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From: Salamy, Jerry/SAC
To: "Vicky Lee"; stephen.okane@AES.com
Cc: John Yee; Andrew Lee; Beattie, Benjamin/SAC; Engel, Elyse/SJC
Subject: RE: AES Alamitos--AEC Questions Set No. 5
Date: Wednesday, February 17, 2016 9:40:00 AM

Hi Vicky,

Below are the responses to your questions. Please let me know if you have any questions on the responses.

Thanks,

28. Annual Fuel Usage and Heat Rates for Startups and Shutdowns
As you know, the maximum fuel consumption rates/annual heat inputs (MMBtu/yr) are used to calculate the toxic contaminants and greenhouse gas emissions. In reviewing the toxic contaminants annual emissions, I am unable to reproduce the annual heat inputs used.

a. Combined-Cycle Turbines

i. On page 5.1-19, *Table 5.1-21—Estimated Facility Fuel Use (MMBtu)* shows the maximum annual fuel consumption is 10,374,700 MMBtu/yr per combined-cycle turbine. In the AES Response Letter, dated 12/11/15, item 12.a.ii., *Table 12-1—Air Toxic Emission Rates Modeled for AEC Operation: Combustion Turbines* shows the annual toxic emissions per turbine. The annual emissions do not appear to be based on 10,374,400 MMBtu/yr. For example, the benzene would be 33.82 lb/yr based on 10,374,400 MMBtu/yr, instead of the 32.9 lb/yr in *Table 12-1*. What is the maximum annual fuel consumption rate on which the annual toxic emissions were based?

Response: The maximum annual fuel consumption rate used in Table 12-1 is calculated using the following equation:

2,250 (2249.5013 rounded up) Million British thermal units per hour (MMBtu/hr-HHV) x 4,612 hours/year = 10,374,400 MMBtu/yr per combined-cycle turbine.

The difference in the example annual benzene emission rate is due to a difference in gas heat content used in converting lb/MMscf emission factors to lb/MMBtu. The SCAQMD default natural gas heat content of 1,050 MMBtu/MMscf was used to convert the emission factors from units of lb/MMscf to lb/MMBtu. As such, the benzene emission factor used in the analysis was updated to a value of 3.17E-06 lb/MMBtu, derived from the 3.33E-03 lb/MMscf emission factor from AP-42, Section 3.1, Background Information, Table 3.4-1.

ii. The startup and shutdown rates do not appear to be based on the annual average heat input of 2250 MMBtu/hr. This is contrary to *Table 12-1,* footnote b, which indicates the annual emissions are based on 4612 hours of turbine operation with an average annual heat input of 2250 MMBtu/hr, which would result in 10,377,000 MMBtu/yr. The annual emissions in Table 12-1 do not appear to be based on 10,377,000 MMBtu/yr, which would result in benzene emissions of 33.83 lb/yr.

aa. What is the hot start fuel consumption rate? If not 2250 MMBtu/hr, please explain the basis.

Response: The maximum annual fuel consumption rate used in Table 12-1 is calculated using the following equation:

2,250 (2249.5013 rounded up) MMBtu/hr-HHV x 4,612 hours/year = 10,374,400 MMBtu/yr per combined-cycle turbine.

bb. What is the warm start fuel consumption rate? If not 2250 MMBtu/hr, please explain the basis.

Response: Please see the response to Item 28(a)(ii)(aa.) above.

cc. What is the cold start fuel consumption rate? If not 2250 MMBtu/hr, please explain the basis.

Response: Please see the response to Item 28(a)(ii)(aa.) above.

dd. What is the shutdown fuel consumption rate? If not 2250 MMBtu/hr, please explain the basis.

Response: Please see the response to Item 28(a)(ii)(aa.) above.

iii. As a summary, please show how the annual fuel consumption rate was derived by providing an equation with numerical values.

Response: The maximum annual fuel consumption rate used in Table 12-1 is calculated using the following equation:

2,250 (2249.5013 rounded up) MMBtu/hr-HHV x 4,612 hours/year = 10,374,400 MMBtu/yr per combined-cycle turbine.

b. <u>Simple-Cycle Turbines</u>

i. On page 5.1-19, *Table 5.1-21—Estimated Facility Fuel Use (MMBtu)* shows the maximum annual fuel consumption is 2,064,775 MMBtu/yr per simple-cycle turbine. As with the combined-cycle turbines, *Table 12-1—Air Toxic Emission Rates Modeled for AEC Operation: Combustion Turbines* shows the annual toxic emissions per simple-cycle turbine. The annual emissions do not appear to be based on 2,064,775 MMBtu/yr. For example, the benzene would be 6.73 lb/yr based on 2,064,775 MMBtu/yr, instead of the 6.55 lb/yr in *Table 12-1*. What is the annual fuel consumption rate on which the annual toxic emissions were based? (The discrepancies could be based on rounding differences.)

Response: The maximum annual fuel consumption rate used in Table 12-1 is calculated using the following equation:

876 (875.64673 rounded up) MMBtu/hr-HHV x 2,358 hours/year = 2,064,775 MMBtu/yr per simple-cycle turbine.

ii. The startup and shutdown rates do not appear to be based on the annual average heat input of 876 MMBtu/hr. This is contrary to *Table 12-1,* footnote c, which indicates the annual emissions are based on 2358 hours of turbine operation with an average annual heat input of 876 MMBtu/hr, which would result in 2,065,608 MMBtu/yr. The annual emissions in Table 12-1 do not appear to be based on 2,065,608 MMBtu/yr, which would result in benzene emissions of 6.73 lb/yr.

aa. What is the startup fuel consumption rate? If not 876 MMBtu/hr, what is the basis?

Response: The start up fuel consumption rate is 875.64673 (rounded up to 876) MMBtu/hr-HHV.

bb. What is the shutdown fuel consumption rate? If not 876 MMBtu/hr, what is the basis?

Response: Please see the response to Item 28(b)(ii)(aa.) above

iii. As a summary, please show how the annual fuel consumption rate was derived by providing an equation with numerical values.

Response: The maximum annual fuel consumption rate used in Table 12-1 is calculated using the following equation:

876 (875.64673 rounded up) MMBtu/hr-HHV) x 2,358 hours/year = 2,064,775 MMBtu/yr per simple-cycle turbine.

c. Auxiliary Boiler, Max Rating of 70.8 MMBtu/hr

i. In the AES Response Letter, dated 1/7/16, your response to item 11.b. shows the calculations to derive the maximum annual fuel consumption (MMBtu/yr). As previously discussed, the 35.3 MMBtu/hr (appx 50% load) is acceptable for the normal operating rate because the boiler is not operated at 100% load at all times.

Please explain why a fuel consumption of 41.36 MMBtu/hr is used for the cold, warm, and hot startups.

Response: The startup of the auxiliary boiler requires a slightly higher fuel consumption rate of 41.36 MMBtu/hr, which was provided by the auxiliary boiler vendor.

29. GHG BACT Analysis

a. Table 5.1B.24—Combined-Cycle: GHG BACT Analysis

i. The overall net heat rate includes 15 minutes of a hot/warm startup because "First fire to base load reached in 15 minutes."

aa. Since a warm start takes 30 minutes, how does the overall net heat rate account for the remaining 15 minutes of the startup during which the turbine is in base load?

Response: The 30 minute warm start up period is associated with heating the heat recovery steam generator (HRSG), steam turbine components, and emission control systems (the selective catalytic reduction and oxidation catalyst) to operating temperatures. For the purposes of assessing the overall net heat rate, warming of these systems is not required and the combined-cycle gas turbines (CCGT) can reach full load within 15 minutes of initiating a start up.

The overall net heat rate presented in Table 5.1B.24 is calculated using the following equation (all values are from Table 5.1B.24).

Overall Heat Rate (btu/kWh-LHV) = (6,454 Btu/kWh-LHV x 900 hours/year + 6314 btu/kWh-LHV x 3,200 hours/hear + 17,651 Btu/kWh-LHV x 127 hours/year + 10,591 Btu/kWh-LHV x 250 hours/year)/(250 hours/year + 127 hours/year + 3,200 hours/year + 900 hours/year) = 6,903 Btu/kWh-LHV

bb. Since a hot start takes 30 minutes, how does the overall net heat rate account for the remaining 15 minutes of the startup during which the turbine is in base load?

Response: The 30 minute hot start up period is associated with heating the HRSG, steam turbine components, and emission control systems (the selective catalytic reduction and oxidation catalyst) to operating temperatures. For the purposes of assessing the overall net heat rate, warming of these systems is not required and the CCGT can reach full load within 15 minutes of initiating a start up.

ii. The overall net heat rate incorporates 20 minutes of a cold startup because "First fire to base load reached in 20 minutes."

aa. Since a cold start takes 60 minutes, how does the overall net heat rate account for the remaining 40 minutes of the startup?

Response: The 60 minute cold start up period is associated with heating the HRSG, steam turbine components, and emission control systems (the selective catalytic reduction and oxidation catalyst) to operating temperatures. For the purposes of assessing the overall net heat rate, warming of these systems is not required and the CCGT can reach full load within 20 minutes of initiating a start up.

iii. The startup net heat rate, for the first 15 minutes of a hot/warm startup and the first 20 minutes of a cold startup, is assumed to be 17,651 Btu/kWh-LHV, which is assumed to be 2.5 times the 44% load heat rate (net plant heat rate for 1-on-1 is 7061 Btu/kWh-LHV at 44% load). What is this assumption based on?

Response: This assumption was based on inspection of the startup heat rate for other combustion turbines. These other combustion turbines had a minimum load heat input of 11,189 btu/kWh-LHV and start up heat rate of 18,267 btu/kWh-LHV. The ratio of the startup heat rate to the minimum load heat rate is approximately 1.6, which was increased to 2.5 to be conservative for AEC.

iv. The shutdown net heat rate, for the entire 30 minutes of a shutdown, is assumed to be 10,591 Btu/kWh-LHV, which is assumed to be 1.5 times the 44% load heat rate (net plant heat rate for 1-on-1 is 7061 Btu/kWh-LHV at 44% load). What is this assumption based on?

Response: This assumption was based on inspection of the shutdown heat rate for other combustion turbines. These other combustion turbines had a minimum load heat input of 11,189 btu/kWh-LHV and a shutdown heat rate 16,520 btu/kWh-LHV. The ratio of the shutdown heat rate to the minimum load heat rate is approximately 1.5.

v. Please explain how the capacity factor of 31.37 was calculated.

Response: The capacity factor of 31.37 was based on the data presented in Table 5.1B.24 using the following calculation.

Capacity Factor = [[245,993 kW (for 1 on 1 output) x 900 hours/year + 501,996 kW (for 2 on 1 output) x 3,200 hours per year]/[665,162 kW (for 2 on 1 output) x 8,760]] x 100 = 31.37 percent

b. Table 5.1B.23—Simple-Cycle: GHG BACT Analysis

i. The overall net heat rate includes 10 minutes of a startup because "Assumed 10 minutes from first fire to full load operation."

aa. Since a start takes 30 minutes, how does the overall net heat rate account for the remaining 20 minutes of the startup during which the turbine is in full operation mode?

Response: The 30 minute start up period is associated with heating emission control systems (the selective catalytic reduction and oxidation catalyst) to operating temperatures. For the purposes of assessing the overall net heat rate, warming of these systems is not required and the simple-cycle gas turbines (SCGT) can reach full load within 10 minutes of initiating a start up.

ii. The startup net heat rate, for the first 10 minutes of a startup, is assumed to be 25,897 Btu/kWh-LHV, which is assumed to be 2.5 times the 50% load heat rate (net heat rate is 10,359 Btu/kWh-LHV at 50%). What is this assumption based on?

Response: This assumption was based on inspection of the startup heat rate for other combustion turbines. These other combustion turbines had a minimum load heat input of 11,189 btu/kWh-LHV and start up heat rate of 18,267 btu/kWh-LHV. The ratio of the startup heat rate to the minimum load heat rate is approximately 1.6, which was increased to 2.5 to be conservative for AEC.

iii. The shutdown net heat rate, for the entire 13 minutes of a shutdown, is assumed to be 15,539 Btu/kWh-LHV, which is assumed to be 1.5 times the 50% load heat rate (net plant heat rate for 1-on-1 is 10,359 Btu/kWh-LHV at 50%). What is this assumption based on?

Response: This assumption was based on inspection of the shutdown heat rate for other combustion turbines. These other combustion turbines had a minimum load heat input of 11,189 btu/kWh-LHV and a shutdown heat rate 16,520 btu/kWh-LHV. The ratio of the shutdown heat rate to the minimum load heat rate is approximately 1.5.

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Cc: John Yee <JYee@aqmd.gov>; Andrew Lee <ALee@aqmd.gov>
Subject: AES Alamitos--AEC Questions Set No. 5

Stephen O'Kane and Jerry Salamy,

28. Annual Fuel Usage and Heat Rates for Startups and Shutdowns
As you know, the maximum fuel consumption rates/annual heat inputs (MMBtu/yr) are used to calculate the toxic contaminants and greenhouse gas emissions. In reviewing the toxic contaminants annual emissions, I am unable to reproduce the annual heat inputs used.

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annual emissions do not appear to be based on 10,374,400 MMBtu/yr. For example, the benzene would be 33.82 lb/yr based on 10,374,400 MMBtu/yr, instead of the 32.9 lb/yr in *Table 12-1*. What is the maximum annual fuel consumption rate on which the annual toxic emissions were based?

ii. The startup and shutdown rates do not appear to be based on the annual average heat input of 2250 MMBtu/hr. This is contrary to *Table 12-1,* footnote b, which indicates the annual emissions are based on 4612 hours of turbine operation with an average annual heat input of 2250 MMBtu/hr, which would result in 10,377,000 MMBtu/yr. The annual emissions in Table 12-1 do not appear to be based on 10,377,000 MMBtu/yr, which would result in benzene emissions of 33.83 lb/yr.

aa. What is the hot start fuel consumption rate? If not 2250 MMBtu/hr, please explain the basis.

bb. What is the warm start fuel consumption rate? If not 2250 MMBtu/hr, please explain the basis.

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iii. As a summary, please show how the annual fuel consumption rate was derived by providing an equation with numerical values.

b. <u>Simple-Cycle Turbines</u>

i. On page 5.1-19, *Table 5.1-21—Estimated Facility Fuel Use (MMBtu)* shows the maximum annual fuel consumption is 2,064,775 MMBtu/yr per simple-cycle turbine. As with the combined-cycle turbines, *Table 12-1—Air Toxic Emission Rates Modeled for AEC Operation: Combustion Turbines* shows the annual toxic emissions per simple-cycle turbine. The annual emissions do not appear to be based on 2,064,775 MMBtu/yr. For example, the benzene would be 6.73 lb/yr based on 2,064,775 MMBtu/yr, instead of the 6.55 lb/yr in *Table 12-1*. What is the annual fuel consumption rate on which the annual toxic emissions were based? (The discrepancies could be based on rounding differences.)

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aa. What is the startup fuel consumption rate? If not 876 MMBtu/hr, what is the basis?

bb. What is the shutdown fuel consumption rate? If not 876 MMBtu/hr, what is the basis?

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As always, thank you for your assistance.

Vicky Lee
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