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| VCMRR Number | [023](http://www.ercot.com/mktrules/issues/VCMRR023) | VCMRR Title | Related to NPRR940, Removal of Language Related to NPRR664, Fuel Index Price for Resource Definition and Real-Time Make-Whole Payments for Exceptional Fuel Cost Events |
| Date Posted | | May 2, 2019 | |
|  | |  | |
| Requested Resolution | | Normal | |
| Verifiable Cost Manual Sections Requiring Revision | | 1.4, Global Definitions  7, Designation of the Fuel Index Price for Resource (FIPRr) (Deleted)  Appendix 3: Example Calculations of Power Purchase & Tolling Agreements Verifiable Cost Caps  Appendix 5: Specification of Relevant Equations  Appendix 6: Calculation and Application of Proxy Heat Rate and the Value of X for the Resource  Appendix 7: Calculation of the Variable O&M Value and Incremental Heat Rate used in Real Time Mitigation for Quick Start Generation Resources (QSGRs)  Appendix 8: Procedure for evaluating actual fuel prices for Reliability Unit Commitments (RUC)  Appendix 9: Procedure for incorporating Variable O&M (VOM) for power augmentation techniques into the Mitigated Offer Cap (MOC) | |
| Related Documents Requiring Revision/Related Revision Requests | | Nodal Protocol Revision Request (NPRR) 940, Removal of Language Related to NPRR664, Fuel Index Price for Resource Definition and Real-Time Make-Whole Payments for Exceptional Fuel Cost Events | |
| Revision Description | | This Verifiable Cost Manual Revision Request (VCMRR) aligns the language in the Verifiable Cost Manual with the revisions proposed in NPRR940. | |
| Reason for Revision | | Addresses current operational issues.  Meets Strategic goals (tied to the [ERCOT Strategic Plan](http://www.ercot.com/content/news/presentations/2013/ERCOT%20Strat%20Plan%20FINAL%20112213.pdf) or directed by the ERCOT Board).  Market efficiencies or enhancements  Administrative  Regulatory requirements  Other: (explain)  *(please select all that apply)* | |
| Business Case | | This VCMRR maintains consistency between the Verifiable Cost Manual and the Protocols. | |

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| Proposed Verifiable Cost Manual Language Revision |

**1.4 Global Definitions**

(1) Where this Manual uses the generic phrase “Verifiable Costs,” it is intended to refer to the sum of any applicable, Verified Operating and Maintenance Costs and any appropriate, Verified Fuel Costs. ERCOT itself calculates Fuel Costs, but does so using Fuel Consumption data that have been submitted and verified. Thus, the Fuel Cost component implied by the term “Verifiable Costs” should be interpreted to mean whichever of the following is contextually appropriate:

(a) Fuel Consumption per-start (MMBtu/start)

(b) Fuel Consumption per-hour at LSL (MMBtu/hr)

(c) Fuel Consumption as determined from submitted heat rate (a measure of generator efficiency) data

(2) The following are several abbreviations that are used throughout this Manual and the intended meaning of each:

(a) “AHR Curve” denotes Average Heat Rate Curve

(b) “CCP” denotes Combined Cycle Plant

(c) “FIP” denotes Fuel Index Price

(d) “FOP” denotes Fuel Oil Price

(e) “IHR Curve” denotes Incremental Heat Rate Curve.

(f) “I/O Curve” denotes Input-Output Curve

(g) “LSL” denotes Low Sustained Limit

(h) “HSL” denotes High Sustained Limit

(i) “Manual” refers to this document, ERCOT’s Verifiable Cost Manual

(j) “MMBtu” denotes one-million British Thermal Units

(k) “O&M costs” denotes Operations and Maintenance costs.

(l) “QSE” denotes Qualifying Scheduling Entity

(m) “RUC” denotes the Reliability Unit Commitment

(n) “SGR” denotes Split Generation Resource

(o) “VOM" denotes Variable O&M

(p) “VCMS” denotes Verifiable Cost Management System

(q) “lb” denotes Pounds-Mass

(r) “WMS” Wholesale Market Subcommittee

(s) “LEL” denotes Low Emergency Limit

(t) “HEL” denotes High Emergency Limit

(u) “PPA” denotes Power Purchase and Tolling Agreements

(v) “Filing Entity” denotes the Entity which files Verifiable Cost data with ERCOT, whether a Qualified Scheduling Entity or a Resource Entity.

(w) “BC” denotes breaker close

(x) “VC” denotes Verifiable Costs

(y) “Shutdown Costs” denotes those fuel costs (Including auxiliary boiler fuel and auxiliary-equipment fuel or electrical power requirements but excluding normal plant heating) which are incurred within three hours after Breaker Open.







**Appendix 3: Example Calculations of Power Purchase & Tolling Agreements Verifiable Cost Caps**

Example 1: PPAs indicating only one (1) cost for the Resource; no fuel volume shown

Example 1 consists of Tables 1, 2, 3 and 4 and demonstrates the cases where the PPA has submitted only the total cost for the Resource and shows the calculations for Startup costs under cold, hot and intermediate conditions as well as costs at LSL (Table 4). This example demonstrates how the PPA is capped under these conditions.

In all the cases where the PPA contains only the total cost for the Resource, the verifiable costs are capped by the highest total cost calculated from similar non-PPA units. The verifiable costs established for the capped PPA Resources are deemed to have the same fuel and O&M costs as the highest non-PPA unit.

Table 1: Cold Start-Up Cost for Simple Cycle > 90 MW Resources

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Cold Type | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 |
| PPA Cost ($) |  |  |  |  | 9,600(1) | 15,000(1) | 10,000(1) |
| Fuel to LSL (MMBtu) | 100 | 120 | 90 | 80 |  |  |  |
| Average FIP over the last 30 days ($/MMBtu) | 10 | 10 | 10 | 10 |  |  |  |
| Total Fuel Cost ($) Fuel x FIP | 1,000 | 1,200 | 900 | 800 |  |  |  |
| Total O&M Cost ($) | 8,700 | 7,000 | 6,000 | 9,000 |  |  |  |
| Total Fuel + O&M Cost ($) | 9,700 | 8,200 | 6,900 | 9,800 |  |  |  |
| Approved VC Fuel Cap (MMBtu) | N/A | N/A | N/A | N/A | N/A | 80 | 80 |
| Approved VC O&M Cap ($) | N/A | N/A | N/A | N/A | 9,600 | 9,000 | 9,000 |

(1) Approved VC = Minimum {Reference Resource or PPA}



In Table 1, the largest cost for the four Resources (Units 1 through 4) is $9,800 which is that for Unit 4. Thus PPAs for Units 6 and 7 are capped at $9,800 while the cost for PPA Unit 5 is set at $9,600 (the submitted amount).

Table 2: Hot Start-Up Cost for Simple Cycle > 90 MW Resources

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Hot Type | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 |
| PPA Cost\* ($) |  |  |  |  | 4800(1) | 7500(1) | 5000(1) |
| Fuel to LSL (MMBtu) | 65 | 80 | 70 | 60 |  |  |  |
| Average FIP over the last 30 days ($/MMBtu) | 10 | 10 | 10 | 10 |  |  |  |
| Total Fuel Cost ($) Fuel x FIP | 650 | 800 | 700 | 600 |  |  |  |
| Total O&M Cost ($) | 6000 | 4000 | 3500 | 6000 |  |  |  |
| Total Fuel + O&M Cost ($) | 6,650 | 4,800 | 4,200 | 6,600 |  |  |  |
| Approved VC Fuel Cap (MMBtu) | N/A | N/A | N/A | N/A | N/A | 65 | N/A |
| Approved VC O&M Cap ($) | N/A | N/A | N/A | N/A | 4,800 | 6,000 | 5,000 |
| (1) Costs for a hot start is calculated by multiplying a Relative Weight 0.5 by the cost for a cold start | | | | | | |  |



In Table 2 the highest cost of the four non-PPA Resources is that of Unit 1 ($6,650); thus the Cap for the PPA Units is set at this level. Note that the verifiable costs for PPA Units 5 and 7 are set at their submitted amounts since they are less than the Cap.

Table 3: Intermediate Start-Up Cost for Simple Cycle > 90 MW Resources

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Inter Type | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 |
| PPA Cost\* ($) |  |  |  |  | 6720(1) | 10500(1) | 7000(1) |
| Fuel to LSL (MMBtu) | 75 | 100 | 80 | 70 |  |  |  |
| Average FIP over the last 30 days ($/MMBtu) | 10 | 10 | 10 | 10 |  |  |  |
| Total Fuel Cost ($) Fuel x FIP | 750 | 1000 | 800 | 700 |  |  |  |
| Total O&M Cost ($) | 7000 | 5000 | 4500 | 7000 |  |  |  |
| Total Fuel + O&M Cost ($) | 7750 | 6000 | 5300 | 7700 |  |  |  |
| Approved VC Fuel Cap (MMBtu) | N/A | N/A | N/A | N/A | N/A | 75 | N/A |
| Approved VC O&M Cap ($) | N/A | N/A | N/A | N/A | 6,720 | 7,000 | 7,000 |
| (1) Costs for an intermediate start is calculated by multiplying a Relative Weight 0.7 by the cost for a cold start | | | | | | |  |



Similarly in Table 3, the highest cost for Resources 1 through 4 is that of Unit 1 and the Cap for the PPAs is $7,750. Please note again that the verifiable costs for PPA units 5 and 7 are set at the submitted amounts (less than the calculated Cap).

Table 4: Minimum Energy {@ LSL} PPA Cap for Simple Cycle > 90MW Resources

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Resource | PPA Cost ($/MWh) | Fuel at LSL (MMBtu/MWhr) | Average FIP over the last 30 days ($/MMBtu) | Resource Fuel MMBtu/MWh = PPA Cost/FIP | Resource Fuel Cost ($/MWh) = Fuel x FIP | O&M ($/MWh) | Total Cost ($/MWh) Fuel +O&M | Approved VC Fuel Cap (MMBtu) | Approved VC O&M Cap ($) |
| 1 | N/A | 19 | 10 | N/A | 190 | 17 | 207 | N/A | N/A |
| 2 | N/A | 21 | 10 | N/A | 210 | 20 | 230 | N/A | N/A |
| 3 | N/A | 18 | 10 | N/A | 180 | 14 | 194 | N/A | N/A |
| 4 | N/A | 15 | 10 | N/A | 150 | 15 | 165 | N/A | N/A |
| 5 | 300 |  |  |  |  |  |  | 21 | 20 |
| 6 | 130 |  |  |  |  |  |  |  | 130 |
| 7 | 200 |  |  |  |  |  |  |  | 200 |



Table 4 demonstrates the calculation of the Cap for Minimum Energy @ LSL when the verifiable costs submitted by the QSE representing the PPA include only a single cost. In this Table the verifiable total costs are shown for Non-PPA units 1 through 4. The highest of these is Unit 2 with a total verifiable cost of $230/MWh which becomes the Cap for the PPA units 5, 6 and 7. As before, if the costs of the PPA units are more than the Cap, the fuel and O&M components for the PPA Resource are set equal to the same components in the Reference Resource (Resource 2). In cases where the PPA submitted costs are less than those of the Reference Resource, the verifiable costs will be treated as O&M only and will not have a fuel component.

Example 2: PPAs indicating both Fuel and O&M costs

Example 2 below demonstrates the calculation of the PPA Cap when the PPA verifiable cost filing by the QSE representing the PPA includes fuel and O&M costs stated separately. The Cap for the PPAs is set by calculating the total O&M cost for the set of similar units and choosing the highest of those as the Cap. This example also shows (Table 5) how ERCOT is going to determine the Reference Resource and the PPA cap for operations above LSL.

Table 1: Cold Start-Up Cost for Simple Cycle > 90 MW Resources

Note: Units 5, 6 and 7 are under a PPA, therefore, their O&M are capped

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Cold Type | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 |
| Fuel to LSL (MMBtu) | N/A | N/A | N/A | N/A | 120 | 80 | 140 |
| Total O&M Cost ($) | 8,700 | 7,000 | 6,000 | 9,000 | 7,000 | 8,000 | 10,000 |
| Approved VC Fuel (MMBtu) | N/A | N/A | N/A | N/A | 120 | 80 | 140 |
| Approved VC O&M Cap ($) | N/A | N/A | N/A | N/A | 7,000 | 8,000 | 9,000 |

In Table 1 above, the Cap is established by Unit 4 at $9,000. Of the three PPA Resources, only unit 7 is higher than the Cap at $10,000. Thus the verifiable O&M cost for PPA Unit 7 is set at $9,000 since Unit 4 establishes the O&M cap.

Table 2: Hot Start-Up Cost for Simple Cycle > 90 MW Resources

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Hot Type | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 |
| Fuel to LSL (MMBtu) | N/A | N/A | N/A | N/A | 55 | 80 | 90 |
| Total O&M Cost ($) | 6,000 | 4,000 | 3,500 | 6,000 | 5,000 | 5,900 | 8,000 |
| Approved VC Fuel (MMBtu) | N/A | N/A | N/A | N/A | 55 | 80 | 90 |
| Approved VC O&M Cap ($) | N/A | N/A | N/A | N/A | 5,000 | 5,900 | 6,000 |

The same principle applies in Table 2. The PPA costs are capped by Unit 1. As in Table 1, the O&M costs for the Unit establishing the Cap are applied to the PPA units which submitted higher total O&M costs than the Cap.

Table 3: Intermediate Start-Up Cost for Simple Cycle > 90 MW Resources

| Inter Type | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Fuel to LSL (MMBtu) | N/A | N/A | N/A | N/A | 100 | 65 | 120 |
| Total O&M Cost ($) | 6,700 | 7,000 | 4,500 | 7,000 | 6,500 | 7,000 | 8,000 |
| Approved VC Fuel (MMBtu) | N/A | N/A | N/A | N/A | 100 | 65 | 120 |
| Approved VC O&M Cap ($) | N/A | N/A | N/A | N/A | 6,500 | 7,000 | 7,000 |

In Table 3 the PPA costs are capped by Unit 4. As in Table 1, the O&M costs for the Unit establishing the Cap are applied to the PPA units which submitted higher total costs than the Cap.

Table 4: Minimum Energy {@ LSL} PPA Cap for Simple Cycle > 90MW Resources

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Resource | HSL (MW) | Fuel at LSL (MMBtu/MWhr) | O&M ($/MWh) | Approved VC Fuel ($/MWh)(1) | Approved VC O&M ($/MWh)(1) |
| 1 | 300 |  | 17 |  |  |
| 2 | 250 |  | 20 |  |  |
| 3 | 280 |  | 14 |  |  |
| 4 | 320 |  | 15 |  |  |
| 5 | 290 | 25 | 25 | 25 | 20 |
| 6 | 310 | 30 | 21 | 30 | 20 |
| 7 | 300 | 15 | 19 | 15 | 19 |
| (1) Approved VC = Minimum {Highest O&M without PPA or O&M with PPA} | | | | | |

Table 4 contains an example for the calculation of the Cap for Minimum Energy Cost @ LSL when the QSE submits verifiable costs which include both fuel and O&M costs. In this example, the highest Total O&M Cost for the non-PPA Resources is that for Resource 2 at $20/MWh. There are two PPAs (Resources 5 & 6) which have total submitted costs greater than this calculated Cap. The verifiable O&M costs components for these capped PPAs will be set equal to those components in Reference Resource 2.

Table 5: Costs for Operation Above LSL, PPA Cap for Simple Cycle > 90MW Resources (This cost is optional)

|  |  |  |
| --- | --- | --- |
| Resource | Average(1) O&M ($/MWh) | Approved VC O&M ($/MWh) |
| 1 | 17 |  |
| 2 | 20 |  |
| 3 | 14 |  |
| 4 | 15 |  |
| 5 | 25 | 20 |
| 6 | 21 | 20 |
| 7 | 19 | 19 |

(1) Simple average for all of the (MMBtu/MWh versus MW) pairs along the IHR curve

Example 3: PPAs indicating only one (1) cost for the Resource; no fuel volume shown and no Reference Unit available

Table 1: Test for Reference Unit

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Simple Cycle > 90 MW Resources | | | |  |  |
|  | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 (with PPA) |
| HSL | 200 | 210 | 180 | 160 | 250 |
| HSL Difference(1) | 50% | 40% | 70% | 90% |  |
| Initial Commercial Operation Date | 1996 | 2005 | 2006 | 2000 | 1990 |
| Differences in years between PPA and non-PPA Resources | 6 | 15 | 16 | 10 |  |
| Meets Criteria(2) | No | No | No | No |  |
| (1) Percent difference with respect to unit with PPA | | | | | |
| (2) Criteria: HSL difference +- 30% and year less than or equal to 5 years | | | | | |

Table 2: Cold, Hot, and Intermediate Start-Up Cost for Simple Cycle > 90 MW Resources

| Cold Type | Unit 5 |  | Hot Type | Unit 5 |  | Inter Type | Unit 5 |
| --- | --- | --- | --- | --- | --- | --- | --- |
| PPA Cost ($) | 6,000 |  | PPA Cost ($) | 4,500 |  | PPA Cost ($) | 3,000 |
| Approved VC Fuel (MMBtu) | N/A |  | Approved VC Fuel (MMBtu) | N/A |  | Approved VC Fuel (MMBtu) | N/A |
| Generic O&M ($) | 5,000 |  | Generic O&M ($) | 5,000 |  | Generic O&M ($) | 5,000 |
| Approved VC O&M Cap ($) | 5,000 |  | Approved VC O&M Cap ($) | 4,500 |  | Approved VC O&M Cap ($) | 3,000 |
|  | | | |  |  |  |  |

Since there is no Reference Resource, the approved verifiable costs will be set at the minimum of the PPA costs or the Generic O&M costs set forth in the Protocols.

Table 3: Minimum Energy {@ LSL} PPA Cap for Simple Cycle > 90MW Resources

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Resource | PPA Cost ($/MWh) | Generic Fuel at LSL (MMBtu/MWhr) | Approved VC Fuel (MMBtu/MWh) | Approved VC O&M Cap ($) |
| 1 |  |  |  |  |
| 2 |  |  |  |  |
| 3 |  |  |  |  |
| 4 |  |  |  |  |
| 5 | 300 | 15 | 15 | 0 |
| 6 | 140 | 15 | 15 | 0 |
| 7 | 200 | 15 | 15 | 0 |
|  | | |  |  |

In this example the submitted PPA costs for Units 6 and 7 were equal to or exceeded the Generic fuel costs and were therefore capped and approved at the Generic level. Since Generic costs at LSL do not include an O&M component, PPA Resources cannot received any O&M costs and their fuel rate is capped at Generic values.

Example 4: PPAs indicating both Fuel and O&M costs but without a Reference Unit

Table 1: Cold, Hot, and Intermediate Start-Up Cost for Simple Cycle > 90 MW Resources

| Cold Type | Unit 5 |  | Hot Type | Unit 5 |  | Inter Type | Unit 5 |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Fuel to LSL (MMBtu) | 120 |  | Fuel to LSL (MMBtu) | 55 |  | Fuel to LSL (MMBtu) | 100 |
| Total O&M Cost ($) | 7,000 |  | Total O&M Cost ($) | 5,000 |  | Total O&M Cost ($) | 6,500 |
| Generic O&M ($) | 5,000 |  | Generic O&M ($) | 5,000 |  | Generic O&M ($) | 5,000 |
| Approved VC Fuel (MMBtu) | 120 |  | Approved VC Fuel (MMBtu) | 55 |  | Approved VC Fuel (MMBtu) | 100 |
| Approved VC O&M Cap ($) | 5,000 |  | Approved VC O&M Cap ($) | 5,000 |  | Approved VC O&M Cap ($) | 5,000 |

Table 2: Minimum Energy {@ LSL} PPA Cap for Simple Cycle > 90MW Resources

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Resource | O&M ($/MWh) | Fuel at LSL (MMBtu/MWhr) | Approved VC Fuel (MMBtu/MWh) | Approved VC O&M Cap ($) |
| 1 |  |  |  |  |
| 2 |  |  |  |  |
| 3 |  |  |  |  |
| 4 |  |  |  |  |
| 5 | 15 | 25 | 25 | 0 |
| 6 | 14 | 30 | 30 | 0 |
| 7 | 18 | 15 | 15 | 0 |

In Table 2 above, Resources 5, 6 and 7 provided O&M costs and fuel rate at LSL, however, ERCOT did not approve the O&M costs since there were no Reference Units and no additional documentation was provided.

**Appendix 5: Specification of Relevant Equations**

**Equation 1: Verifiable Startup Offer Cap ($/Start)**

Verifiable Startup Offer Cap ($/Start) = DAFCRS (MMBtu/Start) \* [(GASPERSU\*FIP + OILPERSU\*FOP)/100] + VOMS

Where: DAFCRS = Total Fuel \* (1+VOXR)

Total Fuel = [FuelStartup-BC + FuelBC-LSL + FuelBO-Shutdown]

The bill determinants utilized above are defined as:

DAFCRS = the adjusted verified fuel consumption for the start type (MMBtu/Start)

GASPERSU = Percentage of natural gas used for a start

FIP = Fuel Index Price ($/MMBtu)

OILPERSU = Percentage of oil used for a start

FOP = Fuel Oil Price ($/MMBtu)

VOMS = the verified O&M cost for a hot start ($/Start)

VOXR= Value of X for the Resource

FuelStartup-BC= Fuel quantity required to bring Resource from Startup to Breaker Close (MMBtu)

FuelBC-LSL= Fuel quantity required to bring Resource from Breaker Close to Minimum Energy at LSL (MMBtu)

FuelBO-Shutdown= Fuel quantity required to take Resource from Breaker Open to Shutdown (MMBtu)

Note 1: GASPERSU and OILPERSU are decimal percentages in the Settlements equations and will be multiplied by 100 during the Integration process.

Note 2: ERCOT will use the solid fuel price and percentages to create Startup offers when no offer is submitted by the QSE for solid fuel Resources.

Note 3: This equation does not include any adjustments made to the final calculation of the Startup Offer cap, as described in Protocol Section 4.4.9.2.1, Startup Offer and Minimum-Energy Offer Criteria*.*



**Equation 2: Verifiable Minimum-Energy Offer Cap ($/MWh)**

Verifiable Minimum-Energy Offer Cap ($/MWh) = AHR\*[(GASPERME\*FIP + OILPERME\*FOP)/100] + VOMLSL

Where: AHR(1)= Fuel Rate (MMBtu/Hour) divided by LSL (MW)

GASPERME = Percentage of natural gas used at LSL

FIP = Fuel Index Price ($/MMBtu)

OILPERME = Percentage of oil used at LSL

FOP = Fuel Oil Price ($/MMBtu)

VOMLSL = the verified O&M cost at Minimum-Energy ($/MWh)

(1) Adjusted by VOXR

And: AHR= (verified fuel consumption/LSL)\*(1+VOXR)

Note 1: GASPERME and OILPERME are decimal percentages in the Settlements equations and will be multiplied by 100 during the Integration process.

Note 2: ERCOT will use the solid fuel price and percentages to create Startup offers when no offer is submitted by the QSE for solid fuel Resources.

Note 3: This equation does not include any adjustments made to the final calculation of the Minimum-Energy Offer cap, as described in Protocol Section 4.4.9.2.1, Startup Offer and Minimum-Energy Offer Criteria*.*



**Equation 3: Calculation of Composite Unit Parameters using Alternate Unit Specifications**

Composite Unit Parameter = [Alt\_Unit\_Par\*Alt\_Unit\_HSL + Non\_Alt\_Unit\_Par\* Non\_Alt\_Unit\_HSL] / [Alt\_Unit\_HSL + Non\_Alt\_Unit\_HSL]

Where: Alt\_Unit\_Par = Relevant parameter of Alternate Unit

Alt\_Unit\_HSL = High Sustained Limit of Alternate Unit

Non\_Alt\_Unit\_Par = Relevant parameter of non-Alternate Unit

Non\_Alt\_Unit\_HSL = High Sustained Limit of non-Alternate Unit

This calculation would be executed for all relevant parameters of the alternate and non-alternate units. This would include for example Startup Cost data, Minimum-Energy Cost data and heat rate data.

**Equation 4: Equation for Calculation of Verifiable Startup Emission Costs**

Verifiable Startup Emission Cost ($/Start) = RAFCRS \* ∑Emission Rate i \* Emission Cost Index i

Where RAFCRS **=** Quantity of approved startup fuel consumed by Resource (including fuel used to shutdown Resource (MMBtu/Start)

Emission Rate i = Quantity of emission i emitted by resource (lbs/MMBtu)

Emission Cost Indexi **=** Published cost index of emission i ($/lb)

i = Index for each emittent approved for inclusion in Startup Cost

**Equation 5: Equation for Calculation of Verifiable Minimum-Energy Emission Costs**

Verifiable Minimum-Energy Emission Costs ($/MWh) =

[AHR] \* ∑Emission Rate i \* Emission Cost Index i

Where AHR = Average heat rate at Minimum Energy (MMBtu/Hr)

Emission Rate i = Quantity of emission i emitted by resource (lbs/MMBtu)

Emission Cost Index i = Published cost index of emission i

i = Index of each emittent approved for inclusion in Minimum-Energy Cost

**Equation 6: Verifiable Startup Costs (VERISU) ($/Start)**

A) For RUC Settlements, the Verifiable Startup Costs are calculated as follows:

VERISU = AFCRS + VOMS

Where AFCRS = [Total Fuel - PHR \* AVGEN + Total Fuel\*VOXR] \* [FIP\*GASPERSU(%) + FOP\*OILPERSU(%) + SFP\*SFPERSU(%)]

Total Fuel = [FuelStartup-BC + FuelBC-LSL + FuelBO-Shutdown]

VOMS = IO&MStart-LSL +IO&MBO-Shutdown + Verifiable Startup Emission Costs

B) For DAM Make-Whole Payments, the Verifiable Startup Costs are calculated as follows:

VERISU = DAFCRS + VOMS

Where DAFCRS = [Total Fuel + Total Fuel\*VOXR] \* [FIP\*GASPERSU(%) + FOP\*OILPERSU(%) + SFP\*SFPERSU(%)]

Total Fuel = [FuelStartup-BC + FuelBC-LSL + FuelBO-Shutdown]

VOMS = IO&MStart-LSL +IO&MBO-Shutdown + Verifiable Startup Emission Costs

The bill determinants utilized above are defined as:

VERISU = Verifiable Startup Costs ($/Start)

AFCRS = Verifiable Startup Fuel Costs adjusted by VOXR and PHR ($/Start)

DAFCRS = the adjusted verified fuel consumption rate for the start type (MMBtu/Start)

VOMS = Verifiable Operations and Maintenance Costs ($/Start)

FuelStartup-BC = Fuel Quantity required to bring Resource from Startup to Breaker Close (MMBtu)

FuelBC-LSL = Fuel Quantity required to bring Resource from Breaker Close to Minimum Energy at LSL (MMBtu)

FuelBO-Shutdown = Fuel Quantity required to take Resource from Breaker Open to Shutdown (MMBtu)

PHR = Proxy Heat Rate (MMBtu/MWh)

AVGEN = Average Generation between Breaker Close and LSL (MWh)

VOXR = Value of X for the Resource

FIP = Fuel Price Index for gas ($/MMBtu)

FOP = Fuel Price Index for oil ($/MMBtu)

SFP = Fuel Price Index for solid fuel = $1.50/MMBtu

GASPERSU = Percent of gas used during startup

OILPERSU = Percent of oil used during startup

SFPERSU = Percent of solid fuel used during startup

IO&MStart-LSL = Incremental O&M costs incurred to bring Resource from Start to LSL ($/Start)

IO&MBO-Shutdown = Incremental O&M costs incurred to take Resource from Breaker Open to Shutdown ($/Start)

Verifiable Startup Emission Costs = The allowable costs of acquiring emission credits required to start up Resource and defined in Equation 4 above.



**Equation 7: The Equation for calculating Verifiable Minimum Energy Costs ($/MWh)**

VERIME = FCLSL + VOMLSL

Where VERIME = Verifiable Minimum Energy Costs

FCLSL = Verifiable Fuel Costs at Minimum Energy

VOMLSL = Verifiable variable O&M costs at Minimum Energy

FCLSL = [(AHR)] \* [FIP\*GASPERME(%) + FOP\*OILPERME(%) + SFP\*SFPERME(%)]

Where AHR = Adjusted average heat rate at Minimum Energy (MMBtu/Hr)

FIP = Fuel Price Index for gas ($/MMBtu)

FOP = Fuel Price Index for oil ($/MMBtu)

SFP = Fuel Price Index for solid fuel = $1.50/MMBtu

GASPERME = Percent of gas used at minimum energy

OILPERME = Percent of oil used at minimum energy

SFPERME = Percent of solid fuel used at minimum energy

VOMLSL = IO&MLSL + Verifiable Emission Costs at Minimum Energy

Where IO&MLSL = Incremental O&M costs at minimum energy

Verifiable Emission Costs at Minimum Energy = The allowable costs of acquiring emission credits required to operate Resource at minimum energy and defined in Equation 5 above.



**Appendix 6: Calculation and Application of Proxy Heat Rate and the Value of X for the Resource**

Proxy Heat Rate Monthly (PHRM) (MMBtu/MWh) = Average (based on values for one standard deviation from the Arithmetic Mean) ERCOT Day-Ahead Hub Price (in period) (DASPPERCOT345BUS )/Average Fuel Price Index (AVGFIP)($/MMBtu) for the same period. The PHR shall be based on the 12 month rolling average of the PHRM values. The value of X for the Resource (VOXR) = Fuel Adder (FA) / Average Fuel Price Index (AVGFIP) ($/MMBtu) (in period).



The PHR is used to estimate the payments received in Real Time by Resources ramping from breaker close to LSL (see Section 14, Appendices, Appendix 5, Specification of Relevant Equations, for additional details). These estimated payments are removed from the RUC Guarantee indirectly by subtracting the product of the PHR and average generation (from breaker close to LSL) from the Resource’s approved fuel rate, which is used to establish the RUC Guarantee.

The value of X for the Resource (VOXR) is used to compensate Resources for the actual cost of transporting and purchasing spot fuel. VOXR = Fuel Adder ($/MMBtu) / Average Fuel Index Price (AVGFIP) ($/MMBtu) (in a 15 day period – see item 2 below).



For additional information on the fuel adder, see Section 3, Verifiable Startup Costs.

1. The period for the FIP and DASPP data used in calculating the PHR and VOXR is the first 15 days of the month prior to the effective month.

2. ERCOT shall publish the results for PHR 8 days prior to the first day of each effective month.

3. ERCOT publishes the PHR on the Market Information System (MIS) Public Area and on the MIS Secure Area as Public Reference Data Extract (PRDE).

**Appendix 7: Calculation of the Variable O&M Value and Incremental Heat Rate used in Real Time Mitigation for Quick Start Generation Resources (QSGRs)**

Variable O&M rate ($/MWh) = Variable O&M (above LSL) + Startup Costs ($) / G (MWh)

Where

Variable O&M (above LSL) = approved Variable O&M above LSL if filed in a resources verifiable costs filing or 0 if not filed.

Startup Costs = Startup O&M Cost + Startup Fuel Cost

Startup O&M Cost = Approved Startup O&M Costs in a cold start position (Verified (QSGR mode) or Standard) or Resource Specific Generic Startup O&M Costs

Startup Fuel Cost = 90% of the approved fuel rate in a cold start position times the sum of the average fuel price for the first 15 days of the previous month and the fuel adder.

G = average generation during Minimum up time (MWh)

Where

G (MWh) = 75% \* HSL (MW) \* L (Hr)

and

HSL (MW) = average of the seasonal HSL in the RARF

L = Max {RARF Min Up Time, Average number of running hours in period, or 2} (hr)

Where:

Average number of running hours in period = average run time over the past 20 days for electrical and physically similar QSGRs at the same plant site.

The equation for calculating Variable O&M rate for QSGR in the MOC is as follows:

Variable O&M rate ($/MWh) = Variable O&M (above LSL) + Startup Costs ($) / {75% \* HSL (MW) \* L (HR)}



**Adj. Incremental Heat Ratep (MMBtu/MWh)** = (Incremental Heat ratep + Minimum Energy Component)

Where

Incremental Heat ratep (IHRp)= approved incremental heat rate (IHR) points file in the resource verifiable cost filing or the generic IHR in the Protocols

Where:

p = number of incremental heat rate point pairs (i.e. MW and IHR) used to describe the cost of the next MW of generation

Minimum Energy Component (MEC) = the difference between the Average Heat Rate (AHR) and the Incremental Heat Rate (IHR) at the Midpoint of the QSGR Dispatch Range. These heat rate values shall be based on the values provided in the resource verifiable cost filing or 0 if the resource has not filed for verifiable costs.

Where:

Midpoint of QSGR Dispatch Range (MDR) = HSL - (HSL – LSL) \* 50%

MEC = AHR@MDR – IHR@MDR

The equation for calculating Adj. Incremental Heat Rate for QSGR used in the MOC calculations is as follows:

Adj. Incremental Heat Ratep (MMBtu/MWh) = IHRp + MEC

**Sample Calculation**

 HSL = 70 MW

 Start O&M = $1,505/Start

 Start Fuel = 100 MMBtu

 Variable O&M (above LSL) = $1.5/MWh

 RARF Min Up Time = 1 hour

 Actual Run Time = 1 hour

 Fuel Index Price (FIP) = $5/MMBtu

 Resource fuel adder = $0.50/MMBtu

 IHR = 10 MMBtu/MWh

 MEC = 2.5 MMBtu/MWh

 Fuel Adder = $0.50/MMBtu

Start Fuel adjusted for energy produced during startup = Start Fuel \* 90%

**Therefore to determine Variable O&M rate:**

Variable O&M rate ($/MWh) = Variable O&M (above LSL) + Startup Costs ($) / {75% \* HSL (MW) \* L (Hr)}

 Startup costs = $1,505 + (100 MMBtu +(100 MMBtu\* 0.1)) \* 90% \* $5/MMBtu

=$1,505 + (110 MMBtu) \* 90% \* $5/MMBtu

=$1,505 + $495 = $2,000

 L = Max {RARF Min Up Time, Average number of running hours in period, or 2} (hr)

= Max{1, 1, 2} = 2

 Variable O&M rate ($/MWh) = $1.50/MWh + $2,000 / (75% \* 70 \* 2)

= $ 20.55/MWh

**And to calculate Incremental Heat Rate for one point:**

Adj. Incremental Heat Ratep (MMBtu/MWh) = IHRp + MEC

 IHRp1 = 10 MMBtu/MWh + 2.5 MMBtu/MWh

= 12.5 MMBtu/MWh

**Therefore the Mitigated Offer Cap (MOC) calculations are as follows:**

MOC ($/MWh) = (IHRp \* (FIP + FA) + Variable O&M rate) \* W

Where

 W = Capacity Factor Multiplier (range of multipliers defined in Protocol Section 4.4.9.4.1, Mitigated Offer Cap) = 1.40

 MOC = (12.5 MMBtu/MWh \* ($5/MMBtu + $0.50) + $20.55/MWh) \* 1.4

= ($68.75/MWh + $20.55/MWh) \* 1.4

= ($89.30) \* 1.4 = $125.02/MWh



**Appendix 8: Procedure for evaluating actual fuel prices for Reliability Unit Commitments (RUC)**

**Description**

Per Nodal Protocol Section 9.14.7, Disputes for RUC Make-Whole Payment for Exceptional Fuel Costs, QSEs may recover the actual price of fuel paid for providing a Reliability Unit Commitment (RUC) if the actual fuel price is higher than FIP (or FOP) plus fuel adder. This procedure describes the methodology ERCOT will use to determine the startup price (SUPR) and Minimum-Energy Price (MEPR) for such disputes.



**Procedure**

There are four possible scenarios that may arise from QSEs disputing additional fuel compensation.

1. Resource has no approved Verifiable Costs nor approved Offers

2. Resource has no approved Verifiable Costs with approved Offers

3. Resource has approved Verifiable Costs but no approved Offers

4. Resource has Approved Verifiable Costs and approved Offers

Scenario 1: Resource has no approved Verifiable Costs nor approved Offers

SUPR

Since the Resource has no verifiable costs approved, there is no fuel rate value to calculate the cost of fuel. SUPR = 0

MEPR

MEPR ($/MWh) = HRGeneric \* AFPrice

Where,

HRGeneric = Generic Heat Rate for the technology type as defined in paragraph (2) of Protocol Section 4.4.9.2.3, Startup Offer and Minimum-Energy Offer Generic Caps

AFPrice = Actual Fuel Price in $/MMBtu

Scenario 2: Resource has no approved Verifiable Costs with approved Offers

SUPR

Since the Resource has no verifiable costs approved, there is no fuel rate value to calculate the cost of fuel. SUPR = 0

MEPR

MEPR ($/MWh) = HROffer \* AFPrice

Where,

HROffer = MEO / (FIP/FOP)

AFPrice = Actual Fuel Price in $/MMBtu

Note: The Heat Rate with the Offer (HROffer) is used instead of the Generic Heat Rate otherwise the Resource could be paid more than what it Offered. The maximum (Cap) Heat Rate value the QSE can submit with an Offer is the Generic Heat Rate. Therefore, ERCOT will calculate the HR with the Offer to establish the value of MEPR.



Scenario 3: Resource has approved Verifiable Costs but no approved Offers

SUPR

SUPR ($) = VC Fuel\* AFPrice + O&MVC

MEPR ($/MWh) = AHRVC \* AFPrice + O&MVC

Where,

VC Fuel= Approved and adjusted startup Fuel (adjusted by VOXR)

O&MVC = Approved verifiable O&M

AHRVC = Approved and adjusted average Heat Rate at LSL (adjusted by VOXR)

AFPrice = Actual Fuel Price in $/MMBtu

Scenario 4: Resource has approved Verifiable Costs and approved Offers

**Offers < than Cap**

When offers are less than the Cap, it is assumed that the QSE has used a lower O&M value to construct its Offers since it’s unlikely a lower fuel rate or price was used.

Therefore,

SUO= VC Fuel\* FIP/FOP + O&MNew

Where,

VC Fuel = approved and adjusted fuel rate (adjusted by VOXR)

SUO = startup offer submitted by QSE, and

O&MNew =Max (0, SUO*q,r,s*  - (VC Fuel\* FIP/FOP))

Or

SUONew **($) =** VC Fuel\* AFPrice + O&MNew

Where,

SUONew= new startup offer submitted by QSE, and

SUPR ($) = SUONew

And

MEO **=** HRVC \* FIP/FOP + O&MNew-LSL

Where,

HRVC = approved and adjusted heat rate (adjusted by VOX)

MEO = Minimum Energy offer submitted by QSE, and

O&MNew-LSL = Max (0, MEO – VC Heat Rate\* FIP/FOP)

Then

MEPR ($/MWh) = HRVC \* AFPrice + O&MNew-LSL

If the Resource does not have approved O&M at Min Energy, then HRVC is replaced with HROffer.

Or

MEPR = HROffer \* AFPrice

Where,

HROffer = MEO / (FIP/FOP)

**Offers = Cap**

SUPR = VC Fuel\* AFPrice + O&MVC

Where,

O&MVC = Approved O&M

And

MEPR= HRVC \* AFPrice



**Appendix 9: Procedure for incorporating Variable O&M (VOM) for power augmentation techniques into the Mitigated Offer Cap (MOC)**

**Description**

Resources using power augmentation techniques such as Peak or Duct Firing, Steam Injection and Air Cooled Condenser Fogging, may be subject to higher operations and maintenance costs, while these technologies are usually not part of the units normal operations. These incremental costs (and possibly changes to the heat rates) cannot be incorporated into the “normal” operating range of the Mitigated Offer Curve (MOC) due to current limitations in the ERCOT systems. As a result, the following procedure offers a manual option to include the VOM into the MOC until a system change is made to allow variations in the variable O&M.

**General Form of the Mitigated Offer Cap**

Resources that are solving non-competitive solutions under Step 2 of SCED are mitigated based on the greater of the reference LMP at the appropriate Resource Node from Step 1 or the MOC. In general, the MOC is calculated as:

The greater of A or B (based on verifiable costs)

A. Generic Heat Rate x Fuel Price

B. [Incremental Heat Rate (IHR) x Fuel Price + VOM]\* W

Where,

W = Factor as defined in paragraph (1)(e) of Protocol Section 4.4.9.4.1, Mitigated Offer Cap.

If the Resource has submitted an actual IHR (verifiable cost),

1. MOC = [IHRi x FIP + VOM]\* W

Where, i = 1...10

And FIP = Fuel Price

And VOM = constant value along the IHR curve

Including units of measurements

2. MOC ($/MWh) = [IHRi (MMBtu/MWh) x FIP ($/MMBtu) + VOM ($/MWh)]\* W

Including a VOM for power Augmentation

3. MOC ($/MWh) = [IHRi (MMBtu/MWh) x FIP ($/MMBtu) + VOM ($/MWh) + VOMP ($/MWh)]\* W

Where,

VOM = average variable O&M for operations without power augmentation, and

VOMP= corresponding variable O&M value for power augmentation technique (assuming only one power augmentation online)

Re-arranging equation 3

4. MOC ($/MWh) = [IHRi (MMBtu/MWh) + VOM ($/MWh)/ FIP ($/MMBtu) + VOMP ($/MWh)/ FIP ($/MMBtu)] \* FIP ($/MMBtu) \* W

Or (and omitting the units)

5. MOC = [IHRi + VOM / FIP + VOMP / FIP ] \* FIP \* W

Note, the term VOMP / FIP is an implied heat rate (IMHR), or

6. MOC = [IHRi + VOM / FIP + IMHR ] \*FIP \* W

And

7. MOC = [(IHRi + IMHRj)\*FIP + VOM]\* W

Where,

IMHRj **=** VOMP/ FIPavg, and j **=** 10 (assuming power augmentation is added to the

last point of the IHR curve as shown in Table 1, Summary, below.

FIPavg = represents the average Fuel Index Price for the first two weeks of the month prior to the effective month. For example, the FIPavg for August is based on the average FIP price for period July 1- July 15.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 1: Summary** | | |  |  |  |  |  |  |
| **Point** | **MW** | **IHR** | **VOM** | **VOMPa** | **IMHRb** | **Final IHR** | **Final VOM** |  |
| 1 | MW1 | IHR1 | VOM | Null | Null | IHR1 | VOM |  |
| 2 | MW2 | IHR2 | IHR2 |  |
| 3 | MW3 | IHR3 | IHR3 |  |
| 4 | MW4 | IHR4 | IHR4 |  |
| 5 | MW5 | IHR5 | IHR5 |  |
| 6 | MW6 | IHR6 | IHR6 |  |
| 7 | MW7 | IHR7 | IHR7 |  |
| 8 | MW8 | IHR8 | IHR8 |  |
| 9 | MW9 | IHR9 | IHR9 |  |
| **10** | MW10 | IHR10 | VOMP | IMHR | IHR10+IMHR |  |
|  |  |  |  |  |  |  |  |  |
| Power Augmentation operating range | | | | |  |  |  |  |
| a VOMP - Incremental variable cost above normal VOM | | | | | | |  |  |
| b IMHR = VOMP/FIPavg | | | |  |  |  |  |  |

**Section 5 – Interim solution sample calculation**

The following example provides an illustration of the manual calculation to incorporate the VOMP of a single power augmentation technique into the MOC.

Typical Power Augmentation Arrangement

Note: Assume the power augmentation block is 10MW and constant IHR equal to the last point on the curve without power augmentation.



Example using Figure 1

 HSL = 120MW (normal)

 FIP = FIPavg = $4/MMBtu

 VOM = $3/MWh

 VOMP = $80/MWh

 W = 1.1

Using equation 7 above:

MOC ($/MWh) = [{IHR + IMHR}\*FIP + VOM]\* W

Where,

IMHR **=** VOMP/ FIPavg

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 2: Summary | |  |  |  |  |  |  |  |  |
| Point | MW | IHR | VOM | VOMPa | IMHRb | Final IHR | Final VOM | MOC |  |
| 1 | 30 | 8 | 3 |  |  | 8 | 3 | 38.5 |  |
| 2 | 40 | 8.2 | 8.2 | 3 | 39.38 |  |
| 3 | 50 | 8.4 | 8.4 | 3 | 40.26 |  |
| 4 | 60 | 8.6 | 8.6 | 3 | 41.14 |  |
| 5 | 70 | 8.8 | 8.8 | 3 | 42.02 |  |
| 6 | 80 | 9 | 9 | 3 | 42.9 |  |
| 7 | 90 | 9.2 | 9.2 | 3 | 43.78 |  |
| **8** | **100** | 9.4 | 9.4 | 3 | 44.66 |  |
| **9** | **110** | 9.6 | 9.6 | 3 | 45.54 |  |
| **10** | **120** | 9.6 | **80** | 20 | 29.6 | 3 | 133.54 |  |
|  |  |  |  |  |  |  |  |  |  |
| Power Augmentation operating range | | | |  |  |  |  |  |  |
| a Incremental cost above normal VOM | | | | |  |  |  |  |  |
| b Excludes VOM for normal operations ($3/MWh) | | | | | |  |  |  |  |
| FIPavg = $4/MMBtu; IMHR = 20($/MWh) / 4($/MMBtu) | | | | | |  |  |  |  |

Note 1: Every month ERCOT calculates a new value of IMHR and combines it with existing IHR. The effective date for the new IMHR value is the first of every month to the end of month.

Note 2: If the Incremental Heat Rate changes over the output range of power augmentation, an appropriate adjustment to the Final IHR will be made.