Pumped Storage Costs

MIC: Electric Storage Resources

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Manual 15: Pumping Efficiency

- **Pumping Efficiency is the Pumped Storage Hydro Unit's version of a heat rate. It measures the ratio of generation produced to the amount of generation used as fuel.**
- **Pumping Efficiency (PE) is calculated by dividing the MWh of generation produced while operating in generation mode by the MWh required to pump the water needed to produce the generation MWh.**

Manual 15, § 7.1 Pumping Efficiency

$$Pumping\ Efficiency = \frac{MWh\ Generation\ Produced}{MWh\ Generation\ Pumped\ as\ Fuel}$$

- **Option 1: 12 month calendar actual Pumping Efficiency.**
- **Option 2: Three month rolling Pumping Efficiency.**
- **Option 3: The previous month actual Pumping Efficiency.**

Manual 15: Pumped Storage Costs

- Pumped storage fuel cost shall be calculated on a seven (7) day rolling basis by multiplying the real time bus LMP at the plant node by the actual power consumed when pumping divided by the pumping efficiency. The pumping efficiency is determined annually based on actual pumping operations or by OEM curves if annual data is not available due to the immaturity of the unit. The following equations govern pumping storage fuel cost

Manual 15, § 7.3 Fuel Costs

- **Basic Pumped Storage Fuel Cost is not mathematically consistent**
- **Pumping cost is currently defined only as a dollar amount**

$$\boldsymbol{Pumping\ Power\ Cost = Real\ Time\ LMP\ (\$\ per\ MWh) * Pumping\ Power\ MWh}$$

- **Fuel Cost is currently defined only as a dollar amount**

$$\boldsymbol{Pumped\ Storage\ Fuel\ Cost\ (\$/MWh) = \frac{PC}{Pumping\ Efficiency}}$$

Proposed Pumping Cost

- **The short run marginal cost of producing energy using a pumped storage hydroelectric turbine is the cost of pumping water to the reservoir divided by the pumping efficiency of the unit.**
- **The pumping cost applicable to the operating day is represented by the average cost per MWh paid for energy to pump water up to the reservoir during the last 100 pump hours. This cost is calculated as settled by PJM, using the Day-Ahead Market or Real-Time Energy Market LMP, as applicable.**

Proposed Pumping Cost

$$PC = \frac{\sum_{h=1}^{100}\{DA\ LMP_h \cdot DA\ PL_h + RT\ LMP_h \cdot (RT\ PL_h - DA\ PL_h)\}}{\sum_{h=1}^{100} RT\ PL_h}$$

- PC is the pumping cost in \$ per MWh
- h indexes hours during the last 100 pumping hours
- $DA\ LMP$ is the Day-Ahead Market Locational Marginal Price in \$ per MWh
- $DA\ PL$ is the day ahead pumping load in MWh, not to exceed the $RT\ PL$.
- $RT\ LMP$ the Real-Time Energy Market Locational Marginal Price in \$ per MWh
- $RT\ PL$ is the real time pumping load in MWh

Proposed Incremental Energy Cost

- The pumping efficiency represents the average amount of energy produced for each MWh used to pump water into the reservoir. The pumping cost divided by the pumping efficiency is the incremental energy cost.

Proposed Pumped Storage energy cost

$$C'(MW) = \frac{PC}{PE}$$

- $C'(MW)$ is the incremental energy cost at any *MW* level in \$ per MWh.
- PC is the pumping cost in \$ per MWh.
- PE is the pumping efficiency (Unchanged from M15).

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