July 30, 2018

David W. Sorrick, LP 3K-C

REQUEST FOR FINAL ACTION – EVALUATION 2017-15516 – HEAT RATE INPUT CALCULATIONS

Attached is the subject final report for your review and final action. Your written comments, which addressed your management decision and actions planned or taken, have been included in the report. Please notify us when final action is complete. In accordance with the Inspector General Act of 1978, as amended, the Office of the Inspector General is required to report to Congress semiannually regarding evaluations that remain unresolved after 6 months from the date of report issuance.

If you have any questions or wish to discuss our findings, please contact Deana D. Scoggins, Senior Auditor, at (423) 785-4822 or E. David Willis, Director, Evaluations, at (865) 633-7376. We appreciate the courtesy and cooperation received from your staff during the evaluation.

David P. Wheeler
Assistant Inspector General
  (Audits and Evaluations)
WT 2C-K

DDS:FAJ
Attachment
cc (Attachment):
    TVA Board of Directors
    Janet J. Brewer, WT 7C-K
    Robertson D. Dickens, WT 9C-K
    Joseph P. Grimes, LP 6A-C
    William D. Johnson, WT 7B-K
    Dwain K. Lanier, MR 6D-C
    Justin C. Maierhofer, WT 7B-K
    Jill M. Matthews, WT 2C-K
    OIG File No. 2017-15516

TVA

Office of the Inspector General　　*Evaluation Report*

To the Senior Vice President,
Power Operations

HEAT RATE INPUT
CALCULATIONS

Senior Auditor
Deana D. Scoggins

Evaluation 2017-15516
June 30, 2018

<u>ABBREVIATIONS</u>

CC   Combined Cycle

MW   Megawatts

TVA   Tennessee Valley Authority

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APPENDIX

MEMORANDUM DATED JULY 24, 2018, FROM DAVID W. SORRICK
TO DAVID P. WHEELER

Evaluation 2017-15516 – Heat Rate Input Calculations

EXECUTIVE SUMMARY

Why the OIG Did This Evaluation

The Tennessee Valley Authority estimates the dispatch costs for coal and gas on a combination of elements including fuel pricing, physical operating characteristics,[i] estimates of variable operating and maintenance costs, and transmission penalty factors.[ii] Since heat rates[iii] are one of the primary physical characteristics used in the calculation of dispatch costs, we performed an evaluation to determine if inputs used in the development of heat rate curves were calculated accurately. The scope of our review was limited to the July 2017 heat rate updates for coal and combined cycle (CC) plants. We did not determine the impact of any inaccurate calculations.

What the OIG Found

We determined some of the inputs used for the July 2017 heat rate curves were not calculated correctly. Specifically, we determined the hourly heat rates were incorrect for four of the five CC plants. We also determined hourly reference heat rates[iv] were not calculated for 6 hours at one of the eight coal plants due to an incorrect generation range being used to calculate hourly reference heat rates. (TVA subsequently corrected the generation range during the course of our review.) Additionally, we were unable to verify the accuracy of the data used to calculate coal hourly reference heat rates due to inconsistencies in system settings or data not being available. Inaccurate calculations increase the risk of relying on erroneous information when making future dispatch decisions.

What the OIG Recommends

We recommend the Senior Vice President, Power Operations, (1) automate or identify methods to reduce inaccurate calculations in the CC hourly heat rate calculation process and (2) determine and document appropriate settings to be utilized in coal plant hourly reference heat rate calculations.

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[i] Physical operating characteristics quantify available generation and incremental fuel consumption rates.

[ii] Transmission Penalty Factor is a way of estimating how far the generation is from the load and indirectly, how the transmission losses are affected.

[iii] Heat rates are the common measure of system efficiency in a thermal power plant.

[iv] Reference heat rates are the heat rates that a particular plant achieved at a given megawatt generation level when the plant was first built.

TVA Management's Comments

In response to our draft report, TVA management provided planned actions to address each of the recommendations including: (1) implementing thermal performance modeling software for CC calculations and (2) documenting appropriate settings for coal plant data. TVA management's response also stated that the identified inaccuracies posed insignificant impacts. See the Appendix for TVA management's complete response.

Auditor's Response

Although management stated the identified inaccuracies posed insignificant impacts, we did not verify the accuracy of their analysis. We concur with TVA management's planned actions for the recommendations.

BACKGROUND

Electric utility companies, including the Tennessee Valley Authority (TVA), are faced with a range of options on how to meet customers' varying demand for electricity in the most reliable and economical manner. TVA has a diverse portfolio of energy resources it uses to meet system demand. TVA's portfolio of energy resources primarily includes the following types of plants: (1) nuclear; (2) coal fired; (3) hydroelectric; and (4) natural gas, which includes combustion turbine and combined cycle (CC)[1] plants. TVA attempts to use its blend of generating assets to meet load demand as economically as possible. As coal and natural gas prices fluctuate, TVA must continually evaluate which generating units are the most economical to commit and dispatch to meet demand at a given time.

The dispatch decision-making process[2] takes into consideration the dispatch costs, which are the variable operating costs of generating each additional megawatt hour. TVA estimates the dispatch costs for coal and gas based on a combination of fuel pricing, physical operating characteristics,[3] estimates of variable operating and maintenance costs, and transmission penalty factors.[4] Heat rates, which are part of the physical operating characteristics, are the common measure of system efficiency in a thermal power plant. In general, as the megawatts (MW) generated increase, heat rate is lowered and the plant becomes more efficient. While fuel pricing is the main influence on dispatch costs, heat rate is one of the primary physical characteristics that influences dispatch costs.

Heat rates are used to develop heat rate curves used in the dispatch decision-making process. Heat rate curves plot heat rates with corresponding MW generated. TVA currently updates heat rates for coal and CC plants approximately twice a year.

Heat Rate Calculations for Coal Plants – For coal plants, hourly reference heat rates[5] are calculated for each unit when generation is within a specified range. A factor (1+P) is then developed to adjust the reference heat rates to the current heat rates. For the update, a weighted average 1+P of the prior 48 bunker periods[6] is calculated. As seen in Figure 1 on the following page, the 1+P factor adjusts the reference heat rate curve to the actual heat rate curve, which is used in dispatch decisions.

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[1] A combined-cycle plant uses both a gas and a steam turbine together to produce up to 50 percent more electricity from the same fuel than a traditional combustion turbine (simple-cycle) plant.

[2] The dispatch decision-making process determines the level at which units run.

[3] Physical operating characteristics quantify available generation and incremental fuel consumption rates.

[4] Transmission Penalty Factor is a way of estimating how far the generation is from the load and indirectly, how the transmission losses are affected.

[5] Reference heat rates are the heat rates that a particular plant achieved at a given MW generation level when the plant was first built.

[6] There are four bunker periods per month. Each bunker period is determined based on the days of the month. For example, the first bunker period consists of days 1-7.
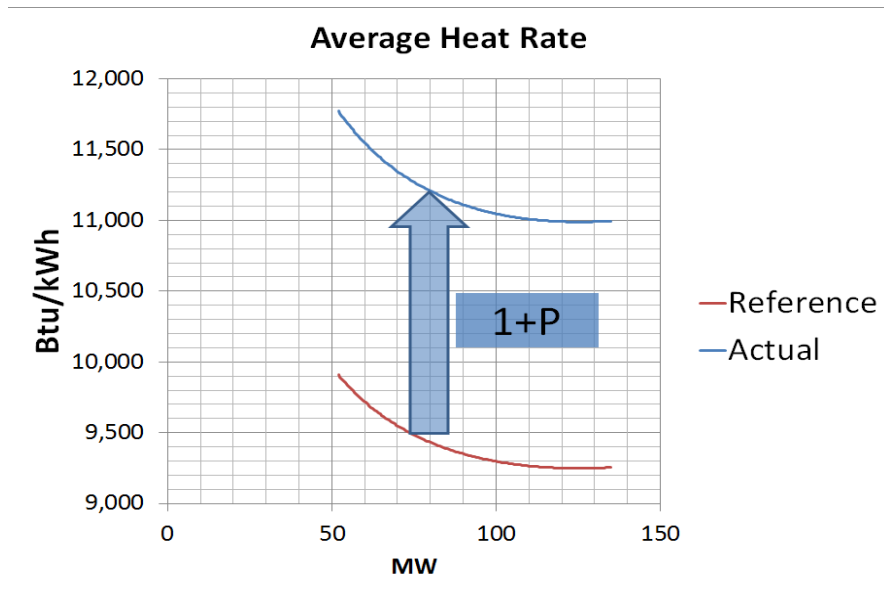
Average Heat Rate

Figure 1

Heat Rate Calculations for CC Plants – For CC plants, new heat rate curves are developed during each update and are based on hourly heat rates for the prior 12 months (at a minimum). As part of the process, three seasonal heat rate curves are developed based on the air temperature associated with the hourly heat rate. As seen in the figure below, each of the hourly heat rates (represented by circles in Figure 2) are plotted to develop heat rate curves.
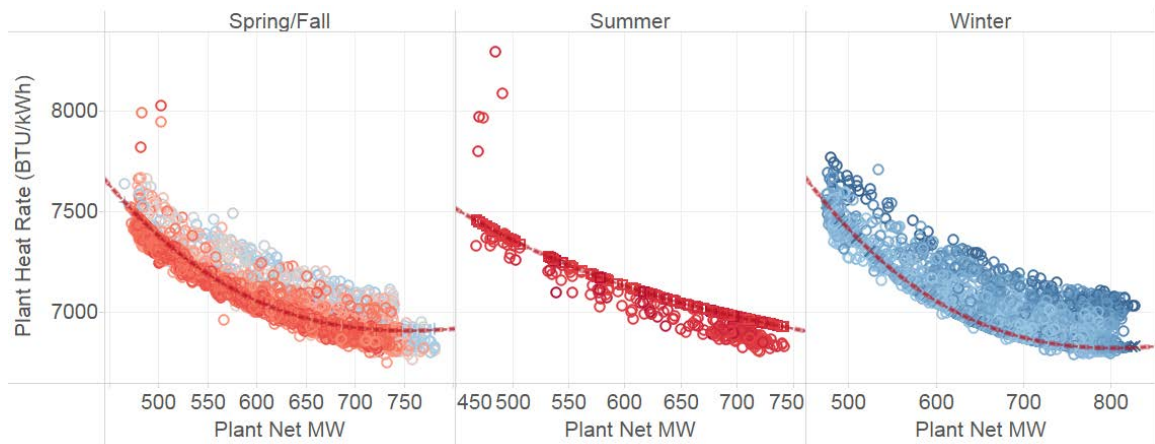

Figure 2

Since heat rates are one of the primary physical characteristics used in the calculation of dispatch costs, we performed an evaluation of the heat rate calculation.

OBJECTIVE, SCOPE, AND METHODOLOGY

The objective of this evaluation was to determine if inputs used in the development of heat rate curves were calculated accurately. We did not determine the impact of any inaccurate calculations. The scope of our review was limited to the July 2017 heat rate updates for coal and CC plants.[7] To achieve our objective, we:

- Interviewed TVA personnel to gain an understanding of the heat rate calculation process.

- Obtained the calculations and supporting documentation used in the July 2017 heat rate curve updates used as part of the dispatch decision-making process.

- Pulled the data from systems used by TVA to verify the correct data was used in heat rate calculations. We were unable to pull some data for coal calculations due to a lack of documented user settings for the program in which the data is stored.

- Reperformed the calculations for hourly reference heat rates and bunker period 1+P factors for coal plants to determine if those inputs were calculated accurately.

- Reperformed the calculations for hourly heat rates for CC plants to determine if this input was calculated accurately.

This evaluation was performed in accordance with the Council of the Inspectors General on Integrity and Efficiency's *Quality Standards for Inspection and Evaluation*.

FINDINGS

We determined some of the inputs used in the calculation of the July 2017 heat rate curves were not calculated correctly. Specifically, we determined the hourly heat rates were incorrect for four of the five CC plants. We also determined hourly reference heat rates were not calculated for 6 hours at one of the eight coal plants due to an incorrect generation range being used to calculate hourly reference heat rates. Additionally, we were unable to verify the accuracy of the data used to calculate coal hourly reference heat rates due to inconsistencies in system settings. Inaccurate calculations increase the risk of relying on erroneous information when making future dispatch decisions.

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[7] There were eight coal plants and five CC plants for which updates to the heat rates were conducted in July 2017. We did not include Ackerman CC because the July 2017 update was not conducted.

INCORRECT CC PLANT HEAT RATE INPUT CALCULATIONS

We determined heat rates were incorrect for four of five CC plants. Additionally, we determined temperatures used to classify heat rates into the appropriate seasonal heat rate curves were incorrect at four of five CC plants due to timing differences.

For CC plants, hourly heat rates were calculated on a unit and plant level for four of the five plants and only on a plant level for one of the five plants. Several of the data types used in the heat rate calculation must be manually adjusted because three systems that account for time differently are part of the process. As a result, the time has to be adjusted so data corresponds to the same time period. The hourly heat rates are then input into Tableau[8] to develop seasonal heat rate curves classified by temperature. The seasonal heat rate curves are then adjusted to meet dispatch system requirements.

We identified the following issues with regard to hourly heat rate calculations:

- Errors were made in the average heating values[9] for three of five plants. This impacted all hourly plant and unit heat rates calculated at those plants.

- Plant and unit heat rates were calculated using the incorrect net generation for one of five plants because of a failure to correct for timing differences discussed above.

- Unit heat rates were calculated using the incorrect gas flow for one of five plants. This was due to overcorrecting for timing differences discussed above. The plant heat rates, which are calculated separately, were calculated correctly for that plant.

- Temperatures for each hourly heat rate calculation were off by 1 hour for four of five CC plants due to a failure to correct for timing differences discussed above.

INCORRECT COAL PLANT REFERENCE HEAT RATE INPUT CALCULATIONS

In general, the July 2017 coal plant hourly heat rates and 1+P calculations were correct; however, we determined hourly reference heat rates were not calculated for 6 hours at one of the eight coal plants. This occurred because the formula, which was designed to calculate hourly reference heat rates when generation is within a specified range, used an incorrect range.

According to TVA personnel, net generation[10] should be used to determine the range hourly reference heat rates should be calculated. However, the hourly

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[8] Tableau is a platform used for data analytics.

[9] Heating value is a measure of the energy available from the fuel.

[10] Net generation is the energy provided to the grid at bulk transmission voltage from a generating plant or unit. It is equal to gross generation less the energy consumed by station auxiliaries (commonly called "station service" which includes energy losses in transformers required to raise generator voltage to transmission voltage).

reference heat rate formulas used a combination of "net" generation for the minimum MW to be included and "gross" generation for the maximum MW to be included. At one of the eight plants, this allowed for 6 hourly reference heat rates to be improperly excluded from being calculated. While these 6 hours should have had reference heat rates calculated, there was no impact to the 48 bunker period 1+P factor that was calculated. Additionally, the incorrect use of the gross generation impacted the formulas at six other coal plants; however, all of the hourly reference heat rates were calculated correctly. After discussions with TVA personnel, the issue was corrected during the course of this evaluation.

INCONSISTENT DATA SETTINGS

During our evaluation, we pulled data TVA used to calculate hourly reference heat rates for coal plants and hourly heat rates for CC plants from DatAWare.[11] However, we were unable to verify the data for the hourly reference heat rates for coal plants was correct. For four of eight coal plants, we were unable to repull data that matched what TVA used to calculate hourly reference heat rates. TVA personnel indicated this was most likely due to settings in DatAWare but they were unable to determine what settings were used. The TVA employee who calculated the 1+P's and hourly reference heat rates in our scope left TVA in late 2017. Since that time, the data being pulled from DatAWare has been pulled using different settings. This change has resulted in numerous differences between the data that was used and what would have been pulled with current settings. While issues with data settings were identified for coal plants, no issues were identified for CC plants.

<u>RECOMMENDATIONS</u>

We recommend the Senior Vice President, Power Operations:

- Automate or identify methods to reduce inaccurate calculations in the CC hourly heat rate calculation process.

- Determine and document appropriate settings to be utilized in coal plant hourly reference heat rate calculations.

TVA Management's Comments – In response to our draft report, TVA management provided planned actions to address each of the recommendations including: (1) implementing thermal performance modeling software for CC calculations and (2) documenting appropriate DatAWare settings for coal plant data. TVA management's response also stated that the identified inaccuracies posed insignificant impacts. See the Appendix for TVA management's complete response.

Auditor's Response – Although management stated the identified inaccuracies posed insignificant impacts, we did not verify the accuracy of their analysis. We concur with TVA management's planned actions for the recommendations.

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[11] DatAWare is used to collect, archive, and retrieve operational data from TVA's power plants.

July 24, 2018

David P. Wheeler, WT 2C-K

REQUEST FOR COMMENT - DRAFT EVALUATION 2017-15516 - HEAT RATE INPUT CALCULATIONS

Power Operations appreciates the opportunity to provide comments on the OIG's draft evaluation on Heat Rate Input Calculations dated June 25, 2018. In keeping with TVA policy pertaining to sensitive information, if this report is disclosed outside TVA it should not contain specific calculations, details, historical or real-time operational or performance data of any TVA assets.

What the OIG Found

- We determined some of the inputs used for the July 2017 heat rate curves were not calculated correctly. Specifically, we determined the hourly heat rates were incorrect for four of the five CC plants. We also determined hourly reference heat rates were not calculated for 6 hours at one of the eight coal plants due to an incorrect generation range being used to calculate hourly reference heat rates. (TVA subsequently corrected the generation range during the course of our review.) Additionally, we were unable to verify the accuracy of the data used to calculate coal hourly reference heat rates due to inconsistencies in system settings or data not being available. Inaccurate calculations increase the risk of relying on erroneous information when making future dispatch decisions.

Please see detailed response for findings under "Additional Comments" section starting on Page 3.

What the OIG Recommends

We recommend the Senior Vice President, Power Operations:

- Automate or identify methods to reduce inaccurate calculations in the CC hourly heat rate calculation process.
- Determine and document appropriate settings to be utilized in coal plant hourly reference heat rate calculations.

Our responses to the recommendations are as follows:

<u>Recommendation</u>

- Automate or identify methods to reduce inaccurate calculations in the CC hourly heat rate calculation process.

The identified inaccuracies posed insignificant impacts to commit and dispatch decisions due to the process and methodology currently used to determine CC heat rates. Power Operations is
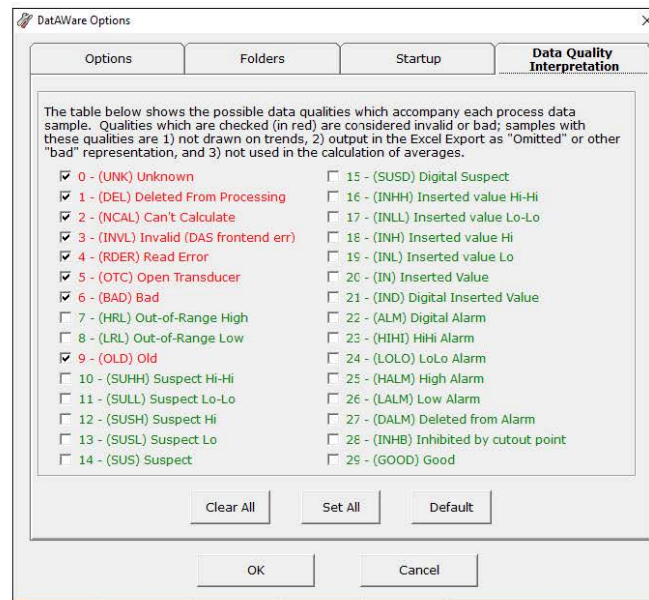
David P. Wheeler
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in the process of implementing a thermal performance modeling software. This software is being purchased with capital project funds and will be implemented starting this fiscal year (FY18) starting with Allen Combined Cycle. This software will allow TVA to automatically monitor unit performance, down to a component level; and calculate daily performance curves, eliminating the need for manual hourly calculations. In the interim, the current process will be modified to prevent inaccurate calculations and data entry.

Recommendation

- Determine and document appropriate settings to be utilized in coal plant hourly reference heat rate calculations.

Response

The coal plant calculations involve extracting unit data using a software called DatAWare, a data historian. The data collection settings in DatAWare will be documented in the procedure for data collection, *CO-SPP-09.050.01 – Operating Statistics & Station Economy Report Procedure*, by September 30, 2018. The settings are shown below:

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Under the Section "Incorrect CC Plant Heat Rate Input Calculations"

The report states "Errors were made in the average heating values for three of five plants."

Response: This impacted all hourly plant and unit heat rates calculated at those plants. The largest plant heat rate error resulted in an insignificant deviation of -0.045% in overall heat rate. Data entry error was likely the cause of all three errors. The installation of gas chromatographs as well as thermal performance modeling software as mentioned above will eliminate the risk of human errors.

The report states "Plant and unit heat rates were calculated using the incorrect net generation for one of five plants because of a failure to correct for timing differences discussed above."

Response: After correcting for timing differences and examining the largest deviation, the error equated to a +0.175% deviation. Process algorithms already in place prevented the error from reaching a significant magnitude that would alter commitment and dispatch decisions. The installation of thermal performance modeling software will eliminate the need for using multiple data sources in which time zones will need to be corrected.

The report states "Unit heat rates were calculated using the incorrect gas flow for one of five plants."

Response: This was due to overcorrecting for timing differences discussed above. The plant heat rates, which are calculated separately, were calculated correctly for that plant. After correcting gas flow error and examining the largest deviation, the error equated to a +0.547% deviation. Processes already in place, combined with aggregation of all admissible data prevented the error from reaching a significant magnitude that would alter commitment and dispatch decisions. As noted earlier, the installation of modeling software will eliminate the need for using multiple data sources in which time zones will need to be corrected.

The report states "Temperatures for each hourly heat rate calculation were off by 1 hour for four of five CC plants due to a failure to correct for timing differences discussed above."

Response: The 13-month hourly heat rate data points are aggregated by seasonal temperatures and have an inconsequential effect on the overall heat rate due to the size of the sample and aggregation of the seasonal curves. As noted earlier, the installation of modeling software will eliminate the need for using multiple data sources in which time zones will need to be corrected.

Additional Comments:

Under the Section "Inconsistent Data Settings"

In brevity, the report states that historical data analyzed from the selected month could not be duplicated due to unknown DatAWare settings. These settings could not be duplicated during

David P. Wheeler
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the course of this investigation, and the previous user left TVA for an outside opportunity. This applies only to the fossil heat rate calculations.

Response: The current settings will be documented in the data collection procedure, CO-SPP-09.050.01. This response fulfills Recommendation 2.

Please let us know if you have other questions or need additional information.

David W. Sorrick
Senior Vice President
Power Operations
LP 3K-C

JCW:MBB:TCH:MLG
cc: R. D. Dickens, WT 9C-K   D. K. Lanier, MR 6D-C
    K. G. Edmondson, LP 3K-C   OIG File No. 2017-15516
    J. P. Grimes, LP 6A-C