



PJM Manual 15:

Cost Development Guidelines

Revision: 18

Effective Date:

Prepared by

Cost Development Subcommittee

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Section 2: Policies for All Unit Types

This section contains information that is relevant for the development of a cost offer for all types of units.

2.8 Regulation Service

Regulation is the capability of a specific resource with appropriate telecommunications, control and response capability to increase or decrease its output in response to a regulating control signal to control for frequency deviations

Total costs to provide Regulation Service from a unit shall include the following components up to but not exceeding:

$$\text{Regulation Costs (\$/ MWh)} \leq$$

$$\begin{aligned} & (\text{Fuel Cost Increase and Unit Specific Heat Rate Degradation due to Operating at Lower Loads}) \\ & + \text{Cost Increase due to Heat Rate Increase during nonsteady state operation} \end{aligned}$$

$$(\text{above heat rate factor not to exceed 0.35\%}) + \text{Cost Increase in VOM} + \text{Margin Risk Adder}$$

Fuel Cost Increase and Unit Specific Heat Rate Degradation due to Operating at lower loads:

The costs (in \$/MWh of Regulation) to provide Regulation service from units shall not exceed the fuel cost increase due to operating the unit at lower loads than at the optimal economic dispatch level load and the unit specific heat rate degradation from operating at lower loads, resulting from operating the unit at lower MW output incurred from the provision of Regulation over the entire generator MW range of providing Regulation service.

Cost Increase due to Heat Rate increase during non-steady state:

The cost (in \$/MWh of Regulation) increase due to the heat rate increase resulting from operating the unit at a non steady-state condition. This heat rate loss factor rate shall not exceed 0.35% of the top Regulation load MW heat rate value.

Cost increase in VOM:

The cost increase (in \$/MWh of Regulation) of variable operations and maintenance (VOM) cost resulting from operating the unit at lower MW output incurred from the provision of Regulation. VOM costs shall be calculated by the following methods and shall not exceed those levels below:

For non-hydro units that have been providing Regulation service for less than 10 years, or all hydro units regardless of the historical years of Regulation service, the following variable operation and maintenance (VOM) costs can be applied by unit type up to the following:

- Super-critical Steam: \$10.00 per MWh of Regulation
- Sub-critical Steam: \$3.50 per MWh of Regulation
- Combined Cycle: \$2.50 per MWh of Regulation



- Combustion Turbine: \$2.00 per MWh of Regulation
- Hydro: \$1.00 per MWh of Regulation
- Energy Storage: Based on OEM estimates initially and actual as history is available

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Exhibit 3: VOM for All Hydro Units or Non-Hydro Units providing service for less than 10 years

For non-hydro units that have been providing Regulation service for more than 10 years, the VOM rates above can be utilized only if the annual VOM dollar amounts resulting from those rates and included in Regulation cost based offers, are subtracted from the escalated 10 or 20 year historical total VOM accounts and the Regulation MWh based on the average of the last three years.

Energy Storage Units that participate only in regulation service shall include all their VOM in the Cost increase in VOM adder in Regulation cost offers.

Margin/Risk Adder:

Margin Risk Adder shall not exceed \$12.00 per MWh of Regulation service provided.

For example, a 100 MW sub-critical coal fired steam unit that has been providing Regulation service for 30 years. The unit averaged 5,000 MWh of Regulation service over the last three years and the escalated 20 year historical total VOM = \$10,000,000.

$$\begin{aligned}
 &\text{Annual VOM costs to subtract} \\
 &= (\$3.50 \text{ per Regulation MWh} * 5,000 \text{ MWh}) * 20 \text{ years} \\
 &= \$17,500 \text{ per year} * 20 \text{ years} \\
 &= \$350,000 \\
 &\text{20-year balance of historical total VOM accounts} \\
 &= \$10,000,000 - \$350,000 \\
 &= \$ 9,650,000
 \end{aligned}$$

Actual Regulation VOM incremental costs submitted and evaluated pursuant to the Cost and Methodology Approval Process.

Exhibit 4: Example of VOM for Non-Hydro Units providing Regulation for more than 10 years:

For Example for a Sub-critical Coal-Fired Steam Unit providing Regulation Service for the last seven years:

Unit Operating Mode	Output	Heat Rate
Steam Unit Highest Regulating Operating Load:	100 MW	9,000 BTU/kWh
Steam Unit Regulation Band:	10 MW	

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Lowest Regulating Operating Load	40 MW	12,500 BTU/kWh
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Base Prices	
Fuel Cost (TFRC):	\$1.50/MBTU
Heat Rate Adjustment (Operating Range)	
Unit Base Load Heat Rate Fuel Input =	$9,000 * 40 / 1000 = 360.0$ MBTU/Hr
Unit Reduced Load Heat Rate Fuel Input =	$12,500 * 40 / 1000 = 500.0$ MBTU/Hr
Difference =	140.0 MBTU/Hr
Heat Rate Adjustment (Non Steady-State Operation)	
Top Operating Point Heat Rate =	9,000 Btu/kWh
Heat Rate Loss Factor =	0.35%
Heat Rate Loss =	$(9,000 * 0.35\%) * 100 \text{ MW} / (1000 \text{ kW/MW})$ = 3.15 MBTU/Hr
Total Regulation Cost:	
(a) Heat Rate Adjustment (Operating Range)	
Fuel Cost Adder – Operating Range =	$140.0 \text{ MBTU/Hr} * \$1.50/\text{MBTU} / 60 \text{ MW Operation Band}$ = \$3.50/Hr/MW of Regulation
(b) Heat Rate Adjustment (Non Steady-State Operation)	
Fuel Cost Adder–Non Steady-State Operation	= $3.15 \text{ MBTU/Hr} * \$1.50 \text{ MBTU} / 10 \text{ MW Regulation Band}$ = \$0.47/Hr/MW of Regulation
(c) VOM Adder	
Regulation VOM Adder	\$3.50/Hr/MW of Regulation (for a Steam Unit)
(d) Margin/Risk Adder	
Margin/Risk Adder =	\$12.00/Hr/MW of Regulation
Total Regulation Cost	
Total Regulation Cost =	(a) Fuel Cost Adder (Operating Range) + (b) Fuel Cost Adder (Non Steady-State Operation) + (c) VOM Adder + (d) Margin/Risk Adder



Total Regulation Cost =	\$3.50 + \$0.47 + 3.50 + \$12.00
Total Regulation Cost =	\$19.47/Hr/MW of Regulation

Exhibit 5: Regulation Maximum Allowable Cost Adder Example

How to Use this Manual

To use this Manual, read sections one and two then go to the chapter for unit type for possible additional information.

Section 3: Nuclear Unit Cost Guidelines

Section 4: Fossil Steam Unit Cost Development

Section 5: Combined Cycle (CC) Cost Development

Section 6: Combustion Turbine (CT) and Diesel Engine Costs

Section 7: Hydro

Section 8: Demand Side Response (DSR)

[Section 9: Wind Units](#)

[Section 10: Solar Units](#)

[Section 11: Energy Storage](#)

Attachment A: Applicable FERC System of Accounts



Section 10: Solar Units

This section contains information for the development of solar unit cost offers.

Solar Units – Solar units use photovoltaic cell collectors made from semiconductors to convert solar radiation directly to electricity.

10.1 Heat Rates

Solar units do not burn fuel so heat rates are not applicable.

10.2 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 solar units.

Solar units do not burn fuel so Performance Factors are equal to 1.0.

10.3 Fuel Cost

Note: The information in Section 2.3 contains basic Fuel Cost information relevant for all unit types. The following additional information only pertains to solar units.

Solar unit's fuel costs are equal to zero.

10.4 Start Cost

Note: The information in Section 2.3 contains basic Start Cost information relevant for all unit types. The following additional information only pertains to solar units.

Solar unit's Start Fuel and Total Fuel Related Costs are equal to zero.

10.5 No Load

Solar units do not have No Load costs.

10.6 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 solar units.



10.7 Synchronized Reserve Cost

Note: The information in Section 2.7 contains basic Synchronized Reserve Cost information relevant for all unit types.

10.8 Regulation Cost

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



Section 11: Energy Storage Units

This section contains information for the development of Battery and Flywheel unit cost offers. Currently energy storage units only participate in the regulation market.

Battery Units – A battery unit consists of electrochemical cells that convert stored chemical energy into electrical energy.

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Flywheel Units – Flywheel units store rotational energy in a rotor (flywheel) turning at very high speed in a vacuum.

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11.1 Heat Rates

Batteries and Flywheels not burn fuel so heat rates are not applicable.

11.2 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 battery and flywheels units.

Battery and Flywheel Units do not burn fuel so Performance Factors are equal to 1.0.

11.3 Fuel Cost

Note: The information in Section 2.3 contains basic Fuel Cost information relevant for all unit types. The following additional information only pertains to battery and flywheel units.

Battery and Flywheel Unit's fuel costs are equal to zero.

11.4 Start Cost

Battery and Flywheel Unit's Start Fuel and Total Fuel Related Costs are equal to zero.

11.5 No Load

Battery and Flywheel Units have do not have No Load costs.

11.6 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 battery and flywheel units.



11.7 Synchronized Reserve Cost

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 battery and flywheel units if applicable.

11.8 Regulation Cost

Note: The information in Section 2.8 contains basic Regulation Cost information relevant for all unit types. The following additional information only pertains to battery and flywheels units.

For a Battery or Flywheel Unit to be consistent with other PJM units within this manual, the term “Fuel Cost Increase and Unit Specific Heat Rate Degradation due to Operating at lower loads” is used to account for the energy losses experienced by an energy storage device while providing regulation service. The “Cost Increase due to Heat Rate Increase during non-steady state operation” shall be equal to zero.

If a Unit Owner wishes to change its method of calculating these losses, the PJM Member shall notify the PJM MMU in writing by December 31 prior to the year of operation, to be evaluated pursuant to the Cost and Methodology 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

Energy Storage Unit Fuel Cost Increase (\$/MW) – shall be the calculated average of seven (7) days of rolling hourly periods where the real time bus LMP (\$/MWh) at the plant node is multiplied by the net energy consumed (MWh) when regulating divided by the regulation offer (MW). The following equation governs energy storage unit’s fuel cost increase:

$$\text{Energy Storage Unit Fuel Cost Increase}(\$/\text{MW}) = \text{Average of 7 Days} \left\{ \frac{\text{Hourly LMP} \left(\frac{\$}{\text{MWh}} \right) * \text{Hourly Net Energy Consumed}(\text{MWh})}{\text{Hourly Regulation Offer} (\text{MW})} \right\}$$