



MISO Adjusted Production Cost Calculation White Paper

Revision History

2018-09-27: RRF ownership modifications

2018-12-19: 80% LSE Return Rate update on Withinpool purchases

2019-02-01: Added definitions for company load weighted LMP, company gen weighted LMP and pool gen weighted LMP

2021-04-22: Updated Withinpool purchaser cost calculation to improve stability in extreme pricing scenarios and updated naming/formatting throughout document for improved readability

Overview

Adjusted Production Cost (APC) savings is one of the metrics used by MISO to measure the economic benefits of potential transmission upgrade options. APC savings shall be calculated as the difference in total production costs of a generation fleet adjusted for import costs and export revenues with and without the proposed transmission upgrade as part of the transmission system. PROMOD IV®, an hourly chronological security constrained unit commitment and dispatch model, is utilized as the primary tool to evaluate economic benefits of proposed transmission upgrades.

Hourly Adjusted Production Cost Calculation

Adjusted Production Cost (APC) is the total production costs of a generation fleet including fuel, variable operations and maintenance (O&M), startup cost, and emissions, adjusted for import costs and export revenues. APC is calculated on an hourly basis for each company, as described below:

Hourly Company Adjusted Production Cost

$$\begin{aligned} &= \text{Company Production Cost [1]} + \text{Company Fixed Trans Cost[2]} \\ &+ \text{Company Emergency Energy Cost[3]} + \text{Company Interpool Transaction Cost[4]} \\ &+ \text{Company Withinpool Transaction Cost[5]} \end{aligned}$$

The following summarizes the detailed calculation for each component of the company level APC. There are two levels of economic transactions in a PROMOD simulation with multiple pool structures, “Withinpool” transaction between companies within the same pool, and “Interpool” transactions between pairs of pools.



[1] Company Production Cost

- Production cost represents the final cost of operating the entity’s thermal fleet, including fuel costs, start-up costs, emission costs and variable O&M costs. The hourly company production cost is obtained from PROMOD output “.UNT” file.

[2] Company Fixed Transaction Cost

Fixed transactions captures the production costs of generators without fuel, such as wind, solar, biomass, etc. Multiparty transactions and External Transactions are not counted as fixed transactions. The hourly company fixed transaction values are obtained from PROMOD output “.ACT” file.

[3] Company Emergency Energy Cost

- Emergency energy is priced at \$1000/MWh. The hourly emergency energy values are obtained from the PROMOD output “.CON” file.

[4] Company Interpool Transaction Cost

- Interpool transaction costs represent a company’s purchases and sales with other pools. Both interpool purchases and sales are priced at pool level generation weighted LMP. Hourly company inter-pool economic transactions are obtained from the PROMOD output “.TRN” file. If the company is selling then interpool transaction cost is negative, and if the company is purchasing then interpool transaction cost is positive.
 - “Company Interpool Transaction Cost” is calculated as follows:
 - **Company Interpool Transaction Cost (\$)**
= Hourly pool gen weighted LMP × Hourly Company Interpool Transaction
 - “Pool Gen Weighted LMP” is calculated as follows:
 - **Pool Gen Weighted LMP** $(\frac{\$}{\text{MWh}}) = \frac{\text{Pool Generation Revenue}}{\text{Pool Total Generation}}$
 - Pool generation revenue and total generation accounts for all thermal, hydro, fixed transactions (all transactions other than aluminum loads, multiparty transactions and external transactions) and pumped hydro generation owned by companies within the pool.

[5] Company Withinpool Transaction Cost

- Withinpool transaction costs represent a company’s purchases and sales with other companies in the same pool. The energy sold is priced at the “Company Gen Weighted LMP” whereas; the energy purchased is priced proportionally to the “Company Load Weighted LMP” and adjusted by the Load Serving Entity (LSE) Return Rate.
 - LSE Return Rate is defined as the percentage of congestion dollars collected during market settlement that are ultimately returned to LSEs through FTR payments.
 - “Company Load Weighted LMP” is calculated as follows:
 - **Company Load Weighted LMP** $(\frac{\$}{\text{MWh}}) = \frac{(\text{Company Load} \times \text{Load Hub LMP}) + \text{Company Aluminum Load Cost} + \text{Company Pump Cost}}{\text{Company Load} + \text{Company Aluminum Load} + \text{Company Pump Load}}$



- Load Hub LMP is obtained from PROMOD output “.BUS” file.
 - “Company Gen Weighted LMP” is calculated as follows:
 - **Company Gen Weighted LMP** ($\frac{\$}{\text{MWh}}$) = $\frac{\text{Company Generation Revenue}}{\text{Company Total Generation}}$
 - Company generation revenue and total generation accounts for all thermal, hydro, fixed transactions (all transactions other than aluminum loads, multiparty transactions and external transactions) and pumped hydro generation owned by company. The information is obtained from the “.UNT” and “.TRN” files of the PROMOD output.
- Sales from utility-scale MISO forecasted renewable resources will not be included in the physical host company’s withinpool transaction but will remain in the sum of MISO pool sales.
- Hourly company Withinpool energy purchases and sales are calculated as follows:
 - Company Withinpool Transaction (MWh)** = Company Load – Unit Generation – Fixed Transaction – Emergency Energy – Interpool Transaction – External Transaction* + Dump Energy + Pumping Energy
 - *External transactions are modeled to capture the influence of the external regions (out of study regions) to the study footprint in a PROMOD model.
- Hourly company Withinpool energy purchase costs and sale revenues are calculated as follows:
 - If the company is a net seller (Company Withinpool Transaction < 0):
 - **Company Withinpool Transaction Cost (\$)**
= Company Gen Weighted LMP × Company Withinpool Transaction
 - If the company is a net purchaser (Company Withinpool Transaction > 0):
 - **Company Withinpool Load Cost (\$)** (intermediate value)
= Company Load Weighted LMP × Company Withinpool Transaction
 - **Pool Withinpool Gen Revenue (\$)**

$$= \sum_{\substack{\text{WithinPool} \\ \text{seller} \\ \text{companies in pool}}} \text{Company Withinpool Transaction} \times \text{Company Gen Weighted LMP}$$

- **Pool Withinpool Load Cost (\$)**

$$= \sum_{\substack{\text{WithinPool} \\ \text{purchaser} \\ \text{companies in pool}}} \text{Company Withinpool Transaction} \times \text{Company Load Weighted LMP}$$

- **Relative Company Withinpool Load Cost (\$)**
 - If any Withinpool purchaser company in the given pool has a Withinpool Load Cost less than \$0, add negative two times the lowest Withinpool purchaser cost in that pool to every company’s Withinpool Load Cost to get the Relative Company Withinpool Load Cost – this ensures that the calculation of Company Withinpool Congestion Return remains stable when load costs go negative.



- If all Withinpool purchaser companies in the given pool have Withinpool Load Costs greater than \$0, then every company in the pool has a Relative Company Withinpool Load Cost equal to its Company Withinpool Load Cost.

- **Relative Pool Withinpool Load Cost (\$)**

$$= \sum_{\substack{\text{WithinPool} \\ \text{purchaser} \\ \text{companies in pool}}} \text{Relative Company Withinpool Load Cost}$$

- **LSE Return Rate (%)**

$$= 80\%, \text{ based on historic FTR market outcomes}$$

- **Pool Returned Withinpool Imbalance (\$)**

$$= (\text{Pool Withinpool Load Cost} - \text{Pool Withinpool Gen Revenue}) * \text{LSE Return Rate}$$

- **Company Withinpool Congestion Return (\$)**

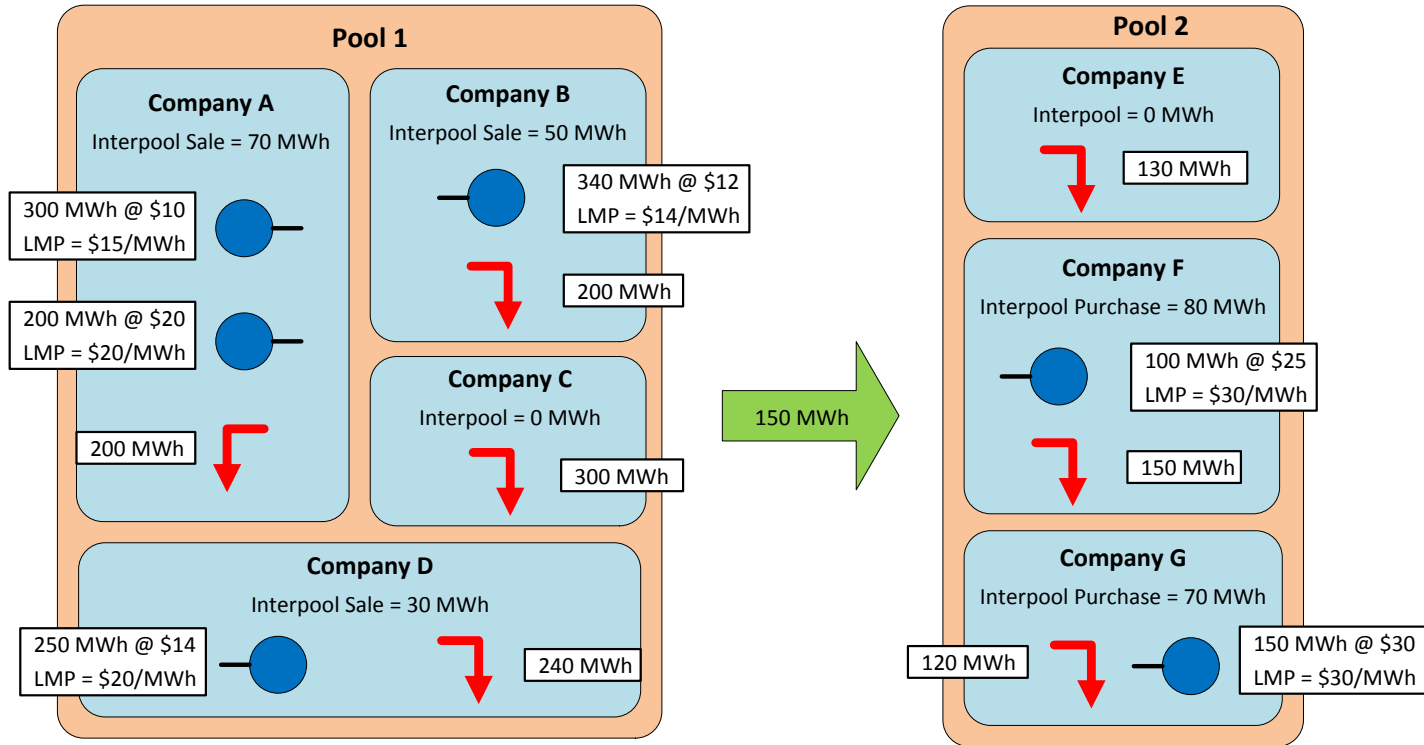
$$= \text{Pool Returned Withinpool Imbalance} * \left(\frac{\text{Relative Company Withinpool Load Cost}}{\text{Relative Pool Withinpool Load Cost}} \right)$$

- **Company Withinpool Transaction Cost (\$)** (final value)

$$= \text{Company Withinpool Load Cost} - \text{Company Withinpool Congestion Return}$$

Example

- In this example Dump Energy, Emergency Energy and Pumping Energy are all considered to be zero.
- Assume Company C and Company D have load weighted LMP of \$25/MWh.
- Assume Company E has load weighted LMP of \$35/MWh.



- Pool 1

Pool Gen Weighted LMP

$$= \frac{300MWh * GLMP_A + 200MWh * GLMP_A + 340MWh * GLMP_B + 250MWh * GLMP_D}{300MWh + 200MWh + 340MWh + 250MWh}$$

$$= \frac{\$16.75}{MWh}$$

$$Pool\ Withinpool\ Gen\ Revenue = 230MWh * \frac{\$17}{MWh} + 90MWh * \frac{\$14}{MWh} = \$5170$$

$$Pool\ Withinpool\ Load\ Cost = 300MWh * \frac{\$25}{MWh} + 20MWh * \frac{\$25}{MWh} = \$8000$$

$$Pool\ Returned\ Withinpool\ Imbalance = (\$8000 - \$5170) * 80\% = \$2264$$

- Company A

$$Company\ Withinpool\ Transaction = 200MWh - 300MWh - 200MWh + 70MWh = -230MWh$$

$$Company\ Gen\ Weighted\ GLMP_A = \frac{300MWh * \frac{\$15}{MWh} + 200MWh * \frac{\$20}{MWh}}{300MWh + 200MWh} = \frac{\$17}{MWh}$$

$$Company\ Production\ Cost = 300MWh * \frac{\$10}{MWh} + 200MWh * \frac{\$20}{MWh} = \$7000$$



$$\text{Company Interpool Transaction Cost} = -70\text{MWh} * \frac{\$16.75}{\text{MWh}} = -\$1172.50$$

$$\text{Company Withinpool Transaction Cost} = -230\text{MWh} * \frac{\$17}{\text{MWh}} = -\$3910$$

$$\text{APC} = \$7000 - \$1172.50 - \$3910 = \$1917.50$$

- Company B

$$\text{Company Withinpool Transaction} = 200\text{MWh} - 340\text{MWh} + 50\text{MWh} = -90\text{MWh}$$

$$\text{Company Gen Weighted GLMP}_B = \frac{\$14}{\text{MWh}}$$

$$\text{Company Production Cost} = 340\text{MWh} * \frac{\$12}{\text{MWh}} = \$4080$$

$$\text{Company Interpool Transaction Cost} = -50\text{MWh} * \frac{\$16.75}{\text{MWh}} = -\$837.50$$

$$\text{Company Withinpool Transaction Cost} = -90\text{MWh} * \frac{\$14}{\text{MWh}} = -\$1260$$

$$\text{APC} = \$4080 - \$837.50 - \$1260 = \$1982.50$$

- Company C

$$\text{Company Withinpool Transaction} = 300\text{MWh}$$

$$\text{Company Load Weighted LMP}_C = \frac{\$25}{\text{MWh}}$$

$$\text{Company Withinpool Congestion Return} = \$2264 * \frac{\$25 * 300\text{MWh}}{\$25 * 300\text{MWh} + \$25 * 20\text{MWh}} = \$2122.50$$

$$\text{Company Withinpool Transaction Cost} = \$25 * 300\text{MWh} - \$2122.50 = \$5377.50$$

$$\text{Company Production Cost} = \$0$$

$$\text{APC} = \$0 + \$5377.50 = \$5377.50$$

- Company D

$$\text{Company Withinpool Transaction} = 240\text{MWh} - 250\text{MWh} + 30\text{MWh} = 20\text{MWh}$$

$$\text{Company Load Weighted LMP}_D = \frac{\$25}{\text{MWh}}$$

$$\text{Company Withinpool Congestion Return} = \$2264 * \frac{\$25 * 20\text{MWh}}{\$25 * 300\text{MWh} + \$25 * 20\text{MWh}} = \$141.50$$

$$\text{Company Withinpool Transaction Cost} = \$25 * 20\text{MWh} - \$141.50 = \$358.50$$

$$\text{Company Production Cost} = 250\text{MWh} * \frac{\$14}{\text{MWh}} = \$3500$$

$$\text{Company Interpool Transaction Cost} = -30\text{MWh} * \frac{\$16.75}{\text{MWh}} = -\$502.50$$

$$\text{APC} = \$3500 - \$502.50 + \$358.50 = \$3356$$

- Pool 2

$$\text{Pool Gen Weighted LMP} = \frac{100\text{MWh} * \text{GLMP}_F + 150\text{MWh} * \text{GLMP}_G}{100\text{MWh} + 150\text{MWh}} = \frac{\$30}{\text{MWh}}$$

$$\text{Pool Withinpool Gen Revenue} = 30\text{MWh} * \frac{\$30}{\text{MWh}} + 100\text{MWh} * \frac{\$30}{\text{MWh}} = \$3900$$



$$\text{Pool Withinpool Load Cost} = 130\text{MWh} * \frac{\$35}{\text{MWh}} = \$4550$$

$$\text{Pool Returned Withinpool Imbalance} = (\$4550 - \$3900) * 80\% = \$520$$

- Company E

$$\text{Company Withinpool Transaction} = 130\text{MWh}$$

$$\text{Company Load Weighted LMP}_E = \frac{\$35}{\text{MWh}}$$

$$\text{Company Withinpool Congestion Return} = \$520 * \frac{\$35 * 130\text{MWh}}{\$35 * 130\text{MWh}} = \$520$$

$$\text{Company Withinpool Transaction Cost} = \$35 * 130\text{MWh} - \$520 = \$4030$$

$$\text{Company Production Cost} = \$0$$

$$\text{APC} = \$0 + \$4030 = \$4030$$

- Company F

$$\text{Company Withinpool Transaction} = 150\text{MWh} - 100\text{MWh} - 80\text{MWh} = -30\text{MWh}$$

$$\text{Company Gen Weighted GLMP}_F = \frac{\$30}{\text{MWh}}$$

$$\text{Company Production Cost} = 100\text{MWh} * \frac{\$25}{\text{MWh}} = \$2500$$

$$\text{Company Interpool Transaction Cost} = 80\text{MWh} * \frac{\$30}{\text{MWh}} = \$2400$$

$$\text{Company Withinpool Transaction Cost} = -30\text{MWh} * \frac{\$30}{\text{MWh}} = -\$900$$

$$\text{APC} = \$2500 + \$2400 - \$900 = \$4000$$

- Company G

$$\text{Company Withinpool Transaction} = 120\text{MWh} - 150\text{MWh} - 70\text{MWh} = -100\text{MWh}$$

$$\text{Company Gen Weighted GLMP}_G = \frac{\$30}{\text{MWh}}$$

$$\text{Company Production Cost} = 150\text{MWh} * \frac{\$30}{\text{MWh}} = \$4500$$

$$\text{Company Interpool Transaction Cost} = 70\text{MWh} * \frac{\$30}{\text{MWh}} = \$2100$$

$$\text{Company Withinpool Transaction Cost} = -100\text{MWh} * \frac{\$30}{\text{MWh}} = -\$3000$$

$$\text{APC} = \$4500 + \$2100 - \$3000 = \$3600$$