Lessons Learned from CHP Development

by

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Acknowledgements

- Bill Barter for overall Solar/Caterpillar Info
- Sten Levin and Bucky Brennan from Caterpillar
- Leslie Witherspoon for Solar
- Rob McMenimon from Co-Energy America
- Rich Lampeter and our Noise Group for their expertise
- Dale Raczynski for his experience and for hiring all of us
- And many clients for their interesting projects
What is CHP?

- Combined Heat and Power (CHP)
  - First and newer method includes engine or turbine and a generator
  - Generates electricity
  - Also recovers heat to generate either steam (secondary steam generation) or hot water
  - Can use duct firing in heat recovery unit to increase production
What is CHP?

- Combined Heat and Power (CHP)
  - The second or older method uses a boiler to generate steam to spin a turbine
  - Secondary products include steam/hot water and/or cooling and heating
What is CHP?

- Fuels for the Prime Mover
  - Natural Gas is the most common fuel
  - Ultra Low Sulfur Diesel (ULSD) - most common backup fuel
    - contains 15 ppm S to minimize SO2 emissions
  - Backup fuels are usually permitted for the following:
    - The equivalent of 15-60 days of continuous operation
    - Storage is usually limited to 1-3 days of operation
    - For most units, this could trigger a Spill Prevention Control and Countermeasures (SPCC) Plan
  - Newer alternate fuels include renewables
    - Wood
    - Renewable oils (biodiesel, yellow grease, etc.)
    - Renewable gas
What is CHP?

- **Different Types of CHP**
  - Cogeneration Products (in Addition to Electricity)
    - Steam
    - Hot Water
  - Cogeneration vs. Trigeneration
    - Power
    - Steam/Hot Water
    - Cooling using Absorption Chillers
  - HRSG Options
    - Duct-Firing
    - Unfired
    - Fresh Air Firing
      - When the Turbine/Engine isn’t firing, generates steam only
What is CHP?

- **Air Pollution Control Equipment & Low Sulfur Fuels**
  - Selective Catalytic Reduction - reduces NOx across a catalyst using ammonia or urea as a reagent
  - Oxidation Catalyst - reduces CO and VOCs across a catalyst
  - Three Way Catalyst - reduces NOx, CO and VOC across a catalyst without any reagents required, similar to car catalytic converters (aka, NSCR)
  - PM Filters - reduces Particulate Matter emissions
  - ULSD - reduces SO2 emissions
**What is CHP?**

- **Sample Facilities**
  - Argonne National Labs
  - 6.5 MW CTG w/ Fresh Air Firing Capability

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Units of Measure</th>
<th>100% Load Test Results</th>
<th>Emission Limit</th>
<th>Limit Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTG Alone</td>
<td>ppmvd @ 15% O2</td>
<td>9.6</td>
<td>15.0</td>
<td>Permit</td>
</tr>
<tr>
<td></td>
<td>lb/MMBtu</td>
<td>0.039</td>
<td>0.060</td>
<td>Permit</td>
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<tr>
<td>GTG + HRSG Supplemental Firing</td>
<td>ppmvd @ 15% O2</td>
<td>16.9</td>
<td>25.0</td>
<td>Permit</td>
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<tr>
<td></td>
<td>lb/MMBtu</td>
<td>0.062</td>
<td>0.11</td>
<td>Permit</td>
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<tr>
<td>HRSG Fresh Air Firing</td>
<td>ppmvd @ 15% O2</td>
<td>-48</td>
<td>54</td>
<td>KKKK &amp; Permit Mod.</td>
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<tr>
<td></td>
<td>lb/MMBtu</td>
<td>0.174</td>
<td>0.2 (originally permitted at 0.15)</td>
<td>KKKK &amp; Permit Mod</td>
</tr>
</tbody>
</table>
What is CHP?

- **Sample Facilities**
  - **Trigen - MATEP CTG3/HRSG300 (Existing Trigen Facility Example)**
    - 14.4 MW nominal CTG (Solar Titan 130) + ~40 MMBtu/hr duct burner (fired HRSG)
  
<table>
<thead>
<tr>
<th>Configuration</th>
<th>CTG Fuel</th>
<th>ppmvdv @ 15%O2</th>
<th>lb/MMBtu</th>
<th>pph</th>
<th>est. lb/MWhelectric</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTG no duct firing</td>
<td>Nat. gas</td>
<td>2.0</td>
<td>0.0074</td>
<td>1.21</td>
<td>0.084</td>
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<tr>
<td>CTG WITH duct firing</td>
<td>Nat. gas</td>
<td>2.0</td>
<td>0.0074</td>
<td>1.51</td>
<td>0.105</td>
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<tr>
<td>CTG no duct firing</td>
<td>ULSD</td>
<td>6.0</td>
<td>0.0233</td>
<td>3.70</td>
<td>0.257</td>
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<tr>
<td>CTG WITH duct firing</td>
<td>ULSD</td>
<td>6.0</td>
<td>0.0231</td>
<td>4.56</td>
<td>0.317</td>
</tr>
</tbody>
</table>

  - **Brigham and Women’s Hospital**
    - 4 MW RICE Engine

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>NOx</th>
<th>NOx</th>
<th>CO</th>
<th>CO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units</td>
<td>ppm @ 15%O2</td>
<td>lb/MW-hr</td>
<td>ppm @ 15%O2</td>
<td>lb/MW-hr</td>
</tr>
<tr>
<td>Nat Gas</td>
<td>4.43</td>
<td>0.11</td>
<td>5.47</td>
<td>0.05</td>
</tr>
</tbody>
</table>
Air Permitting Outline

- Perspectives/overview
- Federal and state air regulatory programs and permitting pathways
- State exemption thresholds
- Streamlined state processes
- Streamlined processes versus air permitting
- Ideal workflow for air permitting
- Case studies (MA, RI, ME, CT, NH)
- Recent, personal CHP experience
- Key, current air permitting issues
- For more information...
Aspects that Promote CHP Implementation

**Favorable**
- State financial incentives
- Utility interconnection approval processes
- Availability of natural gas
- Electricity rate structures
- State environmental regulatory pathways

**Convenient vendor packaged units**

**State financial incentives**
- 2 to 3 year payback vs. 5 to 10 year payback
- MA, RI, ME currently active and attractive
- CT programs expired
**Federal Regulatory Considerations**

<table>
<thead>
<tr>
<th>New Source Performance Standards</th>
<th>Maximum Achievable Control Technology (MACT) Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 40 CFR 60 Subpart IIII (diesel recips)</td>
<td>• 40 CFR 63 Subpart ZZZZ</td>
</tr>
<tr>
<td>• 40 CFR 60 Subpart JJJJ (natural gas recips)</td>
<td>• Applies to all recip engines at all classifications of sources</td>
</tr>
<tr>
<td>• 40 CFR 60 Subparts Dc and Db (older duct burners)</td>
<td>• Points to NSPS Subparts IIII and JJJJJ for new installations for compliance requirements</td>
</tr>
<tr>
<td>• 40 CFR 60 Subpart GG (older CTGs)</td>
<td>• 40 CFR 63 Subpart YYYY</td>
</tr>
<tr>
<td>• Subpart KKKK (newer CTGs and duct burners)</td>
<td>• Applies ONLY to CTGs that are located at a major source of Federal hazardous air pollutants (rare occurrence)</td>
</tr>
</tbody>
</table>
From the simple to the complex
- Exempt from permitting
- Streamlined processes
  - Permit-by-rule,
  - general permit, and/or
  - registration/notification
- Air permit
- Air permit with synthetic minor cap on emissions to avoid major source or major modification status
- Air permit at a major source of air pollutants
  - Operating permit sources
  - Non-attainment new source review (NANSR) sources
  - Prevention of significant deterioration (PSD) sources
  - Grandfathered facilities
### Recip Engine Exemption Thresholds

<table>
<thead>
<tr>
<th>State</th>
<th>Actual Regulatory Threshold for Non-Emergency Use Recips (units of measure and input/output bases vary)</th>
<th>Approximate Equivalent Threshold for Comparison Purposes (kWe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA</td>
<td>50 kWm (mechanical output)</td>
<td>47</td>
</tr>
<tr>
<td>RI</td>
<td>50 hp (mechanical output)</td>
<td>35</td>
</tr>
<tr>
<td>ME</td>
<td>0.5 MMBtu/hr (thermal input, HHV)</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>[note 5 MMBtu/hr threshold applies at unlicensed facilities]</td>
<td></td>
</tr>
<tr>
<td>CT</td>
<td>15 tons/yr (air emissions output, uncontrolled, operating 8,760 hr/yr)</td>
<td>100</td>
</tr>
<tr>
<td>NH</td>
<td>10 MMBtu/hr (thermal input, HHV)</td>
<td>1,000</td>
</tr>
<tr>
<td>VT</td>
<td>300 bhp (mechanical output)</td>
<td>200</td>
</tr>
</tbody>
</table>
Streamlined Processes

- Massachusetts Environmental Results Program (ERP)
- Rhode Island General Permit
- Connecticut Permit-by-Rule with Notification

Comparison of streamlined processes emission limits for NOx for recip engines & CTGs in lb/MWm-hr

<table>
<thead>
<tr>
<th>State</th>
<th>Recip Engines</th>
<th>CTG natural gas</th>
<th>CTG oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA</td>
<td>0.15</td>
<td>0.14 or 0.47</td>
<td>0.34</td>
</tr>
<tr>
<td>RI</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>CT</td>
<td>~0.65 - ~0.83</td>
<td>~0.075 - ~0.095</td>
<td>~0.30 - ~0.39</td>
</tr>
</tbody>
</table>

(1) Depends on heat rate of engine, actual standard is HHV heat input based 0.08 lb/MMBtu
(2) Depends on heat rate of CTG, actual standard is input based 2.5 ppmvd @ 15% O2
(3) Depends on heat rate of CTG, actual standard is input based 9.5 ppmvd @ 15% O2
“Environmental Results Program” (ERP) with advance notification
310 CMR 7.26(43)
CTGs greater than 10 MW output ineligible (subject to air permitting)
Relaxation of standards potentially available if old, dirty units are retired [310 CMR 7.26(45)]
Notification of design details due 30 days prior to commencement of operation
Technologies that can meet MA ERP Standards
- Natural gas fueled, rich burn recip engines with NSCR (3-way catalyst)
- Natural gas fueled, lean burn recip engines with SCR & oxidation catalyst
- Combustion turbines with SCR & oxidation catalyst
- Diesel fueled (rare or unlikely) Tier 4 Final engine with an additional SCR added
  - Case study: Taunton Municipal Light Plant (TMLP)
Rhode Island
- Permit-by-rule with advance notification requirement
- 250-RICR-120-05-43
- Once application materials with design details are submitted, and if the engine or turbine meets the emission standards, a general permit is issued within approximately 120 days, depending on RIDEM staff workload
- The engine or turbine cannot be installed without receipt of the general permit authorization

Connecticut
- Permit-by-rule with advance notification requirement
- RCSA-22a-174-3d
- Equipment nameplate capacity must be <10 MW to be eligible (otherwise subject to air permitting)
- Notification with design details due 30 days before beginning construction
Air Permitting Considerations

**BENEFITS**
- Customize requirements to your facility
- Demonstrate less stringent emission limits are “Best Available Control Technology”

**DOWNSIDES**
- Six months to a year to obtain a permit, depending on jurisdiction & complexity
- Less certainty of specific outcome
- More details (startup/shutdown, monitoring & testing, etc.)
- Additional project expense
Ideal Workflow for Air Permitting

- Conceptual design and permit planning (including air dispersion modeling)
- Pre-application meeting with state air permitting staff
- Development of RFI for potential vendors, including air & noise considerations
- Procurement & review of project offerings by permitting specialists, Q&A
- Preparation & submittal of air permit application
- Receipt of agency questions and comments and preparation of responses
- Receipt of draft permit (some agencies allow applicant to draft permit)
- Negotiation of draft permit terms (longer deadlines allow for negotiation of more favorable terms - so start the process EARLY)
- Public notices, publication of proposed permit, and public hearings (as applicable) - last opportunity for applicant to adjust the permit before final
- Final permit issued
Non-major comprehensive plan approval issued August 25, 2016

Solar Mercury 50-6400R combustion turbine - Ultra Low SoLoNOx Combustor

No SCR, natural gas fueled only, no oxidation catalyst

BACT requirements for NOx and CO satisfied by using credit for retirement of old, dirtier boilers using regulation 310 CMR 7.26(45) for CHP

0.18 lb NOx/MWm-hr and 0.22 lb CO/MWm-hr limits in plan approval

Application process required air dispersion modeling for new + remaining (existing) emission sources

Remaining (existing) combustion sources were 6 dual fueled boilers and 3 diesel recip engines
Case Study (RI): Aspen Aerogels

- No recent health care facility CHP permits issued - Aspen is a mfg. facility
- Combined general permit and minor source permit issued January 11, 2016 (most recent revision)
- Gauscor Power (Siemens/Dresser Rand) HGM-560 recip engine 1.3 Mwe output
- SCR / urea injection & oxidation catalyst, natural gas fueled only
- BACT requirements for NOx and CO satisfied by the general permit limits for distributed generation
- Application process required air dispersion modeling for new + remaining (existing) ammonia emission sources
- 0.15 lb NOx/MWm-hr and 1.00 lb CO/MWm-hr
Case Study (ME): Eastern ME Medical Ctr.

- Eastern Maine Medical Center (EMMC)
- Air Emissions License Renewal issued March 9, 2016
- CTG originally installed in 2006 - air dispersion modeling was required during initial licensing in 2005, including PSD increments analysis and source interactions
- Solar Centaur 50 dual fueled nominal 4.6 MW + unfired HRSG
- No SCR or oxidation catalyst
- In order to maintain synthetic minor status, EMMC will retrofit with SCR only if oil use exceeds 128 days annually, and will have 1 yr to implement retrofit
- Best practical treatment (BPT) governs in Maine for minor sources, instead of BACT, which results in more flexibility
- On natural gas: -1.3 lb NOx/MWm-hr and -1.5 lb CO/MWm-hr
- On oil: -3.8 lb NOx/MWm-hr and 1.6 lb CO/MWm-hr
- Above limits are based on lb/hr limits in license and 4.8 MWm nominal output
- Remaining sources are 5 dual fueled boilers, 4 diesel emergency generators, and 4 snow melters
Case Study (CT): Danbury Hospital

- New Source Review (NSR) permit issued June 8, 2010
- Solar Mercury 50 (4.6 MWe nominal output ISO) + Cleaver-Brooks Natcom duct burner (fired HRSG) 21.2 MMBtu/hr heat input (30,000 pph steam output)
- No SCR, natural gas fueled only, and no oxidation catalyst
- Full BACT analysis required for pollutants that are uncontrolled >15 tons per year, 8,760 hr/yr equipment operation
  - SCR determined to be cost ineffective (annualized $/ton NOx removed)
  - Oxidation catalyst found to be incrementally cost ineffective
- For the CTG only, for comparison to the other states’ limits
  - 0.18 lb NOx/MWm-hr and 0.22 lb CO/MWm-hr (estimated based on lb/hr and nominal mechanical output of 4.8 MWm)
- For the duct burner, 0.08 lb NOx/MMBtu and 0.15 lb CO/MMBtu
- A screening level ambient air impacts analysis was conducted for the source
Temporary (construction) permit reissued most recently December 28, 2018

Caterpillar G3516 recip engine (~0.75 Mwe output) - rich burn

NSCR (i.e., 3-way catalyst for NOx, CO, and VOC)

NSCR needed to meet Federal requirements and to meet synthetic minor air permitting strategy for the facility

BACT analysis not required in NH for minor sources

~2.2 lb NOx/MWm-hr and ~5.9 lb CO/MWm-hr (estimated)

A prior, facility-wide ambient air impacts analysis was used to demonstrate compliance

Total future sources are 3 boilers, 7 emergency diesel generators, in addition to the CHP engine
## Recent, Personal CHP Experience

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>Details</th>
</tr>
</thead>
</table>
| New trigen district energy facility with planning for future expansions (MA) | • Major source (OP, PSD, NANSR)  
• 2 natural gas, lean burn CHP engines 2 MW each, 2 emergency diesel generators, 2 dual fueled boilers, 1 natural gas boiler |
| Existing trigen district energy facility subject to NOx RACT II (MA) | • Major source (OP, PSD, NANSR)  
• Complex NOx “bubble”  
• 6 non-emergency diesel engines, 5 dual fueled boilers, 3 CTG/fired HRSGs |
| Existing cogen facility recently required permit modification (IL) | • Minor source with CTG and fired HRSG (fresh air firing option included) |
| New, then existing cogen facility with swaps & uprates (CT) | • Synthetic minor source with CTG and fired HRSG (fresh air firing option included)  
• Swaps required re-permitting due to uprates (2nd swap and uprate underway) |
Key, Current Air Permitting Issues

- Duct burner emissions
- Low NOx guarantees for latest fleet of combustion turbines (SCR or no SCR)
- Special vendor guarantees
- Ammonia slip limits when using SCR
- Obtaining equipment vendor guarantees for particulate matter emissions (PM, PM10, PM2.5, filterable particulate, condensable particulate)
- Starup/shutdown considerations
- Very low temperature (<0 degrees F ambient) CTG operation
- Regulatory CEMS vs. process CEMS and stack testing
- Make X Model Y, “or equal” equipment, for permitting purposes
- Permitting multiple make model options
- Air toxics analysis requirements (vary by state)
Air Dispersion Modeling and CHP
Goal is to assist in preparing documentation to demonstrate that a new source and a facility as a whole will comply with ambient air standards and not make people sick.

Modeling uses conservative assumptions to bracket operating conditions of the source.

Modeling has an advantage over measurements, as it can account for a suite of meteorological conditions, op.

Project is handed a “permit” which they then need to demonstrate compliance with via stack testing, continuous emissions monitoring and emissions calculations.
Air Dispersion Modeling

- A new or modified source must demonstrate that they will not violate health protective standards as a result of its operation.
- To do this a dispersion model must be run.
- Requires inputs such as:
  - Terrain
  - Meteorology
  - Emissions information
  - Source Operational Characteristics
  - Buildings near the source
- Requires interaction with environmental agencies and the public.
- Often many, many iterations as typically modeling something that has yet to be built and therefore design is often changing.
Modeling Process

Emission Rates
Stack Parameters
Buildings & Structures
Receptor Locations & Terrain Elevations
Meteorological Conditions

Computer Dispersion Model

Predicted concentrations by receptor & time

Add measured background
Add contributions from nearby sources

Compare to Standards

QA Modeled Inputs/Communicate Results

KEEP CALM AND TRUST THE PROCESS
Modeling Process

- Emission Rates
- Stack Parameters
- Buildings & Structures
- Receptor Locations & Terrain Elevations
- Meteorological Conditions

Computer Dispersion Model

Predicted concentrations by receptor & time

Add measured background

Add contributions from nearby sources

Compare to Standards

QA Modeled Inputs/Communicate Results

KEEP CALM AND TRUST THE PROCESS

New England Healthcare Engineers’ Society
Emission Rates/Stack Parameters

- Operating conditions
- Function of load, ambient temperature and fuel
- Duct Firing
- Startups/Shutdowns
- Malfunctions
- Vendor Guarantees can be difficult to obtain for some air pollutants
- Want to be conservative without going overboard
Permit Limit Flexibility often equals more modeling runs

Advantage of modeling versus measurements
- Model for a number of locations in one run
- Identify optimal stack height/location
- Identify problem operation conditions

Existing Sources often have difficulty complying with newer (lower) pollution standards
Example of Modeling Scenarios

<table>
<thead>
<tr>
<th>Scenario Case No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
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</thead>
<tbody>
<tr>
<td>Ambient Temp (F)</td>
<td>50</td>
<td>0</td>
<td>60</td>
<td>0</td>
<td>60</td>
<td>0</td>
<td>60</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>% Load</td>
<td>100</td>
<td>100</td>
<td>75</td>
<td>75</td>
<td>50</td>
<td>50</td>
<td>40</td>
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<td>Turbine Fuel</td>
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<td>NG</td>
<td>NG</td>
<td>NG</td>
<td>NG</td>
<td>NG</td>
<td>NG</td>
<td>NG</td>
<td>NG</td>
</tr>
<tr>
<td>Duct Burner Fuel</td>
<td>NG</td>
<td>NC</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
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<tr>
<td>Turbine Fuel Input (MMBtu/hr, LHV)</td>
<td>197.78</td>
<td>201.01</td>
<td>155.95</td>
<td>161.61</td>
<td>121.86</td>
<td>135.29</td>
<td>158.81</td>
<td>158.91</td>
<td>158.91</td>
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<tr>
<td>Duct Burner Fuel Input (MMBtu/hr, LHV)</td>
<td>112.4</td>
<td>126.5</td>
<td>108</td>
<td>135.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>113.9</td>
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<tr>
<td>Turbine Fuel Input (MMBtu/hr, HHV)</td>
<td>219.01</td>
<td>223.69</td>
<td>172.68</td>
<td>178.95</td>
<td>124.90</td>
<td>138.84</td>
<td>120.49</td>
<td>122.74</td>
<td>212.04</td>
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<tr>
<td>Duct Burner Fuel Input (MMBtu/hr, HHV)</td>
<td>124.46</td>
<td>133.43</td>
<td>117.37</td>
<td>149.71</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>126.12</td>
</tr>
<tr>
<td>CTC Exhaust Temp. (F)</td>
<td>85.9</td>
<td>79.1</td>
<td>83.6</td>
<td>69.7</td>
<td>82.4</td>
<td>68.4</td>
<td>82.0</td>
<td>88.1</td>
<td>84.8</td>
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<tr>
<td>Stack Exit Temp. (F)</td>
<td>180</td>
<td>180</td>
<td>180</td>
<td>180</td>
<td>180</td>
<td>180</td>
<td>180</td>
<td>180</td>
<td>233</td>
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<tr>
<td>CTC Audel Flow Rate (ft³/hr)</td>
<td>307.178</td>
<td>308.161</td>
<td>263.390</td>
<td>267.889</td>
<td>224.135</td>
<td>225.406</td>
<td>209.822</td>
<td>210.532</td>
<td>310.326</td>
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<tr>
<td>Stack Flow Rate (ft³/min)</td>
<td>149.161</td>
<td>156.528</td>
<td>130.069</td>
<td>158.182</td>
<td>111.718</td>
<td>126.163</td>
<td>154.916</td>
<td>118.101</td>
<td>162.638</td>
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<td>Turbines operating</td>
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<td>1</td>
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<td>1</td>
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<table>
<thead>
<tr>
<th>Stack Emissions - Turbine Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO (ppm)</td>
</tr>
<tr>
<td>NO (ppm)</td>
</tr>
<tr>
<td>O₃ (g/hr/100 SCF)</td>
</tr>
<tr>
<td>CO₂ (g/hr/100 SCF)</td>
</tr>
<tr>
<td>NOx (lb/hr)</td>
</tr>
<tr>
<td>SO₂ (lb/hr)</td>
</tr>
</tbody>
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<tr>
<td>NO (lb/hr)</td>
</tr>
<tr>
<td>SO₂ (lb/hr)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stack Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective Stack Diameter (ft)</td>
</tr>
<tr>
<td>Area (ft²)</td>
</tr>
<tr>
<td>Exit Velocity (ft/sec)</td>
</tr>
<tr>
<td>Exit Velocity (mi/hr)</td>
</tr>
</tbody>
</table>
Modeling Process

1. Emission Rates
2. Stack Parameters
3. Buildings & Structures
4. Receptor Locations & Terrain Elevations
5. Meteorological Conditions

Computer Dispersion Model

Predicted concentrations by receptor & time

Add measured background

Add contributions from nearby sources

Compare to Standards

QA Modeled Inputs/Communicate Results
Modeling Challenges
Modeling Process

**Input Data**
- Emission Rates
- Stack Parameters
- Buildings & Structures
- Receptor Locations & Terrain Elevations
- Meteorological Conditions

**Modeling Process**

1. Computer Dispersion Model
2. Predicted concentrations by receptor & time
3. Add measured background
4. Add contributions from nearby sources
5. Compare to Standards
6. QA Modeled Inputs/Communicate Results

**Certificate**

KEEP CALM AND TRUST THE PROCESS
“Receptor” fancy term for where the public can access, and where we’re asking the dispersion model to predict

- Special attention is paid to where “sensitive” populations resides
  - Hospitals, schools, nursing homes, environmental justice populations etc.

- Air intakes/operable windows are often included in the modeling

- Fence line versus no fence line

- Rooftop Gardens, parking garages, balconies are all considered areas where the public can access
Modeling Process

- Emission Rates
- Stack Parameters
- Buildings & Structures
- Receptor Locations & Terrain Elevations
- Meteorological Conditions

Computer Dispersion Model

Predicted concentrations by receptor & time

Add measured background

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Compare to Standards

QA Modeled Inputs/Communicate Results

KEEP CALM AND TRUST THE PROCESS
Other Sources

- Includes other sources at an existing facility
- Nearby large sources, not included in background
- “Permitted” emission rate versus “Actual”
- Emissions information on other sources often dated or incomplete
What’s the Key to Success?

- Early involvement of environmental consulting firm
  - Help establish achievable emission limits
  - Identify stack design issues
  - Negotiate air permitting compliance concerns
  - Understand existing permits/compliance issues
- Direct line of Communication to Design Team
- Early engagement of regulatory agency, based on size of project may involve multiple meetings
- Permit flexibility
- Identify key internal/external stakeholders
- Understanding how you intend to operate to allow for permit flexibility
- Allowing ample time to secure permit
CHP Noise Issues

- Primary Issue in Several States
  - Measure background, depending on the state, meet either absolute limit or an increase over the background
  - Requires predictive sound level modeling to confirm compliance
  - Can require a Best Available Noise Control Technology (BANCT) to confirm that the amount of sound attenuation being performed is sufficient
  - Finishes with a compliance sound test

- BELD
  - Include ancillary equipment in the model as while the sound power level may be significantly less than other power generating equipment, it may be a lot closer to the actual receptors (homes)
  - Failure to account for these items may lead to non-compliance, additional measurements to identify the cause, and retrofit mitigation.
  - The biggest issue was rooftop ventilation fans
CHP Noise

**Hospital in Central MA**

- Be mindful of existing noise complaints at the facility.
- Proper communication with neighboring homeowners is critical otherwise you can have the situation where the sound consultant arrives at a home to take measurements for the new project but the homeowner thinks he is there to work on resolving the existing noise issue.
- Existing complaints may lead to changes in the project in order to address the noise complaints, e.g. cooling tower selection

**Main takeaways**

- Prior to post-construction measurements verify that additional equipment was not installed.
- During the construction process, communication with owner\developer regarding equipment specs with respect to sound can minimize later surprises where equipment as described in the sound level impact assessment was not installed to the same level of noise control
- Verify all mitigation was constructed\installed as described in the pre-construction sound level assessment
- Consider roll-up doors in the pre-construction analysis. Will these be left open typically for ventilation? How does that impact the design of a post-construction sound level measurement program?
- For post-construction noise testing, request/confirm full-load operations of the new equipment (e.g., generator, CT).
CHP Noise
The main choice between prime movers are a gas turbine and reciprocating internal combustion engine (RICE).

There are a variety of pros and cons about the two choices.

For air pollution control purposes, in certain states, a turbine can be installed without supplemental air pollution controls using a combination of extremely low uncontrolled emission rates and credits for avoided emissions.

- This option eliminates the cost of SCR and ammonia/urea handling systems.
- Eliminates emissions associated with ammonia "slip".

Turbines will require a gas compressor, an advantage to the engine.
Prime Mover Choice

- Maximum guaranteed “up-time”
  - RICE 93%
  - Turbine 97%

- Maintenance
  - RICE $0.016/kW, more substantial maintenance complete engine rebuild after 6-7 years of operation
  - Turbine $0.013/kW however turbines typically have a superior maintenance agreement (w/ long term agreements)

- Major Overhauls
  - RICE - Rebuilt in place, much more substantial downtime
  - Turbine - Factory remanufactured tested and warranted like new replacement engine and gearbox. Minimal down time
Prime Mover Choice

- **Sound Attenuation**
  - RICE - Low frequency
  - Turbine - High frequency, easier to attenuate than low frequency

- **Other considerations**
  - Turbine allows for duct firing capability
  - Turbine can uncouple the thermal from the electrical by using a bypass stack

- **Conclusions**
  - Both are permittable
  - They are both excellent bridges from your Central Heating (Boiler) Plant
  - The lessons that we’ve discussed here are summarized here so you do not have to repeat them
Lessons Learned from CHP Development

Any Questions?
Slide Title

- Bullet Point
  - Sub point
Slide Title

- Bullet point

- Bullet Point