



Supplementary Material

Lost Opportunity Cost (LOC) and Forbidden Regions New Equations and Example Calculations

Item 1: Example Calculations

- To simplify, assume DAM_QSI = 0 MW, RT_QSI = AQEI
- FR_LL = 0 MW, FR_UL = 100 MW

$$\begin{aligned} FR_MAX_QTY_AVAIL &= \text{Max}[0, \text{Max}(DAM_QSI, \text{Min}(RT_QSI, AQEI)) - \\ &\quad \text{Max}(FR_LL, DAM_QSI, RT_LC_EOP)] \\ &= \text{Max}[0, \text{Max}(0, \text{Min}(100, 100)) - \text{Max}(0, 0, 5)] \\ &= \text{Max}[0, 100 - 5] \\ &= 95 \text{ MW} \end{aligned}$$

The equations in this example are simplified. The detailed equations are in the red-line Market Rules.

Forbidden
Region

0 to 100 MW

	Energy
Schedule	100
LC EOP (MW)	5

	10S	10N	30R
Schedule (MW)	10	0	15
LOC EOP (MW)	95	0	25
Price (\$/MWh)	15.00	10.00	9.00
Offer Price (\$/MWh)	4.00	3.50	2.00
Offer Qty (MW)	95	25	25

Item 1: Example Calculations 10S

$$FR_QTY_AVAIL_{10S} = FR_MAX_QTY_AVAIL = 95 \text{ MW}$$

$$\begin{aligned} QTY_DIFF_{10S} &= RT_OR_LOC_EOP_{10S} - RT_QSOR_{10S} \\ &= 95 \text{ MW} - 10 \text{ MW} \\ &= 85 \text{ MW} \end{aligned}$$

$$\begin{aligned} QTY_ADJ_{10S} &= \text{Max}(0, QTY_DIFF_{10S} - FR_QTY_AVAIL_{10S}) \\ &= \text{Max}(0, 85 - 95) \\ &= \text{Max}(0, -10) \\ &= 0 \text{ MW} \end{aligned}$$

Item 1: Example Calculations 10S - Continued

$$\begin{aligned} RT_OR_FROP_LOC_{10S} &= [Max(0, OP(RT_PROR_{10S}, RT_OR_LOC_EOP_{10S} - QTY_ADJ_{10S}, BOR_{10S})) \\ &\quad - Max(0, OP(RT_PROR_{10S}, RT_QSOR_{10S}, BOR_{10S}))] \\ &= [Max(0, OP(RT_PROR_{10S}, 95 - 0, BOR_{10S})) - Max(0, OP(RT_PROR_{10S}, 10, BOR_{10S}))] \\ &= [Max(0, OP(RT_PROR_{10S}, 95, BOR_{10S})) - Max(0, OP(RT_PROR_{10S}, 10, BOR_{10S}))] \\ &= Max(0, 95 MW * (\$15/MWh - \$4/MWh)) - Max(0, 10 MW * (\$15/MWh - \$4/MWh)) \\ &= Max(0, 95 MW * \$11/MWh) - Max(0, 10 MW * \$11/MWh) \\ &= Max(0, \$1,045) - Max(\$0, \$110) \\ &= \$935 \end{aligned}$$

$$\begin{aligned} RT_OLOC_{10S} &= [Max(0, OP(RT_PROR_{10S}, RT_OR_LOC_EOP_{10S}, BOR_{10S})) - \\ &\quad Max[0, OP(RT_PROR_{10S}, RT_QSOR_{10S}, BOR_{10S})] - RT_OR_FROP_LOC_{10S}] / 12 \\ &= [Max(0, OP(RT_PROR_{10S}, 95, BOR_{10S})) - Max[0, OP(RT_PROR_{10S}, 10, BOR_{10S})] - \$935] / 12 \\ &= [Max(0, 95 MW * (\$15/MWh - \$4/MWh)) - Max(0, 10 MW * (\$15/MWh - \$4/MWh)) - \$935] / 12 \\ &= [Max(0, \$1,045) - Max(\$0, \$110) - \$935] / 12 \\ &= [\$1,045 - \$110 - \$935] / 12 \\ &= \$0 \end{aligned}$$

The RT_OLOC formula on this and the following slides includes the change proposed for Item 3.

Item 1: Example Calculations 10N

$$\begin{aligned}FR_QTY_AVAIL_{10N} &= FR_QTY_AVAIL_{10S} - (RT_OR_LOC_EOP_{10S} - QTY_ADJ_{10S} \\ &\quad - RT_QSOR_{10S}) \\ &= 95 - (95 - 0 - 10) \\ &= 10 \text{ MW}\end{aligned}$$

$$\begin{aligned}QTY_DIFF_{10N} &= RT_OR_LOC_EOP_{10N} - RT_QSOR_{10N} \\ &= 0 \text{ MW} - 0 \text{ MW} \\ &= 0 \text{ MW}\end{aligned}$$

$$\begin{aligned}QTY_ADJ_{10N} &= \text{Max}(0, QTY_DIFF_{10N} - FR_QTY_AVAIL_{10N}) \\ &= \text{Max}(0, 0 - 10) \\ &= 0 \text{ MW}\end{aligned}$$

Item 1: Example Calculations 10N - Continued

$$\begin{aligned}
 RT_OR_FROP_LOC_{10N} &= [\text{Max}(0, OP(RT_PROR_{10N}, RT_OR_LOC_EOP_{10N} - QTY_ADJ_{10N}, BOR_{10N})) \\
 &\quad - \text{Max}(0, OP(RT_PROR_{10N}, RT_QSOR_{10N}, BOR_{10N}))] \\
 &= [\text{Max}(0, OP(RT_PROR_{10N}, 0 - 0, BOR_{10N})) - \text{Max}(0, OP(RT_PROR_{10N}, 0, BOR_{10N}))] \\
 &= [\text{Max}(0, OP(RT_PROR_{10N}, 0, BOR_{10N})) - \text{Max}(0, OP(RT_PROR_{10N}, 0, BOR_{10N}))] \\
 &= \text{Max}(0, 0 \text{ MW} * (\$10/\text{MWh} - \$3.50/\text{MWh})) - \text{Max}(0, 0 \text{ MW} * (\$10/\text{MWh} - \$3.50/\text{MWh})) \\
 &= \text{Max}(\$0, \$0) - \text{Max}(\$0, \$0) \\
 &= \$0
 \end{aligned}$$

$$\begin{aligned}
 RT_OLOC_{10N} &= [\text{Max}(0, OP(RT_PROR_{10N}, RT_OR_LOC_EOP_{10N}, BOR_{10N})) - \\
 &\quad \text{Max}[0, OP(RT_PROR_{10N}, RT_QSOR_{10N}, BOR_{10N})] - RT_OR_FROP_LOC_{10N}] / 12 \\
 &= [\text{Max}(0, OP(RT_PROR_{10N}, 0, BOR_{10N})) - \text{Max}[0, OP(RT_PROR_{10N}, 0, BOR_{10N})] - \$0] / 12 \\
 &= [\text{Max}(0, 0 \text{ MW} * (\$10/\text{MWh} - \$3.5/\text{MWh})) - \text{Max}(0, 0 \text{ MW} * (\$10/\text{MWh} - \$3.5/\text{MWh})) - \$0] / 12 \\
 &= [\$0 - \$0 - \$0] / 12 \\
 &= \$0
 \end{aligned}$$

Item 1: Example Calculations 30R

$$\begin{aligned} FR_QTY_AVAIL_{30R} &= FR_QTY_AVAIL_{10N} - (RT_OR_LOC_EOP_{10N} - QTY_ADJ_{10N} \\ &\quad - RT_QSOR_{10N}) \\ &= 10 - (0 - 0 - 0) \\ &= 10 \text{ MW} \end{aligned}$$

$$\begin{aligned} QTY_DIFF_{30R} &= RT_OR_LOC_EOP_{30R} - RT_QSOR_{30R} \\ &= 25 \text{ MW} - 15 \text{ MW} \\ &= 10 \text{ MW} \end{aligned}$$

$$\begin{aligned} QTY_ADJ_{30R} &= \text{Max}(0, QTY_DIFF_{30R} - FR_QTY_AVAIL_{30R}) \\ &= \text{Max}(0, 10 - 10) \\ &= 0 \text{ MW} \end{aligned}$$

Item 1: Example Calculations 30R - Continued

$$\begin{aligned}
 RT_OR_FROP_LOC_{30R} &= [\text{Max}(0, OP(RT_PROR_{30R}, RT_OR_LOC_EOP_{30R} - QT_ADJ_{30R}, BOR_{30R,k,h})) \\
 &\quad - \text{Max}(0, OP(RT_PROR_{30R,h}, RT_QSOR_{30R}, BOR_{30R}))] \\
 &= [\text{Max}(0, OP(RT_PROR_{30R}, 25 - 0, BOR_{30R})) - \text{Max}(0, OP(RT_PROR_{30R}, 15, BOR_{30R}))] \\
 &= [\text{Max}(0, OP(RT_PROR_{10R}, 25, BOR_{30R})) - \text{Max}(0, OP(RT_PROR_{30R,h}, 15, BOR_{30R}))] \\
 &= \text{Max}(0, 25 \text{ MW} * (\$9/\text{MWh} - \$2/\text{MWh})) - \text{Max}(0, 15 \text{ MW} * (\$9/\text{MWh} - \$2/\text{MWh})) \\
 &= \text{Max}(0, 25 \text{ MW} * \$7/\text{MWh}) - \text{Max}(\$0, 15 \text{ MW} * \$7/\text{MWh}) \\
 &= \text{Max}(\$0, \$175) - \text{Max}(\$0, \$105) \\
 &= \$70
 \end{aligned}$$

$$\begin{aligned}
 RT_OLOC_{30R} &= [\text{Max}(0, OP(RT_PROR_{30R}, RT_OR_LOC_EOP_{30R}, BOR_{30R})) - \\
 &\quad \text{Max}[0, OP(RT_PROR_{30R}, RT_QSOR_{30R}, BOR_{30R})] - RT_OR_FROP_LOC_{30R}] / 12 \\
 &= [\text{Max}(0, OP(RT_PROR_{30R}, 25, BOR_{30R})) - \text{Max}[0, OP(RT_PROR_{30R}, 15, BOR_{30R})] - \$70] / 12 \\
 &= [\text{Max}(0, 25 \text{ MW} * (\$9/\text{MWh} - \$2/\text{MWh})) - \text{Max}(0, 15 \text{ MW} * (\$9/\text{MWh} - \$2/\text{MWh})) - \$70] / 12 \\
 &= [\text{Max}(\$0, \$175) - \text{Max}(\$0, \$105) - \$70] / 12 \\
 &= [\$175 - \$105 - \$70] / 12 \\
 &= \$0
 \end{aligned}$$