

EDAC Market Rules True Up Locational Marginal Price Calculation



- The LMP formulation has been revised in MR-382
- Previous formulation that was approved as part of (MR-00348-R06) mimics the LMP formulation used by the Dispatch Scheduling Optimization (DSO) engine
- The revision addresses the differences between how the Day-Ahead Calculation Engine (DACE) reaches its solution (different application of loss penalty factor)
- Both the DSO and DACE solve two equations
 - Load Balance Equation \rightarrow Generation = Demand equation.
 - Objective Functions \rightarrow Total cost for supplying energy and reserve plus any violation costs. Each engine tries to minimize this while satisfying the load balance equation.

System	Simplified Power Balance	Simplified Objective Function
DSO	$\sum \text{Schedule} = \text{Demand}$	Minimize ($\sum \text{Schedule} * \text{Cost} * \text{PF}^1$)
DACE	$\sum \text{Schedule}/\text{PF}^1 = \text{Demand}$	Minimize ($\sum \text{Schedule} * \text{Cost}$)

¹where PF is the static loss penalty factor

- When a constraint occurs, its incremental cost is assessed based on its impact to the objective function
 - DSO = 1MW * \$ * PF
 - DACE = 1MW * \$
- When the constraint cost is factored into LMP for the DSO the value needs to be divided by PF to get rid of the scaling that takes place in the objective function

- However since the day-ahead engine does not need to account for scaling within the objective function, the LMP formulation should omit division by PF of the constraint cost
- Both methods will result in the same LMP for the same condition.

System	LMP Formulation	LMP with Constraint Cost
DSO	$\lambda/PF +$ Constraint Cost * Sensitivity / PF	$\lambda/PF +$ 1MW * \$ * PF * Sensitivity / PF
DACE	$\lambda/PF +$ Constraint Cost * Sensitivity	$\lambda/PF +$ 1MW * \$ * Sensitivity

Day Ahead Calculation Engine use of Penalty Factors

Technical Panel Presentation
August 23, 2011



- Q.) Does applying penalty factors in a different fashion between the DSO and the DACE differ the energy dispatch result.
- A.) The economic sequence of dispatch is the same for both engines since the incremental cost of satisfying the next MW with either engine is the same and is equal to:

Incremental Price: Offer Price X Penalty Factor

Energy Dispatch (Example)

	Power Balance ¹	Objective Function
DSO	$\sum \text{Schedule} = \text{Demand}$	Minimize ($\sum \text{Schedule} * \text{Offer} * \text{PF}$)
DACE	$\sum \text{Schedule}/\text{PF} = \text{Demand} + \text{LREF}$	Minimize ($\sum \text{Schedule} * \text{Offer}$)

¹Unlike the DSO engine which solves the power balance using demand, the DACE solves the power balance for the non-dispatchable portion of the forecasted demand.

- Example will demonstrate a simple scenario for each engine where it steps through to determine a solution for a demand requirement of 1MW.

GEN A

Penalty Factor = 2.3
Offer Price = \$10/MW

GEN B

Penalty Factor = 1.1
Offer Price = \$20/MW

DSO Energy Dispatch Example

	Power Balance	Objective Function
DSO	$\sum \text{Schedule} = 1\text{MW}$	Minimize ($\sum \text{Schedule} * \text{Offer} * \text{PF}$)

- In order to satisfy the power balance equation either resource can be scheduled to 1MW.
- In order to minimize the objective function the engine analyzes the impact of dispatching either resource by 1MW:
 - Gen A Cost = $1\text{MW} * \$10 * 2.3 = \23.00
 - Gen B Cost = $1\text{MW} * \$20 * 1.1 = \22.00
- Since the impact of dispatching Gen A would be more costly, the DSO will choose to dispatch Gen B.

GEN A

Penalty Factor = 2.3
Offer Price = \$10/MW

GEN B

Penalty Factor = 1.1
Offer Price = \$20/MW

DACE Energy Dispatch Example

	Power Balance	Objective Function
DACE	$\sum \text{Schedule}/\text{PF} = 0.909\text{MW}$	Minimize ($\sum \text{Schedule} * \text{Offer}$)

- Based on the previous example, we can determine the non-dispatchable portion of the 1MW demand to be 0.909MW.
- In order to satisfy the power balance, the engine recognizes that each resource schedule will have to vary to account for their respective PF:
 - Gen A Schedule = $0.909\text{MW} * \text{PF} = 0.909\text{MW} * 2.3 = 2.09\text{MW}$
 - Gen B Schedule = $0.909\text{MW} * \text{PF} = 0.909\text{MW} * 1.1 = 1.0\text{MW}$
- In order to minimize the objective function the engine analyzes the impact of dispatching either resource to its scheduled amount:
 - Gen A Cost = $2.09\text{MW} * \$10 = \20.90
 - Gen B Cost = $1.0\text{MW} * \$20 = \20.00
- If we were to normalize the calculated cost (by dividing by 0.909) to get to a per MW cost, we would get the same results as the DSO (\$23 and \$22 respectively)
- Since the impact of dispatching Gen A would be more costly the DACE will choose to dispatch Gen B.

Given the example which demonstrated the two different methods of applying penalty factors, since either approach yielded an equivalent normalized cost we can conclude that the incremental cost in response to a 1MW change will be the same with either approach:

	DSO	DACE
Gen A	\$23.00/MW	\$23.00/MW
Gen B	\$22.00/MW	\$22.00/MW

- As a result, with either engine, the economic sequence of dispatch is the same.
- The sequence and quantity of dispatch with either engine will be determined for each lamination according to its incremental cost which can be summarized to be:

$$\text{Offer Price} \times \text{Penalty Factor}$$

- The operating reserve balancing equations and operating reserve cost contributions to the objective function do not differ between the DSO and DACE.
- The simultaneous co-optimization of energy and reserve will not differ with either engine.
 - The decision to schedule energy or operating reserve will be based on the economic savings of scheduling once versus the other.

- Given that there is a discrepancy due to Loss Reference between DSO and DACE, a marginal resource can expect a different schedule.
 - The difference is not due to difference in economics, but the difference in total amount of generation scheduled to satisfy the same demand.
 - DACE accounts for re-dispatch of resources with varying penalty factors.
 - DSI does not account for re-dispatch of resources with varying penalty factors.
 - Re-dispatch of lower penalty factors lowers demand and re-dispatch of higher penalty factors increases demand.
- Introduce a loss reference to the DSO in late October/early November through a patch to the system