DOCKETED

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Description:	Visible Plume Modeling Analysis - The attached corrected Visual Resource Appendix VR-1: Visible Plume Modeling Analysis will replace the Appendix VR-1: Plume Velocity Analysis in the Preliminary Staff Assessment docketed on June 24, 2016; TN 211973
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The attached corrected Visual Resource Appendix VR-1: Visible Plume Modeling Analysis will replace the Appendix VR-1: Plume Velocity Analysis in the Preliminary Staff Assessment docketed on June 24, 2016.

APPENDIX VR-1: VISIBLE PLUME MODELING ANALYSIS

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INTRODUCTION

The following provides the assessment of visible plumes for the proposed new GE7FA.05 combined-cycle turbines with heat recovery steam generators (HRSGs), GE LMS100PB simple-cycle turbines, and auxiliary boiler exhaust stacks for the Amended Huntington Beach Energy Project (HBEP). Staff completed a modeling analysis for the project owner proposed new gas turbines/HRSG and auxiliary boiler.

The Amended HBEP would be a natural-gas-fired, combined-cycle and simple-cycle, air-cooled electrical generating facility located on the site of the existing Huntington Beach Generating Station (HBGS) in Huntington Beach, California. The combined-cycle power block would consist of a two-on-one combined-cycle unit – two GE Frame 7FA.05 gas turbines, two unfired heat recovery steam generators (HRSGs), one steam turbine generator, one air-cooled condenser, one natural-gas-fired auxiliary boiler, and related ancillary equipment. The simple-cycle power block would include two GE LMS100 simple-cycle turbines and their separate ancillary equipment. The Amended HBEP would use dry cooling that would have no potential to create visible water vapor plumes.

SUMMARY OF THE DECISION

On October 29, 2014, the Energy Commission approved the HBEP as a 939 MW (nominal output) combined cycle power plant with two power blocks. Each power block would consist of three Mitsubishi Heavy Industries 501DA gas turbine generators coupled with one steam turbine, in a combined cycle configuration. The Final Commission Decision (CEC 2014bb) of HBEP concluded that power plants like the licensed HBEP produce high velocity, high temperature exhausts that disperse quickly, thereby minimizing the probability that visible plumes would form above the stacks. Therefore, Final Commission Decision concluded that no impact on visual resources would occur pertaining to formation of visible plumes from the licensed HBEP.

VISIBLE PLUME MODELING METHODS

PLUME FREQUENCY AND DIMENSION MODELING

The Combustion Stack Visible Plume (CSVP) model was used to estimate visible plume frequency for the gas turbines/HRSGs and auxiliary boiler. This model provides conservative estimates of visible plume frequency. This model utilizes hourly stack exhaust parameters and hourly ambient condition data to determine the visible plume frequency. This model is based on the algorithms of the Industrial Source Complex model (Version 2), that determine conditions at the plume centerline, but this model does not incorporate building downwash. Wind speeds are set to 1 m/s to represent calm hours.

CLOUD COVER DATA ANALYSIS METHOD

A plume frequency of 20 percent of seasonal (November through April) daylight no rain/fog high visual contrast (i.e. “clear”) hours is used as a plume impact study threshold trigger and to determine potential plume impact significance. The high visual contrast hour determination methodology is provided below:

The Energy Commission staff has identified a “clear” sky category during which plumes have the greatest potential to cause adverse visual impacts. For this project the meteorological data set[1] used in the analysis categorizes sky cover in 10% increments. Staff has included in the “Clear” category a) all hours with sky cover equal to or less than 10% plus b) half of the hours with total sky cover 20-90%. The rationale for including these two components in this category is as follows: a) plumes typically contrast most with sky under clear conditions and, when total sky cover is equal to or less than 10%, clouds either do not exist or they make up such a small proportion of the sky that conditions appear to be virtually clear; and b) for a substantial portion of the time when total sky cover is 20-90% and the opacity of sky cover is relatively low (equal to or less than 50%), this sky cover does not always substantially reduce contrast with plumes; staff has estimated that approximately half of the hours meeting the latter sky cover criteria can be considered high visual contrast hours and are included in the “clear” sky definition.

If it is determined that the seasonal daylight clear hour plume frequency is greater than 20 percent then plume dimensions are determined, and a significance analysis of the plumes is completed.

AMENDED HBEP VISIBLE PLUME MODELING ANALYSIS

GE 7FA.05 TURBINES/HRSGS PARAMETERS

Based on the stack exhaust parameters anticipated by the project owner (HBEP 2015a), the frequency of visual plumes can be estimated. The operating data for the GE 7FA.05 combined-cycle turbines/HRSGs stacks during full loads and average loads are provided in **Visible Plume Table 1**. The project owner anticipates each of the GE 7FA.05 combined-cycle turbines/HRSGs would operate up to 6,100 hours per year at steady state, plus 500 startups and 500 shutdowns (HBEP 2015a).

Staff noticed that the exhaust temperatures for the proposed new GE 7FA.05 turbines/HRSGs (from 216°F to 221°F at full loads) would be lower than the exhaust temperatures (from 358°F to 394°F at full loads [HBEP 2012a]) for the Mitsubishi Heavy Industries 501DA turbines approved by the Energy Commission in 2014. Therefore, staff expects the visual plume potential for the proposed new GE 7FA.05 turbines/HRSGs would be higher than that for the approved Mitsubishi Heavy Industries 501DA turbines.

[1] This analysis uses five-year (2010 through 2014) AERMET data at John Wayne Airport station, provided by the project owner for the air quality impact analysis. Staff processed and reformatted the data according to the data requirements of CSVP.

Visible Plume Table 1 shows that there would be up to 38°F difference in the stack exhaust temperatures between the full-load (230 MW nominal) and average-load (172.5 MW [75 percent load]) cases for the GE 7FA.05 turbines/HRSGs. However, there would not be much reduction in water contents. Staff expects that the average-load cases would result in more visible plume potential than the full-load cases for the proposed GE 7FA.05 turbines/HRSGs. In order to make sure the worst-case visible plume impacts are analyzed, staff has performed visible plume modeling analysis for both the full-load cases and the average-load cases.

Visible Plume Table 1
GE 7FA.05 Turbines/HRSGs Operating and Exhaust Parameters [a]

Parameters	GE Frame 7FA.05					
Stack Height (Feet)	150					
Stack Diameter (Feet)	20					
Ambient Temperature (°F)	32 (low)		65.8 (average)		110 (high)	
Ambient Relative Humidity	87%		58%		8%	
Operating Loads	Full	Average	Full	Average	Full	Average
Exhaust Temperature (°F)	216	178	213	175	221	198
Exhaust Moisture Content (% Mole Basis)	8.21	8.03	9.23	8.77	9.37	8.14
Exhaust Moisture Content (% by Weight) [b]	5.20	5.08	5.86	5.56	5.96	5.15
Exhaust Flow Rate (1000 lbs/hr)	4,360	3,523	4,302	3,381	4,268	3,042
Exhaust Average Molecular Weight	28.44	28.45	28.33	28.37	28.29	28.43

Source: HBEP 2015a and independent staff analysis
Notes:
[a] Values were extrapolated or interpolated between hourly ambient condition data points as necessary.
[b] Staff calculated the moisture content (% by weight) based on project owner provided data for moisture content (% by volume) and Molecular Weight.

GE 7FA.05 TURBINES/HRSGS VISIBLE PLUME MODELING ANALYSIS

Staff modeled the GE 7FA.05 turbines/HRSGs plumes using the CSVP model with a five-year (2010-2014) John Wayne meteorological data set. **Visible Plume Table 2** provides the CSVP model visible plume frequency results for full-load and average-load operations.

Since the plume frequency would be well below 20% of the seasonal (November through April) daylight clear hours for the operation of the GE 7FA.05 turbines/HRSGs, the corresponding plume dimensions were not estimated.

Visible Plume Table 2
Staff Predicted Hours with GE 7FA.05 Turbines/HRSGs Steam Plumes
John Wayne 2010-2014 Meteorological Data

Case	Available (hr)	Full Loads		Average Loads	
		Plume (hr)	Percent	Plume (hr)	Percent
All Hours	43,681	1	0.0%	144	0.3%
Daylights Hours	20,315	0	0.0%	12	0.1%
Daylight No Rain No Fog	20,107	0	0.0%	12	0.1%
Seasonal Daylight Hours*	9,136	0	0.0%	12	0.1%
Seasonal Daylight No Rain No Fog*	8,963	0	0.0%	12	0.1%
Seasonal Daylight Clear**	4,620	0	0.0%	3.5	0.1%

*Seasonal conditions occur anytime from November through April.
**Available hours based on seasonal daylight clear hours.

AUXILIARY BOILER PARAMETERS

The operating data for the auxiliary boiler stack during full load are provided in **Visible Plume Table 3**. The project owner estimated the annual emissions of the auxiliary boiler based on a conservative assumption of 8,760 hours of operation with 120 startups per year. However, staff expects that the auxiliary boiler would be operated much less than 8,760 hours per year because the purpose of the auxiliary boiler is to provide startup steam for the combined-cycle power block.

Visible Plume Table 3
Auxiliary Boiler Operating and Exhaust Parameters

Parameters	Auxiliary Boiler
Stack Height (Feet)	80
Stack Diameter (Feet)	3
Full Load Exhaust Temperature (°F)	318
Full Load Exhaust Moisture Content (% by weight)	10.03
Full Load Exhaust Volumetric Flow Rate (acfm)	29,473
Full Load Exhaust Mass Flow Rate (1000 lbs/hr) [a]	90
Full Load Exhaust Average Molecular Weight (% mole)	28.21

Source: HBEP 2015i and independent staff analysis
Notes:
[a] Staff calculated the exhaust flow rate in 1000 lbs/hr based on project owner provided data volumetric flow rate and exhaust temperature.

AUXILIARY BOILER VISIBLE PLUME MODELING ANALYSIS

Staff modeled the auxiliary boiler plumes using the CSVP model with a five-year (2010-2014) John Wayne meteorological data set. **Visible Plume Table 4** provides the CSVP model visible plume frequency results for the auxiliary boiler.

Visible Plume Table 4
Staff Predicted Hours with Auxiliary Boiler Steam Plumes
John Wayne 2010-2014 Meteorological Data

Case	Available (hr)	Plume (hr)	Percent
All Hours	43,681	104	0.2%
Daylights Hours	20,315	10	0.0%
Daylight No Rain No Fog	20,107	10	0.0%
Seasonal Daylight Hours*	9,136	10	0.1%
Seasonal Daylight No Rain No Fog*	8,963	10	0.1%
Seasonal Daylight Clear**	4,620	3.0	0.1%

*Seasonal conditions occur anytime from November through April.
**Available hours based on seasonal daylight clear hours.

Since the plume frequency would be well below 20% of the seasonal (November through April) daylight clear hours for the operation of the auxiliary boiler, the corresponding plume dimensions were not estimated.

VISIBLE PLUME POTENTIAL FOR GE LMS100PB TURBINES

Staff also reviewed the visible plume potential for the GE LMS100PB simple-cycle turbines. Based on the project owner provided exhaust gas characteristics and ambient air conditions (HBEP 2015a), staff concludes that there would be no visible water vapor plume potential for the GE LMS100PB simple-cycle turbines.

CONCLUSIONS

Visible water vapor plumes from the proposed new GE 7FA.05 turbines/HRSGs and the auxiliary boiler are expected to occur very infrequently, well below 20 percent of seasonal daylight clear hours. It would be unlikely that visible plumes would form above the GE LMS100PB simple-cycle turbines exhaust stacks. Therefore, no further visual impact analysis of the expected plume dimensions has been completed.

REFERENCES

CEC 2014bb - Final Commission Decision (TN 203309). Submitted to CEC/Docket Unit on November 4, 2014.

HBEP 2012a - AES Southland Development, LLC / Stephen O'Kane (TN 66003). Application for Certification (AFC), Volume I & II, dated, 06/27/2012. Submitted to CEC/Dockets on 06/27/2012.

HBEP 2015a - Petition to Amend With Appendices (TN 206087). CEC/Docket Unit on September 9, 2015.

HBEP 2015i - Data Responses, Set1 (Responses to Data Request 1-74) (TN 206858). Submitted to CEC/Docket Unit on December 7, 2015.