Technical Bulletin

2009-05-02

SDG&E Constrained 5-minute Default LAP Price on 4/19/09

May 20, 2009

Technical Bulletin
2009-05-02

SDG&E Constrained 5-minute Default LAP Price on 4/19/09

Background

This analysis evaluates the price setting for one 5-minute real-time dispatch (RTD) interval, HE 16 Interval 1 (15:00 – 15:05) for Trade Date 4/19/09, where the SDG&E Default LAP LMP was $3984. In this interval, there was only one binding transmission constraint, the SDGE Import branch group, and resources within SDG&E service area were not able to provide additional energy, within 5 minutes, to relieve the constraint. This analysis:

- Identifies the marginal resources that set the LMPs;
- Demonstrates how those resources contributed to the system marginal energy component; and
- Shows how those resources contributed to the shadow price on the binding SDGE Import branch group constraint.

In addition to the price construction, this analysis also illustrates how two resources external to the SDG&E service area can be dispatched by the market optimization to leverage the difference in their loss factors to meet additional load within the SDG&E service area while maintaining the flow limit on the SDGE Import branch group.

Scenario Overview

- Scheduling Run: For the first interval of RTD for HE 16 of Trade Date 4/19/2009 (15:00 – 15:05), the scheduling run solution shows a flowgate constraint on the SDGEIMP_BG was violated by 8 MW (or, an 8 MW relaxation of the constraint was required in the scheduling run). The shadow price on this constraint in the scheduling run was at the penalty price of $5,000/MWh.
- Pricing Run: The shadow price on the SDGE Import limit was $3,928/MWh. There were no other binding flowgate constraints in this interval. The system marginal energy component was $429/MWh. PNode LMPs in San Diego area were all above $3,000/MWh and the SDG&E Default LAP LMP was $3,984[1].

[1] A price cap of $2,500 was ultimately applied to final prices.

- SDG&E and the rest of the ISO can be viewed as radially connected to each other by the SDGEIMP_BG branch group. This means that all resources outside of the SDG&E area will have the same shift factor on the SDGEIMP_BG.
- The supplies within the SDG&E area have been exhausted, and that is why the SDGEIMP_BG constraint is relaxed in the scheduling run.

Data Details

The table below lists the potential marginal resources that could have contributed to the system marginal energy component and shadow price on the SDGE Import constraint. This set of resources was identified by selecting resources with a change in dispatch between the scheduling and pricing runs for that interval. All of these resources are located outside the SDG&E service area and all have the same shift factor (0.094) on the SDGEIMP_BG.

Potentially Marginal Resources

RESOURCE	Scheduling Run MW	Pricing Run MW	MW Diff (Pricing - Scheduling)	Marginal (Pricing)	Loss Penalty Factor	Shift Factor	Bid Price
UNIT_A	361.00	372.52	11.52	N	1.129	0.094	$0
UNIT_B	62	60	-2	N	1.0672	0.094	$15, $33
UNIT_C	61.1	60	-1.1	N	1.0672	0.094	$15, $33
UNIT_D	5	5.87	0.87	Y	1.1942	0.094	-$10
UNIT_E	45	36.86	-8.14	Y	1.0244	0.094	$49.5

In a case where the inter-temporal ramping constraints are not binding for the marginal resources, each marginal resource will have a PNode LMP equal to its highest awarded bid. This is true for UNIT_D and UNIT_E. In addition, because there is one transmission constraint binding, we should expect two marginal resources, one which is INC'd and one which is DEC'd to provide a change in flow across the binding constraint while maintaining system energy balance. All these facts suggest it is very likely that UNIT_D and UNIT_E would be the marginal resources for this interval. The following analysis will confirm that this hypothesis is indeed correct.

Impact of Resource Adjustments on Constraint Flow and Prices

In the equations of this section, for notational convenience, UNIT_D and UNIT_E will denote the MW quantities of UNIT_D and UNIT_E, respectively. The impact of adjustments to the output of these resources on the flow on the congested constraint and ultimately on prices can be derived from the resources' loss penalty factors and shift factors. The change in the power balance and the change in branch group flow that would result from changes in the output of these two resources are given by the following equations:

$$\Delta UNIT\_D/1.1942 + \Delta UNIT\_E/1.0244 = Change\, in\, Power\, Balance$$
$$0.094 \cdot \Delta UNIT\_D + 0.094 \cdot \Delta UNIT\_E = Change\, in\, Branch\, Group\, Flow$$

The matrix of the left hand side of this 2x2 system of linear equations is $\begin{bmatrix} 1/1.1942 & 1/1.0244 \\ 0.094 & 0.094 \end{bmatrix}$. The inverse of this matrix is $\begin{bmatrix} -7.20 & 74.82 \\ 7.20 & -64.18 \end{bmatrix}$ and has very interesting interpretation. The first column gives the required change of the two resources UNIT_D and UNIT_E to produce one MW increase of the power balance while the branch group flow remains fixed. In other words, UNIT_D needs to decrease its output by 7.20 MW and UNIT_E needs to increase its output by 7.20 MW simultaneously to meet one extra MW load at the distributed load slack bus. Note that in this instance, the difference in the loss penalty factors of the two resources provides the additional one MW used to meet the additional load. The second column of the matrix gives the MW change in the output of the two resources in response to one MW increase in the branch group flow limit, keeping the power balance fixed and using the same distributed load slack. If the flow limit is increased by 1 MW, then one MW less congestion relief is needed, so UNIT_D needs to increase output by 74.82 MW while UNIT_E needs to decrease output by 64.18 MW simultaneously.

Taking the inner product between the row vector formed by the bid prices of these two resources, namely [–10, 49.5] and the first column of the inverse matrix, we obtain the change in the cost objective per MW increase of the power balance, or $429/MWh. By definition, this should equal the LMP at the distributed slack bus, which is also equal to the system marginal energy component due to the use of the distributed load slack bus. Note that this number agrees exactly with the system-wide LMP energy component of the pricing run solution.

Taking the inner product between the bid price row vector and the second column of the inverse matrix, we obtain the change in cost objective per MW increase of the branch group flow or –$3,925/MWh. By definition, this should equal the absolute value of the shadow price of the flowgate constraint. This number agrees with the $3,928/MWh shadow price of SDGEIMP_BG from the pricing run solution, with very small rounding error.

Thus we have demonstrated that UNIT_D and UNIT_E bids did determine the system marginal energy component and the shadow price of SDGEIMP_BG. The system marginal energy component and the shadow price of SDGEIMP_BG are then used to calculate all LMPs in the system. For example, SDGE DLAP LMP energy component and congestion component are calculated as follows:

SDGE energy component = system marginal energy component = $429/MWh
SDGE congestion component = – shift_factor * SDGEIMP_BG shadow price =
– (–0.906) * (3925) = $3556/MWh
The value (-0.906) is the shift factor of resources located within the SDG&E service area on the SDGEIMP_BG constraint.

These values are also consistent with the pricing run solution.

In summary, UNIT_D and UNIT_E are the two marginal resources that set the system marginal energy component and the shadow price of SDGEIMP_BG for trade day 4/19/2009 HE16 RTD Interval (15:00 – 15:05), which are used in turn to calculate all the RTD LMPs.