Section 7: Hydro

This section contains information for the development of Hydro or Pumped Storage Hydro cost offers.

Hydro Units – Generating unit in which the energy of flowing water drives the turbine generator to produce electricity. This classification includes pumped and run-of-river hydro.

Pumped Storage Hydro Unit – Hydroelectric power generation that stores energy in the form of water by pumping from a lower elevation source to a higher elevation reservoir, then allowing the upper reservoir to drain turning the turbines to produce power.

7.1 Pumping Efficiency (Pumped Storage Hydro Only)

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.

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

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.

For example, it requires 1,000 ft^3 to produce one MWh of generation as water flows from the pond to the sink and it requires 1.4 MWh of pumping load to pump 1,000 ft^3 of water from the sink to the pond. The resultant efficiency is:

$$Pumping\ Efficiency = \frac{MWh\ Generation\ Produced}{MWh\ Generation\ Pumped\ as\ Fuel} = \frac{3.5\ MWh\ (Generated)}{5\ MWh\ (Pumped)} = 0.70$$

In order to account for environmental and physical factors associated with the characteristics of the pond and pumping operations that limit the accuracy of calculating short term pumping efficiency, a seven day rolling total of pumping and generation MWh are utilized for pumping efficiency calculations.

PE can be calculated by one of three methods. A Market Seller must make the choice of method by December 31 prior to the year of operation and cannot change to another method for a period of one calendar year.

- Option 1: Twelve month calendar actual Pumping Efficiency.
    - The previous 12-month calendar year average Pumping Efficiency based on actual pumping operations.
- Option 2: Three month rolling Pumping Efficiency.
    - The previous three months rolling actual efficiency where the average monthly availability is 50% or greater. The calculation must be updated after each month.
- Option 3: The previous month actual Pumping Efficiency.
    - The previous month actual efficiency where the availability is 50% or greater. The calculation must be updated monthly.

7.2 Performance Factors

Note:
The information in Section 2.2 contains basic Performance Factor information relevant for all unit types. The following additional information only pertains to hydro units.

7.3 Fuel Cost

The fuel costs for a run-of-river hydro Unit are equal to zero.

For a Pumped Storage Hydro Unit to be consistent with other PJM units within this manual the term fuel cost is used to account for the energy necessary to pump from the lower reservoir to the upper reservoir.

Note:
The information in Section 2.3 contains basic Fuel Cost information relevant for all unit types. The following additional information only pertains to Pumped Storage Hydro Units.

If a Market Seller wishes to change its method of calculation of pumped storage TFRC, the Market Seller shall notify PJM and the MMU in writing by December 31 prior to the year of operation, to be evaluated pursuant to the Cost Methodology and Approval Process before the beginning of the cycle in which the new method is to become effective. The new cycle starts on February 1st and continues for a period of one year

Basic Pumped Storage Fuel Cost – 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.

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

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

7.3.1 Incremental Energy Cost for Pumped Storage Hydro Plant Generation

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.

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

$\boldsymbol{C'(MW)}$ is the incremental energy cost at any *MW* level in $ per MWh
$\boldsymbol{PC}$ is the pumping cost in $ per MWh
$\boldsymbol{PE}$ is the pumping efficiency

7.4 Start-up Cost

See section 7.7 Condensing Start Costs.

7.5 No-Load Cost

Hydro Units do not have No-Load Costs.

7.6 Maintenance

Note:
The information in Section 2.6 contains basic Maintenance Cost information relevant for all unit types. The following additional information only pertains to hydro units.

This account shall include the cost of labor, materials used and expenses incurred in the maintenance of plant, includible in Account 332 minus labor, Reservoirs, Dams, and Waterways. (See operating expense instruction 2.) However, the cost of labor materials used and expenses incurred in the maintenance of fish and wildlife, and recreation facilities, the book cost of which is includible in Account 332, Reservoirs, Dams, and Waterways, shall be charged to Account 545 minus labor, Maintenance of Miscellaneous Hydraulic Plant. Further, Pumped Storage Hydro Units scheduled by the Office of the Interconnection pursuant to the hydro optimization tool in the Day-ahead Energy Market may not include maintenance costs in their offers because such offers may not exceed an energy offer price of $0.00/MWh.

7.7 Synchronized Reserve: Hydro Unit Costs to Condense

Note:
The information in Section 2.7 contains basic Synchronized Reserve Cost information relevant for all unit types. The following additional information only pertains to hydro units if applicable.

Some Hydro Units have the ability to purge the turbines of water and run backwards effectively creating a capacitor. This method of operation of the machine is referred to as operating the Hydro unit in synchronous condensing mode.

Total synchronous condensing costs for Hydro units shall include the following components:

$$\begin{aligned}&Hydro\ Costs\ to\ Condense\ (\$/MWh)\\&= Condensing\ Start\ Costs + \left(\frac{VOM}{Synchronized\ Reserve\ MW}\right) + Margin\end{aligned}$$

Condensing Start costs if applicable, start costs shall be applied when a unit moves from cold to condensing operations and when a unit moves from condensing operations to energy generation, but shall not be applied when a unit moves from energy generation to condensing operations.

In addition (+) identified **variable Operating and Maintenance** cost in $/Hr. divided by the Synchronized MW provided. These costs shall be totaled over the Maintenance Period and divided by total MWh generated over the maintenance period. These variable Operating and Maintenance costs shall include:

- Maintenance of Electric Plant as derived from FERC Account 544
- Maintenance of Reservoirs as derived from FERC Account 543

In addition (+) **margin** up to $7.50 per MW of Synchronized Reserve service provided.

Total hydro condensing offers must be expressed in dollars per hour per MW of Synchronized Reserve ($/MWh) and must specify the total MW of Synchronized Reserve offered.

7.8 Regulation Cost

Note:
The information in Section 2.8 contains basic Regulation Cost information relevant for all unit types.