APPENDIX C

Cost Effectiveness Analysis for
Proposed Amendments to Rule 4352
(Solid Fuel Fired Boilers, Steam Generators, and Process Heaters)

December 16, 2021

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APPENDIX C
COST EFFECTIVENESS ANALYSIS

I. SUMMARY

The California Health and Safety Code 40920.6(a) requires the San Joaquin Valley Unified Air Pollution Control District to conduct both an "absolute" cost effectiveness analysis and an incremental cost effectiveness analysis of available emission control options prior to adopting each Best Available Retrofit Control Technology (BARCT) rule. The purpose of conducting a cost effectiveness analysis is to evaluate the economic reasonableness of the pollution control measure or rule. The analysis also serves as a guideline in developing the control requirements of a rule.

Absolute cost effectiveness of a control option is the added annual compliance cost to meet the proposed rule requirements, in dollars per year ($/year), of a control technology or technique, divided by the emission reduction achieved in tons reduced per year. The costs includes capital equipment costs, engineering design costs, and labor and maintenance costs.

Incremental cost effectiveness (ICE) is intended to measure the change in costs (in $/year) and emissions reductions (in tons reduced/year) between two progressively more effective control options or technologies. ICE compares the differences in costs and the differences in emissions reductions of candidate control options. ICE does not reveal the emission reduction potential of the control options. Unlike the absolute cost effectiveness analysis that identifies the control option with the greatest emission reduction, ICE does not present any correlation between emissions reductions and cost effectiveness. Therefore, the relative values produced in the ICE analysis and the absolute cost effectiveness values are not comparable and cannot be evaluated in the same way as absolute cost effectiveness numbers.

Table 1 shows the summary of the cost effectiveness analysis for solid fuel fired boilers to comply with the proposed rule. The ‘cost effectiveness range’ shown in the table below represents the values for the technologies that are expected to be installed at solid fuel fired boilers, grouped by fuel type and pollutant, in the San Joaquin Valley.

Table C-1: Summary of Cost Effectiveness*

Compliance Scenarios (Current Permitted Limit to Proposed New Limit)	Cost Effectiveness Range ($/ton)
Municipal Solid Waste – NOx Limit	$26,269
Municipal Solid Waste – PM10 Limit	-
Municipal Solid Waste – SOx Limit	-
Biomass – NOx Limit	-
Biomass – PM10 Limit	-
Biomass – SOx Limit	$7,100 - $29,702

* *Where cost-effectiveness calculations are not shown, there are nominal costs expected. Associated costs would be related to maintaining and testing emissions, which are well controlled through currently installed control technologies, and permit modifications.*

Table 2 shows the total direct and indirect capital cost associated with the technologies required for subject facilities to comply with the proposed emission limits.

Table C-2: Estimated Capital Cost for Control Technology

Technology	Total Direct and Indirect Capital Costs
Municipal Solid Waste – Install Covanta LN	$12,100,000
Biomass – Install SOx CEMs	$2,323,317

**Costs do not include one time permit modification fees*

II. BACKGROUND

Proposed Rule 4352 would implement more stringent NOx limits, and establish PM10 and SOx limits for solid fuel fired boilers. To comply with the proposed requirements, the facility with units fired on municipal solid waste (MSW) will require a significant investment to install combustion modification equipment to meet the proposed NOx limit. Units fired on biomass are expected to be capable of achieving the proposed NOx limit with existing control equipment with nominal additional costs, which may including tuning of controls, testing, monitoring, as well as permit modifications. For the PM10 and SOx emissions limits, subject facilities are also expected to be capable of complying with the proposed updated limits with existing control equipment, and marginal associated costs which may include tuning of controls, testing, and monitoring costs, as well as the cost for permit modification to include permit conditions for the additional pollutants. Two biomass facilities will need to upgrade their continuous emission monitoring systems (CEMs) to monitor SO_2 emissions, and one facility would require the installation of a dry sorbent injection system to control SOx emissions. One additional facility with a biomass fired solid fuel fired boiler, which is currently in the permitting process, would require the installation of SO_2 CEMS and dry sorbent injection to comply with the proposed amendments to Rule 4352.

A. Estimated Compliance Cost

District staff used cost information provided by control equipment manufacturers and vendors, and from stakeholders to conduct a cost effectiveness analysis of the proposed NOx, PM10, and SOx limits in Proposed Rule 4352. Specifically the data used in the analysis came from the following sources:

1. Covanta Stanislaus
2. Rio Bravo Fresno
3. Merced Power LLC
4. Ampersand Chowchilla
5. DTE Stockton
6. Mt. Poso Cogeneration
7. W. L. Gore & Associates, Inc.
8. Tracy Renewable Energy, LLC

Cost information submitted to the District was used to create the range of costs located in Tables C-4 through C-23.

III. SOLID FUEL FIRED BOILER STATUS RELATIVE TO PROPOSED EMISSION LIMITS

There are nine facilities that have active permits to operate solid fuel fired boilers within the District, and all nine will be impacted by this proposed rule amendment. These nine facilities operate a total of eleven furnaces – two are fired on municipal solid waste, and nine are fired on biomass. A summary of these facilities, their control equipment and their current permitted emission limits are shown in the table C-3 below:

Table C-3: Current Facility Control Technology, Size, and Emission Limits

Facility	Pollutant	Current Reduction Technology	Maximum Heat Input Rating (MMBtu/hr)	Current Permitted Emission Limits
Municipal Solid Waste – Facility 1	NOx	Selective Non-Catalytic Reduction (SNCR)	300	165 ppmv
	PM10	Baghouse		0.053 lbs/MMBtu
	SOx	Dry Sorbent Injection		0.085 lbs/MMBtu
Biomass – Facility 1	NOx	SNCR	185	65 ppmv
	PM10	Baghouse		0.04 lbs/MMBtu
	SOx	Dry Sorbent Injection		0.04 lbs/MMBtu
Biomass – Facility 2	NOx	Selective Catalytic Reduction (SCR)	780	50 ppmv
	PM10	Electrostatic Precipitator (ESP)		0.0214 lbs/MMBtu
	SOx	Dry Sorbent Injection		0.054 lbs/MMBtu
Biomass – Facility 3	NOx	SNCR	352	65 ppmv
	PM10	ESP		0.066 lbs/MMBtu
	SOx	Dry Sorbent Injection		0.03 lbs/MMBtu
Biomass – Facility 4	NOx	SNCR	185	65 ppmv
	PM10	Baghouse		0.04 lbs/MMBtu
	SOx	Dry Sorbent Injection		0.035 lbs/MMBtu
Biomass – Facility 5	NOx	SNCR	640	65 ppmv
	PM10	Baghouse		0.012 lbs/MMBtu
	SOx	Dry Sorbent Injection		0.04 lbs/MMBtu
Biomass – Facility 6	NOx	SNCR	317	65 ppmv
	PM10	Baghouse		0.045 lbs/MMBtu
	SOx	Dry Sorbent Injection		0.032 lbs/MMBtu
Biomass – Facility 7	NOx	SNCR	460	90 ppmv
	PM10	Baghouse		0.03 lbs/MMBtu
	SOx	Dry Sorbent Injection		0.063 lbs/MMBtu
Biomass – Facility 8 Unit 1	NOx	SNCR	400	76 ppmv
	PM10	Baghouse		0.045 lbs/MMBtu
	SOx	Dry Sorbent Injection		0.033 lbs/MMBtu
Biomass – Facility 8 Unit 2	NOx	SNCR	315	76 ppmv
	PM10	Baghouse		0.045 lbs/MMBtu
	SOx	Dry Sorbent Injection		0.038 lbs/MMBtu
Biomass – Facility 9	NOx	SNCR	198.6	70 ppmv
	PM10	Baghouse		0.05 lbs/MMBtu
	SOx	None		0.05 lbs/MMBtu

III. COST EFFECTIVENESS ANALYSIS PROCEDURE

To illustrate the cost effectiveness of complying with the proposed limits, District staff's analysis provides varying cost effectiveness values depending on the size of the unit, and the annual capacity factor that the unit is operated. The actual compliance costs and cost effectiveness values would depend on several factors such as the type of unit, site-specific operating conditions, and the appropriate emission limits the unit has to meet.

A. Absolute Cost Effectiveness

Absolute cost effectiveness examines the cost of reaching the proposed emission limits using the current emissions as a baseline. Cost effectiveness is calculated as the added annual cost (in $/year) of a control technology or technique, divided by the emission reduction achieved (in tons reduced/year). The annual costs include annualized capital equipment costs and engineering design costs plus the annual labor and maintenance costs.

The absolute cost effectiveness of a control technology is calculated as follows:

1. Determine an equivalent annual equipment cost using a capital recovery factor based on an assumed interest rate of 4 percent and equipment life of 10 years.
2. Determine the annual electricity, fuel, and operation and maintenance costs of a control technology.
3. Calculate the total annual cost by adding the costs calculated in Step 1 and Step 2.
4. Calculate the emission reduction in tons/year. Appendix B provides a detailed explanation of the calculations performed to determine the emission reductions for the potential rule limits.
5. Calculate the absolute cost effectiveness by dividing the total annual cost in Step 3 by the emissions reduction in Step 4.

B. Incremental Cost Effectiveness

Incremental cost effectiveness (ICE) indicates the additional cost for further controlling a unit from the proposed limit to the lowest possible level. Costs are evaluated similar to absolute costs but are only calculated for the controls and reductions beyond what is required to comply with the rule. ICE does not reveal the emission reduction potential of the control options, but examines the more stringent options that were not considered cost effective. Due to the increased costs and marginal emission reductions, the ICE calculations typically show a much higher cost effectiveness than the absolute cost effectiveness values, and are therefore not directly comparable.

The incremental cost effectiveness of a control technology is calculated as follows:

1. Identify the complying control options appropriate for the existing equipment.
2. Estimate the annual average cost of each control option by using Steps 1 to 3 of the ACE calculation method.
3. Calculate the potential emission reduction for each control option. The potential emission reductions (PE) are the difference between the current emissions and the potential emissions using the new control technology.

For the ICE analysis, the emission reduction is the difference between the current rule emission limits to proposed emission limits.

IV. ABSOLUTE COST EFFECTIVENESS ANALYSIS

Absolute cost effectiveness of a control option is the added annual cost, in dollars per year, of a control technology or technique divided by the emission reductions achieved, in tons reduced per year. Compliance costs include both one-time costs and on-going annual costs. Examples of one-time costs are the purchase of equipment and installation costs. On-going costs are items like maintenance costs, operation costs, and insurance. In order to determine a single figure for costs, District staff use a capital recovery factor to allocate the one-time costs over the life of the equipment. For all cost analyses in this report, District staff used a 4 percent rate of return and a 10-year equipment life to convert the capital costs to equivalent annual cost.

1. NOx Compliance Costs

The District worked with the affected MSW facility operating in the Valley to determine the costs to install proprietary combustion modification technology, Covanta LN at the facility in Stanislaus County. The installation would also include an upgrade to the selective non-catalytic reduction system and an increased operation and maintenance cost (O&M) for the additional ammonia required to operate the system. All biomass facilities in the Valley already have selective non-catalytic reduction (SNCR) or selective catalytic reduction (SCR) to limit NOx emissions, and are expected to be able to meet the proposed limits without major modifications to the existing controls, or are already meeting the proposed emissions limits. Solid fuel fired boilers in the District are expected to be able to comply with the new PM10 emission limits without major modifications to their existing control equipment. The capital costs associated with the PM10 emission limits for biomass fired units are attributed to permit modification fees. Additional costs may be incurred by facilities to upgrade controls, test and monitor emissions to ensure compliance with the proposed emissions limits, but these costs are expected to be marginal.

Table C-4: NOx Compliance Costs

Fuel Type	Capital Cost	O&M ($/yr)	Annualized Cost ($/yr)	Emission Reductions (tons/year)	Cost Effectiveness ($/ton NOx)
Municipal Solid Waste	$12,121,000	$840,987	$2,355,397	144.0	$26,269

2. PM10 Compliance Costs

Most facilities subject to Rule 4352 are expected to be able to comply with the new PM10 emission limits without major modifications to their existing control equipment. All facilities already have the highest degree of control technology available, which include baghouses or electrostatic precipitators to limit particulate matter emissions. However, some facilities may require tuning of their current emission control equipment to ensure compliance with the lower emissions limits, with marginal associated costs.

3. SOx Compliance Costs

Most facilities subject to Rule 4352 are expected to be able to comply with the new SOx emission limits without major modifications to their existing control equipment, and with nominal costs or impacts to current operations. Potential compliance costs could include the cost of additional sorbent used in current control systems, permitting fees, and testing and monitoring costs. The majority of facilities have dry sorbent injection systems to control SOx. One dormant facility would require the installation of SOx control equipment should it become active again. Two facilities in the Valley do not currently have a CEMs channel for SOx. To demonstrate compliance with the proposed SOx limits, the facilities would be required to install a CEMs channel. This would include an initial cost to install the system, estimated at approximately $50,000 per facility, as well as annual costs to maintain the monitor. There is an expected O&M cost associated with the installation of the new CEMs channel of approximately $3,700 per facility annually. There is also one facility with two small biomass fired boilers, which is currently in the permitting process, that would require the installation of SOx CEMs and SOx control technology to comply with the proposed amendments to Rule 4352.

Table C-6: SOx Compliance Costs

Fuel Type	Capital Cost	O&M ($/yr)	Annualized Cost ($/yr)	Emission Reductions (tons/year)	Cost Effectiveness ($/ton SOx)
Biomass	$2,404,317	$783,487	$1,079,939	111.0	$9,729

V. ALTERNATIVE CONTROL TECHNOLOGIES EVALUATED

Selective Catalytic Reduction for Units Fired on MSW to Reduce NOx Emissions

Selective catalytic reduction systems are a post-combustion control for NOx that involves the injection of anhydrous ammonia, aqueous ammonia, or urea solution into the exhaust gas to reduce NOx emissions capable of achieving 50 ppm NOx. District staff evaluated the feasibility of installation of a SCR system at the MSW fired facility in the District to meet a potential 50 ppm limit, and found that this control option would involve very high capital and annual costs. Direct capital costs include the purchase of the SCR, retrofit of the existing structure to accommodate the system, additional ductwork, and installation of a natural gas pipeline for the duct burner. Indirect capital costs include engineering and retrofit downtime resulting in the loss of six months of electricity sales and tipping fees. Total capital cost are approximately $35 million. Annual operation and maintenance costs include periodic catalyst replacement, additional electricity required, insurance, and labor, with associated costs estimated at approximately $2 million annually. Establishing a 50 ppmv NOx emissions limit was not recommended due to the high capital cost and high cost per ton of NOx reduced.

Table C-7: Costs and Cost Effectiveness for Alternative Technology – SCR for Units fired on MSW

Selective Catalytic Reduction for Units Fired on MSW					
Total Capital Cost	Annualized Capital Cost	Annualized O&M $/yr	Annualized Cost $/yr	NOx reduced tons/yr	CE $/ton NOx
$34,635,513	$5,635,198	$2,038,786	$7,673,984	156.9	$62,184

Gore De-NOx for Units Fired on MSW to Reduce NOx Emissions

Gore De-NOx catalytic filter bags is a retrofit control technology that effectually converts an existing pulse-jet baghouse into a selective catalytic reduction control system capable of achieving emissions levels as low as 60 ppm NOx. District staff evaluated the feasibility of installation of a Gore De-NOx system at the MSW fired facility in the District to meet a potential 60 ppm limit, and found that this control option would involve high capital and annual costs. Capital costs include the purchase of the initial Gore filter bags, freight, installation, and three weeks of retrofit downtime. Total capital cost are approximately $5.5 million. O&M costs include sorting of material, periodic catalyst bag replacement, insurance, and labor, with costs estimated at approximately $6.6 million annually. The major O&M cost is the cost to hand sort the municipal solid waste to remove high SOx materials like drywall. This is because Gore-DeNOx filter bags are susceptible to fouling by high levels of SOx. Another factor that led to the District not establishing a 60 ppm NOx limit is that Gore De-NOx technology has never been installed at a MSW facility in the United States.

Table C-8: Costs and Cost Effectiveness for Alternative Technology – Gore De-NOx for Units fired on MSW

Gore De-NOx for Units Fired on MSW					
Total Capital Cost	Annualized Capital Cost	Annualized O&M $/yr	Annualized Cost $/yr	NOx reduced tons/yr	CE $/ton NOx
$5,449,933	$886,704	$6,647,262	$7,533,966	130.5	$88,462

Combined Selective Catalytic Reduction and Covanta LN for Units Fired on MSW to Reduce NOx Emissions

Combining SCR and Covanta LN combustion technology is capable of achieving 35 ppm NOx. District staff evaluated the feasibility of installation of a SCR system at the MSW fired facility in the District to meet a potential 35 ppm limit, and found that this control option would involve very high capital and annual costs. Direct capital costs include the purchase of the SCR, purchase of the Covanta LN combustion modification equipment, retrofit of the existing structure to accommodate the system, additional ductwork, and installation of a natural gas pipeline for the duct burner. Indirect capital costs include engineering and retrofit downtime resulting in the loss of six months of electricity sales and tipping fees. Total capital costs are approximately $42 million. Annual operation and maintenance costs include periodic catalyst bag replacement, additional electricity required, insurance, and labor, with costs estimated at approximately $3 million. Establishing a 35 ppmv NOx emissions limit was not recommended due to the high capital cost and high cost per ton of NOx reduced.

Table C-9: Costs and Cost Effectiveness for Alternative Technology – Combined SCR and Covanta LN for Units fired on MSW

Combined Selective Catalytic Reduction and Covanta LN for Units Fired on MSW					
Total Capital Cost	Annualized Capital Cost	Annualized O&M $/yr	Annualized Cost $/yr	NOx reduced tons/yr	CE $/ton NOx
$42,368,248	$6,893,314	$2,904,021	$9,797,335	179.2	$67,268

Combined Gore De-NOx and Covanta LN for Units Fired on MSW to Reduce NOx Emissions

Combining Gore De-NOx and Covanta LN combustion technology is capable of achieving 45 ppm NOx. District staff evaluated the feasibility of installation of a Gore De-NOx and Covanta LN technologies at the MSW fired facility in the District to meet a potential 45 ppm limit, and found that this control option would involve high capital and annual costs. Capital costs include the purchase of the initial Gore filter bags, purchase of the Covanta LN combustion modification equipment, freight, installation, and three weeks of retrofit downtime. Total capital cost are approximately $5.5 million. Annual O&M costs include sorting of material, periodic catalyst bag replacement, insurance, and labor, with costs estimated at approximately $6.6 million. The major O&M cost is the cost to hand sort the municipal solid waste to remove high SOx materials like drywall. This is because Gore-DeNOx filter bags are susceptible to fouling by high levels of SOx. Another factor that led to the District not establishing a 45 ppm NOx limit is that Gore De-NOx technology has never been installed at a MSW facility in the United States.

Table C-10: Costs and Cost Effectiveness for Alternative Technology – Combine Gore De-NOx and Covanta LN for Units fired on MSW

Combined Gore Den-NOx and Covanta LN for Units Fired on MSW					
Total Capital Cost	Annualized Capital Cost	Annualized O&M $/yr	Annualized Cost $/yr	NOx reduced tons/yr	CE $/ton NOx
$13,140,611	$2,137,977	$6,938,133	$9,076,110	170.2	$67,905

Selective Catalytic Reduction for Units Fired on Biomass to Reduce NOx Emissions

SCR is a post-combustion control for NOx that involves the injection of anhydrous ammonia, aqueous ammonia, or urea solution into the exhaust gas to reduce NOx emissions. SCR systems are capable of achieving emissions as low 50 ppm NOx. One recently installed biomass fired unit installed SCR and is meeting a 50 ppm NOx emissions limit. This new unit was subject to New Source Review (NSR), District Rule 2201 and therefore was required to install best available control technology (BACT). The other nine facilities with active permits would need to retrofit in order to meet a 50 ppm NOx limit. District staff evaluated the feasibility of installation of a SCR system at the biomass fired facilities in the District to meet a potential 50 ppm limit, and found that this control option would involve very high capital and annual costs. Direct capital costs include the purchase of the SCR, retrofit of the existing structure to accommodate the system, additional ductwork, and installation of a natural gas pipeline for the duct burner. Indirect capital costs include engineering and retrofit downtime resulting in the loss of 90 days of electricity sales minus the savings from not purchasing biomass during the retrofit. Total capital cost are approximately $72 million. Annual operation and maintenance costs include periodic catalyst replacement, additional electricity required, insurance, and labor. Annual O&M cost are approximately $13 million. Establishing a 50 ppmv NOx emissions limit was not recommended due to the high capital cost and high cost per ton of NOx reduced.

Table C-11: Costs and Cost Effectiveness for Alternative Technology – SCR for Units fired on Biomass

Selective Catalytic Reduction for Units Fired on Biomass					
Total Capital Cost	Annualized Capital Cost	Annualized O&M $/yr	Annualized Cost $/yr	NOx reduced tons/yr	CE $/ton NOx
$72,001,257	$11,714,605	$13,027,490	$24,742,095	329.5	$75,090

Gore De-NOx for Units Fired on Biomass to Reduce NOx Emissions

Combining Gore De-NOx with a new, state of the art boiler is capable of achieving emissions as low as 50 ppm NOx. District staff evaluated the feasibility of installation of a Gore De-NOx system with a new boiler at the biomass fired facilities in the District to meet a potential 50 ppm limit, and found that this control option would involve very high capital and annual costs. Capital costs include the purchase of the initial Gore filter bags, purchase of the new boiler, freight, installation, and three weeks of retrofit downtime. Total capital cost are approximately $66 million. Annual O&M costs include periodic catalyst bag replacement, insurance, and labor. Annual O&M cost are approximately $8 million. Another factor that led to the District not establishing a 50 ppmv NOx emissions limit is that Gore De-NOx technology has never been installed at biomass facilities and never been installed in the United States, and therefore has not been demonstrated in practice for this type of unit.

Table C-12: Costs and Cost Effectiveness for Alternative Technology – Gore De-NOx for Units fired on Biomass

Gore De-NOx for Units Fired on Biomass					
Total Capital Cost	Annualized Capital Cost	Annualized O&M $/yr	Annualized Cost $/yr	NOx reduced tons/yr	CE $/ton NOx
$65,614,626	$10,675,500	$7,998,587	$18,674,087	329.5	$56,674

Combined Selective Catalytic Reduction with a New Boiler for Units Fired on Biomass to Reduce NOx Emissions

Combining SCR with a new, state of the art boiler is capable of achieving 40 ppm NOx. District staff evaluated the feasibility of installation of a SCR system at the biomass fired facilities in the District to meet a potential 40 ppm limit, and found that this control option would involve very high capital and annual costs. Direct capital costs include the purchase of the SCR, retrofit of the existing structure to accommodate the system, additional ductwork, and installation of a natural gas pipeline for the duct burner. Indirect capital costs include engineering and retrofit downtime resulting in the loss of 90 days of electricity sales minus the savings from not purchasing biomass during the retrofit. Total capital cost are approximately $600 million. Annual O&M costs include periodic catalyst replacement, additional electricity required, insurance, and labor.

Annual O&M cost are approximately $17 million. Establishing a 40 ppmv NOx emissions limit was not recommended due to the high capital cost and high cost per ton of NOx reduced.

Table C-13: Costs and Cost Effectiveness for Alternative Technology – Combined SCR with a New Boiler for Units fired on Biomass

Combined Selective Catalytic Reduction with a New Boiler for Units Fired on Biomass					
Total Capital Cost	Annualized Capital Cost	Annualized O&M $/yr	Annualized Cost $/yr	NOx reduced tons/yr	CE $/ton NOx
$600,951,595	$97,774,824	$16,585,626	$114,360,450	510.3	$224,104

Combined Gore De-NOx with a New Boiler for Units Fired on Biomass to Reduce NOx Emissions

Gore De-NOx catalytic filter bags is a retrofit control technology that effectually converts an existing pulse-jet baghouse into a selective catalytic reduction control system is capable of achieving 40 ppm NOx. District staff evaluated the feasibility of installation of a Gore De-NOx system at the biomass fired facilities in the District to meet a potential 40 ppm limit, and found that this control option would involve high capital and annual costs. Capital costs include the purchase of the initial Gore filter bags, purchase of the new boiler freight, installation, and three weeks of retrofit downtime. Total capital cost are approximately $575 million. O&M costs include periodic catalyst bag replacement, insurance, and labor, estimated to total approximately $8 million annually. Another factor that led to the District not establishing a 40 ppmv NOx emissions limit is that Gore De-NOx technology has never been installed at a MSW facility in the United States.

Table C-14: Costs and Cost Effectiveness for Alternative Technology – Combined Gore De-NOx with a New Boiler for Units fired on Biomass

Combined Gore De-NOx with a New Boiler for Units Fired on Biomass					
Total Capital Cost	Annualized Capital Cost	Annualized O&M $/yr	Annualized Cost $/yr	NOx reduced tons/yr	CE $/ton NOx
$574,974,827	$93,548,404	$8,196,006	$101,744,410	510.3	$199,382

Ceramic Filters to Reduce PM10 Emissions

Ceramic filters can generally achieve lower particulate matter emission rates than fabric filters or electrostatic precipitators, as low as 0.02 lbs/MMBtu. Ceramic filters have the potential to be installed at facilities that are fired on municipal solid waste or biomass. However, these types of filters have not been installed or demonstrated at these types of facilities. With traditional fabric baghouse filters particulate matter is captured on the surface of the filter; however, some particulate matter penetrates deeply into the filter walls and the body of the fabric filter and may be emitted during the baghouse's internal filter cleaning process. Ceramic filters, such as Tri-Mer ceramic filters, have special qualities on the filter surface that result in all of the particulate matter being captured on the face of the filter tubes. However, ceramic filters are much more expensive than fabric filters. Additionally, ceramic filter systems like the Tri-Mer system would require the existing baghouse/ESP to be removed and new ceramic filter modules to be installed. District staff evaluated the feasibility of installation of ceramic filters at facilities in the District to meet a potential 0.02 lbs/MMBtu limit, and found that this control option would involve high capital and annual costs. Total capital costs are estimated to be approximately $63 million. Annual O&M costs include periodic catalyst bag replacement, insurance, and labor. Annual O&M costs are approximately $4 million. Establishing a 0.02 lbs/MMBtu PM10 emissions limit was not recommended due to the high capital cost and high cost per ton of PM10 reduced.

Table C-15: Costs and Cost Effectiveness for Alternative Technology – Ceramic Filters

Ceramic Filters						
Fuel Type	Total Capital Cost	Annualized Capital Cost	Annualized O&M $/yr	Annualized Cost $/yr	NOx reduced tons/yr	CE $/ton NOx
MSW	$11,834,942	$1,925,545	$426,319	$2,351,864	43.6	$53,961
Biomass	$51,499,850	$8,379,028	$3,326,467	$11,705,495	187.6	$62,396

Semi-Dry Absorbers to Reduce SOx Emissions

Semi-dry absorbers (SDA) operate by mixing a small amount of water with the sorbent. These are considered dry scrubber units, since the sorbent is dry when the reaction takes place. Lime is usually the sorbent, but hydrated lime may be used and can provide greater SO_2 removal. SDAs can be installed at facilities that are fired on municipal solid waste or biomass and are capable of SOx emissions as low as 0.003 lbs/MMBtu. District staff evaluated the feasibility of installation of SDAs at facilities in the District to meet a potential 0.003 lbs/MMBtu limit, and found that this control option would involve high capital and annual costs. Total capital costs are approximately $310 million. Annual O&M cost are approximately $62 million. Establishing a 0.003 lbs/MMBtu SOx emissions limit was not recommended due to the high capital cost and high cost per ton of SOx reduced.

Table C-16: Costs and Cost Effectiveness for Alternative Technology – Semi-Dry Absorbers

Semi-Dry Absorbers						
Fuel Type	Total Capital Cost	Annualized Capital Cost	Annualized O&M $/yr	Annualized Cost $/yr	NOx reduced tons/yr	CE $/ton NOx
MSW	$21,500,000	$3,498,050	$4,370,485	$7,868,535	118.0	$66,683
Biomass	$288,750,000	$46,979,625	$57,189,367	$104,168,992	402.3	$258,934

Wet Fluid Gas Desulfurization to Reduce SOx Emissions

Wet Fluid Gas Desulfurization (FGD) controls SO_2 emissions unit using wet solutions containing alkali reagents such as limestone, lime, sodium-based alkaline, or dual alkali-based sorbents. FGDs can be installed at facilities that are fired on municipal solid waste or biomass and are capable of SOx emissions as low as 0.001 lbs/MMBtu. District staff evaluated the feasibility of installation of FGDs at facilities in the District to meet a potential 0.001 lbs/MMBtu limit, and found that this control option would involve high capital and annual costs. Total capital costs are approximately $310 million. Annual O&M cost are approximately $62 million. Establishing a 0.001 lbs/MMBtu SOx emissions limit was not recommended due to the high capital cost and high cost per ton of SOx reduced.

Table C-17: Costs and Cost Effectiveness for Alternative Technology – Wet Fluid Gas Desulfurization

Wet Fluid Gas Desulfurization						
Fuel Type	Total Capital Cost	Annualized Capital Cost	Annualized O&M $/yr	Annualized Cost $/yr	NOx reduced tons/yr	CE $/ton NOx
MSW	$19,350,000	$3,148,245	$3,969,877	$7,118,122	120.6	$59,023
Biomass	$259,875,000	$42,281,663	$51,753,437	$94,035,100	433.5	$216,921

VI. INCREMENTAL COST EFFECTIVENESS ANALYSIS

Health and Safety Code section 40920.6 requires an incremental cost-effectiveness analysis for Best Available Retrofit Control Technology (BARCT) rules or emission reduction strategies when there is more than one control option that would achieve the emission reduction objective of the proposed amendments. The incremental cost effectiveness is the difference in cost between successively more effective controls divided by the additional emission reductions achieved. Incremental cost-effectiveness is calculated as follows:

$$\textit{Incremental cost-effectiveness} = (C_{alt} - C_{proposed}) / (E_{alt} - E_{proposed})$$

Where:
$C_{proposed}$ is the present worth value of the proposed control option;
$E_{proposed}$ are the emission reductions of the proposed control option;
C_{alt} is the present worth value of the alternative control option; and
E_{alt} are the emission reductions of the alternative control option

1. NOx Incremental Cost Effectiveness Analysis

The District evaluated several technology options to lower the NOx emissions at the municipal solid waste facility in the District. The proposed NOx limit of 90 ppm would require the installation of Covanta LN technology. Other more stringent control options included SCR, Gore De-NOx, Covanta LN with SCR, and Covanta LN with Gore De-NOx.

Table C-18: NOx Incremental Cost Effectiveness Analysis for Units fired on MSW

Evaluated Alternative Emissions Limit (ppm)	Potential Control Technology	Annualized Cost ($/year)	Annual Emission Reductions (tons/year)	Incremental Cost Effectiveness ($/ton)
60	Gore De-NOx	$7,533,966	130.5	$78,508
50	SCR	$7,673,984	156.9	$124,965
45	Covanta LN + SCR	$9,797,335	179.2	$82,634
35	Covanta LN + Gore De-NOx	$9,076,110	170.2	$82,911

The District evaluated several technology options to lower the NOx emissions for biomass fueled units. The proposed limit would require the establishment of a 65 ppm NOx limit. Other more stringent control options included SCR, Gore De-NOx, new boilers with SCR, and new boilers with Gore De-NOx.

Table C-19: NOx Incremental Cost Effectiveness Analysis for Units fired on Biomass

Evaluated Alternative Emissions Limit (ppm)	Technology	Annualized Cost ($/year)	Annual Emission Reductions (tons/year)	Incremental Cost Effectiveness ($/ton)
50	SCR	$24,742,095	329.5	$115,517
50	Gore De-Nox	$18,674,087	329.5	$86,972
40	New Boiler with SCR	$114,360,450	510.3	$289,568
40	New Boiler with Gore De-NOx	$101,744,410	510.3	$257,620

The incremental cost effectiveness analysis did not demonstrate that any of the alternative control technologies were more cost effective, therefore these control options were not chosen.

2. PM10 Incremental Cost Effectiveness Analysis

The District evaluated a technology option to lower the PM10 emissions for units fired on municipal solid waste. The proposed limit would require the establishment of a 0.04 lbs/MMBtu or 0.02 gr/dscf at 12% CO_2 PM10 limit. The other control option is the use of ceramic filters.

Table C-20: PM10 Incremental Cost Effectiveness Analysis for Units fired on MSW

Evaluated Alternative Emissions Limit (lbs/MMBtu)	Technology	Annualized Cost ($/year)	Annual Emission Reductions (tons/year)	Incremental Cost Effectiveness ($/ton)
0.02	Ceramic Filters	$2,351,864	43.6	$63,709

The District evaluated a technology option to lower the PM10 emissions for units fired on biomass. The proposed limit would require the establishment of a 0.04 lbs/MMBtu or 0.02 gr/dscf at 12% CO_2 PM10 limit. The other control option is the use of ceramic filters.

Table C-21: PM10 Incremental Cost Effectiveness Analysis for Units fired on Biomass

Evaluated Alternative Emissions Limit (lbs/MMBtu)	Technology	Annualized Cost ($/year)	Annual Emission Reductions (tons/year)	Incremental Cost Effectiveness ($/ton)
0.02	Ceramic Filters	$11,705,495	187.6	$127,263

The incremental cost effectiveness analysis did not demonstrate that the alternative control technology was more cost effective, therefore this control option was not chosen.

3. SOx Incremental Cost Effectiveness Analysis

The District evaluated several technology options to lower the SOx emissions for units fired on municipal solid waste. The proposed limit would require the establishment of a 0.03 lbs/MMBtu or 12 ppm at 12% CO_2 SOx limit. Other more stringent control options evaluated included semi-dry absorbers and wet fluidized gas desulfurization.

Table C-22: SOx Incremental Cost Effectiveness Analysis for Units fired on MSW

Evaluated Alternative Emissions Limit (lbs/MMBtu)	Technology	Annualized Cost ($/year)	Annual Emission Reductions (tons/year)	Incremental Cost Effectiveness ($/ton)
0.003	Semi-Dry Absorbers	$7,868,535	118.0	$201,732
0.001	Wet Fluid Gas Desulfurization	$7,118,122	120.6	$171,085

The District also evaluated technology options to lower the SOx emissions for units fired on biomass. The proposed limit would require the establishment of a 0.02 lbs/MMBtu or 12 ppm at 12% CO_2 SOx limit. Other more stringent control options evaluated included semi-dry absorbers and wet fluidized gas desulfurization.

Table C-23: SOx Incremental Cost Effectiveness Analysis for Units fired on Biomass

Evaluated Alternative Emissions Limit (lbs/MMBtu)	Technology	Annualized Cost ($/year)	Annual Emission Reductions (tons/year)	Incremental Cost Effectiveness ($/ton)
0.003	Semi-Dry Absorbers	$104,168,992	402.5	$357,287
0.001	Wet Fluid Gas Desulfurization	$94,035,100	433.5	$291,520

The incremental cost effectiveness analysis did not demonstrate that any of the alternative control technologies were more cost effective, therefore these control options were not chosen.

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