January 3, 2013

VIA EMAIL

Ms. Felicia Miller, Siting Project Manager
California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

Re: Huntington Beach Energy Project (12-AFC-02)  
Submittal of Email Correspondence Related to Air Quality

Dear Ms. Miller:

On behalf of Applicant AES Southland Development, LLC, please find enclosed herein for docketing email correspondence among the Applicant, South Coast Air Quality Management District, and California Energy Commission Staff regarding air quality.

Should you have any questions regarding this submittal, please do not hesitate to contact me directly at 916.319.4673.

Respectfully submitted,

Kimberly J. Hellwig  
Paralegal

KJH:jmw
Enclosures
cc: Proof of Service List
From: stephen.okane@AES.com  
Sent: Tuesday, December 04, 2012 3:10 PM  
To: CPerri@aqmd.gov  
Cc: Robert.Mason@CH2M.com; Jerry.Salamy@CH2M.com; McKinsey, John A.; Foster, Melissa A.; Tao.Jiang@energy.ca.gov; Gerry.Bemis@energy.ca.gov  
Subject: Re: HBEP GHG emissions

Chris,
Sorry for the slow response I am on the road today. I have CH2M Hill pulling together a clear calculation for you on the CO2 emissions including our assumptions for actual operating conditions. We will provide that and our outstanding start up emissions tomorrow.

Stephen O'Kane
Sent from my mobile device

From: Chris Perri [mailto:CPerri@aqmd.gov]  
Sent: Tuesday, December 04, 2012 11:22 AM  
To: Stephen O'Kane  
Cc: Robert.Mason@CH2M.com; Jerry.Salamy@CH2M.com; 'JAMCKINSEY@stoel.com'; 'mafoster@stoel.com'; Tao.Jiang@energy.ca.gov; Gerry.Bemis@energy.ca.gov  
Subject: HBEP GHG emissions

Good morning Stephen-

I'm looking over the GHG portion of the project today. I noticed that the GHG emissions were calculated to be 1,082 lbs CO2/MW-hr (page 3-25). Could you provide (or point to where in the document) the detailed calculations to support this number? Thanks.

Chris Perri  
Air Quality Engineer  
South Coast Air Quality Management District  
(909) 396-2696

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From: Chris Perri [mailto:CPerri@aqmd.gov]
Sent: Wednesday, December 12, 2012 9:58 AM
To: Stephen O'Kane
Cc: Robert.Mason@CH2M.com; McKinsey, John A.; Foster, Melissa A.; Jerry.Salamy@CH2M.com; Miller, Felicia@Energy; 'Tao.Jiang@energy.ca.gov'; 'Gerry.Bemis@energy.ca.gov'
Subject: RE: HBEP start/stop emissions and GHG performance

Stephen,

Thanks. A follow up question on the start ups – at what point after start up would the SCR become functional?

Chris Perri
Air Quality Engineer
South Coast Air Quality Management District
(909) 396-2696

From: Stephen O'Kane [mailto:stephen.okane@AES.com]
Sent: Friday, December 07, 2012 4:34 PM
To: Chris Perri
Cc: Robert.Mason@CH2M.com; McKinsey, John A.; Foster, Melissa A.; Jerry.Salamy@CH2M.com; Miller, Felicia@Energy; 'Tao.Jiang@energy.ca.gov'; 'Gerry.Bemis@energy.ca.gov'
Subject: HBEP start/stop emissions and GHG performance

Chris,

In response to your questions regarding detail on the estimated start/stop emissions for the Huntington Beach Energy Project turbines and the assumptions that went in to our calculation of GHG emissions per MW-hr, please see the attached letter and accompanying data. If you require further information or explanation for any of our assertions please don’t hesitate to ask.

Thanks
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Chris,

The design engineers estimated that within 12.5 minutes of fuel initiation, the SCR would be reached the minimum operating temperature for ammonia injection to commence for either a hot, warm, or cold start. Therefore, the NOx removal efficiency is 0 percent for the first 12.5 minutes after fuel combustion is initiated and 70 percent thereafter.

For a hot or warm start, the oxidation catalyst system is functional at the initiation of combustion with an average CO and VOC removal efficiencies of 72 percent and 28 percent, respectively. For a cold start, the oxidation catalyst system reaches the minimum operating temperature at 4 minutes of initiating combustion and is fully functional by minute 9. The average CO and VOC removal efficiencies during the 9 minute period are 31 percent and 9 percent, respectively.

For shutdowns, the SCR and oxidation catalyst systems are functional over the entire shutdown period with an average NOx, CO, and VOC removal efficiencies of 30 percent, 80 percent, and 30 percent, respectively.

Thanks,

Jerry Salamy  
Principal Project Manager  
CH2M HILL/Sacramento  
Phone 916-286-0207  
Fax 916-614-3407  
Cell Phone 916-769-8919

---

From: Chris Perri [mailto:CPerri@aqmd.gov]  
Sent: Wednesday, December 12, 2012 9:58 AM  
To: Stephen O'Kane  
Cc: Mason, Robert/SCO; McKinsey, John A.; Foster, Melissa A.; Salamy, Jerry/SAC; Miller, Felicia@Energy;  
'Tao.Jiang@energy.ca.gov'; 'Gerry.Bemis@energy.ca.gov'  
Subject: RE: HBEP start/stop emissions and GHG performance

Stephen,

Thanks. A follow up question on the start ups – at what point after start up would the SCR become functional?

Chris Perri  
Air Quality Engineer  
South Coast Air Quality Management District  
(909) 396-2696
Chris,

In response to your questions regarding detail on the estimated start/stop emissions for the Huntington Beach Energy Project turbines and the assumptions that went into our calculation of GHG emissions per MW-hr, please see the attached letter and accompanying data. If you require further information or explanation for any of our assertions please don't hesitate to ask.

Thanks

Per: Stephen O'Kane
Permitting and Regulatory Approvals, Southland Repower Team

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Chris,

I will try to give you some insight into the fast start capabilities of our combined cycle design, without giving up any of our intellectual property. While we have pieced together off the shelf equipment in our design, it is the design of our fast start CCGT that we want to protect, which is primarily focused on the steam cycle.

Advances in gas turbine technology have largely focused on large industrial gas turbines to improve power density (unit size and MWs) and exhaust energy available to a heat recovery system (overall heat rate). The combination of these design considerations provides an economic benefit by employing fewer units to achieve a very high combined output and efficiency. However, these types of gas turbine combined cycle units require increasingly complex cooling schemes and the heat recovery components become very complex using multiple steam path flows (typically three) in a steam turbine that requires a large quantity of heat exchangers with unique material properties, in order for it to function with the high exhaust energy that is made available from the gas turbine. Thus, an unavoidable consequence of these large combined cycle applications are the limitations they place upon the thermal transient and speed by which these units can startup, heat-up and ramp from minimum to full power. It is also important to note that the efficiency of a gas turbine in a combined cycle application is not static, which is to say that heat rate increases significantly (efficiency drops considerably) when these types of units operate in partial load or off-base design conditions. These are systems designed for high efficiency, base load operations in an "always on" mode. In addition, the cost to start a large, advanced CCGT unit becomes very expensive as the maintenance accruals are very high per start.

AES has worked with all the gas turbine Original Equipment Manufacturer’s to identify gas turbines with a moderate base load output (100-120MW vs. 200-250 MW) and employ the most advanced design features (such as aero-derivative type components and Dry Low NOx combustion) such that the gas turbine retains rapid start capability and environmental performance. It should be noted that the fast start capability of the gas turbine alone is inherent in almost all gas turbine designs, it is the back-end steam cycle that limits the start and ramp speed. Consequently, AES has focused on the exhaust energy conditions of the candidate turbines to determine those that do not exceed the operating limits of
materials suited to the rapid cycling of a heat recovery system. By focusing on a simpler steam cycle and steam turbine (single pressure - single admission) different more malleable materials could be employed. The end result is the "uncoupling" of the steam cycle limitations from the fast start capability of the gas turbine, through the use of proven and robust steam cycle components. There is no limit imposed on the rapid start and loading of the gas turbine to its maximum output by the steam cycle regardless of time after shutdown, i.e. cold, warm or hot. Additionally, the use of mid-sized gas turbines in a 3-on-1 configuration allows the turndown of a single unit (multi-staged) rather than the turndown of the entire facility which results in improved part-load efficiency through the full range of operation; gas turbines are simply turned on and off in stages to retain base load-like performance of the remaining units in operation.

So without giving too much away, we have merely simplified the steam cycle so that we don't limit the gas turbine. While the full load efficiency of our units are not as high as the largest J-class CCGTs because they have not been designed to serve the same load and market, our 3-on-1 design outperforms any simple cycle configuration, including the most recently permitted (and under construction) plants in the SCAQMD. Our units meet or exceed the start and ramp capabilities of the LMS 100, but do it at heat rate about 1000 points lower and at lower NOx and VOC rates. The 501DA turbines are only 9ppm NOx machines (uncontrolled) vs the 25 ppm LMS 100.

I hope this information meets your needs.

Regards,

Stephen O'Kane

From: Chris Perri [mailto:CPerri@aqmd.gov]
Sent: Thursday, December 06, 2012 3:17 PM
To: Stephen O'Kane
Cc: 'Robert.Mason@CH2M.com'; 'Jerry.Salamy@CH2M.com'; 'JAMCKINSEY@stoel.com'; 'mafoster@stoel.com'; 'Tao.Jiang@energy.ca.gov'; 'Gerry.Bemis@energy.ca.gov'; John Yee
Subject: HBEP Fast Start Capabilities

Hi Stephen –

Your application states that the turbines can begin producing power within 10 minutes of a start, and the STGs are also able to produce power ‘almost immediately’ after a start with duct firing. I’d like to get some detailed discussion concerning the fast start capabilities of the Mitsubishi 501DA turbines. Can you provide information on what types of design considerations are incorporated into the turbines, the HRSGs, and other systems that allow these types of quick starts?

Thanks

Chris Perri
Air Quality Engineer
South Coast Air Quality Management District
(909) 396-2696

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From: Stephen O'Kane [mailto:stephen.okane@AES.com]
Sent: Tuesday, December 18, 2012 2:36 PM
To: Chris Perri
Cc: Robert.Mason@CH2M.com; 'Jerry.Salamy@CH2M.com'; McKinsey, John A.; Foster, Melissa A.; Miller, Felicia@Energy; John Yee; John Kistle
Subject: RE: Heat Rate Tables

Chris,

Your values are way off, not even close on heat rate. How did you come up with these? What other information are you using?

Stephen

From: Chris Perri [mailto:CPerri@aqmd.gov]
Sent: Tuesday, December 18, 2012 2:29 PM
To: Stephen O'Kane
Cc: Robert.Mason@CH2M.com; 'Jerry.Salamy@CH2M.com'; McKinsey, John A.; Foster, Melissa A.; Miller, Felicia@Energy; John Yee
Subject: Heat Rate Tables

Stephen,

I’m just now trying to complete my heat rate tables for the 2 on 1 and 1 on 1 cases. I’m using the information you provided in a previous email, however, I’m not coming up with the same heat rates. For the 2 on 1 case, I’ve tried to break it down on a per turbine basis (I also assumed that the net output is 96.6% of the gross output). For both cases, I assumed that HHV/LHV = 1.13. Could you look at these tables and tell me if I’ve misinterpreted the data you provided? Thanks.

2-on-1 Operation
Chris,

Here’s the data I can provide. If you really need the additional performance data at the other temperatures I will have to get our consultants to run some additional heat balance models. Please let me know as this is an extra expenditure and additional time to execute.

With these two temperature cases you can see the performance of the CCGT in both 1-on-1 and 2-on-1 modes. Additional data would merely show the same relative difference compared to the 3-on-1 case for different operating temperatures and humidities. Note the highlighted numbers. Our CCGT design actually provides the best performance on a heat rate basis (and consequently CO2e per MW) in the 2-on-1 case. Which is a big part of the design objective. Instead of the normal heat rate curve of a CCGT that deteriorates as output or load is decreased, this design will maintain a very constant heat rate across a wide range of output, and be able to ramp up and down output very quickly. Thus we achieve approximately 800-1,000 BTU/kwh better heat rate than a simple cycle LMS 100 and still provide the fast ramp and quick start support.
<table>
<thead>
<tr>
<th>Case</th>
<th>Gas Turbine Heat Input, mmbtu/h HHV</th>
<th>Total Heat Input, mmbtu/h HHV (w/duct fire)</th>
<th>Gas Turbine Gross Output, kW</th>
<th>Steam Turbine Gross Output, kW</th>
<th>Total Gross Power Output, kW</th>
<th>Total Net Power Output, Kw</th>
<th>Net Plant Heat Rate, btu/kWh, LHV</th>
<th>Net Plant Heat Rate, btu/kWh, HHV</th>
</tr>
</thead>
<tbody>
<tr>
<td>32 F – 87% RH</td>
<td>1,498</td>
<td>2,005</td>
<td>132,256</td>
<td>49,579</td>
<td>181,835</td>
<td>175,925</td>
<td>7,558</td>
<td>8,516</td>
</tr>
<tr>
<td>(Evaporative Cooling Off, Case 2)</td>
<td>1,388</td>
<td>1,895</td>
<td>121,435</td>
<td>51,865</td>
<td>173,300</td>
<td>167,583</td>
<td>7,354</td>
<td>8,285</td>
</tr>
<tr>
<td>ISO 59 F- 60% RH</td>
<td>1,403</td>
<td>1,910</td>
<td>121,840</td>
<td>50,192</td>
<td>172,032</td>
<td>166,328</td>
<td>7,487</td>
<td>8,435</td>
</tr>
<tr>
<td>(Evaporative Cooling Off)</td>
<td>1,354</td>
<td>1,861</td>
<td>115,962</td>
<td>48,523</td>
<td>164,485</td>
<td>158,901</td>
<td>7,508</td>
<td>8,459</td>
</tr>
<tr>
<td>66 F – 58% RH</td>
<td>1,350</td>
<td>1,857</td>
<td>115,264</td>
<td>43,632</td>
<td>158,896</td>
<td>153,352</td>
<td>7,814</td>
<td>8,803</td>
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<tr>
<td>(Evaporative Cooling On, Case 7)</td>
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</tr>
<tr>
<td>85 F - 45.75% RH</td>
<td>110 F-8% RH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>(Evaporative Cooling On)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
1. Cases 110F, 32F and 66F heat input taken directly from M501DA Gas Turbine Expected Performance and Emissions Provided by MPSA and included in Table 5.1B.2 of **HBEP_Appendix 5.1B_Ops Emissions Calcs.pdf**. ISO 59F Case Heat input taken from GT PRO model.

2. Total Heat Input per gas turbine with duct firing can only be achieved while operating in a 1-on-1 or 2-on-1 mode. The steam cycle is sized such that the maximum heat input into the steam cycle is reached in a 3-on-1 mode without duct firing.

3. All output is provided on a per turbine basis assuming a 3-on-1 operating mode. To calculate total output for the entire power block these values must be multiplied by 3.

Stephen

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**Sent:** Tuesday, December 18, 2012 2:29 PM  
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**Subject:** Heat Rate Tables

Stephen,

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### 2-on-1 Operation

<table>
<thead>
<tr>
<th></th>
<th>85 F – 46% RH (Evaporative Cooling On)</th>
<th>66 F – 58% RH (Evaporative Cooling On)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Turbine Heat Input, mmbtu/h HHV</td>
<td>1,354</td>
<td>1,403</td>
</tr>
<tr>
<td>Total Heat Input, mmbtu/h HHV (w/duct fire)</td>
<td>1,861</td>
<td>1,910</td>
</tr>
<tr>
<td>Gas Turbine Gross Output, kW</td>
<td>115,962</td>
<td>121,840</td>
</tr>
<tr>
<td>Steam Turbine Gross Output, kW</td>
<td>49,751</td>
<td>51,320</td>
</tr>
<tr>
<td>Total Gross Power Output, kW</td>
<td>165,713</td>
<td>173,160</td>
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<tr>
<td>Net Power Output, Kw</td>
<td>160,078</td>
<td>167,273</td>
</tr>
<tr>
<td>Net Plant Heat Rate, btu/kWh, LHV</td>
<td>10,288</td>
<td>10,104</td>
</tr>
<tr>
<td>Net Plant Heat Rate, btu/kWh, HHV</td>
<td>11,626</td>
<td>11,418</td>
</tr>
</tbody>
</table>
1-on-1 Operation

<table>
<thead>
<tr>
<th></th>
<th>85 F – 46% RH (Evaporative Cooling On)</th>
<th>66 F – 58% RH (Evaporative Cooling On)</th>
</tr>
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<tbody>
<tr>
<td>Gas Turbine Heat Input, mmbtu/h HHV</td>
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<td>121,840</td>
</tr>
<tr>
<td>Steam Turbine Gross Output, kW</td>
<td>49,382</td>
<td>47,192</td>
</tr>
<tr>
<td>Total Gross Power Output, kW</td>
<td>171,222</td>
<td>163,152</td>
</tr>
<tr>
<td>Net Power Output, Kw</td>
<td>163,611</td>
<td>155,661</td>
</tr>
<tr>
<td>Net Plant Heat Rate, btu/kWh, LHV</td>
<td>10,066</td>
<td>10,858</td>
</tr>
<tr>
<td>Net Plant Heat Rate, btu/kWh, HHV</td>
<td>11,375</td>
<td>12,270</td>
</tr>
</tbody>
</table>

From: Stephen O'Kane [mailto:stephen.okane@AES.com]
Sent: Thursday, October 25, 2012 4:40 PM
To: Chris Perri
Cc: Robert.Mason@CH2M.com; Jerry.Salamy@CH2M.com; McKinsey, John A.; Foster, Melissa A.; Miller, Felicia@Energy
Subject: RE: HBEP emission rates and modeling results

Chris,

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<table>
<thead>
<tr>
<th>Description</th>
<th>Case 110F</th>
<th>Case 66F</th>
<th>Case 32F</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Plant Heat Rate, btu/kWh, HHV (2-on-1)</td>
<td>8,516</td>
<td>8,285</td>
<td>8,435</td>
<td>8,459</td>
</tr>
<tr>
<td>Steam Turbine Gross Output, kW (2-on-1)</td>
<td>102,640</td>
<td>99,501</td>
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<tr>
<td>Total Gross Power Output, kW (2-on-1)</td>
<td>346,320</td>
<td>331,425</td>
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<tr>
<td>Total Net Power Output, Kw (2-on-1)</td>
<td>334,035</td>
<td>319,363</td>
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<td></td>
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<tr>
<td>Net Plant Heat Rate, btu/kWh, LHV (2-on-1)</td>
<td>7,337</td>
<td>7,408</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Plant Heat Rate, btu/kWh, HHV (2-on-1)</td>
<td>8,400</td>
<td>8,483</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<th>Case 66F</th>
<th>Case 32F</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam Turbine Gross Output, kW (1-on-1)</td>
<td>49,382</td>
<td>47,192</td>
<td></td>
<td></td>
</tr>
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<td>Total Gross Power Output, kW (1-on-1)</td>
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<td>163,611</td>
<td>155,661</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Plant Heat Rate, btu/kWh, LHV (1-on-1)</td>
<td>7,489</td>
<td>7,600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Plant Heat Rate, btu/kWh, HHV (1-on-1)</td>
<td>8,575</td>
<td>8,702</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
1. Cases 110F, 32F and 66F heat input taken directly from M501DA Gas Turbine Expected Performance and Emissions Provided by MPSA and included in Table 5.1B.2 of HBE_P_APPENDIX 5.1B_OPS EMISSIONS CALC.pdf. ISO 59F Case Heat input taken from GT PRO model.
2. Total Heat Input per gas turbine with duct firing can only be achieved while operating in a 1-on-1 or 2-on-1 mode. The steam cycle is sized such that the maximum heat input into the steam cycle is reached in a 3-on-1 mode without duct firing.
3. All output is provided on a per turbine basis assuming a 3-on-1 operating mode. To calculate total output for the entire power block these values must be multiplied by 3.

*Stephen*
Chris,

Here are some more heat rate data for various temperature and operating cases, including a summer temperature one-on-one duct firing case and a two-on-one duct firing case. We will also send over our assumptions and calculation method for calculating annual average CO2/MWh, which includes the contribution of duct firing under the assumed annual operating condition. As discussed, there are different assumptions that go into the different calculations for annual PM2.5 emissions; maximum month daily emissions; and predicted CO2/MWhr emissions. In each case we have made conservative assumptions to calculate the different regulatory requirements. One of the biggest differences our CCGT application will have compared to traditional supplemental fired CCGTs is how the duct burners are employed. The duct burners in our case are for ramp speed and not for power augmentation. It is not expected that the units would be parked at part load with duct firing and in the 3-on-1 case; we are physically constrained by the steam cycle and cannot duct fire with the three turbines at max load.

I hope this information helps. Additional information on our GHG calculations will follow shortly.

Stephen O'Kane

---

From: Chris Perri [mailto:CPerri@aqmd.gov]
Sent: Tuesday, December 18, 2012 2:29 PM
To: Stephen O'Kane
Cc: Robert.Mason@CH2M.com; 'Jerry.Salamy@CH2M.com'; McKinsey, John A.; Foster, Melissa A.; Miller, Felicia@Energy; John Yee
Subject: Heat Rate Tables
Stephen,

I’m just now trying to complete my heat rate tables for the 2 on 1 and 1 on 1 cases. I’m using the information you provided in a previous email, however, I’m not coming up with the same heat rates. For the 2 on 1 case, I’ve tried to break it down on a per turbine basis (I also assumed that the net output is 96.6% of the gross output). For both cases, I assumed that HHV/LHV = 1.13. Could you look at these tables and tell me if I’ve misinterpreted the data you provided? Thanks.

2-on-1 Operation

<table>
<thead>
<tr>
<th></th>
<th>85 F – 46% RH (Evaporative Cooling On)</th>
<th>66 F – 58% RH (Evaporative Cooling On)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Turbine Heat Input, mmbtu/h HHV</td>
<td>1,354</td>
<td>1,403</td>
</tr>
<tr>
<td>Total Heat Input, mmbtu/h HHV (w/duct fire)</td>
<td>1,861</td>
<td>1,910</td>
</tr>
<tr>
<td>Gas Turbine Gross Output, kW</td>
<td>115,962</td>
<td>121,840</td>
</tr>
<tr>
<td>Steam Turbine Gross Output, kW</td>
<td>49,751</td>
<td>51,320</td>
</tr>
<tr>
<td>Total Gross Power Output, kW</td>
<td>165,713</td>
<td>173,160</td>
</tr>
<tr>
<td>Net Power Output, Kw</td>
<td>160,078</td>
<td>167,273</td>
</tr>
<tr>
<td>Net Plant Heat Rate, btu/kWh, LHV</td>
<td>10,288</td>
<td>10,104</td>
</tr>
<tr>
<td>Net Plant Heat Rate, btu/kWh, HHV</td>
<td>11,626</td>
<td>11,418</td>
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</tbody>
</table>

1-on-1 Operation

<table>
<thead>
<tr>
<th></th>
<th>85 F – 46% RH (Evaporative Cooling On)</th>
<th>66 F – 58% RH (Evaporative Cooling On)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Turbine Heat Input, mmbtu/h HHV</td>
<td>1,354</td>
<td>1,403</td>
</tr>
<tr>
<td>Total Heat Input, mmbtu/h HHV (w/duct fire)</td>
<td>1,861</td>
<td>1,910</td>
</tr>
<tr>
<td>Gas Turbine Gross Output, kW</td>
<td>115,962</td>
<td>121,840</td>
</tr>
<tr>
<td>Steam Turbine Gross Output, kW</td>
<td>49,382</td>
<td>47,192</td>
</tr>
<tr>
<td>Total Gross Power Output, kW</td>
<td>171,222</td>
<td>163,152</td>
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<tr>
<td>Net Power Output, Kw</td>
<td>163,611</td>
<td>155,661</td>
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<tr>
<td>Net Plant Heat Rate, btu/kWh, LHV</td>
<td>10,066</td>
<td>10,858</td>
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<tr>
<td>Net Plant Heat Rate, btu/kWh, HHV</td>
<td>11,375</td>
<td>12,270</td>
</tr>
</tbody>
</table>

From: Stephen O'Kane [mailto:stephen.okane@AES.com]
Sent: Thursday, October 25, 2012 4:40 PM
To: Chris Perri
Cc: Robert.Mason@CH2M.com; Jerry.Salamy@CH2M.com; McKinsey, John A.; Foster, Melissa A.; Miller, Felicia@Energy
Subject: RE: HBEP emission rates and modeling results

Chris,

Here’s the data I can provide. If you really need the additional performance data at the other temperatures I will have to get our consultants to run some additional heat balance models. Please let me know as this is an extra expenditure and additional time to execute.
With these two temperature cases you can see the performance of the CCGT in both 1-on-1 and 2-on-1 modes. Additional data would merely show the same relative difference compared to the 3-on-1 case for different operating temperatures and humidities. Note the highlighted numbers. Our CCGT design actually provides the best performance on a heat rate basis (and consequently CO2e per MW) in the 2-on-1 case. Which is a big part of the design objective. Instead of the normal heat rate curve of a CCGT that deteriorates as output or load is decreased, this design will maintain a very constant heat rate across a wide range of output, and be able to ramp up and down output very quickly. Thus we achieve approximately 800-1,000 BTU/kwh better heat rate than a simple cycle LMS 100 and still provide the fast ramp and quick start support.

<table>
<thead>
<tr>
<th>Case Description</th>
<th>Gas Turbine Heat Input, mmmbtu/h HHV</th>
<th>Total Heat Input, mmmbtu/h HHV (w/duct fire)</th>
<th>Gas Turbine Gross Output, kW</th>
<th>Steam Turbine Gross Output, kW</th>
<th>Total Gross Power Output, kW</th>
<th>Total Net Power Output, Kw</th>
<th>Net Plant Heat Rate, btu/kWh, LHV</th>
<th>Net Plant Heat Rate, btu/kWh, HHV</th>
<th>Steam Turbine Gross Output, kW (2-on-1)</th>
<th>Total Gross Power Output, kW (2-on-1)</th>
<th>Total Net Power Output, Kw (2-on-1)</th>
<th>Net Plant Heat Rate, btu/kWh, LHV (2-on-1)</th>
<th>Net Plant Heat Rate, btu/kWh, HHV (2-on-1)</th>
<th>Net Plant Heat Rate, btu/kWh, LHV (1-on-1)</th>
<th>Net Plant Heat Rate, btu/kWh, HHV (1-on-1)</th>
<th>Net Plant Heat Rate, btu/kWh, LHV (1-on-1)</th>
<th>Net Plant Heat Rate, btu/kWh, HHV (1-on-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>32 F – 87% RH (Evaporative Cooling Off, Case 2)</td>
<td>1,498</td>
<td>2,005</td>
<td>132,256</td>
<td>49,579</td>
<td>181,835</td>
<td>175,925</td>
<td>7,558</td>
<td>8,516</td>
<td>346,320</td>
<td>334,035</td>
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</tr>
<tr>
<td>ISO 59 F - 60% RH (Evaporative Cooling Off)</td>
<td>1,388</td>
<td>1,895</td>
<td>121,435</td>
<td>51,865</td>
<td>173,300</td>
<td>167,583</td>
<td>7,354</td>
<td>8,285</td>
<td>331,425</td>
<td>319,363</td>
<td>7,337</td>
<td>8,400</td>
<td>8,483</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>66 F – 58% RH (Evaporative Cooling On, Case 7)</td>
<td>1,403</td>
<td>1,910</td>
<td>121,840</td>
<td>50,192</td>
<td>172,032</td>
<td>166,328</td>
<td>7,487</td>
<td>8,435</td>
<td>346,320</td>
<td>331,425</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>85 F - 45.75% RH (Evaporative Cooling On)</td>
<td>1,354</td>
<td>1,861</td>
<td>115,962</td>
<td>48,523</td>
<td>164,485</td>
<td>158,901</td>
<td>7,508</td>
<td>8,459</td>
<td>346,320</td>
<td>331,425</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>110 F - 8% RH (Evaporative Cooling On, Case 12)</td>
<td>1,350</td>
<td>1,857</td>
<td>115,264</td>
<td>43,632</td>
<td>158,896</td>
<td>153,352</td>
<td>7,814</td>
<td>8,803</td>
<td>346,320</td>
<td>331,425</td>
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<td></td>
</tr>
</tbody>
</table>

Notes:
1. Cases 110F, 32F and 66F heat input taken directly from M501DA Gas Turbine Expected Performance and Emissions Provided by MPSA and included in Table 5.1B.2 of HBEP_Appendix 5.1B_Ops Emissions Calcs.pdf. ISO 59F Case Heat input taken from GT PRO model.
2. Total Heat Input per gas turbine with duct firing can only be achieved while operating in a 1-on-1 or 2-on-1 mode. The steam cycle is sized such that the maximum heat input into the steam cycle is reached in a 3-on-1 mode without duct firing.
3. All output is provided on a per turbine basis assuming a 3-on-1 operating mode. To calculate total output for the entire power block these values must be multiplied by 3

Stephen
that any use, copying or distribution of this e-Mail, in whole or in part, is strictly prohibited. Please notify the sender by return e-Mail and delete this e-Mail from your system. Unless explicitly and conspicuously stated in the subject matter of the above e-Mail, this e-Mail does not constitute a contract offer, a contract amendment, or an acceptance of a contract offer. This e-Mail does not constitute consent to the use of sender's contact information for direct marketing purposes or for transfers of data to third parties.
Seventeen heat balance studies were performed to characterize various operating conditions of the HBEP equipment performance located in Huntington Beach, CA. Case 1 represents the base case full load operating information for three combustion turbines and one steam turbine operating a full load. The typical information shown in Figure 2.1-4 and also the text of the Application for Construction (AFC) is from Heat Balance 1a (Case 1) Three combustion turbines (at max. heat input) without Evaporative Cooling Operation at Site Ambient Average Temperature (SAAT) conditions.

Cases 2 thru 17 represent alternate scenarios used to develop expected plant output, heat rate, and operating conditions at various equipment configurations and ambient temperatures.

<table>
<thead>
<tr>
<th>Case</th>
<th>Heat Balance Number</th>
<th>Description</th>
<th>Ambient Temp Data Set</th>
<th>Dry Bulb (°F)</th>
<th>Wet Bulb (°F)</th>
<th>Relative Humidity (%)</th>
<th>Net Power (MW)</th>
<th>LHV Heat Rate (BTU/kWh)</th>
<th>Heat Input (MBTUh)</th>
<th>Flue Gas Flow (kpph/hr)</th>
<th>Flue Gas Temp (°F)</th>
<th>Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1a</td>
<td>Three combustion turbines (at max. heat input) w/o Evap. Cooling Operation</td>
<td>SAAT 65.8</td>
<td>56.8</td>
<td>57</td>
<td>488.8</td>
<td>7427</td>
<td>3630.9</td>
<td>9362</td>
<td>407</td>
<td>1</td>
<td></td>
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<tr>
<td>2</td>
<td>1b</td>
<td>Two combustion turbines (at max. heat input) w/o Evap. Cooling Operation</td>
<td>SAAT 65.8</td>
<td>56.8</td>
<td>57</td>
<td>326.9</td>
<td>7406</td>
<td>2420.6</td>
<td>624</td>
<td>389</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1c</td>
<td>One combustion turbine (at max. heat input) w/o Evap. Cooling Operation</td>
<td>SAAT 65.8</td>
<td>56.8</td>
<td>57</td>
<td>326.9</td>
<td>7406</td>
<td>2420.6</td>
<td>624</td>
<td>389</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2a</td>
<td>Three combustion turbines (at max. heat input) w/o Evap. Cooling Operation</td>
<td>SAAT 65.8</td>
<td>56.8</td>
<td>57</td>
<td>160</td>
<td>7564</td>
<td>1210.3</td>
<td>912</td>
<td>386</td>
<td>4</td>
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<tr>
<td>5</td>
<td>2b</td>
<td>Two combustion turbines (at max. heat input) w/o Evap. Cooling Operation</td>
<td>SAAT 65.8</td>
<td>56.8</td>
<td>57</td>
<td>326.9</td>
<td>7406</td>
<td>2420.6</td>
<td>624</td>
<td>389</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2c</td>
<td>One combustion turbine (at max. heat input) w/o Evap. Cooling Operation</td>
<td>SAAT 65.8</td>
<td>56.8</td>
<td>57</td>
<td>163.6</td>
<td>7561</td>
<td>1237.1</td>
<td>3170</td>
<td>388</td>
<td>6</td>
<td></td>
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<tr>
<td>7</td>
<td>3a</td>
<td>Three combustion turbines (at max. heat input) w/o Evap. Cooling Operation</td>
<td>SMMAAT 85</td>
<td>69.7</td>
<td>45.75</td>
<td>476.7</td>
<td>7508</td>
<td>3579.9</td>
<td>9200</td>
<td>408</td>
<td>7</td>
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<tr>
<td>8</td>
<td>3b</td>
<td>Two combustion turbines (at max. heat input) w/o Evap. Cooling Operation</td>
<td>SMMAAT 85</td>
<td>69.7</td>
<td>45.75</td>
<td>394.4</td>
<td>7473</td>
<td>2386.6</td>
<td>6134</td>
<td>390</td>
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<tr>
<td>9</td>
<td>3b(1)</td>
<td>Two combustion turbines (at max. heat input) w/o Evap. Cooling and Duct Burner Operation</td>
<td>SMMAAT 85</td>
<td>69.7</td>
<td>45.75</td>
<td>356.1</td>
<td>7769</td>
<td>2384.0</td>
<td>6151</td>
<td>383</td>
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<tr>
<td>10</td>
<td>3c</td>
<td>One combustion turbine (at max. heat input) w/o Evap. Cooling Operation</td>
<td>SMMAAT 85</td>
<td>69.7</td>
<td>45.75</td>
<td>155.7</td>
<td>7666</td>
<td>1193.3</td>
<td>3067</td>
<td>387</td>
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<tr>
<td>11</td>
<td>3c(1)</td>
<td>One combustion turbine (at max. heat input) w/o Evap. Cooling and Duct Burner Operation</td>
<td>SMMAAT 85</td>
<td>69.7</td>
<td>45.75</td>
<td>202.2</td>
<td>8121</td>
<td>1190.7</td>
<td>3087</td>
<td>356</td>
<td>11</td>
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</tr>
<tr>
<td>12</td>
<td>4a</td>
<td>Three combustion turbines (at min. heat input) w/o Evap. Cooling Operation</td>
<td>SMMAAT 85</td>
<td>69.7</td>
<td>45.75</td>
<td>345.9</td>
<td>7810</td>
<td>2701.8</td>
<td>7237</td>
<td>380</td>
<td>12</td>
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<tr>
<td>13</td>
<td>4b</td>
<td>Two combustion turbines (at min. heat input) w/o Evap. Cooling Operation</td>
<td>SMMAAT 85</td>
<td>69.7</td>
<td>45.75</td>
<td>229.5</td>
<td>7849</td>
<td>1801.2</td>
<td>4825</td>
<td>371</td>
<td>13</td>
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<tr>
<td>14</td>
<td>4b(1)</td>
<td>Two combustion turbines (at min. heat input) w/o Evap. Cooling Operation w/ portion of HRSG steam sent to ACC</td>
<td>SMMAAT 85</td>
<td>69.7</td>
<td>45.75</td>
<td>202.2</td>
<td>8907</td>
<td>1801.2</td>
<td>4825</td>
<td>371</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>4c</td>
<td>One combustion turbine (at min. heat input) w/o Evap. Cooling Operation</td>
<td>SMMAAT 85</td>
<td>69.7</td>
<td>45.75</td>
<td>110.5</td>
<td>8150</td>
<td>900.6</td>
<td>2412.3</td>
<td>368</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>5</td>
<td>Three combustion turbines (at max. heat input) w/o Evap. Cooling Operation (minimum winter site temperature of 1 hr. duration)</td>
<td>SMWAT 32</td>
<td>30.75</td>
<td>87.6</td>
<td>527.8</td>
<td>7490</td>
<td>3952.8</td>
<td>10065</td>
<td>411</td>
<td>16</td>
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</tr>
<tr>
<td>17</td>
<td>6</td>
<td>Three combustion turbines (at max. heat input) w/o Evap. Cooling Operation (maximum summer site temperature of 1 hr. duration)</td>
<td>SPSAT 110</td>
<td>67</td>
<td>7.31</td>
<td>460.1</td>
<td>7738</td>
<td>3580.1</td>
<td>9178</td>
<td>415</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>
Information Sources Used for Developing Heat Balance Cases

Heat balances information was obtained inputting manufacturer design information for combustion turbines (CT), heat recovery steam generators (HRSG) and steam turbine (ST) into the GT Pro Heat Balance Software Program. The centerline of the air intake is assumed to be 30 ft. elevation. The site elevation is 7 ft.

The weather data used for the heat balances use Santa Ana (John Wayne Airport), CA Weather Data (Dry Bulb, Wet Bulb, Relative Humidity). The Santa Ana weather data was obtained from the following internet websites:

- Average Wet Bulb: http://www.wrcc.dri.edu/htmlfiles/westcomp.wb.html
- Daily Max Dry Bulb: http://hurricane.ncdc.noaa.gov/cgi-bin/climatenormals/climatenormals.pl
- Daily Min Dry Bulb: http://hurricane.ncdc.noaa.gov/cgi-bin/climatenormals/climatenormals.pl
- MCWB: http://web.utk.edu/~archinfo/EcoDesign/escurriculum/weather_data/reports/los_angeles_ca.pdf
- Daily Max Wet Bulb: http://weather-warehouse.com/WeatherHistory/PastWeatherData_SantaAnaFireStn_SantaAna_CA_July.html
- Daily Min Wet Bulb: http://weather-warehouse.com/WeatherHistory/PastWeatherData_SantaAnaFireStn_SantaAna_CA_December.html
- 30 Year Max Dry Bulb: http://weather-warehouse.com/WeatherHistory/PastWeatherData_SantaAnaFireStn_SantaAna_CA_July.html
- 30 Year Min Wet Bulb: http://weather-warehouse.com/WeatherHistory/PastWeatherData_SantaAnaFireStn_SantaAna_CA_December.html
- 30 Year Max Wet Bulb: http://web.utk.edu/~archinfo/EcoDesign/escurriculum/weather_data/reports/los_angeles_ca.pdf
- 30 Year Min Wet Bulb: http://web.utk.edu/~archinfo/EcoDesign/escurriculum/weather_data/reports/los_angeles_ca.pdf

Various analytical methods were used to determine the dry and wet bulb temperatures and relative humidity data for four temperature cases:

1. Site Peak Summer Ambient Temperature (SAAT) is 65.8 °F (Dry Bulb) and 56.8 °F (Wet Bulb) and relative humidity (RH) of 57%.
2. Site Monthly Maximum Average Ambient Temperature (SMMAAT) is 85 °F (Dry Bulb) and 69.7 °F (Wet Bulb) and relative humidity (RH) of 45.75%.
3. The 30 year, one hour duration, Site Peak Summer Ambient Temperature (SPSAT) is 110 °F (Dry Bulb) and 67 °F (Wet Bulb) and relative humidity (RH) of 7.31%.
4. The 30 year, one hour duration, Site Minimum Winter Ambient Temperature (SMWAT) is 32 °F (Dry Bulb) and 30.75 °F (Wet Bulb) and relative humidity (RH) of 87.6%.
Legend for Typical Equipment Configuration for Huntington Beach Heat Balance Case

(If more than one combustion turbine is installed then the estimated operating information shown represents the sum of the number of combustion turbines modeled. Every combustion turbine represented is paired with its own HRSG)
Case 1

Case 1 Heat Balance Number 1a  Three Combustion Turbines Operating at Maximum Heat Input without Evaporative Cooling

Site Average Annual Temperature (SAAT), Dry Bulb 65.8 °F, Wet Bulb 56.8 °F, Relative Humidity 57%
Case 2

Case 2 Heat Balance Number 1b   Two Combustion Turbines Operating at Maximum Heat Input without Evaporative Cooling

Site Average Annual Temperature (SAAT), Dry Bulb 65.8° F, Wet Bulb 56.8° F, Relative Humidity 57%
Case 3

Case 3 Heat Balance Number 1c  One Combustion Turbine Operating at Maximum Heat Input without Evaporative Cooling

Site Average Annual Temperature (SAAT), Dry Bulb 65.8°F, Wet Bulb 56.8°F, Relative Humidity 57%
Case 4 Heat Balance Number 2a

Three Combustion Turbines Operating at Maximum Heat Input with Evaporative Cooling

Site Average Annual Temperature (SAAT), Dry Bulb 65.8 °F, Wet Bulb 56.8 °F, Relative Humidity 57%
Case 5

Case 5 Heat Balance Number 2b  Three Combustion Turbines Operating at Maximum Heat Input with Evaporative Cooling

Site Average Annual Temperature (SAAT), Dry Bulb 65.8 °F, Wet Bulb 56.8 °F, Relative Humidity 57%

January 2012
Case 6

Case 6 Heat Balance Number 2c  One Combustion Turbine Operating at Maximum Heat Input with Evaporative Cooling

Site Average Annual Temperature (SAAT), Dry Bulb 65.8 °F, Wet Bulb 56.8 °F, Relative Humidity 57%
Case 7

Case 7 Heat Balance Number 3a  Three Combustion Turbines Operating at Maximum Heat Input with Evaporative Cooling

Site Monthly Maximum Average Ambient Temperature (SMMAAT) is 85 °F (Dry Bulb) and 69.7 °F (Wet Bulb) and relative humidity (RH) of 45.75%
Case 8

Case 8 Heat Balance Number 3b  Two Combustion Turbines Operating at Maximum Heat Input with Evaporative Cooling

Site Monthly Maximum Average Ambient Temperature (SMMAAT) is 85 °F (Dry Bulb) and 69.7 °F (Wet Bulb) and relative humidity (RH) of 45.75%
Case 9

Case 9 Heat Balance Number 3b(1)  Two Combustion Turbines Operating at Maximum Heat Input with Evaporative Cooling and Duct Burner

Site Monthly Maximum Average Ambient Temperature (SMMAAT) is 85 °F (Dry Bulb) and 69.7 °F (Wet Bulb) and relative humidity (RH) of 45.75%
Case 10

Case 10 Heat Balance Number 3c  One Combustion Turbine Operating at Maximum Heat Input with Evaporative Cooling

Site Monthly Maximum Average Ambient Temperature [SMMAAT] is 85 °F (Dry Bulb) and 69.7 °F (Wet Bulb) and relative humidity (RH) of 45.75%
Case 11

Case 11 Heat Balance Number 3c(1) One Combustion Turbine Operating at Maximum Heat Input with Evaporative Cooling and Duct Burning

Site Monthly Maximum Average Ambient Temperature (SMMAAT) is 85 °F (Dry Bulb) and 69.7 °F (Wet Bulb) and relative humidity (RH) of 45.75%
Case 12

Case 12 Heat Balance Number 4a  Three Combustion Turbines Operating at Minimum Heat Input without Evaporative Cooling

Site Monthly Maximum Average Ambient Temperature (SMMAAT) is 85 °F (Dry Bulb) and 69.7 °F (Wet Bulb) and relative humidity (RH) of 45.75%
Case 13

Case 13 Heat Balance Number 4b  Two Combustion Turbines Operating at Minimum Heat Input without Evaporative Cooling

Site Monthly Maximum Average Ambient Temperature (SMMAAT) is 85 °F (Dry Bulb) and 69.7 °F (Wet Bulb) and relative humidity (RH) of 45.75%
Case 14

Case 14 Heat Balance Number 4b(1)  Two Combustion Turbines Operating at Minimum Heat Input without Evaporative Cooling w. portion of HRSG steam sent to ACC

Site Monthly Maximum Average Ambient Temperature (SMMAAT) is 85 °F (Dry Bulb) and 69.7 °F (Wet Bulb) and relative humidity (RH) of 45.75%
Case 15

Case 15 Heat Balance Number 4c  One Combustion Turbine Operating at Minimum Heat Input without Evaporative Cooling

Site Monthly Maximum Average Ambient Temperature (SMMAAT) is 85 °F (Dry Bulb) and 69.7 °F (Wet Bulb) and relative humidity (RH) of 45.75%
Case 16

Case 16 Heat Balance Number 5  Three Combustion Turbines Operating at Maximum Heat Input without Evaporative Cooling

Site Minimum Winter Ambient Temperature (SMWAT) is 32 °F (Dry Bulb) and 30.75 °F (Wet Bulb) and relative humidity (RH) of 87.6%
Case 17

Case 17 Heat Balance Number 6  Three Combustion Turbines Operating at Maximum Heat Input with Evaporative Cooling

Site Peak Summer Ambient Temperature (SPSAT) is 110 °F (Dry Bulb) and 67 °F (Wet Bulb) and relative humidity (RH) of 7.31%
Chris,

As promised, here is the additional information on GHG calculations and heat rates including heat rates with duct burning at the 710 average temperature case. We have revised our December 7, 2012 response to Data Request DR7 to clarify how the heat rates and pounds of CO2 per megawatt-hour were calculated. Attached are revised Tables DR7-1R and DR7-3R.

Revised Table DR7-1R presents the same information included in the December 7th submittal, but includes clarifying notes to show where duct burners are being used during each state of power generation. As I already mentioned, duct burners are being used during turbine start ups to close the electrical production gap when the second and third turbine of each power block is started. AES would not operate all three turbines per power block with duct burners firing (nor is this thermally feasible due to the physical rating of the steam turbines). In addition to denoting duct burner usage, we have included a note on the 1 power block table that explains that the states represent the number of turbines in operation (State 1 is a 1 on 1 configuration, State 2 is a 2 on 1 configuration, etc.).

Revised Table DR7-3R includes additional notes explaining how the weighted annual average heat rate (with starts and stops but no degradation) and the CO2 efficiency were calculated. Briefly, we calculated the weighted annual average heat rate by multiplying the average heat rate (including duct burner operation) for each State by the number of hours for that State plus the start up and shutdown heat rates (again multiplied by the number of assumed operating hours for each). This product was divided by the total number of operating hours. The average heat rate of each State was used to represent a realistic heat rate for each State. It is unlikely that HBEP will be called on to operate a significant number of hours at a 70% turbine load rate. Likewise, since the duct burners are not intended to be used as peaking capacity, AES does not expect to operate in the duct fired mode for a significant number of hours. Therefore, the average heat rate for each State was used as a conservative assumption to approximate how HBEP is expected to operate. Below is the annual average heat rate calculation:
The CO2 efficiency was calculated by assuming an 8% degradation on the plant gross heat rate \((7740 \text{ btu/kWh gross} / (1 - 0.08)) = 8413 \text{ btu/kWh gross}) and using the natural gas CO2 emission factor of 53.02 kg CO2/MMBtu-HHV. Below is the calculation:

\[(8413 \text{ btu/kWh} \times 1000 \text{ kWh/MWh} \times 1.1 \text{ HHV/LHV} \times 1\times10^{-6} \text{ MMBtu/Btu} \times 53.02 \text{ kg CO2/MMBtu-HHV} \times 2.205 \text{ lb/kg} = 1082 \text{ lb CO2/MMWH})\]

Stephen

---

From: Stephen O'Kane  
Sent: Wednesday, December 19, 2012 11:36 AM  
To: Chris Perri  
Cc: Robert.Mason@CH2M.com; Jerry.Salamy@CH2M.com; McKinsey, John A.; Foster, Melissa A.; Miller, Felicia@Energy; John Yee  
Subject: RE: Heat Rate Tables

Chris,

Here are some more heat rate data for various temperature and operating cases, including a summer temperature one-on-one duct firing case and a two-on-one duct firing case. We will also send over our assumptions and calculation method for calculating annual average CO2/MWh, which includes the contribution of duct firing under the assumed annual operating condition. As discussed, there are different assumptions that go into the different calculations for annual PM2.5 emissions; maximum month daily emissions; and predicted CO2/MWhr emissions. In each case we have made conservative assumptions to calculate the different regulatory requirements. One of the biggest differences our CCGT application will have compared to traditional supplemental fired CCGTs is how the duct burners are employed. The duct burners in our case are for ramp speed and not for power augmentation. It is not expected that the units would be parked at part load with duct firing and in the 3-on-1 case; we are physically constrained by the steam cycle and cannot duct fire with the three turbines at max load.

I hope this information helps. Additional information on our GHG calculations will follow shortly.

Stephen O'Kane

---

From: Chris Perri [mailto:CPerri@aqmd.gov]  
Sent: Tuesday, December 18, 2012 2:29 PM  
To: Stephen O'Kane  
Cc: Robert.Mason@CH2M.com; Jerry.Salamy@CH2M.com; McKinsey, John A.; Foster, Melissa A.; Miller, Felicia@Energy; John Yee  
Subject: Heat Rate Tables

Stephen,

I’m just now trying to complete my heat rate tables for the 2 on 1 and 1 on 1 cases. I’m using the information you provided in a previous email, however, I’m not coming up with the same heat rates. For the 2 on 1 case, I’ve tried to break it down on a per turbine basis (I also assumed that the net output is 96.6% of the gross output). For both cases, I assumed that HHV/LHV = 1.13. Could you look at these tables and tell me if I’ve misinterpreted the data you provided? Thanks.

2-on-1 Operation

<table>
<thead>
<tr>
<th>85 F – 46% RH</th>
<th>66 F – 58% RH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Evaporative Cooling On)</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Gas Turbine Heat Input, mmbtu/h HHV</td>
<td>1,354</td>
</tr>
<tr>
<td>Total Heat Input, mmbtu/h HHV (w/duct fire)</td>
<td>1,861</td>
</tr>
<tr>
<td>Gas Turbine Gross Output, kW</td>
<td>115,962</td>
</tr>
<tr>
<td>Steam Turbine Gross Output, kW</td>
<td>49,751</td>
</tr>
<tr>
<td>Total Gross Power Output, kW</td>
<td>165,713</td>
</tr>
<tr>
<td>Net Power Output, Kw</td>
<td>160,078</td>
</tr>
<tr>
<td>Net Plant Heat Rate, btu/kWh, LHV</td>
<td>10,288</td>
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<tr>
<td>Net Plant Heat Rate, btu/kWh, HHV</td>
<td>11,626</td>
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</tbody>
</table>

1-on-1 Operation

<table>
<thead>
<tr>
<th></th>
<th>85 F – 46% RH (Evaporative Cooling On)</th>
<th>66 F – 58% RH (Evaporative Cooling On)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Turbine Heat Input, mmbtu/h HHV</td>
<td>1,354</td>
<td>1,403</td>
</tr>
<tr>
<td>Total Heat Input, mmbtu/h HHV (w/duct fire)</td>
<td>1,861</td>
<td>1,910</td>
</tr>
<tr>
<td>Gas Turbine Gross Output, kW</td>
<td>115,962</td>
<td>121,840</td>
</tr>
<tr>
<td>Steam Turbine Gross Output, kW</td>
<td>49,382</td>
<td>47,192</td>
</tr>
<tr>
<td>Total Gross Power Output, kW</td>
<td>163,222</td>
<td>163,152</td>
</tr>
<tr>
<td>Net Power Output, Kw</td>
<td>163,611</td>
<td>155,661</td>
</tr>
<tr>
<td>Net Plant Heat Rate, btu/kWh, LHV</td>
<td>10,066</td>
<td>10,858</td>
</tr>
<tr>
<td>Net Plant Heat Rate, btu/kWh, HHV</td>
<td>11,375</td>
<td>12,270</td>
</tr>
</tbody>
</table>

From: Stephen O'Kane [mailto:stephen.okane@AES.com]  
Sent: Thursday, October 25, 2012 4:40 PM  
To: Chris Perri  
Cc: Robert.Mason@CH2M.com; Jerry.Salamy@CH2M.com; McKinsey, John A.; Foster, Melissa A.; Miller, Felicia@Energy  
Subject: RE: HBEP emission rates and modeling results

Chris,

Here’s the data I can provide. If you really need the additional performance data at the other temperatures I will have to get our consultants to run some additional heat balance models. Please let me know as this is an extra expenditure and additional time to execute.

With these two temperature cases you can see the performance of the CCGT in both 1-on-1 and 2-on-1 modes. Additional data would merely show the same relative difference compared to the 3-on-1 case for different operating temperatures and humidities. Note the highlighted numbers. Our CCGT design actually provides the best performance on a heat rate basis (and consequently CO2e per MW) in the 2-on-1 case. Which is a big part of the design objective. Instead of the normal heat rate curve of a CCGT that deteriorates as output or load is decreased, this design will maintain a very constant heat rate across a wide range of output, and be able to ramp up and down output very quickly. Thus we achieve approximately 800-1,000 BTU/kwh better heat rate than a simple cycle LMS 100 and still provide the fast ramp and quick start support.
<table>
<thead>
<tr>
<th></th>
<th>32 F – 87% RH (Evaporative Cooling Off, Case 2)</th>
<th>ISO 59 F– 60% RH (Evaporative Cooling Off)</th>
<th>66 F – 58% RH (Evaporative Cooling On, Case 7)</th>
<th>85 F – 45.75% RH (Evaporative Cooling On)</th>
<th>110 F–8% RH (Evaporative Cooling On, Case 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Turbine Heat Input, mmbtu/h HHV</td>
<td>1,498</td>
<td>1,388</td>
<td>1,403</td>
<td>1,354</td>
<td>1,350</td>
</tr>
<tr>
<td>Total Heat Input, mmbtu/h HHV (w/duct fire)</td>
<td>2,005</td>
<td>1,895</td>
<td>1,910</td>
<td>1,861</td>
<td>1,857</td>
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<tr>
<td>Gas Turbine Gross Output, kW</td>
<td>132,256</td>
<td>121,435</td>
<td>121,840</td>
<td>115,962</td>
<td>115,264</td>
</tr>
<tr>
<td>Steam Turbine Gross Output, kW</td>
<td>49,579</td>
<td>51,865</td>
<td>50,192</td>
<td>48,523</td>
<td>43,632</td>
</tr>
<tr>
<td>Total Gross Power Output, kW</td>
<td>181,835</td>
<td>173,300</td>
<td>172,032</td>
<td>164,485</td>
<td>158,896</td>
</tr>
<tr>
<td>Total Net Power Output, Kw</td>
<td>175,925</td>
<td>167,583</td>
<td>166,328</td>
<td>158,901</td>
<td>153,352</td>
</tr>
<tr>
<td>Net Plant Heat Rate, btu/kWh, LHV</td>
<td>7,558</td>
<td>7,354</td>
<td>7,487</td>
<td>7,508</td>
<td>7,814</td>
</tr>
<tr>
<td>Net Plant Heat Rate, btu/kWh, HHV</td>
<td>8,516</td>
<td>8,285</td>
<td>8,435</td>
<td>8,459</td>
<td>8,803</td>
</tr>
<tr>
<td>Steam Turbine Gross Output, kW (2-on-1)</td>
<td>102,640</td>
<td>99,501</td>
<td></td>
<td></td>
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<tr>
<td>Total Gross Power Output, kW (2-on-1)</td>
<td>346,320</td>
<td>331,425</td>
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<td></td>
<td></td>
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<tr>
<td>Total Net Power Output, Kw (2-on-1)</td>
<td>334,035</td>
<td>319,363</td>
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<td></td>
</tr>
<tr>
<td>Net Plant Heat Rate, btu/kWh, LHV (2-on-1)</td>
<td>7,337</td>
<td>7,408</td>
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<tr>
<td>Net Plant Heat Rate, btu/kWh, HHV (2-on-1)</td>
<td>8,400</td>
<td>8,483</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Steam Turbine Gross Output, kW (1-on-1)</td>
<td>49,382</td>
<td>47,192</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Gross Power Output, kW (1-on-1)</td>
<td>171,222</td>
<td>163,154</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Net Power Output, Kw (1-on-1)</td>
<td>163,611</td>
<td>155,661</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Plant Heat Rate, btu/kWh, LHV (1-on-1)</td>
<td>7,489</td>
<td>7,600</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Plant Heat Rate, btu/kWh, HHV (1-on-1)</td>
<td>8,575</td>
<td>8,702</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. Cases 110F, 32F and 66F heat input taken directly from M501DA Gas Turbine Expected Performance and Emissions Provided by MPSA and included in Table 5.1B.2 of HBEP_Appendix 5.1B_Ops Emissions Calcs.pdf. ISO 59F Case Heat input taken from GT PRO model.
2. Total Heat Input per gas turbine with duct firing can only be achieved while operating in a 1-on-1 or 2-on-1 mode. The steam cycle is sized such that the maximum heat input into the steam cycle is reached in a 3-on-1 mode without duct firing.
3. All output is provided on a per turbine basis assuming a 3-on-1 operating mode. To calculate total output for the entire power block these values must be multiplied by 3

Stephen
<table>
<thead>
<tr>
<th>Blocks 1 and 2</th>
<th>Hours/yr</th>
<th>250</th>
<th>3200</th>
<th>407140</th>
<th>735826</th>
<th>1460</th>
<th>4910</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Plant Power kW</td>
<td>233954</td>
<td>261500</td>
<td>288570</td>
<td>322300</td>
<td>482162</td>
<td>537404</td>
<td>591440</td>
</tr>
<tr>
<td>Estimated Gross Heat Rate LHV Btu/kW-hr</td>
<td>7730</td>
<td>7562</td>
<td>7439</td>
<td>7351</td>
<td>7740</td>
<td>7501</td>
<td>7359</td>
</tr>
<tr>
<td>State 1</td>
<td>State 2</td>
<td>State 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average State 1</td>
<td>7564</td>
<td>Average State 2</td>
<td>7353</td>
<td>Average State 3</td>
<td>7350</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Plant Power kW</td>
<td>116977</td>
<td>130750</td>
<td>144285</td>
<td>161150</td>
<td>203570</td>
<td>241081</td>
<td>268702</td>
</tr>
<tr>
<td>Net Heat Rate LHV Btu/kW-hr</td>
<td>7969</td>
<td>7796</td>
<td>7669</td>
<td>7578</td>
<td>7979</td>
<td>7733</td>
<td>7587</td>
</tr>
<tr>
<td>Estimated Gross Heat Rate LHV Btu/kW-hr</td>
<td>7730</td>
<td>7562</td>
<td>7439</td>
<td>7351</td>
<td>7740</td>
<td>7501</td>
<td>7359</td>
</tr>
</tbody>
</table>

1. Operating data from TFLINK 71F Part Load Curve.xls.
2. Station loads ranging from 3.3 to 5.7% and selecting a conservatively low load results in a conservatively high gross heat rate, for estimating annual average CO2. Therefore, a 3% station load was selected to convert the gross heat rates to net heat rates.
3. DB = Duct firing.
4. State 1 represents a 1 on 1 configuration, State 2 represents a 2 on 1 configuration, and State 3 represents a 3 on 1 configuration.

Conservative average station load 3%
Table DR7-3R HBEP Calculate Annual Average CO2 (lb/MWh)

### Annual Average - Assume all hours for each State are at the average heat rate for that State

#### Start Up and Stop Heat Rate Calculations

- **624 startups / yr**
  - 9 min / startup
  - 93.6 hours startup / year

  - 18267 Btu/ gross kWh
    - Effective Heat Rate during Turbine Start

- **624 stops / yr**
  - 9.5 min / stop
  - 98.8 hours stops / year

  - 16520 Btu/kWh Gross
    - Effective Heat Rate during Turbine Stops

#### Plant CO2 Efficiency Calculation

- **7740 Btu LHV / kWh Gross**
  - Weighted Annual Average Heat Rate with SU/SD and no Degradation.

  $\frac{(250 \text{ hrs} \times 7564 \text{ Btu/kWh} + 3200 \text{ hrs} \times 7353 \text{ Btu/kWh} + 1460 \text{ hrs} \times 7350 \text{ Btu/kWh} + 18267 \text{ Btu/kWh} \times 93.6 \text{ hrs} + 16520 \text{ Btu/kWh} \times 98.8 \text{ hrs})}{(4910 \text{ hrs} + 93.6 \text{ hrs} + 98.8 \text{ hrs})}$

  - 8% Assumed Plant Degradation

- **8413 Btu LHV / kWh Gross**
  - Annual Average CO2 Efficiency with SU/SD and Degradation

  $(7740 \text{ Btu/kWh} / (1 - 0.08))$

- **1082 lb CO2 /MWh Gross**
  - Annual Average CO2 Efficiency with SU/SD and Degradation

  $(8413 \text{ Btu/kWh} \times 1000 \text{ kWh/MWh} \times 1.1 \text{ HHV/LHV} \times 1 \times 10^{-6} \text{ MMBtu/Btu} \times 53.02 \text{ kg CO2/MMBtu-HHV} \times 2.205 \text{ lb/kg})$
APPLICATION FOR CERTIFICATION FOR THE
HUNTINGTON BEACH ENERGY PROJECT

Docket No. 12-AFC-02
PROOF OF SERVICE
(Revised 12/24/12)

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gstewart@waterboards.ca.gov

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jk0480@aol.com

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Public Adviser’s Office
publicadviser@energy.ca.gov

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Docket Unit
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1516 Ninth Street, MS-4
Sacramento, CA 95814-5512
docket@energy.ca.gov

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Commissioner and Presiding Member

KAREN DOUGLAS
Commissioner and Associate Member

*indicates change
73199610.1 0043653-00005
Raoul Renaud
Hearing Adviser

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Jennifer Nelson
Adviser to Commissioner Douglas

Felicia Miller
Project Manager

Kevin W. Bell
Staff Counsel
DECLARATION OF SERVICE

I, Judith M. Warmuth, declare that on January 3, 2013, I served and filed copies of the attached Submittal of Email Correspondence Related to Air Quality dated January 3, 2013. This document is accompanied by the most recent Proof of Service list, which I copied from the web page for this project at: http://www.energy.ca.gov/sitingcases/huntington_beach_energy/index.html.

The document has been sent to the other parties in this proceeding (as shown on the Proof of Service list) and to the Commission’s Docket Unit, as appropriate, in the following manner:

(Check one)

For service to all other parties and filing with the Docket Unit at the Energy Commission:

✔️ I e-mailed the document to all e-mail addresses on the Service List above and personally delivered it or deposited it in the US mail with first class postage to those parties noted above as “hard copy required”; OR

☐ Instead of e-mailing the document, I personally delivered it or deposited it in the US mail with first class postage to all of the persons on the Service List for whom a mailing address is given.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct, and that I am over the age of 18 years.

Dated: January 3, 2013

_____________________
Judith M. Warmuth