Mariposa Energy Project 09-AFC-3

Jass Singh <jass.singh2000@gmail.com>

Issues and Serious Concerns with Mariposa Power Plan

Dear Mr. Craig,

It was a pleasure meeting you on November 29th at the Mariposa Power Plant Workshop.

I would like to bring to your kind notice some of the concerns that Mountain House residents have:-

a) The input vectors, assumptions, hypothesis and data points taken in the Air dispersion model used are not accurate. Data points used are based on Tracy airport meteorological data. Mountain House wind pattern is different than Tracy. We suggest the applicant and CEC to conduct the study with data points collected from Mountain House instead of any other places to have accurate model with correct input vectors, assumptions, and hypothesis and data points. This study should be based on the wind pattern resting on Mountain house and wind pattern bouncing back from the hills. The flow of the wind tunnel immerging from San Francisco and resting on Mountain House shall be studied and its model shall be replicated in the air dispersion model taking worst scenarios with daily, weekly, monthly, quarterly and yearly data for wet, dry, temperature, velocity, pressure of the air.

Mountain House residents or experts should participate in this study and devote time in evaluating the outcome of the study along with CEC and applicant's scientist who will conduct the study. The whole simulation and air dispersion model should be run and shown with input vectors, assumptions, hypothesis and data points considered, to the team of Mountain House residents or experts.

I also suggest that the analysis should be compared to the attached report on visible plumes – modeling results studied in September 2002.

b) Socioeconomic Impact: Mountain House is a young city of around 10,000 residents; its master plan is to build the city to 10,000 homes. This city has undergone 60% foreclosure in last three years. The values have dropped over 50%. With power plant coming these values will further drop another 7 to 10%. The drop in 10% value in homes will be a loss of

10% of (10,000 homes over 20 yrs) x ($500,000 average home price over 20 yrs) = $500 Million loss in homes values, loss of property tax to San Joaquin county of $5 Million every year.

The job created by Mariposa Energy, LLC is very little as compared to loss of taxes to San Joaquin County. San Joaquin County with additional $5 Million property tax revenue can create additional jobs far more than what Mariposa Energy LLC can create.

I also suggest CEC to conduct the study that racial minorities of San Joaquin County and Mountain House are not impacted and affected by air pollution generated by Mariposa Energy LLC

c) Provide details on companies, organizations and entities with whom Mariposa Energy, LLC has mitigated and reason for mitigating with them and the reason for not providing mitigation plan for Mountain House residents who are socioeconomically distressed in this economy with racial minority population.

d) CEC shall create incentive for residents to Go Green by providing 3 yrs to generate equal amount of electricity through various methods including solar system so that the need of these picker power plant does not exist.

e) CEC shall update top management for investment on electric grid infrastructure so that the power plans be built in the remote location far away from population.

I highly suggest CEC and the application to take into consideration the above points to evaluate and conduct studies to justify building power plant near Mountain House. After this study CEC should conduct another workshop in Mountain House.

Pls. docket this letter for your record and also for the record of interveners and applicant.

Pls. feel free to contact me on my cell (408-828-1788).

Sincerely,

Jass Singh

VISIBLE PLUMES – MODELING RESULTS

Testimony of William Walters

INTRODUCTION

The following provides the assessment of the East Altamont Energy Center (EAEC) Project cooling tower and heat recovery steam generator (HRSG) exhaust stack visible plumes. Staff completed a modeling analysis for both the Applicant's proposed unabated cooling tower and HRSG designs, and potential plume abated designs.

ANALYSIS SUMMARY

Subsequent to the PSA plume analysis document, staff addressed Applicant comments and has remodeled the cooling tower, HRSG and auxiliary boiler using Sacramento meteorological data, and has evaluated cloud cover to determine high visual contrast plume hours. This section presents staff's revised modeling analysis of the cooling tower, HRSG and auxiliary boiler plumes. Data presented in the PSA plume analysis document that is not relevant to the final modeling approach has been purposely left out for clarity and easier reading.

A meteorological data comparison has been added to this analysis to show that staff's use of a Sacramento meteorological data set is an appropriate proxy for the project site, which is established through comparison with the Tracy/Brentwood meteorological data set provided by the Applicant. The numeric meteorological data comparison is presented in **Tables 1** and **2**. Staff chose to use the Sacramento meteorological data set because it includes visual obstruction and cloud cover data not available in the Tracy/Brentwood data set.

The cooling tower and HRSG plumes are predicted to occur more than 10% of seasonal daylight no rain no fog hours and are therefore analyzed in more depth with consideration of cloud cover to determine high visual contrast plume hours. **Tables 4** and **5** present the revised cooling tower modeling results, and **Table 7** provides the high visual contrast plume frequencies. Following **Table 7** are the 10th percentile plume dimensions determined for the cooling towers during high visual contrast hours. **Tables 9** and **10** present the revised HRSG modeling results, and **Table 11** provides the high visual contrast plume frequencies. Following **Table 12** are the 10th percentile plume dimensions determined for the HRSGs during high visual contrast hours.

The auxiliary boiler plumes were not predicted to occur more than 10% of seasonal daylight no rain no fog hours. **Table 13** presents the auxiliary boiler plume modeling results.

PROJECT DESCRIPTION

The project includes a linear 19-cell conventional wet cooling tower. The Applicant has not proposed any methods to abate visible plumes from the cooling tower.

The project includes three separate turbine/heat recovery steam generator (HRSG) systems, each with separate exhaust stacks. The project features very large duct firing capacity, which increases exhaust moisture content, and also features very low exhaust temperatures when duct firing, which combined with the high exhaust moisture content causes a much higher plume frequency potential than in other recent 7F frame turbine projects. The Applicant has not proposed to use any methods to abate visible plumes from the HRSG exhausts.

The project also includes an auxiliary boiler that will be used to provide steam as necessary for supplemental uses.

METEOROLOGICAL DATA ANALYSIS

Staff has reviewed the 1997-1999 Tracy/Brentwood, 1976 Stockton, and 1990-1993 Sacramento meteorological data sets and has determined that the Sacramento meteorological data set provides the most defendable proxy for this project location.

The Applicant discontinued using the Tracy/Brentwood data because present weather and visibility data were not available. Staff believes that the Tracy/Brentwood data is still the most useful data set for certain analyses that do not consider present weather or visibility, such as ground level plume fogging. Staff also believes that the conditions reflected by the Tracy/Brentwood data, namely temperature and relative humidity, should be reflected in the data set that is used to substitute for the Tracy/Brentwood data.

Table 1 compares monthly ambient data from various locations around the project site. **Table 1** shows that the average minimum, maximum, and medium temperatures are very similar for each of the locations shown in the table. Therefore, any of these locations should provide reasonable temperature data for staff's analysis of the project plumes. Unfortunately, similar statistics regarding relative humidity are not available for all of these weather monitoring locations, but they do not exist in the meteorological data files for Tracy/Brentwood, Sacramento and Stockton (see Table 2). Staff observes that the site is primarily influenced by winds coming from the Bay Area. Since the Tracy/Brentwood data set provides the nearest and most accurate temperature and relative humidity data for the project site, staff believes that the most comparable meteorological data set that also has weather conditions and visibility data should be used to determine plume impact potential for this site.

Table 1
Comparison of Average Temperatures

Byron	January	February	March	April	May	June	July	August	September	October	November	December
Avg. High	53 °F	61 °F	65 °F	71 °F	79 °F	86 °F	92 °F	91 °F	86 °F	77 °F	63 °F	53 °F
Avg. Low	36 °F	40 °F	44 °F	47 °F	52 °F	57 °F	60 °F	60 °F	57 °F	51 °F	43 °F	37 °F
Mean	45 °F	51 °F	55 °F	59 °F	66 °F	72 °F	76 °F	76 °F	72 °F	65 °F	54 °F	46 °F
Brentwood	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Avg. High	53 °F	60 °F	65 °F	71 °F	78 °F	85 °F	90 °F	89 °F	85 °F	77 °F	63 °F	53 °F
Avg. Low	35 °F	40 °F	42 °F	45 °F	50 °F	55 °F	56 °F	56 °F	54 °F	49 °F	42 °F	36 °F
Mean	45 °F	50 °F	54 °F	59 °F	65 °F	71 °F	74 °F	73 °F	70 °F	63 °F	53 °F	45 °F
Stockton	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Avg. High	53 °F	61 °F	66 °F	72 °F	80 °F	88 °F	93 °F	92 °F	87 °F	78 °F	64 °F	54 °F
Avg. Low	35 °F	39 °F	42 °F	45 °F	49 °F	54 °F	56 °F	55 °F	53 °F	48 °F	41 °F	36 °F
Mean	45 °F	51 °F	54 °F	59 °F	65 °F	72 °F	75 °F	74 °F	71 °F	64 °F	53 °F	45 °F
Tracy	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Avg. High	53 °F	61 °F	66 °F	72 °F	80 °F	88 °F	93 °F	92 °F	87 °F	78 °F	64 °F	54 °F
Avg. Low	35 °F	39 °F	42 °F	45 °F	49 °F	54 °F	56 °F	55 °F	53 °F	48 °F	41 °F	36 °F
Mean	45 °F	51 °F	54 °F	59 °F	65 °F	72 °F	75 °F	74 °F	71 °F	64 °F	53 °F	45 °F
Sacramento	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Avg. High	52 °F	60 °F	64 °F	71 °F	80 °F	87 °F	93 °F	92 °F	87 °F	77 °F	63 °F	52 °F
Avg. Low	37 °F	41 °F	43 °F	45 °F	50 °F	55 °F	58 °F	58 °F	55 °F	50 °F	43 °F	37 °F
Mean	45 °F	51 °F	54 °F	58 °F	65 °F	72 °F	76 °F	75 °F	72 °F	64 °F	53 °F	45 °F

Source: www.weather.com

Table 2 compares the temperature and relative humidity data of the three meteorological data sets.

Table 2
Meteorological Data Set Relative Humidity Comparison

Meteorological Data Set	Average Temperature	Average Relative Humidity
Tracy Brentwood 1997-1999	60.9°F	69.0%
Stockton 1976	59.8°F	59.6%
Sacramento 1990-1993	60.1°F	66.4%

Table 2 shows that the Sacramento data more closely resembles the Tracy/Brentwood data than does the Stockton data. Additionally, the Stockton data set includes only a single year of data. Staff considers multiple years of meteorological data to be necessary when modeling plume potential due to the variability in weather patterns from year to year. Considering these factors, staff does not believe that the Stockton data adequately reflects the conditions at the project site. Therefore, staff selected the Sacramento meteorological data set for the EAEC plume analysis.

CLOUD COVER DATA ANALYSIS METHOD

A plume frequency of 10% of seasonal (November through April) daylight hours is used as an initial plume impact threshold trigger, where if exceeded, the analysis is further refined by performing a high visual contrast hours analysis of the seasonal daylight no rain no fog plume hours. The high visual contrast hours analysis methodology is provided below:

The Energy Commission 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 total sky cover and opaque sky cover in 10% increments. Staff has included in the "Clear" category a) all hours with total sky cover equal to or less than 10% plus b) half of the hours with total sky cover 20-100% that have a sky opacity equal to or less than 50%. 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 20-100% and the opacity of sky cover is relatively low (equal to or less than 50%), clouds do not substantially reduce contrast with plumes; staff has estimated that approximately half of the hours meeting the latter sky cover and sky opacity criteria can be considered high visual contrast hours and are included in the "clear" sky definition.

[1] This analysis uses an Hourly US Weather Observations (HUSWO) data set.

COOLING TOWER DESIGN PARAMETERS

Using information provided in the Applicant's AFC (EAEC 2001a, AFC Section 8.11.2.4), Data Request Responses #6 and #114 to #120 (EAEC 2001n, pages 21-42; EAEC 2001p, pages 72-76; EAEC 2001ff, pages 4-6), and revised Data Response 117 (EAEC 2001gg, pages 1-4), staff performed an independent psychrometric analysis and dispersion modeling analysis to determine the expected frequency and dimensions of the project's proposed unabated wet cooling tower.

The following are the relevant cooling tower design characteristics, presented below in **Table 3**, were determined through a review of the Applicant's AFC and Data Request Responses, and through additional engineering calculations.

Table 3
Cooling Tower Design Parameters

Parameter	Cooling Tower Design Parameters
Stack Height[1]	17.37 meters
Number of Cells[1]	19 Cells (1 by 19 configuration)
Equivalent Stack Diameter[2]	44.72 meters (10.26 m per cell)
Tower Dimensions[1]	313 meter length by 16.4 meter width
Tower Heat Rejection[1]	807 MW/hr (duct fired)
Tower Inlet Air Flow Rate[1]	17,191 kg/s
Liquid to Gas (L/G) Ratio[1]	1.03 (hot and annual avg. weather), 0.57 (cold weather)
Exhaust Temperature[2]	48.6°F to 98.6°F
Exit Velocity[2]	Calculated hourly based on other parameters
Exhaust mass flow rate[2]	137,250,000 to 140,951,000 lbs/hr
Exhaust Molecular Weight[3]	28.8
Moisture Content (% by weight)[2]	0.73% to 3.30%

1. Source: EAEC 2001a, AFC Section 8.11.2.4, EAEC 2001n, pages 21-42, EAEC 2001p, pages 72-76, EAEC 2001ff, pages 4-6, and EAEC 2001gg, pages 1-4.
2. Source: Staff calculations based on or interpolated from the Applicant's cooling tower data.
3. Source: Staff assumption.

The exhaust temperature and exhaust mass flow rate values were calculated for the hourly ambient conditions modeled through linear interpolation and extrapolation of the data provided by the Applicant for three ambient conditions. The exhaust moisture content was determined by assuming saturated conditions at the calculated exhaust temperature.

Staff notes that the cooling tower parameters presented by the Applicant, particularly the low operating liquid to gas flow rates assumed during cold weather, may not reflect real world cooling tower operating parameters and may underestimate plume potential from the final cooling tower design once it is built and operating. In particular, staff is concerned with the potential need to reduce the tower air flow in cold weather to reduce the potential for ice formation within the tower.

It is the Applicant's contention that the reasonable worst-case plume formation scenario can be based on the plant is using their duct burners from 10 am to 8 pm to meet peak demand. Staff has incorporated this as a reasonable worst-case assumption in the modeling analysis. However, it should be noted that there are no specific requirements that would prohibit duct firing from 8 pm through 10 am. As duct firing increases the steam load, it also increases the heat rejection load to the cooling tower. Thus, the effect of this reasonable worst-case assumption is to substantially drop the exhaust temperature and moisture content from the cooling tower during the overnight and early morning hours. Therefore, the modeled plume frequencies and plume dimensions are determined to be lower than they might be if duct firing is employed from 8 pm through 10 am.

Additionally, the Applicant has indicated that they are going to operate the cooling tower without substantially reducing air flows whether operating with or without duct firing. When the cooling load is reduced the cooling tower could be operated with fewer cells on-line, with lower air flow through the cells, or without any change in the flow rate, as is assumed by the Applicant. Staff considers the Applicant's operating approach to be a de facto plume abatement method, which the model indicates will reduce the frequency of plumes. If the project owner were to employ either of the other two operating methods, the modeled plume frequencies would not change substantially from those modeled for the duct firing case, but the plume dimensions would be smaller due the reduced overall water mass flow rate being exhausted from the tower.

STAFF COOLING TOWER PLUME MODELING RESULTS

Staff modeled the cooling tower plumes using both a modified version of the Combustion Stack Visible Plume (CSVP) model and the Seasonal/Annual Cooling Tower Impact (SACTI) model. In general, staff finds the CSVP model to be more useful for predicting the frequencies and dimensions of the cooling tower plumes. However, the CSVP and SACTI modeling tools each have strengths and limitations. The CSVP model indicates hours when no plume is expected, thereby giving more accurate numbers for the plume frequencies. In addition, the CSVP model uses hourly meteorological data, which allows for greater specificity in the plume frequency analyses. SACTI can be used to provide information about the potential for ground level fogging (which is covered in the Traffic and Transportation section of this FSA), and can be used for plume dimension results comparison to determine if the CSVP model has over or under-predicted the dimensions of the plumes. Another difference is that the SACTI model is designed to model multiple cell cooling towers, whereas the CSVP model is a single point source model. Because the CSVP model is a single point source model, staff used both an equivalent stack diameter modeling approach and a single cell modeling approach (evaluated later in this report), when using CSVP for the analysis of plume dimensions.

As stated above, the CSVP model provides more accurate information about plume frequency. **Table 4** provides the CSVP model visible plume frequency results using the Sacramento 1990 to 1993 meteorological data.

Table 4
Staff Predicted Hours with Cooling Tower Steam Plumes
Sacramento 1990 to 1993 Meteorological Data

		Duct Fired		No Duct Firing		Limited Duct Firing	
	Total Hours Available	**Plume (hr)**	**Percent**	**Plume (hr)**	**Percent**	**Plume (hr)**	**Percent**
All Hours	34,980	20,302	58.0%	12,898	36.9%	15,301	43.7%
Daylight Hours	17,865	6,281	35.2%	3,187	17.8%	4,822	27.0%
Seasonal Daylight	8,004	4,772	59.6%	2,658	33.2%	4,187	52.3%
Seasonal* Daylight No Rain No Fog Hours	6,339	3,116	49.2%	1,098	17.3%	2,555	40.3%

*Seasonal conditions occur from November through April.

Staff's analysis of plume frequencies and plume sizes is based on the limited duct firing case. However, as can be seen in **Table 4**, the plume frequencies could be higher than that assumed for the limited duct firing case if there are more hours of duct firing, or lower if there are fewer hours of duct firing than assumed in the limited duct firing case.

For comparison the CSVP and SACTI model predicted plume size characteristics for the duct firing case are provided in **Table 5**. Staff found an error in the original stack diameter that staff input to the SACTI model. The corrected SACTI modeling results are reflected in this table.

Table 5 indicates that the SACTI model predicts smaller plumes than the equivalent stack CSVP modeling results and larger plumes than the CSVP single cell modeling approach. The SACTI model groups meteorological data and uses only 25 ambient temperature and relative humidity combinations and 9 separate wind speed and stability combinations, while there are actually over 19,600 combinations of temperature, relative humidity, wind speed and stability in the Sacramento meteorological data file, which are all modeled individually by the CSVP model. Therefore, the SACTI plume size results are marked by large step changes while the CSVP model provides a much smoother interpretation of the plume size curve. Additionally, the SACTI model does not model calm hours, which will create differences in the frequency size distribution results, as calm hours would be expected to have very large, specifically very high, plumes. Therefore, staff prefers that the CSVP model over SACTI because it provides a more accurate frequency size distribution of the plumes.

Table 5
Staff Predicted Duct Firing Cooling Tower Steam Plume Dimensions
Sacramento 1990 to 1993 Meteorological Data

	CSVP Model (Equivalent Stack – Duct Firing)			SACTI Model (Duct Firing)*			CSVP Model (Single Cell - Duct Firing)		
	Length (m)	Height (m)	Width (m)	Length (m)	Height (m)	Width (m)	Length (m)	Height (m)	Width (m)
All Hours									
50%	75	95	40	50-60	20-30	40-60	15	27	9
10%	3,490	375	230	800-900	90-100	140-160	584	139	49
Maximum	>5,000	5,186	2,070	>10,000	700-800	1,000-1,200	>5,000	901	686
Seasonal Daylight No Rain No Fog Hours**									
50%	No Plume	No Plume	No Plume	30-40	20-30	40-60	No Plume	No Plume	No Plume
10%	375	389	85	300-400	90-100	120-140	73	64	19
Maximum	>5,000	4,978	1,656	6000-7000	700-800	600-800	3,761	860	421

No Plume – Plumes are not predicted to occur at the listed frequency.
* SACTI height results are from the exhaust height of the cooling tower (17.37 meters), the length results do not include the length of the tower (313 meters). SACTI does not model the calm wind hours which comprised 5,127 hours for all hours, or 14.7% of all hours, and of the all hours plumes and 679 hours for seasonal daylight no rain no fog hours, or 10.7% of seasonal daylight no rain no fog hours. Calm condition plumes are very tall plumes due to the lack of wind induced horizontal mixing.
** Seasonal conditions occur from November through April.

Staff completed a confirmation modeling analysis using ISCST3 as shown in **Table 6**:

Table 6
Confirmation Modeling Analysis Results
Tracy/Brentwood 1997 to 1998 Meteorological Data

Date Modeled	ISCST3		CSVP (Equivalent Diameter Approach)		CSVP (Single Cell Approach)	
(YYMMDDHH)	Length (m)*	Height (m)	Length (m)*	Height (m)	Length (m)*	Height (m)
97011410	180	95	184	184	36	38
97011417	170	120	189	505	38	80
98122112	20	65	32	139	7	34
99010313	>7,000	450	>5,000	2,460	1,235	435
99020912	175	35	87	52	17	22
99042606	300	55	145	82	28	25

* These results are length from the tower, and do not include the length of the 313 meter cooling tower.

This modeling study indicates that the CSVP equivalent stack modeling approach provides conservative, but reasonable, plume dimensions, while the single cell approach dramatically underestimates the plume dimensions. Generally, the plume height may be moderately overestimated due to an increase in the buoyancy induced plume rise of the “combined” stacks using the equivalent stack diameter approach, and the lack of downwash calculations in CSVP. For certain circumstances, such as 100% relative humidity (such as during model hour 99010313) and during high wind conditions (such as during model hours 99020912 and 99042606) the plume length tends to be underestimated, while the plume height remains somewhat overestimated. However, calm hour plume sizes, using staff’s 1 m/s wind speed assumption, will generally be grossly underestimated. Due to the uncertainties in the meteorological conditions and the cooling tower exhaust conditions, staff believes that a conservative modeling analysis as provided by the equivalent diameter modeling approach is appropriate to determine potential visual impacts from cooling tower plumes, but staff recommends additional confirmation of the specific plume dimensions to be used in plume simulations.

Staff uses a plume frequency of 10% of seasonal (November through April) daylight no rain no fog high visual contrast hours as the threshold that triggers the need for a study of the visual impacts from the plumes. Both models predicted large plumes for more than 10% of seasonal daylight hours. Therefore, a cloud cover data analysis has been performed to determine the number of plume hours that occur during hours that are defined as high visual contrast hours. **Table 7** presents the results of the CSVP model plume hours cloud cover data analysis.

Table 7
Staff Predicted Cooling Tower Plume Hours by Cloud Cover Category

Plume Hours by Cloud Cover Type					
All		**Clear**		Scattered/Broken/Overcast	
Hrs	%	**Hrs**	**%**	Hours	%
2,555	40.3	**1,048**	**16.5**	1,507	23.8

* Percentiles calculated by dividing the number of plume hours by the reference number of seasonal daylight no rain no fog hours (6,339).

Cooling tower plumes will occur during clear conditions a total of 1,048 hours or 16.8% of seasonal daylight no rain no fog hours.

The 10th percentile clear sky plume dimensions are estimated by the CSVP model, using the equivalent stack diameter approach, as follows:

Length – 53 meters (174 feet)
Height – 91 meters (298 feet)
Width – 37.8 meters (124 feet)

The actual 10th percentile clear sky plume dimensions could be larger than those provided above if there are more hours of duct firing than assumed in the limited duct firing case, or smaller if there are fewer hours of duct firing than assumed in the limited duct firing case. These dimensions include the height of the tower (17.37 meters) but do not include the length of the tower, which is 313 meters long. Therefore, the actual visible plume length is 313 meters (1,027 feet) plus a portion of the 53 meter plume length, which depends on the angle of the wind relative to the long axis of the cooling tower.

The plume sizes given above were used by staff to complete the visual simulation of the cooling tower plumes during clear sky conditions. For the simulation the plume width is adjusted for the number and diameter of the cooling tower cells, and a vertical plume dimension component is determined by the model using an initial vertical dispersion term and standard rural land use classification calculations.

HRSG VISIBLE PLUME MODELING ANALYSIS

Staff evaluated the Applicant's Data Response #7 and #119 (EAEC 2001n, pages 42-61; EAEC 2001p, pages 74-76; EAEC 2001ff, pages 4-6) and performed an independent psychrometric analysis and dispersion modeling analysis. The CSVP model was used to estimate the worst-case potential plume frequency, and provide data on predicted plume length, width, and height for each HRSG stack.

HRSG PARAMETERS

Based on the revised stack exhaust parameters anticipated by the Applicant for each HRSG stack, the frequency and size of visual plumes can be estimated. The operating data for these stacks are provided in **Table 8**. The Applicant provided the revisedHRSG exhaust temperature parameters in revised Data Response 119 (EAEC 2001gg, pages 4-6).

Table 8
HRSG Stack Exhaust Parameters

	HRSG Stack Exhaust Parameters		
Parameter	**Unabated HRSG Full Load – With Duct Firing and Power Augmentation***	**Unabated HRSG Full Load – With Duct Firing, No Power Augmentation**	**Unabated HRSG Full Load – No Duct Firing or Power Augmentation**
Stack Height	53.34 meters		
Stack Diameter	5.64 meters		
Exhaust Temperature	342°K (155°F)	342°K (155°F)	360°K (188°F)
Exit Velocity	Calculated for each hour modeled		
Exhaust Mass Flow Rate	3,414,714 to 4,128,241 lbs/hr	3,196,873 to 3,910,400 lbs/hr	3,108,980 to 3,822,507 lbs/hr
Exhaust Molecular Weight	28.5 lbs/lb-mol (est.)		
Moisture Content (% by wt)	9.03 to 9.36%	7.15 to 7.48%	5.30 to 5.63%

* Unabated worst-case

STAFF HRSG PLUME MODELING ANALYSIS

The predicted HRSG visible plume frequencies estimated by the CSVP model using the revised HRSG exhaust temperatures and the Sacramento meteorological data are shown in **Table 9**.

Table 9
Staff Predicted Hours with HRSG Steam Plumes
Sacramento 1990-1993 Meteorological Data

		Staff Modeling Results	
		Unabated HRSG Worst Case	
	Available (hr)	**Plume (hr)**	**Percent**
All Hours	34,980	24,394	69.7%
Daylight	17,865	8,787	49.2%
Seasonal Daylight*	8,004	6,442	80.5%
Seasonal Daylight No Fog/No Rain*	6,339	4,777	75.4%
		Unabated HRSG – Duct Firing	
	Available (hr)	**Plume (hr)**	**Percent**
All Hours	34,980	18,148	51.9%
Daylight	17,865	5,433	30.4%
Seasonal Daylight*	8,004	4,433	55.4%
Seasonal Daylight No Fog/No Rain*	6,339	2,787	44.0%
		Unabated HRSG – No Duct Firing or Power Augmentation	
	Available (hr)	**Plume (hr)**	**Percent**
All Hours	34,980	4,465	12.8%
Daylight	17,865	1,006	5.63%
Seasonal Daylight*	8,004	995	12.4%
Seasonal Daylight No Fog/No Rain*	6,339	203	3.20%
		Limited Duct Firing	
	Available (hr)	**Plume (hr)**	**Percent**
All Hours	34,980	7,901	22.6%
Daylight	17,865	3,156	17.7%
Seasonal Daylight*	8,004	3,032	37.9%
Seasonal Daylight No Fog/No Rain*	6,339	1,740	27.4%

* Seasonal conditions occur from November through April.
Worst case - Duct firing and power augmentation on at maximum capacity.

Staff's analysis of plume frequencies and plume sizes is based on the limited duct firing case. However, as can be seen in **Table 9**, the plume frequencies could be much higher than that assumed for the limited duct firing case if there are more hours of duct firing or a significant amount of hours with steam injection power augmentation, or somewhat lower if there are fewer hours of duct firing than assumed in the limited duct firing case.

Table 10 presents the staff predicted HRSG plume dimensions for the limited duct firing case.

Table 10
Staff Predicted HRSG Steam Plume Dimensions (meters)
Revised HRSG Operating Data
Sacramento 1990-1993 Meteorological Data

	Limited Duct Firing Case		
All Hours	**Length (m)**	**Height (m)**	**Width (m)**
50%	No Plume	No Plume	No Plume
10%	637	178	54
5%	1,669	224	106
Maximum	>5,000	1,430	2,095
Daylight Hours			
50%	No Plume	No Plume	No Plume
10%	160	126	27
5%	452	263	52
Maximum	>5,000	1,430	2,045
Seasonal Daylight Hours No Fog No Rain*			
50%	No Plume	No Plume	No Plume
10%	142	127	25
5%	212	190	34
Maximum	3,995	1,388	459

* Seasonal conditions occur from November through April.
No Plume – Plumes are not predicted to occur at the listed frequency.

The actual plume dimensions could be larger than those shown in **Table 10** if there are more hours of duct firing than assumed in the limited duct firing case, or if there are a significant amount of hours with steam injection power augmentation; or smaller if there are fewer hours of duct firing than assumed in the limited duct firing case. The maximum plume dimensions occur when the relative humidity is 100%, which are generally characterized as hours with low visibility (rain, fog, or low visual range). Plume dimensions decrease rapidly as the relative humidity decreases from 100%.

A cloud cover data analysis has been performed to determine the number of HRSG plume hours that occur during clear sky condition hours. **Table 11** presents the results of the cloud cover data analysis.

Table 11
Staff Predicted HRSG Plume Hours Cloud Cover*

Plume Hours by Cloud Cover Type					
All		**Clear**		**Scattered/Broken/Overcast**	
Hours	**%**	**Hours**	**%**	**Hours**	**%**
1,740	27.4	745	11.8	995	15.7

* Percentiles calculated by dividing the number of plume hours by the reference number of seasonal daylight no rain no fog hours (6,339).

HRSG plumes will occur a total of 745 hours or 11.8% of clear, seasonal daylight no rain no fog hours.

The 10th percentile clear sky plume dimensions are estimated by the CSVP model as follows:

Length – 57.0 meters (187 feet)
Height – 87.0 meters (285 feet)
Width – 14.5 meters (47 feet)

As noted previously, the actual 10th percentile clear sky plume dimensions could be larger or smaller depending on the actual schedule for duct firing and steam injection.

The plume sizes given above were used by staff to complete the visual simulation of the HRSG plumes during clear sky conditions. For the simulation the plume width is adjusted for the diameter of the HRSG exhaust, and a vertical plume dimension component is determined by the model using an initial vertical dispersion term and standard rural land use classification calculations. It is possible that the plumes from the HRSGs will combine into one larger plume mass under certain conditions.

AUXILIARY BOILER VISIBLE PLUME MODELING ANALYSIS

The Applicant provided the following exhaust parameters for the auxiliary boiler.

Table 12
Auxiliary Boiler Exhaust Parameters

Parameter	Cooling Tower Design Parameters
Exhaust Temperature	325°F
Exhaust mass flow rate	110,513 lbs/hr
Exhaust Molecular Weight	27.71
Moisture Content (% by weight)	11.43%

Table 13 provides the CSVP model visible plume frequency results using the Sacramento meteorological data.

Table 13
Staff Predicted Hours with Auxiliary Boiler Steam Plumes
Sacramento 1990 to 1993 Meteorological Data

		Unabated Cooling Tower	
	Available (hr)	Plume (hr)	Percent
All Hours	34,980	6,885	19.7%
Daylight	17,865	1,059	5.9%
Seasonal Daylight	8,004	1.054	13.2%
Seasonal Daylight No Rain No Fog Hours*	6,339	371	5.9%

* Seasonal conditions occur from November through April.

A plume frequency of 10% of seasonal (November through April) daylight no rain/fog hours is used as a plume impact study threshold trigger. The CSVP model predicted plume frequencies less then 10% of seasonal daylight no rain/fog hours. Considering the low frequency of plume formation staff did not complete a plume dimension analysis for the auxiliary boiler.

It should be noted that the plume frequency results are based on continuous auxiliary boiler operation. The auxiliary boiler, however, will not operate 8760 hours per year, thereby further reducing the frequency of plume formation.

PLUME ABATEMENT METHODS

Effective plume abatement methods include air cooled condensers or wet/dry cooling systems for cooling tower plume abatement; and increasing stack temperature for HRSG plume abatement. As a comparison to the EAEC project, the proposed Tesla Power Plant Project (Tesla) is proposing a plume abated cooling tower and has higher HRSG exhaust temperatures than those proposed by EAEC, which for the Tesla project have resulted in predicted plume frequencies that are less than the significance thresholds that require visual impact analysis (i.e. insignificant plume impacts).

It should be noted that staff tried to obtain information regarding the ability to incorporate an economizer bypass to mitigate HRSG plumes, but the Applicant objected to the data request (EAEC 2001z) and did not provide the requested information.

COOLING TOWER PLUME ABATEMENT METHODS

Cooling tower plumes can be abated through cooling apparatus design modification. Two potential abatement methods are provided for discussion: 1) air-cooled condensers; and 2) wet/dry cooling systems. The use of once-through cooling would also eliminate plumes; however, this option is not available at this project location.

Air-Cooled Condensers (Dry Cooling)

Air-cooled condensers, in place of a wet cooling tower, completely eliminate the potential for plume formation; however, this technology is much more expensive (as much as 10 times as expensive) than a traditional cooling tower, requires more space, and creates a much higher structure that may itself impact project aesthetics. The operating costs are also higher due to the higher electrical demand for the fans. Based solely on economic criteria, a project developer will generally only consider air-cooled condensers for power plant installations when water constraints will not allow for wet cooling technologies. However, due to overriding environmental considerations (i.e. water use and visual impacts) many states, such as New York, Oregon, and Colorado to name a few, have mandated dry cooling for all or most of their new power projects that have been licensed within the last 15 years.

Wet/Dry Cooling Towers

Wet/dry cooling tower systems can also be used to lessen or completely eliminate plume formation during normal weather conditions. Wet/dry systems are also more expensive (approximately 1.5 to 3 times as expensive) than traditional cooling towers and have higher operating costs. However, the relative cost of these systems is decreasing as their use has become more frequent and more cooling tower manufacturers are entering this market. The size of these systems is dependent on the specific design; however, in general these towers will either increase the footprint size or the height compared to a conventional wet cooling tower. Water use will decrease in proportion to the heat duty of the dry section of the wet/dry tower. Noise emissions from wet/dry towers are dependent on the specific design, and are generally thought to be higher than for wet cooling, but in some cases are essentially equivalent to the noise emissions from conventional wet cooling towers.

Over-Sizing Tower Air Flow

Increasing tower air flow rates (i.e. decreasing L/G) can reduce the frequency, size and density of plume formation. The increase in air flow causes the exhaust temperature and moisture content to move down the saturation line which then requires less dispersion to dissipate the plume, resulting in less frequent and shorter plumes. This may be accomplished through providing oversized variable speed fans and motors and additional air intake area. However, this method is not as effective as the other plume abatement methods and would increase the size of the cooling tower, which may increase the capital cost as much as a wet/dry or hybrid design and would likely have a higher associated operating cost. Whether by design or not, the Applicant's cooling tower design in effect uses this method to reduce plume formation.

Power plants have recently been proposed that use all three of these design modifications to eliminate or mitigate cooling tower plumes. The appropriate abatement design is based on each project's plume sensitivity. According to Don Dobney of Marley Cooling Tower (Dobney 2001), due to the reasonably high winter temperatures in most of California, it is generally cheaper to add a small dry cooling section (i.e. like their "ClearFlow" design) to a cooling tower than oversize the airflow. This method would also be more effective and have lower operating costs.

HRSG PLUME ABATEMENT METHODS

There are two methods that can be used alone or together, to reduce HRSG plume formation. These two methods are 1) increasing the stack temperature, and 2) decreasing the water content of the exhaust.

Increase Stack Temperature

Stack temperature can be increased by transferring less heat in the HRSG. This method is relatively easy to monitor, but will result in a small loss in efficiency and total MW production. This method is used at the Crockett facility, where an economizer bypass is used to increase stack temperatures to eliminate HRSG plumes during cold weather. This method has also been proposed for several other facilities, including two other facilities proposed by the EAEC project Applicant.

Decrease Exhaust Water Content

The water content in HRSG exhausts comes from three major sources: 1) water from the ambient inlet air; 2) water produced in the combustion process; and 3) water added for power augmentation. It is not feasible or desirable to reduce the water content of the ambient air. Therefore, the most feasible method for the EAEC project to reduce the HRSG exhaust water content is to reduce duct firing or power augmentation. As can be seen in the plume frequency results provided in Table 5 reducing duct firing and power augmentation can lower the plume frequency significantly.
This method is generally not considered desirable to project applicants due to the fact that it restricts the operations and power output of the facility. However, it should be noted that power produced by duct firing is less efficient than power produced without duct firing, so limiting duct firing actually increases overall fuel efficiency.

STAFF ASSUMED PLUME ABATED DESIGN MODELING

Considering the frequent large plumes predicted for the proposed unabated cooling tower and HRSG designs, staff has modeled potential plume abated designs for consideration.

Staff performed this modeling analysis using the Tracy/Brentwood meteorological data set. After a comparison of the Stockton data set with the Tracy/Brentwood data set and other area data sets it was found that the single year Stockton data set had significantly lower average and median relative humidities, which would likely underestimate plume frequency and plume dimensions. Therefore, while staff did provide modeling results using both data sets, staff considers the Tracy/Brentwood meteorological data set to be more representative of site conditions.

Abated Cooling Tower Visible Plume Modeling Analysis

For comparison with the proposed project designs the following minimum plume abated designs have been assumed by staff and modeled for the cooling tower and HRSG:

Cooling tower abated to 38°F and 80% relative humidity as is currently proposed by Calpine for Russell City. Cooling tower operating data provided for Russell City has been used in this modeling analysis.

Table 14 provides the abated cooling tower plume frequency modeling results.

Table 14
Staff Predicted Hours with Abated Cooling Tower Steam Plumes
Tracy/Brentwood 1997 to 1999 Meteorological Data

		Abated Cooling Tower	
	Available (hr)	**Plume (hr)**	**Percent**
All Hours	26,280	2,027	7.71%
Daylight Hours	13,374	582	4.35%
*Seasonal Daylight Hours	6,000	582	9.70%

* Seasonal conditions occur from November through April.

It should be noted that 524 of the 582 daylight hours (90%) that are predicted to have a plume have ambient relative humidities at or above 95%; therefore, it is assumed that many of these hours would be during fog or rain hours that are not considered hours that are impacted by visual water vapor plumes. Therefore, staff expects that the actual operating plume frequency with the staff assumed abated cooling tower design would be well below the 10% seasonal daylight high constrast hour impact study threshold trigger value.

Abated HRSG Visible Plume Modeling Analysis

For comparison with the proposed project designs the following minimum plume abated designs have been assumed and modeled for the cooling tower and HRSG:

> HRSG with economizer bypass that would allow the stack temperature to be raised to a minimum of 270°F. Again, this is the same as the HRSG plume mitigation currently proposed by Calpine for Russell City.

Staff understands that the specific HRSG abatement design assumptions do not reflect the EAEC's high-powered density design; however, the Applicant did not respond to staff's request to provide project specific HRSG abatement information (CEC 2001i, page 5; EAEC 2001z, pages 1-3), so staff was forced to use the Russell City abatement design as a starting point in the HRSG abatement discussion for this project. Additionally, staff received revised HRSG exhaust temperature information and revised HRSG and cooling tower modeling analyses from the Applicant in November. This new information, and the project specific HRSG abatement design questions and considerations, will be addressed in the Final Staff Assessment. Staff has serious concerns about the visual impacts that would occur as a result of the unabated water vapor plumes predicted for this project, and we hope that the Applicant will work with us in a good faith effort to address our concerns and answer our questions regarding potential plume abatement designs.

Table 15 provides the abated HRSG plume frequency modeling results.

Table 15
Staff Predicted Hours with Abated HRSG Steam Plumes
Tracy/Brentwood 1997 to 1999 Meteorological Data

		Abated HRSG Worst Case	
	Available (hr)	**Plume (hr)**	**Percent**
All Hours	26,280	4,147	15.78%
Daylight	13,374	1,124	8.40%
Seasonal Daylight*	6,000	1,102	18.37%
		Abated HRSG – Duct Firing	
	Available (hr)	**Plume (hr)**	**Percent**
All Hours	26,280	1,609	6.12%
Daylight	13,374	492	3.68%
Seasonal Daylight*	6,000	492	8.20%
		Abated HRSG – No Duct Firing and No Power Augmentation	
	Available (hr)	**Plume (hr)**	**Percent**
All Hours	26,280	315	1.20%
Daylight	13,374	100	0.75%
Seasonal Daylight*	6,000	100	1.67%

* Seasonal conditions occur from November through April.
Worst case for plume is operating with duct firing and power augmentation on.

It should be noted that 805 of the 1,102 seasonal daylight hours (77%) that are predicted to have a plume during worst case operation have ambient relative humidities at or above 95%; therefore, it is assumed that most of these hours would be fog or rain hours that are not considered hours that are impacted by visual water vapor plumes. Additionally, it is reasonable to expect that maximum duct firing and power augmentation would not generally occur during the cold morning hours, before 10 am, where a plume is most frequently predicated to occur. Therefore, staff expects that the actual operating plume frequency with the staff assumed abated HRSG design would be well below the 10% seasonal daylight high contrast hour impact study threshold trigger value.

APPLICANT'S MODELING RESULTS REVIEW

The Applicant believes that staff's cooling tower and HRSG plume dimensions are overestimated, while staff believes that the Applicant's modeling approach has underestimated the cooling tower and HRSG plume dimensions. In general, the Applicant's plume frequency results agree closely with staff's modeling results and the modeled plume frequencies have not been at issue. Staff and the Applicant are reviewing each other's model source code to determine if there are any programming error's that may be partially to blame for the discrepancies in the plume dimension results.

Additionally, in their modeling assessment the Applicant used a 1976 Stockton meteorological data set which, as noted earlier in this assessment, does not provide a good meteorological data proxy for the EAEC project site. The Applicant's use of the

Stockton meteorological file causes their analysis to underestimate the project's cooling tower and HRSGs plume frequencies and plume dimensions.

A more detailed discussion of the modeling result issues for the cooling tower and HRSG are noted below.

COOLING TOWER COMPARISON

The Applicant, in their revised modeling analysis (EAEC 2002zz), used a model and modeling techniques that in many ways are similar to staff's CSVP model and modeling techniques. The difference between the way staff and the Applicant modeled the plumes has to do with the way in which the CSVP model was used. For the CSVP modeling runs, staff grouped the 19 cells into a single stack of equivalent diameter; while the Applicant did not attempt to group the cooling tower cells in any fashion, they modeled a single cooling tower cell at a time, without identifying plume interaction between the adjacent cells. The Applicant's modeling method only models $1/19^{th}$ of the entire exhaust volume (i.e. water emissions) from the cooling tower, which will cause the plume size from the 19-cell cooling tower to be severely underestimated. Therefore, the Applicant's current analysis cannot be used to describe the plume dimensions for the 19-cell cooling tower and their plume dimension modeling results cannot be directly compared to the results from staff's modeling analysis.

HRSG COMPARISON

In general, the Applicant's results indicate plumes that have lower lengths and heights than staff's estimates, but often with much larger plume widths. Staff is concerned that these large plume widths, which seem to be much larger than should be found using conventional rural land use classification calculations, indicate a potentially major problem with the Applicant's modeling program.

REFERENCES

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