission corridors and disseminated in the public domain, aiding in the administration of the market. The economic decisions by buyers and sellers, located in different regions, are formulated into contracts considering grid security and reliability. These contracts are coordinated and implemented by the system operator in the form of schedules.

Indian electricity stakeholders have expressed a need to increase the frequency of market opportunities available for market participants to balance their portfolios (CERC 2018b). Achieving this objective would entail shortening the time between procurement period closure and real-time dispatch. The introduction of gate closure may allow enhanced valuation of the product and, notably, the foregone value of the capacity in other market segments, thereby enhancing flexibility and reducing risk.

## 6.1 Flexibility in the Indian Electricity Market

An important aspect of the Indian electricity market is the decentralized nature of scheduling and dispatch decisions. This approach gives freedom and choice to the load serving entities (i.e., state utilities, also known as distribution companies) to revise capacity requisitions, as well as allow inadvertent deviations from schedule within limits if grid conditions permit. It borrows from the basic philosophy of homeostatic control, proposed by Schweppe et al. (1980), in which the supply (generation) and demand (load) respond to each other in a cooperative fashion and are in a state of continuous equilibrium to the benefit of both the utilities and their customers. The revision windows for different contracts (i.e., long-term, medium-term, and short-term) have been specified in the Indian Electricity Grid Code. Further, in case of transmission congestion, there is inter se priority in the curtailment of contracts, with Bilateral Short-Term contracts having lowest priority, then Day-Ahead Power Exchange Spot Market contracts, followed by Medium-Term Open Access (MTOA) Contracts. Long-Term Access (LTA) contracts have the highest priority.

## 6.2 Continuum of Contracts

Presently, the electricity market in India comprises physical delivery only contracts between generating resources and load serving entities. These contracts have to be intimated to the respective load dispatch centers a day in advance. The Indian Electricity Grid Code lays the foundation for the scheduling and dispatch process as a continuum of different long-term, medium-term, and short-term contracts, as well as close-to-real-time windows and products across the spectrum of stakeholders. In case of complex systems like power systems, it is likely that the cessation of challenges at one level will result not in the steady state, but in a move to some other level of dynamic state; however, the common thread throughout the range of continuum is a strategic goal of ensuring reliability, security, and economy in the electricity grid, from planning to operations to settlement.

### *6.2.1 Windows Available for Various Market Products*

Open access in interstate transmission was introduced in 2004 along with the initiation of bilateral transactions. Subsequently, in 2008, collective transactions through the power exchanges were also introduced. Over the years, the various products available and the associated processes have undergone changes depending on the requirements of the market. Market conditions, such as liquidity and prevailing (or likely) prices, drive the preferences of market participants in terms of choice of different products in different windows to balance the portfolio. These windows can be categorized as short-term, medium-

term, or long-term. The various Indian electricity market products, along with their timelines for delivery in the current market design, are depicted in Figure 5.

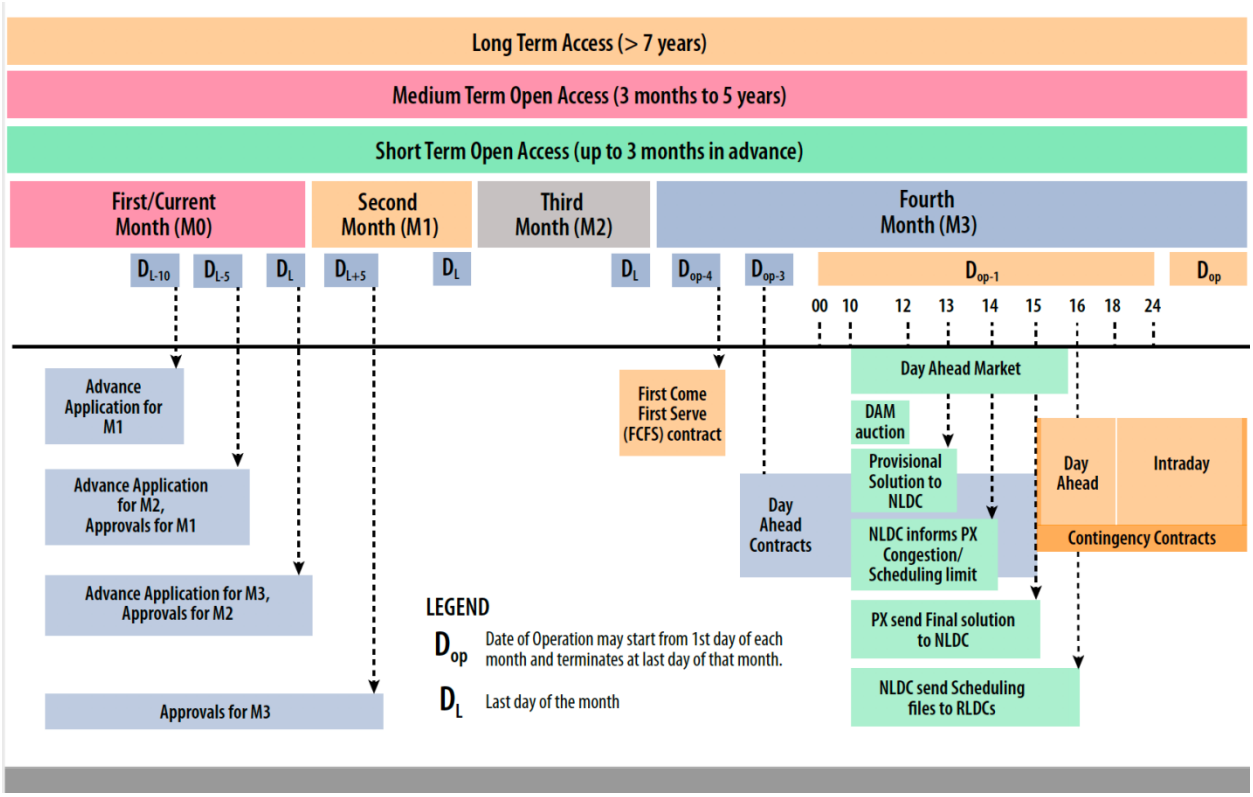


**Figure 5. Electricity market products in India**

Source: POSOCO

The longest window available in the current Indian Electricity Market is the LTA, which refers to the right for market participants to use the interstate transmission system for a period exceeding seven years. An MTOA grants market participants the right to use the interstate transmission system for a period equal to or exceeding three months but not exceeding five years. After LTA and MTOA, the next window available is that of Short-Term Open Access (STOA), applying to the period up to three months in advance. The different products available in the STOA in different time frames are as follows:

- The window for application for Advance STOA-Bilateral product to respective the RLDC is three months in advance but approved one month at a time. In case of congestion in Advance STOA-Bilateral product, electronic bidding is conducted by the respective Regional Load Dispatch Center (RLDC).
- The next window for application for first-come, first-serve STOA-Bilateral product occurs four days prior to day of operation. The processing is done on a first-come first-serve basis for transactions commencing and terminating in the same calendar month.
- The applications received within three days prior and up to 1500 hours of the day immediately preceding the day of operation is treated with the same priority as the day-ahead STOA-Bilateral product; however, the processing of a day-ahead STOA-Bilateral application is done only after processing of the collective transactions of the power exchanges, a sort of mutually exclusive window.

- The double-sided closed-bid auction is done for every time block in 96 time blocks of 15 minutes in the Day-Ahead Market through the Power Exchanges. The auction window is from 1000 hours-1200 hours. The final clearing result is communicated at 1500 hours to the National Load Despatch Centre (NLDC).
- The window for Contingency STOA-Bilateral product is opened after 1500 hours of the day immediately preceding the day of operation. All Contingency STOA-Bilateral applications received up to 1800 hours are clubbed together with the same priority. If the Contingency STOA-Bilateral application is received in intraday, subject to approval, the scheduling of the transaction commences within 91 minutes after application is received.

The summary of windows available in the Indian Electricity market is depicted in Figure 6. The windows are, at times, mutually exclusive (i.e., no two windows or electricity market products are open at the same time for the same delivery period). When a new window for a particular product is opening, it is accompanied by a closing of the preceding window of another product. Therefore, each window of different products offers a new opportunity to the market participants to balance through a portfolio of products, thereby enhancing grid security and reliability.

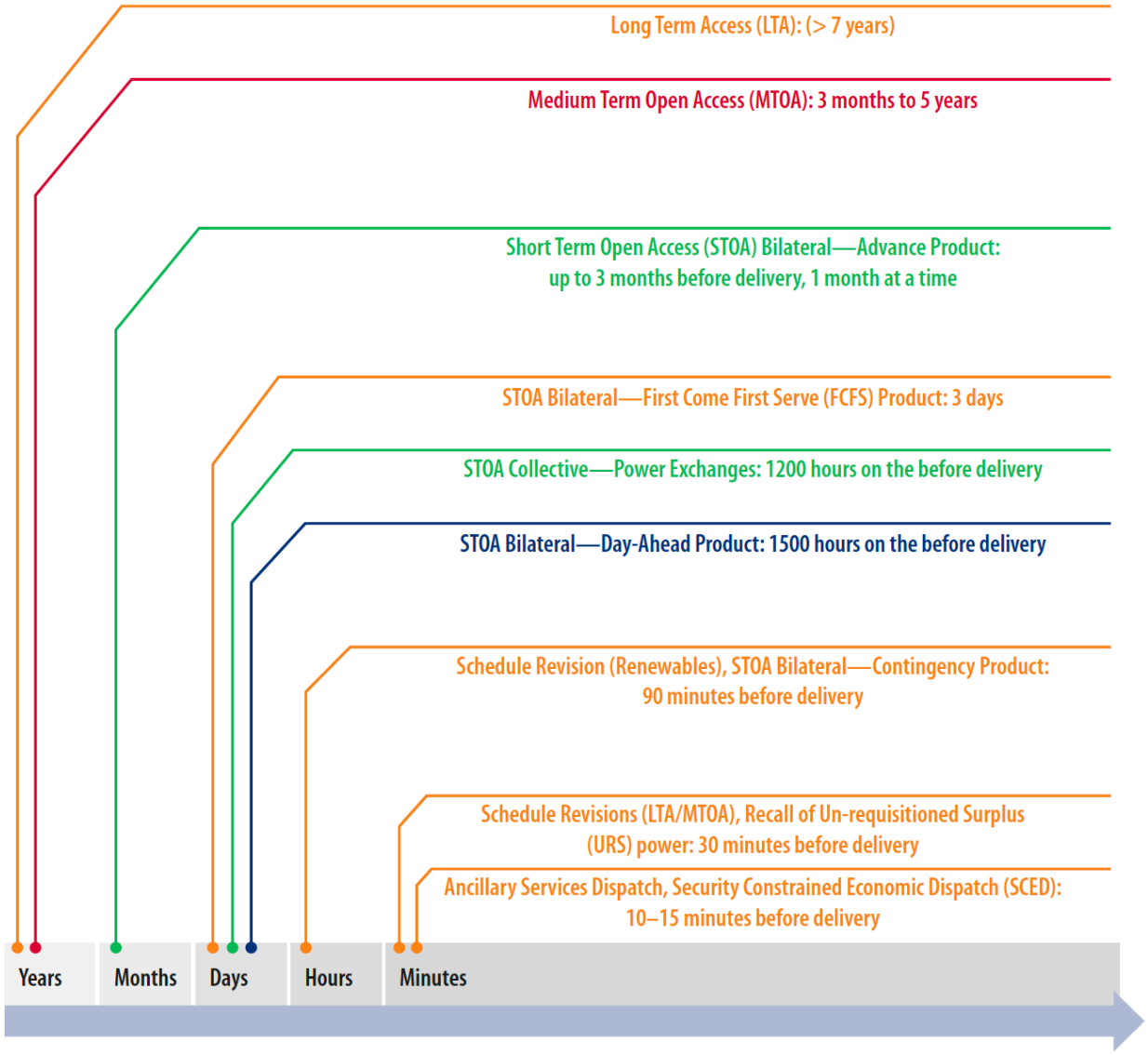


**Figure 6. Gates and windows in the Indian electricity market**

Source: POSOCO

The available transfer capability in the interregional transmission corridors would be honored in all time frames while scheduling trades in different windows.

## 6.3 Scheduling Framework

Figure 7 illustrates the current approach to day-ahead and intraday scheduling in India's electricity market.

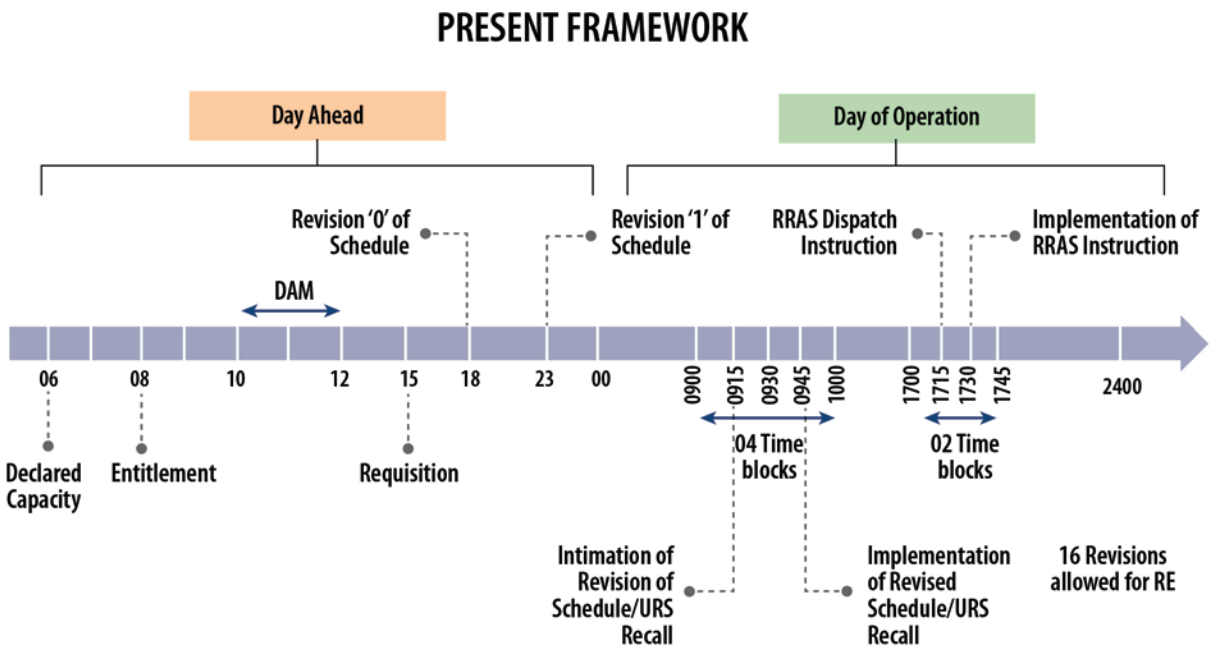


**Figure 7. Current scheduling framework for India's electricity market**

Source: POSOCO

### 6.3.1 Day-Ahead Scheduling

In the present framework mandated in the Indian Electricity Grid Code, each interstate generating station (ISGS) submits its declared capacity (given in megawatts [MW]) and generation (DC, given in megawatt-hours [MWh]) capabilities foreseen for the next day (i.e., 0000 hrs to 2400 hrs for 96 blocks of 15 minutes duration each) to the respective Regional Load Despatch Center (RLDC). By 0800 hours, each State Load Despatch Centre (SLDC) submits to its respective RLDC the ISGS shares (MW and MWh) to which the state is entitled during the following day at 15-minute intervals.

The load serving entity communicates its consent for the sale of unrequisitioned generating capacity to the ISGS at least 24 hours before 0000 hrs of the day of operation (i.e., the day of dispatch). In the meantime, the submission of bids and offers in the power exchanges for day-ahead market is done from 1000-1200 hrs on the day before dispatch. The requisition in each of the ISGS in which the states have long term, medium term, bilateral interchanges, approved short term bilateral interchanges are communicated to the respective RLDC by 1500 hrs.

The scheduling request of day-ahead collective transactions in power exchanges is communicated by the NLDC to the respective RLDCs by 1600 hrs. The interchange schedule (i.e., Revision 0, in MW, after deducting the apportioned estimated transmission losses) is communicated by RLDC to each regional entity by 1800 hrs.[4] The modifications, if any, in view of grid conditions have to be communicated by the respective SLDC, ISGS, or regional entity to RLDC by 2200 hrs. At 2300 hours, the RLDC communicates the final generation/drawal schedule for the next day (i.e., Revision 1) to the respective SLDC, ISGS, or regional entity.

[4] As defined in the Indian Electricity Grid Code, regional entities are those within an RLDC control area whose metering and accounting are done at the regional level. RLDCs conduct scheduling for regional entities.

## 6.4 Intraday Scheduling and Dispatch

There are many instances throughout the day of operation when either a regional entity or load dispatch center may initiate revisions in the schedules on account of various contingencies. As per the Grid Code, at present, there are various provisions for revision in schedules effectively up to 31 minutes before the dispatch period. A regional entity (including a renewable energy generator) can initiate a revision in its DC and STOA (Bilateral) injection schedule if a forced outage occurs. In case of a STOA contingency application, ISGSs can revise their schedules, with changes implemented within up to 91 minutes after the application is received.

Based on real-time conditions, NLDC issues the instructions for Reserve Regulation Ancillary Services (RRAS) Up/Down schedule to each ISGS. Once added to the generation schedule, the revision is operationalized, at the earliest, from the time block starting 15 minutes after issue of the dispatch instruction. A pilot project on Security Constrained Economic Dispatch (SCED) has been deployed, effective April 1, 2019. The SCED schedule is incorporated by the ISGS before the start of the delivery block. Further, RLDCs can revise schedules on their own in case of bottleneck in evacuation of power from ISGS, transmission constraints, and in the interest of better grid operation.

## 6.5 Context for Gate Closure in India

### *6.5.1 Regulatory Mandate and Initiatives*

The Ministry of Power notified a scheme on *Flexibility in Generation and Scheduling of Thermal Power Stations to reduce the cost of power to the consumer* in which it emphasized that suitable provision for gate closure for operationalizing the scheme may be provided by the Appropriate Commission (Ministry of Power, Government of India 2018).

The Central Electricity Regulatory Commission's (CERC's) *Discussion Paper on Re-designing Real Time Electricity Markets in India* suggests that the intraday/real-time market design for India needs to incorporate the concept of gate closure for guaranteeing firmness and sanctity of schedules in intraday trades (CERC 2018b). Figure 8. shows the preliminary concept for gate closure as outlined in this paper. CERC's *Discussion Paper on Designing Market for Tertiary Ancillary Services in India* also highlighted the importance of gate closure in the proposed market-based ancillary services mechanism (CERC 2018a).

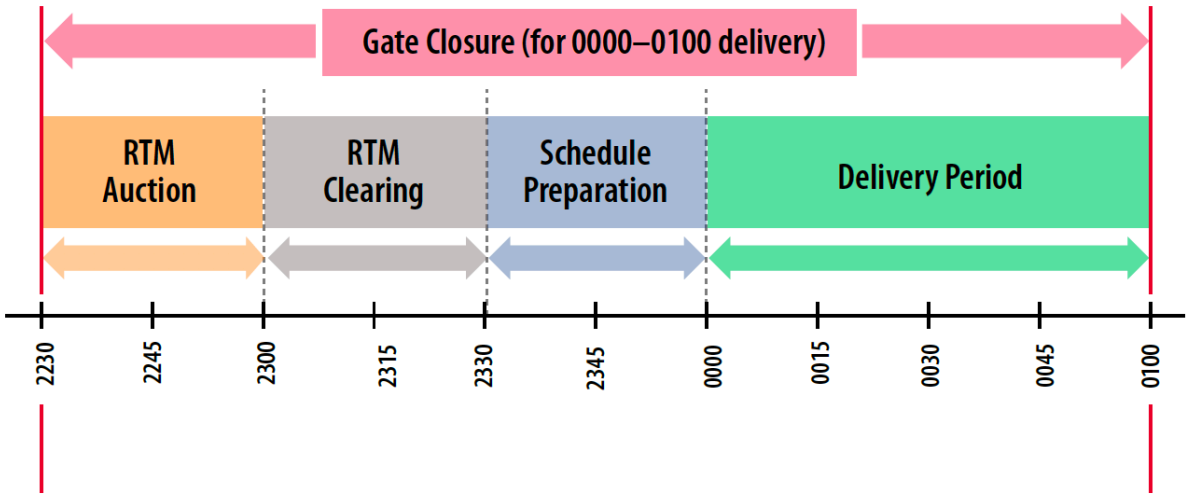


**Figure 8. Concept of gate closure, as per CERC staff paper**

Source: CERC 2018b

The Power System Operation Corporation (POSOCO) *Consultation Paper on Security Constrained Economic Despatch of ISGS Pan-India* emphasized that with the large number of participants, there are requests for revisions in schedule on an almost continuous basis (POSOCO 2018). This reality can create challenges in real-time assessment of the hot and cold reserves available in the system. To efficiently implement the proposed optimization process at the regional and national level, the introduction and timing of gate closures may play an important role. Conceptually, prior to gate closure, the flexibility of revising the schedules is with the market participants; post gate closure, the system operators take over and prepare for the predetermined delivery period. Gate closure time is intended to be implemented to enable a thin centralized layer of optimization over the present decentralized scheduling. This optimization could also extend to tertiary reserves where more opportunities for co-optimization of energy, ancillary services, and reserves are being considered.

The Forum of Regulator of India deliberated the concept of gate closure (Forum of Regulators 2018a). The Forum endorsed the recommendation of the Technical Committee for the introduction of a real-time market with gate closure and requested CERC to take the idea forward. It was also reiterated that automation of the process and preparedness of the stakeholders, especially distribution companies and power exchanges, were essential requisites to the success of the framework.

The Forum of Regulators *Sub-Group Report on Introduction of Five Minute Scheduling, Metering, Accounting and Settlement in Indian Electricity Market* recognized that with coordinated multilateral scheduling processes, the various activities, such as rescheduling of undispatched surplus and tripping of power system elements, may be contributing to overlap with the schedule modifications being carried out by the concerned RLDC (Forum of Regulators 2018b). The available reserve quantum is thus changing continuously, and simultaneous ancillary service dispatch has added another dimension of complexity to the process with potential parallel changes by the NLDC (for ancillary services) and the RLDCs (schedules).

CERC's *Report of the Expert Group Volume – II "Review of the Principles of Deviation Settlement Mechanism (DSM), Including Linkage with Frequency, in the Light of Emerging Markets* recommended the need for introduction of gate closure concept in the scheduling process so that the system operator has

clarity of the quantum of reserve and resources at hand at any given point of time CERC 2017). This would facilitate better optimization of the scheduled dispatch and the real time ancillary dispatch.

The POSOCO *Report on Reserve Regulation Ancillary Services (RRAS) Implementation in Indian Grid - Half Year Analysis and Feedback* emphasized that improved co-optimization of the scheduled dispatches and the real-time ancillary services dispatch needs to be formulated (POSOCO 2016). The report also highlighted another limitation of the absence of gate closure in the extant RRAS Regulations (i.e., that the original beneficiaries have the right to recall unrequisitioned power from ISGSs any time as per the provisions of the regulations). Therefore, the ownership and rights remain with the original beneficiary, and original beneficiaries should continue to pay the fixed charges. This market design has created a perverse incentive for load serving entities to take a passive approach and avoid keeping reserves on bar. In order to maintain grid security, NLDC and the RLDCs will try to keep spinning reserves in the system, and they will utilize this reserve as per their requirement. The beneficiary gets a refund of fixed charges despite a passive approach. To alleviate these issues, some amendments in the scheduling timelines prescribed in the Grid Code may be necessary. POSOCO suggested that the process of revision of ISGS schedules may be examined afresh considering Day-Ahead Market, 24 x 7 Market, sale by ISGS and ancillary services, among other considerations. In physical terms, the concept of gate closure may also facilitate more efficient system balancing through a thin layer of centralized scheduling over decentralized scheduling by the constituents.

# 7 Considerations Going Forward—Perspectives from India

### *Successful Gate Closure Implementation in India*

Essential considerations for successful implementation of gate closure in any typical power system include:

- Primary control
- Secondary control through automatic generation control
- Different types of reserves (e.g., fast and slow) with sufficient quantum (either mandatory or through market)
- Market design and regulatory framework
- Robust communication and IT infrastructure
- Skilled workforce and capacity building.

In India, with the current majority of generation resources being coal based, generators need to receive dispatch instructions at least 15 minutes in advance. As a result, a reduction of gate closure to anything less than an hour may create new challenges for system operators, even if the transition to five-minute scheduling and settlement occurs. In the future, as new market products with newer attributes are introduced in light of the evolving power system, gate closure could mitigate some of these challenges. Hourly gate closure complements current renewable energy forecasting practice in India, as granular solar irradiance data is available on a 30-minute basis. It could also help to ensure adequate time is available for suitable technology upgrades for more than 6,000 market participants at the interstate level. With operationalization of retail-level competition and new market participants such as aggregators, the current market dynamics are likely to change significantly, including consideration of new market arrangements with real-time market and gate closure.

In a large grid like India, there are **multiple regional-level control areas** for the purpose of scheduling and energy accounting. All buyers and sellers in a regional-level control area are treated as **nested control areas** within that respective regional-level control area and are clubbed together into a separate group. **Scheduling, energy accounting, and settlement** for the individual transactions for **nested (embedded) control areas** are handled by the respective states. Cooperation and commitment of the internal control areas are essential; otherwise, the combined control performance of national control area can easily be worse than the sum of individual regional and state level control areas. Hence, the **seams between different control areas and jurisdictions** would be an important consideration for introduction of gate closure concept.

Considering the predominance of thermal generation in India, communication infrastructure, forecasting granularity challenges, the seams between different jurisdictions, limitations of granular weather data information technology upgradation, newer products in marketplace, decentralized scheduling and dispatch model, international experience, complexity of contracts, available windows and products; hourly (versus a shorter time frame) gate closure could potentially support greater efficiency and optimization with the Indian electricity market. In order to ensure all market participants benefit from the use of this mechanism with gate closure, the concept would also likely need to be introduced via an amendment of the Indian Electricity Grid Code to ensure market clarity, ability to operationalize, and compliance. Further, efficient and effective implementation of gate closure approach would likely require parallel introduction of related state grid codes via the State Electricity Regulatory Commissions.

# References


ACER (Agency for the Cooperation of Energy Regulators). *Recommendation of the Agency for the Cooperation of Energy Regulators No 03/2015 of 20 July 2015 On the Network Code on Electricity Balancing*. July 2015. https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Recommendations/ACER Recommendation 03-2015.pdf.

ACER. (2018a). Annex I: Intraday cross-zonal gate opening and gate closure times in accordance with Article 59 of Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management.

ACER. *Decision of the Agency for the Cooperation of Energy Regulators No 04/2018 of 24 April 2018 on All Transmission System Operators' Proposal for Intraday Cross-Zonal Gate Opening and Intraday Cross-Zonal Gate Closure Times.* April 2018. https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Individual decisions/ACER Decision 04-2018 on IDCZGTs.pdf.

ACER. *Intraday Cross-Zonal Gate Opening and Gate Closure Times*. July 2009. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:211:0001:0014:EN:PDF

AEMC (Australian Energy Market Commission). *Bidding in Good Faith, Final Rule Determination*. December 2015. https://www.aemc.gov.au/sites/default/files/content/815f277c-a015-47d0-bc13-ce3d5faaf96d/Final-Determination.pdf.

CERC (Central Electricity Regulatory Commission). *Report of the Expert Group (Volume II): Review of the Principles of Deviation Settlement Mechanism (DSM) Including Linkage with Frequency in light of Emerging Markets*. New Delhi. December 2017. http://www.cercind.gov.in/2018/Reports/ASB.pdf.

CERC. *Discussion Paper on Designing Market for Tertiary Ancillary Services in India*. New Delhi. September 2018. http://www.cercind.gov.in/2018/draft_reg/DP.pdf.

CERC. *Discussion Paper on Re-designing Real Time Electricity Markets in India*. New Delhi. July 2018. http://www.cercind.gov.in/2018/draft_reg/RTM.pdf.

CIGRE. *Electric Power System Planning with the Uncertainty of Wind Generation*. 2006. https://e-cigre.org/publication/293-electric-power-system-planning-with-the-uncertainty-of-wind-generation.

Cochran, Jaquelin, Michael Milligan, and J. Katz. "Greening the Grid: Sources of Operational Flexibility." Golden, CO: NREL. NREL/FS-6A20-63039. May 2015. https://www.nrel.gov/docs/fy15osti/63039.pdf.

Collier, Mike, and Steve Smith. "The Flight Dispatch Process." Presented at the Cross Polar Working Group, May 30-June 1 2017. Washington, D.C. https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/systemops/ato_intl/documents/cross_polar/CPWG23/CPWG23_Brf_AAL_Dispatch_Process.pdf.

Competition Economists Group. *International review of rebidding activity and regulation*. December 2014. https://www.aemc.gov.au/sites/default/files/content/1694f30d-2165-4e5a-b464-e28de02d02e9/CEG-International-review-of-rebidding-activity-and-regulation-Final-report.PDF.

Economic Regulation Authority. "Rule Change: RC_2017_02." Accessed February 8, 2019. https://www.erawa.com.au/rule-change-panel/market-rule-changes/rule-change-rc_2017_02.

Elexon. "The Electricity Trading Arrangements: A Beginner's Guide." February 2019. https://www.elexon.co.uk/documents/training-guidance/bsc-guidance-notes/beginners-guide-2/.

Elexon. "Modification Report - Modification Proposal P12: Reduction of Gate Closure from 3.5 Hours to 1 Hour." Last modified September 29, 2010. https://www.elexon.co.uk/mod-proposal/p012-reduction-of-gate-closure-from-3-5-hours-to-1-hour/.

EPEX SPOT. "Intraday market with delivery on the German TSO zone." Accessed February 8, 2019. https://www.epexspot.com/en/product-info/intradaycontinuous/germany.

Facchini, Angelo, Alessandro Rubino, Guido Caldarelli, and Giuseppe Di Liddo. "Changes to Gate Closure and its impact on wholesale electricity prices: The case of the UK." *Energy Policy* 125 (February 2019): 110–121. https://doi.org/10.1016/J.ENPOL.2018.10.047.

Forum of Regulators. "Minutes of the 63rd Meeting of the Forum of Regulators." New Delhi. April 9, 2018. http://www.forumofregulators.gov.in/Data/Meetings/Minutes/63.pdf.

Forum of Regulators. *Sub-Group Report on Introduction of Five Minute Scheduling, Metering, Accounting and Settlement in Indian Electricity Market*. February 2018. http://www.forumofregulators.gov.in/Data/Reports/5.pdf.

Holttinen, Hannele, Jari Miettinen, Antonio Couto, Hugo Algarvio, Luis Rodrigues, and Ana Estanqueiro. "Wind power producers in shorter gate closure markets and balancing markets." 2016 13th International Conference on the European Energy Market (EEM) (pp. 1–5). IEEE. June 6-9 2016. https://doi.org/10.1109/EEM.2016.7521309.

King, J., B. Kirby, M. Milligan, and S. Beuning. *Flexibility Reserve Reductions from an Energy Imbalance Market with High Levels of Wind Energy in the Western Interconnection*. Golden, CO: NREL. NREL/TP-5500-52330. October 2011. https://www.nrel.gov/docs/fy12osti/52330.pdf.

Market Administration, E. M. C. Gate Closure Reduction, Pub. L. No. EMC/BD/07/2005/14(b), Chapter 6, section 10.4; Appendix 6A. January 2006. https://www.emcsg.com/f311,9288/EMC_246-EMA-wg_revised.pdf.

Midkiff, Alan, R. John Hansman, and Tom G. Reynolds. *Air Carrier Flight Operations*. Cambridge, MA: MIT/ICAT. July 2004. https://dspace.mit.edu/bitstream/handle/1721.1/35725/FlightOpsICATfinal2.pdf.

Ministry of Power Government of India. "Scheme on Flexibility in Generation and Scheduling of Thermal Power Stations to reduce the cost of power to the consumer." August 2018. https://powermin.nic.in/sites/default/files/webform/notices/Merit Order operation.pdf.

New York Independent System Operator. *Manual 12: Transmission and Dispatch Operations Manual*. July 2019. https://www.nyiso.com/documents/20142/2923301/trans_disp.pdf/9d91ad95-0281-2b17-5573-f054f7169551.

Pelland, Sophie, Jan Remund, Jan Kleissl, Takashi Oozeki, and Karel De Brabandere. "Photovoltaic and Solar Forecasting: State of the Art." October 2013. http://iea-pvps.org/index.php?id=278.

Petitet, Marie, Marie Perrot, Sébastien Mathieuc, Damien Ernstc, Yannick Phulpina. "Impact of gate closure time on the efficiency of power systems balancing." June 2019. https://www.sciencedirect.com/science/article/pii/S0301421519301223

POSOCO (Power System Operation Corporation Limited). *Report on Reserve Regulation Ancillary Services (RRAS) Implementation in Indian Grid - Half Year Analysis and Feedback*. New Delhi. November 2016. https://posoco.in/download/half-year-feedback-to-cerc/?wpdmdl=8916.

POSOCO. *Consultation Paper on Security Constrained Economic Dispatch of ISGS Pan India*. New Delhi. September 2018. https://posoco.in/download/consultation-paper-on-security-constrained-economic-dispatch-of-isgs-pan-india/?wpdmdl=19708.

Schweppe, F. C., Tabors, R. D., Kirtley, J. L., Outhred, H. R., Pickel, F. H., & Cox, A. J. (1980). Homeostatic Utility Control. IEEE Transactions on Power Apparatus and Systems, PAS-99(3), 1151–1163.

van der Veen, Reinier, and Rudi Hakvoort. "The electricity balancing market: Exploring the design challenge." *Utilities Policy* 43 (December 2016): 186–194. https://doi.org/10.1016/J.JUP.2016.10.008.

# Appendix A: Data Sources for Figure 3

**Alberta**

Alberta Electric System Operator. "Guide to understanding Alberta's electricity market." Accessed August 6, 2019. https://www.aeso.ca/aeso/training/guide-to-understanding-albertas-electricity-market/.

**Australia (WEM)**

Economic Regulation Authority. "Rule Change: RC_2017_02." Accessed February 8, 2019. https://www.erawa.com.au/rule-change-panel/market-rule-changes/rule-change-rc_2017_02.

**Austria**

EPEX SPOT. "Intraday market with delivery on the Austrian TSO zone." Accessed August 6, 2019. https://www.epexspot.com/en/product-info/intradaycontinuous/Austria.

**Belgium**

EPEX SPOT Belgium. "EPEX SPOT CIM." Accessed August 6, 2019. https://www.belpex.be/trading-clearing/belpex-cim/.

**California**

California ISO (Independent System Operator). "Market processes and products." Accessed August 6, 2019. http://www.caiso.com/market/Pages/MarketProcesses.aspx.

**Croatia**

ACER and Council of European Energy Regulators. *Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2017-Electricity Wholesale Markets Volume*. October 2018. https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/MMR 2017 - ELECTRICITY.pdf.

**Czech Republic**

OTE. "Daily Market-Spot Market Index." Last modified August 20, 2019. http://www.ote-cr.cz.

**Denmark**

Nord Pool. "Price Development." Accessed August 6, 2019. https://www.nordpoolgroup.com/.

**Estonia**

Nord Pool. "Price Development." Accessed August 6, 2019. https://www.nordpoolgroup.com/.

**Finland**

Nord Pool. "Price Development." Accessed August 6, 2019. https://www.nordpoolgroup.com/.

**France**

EPEX SPOT. "Intraday market with delivery on the French TSO zone." Accessed August 6, 2019. https://www.epexspot.com/en/product-info/intradaycontinuous.

**Germany**

ACER and Council of European Energy Regulators. *Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2017-Electricity Wholesale Markets Volume*. October 2018.

https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/MMR 2017 - ELECTRICITY.pdf.

EPEX SPOT. "Intraday market with delivery on the German TSO zone." Accessed August 6, 2019. https://www.epexspot.com/en/product-info/intradaycontinuous/germany.

Nord Pool. "Price Development." Accessed August 6, 2019. https://www.nordpoolgroup.com/.

**Hungary**

Hungarian Power Exchange. "HUPX Intraday market." https://hupx.hu/en/product/id.

**Iberian Peninsula (Portugal and Spain)**

ACER and Council of European Energy Regulators. *Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2017-Electricity Wholesale Markets Volume*. October 2018. https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/MMR 2017 - ELECTRICITY.pdf.

OMI-Polo Español S.A. "Intraday Market." Accessed August 6, 2019. http://www.omel.es/en/home/markets-and-products/electricity-market/our-electricity-markets/intraday-market.

**Ireland**

Single Electricity Market Committee. *Quick Guide to the I-SEM*. https://www.semcommittee.com/sites/semc/files/media-files/ISEM quick guide_1.pdf.

**Latvia**

Nord Pool AS. "Price Development." Accessed August 6, 2019. https://www.nordpoolgroup.com/.

**Lithuania**

ACER and Council of European Energy Regulators. *Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2017-Electricity Wholesale Markets Volume*. October 2018. https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/MMR 2017 - ELECTRICITY.pdf.

**Luxembourg**

ACER and Council of European Energy Regulators. *Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2017-Electricity Wholesale Markets Volume*. October 2018. https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/MMR 2017 - ELECTRICITY.pdf.

**Netherlands**

EPEX Spot. "EPEX SPOT Intraday in the Netherlands." Accessed August 6, 2019. https://www.epexspot.com/en/product-info/intradaycontinuous/the_netherlands.

**New Zealand**

Electricity Authority. "Electricity Industry Participation Code Amendment (Shortened Gate Closure and Revised Bid and Offer Provisions) 2017." Accessed August 6, 2019. https://www.ea.govt.nz/code-and-compliance/the-code/amendments/2017-code-amendments/.

**Norway**
Nord Pool AS. "Price Development." Accessed August 6, 2019. https://www.nordpoolgroup.com/.

**New York**
NYISO (New York Independent System Operator). *Manual 12: Transmission and Dispatch Operations Manual*. July 2019. https://www.nyiso.com/documents/20142/2923301/trans_disp.pdf/9d91ad95-0281-2b17-5573-f054f7169551.

**PJM**
PJM. "PJM Real-Time Energy Market." October 2018. https://pjm.com/-/media/training/nerc-certifications/gen-exam-materials-feb-18-2019/training-material/02-generation/2-4-real-time-energy-market.ashx?la=en.

PJM. *PJM Manual 11: Energy and Ancillary Services Market Operations, Revision 106*. May 2019. https://www.pjm.com/-/media/documents/manuals/m11.ashx?la=en.

**Poland**
ACER and Council of European Energy Regulators. *Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2017-Electricity Wholesale Markets Volume*. October 2018. https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/MMR 2017 - ELECTRICITY.pdf.

**Romania**
ACER and Council of European Energy Regulators. *Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2017-Electricity Wholesale Markets Volume*. October 2018. https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/MMR 2017 - ELECTRICITY.pdf.

**Singapore**
Energy Market Authority. "Singapore Electricity Market Rules: Appendix 6A, Market Operations Timetable." January 2019. https://www.emcsg.com/f283,7867/Appendix_6A_Market_Operations_Timetable_1Jan19.pdf.

**Slovakia**
ACER and Council of European Energy Regulators. *Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2017-Electricity Wholesale Markets Volume*. October 2018. https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/MMR 2017 - ELECTRICITY.pdf.

**Slovenia**
ACER and Council of European Energy Regulators. *Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2017-Electricity Wholesale Markets Volume*. October 2018. https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/MMR 2017 - ELECTRICITY.pdf.

**Sweden**
Nord Pool AS. "Price Development." Accessed August 6, 2019. https://www.nordpoolgroup.com/.

**Switzerland**
EPEX SPOT. "Intraday market with delivery on the Swiss TSO zone." Accessed August 6, 2019. https://www.epexspot.com/en/product-info/intradaycontinuous/switzerland.

**Turkey**
Enerji Piyasaları İşletme A.Ş. "Spot Electricity Market: Phases." Accessed August 6, 2019. https://www.epias.com.tr/en/intra-day-market/phases.

**United Kingdom**
ACER and Council of European Energy Regulators. *Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2017-Electricity Wholesale Markets Volume*. October 2018. https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/MMR 2017 - ELECTRICITY.pdf.

ELEXON. "Glossary Term: Gate Closure." Accessed August 6, 2019. https://www.elexon.co.uk/glossary/gate-closure/.

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The United States Agency for International Development (USAID) is an independent government agency that provides economic, development, and humanitarian assistance around the world in support of the foreign policy goals of the United States. USAID's mission is to advance broad-based economic growth, democracy, and human progress in developing countries and emerging economies.

### About the Ministry of Power, Government of India

The Ministry of Power is primarily responsible for the development of electrical energy in the country. The Ministry is concerned with perspective planning, policy formulation, processing of projects for investment decision, monitoring of the implementation of power projects, training and manpower development, and the administration and enactment of legislation in regard to thermal, hydro power generation, transmission, and distribution.

### About NREL

The National Renewable Energy Laboratory (NREL) is the U.S. Department of Energy's (DOE's) primary national laboratory for renewable energy and energy efficiency research. NREL deploys its deep technical expertise and unmatched breadth of capabilities to drive the transformation of energy resources and systems.

### About Power System Operation Corporation Limited

Power System Operation Corporation Limited (POSOCO) is an independent government company in India that operates the National Load Despatch Centre and Regional Load Despatch Centres. POSOCO ensures integrated operation of regional and national power systems to facilitate transfer of electric power within and across regions.




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