



# Marginal Losses Implementation Frequently Asked Questions

Revision 4 (April 27, 2007)

## Market Operations & Dispatch (LMP Calculation)

**1. Q: Several RTO/ISOs have already implemented Marginal Losses into their market designs. What are the differences between the PJM implementation and the features of the other RTO/ISOs implementation?**

A: Below is a table providing an overview of the major features of the MISO, ISO-NE, and NYISO marginal loss implementation compared to the PJM implementation.

Approach	PJM	MISO	NY	NEISO
Loss charged on average loss or on marginal loss	Currently Average	Marginal	Marginal	Marginal
Marginal Loss Reference	Distributed Load Reference	Distributed Load Reference	Fixed Single Station Reference	Distributed Load Reference
Penalty Factor Calculation	Determined from the incremental losses calculated in an Optimal Power Flow	Determined from the incremental losses calculated in an Optimal Power Flow	Determined from the incremental losses calculated in an Optimal Power Flow	Determined from the incremental losses calculated in an Optimal Power Flow
Allocation Method	Allocated to Transmission Users based on load plus exports ratio share.	Load Ratio Share within loss pools. Allocation to loss pools determined according to "loss charge" incurred from generation to load within each pool	Over collection reduces amount of Minimum Generation and Startup Residual Uplift allocated through Schedule 1. Essentially reduces load ratio share charges	Allocated according to Real-Time Adjusted Load Obligation



**2. Q: Are penalty factors applied to Generation and Incremental offers?**

A: Yes. The penalty factors are applied to each and every location within the PJM network model. Every generator, load, inc, dec, fixed demand, price sensitive demand, etc will have the marginal loss effect associated with their location included in the clearing process as well as the resulting prices.

**3. Q: Will virtual transactions have an impact on marginal loss calculations?**

A: Virtual transactions are considered in the Day Ahead clearing just as any other generator or load. Therefore, their effect on losses will be taken into consideration and they will be cleared in the same manner as generation or demand. In other words, they will be treated on an equal basis as actual generation or load within the Day Ahead market. Since virtuals do not appear in Real Time, they have no impact on Real Time losses.

**4. Q: If incremental losses are a function of power injections, how are penalty factors determined for load?**

A: The penalty factors are calculated for every location within the PJM network model by determining the change in system losses for a given increase in power injection. This calculation is done for every location regardless if there is a physical generator or load at the location. Therefore, a penalty factor for every location on the system is obtained. From this comprehensive set of penalty factors, the marginal loss effect at every location, including load and generation, can be determined. **Day-Ahead penalty factors are based on the Day-Ahead model and the Real-Time penalty factors are based on real-time system conditions.**

**5. Q: How will the reference bus be chosen?**

A: The reference bus will be chosen by using a load weighted average of all load buses within the PJM footprint. This load weighted average is called a distributed load reference or “center of load” reference.

**6. Q: Why is PJM using a distributed reference bus?**

A: The reason for using a distributed load reference with the ability to change every execution based on actual system conditions is that this method minimizes the error introduced by the linear approximation of the actual differential equations used to model transmission loss impacts. This method is being utilized in other RTOs including Midwest ISO and ISO-NE.



**7. Q: How often will the reference bus change?**

A: PJM will use a distributed load reference in the calculation of Marginal Losses. Because the demand at each load bus can change with every execution, the distributed load reference is recalculated each and every execution. For the Real-time LMP calculation, this occurs every 5 minutes and will use the actual load MWs at each load bus for the given period the calculation is executing. For the Day-ahead LMP calculation, this occurs every hour and will use the fixed load Mw at each load bus.

**8. Q: Can a generator lose money by getting a LMP less than their offer?**

A: The PJM implementation of Marginal Losses includes the incremental loss effect of each location within the optimization. Therefore, the solution to the dispatch and the pricing will be consistent and each will consider the effect of Marginal Losses on a generating unit. As long as the unit is following PJM dispatch and determined to be eligible to set price, the dispatch instructions and pricing will be consistent. Any discrepancies between the dispatch and resulting price for units following PJM dispatch will not be a result of Marginal Losses.<sup>1</sup>

**9. Q: Where will the distributed reference or “load center” be located within PJM?**

A: Because the distributed load reference or “load center” is a load MW weighted value, the location of this reference will change as load changes. The actual load MWs are used for the Real-Time LMP calculation and the fixed load Mw are used for the Day-ahead LMP calculation to calculate the distributed load reference. Therefore, the location can vary each and every execution. Because it is load weighted, the location of the distributed load reference will be near the load center and is at times referred to as the “load center”.

**10. Q: Can Marginal Losses be negative with respect to the reference bus?**

A: Yes. The marginal loss component of LMP can and will be negative for some buses with respect to the reference. If an increase in generation at the bus results in an increase in losses, then the marginal loss component of that bus will be negative.

---

<sup>1</sup> There currently exist situations when unit are uneconomically run because of factors such as physical generator limitations. The Operating Reserve calculation was created to provide a daily guarantee for generation following PJM dispatch instructions to be made whole up to their offer if asked to run uneconomically.



**11. Q: How will the approximately \$100 Million of total production cost savings be distributed among the various zones?**

A: There will not be a \$100 Million “pot of dollars” to be allocated annually following implementation of Marginal Losses. The approximately \$100 Million of potential production cost savings from implementing Marginal Losses is a result of considering a generators effect on system losses. Because the dispatch will change to minimize the losses incurred on the transmission system to the extent it is economic to do so, the total MW produced in order to serve actual load plus losses will be reduced, thereby resulting in the reduced production cost. The resulting dispatch will be more efficient and the total production cost will be reduced.

**12. Q: Why is there an over collection with the implementation of Marginal Losses?**

A: The implementation of Marginal Losses will include the loss penalty factor into the dispatch and pricing calculations. By including the penalty factor, losses will be paid on the margin instead of on the average. By paying for losses on the margin instead of on the average, an over collection occurs. For example, if there is energy flowing on a line because of only one party, the losses on the line may be 0.5%. If energy from another party is added to the line the losses may go up to 0.8%. If even more energy from another party is added to the line the losses may rise to 1.3%. If this process continues until all the energy from the various parties is flowing on the line, the losses may be at 4.5%. Because everyone will pay losses on the margin, they are all paying based on the 4.5% of losses instead of the average losses. Since the average losses will be less than the 4.5% Marginal Losses, an over collection occurs.

**13. Q: Why can't Marginal Losses be implemented without an over collection?**

A: The implementation of Marginal Losses will include the loss penalty factor into the dispatch and pricing calculations. By including the penalty factor, losses will be paid on the margin instead of on the average. It is impossible to include the effect of Marginal Losses and not create an over collection.

**14. Q: Does the over collection mean that some parties over pay for losses while some under pay?**

A: No. The over collection occurs because of paying losses on the margin instead of on the average. Using the example in Question #12, it is impossible to determine which party was “on the line first” and would therefore get the 0.5% charge. Everyone is charged equally based on the Marginal Losses and an over collection occurs. Therefore, it is not possible to determine if a certain party over pays or under pays for losses.



**15. Q: If the loss component is negative does the unit look more attractive to dispatch or less attractive?**

A: If the loss component is negative, an increase in generation results in an increase of losses on the system. Therefore, the unit will look less attractive to dispatch. If the loss component is positive, an increase in generation results in a decrease of system losses and the unit will look more attractive to dispatch.

**16. Q: Are the loss components the penalty factors or adders to the total price?**

A: The penalty factor is a measure of the change in system losses for a given increase in power injection at each location. The penalty factors are used in the pricing to take the marginal loss effect into consideration when calculating the prices. The marginal loss effect contained within the penalty factor is turned into a loss component that is then used as an adder or component of the total price. The total price includes three components; 1) the marginal cost of generation, 2) the transmission congestion cost and 3) the Marginal Losses.



**17. Q: PJM has stated that they will use a linear approximation to model the incremental losses. How will PJM model incremental losses and what is the linear approximation?**

A: The model of losses used is a linearized model based on the sensitivities of overall system network losses to location-specific changes in power injection/withdrawal. Using this linearized model, we can write the total network losses as

$$\begin{aligned}
 Loss(P_1, P_2, \dots, P_N) &= \left( \sum_i \frac{\partial Loss}{\partial P_i} \cdot P_i \right) + Offset \\
 &= \left( \sum_i \left( 1 - \frac{1}{Pf_i} \right) \cdot P_i \right) + Offset
 \end{aligned}$$

where

$Loss$  total system loss demand (in MW) as a function of location-specific injections and withdrawals

$P_i$  real power injection (+) or withdrawal (-) by resource  $i$  at its location in the network

$\frac{\partial Loss}{\partial P_i}$  rate of change in total losses for a change in the injection for a resource at location  $i$

$Pf_i$  Penalty Factor for resource  $i$ .  $Pf_i = \left( 1 - \frac{\partial Loss}{\partial P_i} \right)^{-1}$

$Offset$  is a constant term to account for errors in the linearization of losses as a function of net injections.

The linear approximation of losses as a function of net injections is made at a particular system state. The state of the power system includes an electrical network model, a topology, and a set of nodal injections and withdrawals.



**18. Q: Using the linear approximation for incremental losses, how will PJM calculate the marginal loss penalty factors?**

A: The calculation of the marginal loss penalty factors is accomplished utilizing the Newton-Raphson portion of the Optimal Power Flow function. The penalty factors are a function of the loss sensitivities calculated for the real-time state of the network. The loss sensitivities can be viewed as the change in MW at the reference bus due to a change in MW injection at a generator bus. Such sensitivity terms can be determined for all busses by solving the following equation using Gaussian Elimination:

$$[J^T] \begin{bmatrix} \frac{\partial P_{ref}}{\partial P_1} \\ \frac{\partial P_{ref}}{\partial P_{ref}} \\ \frac{\partial Q_1}{\partial P_{ref}} \\ \vdots \\ \frac{\partial P_{ref}}{\partial P_n} \\ \frac{\partial P_{ref}}{\partial P_{ref}} \\ \frac{\partial Q_n}{\partial P_{ref}} \end{bmatrix} = \begin{bmatrix} \frac{\partial P_{ref}}{\partial \theta_1} \\ \frac{\partial P_{ref}}{\partial V_1} \\ \vdots \\ \frac{\partial P_{ref}}{\partial \theta_n} \\ \frac{\partial P_{ref}}{\partial V_n} \end{bmatrix}$$

If a unit  $j$  is connected to bus  $i$  then unit  $j$ 's loss sensitivity is given by

$$\frac{\partial loss}{\partial Inj_j} = \frac{\partial P_{ref}}{\partial P_i}$$

and the corresponding loss penalty factor is

$$Pf_j = \frac{1}{1 - \frac{\partial loss}{\partial Inj_j}} = \frac{1}{1 - \frac{\partial P_{ref}}{\partial P_i}}$$



**19. Q: What is the pricing formulation that PJM plan to implement for Marginal Losses?**

A: Given the linear approximation of losses discussed in FAQ 21 and the calculation of the marginal loss penalty factors in FAQ 22, we can define the formulation for the calculation of LMP inclusive of losses as

Minimize

$$\sum_i C_i \Delta P_i$$

Subject to

$$\sum_{i=1}^n \Delta P_i - Loss = 0 \quad \text{(power balance)}$$

$$\sum_{i=1}^n A_{ij} (\Delta P_i - D_i^{Loss} \times Loss) \leq 0 \quad \text{(network constraints)}$$

$$\Delta P_i^{\min} \leq \Delta P_i \leq \Delta P_i^{\max} \quad \text{(resource limits)}$$

Where

- $C_i$  the calculated real-time price for resource  $i$ .
- $\Delta P_i$  the change in rate of energy injection (+) or energy consumption (-) in MW for resource  $i$ .
- $i$  an index over the set of flexible resources.
- $A_{ij}$  the sensitivities for resource  $i$  and active constraint  $j$  with respect to the reference.
- $P_i^{\min}$  the lower MW bound for resource  $i$ .
- $P_i^{\max}$  the upper MW bound for resource  $i$ .
- $D_i^{loss}$  normalized distribution of system losses to network location  $i$ .

**20. Q: Does PJM use a DC transmission model in the dispatch algorithm? If yes, that would indicate the reference bus in the DC model makes up for the total system loss, which will lead to a different load flow than the state estimator. How does PJM deal with inconsistent line flows between the DC model and the state estimator?**

A: PJM utilizes an incremental dispatch algorithm that begins with the full AC powerflow solution from the state estimator. Generation is dispatched to meet load plus losses and the error that would be introduced from using the reference bus to make up system losses is therefore not introduced.



**21. Q: How will new assets be incorporated into the model?**

A: New assets are included in the network model and since the incremental loss factors are calculated each 5-minute execution from the network model, their effect is automatically taken into consideration.

**22. Q: How will verbal dispatch instructions or off-cost dispatch affect the model?**

A: The UDS solution will consider marginal loss effects for economic dispatch, regardless of whether there are binding transmission constraints in the solution resulting in off-cost dispatch. Because consideration of marginal loss impacts will better represent the physical system and improve dispatch efficiencies, verbal dispatch instructions should be reduced.

**22. Q: Will Marginal Losses be applied to both Day-Ahead and Real-Time dispatch? How will this affect the allocation methodology? What happens when RT power flows are significantly different from a modeled Day-Ahead flow?**

A: Yes – Marginal Losses will be applied to both Day Ahead and Real Time dispatch and pricing. The effect is described in the formulations given in FAQ 19. The Day Ahead and Real Time calculations will look at the marginal loss effect independent of the other. Since balancing settlement is based upon deviations from Day Ahead scheduled quantities, Real Time prices account for the difference between Real Time and Day Ahead flows.

**23. Q: When will PJM begin posting of the LMP information with Marginal Losses included?**

A: Day-Ahead Market Trials where PJM will post Day-Ahead Market results with Marginal Losses included are scheduled to begin in late March or early April.

**24. Q: Will PJM publish Penalty Factors for all units in the RTO for a Reference Case?**

A: No, penalty factors can be calculated based on LMP prices that are posted.

**Load Carve-Out Process**

**25. Q: How and why will the Zonal EDC De-Ration Factors be applied?**

A: Implementation of Marginal Losses creates potential for double counting of losses because a) EDCs gross up the derived loads measured at individual retail meters to account for losses based on State-filed retail rates; and b) PJM Settlement calculations now account for losses using the marginal loss component of LMP. To address these issues, hourly EDC Loss De-ration Factors will be computed to de-rate the loss-loaded



schedules submitted in eSchedules by the amount of losses included in the marginal loss component of the LMP. Loads will be reduced based on a hourly EDC Loss De-ration Factor determined by state-estimated losses. The factor is then used to de-rate loss-loaded schedules as an alternative to re-filing state tariffs that include a loss loading factor.

**26. Q: How will Demand Side Response programs be affected?**

A: Gross-up factors for reductions under the PJM demand response programs will need to be adjusted by the same factor as load carve-outs.

**27. Q: Do the hourly Zonal EDC De Ration Factors change after the Load Reconciliation data is submitted?**

A: No. The Zonal EDC De Ration Factors are based on the MW quantity of losses on facilities in the PJM model as a percentage of the total revenue quality metered load in the zone. These values would not change based on the entities within the zone who actually wind up with the load responsibility.

**28. Q: What do we do if the de-rated load turns out to be less than the true metered load? I.e. if the EDC loss deration factor that we apply is greater than the original gross-up that the EDC applied.**

A: The de-ration factor will not change based on the results of the calculation. The Zonal EDC De Ration Factors is not capped based on the EDC gross-up quantity.

**29. Q: When will we begin posting of the Zonal EDC De Ration Factors prior to 6/1/07?**

A: The Zonal EDC De Ration Factors will be calculated on an hourly basis from the actual metered load for the zone and the state estimator losses for each hour. Therefore, it is not possible to post them ahead of time. However, zonal estimates of these quantities are posted on the Marginal Loss web site based on historical data.

The MSWG has requested sample data showing the EDC loss amounts from the SE and the resulting Zonal EDC De Ration Factors, and this will be provided at MSWG in the March/April timeframe.

**30. If there is a difference in load between the PJM calculated value and the EDC value submitted in eMTR, how is this handled?**

A: PJM will use the value submitted by the EDC through eMTR for the first Market Settlements.—PJM will use the eMTR calculated load for the EDC in the original energy market settlements. The EDC-submitted load value is only used for determining future peak load quantities for transmission planning, network service billing, and capacity obligations



## Market Settlements and Billing

### **31. Q: How will the Transmission Loss surplus be allocated?**

Implementation of Marginal Losses results in a surplus of loss charges collected. This surplus is allocated to Transmission Users based on load plus exports ratio shares.

$$\text{Loss Credit} = \text{Total Loss Surplus (\$)} * \frac{\text{Customer total MWh of energy delivered to load + exports}}{\text{Total PJM MWh of energy delivered to load + exports}}$$

### **32. Q: Will there be a separate line item in the invoice for Marginal Losses and the allocation of the surplus?**

A: Yes – there will be a separate line item in the invoice for Transmission Losses and the allocation of the over-collection.

### **33. Q: Is the Total Loss Surplus calculated hourly or monthly?**

A: The Total Loss Surplus is calculated hourly, and billed monthly.

### **34. When will the PJM Mid-Atlantic 500 kV losses be available to the EDCs?**

A: The 500 kV losses should be available to the EDCs through eMTR within several minutes of the eMTR deadline.

### **35. Why are only external tie meter errors allocated to all LSEs and not internal or generator meter errors?**

A: External tie meter errors impact the inadvertent interchange values. Inadvertent interchange will now be allocated to all LSEs, so it made sense to include external tie meter errors as they are related. Internal meter errors and generation meter errors will still be allocated to the EDCs. If the stakeholders desire the internal tie and generation meter errors be allocated directly to the LSEs, they should bring it up at the Market Settlement Working Group as a possible future enhancement. Note: This change is not related to Marginal Loss implementation.



## **PJM System & Application Changes**

### **36. Q: What changes are being made to eMKT for Marginal Losses.**

The marginal loss effect will now be included into the Day-Ahead formulation. In eMKT, components (Total LMP, Loss Price, and Congestion Price) of Day-Ahead LMPs will be posted in the reports. There will be modifications to XML queries to download all three LMP components.

**It is important to note, that although there will be no screen changes in eMKT, Demand Bids submitted by participants should NOT reflect losses.**

### **37. Will PJM be making dummy reports available through eSchedules for companies to test their revised XML capabilities prior to the Marginal Loss Implementation?**

A: This was not planned, but the MSWG will be addressing requests for specific sample reports for testing purposes at their upcoming meeting. Also, note that eSchedules does not have XML capability, so I assume that they are referring to CSV downloads via browserless interface.

### **38. Can PJM provide a chart showing when the timing of when the revised reports are available (monthly, daily, inter-month) and when the new data (i.e. EDC Loss Deration factor, Derated Load, etc) will be available?**

A: We will try to put something together for the upcoming MSWG meeting.

## **Miscellaneous**

### **39. Q: How will FTRs be adjusted if Marginal Losses are implemented in the middle of a planning year?**

A: FTR's will not be adjusted if Marginal Losses are implemented in the middle of a planning year. FTR settlements will be based on the congestion component of the LMP..

### **40. Q: To what extent will the implementation of Marginal Losses impact the FTR/ARR allocations? Will participants get fewer amounts of FTRs? Will it impact the Simultaneous Feasibility Test (SFT)?**



A: The implementation of Marginal Losses will not impact the FTR/ARR allocation or the SFT.

**41. Q: How will capacity obligations be affected?**

A: The calculation method for capacity obligations will not change as a result of marginal loss implementation.

**42. . Q: How will Marginal Losses be accounted for in the Regional Transmission Expansion Planning Process (RTEP)?**

A: The RTEP process looks at demand regardless of whether it is load or losses. Therefore, RTEP is currently accounting for losses and will do so in the future. The amount of losses they account for may reduce with the implementation of Marginal Losses due to the more efficient dispatch.

**43. Q: How will grandfathered transactions be affected?**

A: To the extent a Grandfathered contract is currently exempt from loss charges (i.e. – the 2.5 or 3% gross-up of the scheduled MW quantity), it will be exempt from loss LMP differences when PJM moves to marginal loss pricing.

**2005 LMP Simulation Results**

**44. Q: Can we see the results for West Hub?**

A: No. The MAPS MW application utilized to do the 2005 LMP simulations does not contain the PJM hub, aggregate, interface, etc. definitions.

**45. Q: What defines GPUE & GPUW? Specifically where is JCPL?**

JCPL is in GPUE. Penelec is in GPUW, and MetEd is split with the Eastern Division of MetEd in GPUE and the Lebanon division of MetEd in GPUW.

**46. Q: Can PJM consider doing a forward-looking simulation (ie Summer 07), since these results are somewhat stale?**

No. The simulation results would not change appreciably given the relatively consistent state of the network model over the last couple years. That is, there hasn't been the kind of backbone transmission upgrades that would significantly alter the results.

**47. Q: Does PJM have an estimate on the total loss MW reduction in the RTO at peak conditions (or average for the year) based on the ML implementation?**

A: No.



## **2007 Day-Ahead Market Trials for Marginal Losses**

**48. Q: How are the percentage factors for scaling down fixed demand bids being determined for the Day-Ahead Market Trials?**

A: The current demand bids in production have loss estimated in their values. For the Day-Ahead Market Trial, PJM has been using an estimated percentage to scale down fixed demand bids. The scaling factor is based on PJM's estimation of that day's day-ahead model. During the Market Trial the estimated scaling factor may vary from day to day.

**49. Q: In the Day-Ahead Market Trial solution, does total generation committed exceed total Day-Ahead Demand? Specifically, does Generation Committed equal Total DA Demand plus System Losses Implied by the System solution?**

A: Yes. Generation, Load, virtual bids and offers, transactions and loss will be automatically balanced in the algorithm

**50. Q: In the current DA Market solutions, does Generation exactly equal Day-Ahead Demand (since Day-Ahead Demand is the net of all demand in PJM)?**

A: Yes. Generation, Load, virtual bids, transactions will be always balanced. We are considering loss in the power balance. But, loss is estimated into the load bids now.

**51. Q: Will the Losses be calculated in order to carry out economic dispatch or will it be calculated post-dispatch?**

A: PJM will apply Marginal Loss in the process of commitment, dispatching and pricing. Real-time penalty factors are calculated based on the real-time SE solution. And Day-Ahead penalty factors are based on the Day-Ahead model.

**52. Q: Second, when understanding demand in the Day-ahead and in the Real-time, is a losses component already taken into account (as in an assumed 5% loss) or will the procedure be changed?**

A: PJM will be de-rating real-time load responsibilities hourly based on that hour's ratio of state-estimated transmission losses vs. the total zonal load. Your Day-Ahead demand bids should also exclude losses based on the load server's best guess at losses.

**53. Q: My understanding is that PJM is going to select certain Day-Ahead operations and re-run the Day-Ahead Market with marginal losses included and**



**post those results. My question is has this process begun? and if not when? and how will we be notified?**

A: Yes, PJM is going to re-rerun certain DA markets with marginal losses included in those results.

We will post notification to all market participants via eSuite messaging and eMKT and various PJM majordomos when we plan on generating and posting these results in the PJM sandbox environment.