Proposed Rule 1179.1
NOx Emission Reductions from Combustion Equipment at Publicly Owned Treatment Works Facilities

Working Group Meeting #4
Date: February 12, 2020
Conference call #: 1-866-705-2554
Passcode: 220103
Agenda

- Summary of last working group meeting
- Public Comments
- Applicability
- BARCT assessment
  - Microturbines
  - Boilers ≤ 2 mmbtu/hr
  - Boilers > 2 mmbtu/hr
  - Turbines
Summary of Last Working Group Meeting

- **Applicability**
  - Engine applicability and associated fees with including engines
    - Engine survey
  - Boilers, turbines, and microturbines located at POTWs that fire either natural gas and/or digester gas

- **Technology Assessment**
  - Control technologies and gas treatment systems
  - Application of technologies
  - Feasibility of NOx emission levels with technologies
  - Proposed initial NOx limits for boilers >2 mmbtu/hr and turbines

- Listed sources for obtaining cost information
Stakeholders commented:
- Fees for permit revisions for engines can be waived
- Future working group meeting should focus on costs and cost effectiveness
- One facility is experiencing damage to burners on their digester gas boilers

South Coast AQMD responses:
- South Coast cannot guarantee that the Governing Board will waive fees
- Working group meeting #4 will focus on costs and cost effectiveness
- Issue appears to be specific to one facility
  Seeking input from other facilities
Stakeholders commented:

Boiler results did not include results at low and high loads (only average loads presented)

Do not agree that the Biogas Toolkit is an accurate source for cost information

South Coast AQMD responses:

Staff will present source test results for all loads that boilers were tested at

Biogas toolkit information will not be used to obtain cost information. Costs for gas treatment systems will rely on information from facilities and suppliers.
Engines – Survey Results

- Staff sent a survey out on December 12, 2019 to all POTWs with engines to determine the consensus of including engines in the applicability of PR 1179.1
- 8 agencies (12 facilities) had a biogas or natural gas engine
  - 6 agencies are in favor of including only biogas engines
  - 1 agency that has 5 natural gas engines is in favor of including engines
  - 1 agency that has one natural gas engine is not in favor of including engines
Staff Recommendation for Engines

- **Natural gas engines**
  - 4 out of 5 facilities with natural gas engines responded that they prefer that natural gas engines remain in Rule 1110.2
  - **Staff recommendation:** Natural gas engines will remain in Rule 1110.2

- **Biogas engines**
  - All facilities with biogas engines responded that they prefer that biogas engines be included in Proposed Rule 1179.1
  - **Staff recommendation:**
    - Include biogas engines in Proposed Rule 1179.1
    - Provisions in Rule 1110.2 (emission limits, averaging times, monitoring, reporting, and recordkeeping requirements) will be incorporated in Proposed Rule 1179.1
    - Considering implementation timeframe to revise permit – possibly 2 to 3 years
BARCT Assessment
BARCT Assessment – Small boilers ≤ 2 mmbtu/hr and Microturbines

- Previous working group meetings focused on the technology assessment and initial NOx emission limits for boilers > 2 mmbtu/hr and turbines
- Presenting BARCT assessment for microturbines
  - Technology assessment
  - Initial NOx emission limit
  - Cost-Effectiveness
  - Propose NOx BARCT emission limits
- Beginning BARCT assessment for small boilers ≤ 2 mmbtu/hr
BARCT Assessment – Boilers > 2 mmbtu/hr and Turbines

- Previous working group meetings focused on the technology assessment
  - Low NOx burners, SCR, and gas treatment
- Proposed initial NOx emission limits
  - Boilers retrofit with low NOx burner
  - Turbines retrofit with SCR and implementing gas treatment
- Continuing with BARCT assessment
  - Technology assessment and propose initial NOx emission limit
    - Boilers retrofit with SCR
    - Turbine replacement
  - Cost-effectiveness and propose NOx BARCT emission limits
## Progress of BARCT Assessment

<table>
<thead>
<tr>
<th>Equipment Category</th>
<th>Assessment of South Coast AQMD Regulatory Requirements</th>
<th>Assessment of Emission Limits for Existing Units</th>
<th>Other Regulatory Requirements</th>
<th>Assessment of Pollution Control Technologies</th>
<th>Initial BARCT Emission Limits and Other Considerations</th>
<th>Cost-Effectiveness Analysis</th>
<th>BARCT Emission Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microturbines</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Boilers ≤2 mmbtu/hr</td>
<td>✓</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Boilers &gt;2mmbtu/hr</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Turbines</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
BARCT Analysis for Microturbines and Boilers ≤ 2 mmbtu/hr
Microturbines (Digester Gas)

- A microturbine is a turbine that is < 0.3 MW
- Currently no rule for microturbines at South Coast AQMD
- Rule 219 allows microturbines ≤ 3.5 mmbtu/hr (total output < 2 MW) to be exempt from permitting provided that a filing pursuant to Rule 222 is submitted; and:
  - Microturbines were in operation prior to May 3, 2013; or
  - Microturbines were certified by the state of California at time of manufacture
Two facilities have a total of 10 microturbines

**Facility 1**
- Five 0.03 MW turbines
- 100% digester gas fired
- Exempt from permitting – in operation prior to May 3, 2013

**Facility 2**
- Five 0.2 MW turbines
- Permitted to fire digester gas or a blend of digester gas and natural gas
- Not yet in commission
**Microturbines Technology Assessment**

- Limited source test information from facilities and supplier
  - 1 source test result of 1.25 ppm
- Supplier can guarantee 9 ppm with proper maintenance and gas treatment
  - 9 ppm achievable with varying loads and HHV
- Gas treatment required for digester gas use
  - Published limit for siloxanes is < 5 ppb (real operations show that higher levels are permissible)
- Control technology
  - Uses a lean premix
  - Addition of SCR difficult due to low exhaust temperature
Initial NOx Limit for Microturbines

Proposed limit for microturbines that fire digester gas or a blended fuel with digester gas

| Turbines < 0.3 MW | Permitted at 9 ppm | 1.25 ppm | No known rule limits or permitted digester gas microturbines | 9 ppm | 9 ppm (Units in operation meeting limit) |

Cost-effectiveness analysis not conducted since existing sources are meeting the Proposed BARCT NOx Limit
Boilers ≤ 2 mmbtu/hr – Digester Gas

- Currently no rule at South Coast AQMD for boilers ≤ 2 mmbtu/hr that fire digester gas
- 12 boilers that range from 0.75 mmbtu/hr – 1.95 mmbtu/hr
  - 10 permitted at 30 ppm
  - 2 permitted at 6 lbs/day
- Staff is assessing the differences between boilers greater than and less than 2 mmbtu/hr
  - Conducting technology assessment to understand if burners that can meet 9 ppm are available for boilers ≤ 2 mmbtu/hr
Cost-Effectiveness Methodology and Assumptions
Cost-effectiveness analysis is conducted on the initial BARCT emission limit.

Cost-effectiveness is the cost (capital plus annual operating costs) over the emission reductions for the life of the equipment.

Staff uses the 2016 AQMP cost-effectiveness threshold of $50,000 per ton of NOx reduced as guidance for establishing the BARCT limit.
BARCT

California H&SC §40406 defines BARCT as:

“...an emission limitation that is based on the maximum degree of reduction achievable, taking into account environmental, energy, and economic impacts by each class or category of source.”

- Includes a technology assessment and cost-effectiveness analysis
- Applicable to equipment retrofits and replacement
Cost-Effectiveness Calculation

- Threshold is $50,000/ton NOx reduced
- Calculated using Discounted Cash Flow Method
  - Cost Effectiveness = Present Value / Emissions Reduction Over Equipment Life
  - Present Value = Capital Cost + (Annual Operating Costs * Present Value Formula)
  - Present Value Formula = \( \frac{1 - \frac{1}{(1 + r)^n}}{r} \)  
  - \( r = \frac{(i - f)}{(1 + f)} \)
  - \( i = \) nominal interest rate
  - \( f = \) inflation rate
Elements Included in Capital and Annual Operating Costs

<table>
<thead>
<tr>
<th>Capital Costs</th>
<th>Annual Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Equipment needed to achieve the initial BARCT limit</td>
<td>▪ Labor</td>
</tr>
<tr>
<td>▪ Installation (includes construction)</td>
<td>▪ Maintenance</td>
</tr>
<tr>
<td></td>
<td>▪ Electricity</td>
</tr>
<tr>
<td></td>
<td>▪ Catalyst (turbine only)</td>
</tr>
<tr>
<td></td>
<td>▪ Reagent (turbine only)</td>
</tr>
<tr>
<td></td>
<td>▪ Gas treatment media (turbine only)</td>
</tr>
<tr>
<td></td>
<td>▪ Testing</td>
</tr>
</tbody>
</table>
Other Cost Considerations

Stranded Assets

- Accounts for costs associated with the replacement of equipment before the equipment life
  - Equipment age based on either the permitted or installation date
- Cost analysis accounted for stranded assets for new equipment replacements
- Additional cost calculated by:
  - \( \text{Stranded Asset Cost} = \left( \frac{\text{Equipment Life} - \text{Existing Equipment Age}}{\text{Equipment Life}} \right) \times (\text{Existing Equipment Cost}) \)
  - \( \text{Total New Equipment Cost} = (\text{New Equipment Cost}) + (\text{Stranded Asset Cost}) \)

Nominal Interest Rate

- 4%
Other Cost Considerations (continued)

Equipment Life
- Burners = 15 years
- Turbines = 25 years
- SCR = 25 years
- Gas treatment system = 25 years

Equipment Replacement
- Equipment replacement is normal component of business operations
  - Replacing equipment after equipment life is not expected to add any additional cost
  - No additional operating & maintenance costs for replacing equipment with similar equipment
Estimated Emission Reductions

- Emission reductions calculated over same timeframe as equipment life
- Reductions only calculated for units with source test results or permit limits above the initial BARCT limits

Baseline NOx Concentration
- Use NOx concentration from source test results if available
- If source test results not available, use permitted NOx limit

Baseline Throughput
- Use actual throughput reported in Annual Emissions Report (AER) if available
- If no AER data, use scaled average throughput for unit’s specific source category
Cost-Effectiveness Analysis
Implementation Approach for Retrofit or Replacement

Overall Goal
- Apply emission limit to equipment via the most cost-effective schedule
- Staff aimed to reduce stranded asset costs and only require replacement when cost-effective to do so

Two Compliance Scenarios
1. Fixed-Date: Emission limit effective at a set point in time
2. Phase-in: Emission limit effective upon replacement
Proposed Compliance and Cost-Effectiveness Approach

- **Fixed-Date Approach**
  - Comply by fixed-date
  - Emission limit effective on a fixed-date

- **Phase-in Approach**
  - Comply upon replacement
  - Emission limit effective when burner or unit is replaced

- Evaluated cost-effectiveness for all units

- Considerations for a fixed-date or a phase-in approach are based on:
  - Average cost-effectiveness
  - Financial challenges for essential public services
  - Operation and maintenance of equipment
Boilers > 2 mmbtu/hr
Stakeholders commented that all boiler source test results were not represented for all loads in previous working group meeting.

Analyzed all source test results:
- Low, mid, high loads are shown respectively.*
- 9 out of 22 boilers meet 9 ppm for all their source test results.
- 6 boilers meeting NOx emissions as low as 7 ppm.
- Using new and retrofit burners.

* Some boilers were only tested at mid loads. One boiler was tested at low and mid load.
Cost-Effectiveness of NOx Limit of 9 ppm (Retrofit Boiler with Low NOx Burners)

- Cost-effectiveness excluded units that already meet 9 ppm
- Average cost-effectiveness >>$50,000 per ton of NOx reduced
  - No capital and annual cost increase assumed to implement burner that can meet 9 ppm
  - Associated costs solely from stranded assets
- It is not cost-effective to retrofit boilers with a burner that can meet 9 ppm if existing burner operations started less than 15 years ago

Staff recommendation: Meet 9 ppm at burner replacement
Retrofitting boilers with SCR was analyzed for an initial NOx limit of 5 ppm that was determined feasible in the Rule 1146 series rulemaking.

- > 2 mmbtu/hr boiler universe ranges from 2.52 mmbtu/hr – 63.5 mmbtu/hr

Cost-effectiveness was calculated for boilers ≥ 20 mmbtu/hr that do not meet 5 ppm.
- Average cost-effectiveness is over $1 million per ton of NOx reduced and exceeds the $50,000 per ton of NOx reduced threshold.

Staff recommendation:
- Not cost-effective to retrofit boilers ≥ 20 mmbu/hr to meet 5 ppm
- Boilers ≥ 20 mmbu/hr to meet 9 ppm at burner replacement

◊ SCR requires a gas clean up system. Cost of gas clean up was not included in the cost-effectiveness for SCR retrofits.
New Turbine Technology Assessment

- Turbines manufactured after year 2000 are in the 4-25 ppm range when firing natural gas
- Use of digester gas may affect NOx emissions and turbine suppliers warranty higher NOx levels for biogas than natural gas
- Turbine performance in real world applications:
  - 10 turbines in use at landfills without SCR
    - Source test results that range 3.1 ppm – 7.6 ppm
    - Gas treated prior to combustion in turbine
- Staff proposes that initial limits for turbines at landfills can apply to new turbines at POTWs
  - Initial NOx limit = 12.5 ppm
### Initial NOx Limits for Turbine Replacement

<table>
<thead>
<tr>
<th>BARCT Assessment Results</th>
<th>Only permit limits apply (12.5 – 25 ppm)</th>
<th>&lt; 10 ppm (landfill units)</th>
<th>3 – 15 ppm</th>
<th>&lt; 10 – 25 ppm</th>
<th>12.5 ppm</th>
<th>Need to conduct cost-effectiveness on initial BARCT NOx limit</th>
</tr>
</thead>
</table>

Emissions from this category are the largest in the POTW universe. Total NOx emission for 6 digester turbines is 0.25 tpd

Staff will continue to explore turbine replacement options
Cost-effectiveness evaluated for three NOx limits that can be achieved by different methods

- **SCR + gas treatment**
  - Reduce NOx emissions to 2.5 ppm
  - Based on technology assessment presented last working group meeting

- **Water injection**
  - Reduce NOx emissions to 18.8 ppm
  - Based on facility claim during Rule 1134 rulemaking

- **Replacement**
  - Reduce NOx emissions to 12.5 ppm
  - Based on technology assessment – presented in this working group meeting
Obtaining Costs

- Staff obtained costs from facilities, suppliers, and cost estimating tools

- SCR
  - Facilities
  - EPA Cost Manual Spreadsheet
  - Engineering consultants
  - Catalyst supplier

- Gas Treatment
  - Facilities
  - Gas treatment supplier

- Water Injection
  - Facility
  - Demineralized water supplier

- Turbine Replacement
  - Facility
  - EPA Manual for CHP Technologies
## SCR Costs

### Assumptions for EPA Cost Manual for SCR and supplier estimates:
- HHV = 665 Btu/scf
- Number of days operating = 365
- Inlet NOx = 22 ppm
- Removal efficiency = 90%
- Operating life of catalyst = 24,000 hours
- Equipment life = 25 years
- Design = 5 ppm NH₃ slip (19% aqueous)
- Inlet temperature = 866F
- Electricity = $0.19/kwh - $0.25/kwh

<table>
<thead>
<tr>
<th>Source</th>
<th>Capital Cost</th>
<th>Annual Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPA Cost Manual for SCR</td>
<td>$8.3 million (3 SCRs)</td>
<td>$1.2 million (3 SCRs)</td>
</tr>
<tr>
<td>Supplier A</td>
<td>$8.0 million (3 SCRs)</td>
<td>$489,500 (3 SCRs)</td>
</tr>
<tr>
<td>Supplier B</td>
<td>$2.5 million* (3 SCRs)</td>
<td>$450,000 (3 SCRs)</td>
</tr>
<tr>
<td>Rule 1110.2 staff report</td>
<td>$1.4 million-$6.6 million (3 SCRs)</td>
<td>EPA Cost Manual</td>
</tr>
<tr>
<td>Facility A</td>
<td>Unavailable</td>
<td>$38,000 (3 SCRs) new, no catalyst replacement</td>
</tr>
<tr>
<td>Facility B</td>
<td>Unavailable</td>
<td>$48,000 (5 SCRs) new, no catalyst replacement</td>
</tr>
<tr>
<td>Average cost for 3 SCRs</td>
<td>$7.6 million</td>
<td>$458,500</td>
</tr>
</tbody>
</table>

* Not included in average cost.
* Average costs adds $33,300/year for Facility A and Facility B for catalyst costs
Gas Treatment Costs – Annual

- Obtained annual costs from 8 facilities
  - All costs obtained from facilities that use SCR
- Siloxane levels for these facilities range from 4.4 ppmv to 15 ppmv
- Gas treatment systems designed to remove siloxane levels to less than <100 ppb
  - One facility treated digester gas to pipeline quality gas – has highest operating costs
Gas Treatment Costs – Capital

- Obtained capital costs from 3 facilities
- Obtained equipment only costs from one supplier
- Costs assume a gas treatment system that will achieve <100 ppb siloxane level with inlet siloxane levels at <10 ppm
Costs for Increasing Water Injection

- Facility has stated that they can meet 18.8 ppm with doubling the amount of injected demineralized water
  - Increase of 5,000 – 8,000 gallons per turbine per day
- Facility estimated that the cost of demineralized water is about 10x the cost of potable water
- Staff received cost estimate from supplier for 24,000 gallons per day to meet the needs of 3 turbines

<table>
<thead>
<tr>
<th>Source</th>
<th>Cost of Demineralized Water</th>
<th>Annual Cost per Turbine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility</td>
<td>$0.07 per gallon (10x cost of regular water)</td>
<td>$204,400</td>
</tr>
<tr>
<td>Demineralized water supplier</td>
<td>$0.0281 per gallon</td>
<td>$82,052</td>
</tr>
</tbody>
</table>
### Costs for Replacement

- Staff obtained costs for new turbines from an EPA publication and one landfill facility.

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<thead>
<tr>
<th>Source</th>
<th>Capital Cost</th>
<th>Annual Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPA Catalog of CHP Technologies</td>
<td>$1.2 – $1.5 million/MW</td>
<td>$0.0092 - $0.0093/kWh</td>
</tr>
<tr>
<td>Facility A</td>
<td>$8.7 million (3 turbines) $21 million (installation + CEMS)</td>
<td>$100,000 per turbine</td>
</tr>
</tbody>
</table>
Cost-Effectiveness to Meet 2.5 ppm with SCR + Gas Treatment

Cost-effectiveness to retrofit three existing turbines with SCR and implement gas treatment technology that processes 6000 scfm of digester gas

<table>
<thead>
<tr>
<th>System</th>
<th>Capital Cost</th>
<th>O&amp;M Cost</th>
<th>Emission Reductions (25 years)</th>
<th>Cost-effectiveness ($/ton of NOx reduced)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas treatment</td>
<td>$26,250,000</td>
<td>$250,000</td>
<td>1,480 tons</td>
<td>$30,400</td>
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<tr>
<td>SCR</td>
<td>$7.6 million</td>
<td>$470,000</td>
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</table>
Cost-Effectiveness to Meet 18.8 ppm with Increased Water Injection

- Cost-effectiveness to increase water injection rates on existing turbines

<table>
<thead>
<tr>
<th>Source</th>
<th>Cost of Demineralized Water</th>
<th>Annual Cost per Turbine</th>
<th>Emission Reductions (25 years)</th>
<th>Cost-effectiveness for 3 Turbines ($/per ton of NOx reduced)</th>
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</thead>
<tbody>
<tr>
<td>Facility</td>
<td>$0.07 per gallon (10x cost of regular water)</td>
<td>$204,400</td>
<td>239 tons</td>
<td>$40,050</td>
</tr>
<tr>
<td>Demineralized water supplier</td>
<td>$0.0281 per gallon</td>
<td>$82,052</td>
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<td>$16,077</td>
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</table>

Average Cost Effectiveness $28,064
Cost-effectiveness to replace 3 turbines with 6 smaller turbines that can meet 12.5 ppm

- Gas treatment may not be required – lower levels of gas treatment than that required for SCR may be permissible

<table>
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<tr>
<th>System</th>
<th>Capital Cost</th>
<th>O&amp;M Cost</th>
<th>Emission Reductions (25 years)</th>
<th>Cost-effectiveness ($/ton of NOx reduced)</th>
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</thead>
<tbody>
<tr>
<td>New Turbines</td>
<td>$45 million</td>
<td>$600,000</td>
<td>600 tons</td>
<td>$90,500</td>
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</tbody>
</table>
BARCT Analysis Summary

Assessment of South Coast AQMD Regulatory Requirements

Assessment of Emission Limits for Existing Units

Other Regulatory Requirements

Assessment of Pollution Control Technologies

Initial BARCT Emission Limits and Other Considerations

Cost-Effectiveness Analysis

**BARCT Emission Limits**

- **NOx Limit 18.8 ppm (water injection)**
  - 18.8 – 25 ppm
  - 2.5 – 22 ppm
  - 3 – 15 ppm
  - < 2.5 ppm
  - 2.5 ppm
  - < $50,000 per ton of NOx reduced

- **NOx Limit 2.5 ppm (SCR)**
  - 18.8 ppm
  - 2.5 ppm (at replacement)
Rulemaking Schedule

4-6 weeks
Next Working Group Meeting

2nd Quarter 2020
Public Workshop

3rd Quarter 2020
Set Hearing

3rd Quarter 2020
Public Hearing
To receive e-mail notifications for Rule 1179.1 - NOx Emission Reductions from Combustion Equipment at Publicly Owned Treatment Works Facilities, sign up at: www.aqmd.gov/sign-up