

APPENDIX G

Reasonably Available Control Measures

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APPENDIX G-1

OZONE TRANSPORT COMMISSION Identification and Evaluation of Candidate Control Measures: Final Technical Support Document

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Identification and Evaluation of Candidate Control Measures

Final Technical Support Document

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Acronyms and Abbreviations

Acronym	Description
BOTW	Beyond-on-the-Way – refers to additional emission controls that are being considered
CAIR	Clean Air Interstate Rule
EGAS 5.0	Economic Growth Analysis System Version 5.0
EGU	Electric Generating Unit
EPA	U.S. Environmental Protection Agency
IPM	Integrated Planning Model
MANE-VU	Mid-Atlantic/Northeast Visibility Union
MARAMA	Mid-Atlantic Regional Air Management Association
MOBILE6	U.S. EPA's emission model for onroad sources
NESCAUM	Northeast States for Coordinated Air Use Management
NH ₃	Ammonia
NIF3.0	National Emission Inventory Input Format Version 3.0
NONROAD	U.S. EPA's emission model for certain types of nonroad equipment
NO _x	Oxides of nitrogen
OTB/W	On-the-Books/On-the-Way – refers to emission control programs already adopted and proposed emission controls that will result in post-2002 emission reductions
OTC	Ozone Transport Commission
OTC 2001 model rules	Model rules developed by the OTC in 2001
OTC 2006 model rules	Model rules developed by the OTC in 2006
PM ₁₀ -PRI	Particulate matter less than or equal to 10 microns in diameter that includes both the filterable and condensable components of particulate matter
PM ₂₅ -PRI	Particulate matter less than or equal to 2.5 microns in diameter that includes both the filterable and condensable components of particulate matter
SIC	Standard Industrial Classification code
SIP	State Implementation Plan
SCC	Source Classification Code
SO ₂	Sulfur dioxide
VOC	Volatile organic compounds

1.0 EXECUTIVE SUMMARY

The States of the Ozone Transport Region (OTR) are faced with the requirement to submit attainment demonstration plans for the 8-hour ozone National Ambient Air Quality Standards (NAAQS). To accomplish this, most of the states will need to implement additional measures to reduce emissions that either directly impact their nonattainment status, or contribute to the nonattainment status in other states. As such, the Ozone Transport Commission (OTC) undertook an exercise to identify a suite of additional control measures that could be used by the OTR states in attaining their goals.

The OTC staff and member states formed several workgroups to identify and evaluate candidate control measures. Initially, the Workgroups compiled and reviewed a list of approximately 1,000 candidate control measures. These control measures were identified through published sources such as the U.S. Environmental Protection Agency's (EPA's) Control Technique Guidelines, STAPPA/ALAPCO "Menu of Options" documents, the AirControlNET database, emission control initiatives in member states as well as other states including California, state/regional consultations, and stakeholder input. The Workgroups developed a preliminary list of 30 candidate control measures to be considered for more detailed analysis. These measures were selected to focus on the pollutants and source categories that are thought to be the most effective in reducing ozone air quality levels in the Northeastern and Mid-Atlantic States.

The Workgroups discussed the candidate control measures during a series of conference calls and workshops held periodically from the spring of 2004 through the autumn of 2006. The Workgroups collected and evaluated information regarding emission benefits, cost-effectiveness, and implementation issues. Each of the candidate control measures were summarized in a series of "Control Measure Summary Sheets". Stakeholders were provided multiple opportunities to review and comment on the Control Measure Summary Sheets.

Based on the analyses by the OTC Workgroups, the OTC Commissioners made several recommendations at the June 2006 Commissioners' meeting in Boston (OTC 2006a-d) and at the November 2006 Commissioners' meeting in Richmond (OTC 2006e-g). The Commissioners recommended that States consider emission reductions from the following source categories:

- Consumer Products
- Portable Fuel Containers
- Adhesives and Sealants Application
- Diesel Engine Chip Reflash
- Cutback and Emulsified Asphalt Paving

- Asphalt Production Plants
- Cement Kilns
- Glass Furnaces
- Industrial, Commercial, and Institutional (ICI) Boilers
- Regional Fuels

Additionally, the Commissioners directed the OTC to evaluate control measures for Electric Generating Units (EGUs) and high electric demand day units (these measures will be addressed in a separate OTC report) Finally, the Commissioners requested that EPA pursue federal regulations and programs designed to ensure national development and implementation of control measures for the following categories: architectural and maintenance coatings, consumer products, ICI boilers over 100 mmBtu/hour heat input, portable fuel containers, municipal waste combustors, regionally consistent and environmentally sound fuels, small offroad engine emission regulation, and gasoline vapor recovery (OTC 2006d).

See Appendix A for a full description of the process used by the OTC to identify and evaluate candidate control measures.

Table 1-1 summarizes information about the control measures identified by the OTC Commissioners at the June 2006 and November OTC meetings. Table 1-1 identifies the sector, the source category, and a brief description of the control measure. Next is a column that identifies the recommended approach for implementing the rule, such as an OTC model rule or updates to existing state-specific rules. The next two columns show the percent reduction from 2009 emission levels. The final column provides the cost effectiveness estimate in units of dollars per ton of pollutant removed.

Table 1-2 summarizes the expected emission reductions by pollutant, control measure and State. The emission reductions listed in Table 1-2 are for 2009, and take into account only the incremental reductions from the control measures listed in Table 1-1. Figures 1-1 and 1-2 show the anticipated emission reductions by state for VOC and NO_x, respectively.

Table 1-1 Summary of OTC 2006 Control Measures

Sector	Source Category	Control Measure	Implementation Method	Percent Reduction from 2009 OTB/W Emission Levels		Cost Effectiveness (\$/ton)
				NOx	VOC	
Area	Adhesives, Sealants, Adhesive Primers, and Sealant Primers (Industrial)	Enact VOC content limits similar to those contained in the CARB RACT/BARCT document for adhesives and sealants (Dec. 1998)	Model Rule	---	64	VOC: 2,500
Area	Cutback and Emulsified Asphalt Paving	Prohibits the use of cutback asphalt during the ozone season Limits the use of emulsified asphalt during the ozone season to that which contains not more than 0.5 mL of oil distillate from a 200 mL sample as determined using ASTM Method D244	State Rule Update	---	State specific depending on current rules	VOC: minimal
Area	Consumer Products	Adopt the CARB 7/20/05 Amendments which sets new or revises existing VOC limits on 12 consumer product categories (does not include reductions for Tier2 shaving gels and antistatic aerosols since they have a later compliance date).	Model Rule	---	2	VOC: 4,800
Area	Portable Fuel Containers	Adopt the CARB 2006 Amendments broadening the definition of PFCs to include kerosene and diesel containers and utility jugs used for fuel, and other changes to make OTC Model Rule consistent with CARB requirements.	Model Rule	---	State specific	VOC: 800 to 1,400
Area and Point	Asphalt Production Plants	Area/Point Sources Batch Natural Gas 0.02 lb/ton or equivalent ppm Batch Distillate 0.09 lb/ton or equivalent ppm Drum Natural Gas 0.02 lb/ton or equivalent ppm Drum Distillate 0.04 lb/ton or equivalent ppm or Low NOx Burners, Best Management Practices	State Rule Update	10 - 35	---	NOx: <500 to 1,250

Sector	Source Category	Control Measure	Implementation Method	Percent Reduction from 2009 OTB/W Emission Levels		Cost Effectiveness (\$/ton)
				NOx	VOC	
Area and Point	Industrial/ Commercial/ Institutional (ICI) Boilers >250 mmBtu/hour	Option 1 – Purchase current year NOx allowances equal to reductions needed to achieve the required emission rates Option 2 – Phase I 2009 emission rate equal to EGUs of similar size; Phase II 2013 emission rate equal to EGUs of similar size	Model Rule	Boiler and State specific	---	NOx: 600 to 18,000
Area and Point	ICI Boilers 100-250 mmBtu/hour	NOx Strategy #1: Nat gas: 0.10 lb/mmBtu #2, #4, #6 Oil: 0.20 lb/mmBtu Coal: 0.08 to 0.22 lb/mmBtu, depending on boiler type NOx Strategy #2: Reductions achievable through LNB/SNCR, LNB/FGR, SCR or some combination of these controls NOx Strategy #3: 60% reduction from uncontrolled NOx Strategy #4: Purchase current year CAIR allowances	State Rule Update	Boiler and State specific	---	NOx: 600 to 18,000
Area and Point	ICI Boilers 25-100 mmBtu/hour	NOx Strategy #1: Nat gas: 0.05 lb/mmBtu #2 Oil: 0.08 lb/mmBtu #4, #6 Oil: 0.20 lb/mmBtu Coal: 0.30 lb/mmBtu NOx Strategy #2: 50% reduction from uncontrolled NOx Strategy #3: Purchase current year CAIR allowances	State Rule Update	Boiler and State specific	---	NOx: 600 to 18,000
Area and Point	ICI Boilers <25 mmBtu/hour	Annual boiler tune-up	State Rule Update	State specific	---	

Sector	Source Category	Control Measure	Implementation Method	Percent Reduction from 2009 OTB/W Emission Levels		Cost Effectiveness (\$/ton)
				NOx	VOC	
Point	Glass Furnaces	Require furnace operators to meet the emission limits in the San Joaquin Valley rule by 2009. These limits are achievable through implementation of “oxyfiring” technology for each furnace at furnace rebuild. If the operator does not rebuild the furnace by 2009 or implement measures to meet the limits in the San Joaquin Valley rule, the operator would be required to purchase NOx allowances equal to the difference between actual emissions and the limits in the San Joaquin Valley rule. Compliance with Rule 4354 will allow manufacturers to use a mix of control options to meet the suggested limits. Manufacturers may propose alternative compliance methods to meet the specified limits, including emissions averaging.	State Rule or Permit	Source specific	---	NOx: 1,254 to 2,500
Point	Cement Plants	Require existing kilns to meet a NOx emission rate of 3.88 lbs/ton clinker for wet kiln 3.44 lbs/ton clinker for long dry kiln 2.36 lbs/ton clinker for pre-heater kiln 1.52 lbs/ton clinker for pre-calciner kiln	State Rule Update	Source specific	---	NOx: <2,500
Onroad Mobile	Diesel Truck Chip Reflash	Mandatory program to upgrade the version of software in engine electronic control module (ECM), (also known as “chip reflash) to reduce off-cycle NOx emissions.	Model Rule	10	---	NOx: 20-30
Onroad Mobile	Regional Fuel based on Reformulated Gasoline Options	Extend RFG requirements to counties in OTC that currently do not have RFG.	Memorandum of Understanding - OTC	State specific	State specific	VOC: 5,200 NOx: 3,700

**Table 1-2 Estimated Emission Benefits in 2009 by State
Resulting from the OTC 2006 Control Measures**

State	VOC Emission Reduction Benefit (summer tpd)							NOx Emission Reduction Benefit (summer tpd)							
	Adhesives & Sealants	Cutback/Emulsified Asphalt Paving	Consumer Products	PFC (Area) ^a	PFCs (Nonroad) ^a	Regional Fuels	Total VOC Reduction	Diesel Engine Chip Reflash	Regional Fuels	Asphalt Production	Cement Kilns	Glass/Fiberglass ^b	ICI Boilers Area Sources	ICI Boilers Point Sources	Total NOx Reduction
CT	4.2	4.3	0.7	0.4	0.1	0.0	9.7	3.5	0.0	0.0	0.0	0.0	2.8	2.1	8.4
DE	1.0	0.0	0.1	0.1	<0.1	0.0	1.4	0.6	0.0	0.2	0.0	0.0	1.2	0.1	2.1
DC	0.1	0.0	0.1	0.1	<0.1	0.0	0.4	0.8	0.0	0.0	0.0	0.0	0.4	0.4	1.6
ME	2.5	10.6	0.2	0.1	<0.1	9.1	22.6	1.4	0.2	0.7	0.0	0.0	1.1	2.8	6.2
MD	5.8	0.0	1.0	1.4	0.4	3.2	11.8	5.6	0.0	0.1	13.1	0.3	1.2	2.4	22.7
MA^d	8.9	8.1	10.2	1.7	0.5	0.0	29.3	6.7	0.0	0.6	0.0	1.5	6.6	6.8	22.2
NH	2.3	4.4	0.3	0.2	0.1	4.3	11.5	2.0	0.2	0.0	0.0	0.0	3.4	1.9	7.5
NJ	9.2	4.7	1.4	1.0	0.3	0.0	16.7	9.7	0.0	1.0	0.0	4.9	0.0	3.4	19.0
NY	21.5	16.4	3.7	2.6	0.8	56.9	101.9	16.1	2.1	0.0	15.3	5.8	33.8	7.0	80.1
PA	21.9	8.4	2.1	1.6	0.5	58.0	92.3	12.4	2.0	0.2	14.0	24.3	12.2	9.8	73.9
RI	1.5	1.1	0.2	0.2	<0.1	0.0	3.0	0.8	0.0	0.0	0.0	0.5	2.1	0.5	3.9
VT	2.2	1.8	0.1	0.1	<0.1	7.9	12.1	0.9	0.3	0.0	0.0	0.0	0.9	0.4	2.5
No. VA^c	1.0	<0.1	0.5	0.4	0.1	0.0	1.9	2.5	0.0	0.1	0.0	0.0	3.9	0.1	6.6
OTR	82.3	59.8	20.5	9.9	3.0	139.4	314.8	63.0	4.8	3.0	42.5	37.3	69.5	37.7	257.8

- a) The table shows the estimated emission reduction that will occur in 2009; additional reductions will occur in later years as new, less-emitting PFCs that comply with the OTC 2006 control measure penetrate the market.
- b) The table show the maximum emission reduction from glass/fiberglass furnaces when the OTC 2206 control measure is fully implemented. No all of the reduction shown will be achieved by 2009.
- c) The following jurisdictions in Virginia are part of the OTR: Arlington County, Alexandria, Fairfax County, Fairfax City, Fall Church, Loudon County, Manassas City, Manassas Park, and Prince William County.
- d) MA proposed rule has a January 1, 2009 effective date and includes the VOC limits from the OTC 2001 model rule and those in the OTC 2006 model rule. The 2009 benefit MA shows the benefit from both sets of limits. For all other States, the 2009 benefit shows the change in emissions from the OTC 2006 model rule only.

Figure 1-1 VOC Emission Reduction Benefits from OTC 2006 Control Measures in 2009

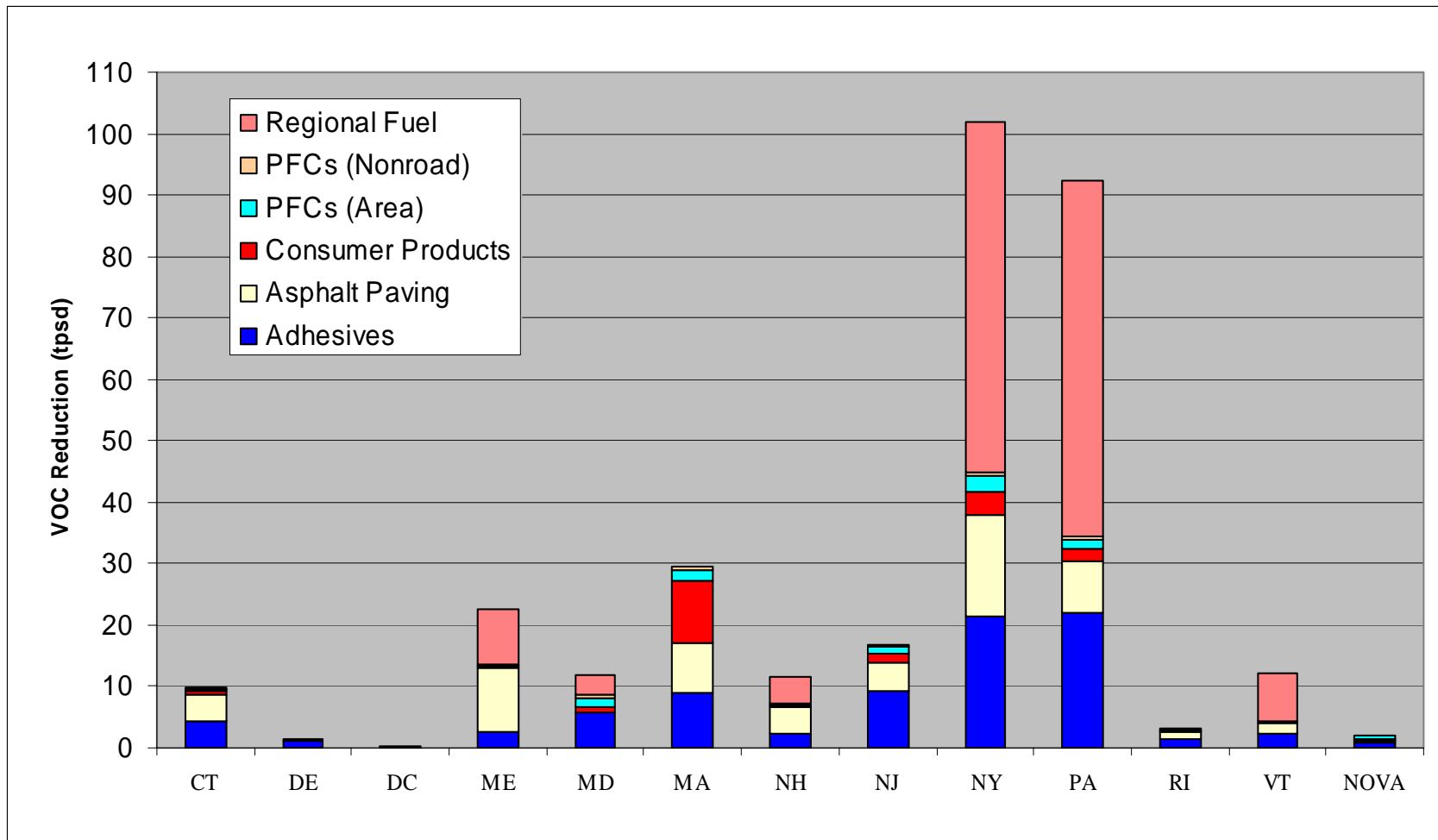
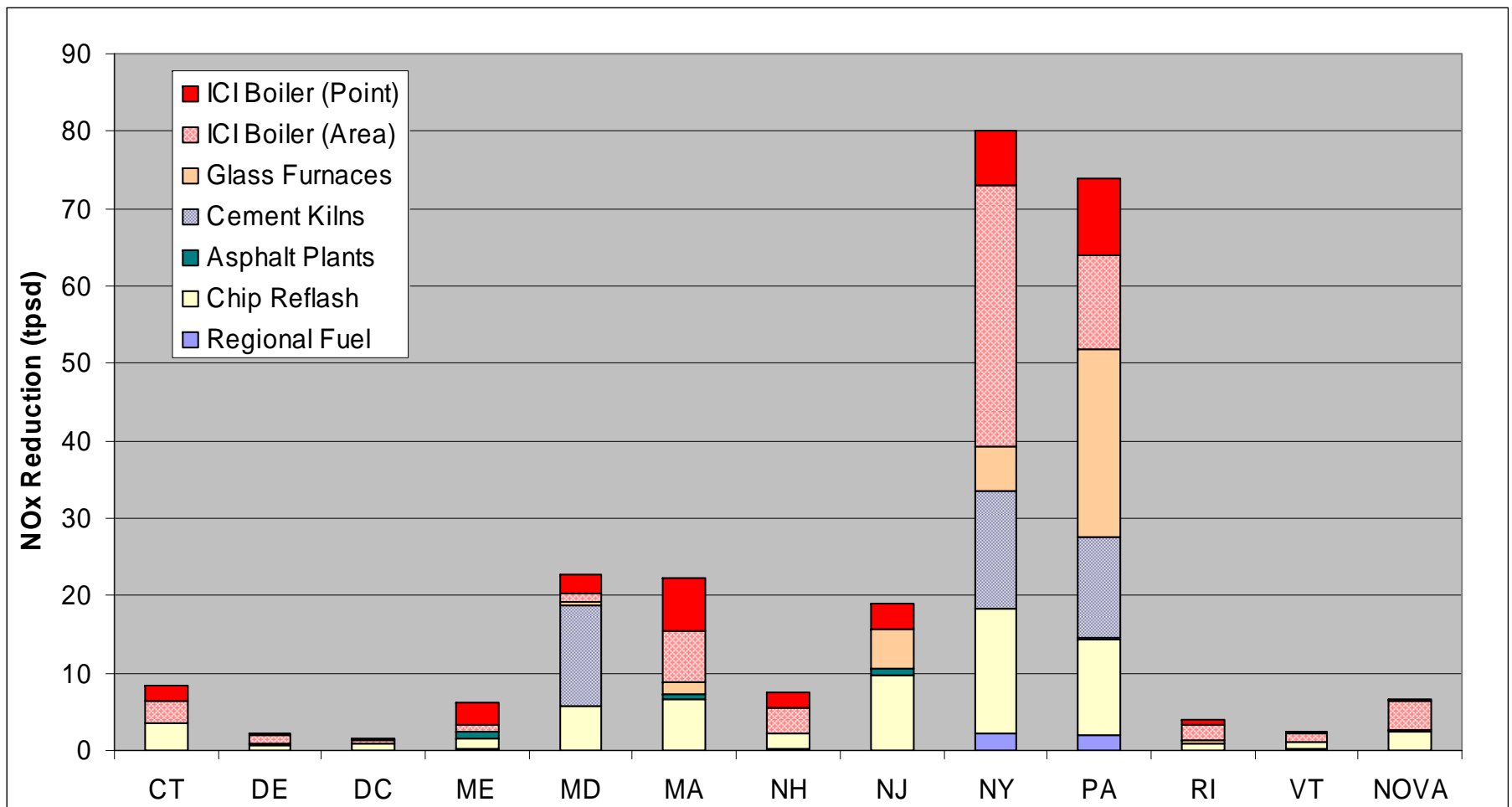


Figure 1-2 NOx Emission Reduction Benefits from OTC 2006 Control Measures in 2009



2.0 INTRODUCTION

The Ozone Transport Commission (OTC) is a multi-state organization created under the Clean Air Act (CAA). The OTC is responsible for advising EPA on transport issues and for developing and implementing regional solutions to the ground-level ozone problem in the Northeast and Mid-Atlantic regions. To supplement local and state-level efforts to reduce ozone precursor emissions, which may not alone be sufficient to attain federal standards, the OTC member states are considering control measures appropriate for adoption by all states in the region as part of their planning to attain and maintain the 8-hour ozone National Ambient Air Quality Standards (NAAQS).

The development of the control measures described in this document parallels a prior effort. The OTC developed a series of model rules in 2001 for the States to consider in adopting control measures to reduce volatile organic compound (VOC) emissions and oxide of nitrogen (NO_x), which are ozone precursors, to (1) assist in the attainment of the one-hour ozone health standard, (2) address the VOC and NO_x emission reduction shortfalls identified by EPA, and (3) implement the State Implementation Plans (SIP) commitments to EPA. These model rules, which have been adopted in many OTC states, will be referred to as the “OTC 2001 model rules” in this document.

The analysis in this report provides a description of the control measures identified by the OTC to help states attain the 8-hour ozone NAAQS. It also describes the associated incremental emission reductions and costs associated with each measure. The control measures analyzed in this report are those that were identified by the OTC Commissioners at the June 2006 OTC annual meeting in Boston (OTC 2006a, OTC 2006b, OTC 2006c) and at the November 2006 OTC fall meeting in Richmond (OTC 2006d, OTC 2006e, OTC 2006f). These control measures will be referred to as the “OTC 2006 control measures” in this document. For some source categories, the OTC has amended the OTC 2001 model rules or developed new model rules. These model rules will be referred to as the “OTC 2006 model rules” in this document.

The OTC 2006 model rules for volatile organic compounds (VOC) will reduce emissions from adhesives, sealants, adhesive primer, and sealant primer application; cutback and emulsified asphalt paving; consumer products; regional fuels; and portable fuel containers. The OTC 2006 control measures for oxides of nitrogen (NO_x) will reduce emissions from asphalt production plants, cement kilns, diesel engine chip reflash, regional fuels, electric generating units (EGUs), glass and fiberglass furnaces, and industrial, commercial, institutional (ICI) boilers.

Section 3 describes the methods used to estimate the emission benefits of the VOC control measures. For each source category, there are subsections that describe the existing Federal and OTC State

regulations that affect the VOC emissions, summarize the major elements of the control measures, discuss how the emission benefits were quantified, and present information on anticipated costs and cost-effectiveness. VOC emissions and reductions by State and source category in 2002 and 2009 are presented at the end of Section 3. Section 4 presents similar information for the NO_x source categories. Section 5 presents similar information for the SO₂ source categories. Section 6 provides a list of references used in developing this report.

Appendix A presents a brief description of the process that the OTC followed in identifying and evaluating candidate control measures. Appendix B lists the approximately 1,000 control measures that were initially analyzed. Appendix C contains the control measure summary sheets that were developed during this analysis. Appendices D, E, and F present the emission benefits by county for VOC, NO_x, and SO₂ respectively. Each appendix contains a tabulation of the 2002 base emissions, the projected 2009/2012/2018 emissions and expected emission reduction benefit from the additional control measures in 2009/2012/2018). Appendix G contains a listing of State ICI boiler regulations.

3.0 VOC ANALYSIS METHODS

This Section describes the analysis of the 2006 OTC control measures to reduce VOC emissions from five source categories: adhesives, sealants, adhesive primer, and sealant primer application; cutback and emulsified asphalt paving; consumer products; regional fuels; and portable fuel containers. For each of the five categories, there are separate subsections that discuss existing Federal/state rules, summarize the requirements of the 2006 OTC control measure, describe the methods used to quantify the emission benefit, and provide an estimate of the anticipated costs and cost-effectiveness of the control measure. At the end of Section 3, we provide the estimated emissions for 2002 and 2009 by source category and State. Appendix D provides county-by-county summaries of the emission reductions for each of the categories and projection years.

3.1 ADHESIVES, SEALANT, ADHESIVE PRIMER, AND SEALANT PRIMER APPLICATION

Adhesives, sealants, adhesive primer, and sealant primer are used in product manufacturing, packaging, construction, and installation of metal, wood, rubber, plastic, ceramics, or fiberglass materials. In general, an adhesive is any material used to bond two surfaces together. In general, a sealant is a material with adhesive properties that is used primarily to fill, seal, waterproof or weatherproof gaps or joints between two surfaces.

VOC emissions from this category result from evaporation of solvents during transfer, drying, surface preparation and cleanup operations. These solvents are the media used to solubilize the adhesive, sealant, or primer material so that it can be applied. The solvent is also used to completely wet the surface to provide a stronger bond. In plastic pipe bonding, the solvent dissolves the polyvinyl chloride pipe and reacts with the pipe to form a bond. Solvents used to clean the surface before bonding and to clean the application equipment after bonding also contribute to VOC emissions.

VOC emissions in this category are primarily from industrial and commercial operations such as wood product manufacturers, upholstery shops, adhesives retailers and architectural trades, such as building construction, floor covering installation and roof repair.

3.1.1 Existing Federal and State Rules

EPA published the consumer and commercial products rule on September 11, 1998 (40 CFR Part 59 Subpart D) under authority of Section 183(e) of the Clean Air Act. The Federal Part 59

Subpart C requirements for consumer products regulate five types of “household” adhesives (aerosols, contact, construction and panel, general purpose and structural waterproof). The VOC content limits for these products apply only to “household products”, defined as “any consumer product that is primarily designed to be used inside or outside of living quarters or residences, including the immediate surroundings, that are occupied or intended for occupation by individuals.” Thus, the Part 59 rule applies only to adhesives used in household settings and not to adhesives used in industrial or commercial applications.

The OTC developed a model rule for consumer and commercial products in 2001 (referred to as the “OTC 2001 model rule for consumer products” in this document) to regulate additional consumer product categories by requiring more stringent VOC content limits than the Federal rule. The OTC 2001 model rule for consumer products contains VOC limits for adhesives and sealants. However, with the exception of aerosol adhesives, the definitions of these products generally exempt products sold in larger containers. Specifically, the OTC 2001 model rule includes the following definitions (*italics added for emphasis*):

- Section 2(8) Adhesive. “Adhesive” means any product that is used to bond one surface to another by attachment. “Adhesive” does not include products used on humans and animals, adhesive tape, contact paper, wallpaper, shelf liners, or any other product with an adhesive incorporated onto or in an inert substrate. For “Contact Adhesive,” *adhesive does not include units of product, less packaging, which consist of more than one gallon.* For “Construction, Panel, and Floor Covering Adhesive,” and “General Purpose Adhesive,” *adhesive does not include units of product, less packaging, which weigh more than one pound and consist of more than 16 fluid ounces.* This limitation does not apply to aerosol adhesives.
- Section 2(148) Sealant and Caulking Compound. “Sealant and Caulking Compound” means any product with adhesive properties that is designed to fill, seal, waterproof, or weatherproof gaps or joints between two surfaces. “Sealant and Caulking Compound” does not include roof cements and roof sealants; insulating foams; removable caulking compounds; clear/paintable/water resistant caulking compounds; floor seam sealers; products designed exclusively for automotive uses; or sealers that are applied as continuous coatings. “*Sealant and Caulking Compound*” *also does not include units of product, less packaging, which weigh more than one pound and consist of more than 16 fluid ounces.* For the purposes of this definition only, “removable caulking compounds” means a compound which temporarily seals windows or doors for three to six month time intervals, and “clear/paintable/water resistant caulking compounds” means a compound which contains no appreciable level of opaque fillers or pigments; transmits most or all visible light through the caulk when cured; is paintable; and is immediately resistant to precipitation upon application.

Thus, the same products sold in containers larger than the above thresholds are not covered by the OTC 2001 model rule for consumer products.

3.1.2 Description of the OTC 2006 Model Rule

The OTC 2006 model rule for adhesives and sealants is based on the reasonably available control technology (RACT) and best available retrofit control technology (BARCT) determination by the California Air Resources Board (CARB) developed in 1998. The OTC 2006 model rule has the following requirements:

- A. Regulates the application of adhesives, sealants, adhesive primers and sealant primers by providing options for applicators to either to use a product with a VOC content equal to or less than a specified limit or to use add-on controls;
- B. Limits the VOC content of aerosol adhesives to 25 percent by weight;
- C. Requirements for cleanup solvents;
- D. A VOC limit for surface preparation solvents;
- E. An alternative add-on control system requirement of at least 85 percent overall control efficiency (capture and destruction efficiency), by weight;
- F. VOC containing materials must be stored or disposed of in closed containers;
- G. Prohibits the sale of any adhesive, sealant, adhesive primer or sealant primer which exceeds the VOC content limits listed in the model rule;
- H. Manufacturers must label containers with the maximum VOC content as supplied, as well as the maximum VOC content on an as-applied basis when used in accordance with the manufacturer's recommendations regarding thinning, reducing, or mixing with any other VOC containing material; and
- I. Prohibits the specification of any adhesive, primer, or sealant that violates the provisions of the model rule.

Several adhesive and sealant applications and products are exempt from this model rule: tire repair, assembly and manufacturing of undersea-based weapon systems, testing and evaluation associated with research and development, solvent welding operations for medical devices, plaque laminating operations, products or processes subject to other state rules, low-VOC products (less than 20 g/l), and adhesives subject to the state rules based on the OTC 2001 consumer products model rule. Additionally, the model rule provides an exemption for adhesive application operations at stationary sources that use less than 55 gallons per calendar year of noncomplying adhesives and for stationary sources that emit not more than 200 pounds of VOCs per year from adhesives operations.

3.1.3 Emission Benefit Analysis Methods

Emissions from this category are classified as both point sources and area sources. About 96 percent of adhesive and sealant VOC emissions in the OTC states fall into the area source category. The remaining four percent of the VOC emissions are included in the point source inventory.

The emission reduction benefit estimation methodology for area sources is based on information developed and used by CARB for their RACT/BARCT determination in 1998. CARB estimates that the total industrial adhesive and sealant emissions in California to be about 45 tons per day (tpd). Solvent-based emissions are estimated to be about 35 tpd of VOC and water-based adhesive and sealant emissions are about 10 tpd of VOC. CARB indicated that the emission reductions would be achieved mainly due to the switch from high-VOC to low-VOC products rather than from the use of add-on control devices. CARB estimated that emission reductions achieved by statewide compliance with the VOC limits in the RACT/BARCT determination will range from approximately 29 to 35 tpd (CARB 1998, pg. 18). These emission reductions correspond to a 64.4 to 77.8 percent reduction from uncontrolled levels. For OTC modeling purposes, we used the lower end of this range (i.e., 64.4 percent reduction) to estimate the emission benefit for area sources due to the OTC 2006 model rule.

For point sources, we first identified those sources that were applying adhesives and sealants (using the source classification code of 4-02-007-xx, adhesives application). Next, we reviewed the MANEVU inventory to determine whether sources had existing capture and control systems. Several sources reported capture and destruction efficiencies in the 70 to 99 percent range. A few sources reported capture and destruction efficiencies of 99+ percent. Most of the controlled sources reported capture and destruction efficiencies in the 90-98 percent range. Sources with existing control systems that exceed an 85 percent overall capture and destruction efficiency would meet the OTC 2006 model rule provision for add-on air pollution control equipment; no additional reductions were calculated for these sources. For point sources without add-on control equipment, we used the 64.4 percent reduction discussed in the previous paragraph based on the CARB determination.

3.1.4 Cost Estimates

The cost of complying with the new requirements includes the cost of using alternative formulations of low-VOC or water-based adhesives, sealants, adhesive primers, and sealant primers and cleanup products. Based on information provided by the Ventura County Air Pollution Control District, CARB determined that the cost-effectiveness of their adhesives rule

ranges from a savings of \$1,060 per ton to a cost of \$2,320 per ton of VOC reduced (CARB 1998, pg. 17). These costs are likely to be less in the OTR, because some of the one-time research and reformulation costs incurred for products sold in California will not have to be incurred again for products sold in the OTR. CARB also reports a cost-effectiveness of \$9,000 to \$110,000 per ton of VOC reduced for the use of add-on control equipment to comply with the requirements.

3.2 CUTBACK AND EMULSIFIED ASPHALT PAVING

Asphalt paving is used to pave, seal and repair surfaces such as roads, parking lots, drives, walkways and airport runways. Asphalt paving is grouped into three general categories: hot-mix, cutback, and emulsified. Hot-mix asphalt is the most commonly used paving asphalt. Hot-mix asphalt produces minimal VOC emissions because its organic components have high molecular weights and low vapor pressures. Cutback asphalt is used in tack and seal operations, in priming roadbeds for hot-mix application and for paving operations for pavements up to several inches thick. In preparing cutback asphalt, asphalt cement is blended or “cut back” with a diluent, typically from 25 to 45 percent by volume of petroleum distillates, depending on the desired viscosity. Emulsified asphalt is used in most of the same applications as cutback asphalt but is a lower emitting alternative to cutback asphalt. Instead of blending asphalt cement with petroleum distillates, emulsified asphalts use a blend of asphalt cement, water and an emulsifying agent, such as soap. Some emulsified asphalts contain virtually no VOC diluents; however, some emulsified asphalts may contain up to 12 percent VOC by volume.

3.2.1 Existing Federal and State Rules

The EPA published a Control Technique Guideline (CTG) for the use of cutback asphalt in December 1977. The CTG recommended replacing cutback asphalt binders with emulsified asphalt during the ozone season. In 1979, EPA added a specification for emulsified asphalt to the CTG recommendations to limit the content of oil distillate in emulsified asphalt to no higher than 7 percent oil distillate.

Table 3-1 summarizes the current asphalt paving rules for the 13 OTR states. Most of the states in the OTR have adopted the CTG banning cutback asphalt in the ozone season. Some states have exemptions to this rule, allowing the use of cutback asphalt with up to 5 percent VOC. For emulsified asphalt, the requirements vary greatly. The VOC content of emulsified asphalt is limited to 0-12 percent, depending on the State and the type of emulsified asphalt. Delaware completely bans the use of emulsified asphalt that contains any VOC.

Table 3-1 Summary of OTC State Rules for Cutback and Emulsified Asphalt

State	Cutback Asphalt	Emulsified Asphalt
CT	22a-174-20 (k): VOC content limited to 5% during June, July, August, and September	Nothing specified
DE	Reg. No. 24, Section 34: Ban during ozone season	Reg. No. 24, Section 34: Ban on use of emulsified asphalt that contains any VOC
DC	Chapter 7 Section 8-2:707(k): Ban during the months of April, May, June, July, August, and September	Nothing specified
ME	Chapter 131: Ban during the period May 1 through September 15, with some exceptions	Chapter 131: VOC content limited to 3-12%, depending on the type of use
MD	COMAR 26.11.11.02: Ban during the period April 16 through October 14	COMAR 26.11.11.02: Allowed upon approval of the Department; no VOC content limit specified
MA	310 CMR 7.18(9): Ozone season ban on cutback asphalt with VOC content greater than 5% by weight with exemptions including use as prime coat	Nothing Specified
NH	Env-A 1204.42: Ban during the months of June through September; cutback with up to 5% VOC allowed upon approval of Department	Env-A 1204.42: VOC content limited to 3-12%, depending on the type of use
NJ	7:27-16.19: Ban from April 16 through October 14, with some exemptions	7:27-16.19: VOC content limited to 8% by volume
NY	Part 211: Ban from May 2 through October 15	Part 211: VOC content limited to 2-12%, depending on the type of ASTM grade
PA	25 Pa. Code Section 129.64: Ban from May 1 to October 30	25 Pa. Code Section 129.64: VOC content limited to 0-12%, depending on type
RI	Reg. No. 25: Ban from April 1 to September 30, with some exemptions	Reg No. 25: VOC content limited to 3-12%, depending on application/use
VT	5-253.15: Ban on cutback asphalt with VOC content greater than 5% by weight, with some exemptions	5-253.15: Ban on emulsified asphalt with VOC content greater than 5% by weight
VA	Chapter 40, Article 39: Ban during April through October	Chapter 40, Article 39: VOC content limited to 6% by volume

3.2.2 Description of the OTC 2006 Model Rule

The OTC 2006 model rule for the asphalt paving control measure prohibits the use of cutback asphalt during the ozone season and limits the use of emulsified asphalt to that which contains not more than 0.5 mL of oil distillate from a 200 mL sample (as determined using American Society for Testing and Materials {ASTM} Method D244 - Test Methods for Emulsified Asphalts) regardless of application. This is equivalent to a VOC content of 0.25 percent. Exemptions may be granted under certain circumstances upon the approval of the State commissioner.

3.2.3 Emission Benefit Analysis Methods

The OTC 2006 control measure for asphalt paving calls for a complete ban on the use of cutback asphalt during the ozone season. As shown in Table 3-1, current state regulations generally ban the use of cutback asphalt during the ozone season. However, there are exemptions from the ban and as a result there are VOC emissions from the use of cutback asphalt during the ozone season. The OTC 2006 control measure eliminates any exemptions and totally eliminates any VOC emissions from the use of cutback asphalt during the ozone season.

The emission reductions resulting from OTC 2006 control measure for emulsified asphalt vary by State. The two percent VOC content limit on emulsified asphalt depend on the baseline VOC content of emulsified asphalt. The control measure limits emulsified asphalt to not more than 0.5 mL of oil distillate from a 200 mL sample as determined using ASTM Method D244. This is equivalent to a VOC content of 0.25 percent. The baseline VOC content may range from 0 to 12 percent. New Jersey used a VOC content of 8 percent in their baseline emission calculations (based on the 8 percent limit in their current rule). Reducing the VOC content to 0.25 percent in New Jersey will result in a 96.9 percent reduction. Delaware already bans the use of emulsified asphalt that contains any VOC, so there is no reduction in Delaware. Several other states used an average VOC content of 2.5 percent when developing their emission inventory. Thus, reducing the average VOC content from 2.5 percent to 0.25 percent results in a 90 percent reduction in VOC emissions. For States that did not supply a baseline VOC content for asphalt paving, we used the 90 percent reduction in VOC emissions from emulsified asphalt paving during the ozone season.

3.2.4 Cost Estimates

Low-VOC alternatives are currently available and no additional costs are expected from their use.

3.3 CONSUMER PRODUCTS

Consumer and commercial products are those items sold to retail customers for personal, household, or automotive use, along with the products marketed by wholesale distributors for use in commercial or institutional settings such as beauty shops, schools and hospitals. VOC emissions from these products are the result of the evaporation of propellant and organic solvents during use. Consumer and commercial products include hundreds of individual products, including personal care products, household products, automotive aftermarket products, adhesives and sealants, FIFRA-related insecticides, and other miscellaneous products.

3.3.1 Existing Federal and State Rules

EPA published the Federal consumer and commercial products rule on September 11, 1998 (40 CFR Part 59 Subpart D) under authority of Section 183(e) of the Clean Air Act. This rule limits the VOC content of 24 product categories representing 48 percent of the consumer and commercial products inventory nationwide. According to EPA, VOC emissions from those 24 product categories were reduced by 20 percent. But since over half of the inventory is unaffected by the rule, the Federal rule is estimated to yield VOC reductions of 9.95 percent of the total consumer products inventory (Pechan 2001, pg 7).

Since over half of the inventory is unregulated by the Federal Part 59 rule, the OTC developed a model rule for consumer and commercial products in 2001 (referred to as the “OTC 2001 model rule for consumer products” in this document) to be used by the OTC jurisdictions to develop regulations for additional consumer product categories and to specify more stringent VOC content limits than the Federal rule. The VOC content limits and products covered in the OTC 2001 model rule are similar to the rules developed by CARB in the late 1990s. The OTC 2001 model rule for consumer products provides background for OTC jurisdictions to develop programs to regulate approximately 80 consumer product categories and includes technologically feasible VOC content limits. The emission reductions for state programs based on the OTC 2001 model rule are estimated to be 14.2 percent of the total consumer product inventory beyond the national rule reduction (Pechan 2001, pg. 8).

Most, but not all, states in the OTR have adopted regulatory programs based on the OTC 2001 model rule for consumer products. Table 3-2 summarizes the adoption status for the 13 OTR jurisdictions.

**Table 3-2 Status of OTC State's Promulgation
of the OTC 2001 Model Rule for Consumer Products.**

State	Effective Date of VOC Limits	Regulatory Citation
CT ^a	Initiated process to adopt in 2006	R.C.S.A. section 22a-174-40
DE	Effective January 1, 2005	Regulation Number 41
DC	Effective June 30, 2004	Regulation 719
ME	Effective May 1, 2005	Chapter 152
MD	Effective January 1, 2005	COMAR 26.11.32
MA ^b	In progress – proposed effective date is January, 2009	310 CMR 7.25(12)
NH	Effective January 1, 2007	Chapter Env-A 4100
NJ	Effective January 1, 2005	Chapter 27, Subchapter 24
NY	Effective January 1, 2005	Chapter 3, Part 235
PA	Effective January 1, 2005	25 Pa. Code Chapter 130, Subchapter B
RI	Intend to develop in 2006	n/a
VT	Under Consideration	n/a
VA ^c	Effective July 1, 2005	Chapter 40, Article 50

- a) Connecticut's proposed rule includes both the VOC limits from the OTC 2001 model rule and the new and revised VOC emissions limits and related provisions that were adopted by the California Air Resources Board on July 20, 2005. These new and revised VOC limits are identical to those in the OTC 2006 model rule.
- b) Massachusetts's proposed rule includes the VOC limits from the OTC 2001 model rule and those in the OTC 2006 model rule.
- c) Virginia's rule applies only in Northern Virginia VOC Emission Control Area (10 northern Virginia jurisdictions in the OTR)

3.3.2 Description of the OTC 2006 Model Rule

The OTC 2001 model rule for consumer products closely mirrored a series of five CARB consumer products rules. CARB recently amended their consumer products rules in July 2005. As shown in Table 3-3, these amendments to the CARB rule affected 18 categories of consumer products (14 new categories, including subcategories, with new product category definitions and VOC limits; one previously regulated category with a more restrictive VOC limit; and two previously regulated categories with additional requirements).

Table 3-3 Consumer Products Affected by CARB's July 2005 Rule Amendments

New Categories with VOC Limits for Regulation	
Adhesive Remover – 4 subcategories Anti-Static Product Electrical Cleaner Electronic Cleaner Fabric Refresher	Footwear or Leather Care Product Hair Styling Product ^a Graffiti Remover Shaving Gel Toilet/Urinal Care Product Wood Cleaner
Previously Regulated Category with More Restrictive Limit	
Contact Adhesive ^b	
Previously Regulated Categories with Additional Requirements	
Air Fresheners	General Purpose Degreasers

a) This product category will incorporate Hair Styling Gel and include additional forms of hair styling products (i.e., liquid, semi-solid, and pump spray) but does not include Hair Spray Product or Hair Mousse.

b) This product category has been separated into 2 subcategories: General Purpose and Special Purpose

Most of these new CARB limits become effective in California by December 31, 2006. Two of the limits, anti-static products (aerosol) and shaving gels, have effective dates in either 2008 or 2009. For shaving gels, there is a VOC limit that becomes effective on December 31, 2006, with a more stringent second tier limit that becomes effective on December 31, 2009. The anti-static product (aerosol) limit becomes effective on December 31, 2008.

The OTC 2006 model rule will modify the OTC 2001 model rule based on the CARB July 20, 2005 amendments. The OTC is not including the anti-static aerosol products and the second tier shaving gel limit in its revisions to the OTC 2001 model rule because of industry concerns that meeting these limits may not be feasible. CARB acknowledged these concerns by requiring a technology review of these product categories in 2008 to determine whether the limits are achievable.

3.3.3 Emission Benefit Analysis Methods

The emission reduction benefit estimation methodology is based on information developed by CARB. CARB estimates 6.05 tons per day of VOC reduced in California from their July 2005 amendments (CARB 2004a, pg. 8), excluding the benefits from the two products (anti-static products and shaving gels) with compliance dates in 2008 or 2009. This equates to about 2,208 tons per year in California. The population of California as of July 1, 2005 is 36,132,147

(Census 2006). On a per capita basis, the emission reduction from the CARB July 2005 amendments equals 0.122 lbs/capita.

Since the OTC's 2006 control measure is very similar to the CARB July 2005 amendments (with the exclusion of the anti-static products and shaving gel 2008/2009 limits), the per capita emission reductions are expected to be the same in the OTR. The per capita factor after the implementation of the OTC 2001 model rule is 6.06 lbs/capita (Pechan 2001, pg. 8). The percentage reduction from the OTC's 2006 control measure was computed as shown below:

$$\begin{aligned}\text{Current OTC Emission Factor} &= 6.06 \text{ lbs/capita} \\ \text{Benefit from CARB 2005 amendments} &= 0.122 \text{ lbs/capita} \\ \text{Percent Reduction} &= 100\% * (1 - (6.06 - 0.122)/6.06) \\ &= 2.0\%\end{aligned}$$

3.3.4 Cost Estimates

CARB estimates that the cost effectiveness of VOC limits with an effective date of December 31, 2006, to be about \$4000 per ton of VOC reduced (CARB 2004, pg. 21). CARB further estimates that the average increase in cost per unit to the manufacturer to be about \$0.16 per unit. Assuming CARB's estimates for the OTR provides a conservative estimate, because some of the one-time research and reformulation costs incurred for products sold in California will not have to be incurred again for products sold in the OTR.

3.4 PORTABLE FUEL CONTAINERS

Portable fuel containers (PFCs) are designed for transporting and storing fuel from a retail distribution point to a point of use and the eventual dispensing of the fuel into equipment. Commonly referred to as "gas cans," these products come in a variety of shapes and sizes with nominal capacities ranging in size from less than one gallon to over six gallons. Available in metal or plastic, these products are widely used to refuel residential and commercial equipment and vehicles when the situation or circumstances prohibits direct refueling at a service station. PFCs are used to refuel a broad range of small off-road engines and other equipment (e.g., lawnmowers, chainsaws, personal watercraft, motorcycles, etc.). VOC emissions from PFCs are classified by five different activities:

- **Transport-spillage** emissions from PFCs occur when fuel escapes from PFCs that are in transit.
- **Diurnal** emissions result when stored fuel vapors escape to the air through any possible openings while the container is subjected to the daily cycle of increasing and decreasing

ambient temperatures. Diurnal emissions depend on the closed- or open- storage condition of the PFC.

- **Permeation** emissions are produced after fuel has been stored long enough in a container for fuel molecules to infiltrate and saturate the container material, allowing vapors to escape through the walls of containers made from plastic.
- Equipment refueling **vapor displacement** and **spillage** emissions result when fuel vapor is displaced from nonroad equipment (e.g., lawnmowers, chainsaws, personal watercraft, motorcycles, etc.) and from gasoline spillage during refueling of the equipment with PFCs. These VOC emissions are already taken into account in the nonroad equipment emission inventory by the NONROAD model.

Diurnal evaporative emissions are the largest category.

3.4.1 Existing Federal and State Rules

The OTC developed a model rule for PFCs in 2001. The OTC 2001 model rule was very similar to a rule adopted by CARB in 2000. The OTC 2001 model rule provides background for OTC jurisdictions to develop regulatory programs that require spill-proof containers to meet performance standards that reduce VOC emissions. The performance standards include a requirement that all PFCs to have an automatic shut-off feature preventing overfilling and an automatic closing feature so the can will be sealed when it is not being used. The performance standards also eliminate secondary venting holes and require new plastics to reduce vapor permeation through container walls. There is no requirement for owners of conventional PFCs to modify their PFCs or to scrap them and buy new ones. Compliance will be accomplished primarily through attrition. As containers wear out, are lost, damaged, or destroyed, consumers will purchase new spill-proof containers to replace the conventional containers. CARB determined that the average useful life of a PFC is five years. The OTC chose to assume a more conservative ten-year turnover rate, with 100 percent rule penetration occurring 10 years after adoption of the rule.

CARB estimated that the performance standards would reduce VOC emissions by 75 percent. CARB's 2004 analysis (CARB 2004b) reevaluated the estimate reductions due to some unforeseen issues with the new cans and new survey information. Based on CARB's updated data, CARB estimated that VOC emissions would be reduced by 65 percent from the first set of amendments.

CARB has also adopted a second set of amendments in two phases. The first phase was filed on January 13, 2006, effective February 12, 2006. For Phase I, CARM amended their PFC regulation to address the use of utility jugs and kerosene containers that are sometimes used by

consumers for gasoline. The second phase of the amendments was filed on September 11, 2006, effective October 11, 2006. These amendments (CARB 2006) will:

- Establish a mandatory certification program and accompanying test procedures;
- Amend the existing performance standards to eliminate the automatic shutoff performance standard effective July 1, 2007;
- Amend the existing performance standards to eliminate the fill height and flow rate performance standards;
- Amend the existing PFC pressure standard;
- Amend the current test methods;
- Change the permeability standard from 0.4 to 0.3 grams/gallon-day;
- Establish a voluntary consumer acceptance-labeling program that allows participating manufacturers to label their PFCs with an ARB “Star Rating” indicating how consumers rate their products’ ease of use; and
- Combine the currently separate evaporation requirement and permeation standard and test method into a single diurnal standard and test method.

In February 2007, EPA finalized a national regulation to reduce hazardous air pollutant emissions from mobile sources. Included in the final rule are standards that would reduce PFC emissions from evaporation, permeation, and spillage. EPA included a performance-based standard of 0.3 grams per gallon per day of hydrocarbons, determined based on the emissions from the can over a diurnal test cycle specified in the rule. The standard applies to containers manufactured on or after January 1, 2009. The standards are based on the performance of best available control technologies, such as durable permeation barriers, automatically closing spouts, and cans that are well-sealed.

3.4.2 Description of the OTC 2006 Model Rule

As shown in Table 3-4, most states in the OTR have already adopted PFC regulations based on the OTC 2001 model rule. The OTC 2001 model rule for PFCs closely mirrors the 2000 version of CARB’s PFC rule. CARB recently amended their gas can regulation as discussed above in Section 3.4.1. The OTC 2006 model rule closely mirrors these CARB amendments. The 2006 amendments are estimated to reduce VOC emissions by 18.4 tons per day in California at full implementation in the year 2015, in addition to the benefits from the existing regulation. The OTC 2006 model rule will modify the OTC 2001 model rule based on the recent CARB amendments.

**Table 3-4 Status of OTC State's Promulgation
of the OTC 2001 Model Rule for Portable Fuel Containers**

State	Date When New Containers are Required	Regulatory Citation
CT	Effective May 1, 2004	Section 22a-174-43
DE	Effective January 1, 2004	Reg. No. 41, Section 3
DC	Effective November 15, 2003	Rule 720
ME	Effective January 1, 2004	Chapter 155
MD	Effective January 1, 2003	COMAR 26.11.13.07
MA ^a	In progress (effective date will be January 1, 2009)	n/a
NH	Effective March 1, 2006	Env-A 4000
NJ	Effective January 1, 2005	Subchapter 24 (7:27-24.8)
NY	Effective January 1, 2003	Part 239
PA	Effective January 1, 2003	25 Pa. Code Chapter 130, Subchapter A
RI	In progress (late 2006 target date for final rule)	n/a
VT	Under Consideration	n/a
VA ^b	Effective January 1, 2005	Chapter 40, Article 42

a) Massachusetts' proposed rule will be based only on the OTC 2006 model rule; Massachusetts will not adopt the OTC 2001 model rule.

b) Virginia's rule applies only in Northern Virginia VOC Emission Control Area (10 northern Virginia jurisdictions in the OTR)

3.4.3 Emission Benefit Analysis Methods

Emissions from PFCs are accounted for in both the area and nonroad source inventories. The NONROAD model accounts for equipment refueling vapor displacement and spillage emissions result when fuel vapor is displaced from nonroad equipment (e.g., lawnmowers, chainsaws, personal watercraft, motorcycles, etc.) and from gasoline spillage during refueling of the equipment with PFCs. The area source inventory accounts for diurnal and permeation emissions associated with the fuel present in stored PFCs and transport-spillage emissions associated with refueling of a gas can at the gasoline pump. Based on the OTC 2001 model rule (Pechan 2001, pg. 11) roughly 70 percent of the VOC emissions are accounted for in the area source inventory, while the remaining 30 percent is from equipment refueling vapor displacement and spillage that is accounted for in the nonroad inventory.

The emission benefits have been calculated for the emissions accounted for in both the area and nonroad source inventory. Emissions from the nonroad category were estimated to be 30 percent of the PFC emissions accounted for in the area source inventory.

Also note that the OTC baseline emissions (i.e., 2002 emissions) do not include changes to the emission estimation methodology made by CARB in 2004. CARB conducted a new survey of PFCs in 2004, which included kerosene containers and utility jugs. Using this survey data, CARB adjusted their baseline emissions; a similar adjustment to the OTC baseline inventory has not been made.

Estimated emission reductions were based on information compiled by CARB to support their recent amendments. CARB estimated that PFC emissions in 2015 will be 31.9 tpd in California with no additional controls or amendments to the 2000 PFC rules (CARB 2005a, pg. 10). CARB further estimates that the 2006 amendment will reduce emission from PFCs by 18.4 tpd in 2015 in California compared to the 2000 PFC regulations (CARB 2005a, pg. 23). Thus, at full implementation, the expected incremental reduction is approximately 58 percent, after an estimated 65 percent reduction from the original 2000 rule.

The OTC calculations assume that States will adopt the rule by July 2007 (except in Massachusetts) and provide manufacturers one year from the date of the rule to comply. Thus, new compliant PFCs will not be on the market until July 2008. Assuming a 10-year turnover to compliant cans, only 10 percent of the existing inventory of PFCs will comply with the new requirements in the summer of 2009. Therefore, only 10 percent of the full emission benefit estimated by CARB will occur by 2009 – the incremental reduction will be 5.8 percent in 2009.

3.4.4 Cost Estimates

CARB estimates that the cost-effectiveness of the 2005/2006 amendments will range from \$0.40 to \$0.70 per pound of VOC reduced, or \$800 to \$1,400 per ton of VOC reduced (CARB 2005a, pg. 27). Assuming CARB's costs for the OTR provides a conservative estimate, because some of the one-time research and reformulation costs incurred for products sold in California will not have to be incurred again for products sold in the OTR.

3.5 REGIONAL FUELS

The Clean Air Act Amendments of 1990 required significant changes to conventional fuels used by motor vehicles. Beginning in 1995, "reformulated" gasoline must be sold in certain non-attainment areas and other states with non-attainment areas are permitted to opt-in.

Reformulated gasoline results in lower VOC emissions than would occur from the use of normal “baseline” gasoline.

3.5.1 Existing Federal and State Rules

All but two states in the OTR are participating, in whole or in part, with the federal reformulated gasoline program. However, nearly one-third of the gasoline sold in the OTR is not reformulated gasoline. NESCAUM has estimated the following fraction of gasoline that is reformulated by State:

State	Current RFG Fraction	State	Current RFG Fraction
CT	100%	NJ	100%
DC	100%	NY	54%
DE	100%	PA	24%
MA	100%	RI	100%
MD	86%	NoVA	100%
ME	0%	VT	0%
NH	64%		

3.5.2 Description of the OTC 2006 Control Measure

The Energy Policy Act of 2005 provides the opportunity for the OTR to achieve a single clean-burning gasoline and is consistent with what OTR states have promoted through the long debate over MTBE/ethanol/RFG. Approximately one-third of the gasoline currently sold in the OTR is not reformulated. The new authority plus the potential for emission reductions from the amount of non-reformulated gasoline sold in the OTR provides an opportunity for additional emission reductions in the region as well as for a reduced number of fuels, and possibly a single fuel, to be utilized throughout the region. The OTC Commissioners recommended that the OTC member states pursue a region fuel program consistent with the Energy Act of 2005 (OTC 2006b).

3.5.3 Emission Benefit Analysis Methods

Emission benefits resulting from extending reformulated gasoline to all areas of the OTR have been calculated for 2006 by NESCAUM (NESCAUM 2006a).

3.5.4 Cost Estimates

According to USEPA’s regulatory impact analysis for reformulated gasoline (USEPA 1993), the cost per ton of VOC reduced for Phase I RFG is \$5,200 to \$5,900. USEPA also estimated the

cost of Phase II RFG was \$600 per ton of VOC reduced – this reflects the incremental cost over the cost of implementing Phase I of the RFG program.

3.6 VOC EMISSION REDUCTION SUMMARY

The results of the emission benefit calculations for the OTC states are described in this subsection. The starting point for the quantification of the emission reduction benefits is the MANEVU emission inventory, Version 3 (Pechan 2006, MACTEC 2006a) and the VISTAS emission inventory, BaseG (MACTEC 2006b), for the northern Virginia counties that are part of the OTR. The MANEVU and VISTAS inventories include a 2002 base year inventory as well as projection inventories for 2009 and 2018 (MANEVU also has projections for 2012, but VISTAS does not). The projection inventories account for growth in emissions based on growth indicators such as population and economic activity. The projection inventories also account for “on-the-books/on-the-way” (OTB/W) emission control regulations that have (or will) become effective between 2003 and 2008 that will achieve post-2002 emission reductions. For example, many States have already adopted the 2001 OTC model rules for consumer products and portable fuel containers. The emission reduction benefit from the 2001 OTC model rules are already accounted for in the MANEVU and VISTAS projection inventories. Emission reductions from existing regulations are already accounted for to ensure no double counting of emission benefits occurs.

Note that the emission reductions contained in this Section are presented in terms of tons per summer day. The MANEVU base and projection emission inventories do not contain summer day emissions for all States and source categories; the VISTAS inventory only contains annual values. When States provided summer day emissions in the MANEVU inventory, these values were used directly to quantify the emission benefit from the 2006 OTC control measure. When summer day emissions were missing from the MANEVU or VISTAS inventories, the summer day emissions were calculated using the annual emissions and the seasonal throughput data from the NIF Emission Process table. If the seasonal throughput data was missing, the summer day emissions were calculated using the annual emissions and a summer season adjustment factor derived from the monthly activity profiles contained in the SMOKE emissions modeling system.

Tables 3-5 to 3-10 show State summaries of the emission benefits from the OTC 2006 VOC control measures described previously in this Section. For each of the source categories, the Tables show four columns: (1) the actual 2002 summer daily emissions; (2) the summer daily emissions for the 2009 OTB/W scenario that accounts for growth and for the emission control regulations that have (or will) become effective between 2003 and 2008 that will achieve post-2002 emission reductions; (3) the summer daily emissions for 2009 with the implementation of

the OTC 2006 control measures identified in this Section, and (4) the emission benefit in 2009 resulting from the OTC 2006 control measure. Table 3-11 shows the same information for the total of all six source categories.

The largest estimated VOC emission reductions are in the most populous States – New York and Pennsylvania. The emission benefits listed for Virginia just include the Virginia counties in the northern Virginia area that are part of the OTR. Benefit estimates for all other States include the entire state. The emission benefits also assume that all OTC members will adopt the rules as described in the previous sections.

The requirement for a regional fuel throughout the OTR provides the largest emission benefit, about 139.4 tons per day across the OTR. The adhesives and sealants application model rule provides the second largest emission benefit in 2009 – 82.3 tons per day across the OTR. The incremental benefits accrued from the amendments to State's existing consumer products and portable fuel container model rules are not as large, since the States already have accrued substantial benefits from the adoption of these rules.

Appendix D provides county-by-county summaries of the VOC emission benefits from the OTC 2006 VOC model rules described previously in this Section. Appendix D also provides additional documentation regarding the data sources and emission benefit calculations that were performed. These tables can be used by the States to create additional summaries, for example, by nonattainment area.

**Table 3-5 OTC 2006 VOC Model Rule Benefits by State for 2009
 Adhesives and Sealants Application**

State	Adhesives/Sealants Application Summer VOC Emissions (tpd)			
	2002 Actual	2009 Base	2009 Control	2009 Benefit
CT	4.8	6.6	2.4	4.2
DE	1.4	1.6	0.6	1.0
DC	0.2	0.2	0.1	0.1
ME	3.1	3.9	1.4	2.5
MD	6.9	9.1	3.3	5.8
MA	10.6	14.7	5.8	8.9
NH	2.5	3.6	1.3	2.3
NJ	14.9	15.2	6.0	9.2
NY	24.7	33.4	11.9	21.5
PA	25.5	34.0	12.2	21.8
RI	1.8	2.4	0.9	1.5
VT	2.4	3.4	1.2	2.2
NOVA	1.2	1.6	0.6	1.0
OTR	99.8	129.8	47.5	82.3

2002 Actual emissions based on the MANEVU 2002 Version 3 inventory and VISTAS 2002 Base G inventory (for the 10 northern Virginia jurisdictions that are part of the OTR).

2009 Base Inventory emissions are based on the emissions forecasted in the MANEVU 2009 OTB/W Version 3.1 inventory and the VISTAS 2009 Base G inventory, and account for growth and any emission reductions associated with on-the-books/on-the-way controls measures.

2009 Control Inventory emissions are the emissions remaining after implementation of the beyond-on-the-way control measures described in this Section.

2009 Emission Reduction Benefit is the incremental emission reduction from the control measures described in this section (i.e., the difference between the 2009 base emissions and the 2009 control emissions).

Table 3-6 OTC 2006 VOC Model Rule Benefits by State for 2009
Cutback and Emulsified Asphalt Paving

State	Cutback and Emulsified Asphalt Paving Summer VOC Emissions (tpd)			
	2002 Actual	2009 Base	2009 Control	2009 Benefit
CT*	4.5	4.5	0.3	4.3
DE	0.1	0.1	0.1	0.0
DC	0.0	0.0	0.0	0.0
ME	8.6	10.6	0.0	10.6
MD	0.0	0.0	0.0	0.0
MA*	8.4	8.6	0.5	8.1
NH	3.8	4.8	0.5	4.4
NJ	4.9	4.8	0.1	4.7
NY	15.4	18.3	1.8	16.4
PA	7.7	9.3	0.9	8.4
RI	1.0	1.2	0.1	1.1
VT	1.4	1.8	0.0	1.8
NOVA	<0.1	<0.1	<0.1	<0.1
OTR	55.9	64.0	4.3	59.8

2002 Actual emissions based on the MANEVU 2002 Version 3 inventory and VISTAS 2002 Base G inventory (for the 10 northern Virginia jurisdictions that are part of the OTR).

2009 Base Inventory emissions are based on the emissions forecasted in the MANEVU 2009 OTB/W Version 3.1 inventory and the VISTAS 2009 Base G inventory, and account for growth and any emission reductions associated with on-the-books/on-the-way controls measures.

2009 Control Inventory emissions are the emissions remaining after implementation of the beyond-on-the-way control measures described in this Section.

2009 Emission Reduction Benefit is the incremental emission reduction from the control measures described in this section (i.e., the difference between the 2009 base emissions and the 2009 control emissions).

* CT and MA provided revised emission estimates that differ from those in the MANEVU Version 3 inventories.

**Table 3-7 OTC 2006 VOC Model Rule Benefits by State for 2009
Consumer Products**

State	Consumer Products Summer VOC Emissions (tpd)			
	2002 Actual	2009 Base	2009 Control	2009 Benefit
CT	40.1	35.4	34.7	0.7
DE	7.3	6.7	6.5	0.1
DC	5.7	5.1	5.0	0.1
ME	10.9	9.7	9.5	0.2
MD	52.8	48.4	47.4	1.0
MA*	62.2	64.1	53.9	10.2
NH	13.7	12.6	12.4	0.3
NJ	82.9	71.9	70.5	1.4
NY	209.6	183.3	179.6	3.7
PA	119.6	104.4	102.4	2.1
RI	10.6	9.3	9.1	0.2
VT	6.1	5.6	5.5	0.1
NOVA	21.5	23.0	22.5	0.5
OTR	642.9	579.5	559.0	20.5

2002 Actual emissions based on the MANEVU 2002 Version 3 inventory and VISTAS 2002 Base G inventory (for the 10 northern Virginia jurisdictions that are part of the OTR).

2009 Base Inventory emissions are based on the emissions forecasted in the MANEVU 2009 OTB/W Version 3.1 inventory and the VISTAS 2009 Base G inventory, and account for growth and any emission reductions associated with on-the-books/on-the-way controls measures.

2009 Control Inventory emissions are the emissions remaining after implementation of the beyond-on-the-way control measures described in this Section.

2009 Emission Reduction Benefit is the incremental emission reduction from the control measures described in this section (i.e., the difference between the 2009 base emissions and the 2009 control emissions).

* MA proposed rule has a January 1, 2009 effective date and includes the VOC limits from the OTC 2001 model rule and those in the OTC 2006 model rule. The 2009 benefit for MA shows the benefit from both sets of limits. For all other States, the 2009 benefit shows the change in emissions from the OTC 2006 model rule only.

Table 3-8 OTC 2006 VOC Model Rule Benefits by State for 2009
Portable Fuel Containers – Area Sources

State	Portable Fuel Containers Summer VOC Emissions (tpd)			
	2002 Actual	2009 Base	2009 Control	2009 Benefit
CT	9.7	6.5	6.1	0.4
DE	3.0	2.1	1.9	0.1
DC	3.6	2.5	2.4	0.1
ME	3.6	2.4	2.3	0.1
MD	39.6	24.5	23.1	1.4
MA*	18.1	18.6	16.9	1.7
NH	3.6	3.0	2.8	0.2
NJ	24.4	17.7	16.7	1.0
NY	76.6	45.0	42.4	2.6
PA	47.0	27.6	26.0	1.6
RI	3.0	2.7	2.5	0.2
VT	1.7	1.5	1.5	0.1
NOVA	<u>8.6</u>	<u>6.1</u>	<u>5.7</u>	<u>0.4</u>
OTR	242.5	160.1	150.3	9.9

2002 Actual emissions based on the MANEVU 2002 Version 3 inventory and VISTAS 2002 Base G inventory (for the 10 northern Virginia jurisdictions that are part of the OTR).

2009 Base Inventory emissions are based on the emissions forecasted in the MANEVU 2009 OTB/W Version 3.1 inventory and the VISTAS 2009 Base G inventory, and account for growth and any emission reductions associated with on-the-books/on-the-way controls measures.

2009 Control Inventory emissions are the emissions remaining after implementation of the beyond-on-the-way control measures described in this Section.

2009 Emission Reduction Benefit is the incremental emission reduction from the control measures described in this section (i.e., the difference between the 2009 base emissions and the 2009 control emissions).

Note: The table shows the estimated emission reduction that will occur in 2009; additional reductions will occur in later years as new, less-emitting PFCs that comply with the OTC 2006 control measure penetrate the market.

* MA PFC regulation will be based on only the OTC 2006 model rule (which updates the provisions of the OTC 2001 model rule) and will have an effective date of January 1, 2009. The 2009 base emissions in MA are uncontrolled emissions. The 2009 emission benefits represent the total emission reductions from the MA rule.

Table 3-9 OTC 2006 VOC Model Rule Benefits by State for 2009
Portable Fuel Containers – Nonroad Sources

State	Portable Fuel Containers Summer VOC Emissions (tpd)			
	2002 Actual	2009 Base	2009 Control	2009 Benefit
CT	2.9	1.9	1.8	0.1
DE	0.9	0.6	0.6	0.0
DC	1.1	0.8	0.7	0.0
ME	1.1	0.7	0.7	0.0
MD	11.9	7.4	6.9	0.4
MA*	5.4	5.6	5.1	0.5
NH	1.1	0.9	0.8	0.1
NJ	7.3	5.3	5.0	0.3
NY	23.0	13.5	12.7	0.8
PA	14.1	8.3	7.8	0.5
RI	0.9	0.8	0.8	0.0
VT	0.5	0.5	0.4	0.0
NOVA	2.6	1.8	1.7	<u>0.1</u>
OTR	72.8	48.0	45.1	3.0

2002 Actual emissions estimated to be 30 percent of area source emissions (based on Pechan 2001, pg. 11)

2009 Base Inventory emissions estimated to be 30 percent of area source emissions, and account for growth and any emission reductions associated with on-the-books/on-the-way controls measures.

2009 Control Inventory emissions are the emissions remaining after implementation of the beyond-on-the-way control measures described in this Section.

2009 Emission Reduction Benefit is the incremental emission reduction from the control measures described in this section (i.e., the difference between the 2009 base emissions and the 2009 control emissions).

Note: The table shows the estimated emission reduction that will occur in 2009; additional reductions will occur in later years as new, less-emitting PFCs that comply with the OTC 2006 control measure penetrate the market.

* MA PFC regulation will be based on only the OTC 2006 model rule (which updates the provisions of the OTC 2001 model rule) and will have an effective date of January 1, 2009. The 2009 base emissions in MA are uncontrolled emissions. The 2009 emission benefits represent the total emission reductions from the MA rule.

Table 3-10 OTC 2006 VOC Model Rule Benefits by State for 2009
Regional Fuels

State	Regional Fuels Summer VOC Emissions (tpd)			
	2006 Actual	2006 Base	2006 Control	2006 Benefit
CT	87.9	87.9	87.9	0.0
DE	26.6	26.6	26.6	0.0
DC	9.1	9.1	9.1	0.0
ME	56.2	56.2	47.1	9.1
MD	158.7	158.7	155.6	3.2
MA	148.6	148.6	148.6	0.0
NH	45.3	45.3	41.0	4.3
NJ	219.6	219.6	219.6	0.0
NY	465.0	465.0	408.1	56.9
PA	363.0	363.0	305.0	58.0
RI	22.2	22.2	22.2	0.0
VT	35.9	35.9	27.9	7.9
NOVA	54.9	54.9	54.9	0.0
OTR	1693.1	1693.1	1553.7	139.4

Note: NESCAUM analysis was only completed for 2006. Data for 2002 and 2009 are not currently available

Table 3-11 OTC 2006 VOC Model Rule Benefits by State for 2009
All Six VOC Categories

State	All Six Categories Summer VOC Emissions (tpd)			
	2002 Actual	2009 Base	2009 Control	2009 Benefit
CT	149.9	142.9	133.2	9.7
DE	39.3	37.7	36.3	1.4
DC	19.6	17.6	17.2	0.4
ME	83.5	83.6	60.9	22.6
MD	270.0	248.1	236.3	11.8
MA	253.3	260.1	230.8	29.3
NH	70.0	70.3	58.8	11.5
NJ	354.1	334.6	317.9	16.7
NY	814.2	758.4	656.5	101.9
PA	576.8	546.7	454.3	92.3
RI	39.5	38.6	35.6	3.0
VT	48.0	48.7	36.5	12.1
NOVA	<u>88.8</u>	<u>87.4</u>	<u>85.4</u>	<u>1.9</u>
OTR	2,807.0	2,674.6	2,359.8	314.8

2002 Actual emissions based on the MANEVU 2002 Version 3 inventory and VISTAS 2002 Base G inventory (for the 10 northern Virginia jurisdictions that are part of the OTR).

2009 Base Inventory emissions based on the emissions forecasted in the MANEVU 2009 OTB/W Version 3.1 inventory and the VISTAS 2009 Base G inventory, and account for growth and any emission reductions associated with on-the-books/on-the-way controls measures.

2009 Control Inventory emissions are the emissions remaining after implementation of the beyond-on-the-way control measures described in this Section. Assumes that 2009 reductions from RFG are the same as those calculated for 2006.

2009 Emission Reduction Benefit is the incremental emission reduction from the control measures described in this section (i.e., the difference between the 2009 base emissions and the 2009 control emissions). Assumes that 2009 reductions from RFG are the same as those calculated for 2006.

4.0 NOx ANALYSIS METHODS

This Section describes the analysis of the 2006 OTC control measures to reduce NOx emissions from six source categories: diesel engine chip reflash, regional fuels, asphalt production plants, cement kilns, glass/fiberglass furnaces, ICI boilers. For each of the categories, there are separate subsections that discuss existing Federal/state rules, summarize the requirements of the 2006 OTC control measure, describe the methods used to quantify the emission benefit, and provide an estimate of the anticipated costs and cost-effectiveness of the control measure. At the end of Section 4, we provide the estimated emissions for 2002 and 2009 by source category and State. Appendix E provides county-by-county summaries of the emission reductions for each of the categories.

4.1 HEAVY-DUTY TRUCK DIESEL ENGINE CHIP REFLASH

In the mid-1990s, the U.S. Department of Justice (DOJ), EPA, and CARB determined that seven major engine manufacturers had designed their 1993 through 1998 model heavy-duty diesel engines to operate with advanced electronic engine controls that resulted in excessive NOx emissions. When these engines were operated in the vehicle under “real world” conditions, the electronic calibration would change, altering the fuel delivery characteristics and resulting in elevated NOx levels. DOJ, EPA and ARB developed Consent Decrees that required the manufacturers to provide software (the “Low-NOx Rebuild Kit” or “chip reflash”) that modifies the injection timing adjustment that caused the excess NOx emissions. The kits are to be installed at the time the vehicle is brought in for a major engine rebuild/overhaul. The rate of rebuild has been considerably lower than what was envisioned under the Consent Decrees; the primary reasons being that engine rebuilds occur at considerably higher elapsed vehicle mileage than what was contemplated when the Consent Decrees were negotiated, and there is no federal oversight program to ensure that individual rebuilds are occurring at the time of rebuild. In response to this low rebuild rate, CARB has adopted a mandatory program, not tied to the time of rebuild, but rather to a prescribed period of time, within which owners must bring their vehicles into the dealer to have the reflash operation performed, with all costs borne by the engine manufacturers. (NESCAUM 2006b).

4.1.1 Existing Federal and State Rules

California entered into Settlement Agreements, separate from the federal Consent Decrees, but with analogous requirements for low-NOx rebuilds. The slow rate of progress in

California mirrored the progress nationally. Accordingly, California embarked upon its own program, by rule, to accelerate and ultimately complete the rebuilds for trucks registered in California and for out-of-state registered trucks traveling on roadways within the state. The ARB rule, effective March 21, 2005, mandates that rebuilds occur over a prescribed time period, with a final rebuild compliance date of December 31, 2006. The CARB mandatory program faced two separate legal challenges, alleging that CARB has breached its settlement agreement and alleging that CARB is illegally establishing different emissions standards on “new engines”. The Sacramento County Superior Court ruled that the Low NOx Software Upgrade Regulation is invalid. CARB indicates that it will not appeal that ruling and is suspending further enforcement of this regulation.

4.1.2 Description of the OTC 2006 Control Measure

NESCAUM developed a model rule for consideration by its member states to implement a low-NOx rebuild program, similar California’s program. The regulation applies to the engine manufacturers and to owners, lessees, and operators of heavy-duty vehicles powered by the engines that are required to have the low-NOx rebuild. Consistent with the Consent Decrees, the engine manufacturers are required to provide the rebuild kits at no cost to dealers, distributors, repair facilities, rebuild facilities, owners, lessees, and operators, upon their request and to reimburse their authorized dealers, distributors, repair facilities and rebuild facilities for their labor costs.

4.1.3 Emission Benefit Analysis Methods

NESCAUM estimated potential NOx emissions reductions (tons per day) if the Northeast States were to adopt a rebuild program similar to the California program. These estimates are based on the ratio of Northeast to California in-state heavy-duty vehicle registrations, and ARB-estimated California NOx reductions of 35 TPD (NESCAUM 2006b, pg. 5). NESCAUM also estimated potential NOx emissions reductions for the Mid-Atlantic States by scaling the NESCAUM projections based on population. For the Mid-Atlantic States, the NOx benefit was calculated based on the per capita factors of a one ton per day reduction for each one million people (NESCAUM 2005).

4.1.4 Cost Estimates

The cost associated with the reflash has been estimated at \$20-\$30 per vehicle, which is borne by the engine manufacturer. There may be costs associated with potential downtime to the trucking firms, and record-keeping requirements on the dealer performing the reflash

and the vehicle owner. The MRPO estimated cost effectiveness to be \$1,800 to \$2,500 (depending on vehicle size) due to incremental “fuel penalty” of 2 percent increase in fuel consumption (ENVIRON 2006).

4.2 REGIONAL FUELS

The Clean Air Act Amendments of 1990 required significant changes to conventional fuels used by motor vehicles. Beginning in 1995, “reformulated” gasoline (RFG) must be sold in certain non-attainment areas and other states with non-attainment areas are permitted to opt-in. Reformulated gasoline results in lower VOC emissions than would occur from the use of normal “baseline” gasoline. Phase II of the RFG program began in 2000.

4.2.1 Existing Federal and State Rules

All but two states in the OTR are participating, in whole or in part, with the federal RFG program. However, nearly one-third of the gasoline sold in the OTR is not RFG.

NESCAUM has estimated the following fraction of gasoline that is reformulated by State:

State	Current RFG Fraction	State	Current RFG Fraction
CT	100%	NJ	100%
DC	100%	NY	54%
DE	100%	PA	24%
MA	100%	RI	100%
MD	86%	NoVA	100%
ME	0%	VT	0%
NH	64%		

4.2.2 Description of the OTC 2006 Control Measure

The Energy Policy Act of 2005 provides the opportunity for the OTR to achieve a single clean-burning gasoline and is consistent with what OTR states have promoted through the long debate over MTBE/ethanol/RFG. Approximately one-third of the gasoline currently sold in the OTR is not reformulated. The new authority plus the potential for emission reductions from the amount of non-reformulated gasoline sold in the OTR provides an opportunity for additional emission reductions in the region as well as for a reduced number of fuels, and possibly a single fuel, to be utilized throughout the region. The OTC Commissioners recommended that the OTC member states pursue a region fuel program consistent with the Energy Act of 2005 (OTC 2006b).

4.2.3 Emission Benefit Analysis Methods

Emission benefits resulting from extending reformulated gasoline to all areas of the OTR have been calculated for 2006 by NESCAUM (NESCAUM 2006a).

4.2.4 Cost Estimates

According to USEPA's regulatory impact analysis for reformulated gasoline (USEPA 1993), the cost per ton of NO_x reduced for Phase II RFG is \$5,200 to \$3,700.

4.3 ASPHALT PAVEMENT PRODUCTION PLANTS

Hot mix asphalt (HMA) is created by mixing and heating size-graded, high quality aggregate (which can include reclaimed asphalt pavement) with liquid asphalt cement. HMA can be manufactured by batch mix, continuous mix, parallel flow drum mix, or counterflow drum mix plants. The dryer operation is the main source of pollution at hot mix asphalt manufacturing plants. Dryer burner capacities are usually less than 100 mmBtu/hr, but may be as large as 200 mmBtu/hr. Natural gas is the preferred source of heat used by the industry, although oil, electricity and combinations of fuel and electricity are used. The reaction of nitrogen and oxygen in the dryer creates nitrogen oxide (NO_x) emissions in the combustion zone,

4.3.1 Existing Federal and State Rules

Only two of the OTR states have regulations that specifically address NO_x emissions from asphalt pavement manufacturing plants. New Hampshire limits NO_x emissions to 0.12 pound per ton of asphalt produced, or 0.429 lb per mmBtu {Chapter Env-A 1211.08 (c)} for units greater than 26 mmBTU/hour in size. New Jersey limits NO_x emissions to 200 ppmvd at seven percent oxygen {7:27-19.9(a)}. Asphalt plants in other OTR states are subject to more general fuel combustion requirements or case-by-case RACT determinations.

4.3.2 Description of the OTC 2006 Control Measure

NO_x emissions from asphalt plants can be reduced through installation of low-NO_x burners and flue gas recirculation (FGR). The OTC Commissioners recommended that OTC member states pursue as necessary and appropriate state-specific rulemakings or other implementation methods to establish emission reduction percentages, emission rates or technologies that are consistent with the guidelines shown in Table 4.1 (OTC 2006b).

**Table 4.1 Addendum to OTC Resolution 06-02 Emission Guidelines
for Asphalt Plants**

Plant Type	Emission Rate (lbs NOx/ton asphalt produced)	% Reduction
Area/Point Sources		
Batch Mix Plant – Natural Gas	0.02	35
Batch Mix Plant – Distillate/Waste Oil	0.09	35
Drum Mix Plant – Natural Gas	0.02	35
Drum Mix Plant – Distillate/Waste Oil	0.04	35
or Best Management Practices		

Industry leaders have identified a number of Best Management Practices that allow for substantial reduction in plant fuel consumption and the corresponding products of combustion including NOx. Best management practices include:

- **Burner tune-ups:** A burner tune-up may reduce NOx emissions by up to 10 percent and may also help reduce fuel consumption. In other words, there can be a direct pay-back to the business from regular burner tune-ups.
- **Effective stockpile management to reduce aggregate moisture content:** Current information indicates that effective stockpile management can reduce aggregate moisture content by about 25 percent, corresponding to a reduction in fuel consumption by approximately 10 - 15 percent. There are a number of ways to reduce aggregate moisture: covering stockpiles, paving under stockpiles, and sloping stockpiles are all ways that prevent aggregate from retaining moisture. Best Practices are plant- and geographic locale-specific.
- **Lowering mix temperature:** A Technical Working Group of FHWA is currently investigating a number of newer formulation technologies, to understand the practicality and performance of lowering mix temperatures. Substantial reductions in mix temperatures, on the order of 20 percent or more, appear to be plausible. Lowering mix temperatures, by this amount, may reduce fuel consumption, as less heat is needed to produce the mix.
- **Other maintenance and operational best practices:** Additional practices can be employed throughout the plant to help optimize production and operations. For example, regular inspection of drum mixing flites and other measures can be taken – all in the effort to make a plant operate more efficiently, thereby using less fuel.

4.3.3 Emission Benefit Analysis Methods

The emission rates and percent reductions estimates shown above for major sources were developed the state of New York based on the use of low-NOx burners and FGR. For minor sources, the requirement is the use of low-NOx burner technology. NOx emissions can be reduced by 35 to 50 percent with low-NOx burners and FGR, and by 25 to 40 percent with low-NOx burners alone. For modeling purposes, a 35 percent reduction was assumed to apply all types of asphalt plants.

The reductions estimated for this category only include emissions included in the MANEVU point source emission inventory. Only emissions from major point sources are typically included in the MANEVU point source database. Emissions from non-major sources are not explicitly contained in the area source inventory. The emissions from non-major asphalt plants are likely lumped together in the general area source industrial and commercial fuel use category. Reductions from area source emissions at asphalt production plants are included in the ICI boiler source category. Therefore, there is some uncertainty regarding the actual reductions that will occur as no accurate baseline exists for both major and minor facilities.

4.3.4 Cost Estimates

The anticipate costs for control are similar to those of small to midsize boilers or process heaters. Low NOx burners range from \$500 to \$1,250 per ton and low-NOx burners in combination with FGR range from \$1,000 to \$2,000 per ton. These cost-effectiveness data were provided by NYSDEC. These control efficiencies and cost-effectiveness estimates for low-NOx burners plus FGR are generally consistent EPA's published data for small natural gas-fired and oil-fired process heaters and boilers (Pechan 2005).

4.4 CEMENT KILNS

Portland cement manufacturing is an energy intensive process in which cement is made by grinding and heating a mixture of raw materials such as limestone, clay, sand and iron ore in a rotary kiln. Nationwide, about 82 percent of the industry's energy requirement is provided by coal. Waste-derived fuels (such as scrap tires, used motor oils, surplus printing inks, etc.) provide about 14 percent of the energy. NOx emissions are generated during fuel combustion by oxidation of chemically-bound nitrogen in the fuel and by thermal fixation of nitrogen in the combustion air.

There are four main types of kilns used to manufacture portland cement: long wet kilns, long dry kilns, dry kilns with preheaters, dry kilns with precalciners. Wet kilns tend to be older units and are often located where the moisture content of feed materials from quarries tends to be high.

Cement kilns are located in Maine, Maryland, New York, and Pennsylvania. There are no cement kilns in the other OTR states. According to the MANEVU 2002 inventory (Pechan 2006), the number of cement kilns operating in 2002 by size and type was:

State	Number of Facilities	Number of Long Wet Kilns	Number of Long Dry Kilns	Number of Preheater or Precalciner Kilns
Maine	1	1	0	0
Maryland	3	2	2	0
New York	3	2	1	0
Pennsylvania	10	5	11	5

4.4.1 Existing Federal and State Rules

The NOx SIP Call required states to submit revisions to their SIPs to reduce the contribution of NOx from cement kilns. All kilns in the OTR, except for the one kiln in Maine, are subject to the NOx SIP Call. Based on its SIP Call analysis, EPA determined 30 percent reduction of baseline uncontrolled emission levels was highly cost-effective for cement kilns emitting greater than 1 ton/day of NOx. Some states elected to include cement kilns in their NOx Budget Trading Programs. For example, requirements in Pennsylvania's regulations in 25 Pa. Code Chapter 145 set a kiln allowable limit of 6 pounds per ton of clinker produced, and require sources to purchase NOx allowances for each ton of NOx actual emissions that exceed the allowable limits. Maryland did not include kilns in the trading program but instead provided two options for reducing NOx emissions:

- Option 1 – for long wet kilns, meet NOx emission limit of 6.0 pounds per ton of clinker produced; for long dry kilns, meet limit of 5.1 pounds per ton of clinker produced; and for pre-heater/pre-calciner or pre-calciner kilns, meet limit of 2.8 pounds per ton of clinker produced;
- Option 2 – install low NOx burners on each kiln or modify each kiln to implement mid-kiln firing.

The one kiln in Maine is a wet process cement kiln and has been licensed to modernize by converting to the more efficient dry cement manufacturing process. The new kiln is subject to BACT requirements.

4.4.2 Description of the OTC 2006 Control Measure

There is a wide variety of proven control technologies for reducing NO_x emissions from cement kilns. Automated process control has been shown to lower NO_x emissions by moderate amounts. Low-NO_x burners have been successfully used, especially in the precalciner kilns. CemStarSM is a process that involves adding steel slag to the kiln, offering moderate levels of NO_x reduction by reducing the required burn zone heat input. Mid-kiln firing of tires provides moderate reductions of NO_x emissions while reducing fuel costs and providing an additional revenue stream from receipt of tire tipping fees. SNCR technology has the potential to offer significant reductions on some precalciner kilns. SNCR is being used in numerous cement kilns in Europe. A recent study (EC 2001a) indicates that there are 18 full-scale SNCR installations in Europe. Most SNCR installations are designed and/or operated for NO_x reduction rates of 10-50% which is sufficient to comply with current legislation in some countries. Two Swedish plants installed SNCR in 1996/97 and have achieved a reduction of 80-85%. A second recent study (ERG 2005) of cement kilns in Texas has identified a variety of NO_x controls for both wet and dry cement kilns, with reductions in the 40 to 85% range.

The OTC Commissioners recommended that OTC member states pursue, as necessary and appropriate, state-specific rulemakings or other implementation methods to establish emission reduction percentages, emission rates or technologies that are consistent with the guidelines shown in Table 4.2 (OTC 2006b). The guidelines were presented in terms of both an emission rate (lbs/ton of clinker by kiln type) as well as a percent reduction from uncontrolled levels.

Table 4.2 OTC Resolution 06-02 Emission Guidelines for Cement Kilns

Kiln Type	Emission Rate (lbs NO_x/ton of clinker produced)	% Reduction from Uncontrolled
Wet Kiln	3.88	60
Long Dry Kiln	3.44	60
Pre-heater Kiln	2.36	60
Pre-calciner Kiln	1.52	60

4.4.3 Emission Benefit Analysis Methods

To calculate the additional reductions from the OTC 2006 Control Measure, MACTEC calculated the 2002 emission rate (lbs NOx per ton of clinker produced) for each kiln. The 2002 emission rate was compared to the OTC 2006 control measure emission rate list above to calculate a kiln-specific percent reduction. The kiln-specific percent reduction was then applied to the 2002 actual emissions to calculate the emissions remaining after implementation of the control measure.

4.4.4 Cost Estimates

The TCEQ study (ERG 2005) estimated a cost-effectiveness of \$1,400-1,600 per ton of NOx removed for an SNCR system achieving a 50 percent reduction on modern dry preheat precalcination kilns. The study also estimate a cost-effectiveness of \$2,200 per ton of NOx removed for SNCR systems achieving a 35 percent reduction on wet kilns. The most recent EPA report (EC/R 2000) shows data for two SNCR technologies, biosolids injection and NOXOUT®. These technologies showed average emission reductions of 50 and 40 percent, respectively. The cost effectiveness was estimated to be \$1,000-2,500/ton depending on the size of the kiln. Costs and the cost effectiveness for a specific unit will vary depending on the kiln type, characteristics of the raw material and fuel, uncontrolled emission rate, and other source-specific factors.

4.5 GLASS/FIBERGLASS FURNACES

The manufacturing process requires raw materials, such as sand, limestone, soda ash, and cullet (scrap and recycled glass), be fed into a furnace where a temperature is maintained in the 2,700°F to 3,100°F range. The raw materials then chemically react creating a molten material, glass. The reaction of nitrogen and oxygen in the furnace creates NOx emissions.

The main product types are flat glass, container glass, pressed and blown glass, and fiberglass. In the OTR, the preponderance of glass manufacturing plants is in Pennsylvania. New York and New Jersey also have several plants. Massachusetts, Maryland, and Rhode Island each have one glass manufacturing plant.

4.5.1 Existing Federal and State Rules

Only Massachusetts and New Jersey have specific regulatory limits for NOx emissions from glass melting furnaces. Massachusetts has a 5.3 pound per ton of glass removed limit for container glass melting furnaces having a maximum production of 15 tons of glass per

day or greater. New Jersey has a 5.5 pound per ton of glass limit for commercial container glass manufacturing furnaces and an 11 pound per ton of glass for specialty container glass manufacturing furnaces. New Jersey also required borosilicate recipe glass manufacturing furnaces to achieve at least a 30 percent reduction from 1990 baseline levels by 1994. The regulations for other states with glass furnaces (Maryland, New York, Pennsylvania, and Rhode Island) do not contain specific emission limitation requirements, but rather require RACT emission controls as determined on a case-by-case basis.

4.5.2 Description of the OTC 2006 Control Measure

Several alternative control technologies are available to glass manufacturing facilities to limit NOx emissions (MACTEC 2005). These options include combustion modifications (low NOx burners, oxy-fuel firing, oxygen-enriched air staging), process modifications (fuel switching, batch preheat, electric boost), and post combustion modifications (fuel reburn, SNCR, SCR). Oxyfiring is the most effective NOx emission reduction technique and is best implemented with a complete furnace rebuild. This strategy not only reduces NOx emissions by as much as 85 percent, but reduces energy consumption, increases production rates by 10-15 percent, and improves glass quality by reducing defects. Oxyfiring is demonstrated technology and has penetrated into all segments of the glass industry.

The OTC Commissioners recommended that OTC member states pursue, as necessary and appropriate, state-specific rulemakings or other implementation methods to establish emission reduction percentages, emission rates or technologies that are consistent with the guidelines shown in Table 4.3 (OTC 2006g). The guidelines were presented in terms of both an emission rate (lbs/ton of glass produced) as well as a percent reduction from uncontrolled levels for the different types of glass manufactured.

Table 4.3 Addendum to OTC Resolution 06-02 Guidelines for Glass Furnaces

Type of Glass	Emission Rate (lbs NOx/ton of glass pulled) Block 24-hr Ave.	Emission Rate (lbs NOx/ton of glass pulled) Rolling 30-day Ave.
Container Glass	4.0	n/a
Flat Glass	9.2	7.0
Pressed/blown Glass	4.0	n/a
Fiberglass	4.0	n/a

Note: Compliance date is 2009. NOx allowances may be surrendered in lieu of meeting the emission rate based on a percentage of the excess emissions at the facility, at the discretion of the State.

4.5.3 Emission Benefit Analysis Methods

The NOx emission reduction benefit calculation varied by State depending upon the availability of data:

- New Jersey DEP evaluated the existing controls at each facility. NJDEP identified furnaces that have closed, indicated whether the facility requested banking of emissions, and specified whether the emissions from the closed furnace should remain in the projection year inventory. NJDEP also identified furnace-specific projected emission rates based on the use of oxyfuel technology.
- Pennsylvania DEP provided 2002 throughput (tons of glass pulled) and emission rate data (lbs NOx/ton of glass pulled). The 2002 emission rate was compared to the OTC 2006 control measure emission rate list above to calculate a furnace-specific percent reduction. The furnace-specific percent reduction was then applied to the 2002 actual emissions to calculate the emissions remaining after implementation of the control measure. If a furnace had an emission rate below the OTCC 2006 control measure emission rate, then no incremental reduction was calculated. PADEP also identified several furnaces that have shut down – emissions from these furnaces were set to zero in the projection year inventory.
- For all other States with glass furnaces (MA, MD, NY, and RI), furnace specific data were not available. The NOx emission reduction benefit was calculated by applying an 85 percent reduction for oxyfiring technology to the projected 2009 base inventory. This approach does not take into account existing controls at the facilities.

4.5.4 Cost Estimates

A recent study by the European Commission (EC 2001b) reports a 75 to 85 percent reduction in NOx based on oxyfiring technology, resulting in emission rates of 1.25 to 4.1 pounds of NOx per ton of glass produced. The cost effectiveness was determined to be \$1,254 to \$2,542 depending on the size of the furnace. EPA's Alternative Control Techniques Document (USEPA 1994) estimated an 85 percent reduction in NOx emissions for oxyfiring with a cost-effectiveness of \$2,150 to \$5,300.

Other technologies may be used to meet the limits in Table 4.3. The costs associated with meeting those limits are source-specific and depend on the existing controls in place and the emission rates being achieved. Site-specific factors greatly influence the actual achievable performance level and control costs at a particular facility.

4.6 ICI BOILERS

Industrial/commercial/institutional (ICI) boilers combust fuel to produce heat and process steam for a variety of applications. Industrial boilers are routinely found in applications the chemical, metals, paper, petroleum, food production and other industries. Commercial and institutional boilers are normally used to produce steam and heat water for space heating in office buildings, hotels, apartment buildings, hospitals, universities, and similar facilities. Industrial boilers are generally smaller than boilers in the electric power industry, and typically have a heat input in the 10-250 mmBtu/hr range; however, industrial boilers can be as large as 1,000 mmBtu/hr or as small as 0.5 mmBtu/hour. Most commercial and institutional boilers generally have a heat input less than 100 mmBtu/hour. It is estimated that 80 percent of the commercial/institutional population is smaller than 15 mmBtu/hour. The ICI boiler population is highly diverse – encompassing a variety of fuel types, boiler designs, capacity utilizations and pollution control systems – that result in variability in emission rates and control options.

For emission inventory purposes, emissions from ICI boilers are included in both the point and area source emission inventories. Generally, the point source emission inventory includes all ICI boilers at major facilities. The point source inventory lists individual boilers, along with their size and associated emissions. The area source inventory generally includes emissions for ICI boilers located at non-major facilities. It does not provide emissions by the size of boiler, as is done in the point source inventory. Area sources emissions are calculated based on the fuel use not accounted for in the point source inventory. This is done by taking the total fuel consumption for the state (by fuel type and category), as published by the U.S. Department of Energy, and subtracting out the fuel usage reported in the point source inventory. Emissions are then calculated on a county-by-county basis using the amount of fuel not accounted for in the point source inventory and average emission factors for each fuel type.

4.6.1 Existing Federal and State Rules

ICI boilers are subject to a variety of Clean Air Act programs. Emission limits for a specific source may have been derived from NSPS, NSR, NO_x SIP Call, State RACT rules, case-by-case RACT determinations, or MACT requirements. Thus, the specific emission limits and control requirements for a given ICI boiler vary and depend on fuel type, boiler age, boiler size, boiler design, and geographic location.

The OTC developed a draft model rule in 2001 with the following thresholds and limits:

OTC 2001 Model Rule ICI Boiler Thresholds and Limits		
Applicability Threshold	Emission Rate Limit	Percent NO_x Reduction
5-50 mmBtu/hr	None	Tune-up Only
50-100 mmBtu/hr	Gas-fired: 0.10 lbs/mmBtu Oil-fired: 0.30 lbs/mmBtu Coal-fired: 0.30 lbs/mmBtu	50%
100-250 mmBtu/hr	Gas-fired: 0.10 lbs/mmBtu Oil-fired: 0.20 lbs/mmBtu Coal-fired: 0.20 lbs/mmBtu	50%
>250 mmBtu/hr*	Gas-fired: 0.17 lbs/mmBtu Oil-fired: 0.17 lbs/mmBtu Coal-fired: 0.17 lbs/mmBtu	50%

* Only for boilers not subject to USEPA's NO_x SIP Call

Implementation of the OTC 2001 model rule limits varied by State – some OTC states adopted these limits while others did not. MACTEC researched current State regulations affecting ICI boilers and summarized the rules in Appendix F. The specific requirements for each state were organized into a common format to efficiently include the State-by-State differences by fuel type and boiler size. This organization oversimplifies the source categories and size limitations that differ from State-to-State. This simplification was necessary to match the rules to the organization of the emission data bases (i.e., Source Classification Codes) being used in the analysis.

4.6.2 Description of the OTC 2006 Control Measure

The OTC Commissioners recommended that OTC member states pursue as necessary and appropriate state-specific rulemakings or other implementation methods to establish emission reduction percentages, emission rates or technologies for ICI boilers (OTC 2006b). These guidelines have undergone revision based on a more refined analyses. Table 4.4 provides the current OTC proposal for ICI boilers.

4.6.3 Emission Benefit Analysis Methods

The emission reduction benefits resulting from the OTC ICI boiler control measure were calculated differently for point and area sources. For point sources, the emission reductions were estimated by comparing the emission limits in the existing (2006) state regulations with the limits contained in the OTC ICI boiler proposal.

Table 4.4 Addendum to OTC Resolution 06-02 Guidelines for ICI Boilers

ICI Boiler Size (mmBtu/hr)	Control Strategy/ Compliance Option	NO _x Control Measure
5-25		Annual Boiler Tune-Up
25-100	Option #1	Natural Gas: 0.05 lb NO _x /mmBtu #2 Fuel Oil: 0.08 lb NO _x /mmBtu #4 or #6 Fuel Oil: 0.20 lb NO _x /mmBtu Coal: 0.30 lb NO _x /mmBtu**
	Option #2	50% reduction in NO _x emissions from uncontrolled baseline
	Option #3	Purchase current year CAIR NO _x allowances equal to reduced needed to achieve the required emission rates
100-250	Option #1	Natural Gas: 0.10 lb NO _x /mmBtu #2 Fuel Oil: 0.20 lb NO _x /mmBtu #4 or #6 Fuel Oil: 0.20 lb NO _x /mmBtu Coal: Wall-fired 0.14 lb NO _x /mm Btu Tangential 0.12 lb NO _x /mm Btu Stoker 0.22 lb NO _x /mm Btu Fluidized Bed 0.08 lb NO _x /mm Btu
	Option #2	LNB/SNCR, LNB/FGR, SCR, or some combination of these controls in conjunction with Low NO _x Burner technology
	Option #3	60% reduction in NO _x emissions from uncontrolled baseline
	Option #4	Purchase current year CAIR NO _x allowances equal to reduced needed to achieve the required emission rates
>250	Option #1	Purchase current year CAIR NO _x allowances equal to reduced needed to achieve the required emission rates
	Option #2	Phase I – 2009 Emission rate equal to EGUs of similar size Phase II – 2012 Emission rate equal to EGUs of similar size

Tables 4-5 through 4-10 shows the current state emission limits by size range and fuel type, and the percentage reduction from the OTC proposed limits to the current state requirement. In cases where a state did not have a specific limit for a given size range, then the more general percent reduction from uncontrolled values in Table 4-4 was used. The fuel types/boiler types shown in Tables 4-5 through 4-10 were matched to SCCs in the point source inventory. MACTEC used the SCC and design capacity (mmBtu/hour) from the MANEVU and VISTAS emission inventories to apply the appropriate state specific reduction factor to estimate the emission reduction benefit.

The emission limits shown in Tables 4-5 through 4-10 generally apply only to ICI boilers located at major sources (i.e. point sources). ICI boilers located at minor sources (i.e., area sources) are generally not subject to the emissions limits. In general, emissions from area source ICI boilers are uncontrolled (except possibly for an annual tune-up requirement). The one exception is New Jersey: beginning on March 7, 2007, N.J.A.C. 27.27-19.2 requires any ICI boiler of at least 5 mmBtu/hr heat input to comply with applicable NO_x emission limits whether or not it is located at a major NO_x facility.

To calculate the reductions from area source ICI boilers, MACTEC applied the general percent reduction from uncontrolled values in Table 4-4 to the area source inventory (i.e., 10 percent reduction for annual tune-ups for boilers < 25 mmBtu/hr, and a 50 percent reduction for boilers between 25 and 100 mmBtu/hr).

The area source inventory does not provide information on the boiler size. To estimate the boiler size distribution in the area source inventory, we first assumed that there were no boilers > 100 mmBtu/hr in the area source inventory. Next, we used boiler capacity data from the USDOE's Oak Ridge National Laboratory (EEA 2005) to estimate the percentage of boiler capacity in the < 25 mm Btu/hr and 25-100 mm Btu/hr categories. Third, we assumed that emissions were proportional to boiler capacity. Finally, we calculated the weighted average percent reduction for area source ICI boilers based on the capacity in each size range and the percent reduction by size range discussed in the previous paragraph. For industrial boilers, the weighted average reduction was 34.5 percent; for commercial/institutional boilers, the weighted average reduction was 28.1 percent.

**Table 4.5 Current State Emission Limits and Percent Reduction Estimated from
Adoption of OTC ICI Boiler Proposal**

Point Source Natural Gas-Fired Boilers

State	Current 2006 NOx RACT Limit (lbs/mmBtu) (from State regulations) Applicability Threshold mmBtu/hour Heat Input					OTC Limits (lbs/mmBtu):	OTC 2006 Percent Reduction (Current State reg compared to OTC Limit) Applicability Threshold mmBtu/hour Heat Input				
	> 250*	100 to 250	50 to 100	25 to 50	5 to 25		> 250*	100 to 250	50 to 100	25 to 50	<25
							0.12	0.10	0.05	0.05	NL
CT	0.20	0.20	0.20	0.20	0.20		40.0	50.0	75.0	75.0	10.0
DE	0.10	0.10	LNB	NL	NL		0.0	0.0	0.0	0.0	0.0
DC	0.20	0.20	NL	NL	NL		40.0	50.0	50.0	50.0	10.0
ME	0.20	NL	NL	NL	NL		40.0	60.0	50.0	50.0	10.0
MD	0.20	0.20	0.20	0.20	0.20		40.0	50.0	75.0	75.0	10.0
MA	0.20	0.20	0.10	NL	NL		40.0	50.0	50.0	50.0	10.0
NH	0.10	0.10	0.10	NL	NL		0.0	0.0	50.0	50.0	10.0
NJ	0.10	0.10	0.10	NL	NL		0.0	0.0	50.0	50.0	10.0
NY	0.20	0.20	0.10	NL	NL		40.0	50.0	50.0	50.0	10.0
PA	Source Specific NOx RACT						29.4	50.0	50.0	50.0	10.0
SE PA	0.17	0.10	Source Specific RACT				29.4	0.0	50.0	50.0	10.0
RI	0.10	0.10	0.10	NL	NL		0.0	0.0	50.0	50.0	10.0
VT	0.20	NL	NL	NL	NL		40.0	60.0	50.0	50.0	10.0
NOVA	0.2	0.2	0.2	0.2	0.2		40.0	50.0	75.0	75.0	10.0

NL indicates no limit specified in a state rule; in those cases, the more general percent reduction from Table 4-4 was used.

Source Specific NOx RACT indicates that there are no specific limits in the States' rule (i.e., limits were determined on a case-by-case basis); in those cases, the more general percent reduction from Table 4-4 was used.

SE PA refers to the five southeastern Pennsylvania counties (Bucks, Chester, Delaware, Montgomery, and Philadelphia) affected by Pennsylvania's Addition NOx Requirements (129.201)

NOVA refers to the following jurisdictions in Virginia are part of the OTR: Arlington County, Alexandria, Fairfax County, Fairfax City, Fall Church, Loudon County, Manassas City, Manassas Park, and Prince William County.

**Table 4.6 Current State Emission Limits and Percent Reduction Estimated from
Adoption of OTC ICI Boiler Proposal**

Point Source Distillate Oil-Fired Boilers

State	Current 2006 NO _x RACT Limit (lbs/mmBtu) (from State regulations) Applicability Threshold mmBtu/hour Heat Input						OTC 2006 Percent Reduction (Current State reg compared to OTC Limit) Applicability Threshold mmBtu/hour Heat Input				
	> 250*	100 to 250	50 to 100	25 to 50	5 to 25		> 250*	100 to 250	50 to 100	25 to 50	<25
						OTC Limits (lbs/mmBtu):	0.12	0.20	0.08	0.08	NL
CT	0.20	0.20	0.20	0.20	0.20		40.0	0.0	60.0	60.0	10.0
DE	0.10	0.10	LNB	NL	NL		0.0	0.0	0.0	0.0	0.0
DC	0.30	0.30	0.30	NL	NL		60.0	33.3	73.3	50.0	10.0
ME	0.20	0.30	0.30	NL	NL		40.0	33.3	73.3	50.0	10.0
MD	0.25	0.25	0.25	0.25	0.25		52.0	20.0	68.0	68.0	10.0
MA	0.25	0.30	0.12	NL	NL		52.0	33.3	33.3	50.0	10.0
NH	0.30	0.30	0.12	NL	NL		60.0	33.3	33.3	50.0	10.0
NJ	0.20	0.20	0.12	NL	NL		40.0	0.0	33.3	50.0	10.0
NY	0.25	0.30	0.12	NL	NL		52.0	33.3	33.3	50.0	10.0
PA	Source Specific NO _x RACT						29.4	33.3	33.3	50.0	10.0
SE PA	0.17	0.20	Source Specific RACT				29.4	0.0	33.3	50.0	10.0
RI	0.12	0.12	0.12	NL	NL		0.0	0.0	33.3	50.0	10.0
VT	0.30	NL	NL	NL	NL		60.0	60.0	50.0	50.0	10.0
NOVA	0.25	0.25	0.25	0.25	0.25		52.0	20.0	68.0	68.0	10.0

NL indicates no limit specified in a state rule; in those cases, the more general percent reduction from Table 4-4 was used.

Source Specific NO_x RACT indicates that there are no specific limits in the States' rule (i.e., limits were determined on a case-by-case basis); in those cases, the more general percent reduction from Table 4-4 was used.

SE PA refers to the five southeastern Pennsylvania counties (Bucks, Chester, Delaware, Montgomery, and Philadelphia) affected by Pennsylvania's Addition NO_x Requirements (129.201)

NOVA refers to the following jurisdictions in Virginia are part of the OTR: Arlington County, Alexandria, Fairfax County, Fairfax City, Fall Church, Loudon County, Manassas City, Manassas Park, and Prince William County.

**Table 4.7 Current State Emission Limits and Percent Reduction Estimated from
Adoption of OTC ICI Boiler Proposal**

Point Source Residual Oil-Fired Boilers

State	Current 2006 NO _x RACT Limit (lbs/mmBtu) (from State regulations) Applicability Threshold mmBtu/hour Heat Input					OTC Limits (lbs/mmBtu):	OTC 2006 Percent Reduction (Current State reg compared to OTC Limit) Applicability Threshold mmBtu/hour Heat Input				
	> 250*	100 to 250	50 to 100	25 to 50	5 to 25		> 250*	100 to 250	50 to 100	25 to 50	<25
							0.12	0.20	0.20	0.20	NL
CT	0.25	0.25	0.25	0.25	0.25		52.0	20.0	20.0	20.0	10.0
DE	0.10	0.10	LNB	NL	NL		0.0	0.0	0.0	0.0	0.0
DC	0.30	0.30	0.30	NL	NL		60.0	33.3	33.3	50.0	10.0
ME	0.20	0.30	0.30	NL	NL		40.0	33.3	33.3	50.0	10.0
MD	0.25	0.25	0.25	0.25	0.25		52.0	20.0	20.0	20.0	10.0
MA	0.25	0.30	0.30	NL	NL		52.0	33.3	33.3	50.0	10.0
NH	0.30	0.30	0.30	NL	NL		60.0	33.3	33.3	50.0	10.0
NJ	0.20	0.20	0.30	NL	NL		40.0	0.0	33.3	50.0	10.0
NY	0.25	0.30	0.30	NL	NL		52.0	33.3	33.3	50.0	10.0
PA	Source Specific NO _x RACT						29.4	33.3	33.3	50.0	10.0
SE PA	0.17	0.20	Source Specific RACT				29.4	0.0	50.0	50.0	10.0
RI	LNB/FGR	LNB/FGR	LNB/FGR	NL	NL		0.0	0.0	0.0	50.0	10.0
VT	0.30	NL	NL	NL	NL		60.0	60.0	50.0	50.0	10.0
NOVA	0.25	0.25	0.25	0.25	0.25		52.0	20.0	20.0	20.0	10.0

NL indicates no limit specified in a state rule; in those cases, the more general percent reduction from Table 4-4 was used.

Source Specific NO_x RACT indicates that there are no specific limits in the States' rule (i.e., limits were determined on a case-by-case basis); in those cases, the more general percent reduction from Table 4-4 was used.

SE PA refers to the five southeastern Pennsylvania counties (Bucks, Chester, Delaware, Montgomery, and Philadelphia) affected by Pennsylvania's Addition NO_x Requirements (129.201)

NOVA refers to the following jurisdictions in Virginia are part of the OTR: Arlington County, Alexandria, Fairfax County, Fairfax City, Fall Church, Loudon County, Manassas City, Manassas Park, and Prince William County.

**Table 4.8 Current State Emission Limits and Percent Reduction Estimated from
Adoption of OTC ICI Boiler Proposal**

Point Source Coal Wall-Fired Boilers

State	Current 2006 NOx RACT Limit (lbs/mmBtu) (from State regulations) Applicability Threshold mmBtu/hour Heat Input						OTC 2006 Percent Reduction (Current State reg compared to OTC Limit) Applicability Threshold mmBtu/hour Heat Input				
	> 250*	100 to 250	50 to 100	25 to 50	5 to 25		> 250*	100 to 250	50 to 100	25 to 50	<25
						OTC Limits (lbs/mmBtu):	0.12	0.14	0.30	0.30	NL
CT	0.38	0.38	0.38	0.38	0.38		68.4	63.2	21.1	21.1	10.0
DE	n/a	n/a	n/a	n/a	n/a		0.0	0.0	0.0	0.0	0.0
DC	0.43	0.43	NL	NL	NL		72.1	67.4	50.0	50.0	10.0
ME	n/a	n/a	n/a	n/a	n/a		0.0	0.0	0.0	0.0	0.0
MD	0.38	0.65	0.38	0.38	0.38		68.4	78.5	21.1	21.1	10.0
MA	0.45	0.45	NL	NL	NL		73.3	68.9	50.0	50.0	10.0
NH	n/a	n/a	n/a	n/a	n/a		0.0	0.0	0.0	0.0	0.0
NJ	n/a	n/a	n/a	n/a	n/a		0.0	0.0	0.0	0.0	0.0
NY	0.45	0.5	NL	NL	NL		73.3	72.0	50.0	50.0	10.0
PA	Source Specific NOx RACT						29.4	72.0	50.0	50.0	10.0
SE PA	0.17	0.20	Source Specific RACT				29.4	30.0	50.0	50.0	10.0
RI	n/a	n/a	n/a	n/a	n/a		0.0	0.0	0.0	0.0	0.0
VT	n/a	n/a	n/a	n/a	n/a		0.0	0.0	0.0	0.0	0.0
NOVA	0.38	0.38	0.38	0.38	0.38		68.4	63.2	21.1	21.1	10.0

n/a indicates that there are no coal-fired ICI boilers in the state.

NL indicates no limit specified in a state rule; in those cases, the more general percent reduction from Table 4-4 was used.

Source Specific NOx RACT indicates that there are no specific limits in the States' rule (i.e., limits were determined on a case-by-case basis); in those cases, the more general percent reduction from Table 4-4 was used.

SE PA refers to the five southeastern Pennsylvania counties (Bucks, Chester, Delaware, Montgomery, and Philadelphia) affected by Pennsylvania's Addition NOx Requirements (129.201)

NOVA refers to the following jurisdictions in Virginia are part of the OTR: Arlington County, Alexandria, Fairfax County, Fairfax City, Fall Church, Loudon County, Manassas City, Manassas Park, and Prince William County.

**Table 4.9 Current State Emission Limits and Percent Reduction Estimated from
Adoption of OTC ICI Boiler Proposal**

Point Source Coal Tangential-Fired Boilers

State	Current 2006 NOx RACT Limit (lbs/mmBtu) (from State regulations) Applicability Threshold mmBtu/hour Heat Input					OTC Limits (lbs/mmBtu):	OTC 2006 Percent Reduction (Current State reg compared to OTC Limit) Applicability Threshold mmBtu/hour Heat Input				
	> 250*	100 to 250	50 to 100	25 to 50	5 to 25		> 250*	100 to 250	50 to 100	25 to 50	<25
							0.12	0.12	0.30	0.30	NL
CT	0.20	0.20	0.20	0.20	0.20		40.0	40.0	0.0	0.0	10.0
DE	n/a	n/a	n/a	n/a	n/a		0.0	0.0	0.0	0.0	0.0
DC	0.43	0.43	NL	NL	NL		72.1	72.1	50.0	50.0	10.0
ME	n/a	n/a	n/a	n/a	n/a		0.0	0.0	0.0	0.0	0.0
MD	0.38	0.65	0.38	0.38	0.38		68.4	81.5	21.1	21.1	10.0
MA	0.38	0.38	NL	NL	NL		68.4	68.4	50.0	50.0	10.0
NH	n/a	n/a	n/a	n/a	n/a		0.0	0.0	0.0	0.0	0.0
NJ	n/a	n/a	n/a	n/a	n/a		0.0	0.0	0.0	0.0	0.0
NY	0.42	0.5	NL	NL	NL		71.4	76.0	50.0	50.0	10.0
PA	Source Specific NOx RACT						29.4	76.0	50.0	50.0	10.0
SE PA	0.17	0.20	Source Specific RACT				29.4	40.0	50.0	50.0	10.0
RI	n/a	n/a	n/a	n/a	n/a		0.0	0.0	0.0	0.0	0.0
VT	n/a	n/a	n/a	n/a	n/a		0.0	0.0	0.0	0.0	0.0
NOVA	0.38	0.38	0.38	0.38	0.38		68.4	68.4	21.1	21.1	10.0

n/a indicates that there are no coal-fired boilers in the state.

NL indicates no limit specified in a state rule; in those cases, the more general percent reduction from Table 4-4 was used.

Source Specific NOx RACT indicates that there are no specific limits in the States' rule (i.e., limits were determined on a case-by-case basis); in those cases, the more general percent reduction from Table 4-4 was used.

SE PA refers to the five southeastern Pennsylvania counties (Bucks, Chester, Delaware, Montgomery, and Philadelphia) affected by Pennsylvania's Addition NOx Requirements (129.201)

NOVA refers to the following jurisdictions in Virginia are part of the OTR: Arlington County, Alexandria, Fairfax County, Fairfax City, Fall Church, Loudon County, Manassas City, Manassas Park, and Prince William County.

Table 4.10 Current State Emission Limits and Percent Reduction Estimated from Adoption of OTC ICI Boiler Proposal

Point Source Coal-Fired Stoker Boilers

State	Current 2006 NOx RACT Limit (lbs/mmBtu) (from State regulations) Applicability Threshold mmBtu/hour Heat Input						OTC 2006 Percent Reduction (Current State reg compared to OTC Limit) Applicability Threshold mmBtu/hour Heat Input				
	100										
	> 250*	to 250	50 to 100	25 to 50	5 to 25		> 250*	100 to 250	50 to 100	25 to 50	<25
						OTC Limits (lbs/mmBtu):	0.12	0.22	0.30	0.30	NL
CT	0.20	0.20	0.20	0.20	0.20		40.0	0.0	0.0	0.0	10.0
DE	n/a	n/a	n/a	n/a	n/a		0.0	0.0	0.0	0.0	0.0
DC	0.43	0.43	NL	NL	NL		72.1	48.8	50.0	50.0	10.0
ME	n/a	n/a	n/a	n/a	n/a		0.0	0.0	0.0	0.0	0.0
MD	0.38	0.65	0.38	0.38	0.38		68.4	66.2	21.1	21.1	10.0
MA	0.33	0.33	NL	NL	NL		63.6	33.3	50.0	50.0	10.0
NH	n/a	n/a	n/a	n/a	n/a		0.0	0.0	0.0	0.0	0.0
NJ	n/a	n/a	n/a	n/a	n/a		0.0	0.0	0.0	0.0	0.0
NY	0.3	0.3	NL	NL	NL		60.0	26.7	50.0	50.0	10.0
PA	Source Specific NOx RACT						29.4	26.7	50.0	50.0	10.0
SE PA	0.17	0.20	Source Specific RACT				29.4	0.0	50.0	50.0	10.0
RI	n/a	n/a	n/a	n/a	n/a		0.0	0.0	0.0	0.0	0.0
VT	n/a	n/a	n/a	n/a	n/a		0.0	0.0	0.0	0.0	0.0
NOVA	0.4	0.4	0.4	0.4	0.4		70.0	45.0	25.0	25.0	10.0

n/a indicates that there are no coal-fired boilers in the state.

NL indicates no limit specified in a state rule; in those cases, the more general percent reduction from Table 4-4 was used.

Source Specific NO_x RACT indicates that there are no specific limits in the States' rule (i.e., limits were determined on a case-by-case basis); in those cases, the more general percent reduction from Table 4-4 was used.

SE PA refers to the five southeastern Pennsylvania counties (Bucks, Chester, Delaware, Montgomery, and Philadelphia) affected by Pennsylvania's Addition NO_x Requirements (129.201)

NOVA refers to the following jurisdictions in Virginia are part of the OTR: Arlington County, Alexandria, Fairfax County, Fairfax City, Fall Church, Loudon County, Manassas City, Manassas Park, and Prince William County.

4.6.4 Cost Estimates

The OTC recently completed an analysis of ICI boiler NO_x control cost estimates (Bodnarik 2006) using detailed information on direct capital equipment costs, direct installation costs, indirect capital costs, and direct and indirect operating costs. The analysis examined five types of NO_x control technologies – low-NO_x burners (LNB), ultra low-NO_x burners (ULNB), LNB plus flue gas recirculation (LNB+FGR), LNB plus selective non-catalytic reduction (LNB+SNCR), and selective catalytic reduction (SCR). The analysis also considered various fuel types – coal, residual oil, distillate oil, and natural gas. The cost effectiveness varies by fuel type, boiler size, current regulatory requirements, current control technology, and boiler firing type. The annual cost-effectiveness was found as low as \$600 per ton and as high as \$18,000 per ton. In general, for most scenarios the cost effectiveness was estimated to be less than \$5,000 per ton of NO_x removed.

4.7 NO_x EMISSION REDUCTION SUMMARY

The results of the emission benefit calculations for the OTC states are described in this subsection. The starting point for the quantification of the emission reduction benefits is the MANEVU emission inventory, Version 3 (Pechan 2006, MACTEC 2006a) and the VISTAS emission inventory, BaseG (MACTEC 2006b), for the northern Virginia counties that are part of the OTR. The MANEVU and VISTAS inventories include a 2002 base year inventory as well as projection inventories for 2009 and 2018 (MANEVU also has projections for 2012, but VISTAS does not). The projection inventories account for growth in emissions based on growth indicators such as population and economic activity. The projection inventories also account for “on-the-books/on-the-way” (OTB/W) emission control regulations that have (or will) become effective between 2003 and 2008 that will achieve post-2002 emission reductions. Emission reductions from existing regulations are already accounted for to ensure no double counting of emission benefits occurs.

Note that the emission reductions contained in this Section are presented in terms of tons per summer day. The MANEVU base and projection emission inventories do not contain summer day emissions for all States and source categories; the VISTAS inventory only contains annual values. When States provided summer day emissions in the MANEVU inventory, these values were used directly to quantify the emission benefit from the 2006 OTC control measure. When summer day emissions were missing from the MANEVU or VISTAS inventories, the summer day emissions were calculated using the annual emissions and the seasonal throughput data from the NIF Emission Process table. If the

seasonal throughput data was missing, the summer day emissions were calculated using the annual emissions and a summer season adjustment factor derived from the monthly activity profiles contained in the SMOKE emissions modeling system.

Tables 4-11 to 4-17 show State summaries of the emission benefits from the OTC 2006 NOx control measures described previously in this Section. For each of the seven source categories, the Tables show four emission numbers: (1) the actual 2002 summer daily emissions; (2) the summer daily emissions for the 2009 OTB/W scenario that accounts for growth and for the emission control regulations that have (or will) become effective between 2003 and 2008 that will achieve post-2002 emission reductions; (3) the summer daily emissions for 2009 with the implementation of the OTC 2006 control measures identified in this Section, and (4) the emission benefit in 2009 resulting from the OTC 2006 control measure. Table 4-18 shows the same information for the total of all seven source categories.

The largest estimated NOx emission reductions are in the more industrialized States – New York and Pennsylvania – which have most of the cement kilns and glass furnaces in the OTR. These two states also have a large population of ICI boilers. The emission benefits listed for Virginia just include the Virginia counties in the northern Virginia area that are part of the OTR. Benefit estimates for all other States include the entire state. The emission benefits also assume that all OTC members will adopt the rules as described in the previous sections.

Appendix E provides county-by-county summaries of the NOx emission benefits from the OTC 2006 NOx control measures described previously in this Section. Appendix E also provides additional documentation regarding the data sources and emission benefit calculations that were performed. These tables can be used by the States to create additional summaries, for example, by nonattainment area.

**Table 4-11 OTC 2006 NOx Model Rule Benefits by State for 2009
Heavy-Duty Truck Diesel Engine Chip Reflash**

State	Heavy-Duty Truck Diesel Engine Chip Reflash Summer NOx Emissions (tpd)			
	2002 Actual	2009 Base	2009 Control	2009 Benefit
CT	66.7	n/a	n/a	3.5
DE	21.8	n/a	n/a	0.6
DC	8.1	n/a	n/a	0.8
ME	82.8	n/a	n/a	1.4
MD	105.0	n/a	n/a	5.6
MA	152.7	n/a	n/a	6.7
NH	30.5	n/a	n/a	2.0
NJ	133.5	n/a	n/a	9.7
NY	177.6	n/a	n/a	16.1
PA	437.1	n/a	n/a	12.4
RI	8.3	n/a	n/a	0.8
VT	13.7	n/a	n/a	0.9
NOVA	<u>16.6</u>	<u>n/a</u>	<u>n/a</u>	<u>2.5</u>
OTR	1254.5	0.0	0.0	63.0

n/a – not available due to lack of 2009 emissions data for on-road vehicles in NIF format.

Table 4-12 OTC 2006 NOx Model Rule Benefits by State for 2009
Regional Fuels

State	Regional Fuels Summer NOx Emissions (tpd)			
	2006 Actual	2006 Base	2006 Control	2006 Benefit
CT	81.3	81.3	81.3	0.0
DE	24.8	24.8	24.8	0.0
DC	8.4	8.4	8.4	0.0
ME	44.1	44.1	43.8	0.2
MD	144.0	144.0	144.0	0.0
MA	137.4	137.4	137.4	0.0
NH	38.4	38.4	38.2	0.2
NJ	204.2	204.2	204.2	0.0
NY	381.3	381.3	379.1	2.1
PA	284.8	284.8	282.9	2.0
RI	20.5	20.5	20.5	0.0
VT	26.3	26.3	26.0	0.3
NOVA	<u>50.8</u>	<u>50.8</u>	<u>50.8</u>	<u>0.0</u>
OTR	1446.2	1446.2	1441.4	4.8

NESCAUM analysis was only completed for 2006. Data for 2002 and 2009 are not currently available

Table 4-13 OTC 2006 NOx Model Rule Benefits by State for 2009
Asphalt Pavement Production Plants

State	Asphalt Pavement Production Plants Summer NOx Emissions (tpd)			
	2002 Actual	2009 Base	2009 Control	2009 Benefit
CT	0.0	0.0	0.0	0.0
DE	0.6	0.6	0.4	0.2
DC	0.0	0.0	0.0	0.0
ME	1.7	2.0	1.3	0.7
MD	0.2	0.2	0.1	0.1
MA	1.1	1.8	1.2	0.6
NH	0.0	0.0	0.0	0.0
NJ	1.3	2.8	1.8	1.0
NY	0.0	0.1	0.0	0.0
PA	0.6	0.7	0.5	0.2
RI	0.1	0.1	0.1	0.0
VT	0.0	0.0	0.0	0.0
NOVA	<u>0.3</u>	<u>0.3</u>	<u>0.2</u>	<u>0.1</u>
OTR	5.9	8.6	5.6	3.0

2002 Actual emissions come from the MANEVU 2002 Version 3 inventory and VISTAS 2002 Base G inventory (for the 10 northern Virginia jurisdictions that are part of the OTR).

2009 Base Inventory emissions are the emissions forecasted in the MANEVU 2009 OTB/W Version 3.1 inventory and the VISTAS 2009 Base G inventory, and account for growth and any emission reductions associated with on-the-books/on-the-way controls measures.

2009 Control Inventory emissions are the emissions remaining after implementation of the beyond-on-the-way control measures described in this Section.

2009 Emission Reduction Benefit is the incremental emission reduction from the control measures described in this section (i.e., the difference between the 2009 base emissions and the 2009 control emissions).

Table 4-14 OTC 2006 NOx Model Rule Benefits by State for 2009
Cement Kilns

State	Cement Kilns Summer NOx Emissions (tpd)			
	2002 Actual	2009 Base	2009 Control	2009 Benefit
CT	0.0	0.0	0.0	0.0
DE	0.0	0.0	0.0	0.0
DC	0.0	0.0	0.0	0.0
ME	4.7	4.7	4.7	0.0
MD	17.2	17.2	4.1	13.1
MA	0.0	0.0	0.0	0.0
NH	0.0	0.0	0.0	0.0
NJ	0.0	0.0	0.0	0.0
NY	35.1	35.1	19.8	15.3
PA	44.7	44.7	30.7	14.0
RI	0.0	0.0	0.0	0.0
VT	0.0	0.0	0.0	0.0
NOVA	<u>0.0</u>	<u>0.0</u>	<u>0.0</u>	<u>0.0</u>
OTR	101.9	101.9	59.4	42.5

2002 Actual emissions come from the MANEVU 2002 Version 3 inventory and VISTAS 2002 Base G inventory (for the 10 northern Virginia jurisdictions that are part of the OTR).

2009 Base Inventory emissions are the emissions forecasted to be the same as in 2002 (i.e., no growth was assumed).

2009 Control Inventory emissions are the emissions remaining after implementation of the beyond-on-the-way control measures described in this Section.

2009 Emission Reduction Benefit is the incremental emission reduction from the control measures described in this section (i.e., the difference between the 2009 base emissions and the 2009 control emissions).

Table 4-15 OTC 2006 NOx Model Rule Benefits by State for 2009
Glass/Fiberglass Furnaces

State	Glass/Fiberglass Furnace Summer NOx Emissions (tpd)			
	2002 Actual	2009 Base	Maximum Control	Maximum Benefit
CT	0.0	0.0	0.0	0.0
DE	0.0	0.0	0.0	0.0
DC	0.0	0.0	0.0	0.0
ME	0.0	0.0	0.0	0.0
MD	0.3	0.3	0.1	0.3
MA	1.4	1.8	0.3	1.5
NH	0.0	0.0	0.0	0.0
NJ	7.7	7.1	2.2	4.9
NY	6.1	6.8	1.0	5.8
PA	36.3	44.3	20.0	24.3
RI	0.7	0.5	0.1	0.5
VT	0.0	0.0	0.0	0.0
NOVA	<u>0.0</u>	<u>0.0</u>	<u>0.0</u>	<u>0.0</u>
OTR	52.5	60.9	23.6	37.3

2002 Actual emissions come from the MANEVU 2002 Version 3 inventory and VISTAS 2002 Base G inventory (for the 10 northern Virginia jurisdictions that are part of the OTR).

2009 Base Inventory emissions are the emissions forecasted in the MANEVU 2009 OTB/W Version 3.1 inventory and the VISTAS 2009 Base G inventory, and account for growth and any emission reductions associated with on-the-books/on-the-way controls measures.

Maximum Control Inventory emissions are the emissions remaining after full implementation of the beyond-on-the-way control measures described in this Section. Not all of the anticipated reductions from the glass/fiberglass OTC 2006 control measure will be achieved by 2009. This column shows the emissions remaining after full implementation of the measure, which may not occur until 2012 or 2018.

Maximum Emission Reduction Benefit is the incremental emission reduction from the control measures described in this section (i.e., the difference between the base emissions and the maximum control emissions).

Note: The table shows the maximum emission reduction from glass/fiberglass furnaces when the OTC 2006 control measure is fully implemented. Not all of the reduction shown will be achieved by 2009.

Table 4-16 OTC 2006 NOx Model Rule Benefits by State for 2009
ICI Boilers – Area (Minor) Source

State	ICI Boilers – Area (Minor) Sources Summer NOx Emissions (tpd)			
	2002 Actual	2009 Base	2009 Control	2009 Benefit
CT	8.9	9.4	6.5	2.8
DE	3.4	3.5	2.3	1.2
DC	1.3	1.6	1.1	0.4
ME	5.0	5.3	4.2	1.1
MD	3.5	4.0	2.9	1.2
MA	24.4	25.8	19.1	6.6
NH	21.3	24.2	20.8	3.4
NJ	20.5	15.6	15.6	0.0
NY	105.2	112.2	78.4	33.8
PA	38.0	39.8	27.6	12.2
RI	6.6	7.3	5.3	2.1
VT	2.3	2.9	1.9	0.9
NOVA	<u>11.8</u>	<u>11.9</u>	<u>8.1</u>	<u>3.9</u>
OTR	252.0	263.4	193.9	69.5

2002 Actual emissions come from the MANEVU 2002 Version 3 inventory and VISTAS 2002 Base G inventory (for the 10 northern Virginia jurisdictions that are part of the OTR).

2009 Base Inventory emissions are the emissions forecasted in the MANEVU 2009 OTB/W Version 3.1 inventory and the VISTAS 2009 Base G inventory, and account for growth and any emission reductions associated with on-the-books/on-the-way controls measures.

2009 Control Inventory emissions are the emissions remaining after implementation of the beyond-on-the-way control measures described in this Section.

2009 Emission Reduction Benefit is the incremental emission reduction from the control measures described in this section (i.e., the difference between the 2009 base emissions and the 2009 control emissions).

Table 4-17 OTC 2006 NOx Model Rule Benefits by State for 2009
ICI Boilers – Point (Major) Source

State	ICI Boilers – Point (Major) Sources Summer NOx Emissions (tpd)			
	2002 Actual	2009 Base	2009 Control	2009 Benefit
CT	5.8	5.6	3.5	2.1
DE	7.7	7.3	7.3	0.0
DC	1.0	1.1	0.8	0.4
ME	10.2	12.8	10.1	2.8
MD	14.2	11.2	8.8	2.4
MA	13.8	15.4	8.7	6.8
NH	3.9	4.8	2.9	1.9
NJ	12.9	10.8	7.4	3.4
NY	31.4	30.8	23.8	7.0
PA	33.4	36.5	26.7	9.8
RI	4.2	4.9	4.3	0.5
VT	0.7	0.9	0.5	0.4
NOVA	<u>0.2</u>	<u>0.2</u>	<u>0.0</u>	0.1
OTR	139.3	142.3	104.6	37.7

2002 Actual emissions come from the MANEVU 2002 Version 3 inventory and VISTAS 2002 Base G inventory (for the 10 northern Virginia jurisdictions that are part of the OTR).

2009 Base Inventory emissions are the emissions forecasted in the MANEVU 2009 OTB/W Version 3.1 inventory and the VISTAS 2009 Base G inventory, and account for growth and any emission reductions associated with on-the-books/on-the-way controls measures.

2009 Control Inventory emissions are the emissions remaining after implementation of the beyond-on-the-way control measures described in this Section.

2009 Emission Reduction Benefit is the incremental emission reduction from the control measures described in this section (i.e., the difference between the 2009 base emissions and the 2009 control emissions).

Table 4-18 OTC 2006 NOx Model Rule Benefits by State for 2009
All Seven NOx Categories

State	All Seven NOx Categories Summer NOx Emissions (tpd)			
	2002 Actual	2009 Base	2009 Control	2009 Benefit
CT	162.7	n/a	n/a	8.4
DE	58.2	n/a	n/a	2.1
DC	18.8	n/a	n/a	1.6
ME	148.5	n/a	n/a	6.2
MD	284.4	n/a	n/a	22.7
MA	330.8	n/a	n/a	22.2
NH	94.1	n/a	n/a	7.5
NJ	380.0	n/a	n/a	19.0
NY	736.8	n/a	n/a	80.1
PA	874.9	n/a	n/a	74.9
RI	40.5	n/a	n/a	3.9
VT	42.9	n/a	n/a	2.5
NOVA	79.6	n/a	n/a	6.6
OTR	3252.3	n/a	n/a	257.8

n/a – not available due to lack of 2009 emissions data for on-road vehicles in NIF format.

5.0 REFERENCES

- Bodnarik 2006: Bodnarik, Andrew M., New Hampshire Department of Environmental Services, “ICI Boiler NO_x Control Cost Estimates from OTC Methodology”, presented at the OTC Control Strategy/SAS Committee Meeting, November 2, 2006.
- CARB 1998: California Air Resources Board, “Determination of Reasonably Available Control Technology and Best Available Retrofit Control Technology for Adhesives and Sealants”, December, 1998.
- CARB 1999: California Air Resources Board, “Initial Statement of Reasons for Proposed Rule Making Public Hearing to Consider the Adoption of Portable Fuel Container Spillage Control Regulations”, August 6, 1999.
- CARB 2004a: California Air Resources Board, “Initial Statement of Reasons for Proposed Amendments to the California Aerosol Coating Products, Antiperspirants and Deodorants, and Consumer Products Regulations, Test Method 310, and Airborne Toxic Control Measure for Para-dichlorobenzene Solid Air Fresheners and Toilet/Urinal Care Products Volume I: Executive Summary”, June 24, 2004.
- CARB 2004b: California Air Resources Board, Letter from William V. Loscutoff to Stakeholders, June 7, 2004.
- CARB 2005a: California Air Resources Board, “Staff Report: Initial Statement of Reasons for Proposed Amendments to the Portable Fuel Container Regulations”, July 29, 2005.
- CARB 2005b: California Air Resources Board, “Final Statement of Reasons: Public Hearing to Consider Amendments to the Regulations for Portable Fuel Containers”, October 2005.
- CARB 2006: California Air Resources Board, “Final Statement of Reasons: Public Hearing to Consider Amendments to the Regulations for Portable Fuel Containers”, July 2006.
- Census 2006: U.S. Census Bureau, web site www.census.gov/popest/counties/tables/ containing county population files for 2005.
- EC 2001a. European Commission, “Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques in the Cement and Lime Manufacturing Industries”, December 2001.
- EC 2001b. European Commission, “Integrated Pollution Prevention and Control (IPPC) Bureau Reference Document on Best Available Techniques in the Glass Manufacturing Industry”, December 2001.

- EC/R 2000. EC/R Incorporated, “NO_x Control Technologies for the Cement Industry – Final Report”, prepared for the U.S. Environmental Protection Agency, September 19, 2000.
- EEA 2005: Energy and Environmental Analysis, Inc. “Characterization of the U.S. Industrial/Commercial Boiler Population”, prepared for Oak Ridge National Laboratory, May 2005.
- ENVIRON 2006: ENVIRON International Corporation, “Evaluation of Candidate Mobile Source Control Measures”, prepared for Lake Michigan Air Directors Consortium, January 5, 2006.
- ERG 2005. Eastern Research Group, Inc., “Assessment of NO_x Emissions Reduction Strategies for Cement Kilns – Ellis County”, prepared for the Texas Commission on Environmental Quality, December 19, 2005.
- MACTEC 2005: MACTEC Federal Programs, Inc., “Interim White Paper - Midwest RPO Candidate Control Measures: Glass Manufacturing”, prepared for Lake Michigan air Directors Consortium, December 2005.
- MACTEC 2006a: MACTEC Federal Programs, Inc., “Draft Final Technical Support Document: Development of Emission Projections for 2009, 2012, and 2018 for NonEGU Point, Area, and Nonroad Sources in the MANE-VU Region”, prepared for Mid-Atlantic Regional Air Management Association, December 7, 2006.
- MACTEC 2006b: MACTEC Federal Programs, Inc., “Draft Documentation for the 2002, 2009, and 2018 Emission Inventories for VISTAS”, prepared for Visibility Improvement State and Tribal Association of the Southeast, under development.
- NESCAUM 2005a: The Clean Air Association of the Northeast States, email from Arthur Marin NESCAUM to Chris Recchia OTC, December 7, 2005.
- NESCAUM 2005b: The Clean Air Association of the Northeast States, “Low Sulfur Heating Oil in the Northeast States: An Overview of Benefits, Costs and Implementation Issues,” December 2005.
- NESCAUM 2006a: The Clean Air Association of the Northeast States, email from Arthur Marin NESCAUM to Seth Barna OTC, February 2006.
- NESCAUM 2006b: The Clean Air Association of the Northeast States, “Low NO_x Software Upgrade for Heavy-Duty Trucks: Draft Model Rule Staff Report, February 20, 2006.
- OTC 2006a: Ozone Transport Commission, “Memorandum of Understanding Among the States of the Ozone Transport Commission on a Regional Strategy Concerning the Integrated Control of Ozone Precursors from Various Sources”, June 7, 2006.

OTC 2006b: Ozone Transport Commission, “Resolution 06-02 of the Ozone Transport Commission Concerning Coordination and Implementation of Regional Ozone Control Strategies for Certain Source Categories”, June 7, 2006.

OTC 2006c: Ozone Transport Commission, “Statement of the Ozone Transport Commission Concerning Multi-Pollutant Emission Control of Electric Generating Units”, June 7, 2006.

OTC 2006d: Ozone Transport Commission, “Resolution 06-03 of the Ozone Transport Commission Concerning Federal Guidance and Rulemaking for Nationally-Relevant Ozone Control Measures”, June 7, 2006.

OTC 2006e: Ozone Transport Commission, “Modified Charge of the Ozone Transport Commission to the Stationary Area Source Committee Regarding Electric Generating Units”, November 15, 2006.

OTC 2006f: Ozone Transport Commission, “Statement of the Ozone Transport Commission Concerning Regional and State Measures to Address Emissions from Mobile Sources”, November 15, 2006.

OTC 2006g: Ozone Transport Commission, “Addendum to Resolution 06-02 of the Ozone Transport Commission Concerning Coordination and Implementation of Regional Ozone Control Strategies for Various Sources”, November 15, 2006.

Pechan 2001: E.H. Pechan & Associates, Inc., “Control Measure Development Support Analysis of Ozone Transport Commission Model Rules”, prepared for Ozone Transport Commission, March 31, 2001.

Pechan 2005: E.H. Pechan & Associates, Inc., “AirControlNET Version 4.1 Documentation Report”, prepared for the U.S. Environmental Protection Agency, September, 2005.

Pechan 2006: E.H. Pechan & Associates, Inc., “Documentation for 2002 Emission Inventory, Version 3”, prepared for Mid-Atlantic Regional Air Management Association, April 2006.

USEPA 1993. U.S. Environmental Protection Agency, “Final Regulatory Impact Analysis for Reformulated Gasoline”, EPA-420/R-93-017, December 1993.

USEPA 1994. U.S. Environmental Protection Agency, “Alternative Control Techniques Document – NO_x Emissions from Glass Manufacturing”, EPA-453/R-94-037, June 1994.

Appendix A – Process for Identifying and Evaluating Control Measures

Background

The States of the Ozone Transport Region (OTR) are faced with the requirement to demonstrate attainment with the 8-hour ozone NAAQS 8-hour ozone National Ambient Air Quality Standards (NAAQS) by June 15, 2008. To accomplish this, most of the states will need to implement additional measures to reduce emissions that either directly impact their nonattainment status, or contribute to the nonattainment status in other states. In addition, the States are conducting attainment planning work to support development of PM_{2.5} and regional haze State Implementation Plans (SIPs). As such, the Ozone Transport Commission (OTC) undertook an exercise to identify a suite of additional control measures that could be used by the OTR states in attaining their goals.

In March 2005, the Ozone Transport Commission (OTC) established the Control Strategies Committee as an ad-hoc committee to assist with coordination of the attainment planning work. The Control Strategies Committee works with three other OTC committees. The Stationary and Area Source (SAS) Committee evaluates control measures for specific stationary source sectors or issues. The Mobile Source Committee examines control measures for on-road and non-road mobile sources. And the Modeling Committee develops and implements a strategic plan for SIP-quality modeling runs to support attainments demonstrations.

The SAS Committee is comprised of various workgroups that evaluate control measures for specific sectors or issues. These workgroups included:

- Control Measures Workgroup focuses on stationary area sources;
- Reasonably Available Control Technology (RACT) workgroup focuses on major point sources;
- Multi-Pollutant Workgroup focuses on electric generating units (EGUs);
- High Electric Demand Day (HEDD) examines EGU peaking units; and
- Industrial, Commercial, and Institutional (ICI) Boiler Workgroup focuses on control technologies for different fuels and boiler size ranges.

The OTC also issued a contract to MACTEC to help the SAS Committee identify and evaluate candidate control measures as well as to quantify expected emission reductions for each control measure.

Workgroup Activities

Initially, the Workgroups compiled and reviewed a list of approximately 1,000 candidate control measures. These control measures were identified through published sources such as the U.S. Environmental Protection Agency's (EPA's) Control Technique Guidelines, STAPPA/ALAPCO "Menu of Options" documents, the AirControlNET database, emission control initiatives in member states as well as other states including California, state/regional consultations, and stakeholder input. Appendix B provides the initial list of control measures that were evaluated.

Based on the review of the 1,000 candidate control measures, the Workgroups developed a short list of measures to be considered for more detailed analysis. These measures were selected to focus on the pollutants and source categories that are thought to be the most effective in reducing ozone air quality levels in the Northeastern and Mid-Atlantic States. The Workgroups reviewed information on current emission levels, controls already in place, expected emission reductions from the control measures, when the emission reductions would occur, preliminary cost and cost-effectiveness data, and other implementation issues. Each of the candidate control measures on the short list were summarized in a series of "Control Measure Summary Sheets". The Control Measure Summary Sheets are contained in Appendix C. The Workgroups discussed the candidate control measures during a series of conference calls and workshops to further refine the emission reduction estimates, the cost data, and any implementation issues. The Workgroups also discussed comments from stakeholders. The Workgroups prioritized the control measures and made preliminary recommendations regarding which measures to move forward on.

OTC Commissioners' Recommendations

Based on the analyses by the OTC Workgroups, the OTC Commissioners made several recommendations at the Commissioner's meeting in Boston June 2006 and November 2006. The Commissioners recommended that States consider emission reductions from the following source categories:

- Consumer Products
- Portable Fuel Containers
- Adhesives and Sealants Application
- Diesel Engine Chip Reflash
- Cutback and Emulsified Asphalt Paving
- Asphalt Production Plants

- Cement Kilns
- Glass Furnaces
- Industrial, Commercial, and Institutional (ICI) Boilers
- Regional Fuels
- Electric Generating Units (EGUs)

Additionally, the Commissioners requested that EPA pursue federal regulations and programs designed to ensure national development and implementation of control measures for the following categories: architectural and maintenance coatings, consumer products, ICI boilers over 100 mmBtu/hour heat input, portable fuel containers, municipal waste combustors, regionally consistent and environmentally sound fuels, small offroad engine emission regulation, and gasoline vapor recovery. The various recommendations by the OTC Commissioners made from 2004 to 2006 are summarized in Table A-1.

Stakeholder Input

Stakeholders were provided multiple opportunities to review and comment on the Control Measure Summary Sheets. Table A-2 lists the public meetings that were held as an opportunity for stakeholders to review and respond to the Control Measure Summary Sheets and Commissioner's recommendations. Stakeholders provided written comments, as listed in Table A-3. In addition to submitting written comments, the Workgroups conducted teleconferences with specific stakeholder groups to allow stakeholders to vocalize their concerns directly to state staff and to discuss the control options. These stakeholder conference calls and meeting are listed in Table A-4. The OTC staff and state Workgroups carefully considered the verbal and written comments received during this process.

Table A-1: OTC Formal Actions, 2004-2006

Date	Action/Synopsis
Nov. 10, 2004	<i>Charge to Stationary and Area Sources Committee</i> Directs SAS Committee to continue to seek out innovative programs to address emissions from all stationary and area sources.
Nov. 10, 2004	<i>Charge to Stationary and Area Sources Committee Regarding Multi-Pollutant Emission Control for Electrical Generating Units and Large Industrial Sources</i> Directs the SAS Committee to develop an implementation strategy for to implement the OTC's multi—pollutant position, recommend methods for allocating NOx and SO2 caps, assess methods to advance the OTC's Multi0Pollutant position beyond the OTR, develop a program implementation structure, and present a Memorandum of Understanding for consideration by the Commission.
Nov. 10, 2004	<i>Charge to the Mobile Source Committee</i> Directs the Mobile Source Committee to identify selected scenarios to be modeled and evaluate strategies including anti-idling programs, voluntary and regulatory retrofit programs, VMT growth strategies, port and marine engine programs, national mobile source programs, California Low Emission Vehicle programs, and model incentive programs.
Nov. 10, 2004	<i>Statement on OTC Modeling</i> Directs the Modeling Committee to coordinate inventories and modeling needed for ozone, regional haze, and PM; seek input for air directors and OTC committees on regional strategies for modeling; continue to use CALGRID as a screening tool; and continue to explore application of emerging tools.
June 8, 2005	<i>Resolution of the States of the Ozone Transport Commission Regarding Development of a Regional Strategy for the Integrated Control of Ozone Precursors and Other Pollutants of Concern from Electrical Generating Units (EGUs) and Other Large Sources</i> Resolves that member States: develop a regional Multi-Pollutant program to assist in attaining and maintaining the 8-hour ozone NAAQS; seek to gain support from other states for a broader inter-regional strategy; develop an emissions budget and region-wide trading program; explore all feasible options to utilize the CAIR framework; and develop implementation mechanisms including a Memorandum of Understanding among the states.
Nov. 3, 2005	<i>Statement of the Ozone Transport Commission With Regard to Advancement of Potential Regional Control Measures for Emission Reduction from Appropriate Sources and State Attain Planning Purposes</i> Directs the staff of the OTC to continue investigation and modeling work associated with all potential regional control measures.
Feb. 23, 2006	<i>Action Items</i> Directs OTC staff to continue efforts on the following issues: Letter to EPA on Small Engines, Consumer Products, Architectural/Industrial Maintenance Coatings (AIM), Chip Reflash, Diesel Emissions Reductions, Modeling Efforts.
June 7, 2006	<i>Memorandum of Understanding Among the States of the Ozone Transport Commission on a Regional Strategy Concerning the Integrated Control of Ozone Precursors from Various Sources</i> Commits OTC States to continue to

Date	Action/Synopsis
	work with interested stakeholders and pursue state-specific rulemakings as needed and appropriate regarding the following sectors to reduce emission of ozone precursors: Consumer Products, Portable Fuel Containers, Adhesives and Sealants, and Diesel Engine Chip Reflash.
June 7, 2006	<i>Statement of the Ozone Transport Commission Concerning Multi-Pollutant Emission Control of Electric Generating Units</i> Directs OTC staff and its workgroups to continue to formulate a program beyond CAIR to address emissions from this sector and to evaluate and recommend options to address emissions associated with high electrical demand days during the ozone season.
June 7 2006	<i>Resolution 06-02 of the Ozone Transport Commission Concerning Coordination and Implementation of Regional Ozone Control Strategies for Certain Source Categories</i> Resolves that OTC States continue to work with interested stakeholders and pursue state-specific rulemakings as needed to establish emission reduction percentages, emission rates or technologies as appropriate for the following source categories: asphalt paving (cutback and emulsified), asphalt plants, cement kilns, regional fuels, glass furnaces, and ICI boilers.
June 7, 2006	<i>Resolution 06-03 of the Ozone Transport Commission Concerning Federal Guidance and Rulemaking for Nationally-Relevant Ozone Control Measures</i> Resolves that OTC States request that EPA pursue federal regulations and programs for national implementation of control measures comparable to the levels the OTC has adopted; these areas include AIM Coatings, Consumer Products, ICI Boilers over 100 MMBTU, Portable Fuel Containers, Municipal Waste Combustors, Regional Fuels, Small Engine Emission Regulation, and Gasoline Vapor Recovery.
Nov. 15, 2006	<i>Modified Charge of the Ozone Transport Commission to the Stationary Area Source Committee Regarding Electric Generating Units</i> Directs the SAS Committee and workgroups to continue work on EGU emission reduction strategies to incorporate “CAIR Plus” and High Energy Demand Day (HEDD) emission reduction strategies.
Nov. 15, 2006	<i>Statement of the Ozone Transport Commission Concerning Regional and State Measures to Address Emissions from Mobile Sources</i> Supports the aggressive implementation of a suite of controls through the OTC Clean Corridor Initiative including: diesel retrofits, the Smartways program, California Low Emission Vehicle programs, anti-idling programs, low-NOx diesel alternatives, transportation demand management to reduce the growth in VMT, and voluntary action and outreach programs.
Nov. 15, 2006	<i>Addendum to Resolution 06-02 of the Ozone Transport Commission Concerning Coordination and Implementation of Regional Ozone Control Strategies for Various Sources</i> Resolves that OTC States continue to pursue state-specific rulemakings as needed to establish emission reduction percentages, emission rates or technologies as appropriate for the following source categories: asphalt plants, glass furnaces, and ICI boilers.

OTC formal actions can be found on the OTC website at the following address:

<http://www.otcair.org/document.asp?fview=Formal>

Table A-2: OTC Control Measures Public Meetings, 2004-2006

Date	Meeting	Location
June 8-9, 2004	OTC/MANE-VU Annual Meeting	Red Bank, NJ
Nov. 9-10, 2004	OTC Fall Meeting	Annapolis, MD
Apr. 21-22, 2005	OTC Stationary and Area Source/Mobile Source Committee Meeting	Linthicum, MD
June 7-8, 2005	OTC Annual Meeting	Burlington, VT
Oct. 5, 2005	OTC Control Strategy Committee Meeting	Linthicum, MD
Nov. 2-3, 2005	OTC Fall Meeting	Newark, DE
Jan. 24, 2006	OTC Control Strategy Committee Meeting	Linthicum, MD
Feb. 22-23, 2006	OTC Special Meeting	Washington, DC
Apr. 5-6, 2006	OTC Control Strategy Committee Meeting	Linthicum, MD
June 6-7, 2006	OTC Annual Meeting	Boston, MA
July 28, 2006	OTC/RTO/ISO Meeting	Herndon, VA
Sep. 18, 2006	OTC High Energy Demand Day Workgroup Meeting	Herndon, VA
Sep. 19, 2006	OTC Stationary and Area Source Committee Meeting	Herndon, VA
Nov. 2, 2006	OTC Control Strategies and Stationary and Area Source Committee Meeting	Linthicum, MD
Nov. 15, 2006	OTC Fall Meeting	Richmond, VA
Dec. 5-6, 2006	OTC High Energy Demand Day Workgroup Meeting	Hartford, CT

Meeting agendas and presentations can be found on the OTC website at the following address:

<http://www.otcair.org/document.asp?fview=meeting>

Table A-4: Stakeholder Comments on OTC Control Strategies

Stakeholder	Source Category
Adhesive and Sealant Council	Adhesives and Sealants
National Paint & Coatings Association (NPCA)	Adhesives and Sealants
Ameron International	AIM Coatings
McCormick Paints	AIM Coatings
National Paint and Coatings Association (NPCA)	AIM Coatings
Painting and Decorating Contractors of America (PDCA)	AIM Coatings
PROSOCO, Inc.	AIM Coatings
RUDD Company Inc.	AIM Coatings
TEX COTE	AIM Coatings
The Master Painters Institute (MPI)	AIM Coatings
The Society for Protective Coatings (SSPC)	AIM Coatings
Wank Adams Slavin and Associates, LLC (WASA)	AIM Coatings
NAPA Asphalt Production	Asphalt Production
MATRIX Systems Auto Refinishing	Auto Refinishing
Portland Cement Association (PCA)	Cement Kilns
St Lawrence Cement	Cement Kilns
Consumer Specialty Products Association (CSPA)	Consumer Products
Cosmetic, Toiletry and Fragrance Association (CTFA)	Consumer Products
National Paint & Coatings Association (NPCA)	Consumer Products
Clean Air Task Force	Diesel Retrofits
Center for Energy and Economic Development, Inc. (CEED)	EGUs
Chesapeake Bay Foundation	EGUs
Clean Air Task Force	EGUs
Conectiv Energy	EGUs
Dominion	EGUs
Exelon	EGUs
International Brotherhood of Electrical Workers , United Mine Workers of America, Center for Energy & Economic Development, Inc., Pennsylvania Coal Association	EGUs
NRG	EGUs
PPL Services	EGUs
The Clean Energy Group	EGUs
National Lime Association (NLA)	Lime Kilns
Debra Jacobson, Prof. Lecturer in Energy Law	NOx Sources
Flexible Packaging Association (FPA)s	Printing/Graphic Arts
Graphic Arts Coalition Flexography Air Regulations	Printing – Flexography
Graphic Arts Coalition Printing & Graphic Arts	Printing/Graphic Arts
Graphic Arts Coalition Screen Litho Air Regulations	Printing – Lithography

Stakeholder comments can be found on the OTC website at the following address:

http://www.otcair.org/projects_details.asp?FID=95&fview=stationary

Table A-4: OTC Conference Calls and Meetings with Stakeholders, 2006

Source Category	Date(s)	Industry Lead
Adhesives and Sealants	Aug. 30, 2006	Adhesives Council
Asphalt Paving	Mar. 30, 2006 Sep. 21, 2006 Sep. 28, 2006 Oct. 13, 2006	National Asphalt Paving Association (meeting) National Asphalt Paving Association Asphalt Emulation Manufacturers Association Asphalt Emulation Manufacturers Association
Asphalt Production	Oct. 25, 2006	National Asphalt Paving Association (meeting)
Consumer Products	Mar. 24, 2006 June 22, 2006 June 22, 2006 Aug. 29, 2006	Consumer Specialty Products Association American Solvents Council (meeting) Consumer Specialty Products Association Consumer Specialty Products Association
Glass Manufacturers	July 5, 2006 Aug. 16, 2006 Sep. 14, 2006 Oct. 19, 2006	North American Insulation Manufacturers Assoc. North American Insulation Manufacturers Assoc. Glass Association of North America Glass Association of North America
ICI Boilers	Mar. 14, 2006 Mar. 24, 2006 July 18, 2006 Aug. 1, 2006	Council of Industrial Boiler Owners Institute of Clean Air Companies Council of Industrial Boiler Owners (meeting) Council of Industrial Boiler Owners (conference)

Appendix B – Initial List of Control Measures

The comprehensive list of control measures can be found at:

<http://www.otcair.org>

Appendix C – Control Measure Worksheets

This Appendix contains the Control Measure Summary Worksheets for the following source categories:

Manufacture and Use of Adhesives and Sealants
Architectural and Industrial Maintenance Coatings
Asphalt Paving (Emulsified and Cutback)
Asphalt Production Plants
Automotive Refinish Coatings
Cement Kilns
Chip Reflash (Heavy Duty Diesel Engines)
Consumer Products
Glass and Fiberglass Furnaces
Industrial, Commercial, Institutional Boilers
Industrial Surface Coatings – Fabric Printing, Coating, and Dyeing
Industrial Surface Coatings – Large Appliances
Industrial Surface Coatings – Metal Cans
Industrial Surface Coatings – Metal Coils
Industrial Surface Coatings – Metal Furniture
Industrial Surface Coatings – Miscellaneous Metal Parts
Industrial Surface Coatings – Paper and Web Coating
Industrial Surface Coatings – Plastics Parts
Industrial Surface Coatings – Wood Building Products
Industrial Surface Coatings – All Categories
Lime Kilns
Municipal Waste Combustors
Printing and Graphic Arts
Portable Fuel Containers
Reformulated Gasoline

CONTROL MEASURE SUMMARY
Manufacture and Use of Adhesives and Sealants
(SCC- 2440020000)

Control Measure Summary

The provisions of this model rule limit emissions of volatile organic compounds (VOCs) from adhesives, sealants and primers. The model rule achieves VOC reductions through two basic components: sale and manufacture restrictions that limit the VOC content of specified adhesives, sealants and primers sold in the state; and use restrictions that apply primarily to commercial/industrial applications. By reducing the availability of higher VOC content adhesives and sealants within the state, the sales prohibition is also intended to address adhesive and sealant usage at area sources. Emissions from residential use of regulated products are addressed through the sales restrictions and simple use provisions.

A reasonably available control technology determination prepared by the California Air Resources Board (CARB) in 1998 forms the basis of this model rule. In the years 1998-2001, the provisions of the CARB determination were adopted in regulatory form in various air pollution control districts in California including the Bay Area, South Coast, Ventura County, Sacramento Metropolitan and San Joaquin Valley.

Costs and Emissions Reductions

2002 existing measure: No existing limitations for this category

Candidate measure: Approximately 75% of VOC emissions originate from solvent-based adhesives and sealants, the remaining 25% of VOC in this category are due to water-based materials. VOC content limits have been enacted by various APCD in California from 1998 to 2001.

Emissions reductions: VOC content limits for the solvent-based materials can result in 64.4% reduction in total emissions from this category. (CARB RACT/BARCT for Adhesives/ Sealants, Dec 1998)

Control costs: Costs for control by reformulation are estimated by the CARB at less than \$2500 / ton (1999\$). Many manufacturers have either reformulated solvent-based products to reduce the VOC content or have developed low-VOC water-based latex and acrylic products, or polyurethane or silicone products in response to the adoption of similar regulations in California. Thus, the actual costs in the OTC region are anticipated to be lower.

Estimated costs for add-on controls carbon and thermal oxidizers ranged from \$10,000 to \$100,000 per ton.

Timing of implementation: 01/01/09

Implementation area: Region-wide

Annual VOC

2002 Emissions: 35,489 tpy
2009 Emissions: 46,241 tpy
2009 Reduction: 29,438 tpy
2009 Remaining: 16,803 tpy

Summer VOC

2002 Emissions: 99.8 tpd
2009 Emissions: 129.8 tpd
2009 Reduction: 82.3 tpd
2009 Remaining: 47.5 tpd

Interaction with other OTC Model Rules

The products regulated in this model rule do not overlap with the products regulated by either the architectural and industrial maintenance (AIM) or consumer product rules. A “coating,” as contemplated in the AIM rule, is a “material applied onto or impregnated into a substrate for protective, decorative or functional purposes.” Because the coating is applied only to one substrate, it is clearly distinguished from adhesives and sealants, which are defined in both the consumer product and adhesive rules by application to two surfaces; in the case of adhesives, the two surfaces are directly bonded while in the case of sealants, a gap between two surfaces is filled.

The overlap between the consumer product and adhesive rules is addressed mainly by an exemption in the adhesive rule for adhesives and sealers subject to the state’s consumer products regulation.

Reference:

California Air Resources Board. *Determination of Reasonably Available Control Technology and Best Available Retrofit Technology for Adhesives and Sealants*. December 1998. Page 18 provides the emission reduction estimates for California: the ARB emission inventory estimates 45 tons per day pre-rule; reductions will range from approximately 29 to 35 tons per day. We used the low end of this range to calculate the percent reduction of 64.4% (i.e. 29 tpd/45 tpd). Page 17 provides the cost-effectiveness information: the cost of complying with the determination reflects the cost of using alternative formulations of low-VOC or water-based adhesives, sealants, and cleanup products. Ventura County APCD staff determined that the cost-effectiveness of their adhesives rule ranges from a savings of \$0.53 per pound to a cost of \$1.16 per pound of VOC reduced (\$1,060 to 2,320). The use of add-on control equipment to comply was \$4.50 to \$55.00 per pound (\$9,000 to \$110,000).

CONTROL MEASURE SUMMARY FOR AIM Coatings

<p>Control Measure Summary: VOC emission reductions can be obtained through modifying the current formulation of the coating to obtain a lower VOC content. The regulatory approach for reducing emissions is to establish VOC content limits for specific coatings that manufacturers are required to meet either through reformulating products or substituting products with compliant coatings.</p>	<p>Emissions (tons/year)</p>
<p>2001 existing measure: Federal AIM rules 40CFR Part 59 <i>Emission Reductions:</i> 20% reduction from uncontrolled levels <i>Control Cost:</i> \$228 per ton <i>Timing of Implementation:</i> Compliance required by September 1999 <i>Implementation Area:</i> Nationwide</p>	<p>VOC (with Part 59 limits) 2002 OTR total: 124,173</p>
<p>2009 On-the-Way Measure: OTC Model Rule based on a model rule adopted by the California Air Resources Board (CARB) in June, 2000 for 33 air control districts. <i>Emission Reductions:</i> 31% beyond Federal AIM rule <i>Control Cost:</i> \$6,400 per ton</p>	<p>VOC (After OTC Model Rule) 2009 Reduction: <u>-25,150</u> 2009 Remaining: 99,023</p>
<p>Candidate measure: Follow CARB 2007 Rulemaking. Modify rule as appropriate when complete (in time for 2009) Participate actively in CARB process. Conduct survey in 2006 for 2005 sales data. <i>Emission Reductions :</i> 6% emissions reduction For modeling purposes we split the difference between SCAQMD and OTC model rule. But we go 75% of the way toward SCAQMD on the top four sales products, and set a 250 g/l VOC limit for Industrial Maintenance coatings. The reductions are calculated using the “reg neg” spreadsheet. <i>Control Cost:</i> Cost of OTC Survey (revise with cost data from the future CARB SCM when available in 2007) SCAQMD estimated the overall cost-effectiveness for their 1999 Amendments to \$13,317 per ton. For Dec. 5 2003 amendments to Rule 1113, SCAQMD estimated the cost-effectiveness to be in the range of \$4,229 to \$11,405 per ton <i>Timing of Implementation:</i> 01/01/09 <i>Implementation Area:</i> Throughout OTR and MRPO</p>	<p>VOC (After CARB 2007 Rule) 2009 Reduction: <u>-5,941</u> 2009 Remaining: 93,082</p>
<p>REFERENCES: 2002 Existing Measure (Federal Part 59 Rules): E.H. Pechan & Associates, Inc., <i>AirControlNET Version 4.1: Documentation Report</i>, September 2005. Pages III-1347 and III-1348 shows the 20% reduction for the Federal Part 59 rule at a cost of \$228 per ton (1990\$). 2009 On-the-Books Measure (OTC Model Rule): E.H. Pechan & Associates, Inc., <i>Control Measure Development Support Analysis of Ozone Transport Commission Model Rules</i>, March 31, 2001. Table II-6 shows 31% reduction (OTC Model Rule beyond Federal rule). Page 15 presents cost of \$6,400 per ton based on CARB’s 2000 Staff Report for the Suggested Control Measure for Architectural Coatings. Candidate Measure (CARB 2007 Suggested Control Measure): CARB is in the process of updating the 2000 Suggested Control Measure (SCM) for Architectural Coatings this year. They will be using 2004 survey data as an important resource to update the SCM, but will not begin the formal SCM update process until the survey is completed. They anticipate bringing the SCM update to our Board in mid to late 2007.</p>	

CARB is developing an analysis of costs for implementing an updated it's Suggested Control Measure. Results of the analysis will not be available until 2007.

Cost information for the South Coast Phase rules were obtained from:

South Coast Air Quality Management District. *Final Staff Report for Proposed Amended Rule 1113 – Architectural Coatings*. December 5, 2003. “estimated the cost-effectiveness to be in the range of \$4,229 to \$11,405 per ton of VOC reduced. The low end of the range was determined based on the retail cost of compliant coatings reported by coating manufacturers surveyed by staff. The upper end of the range was derived by estimating the increased cost at the retail level due to the increase in cost of raw materials, reformulation, testing and packaging a new product prior to commercialization.” The Dec. 2003 amendments lowered the VOC limit for the following specialty coating categories: clear wood finishes including varnishes and sanding sealers, roof coatings, stains, and waterproofing sealers including concrete and masonry sealers.

South Coast Air Quality Management District. *Appendix F Addendum to Staff Report, Final Socioeconomic Impact Assessment, Proposed Amendments to Rule 1113*. May 1999. The May 1999 amendments to Rule 1113 lower VOC limits for the coating categories of industrial maintenance; non-flats; primers, sealers, and undercoaters; quick-dry enamels; quick-dry primers, sealers, and undercoaters; roof coatings; floor coatings, rust preventative coatings, stains, and waterproofing wood sealers. The overall cost-effectiveness of the proposed amendments, (total costs/total emission reductions) over the years 2002-2015, is estimated to be \$13,317 per ton.

CONTROL MEASURE SUMMARY FOR EMULSIFIED AND CUTBACK ASPHALT PAVING

Control Measure Summary: OTC Regional Ban on Cutback Asphalt in Ozone Season, with lower VOC/Solvent Contents for Emulsified Asphalt.	VOC Emissions in Ozone Transport Region
<p>2002 existing measures:</p> <ol style="list-style-type: none"> <i>Cutback asphalt: The OTC states typically ban the use of cutback asphalt during the ozone season. States do provide various exemptions to the ban, most notably allowances may be made for cutbacks which contain less than 5% VOC.</i> <i>Emulsified asphalt: Ten of the OTC states regulate emulsified asphalt by providing allowable VOC content limits for the various applications. Three of the states do not address emulsified asphalts in their regulation.</i> <p>Control Cost: According to the 1977 CTG (EPA-450/2-77-037), which formed the basis for the existing regulations, the use of emulsified asphalts (no VOC) presented a cost savings.</p> <p>Timing of Implementation: All regulations implemented in 1990s or earlier under the 1-hour ozone standard.</p> <p>Implementation Area: OTC 1-hour ozone non-attainment areas.</p>	<p>Annual VOC</p> <p>2002 cutback: 9,154 tpy 2002 emulsified: 10,379 tpy 2002 total: 19,533 tpy</p> <p>Summer VOC</p> <p>2002 cutback: 17.5 tpd 2002 emulsified: 38.5 tpd 2002 total: 56.0 tpd</p>
<p>Candidate measure: For cutback asphalt paving</p> <p>Measure ID: BOTW09-AP-Cutback</p> <p>Place a complete prohibition on the use of cutback asphalt during the ozone season.</p> <p>Emission Reductions: to be achieved from using lower VOC content emulsified asphalt products or working outside the ozone season.</p> <p>Control Cost: Negligible.</p> <p>Timing of Implementation: 01/01/09</p> <p>Implementation Area: All OTC 8-hour ozone non-attainment counties or individual state-wide.</p>	<p>Summer VOC</p> <p>2009 OTB: 19.9 tpd 2009 Reduction: 19.9 tpd 2009 Remaining: 0.0 tpd</p>
<p>Candidate measure: For emulsified asphalt paving</p> <p>Measure ID: BOTW09-AP-Emulsified</p> <p>Proposes to limit ozone season use of emulsified asphalt to that which contains not more than 0.5 ml of oil distillate from the 200 mL sample using the ASTM D244 test method regardless of application (which is 0.25% VOC by volume)</p> <p>Emission Reductions: to be achieved from using lower VOC content emulsified asphalt products or working outside the ozone season.</p> <p>Control Cost: Negligible</p> <p>Timing of Implementation: 01/01/09</p> <p>Implementation Area: All OTC 8-hour ozone non-attainment counties or individual state-wide.</p>	<p>Summer VOC</p> <p>2009 OTB: 44.2 tpd 2009 Reduction: 39.9 tpd 2009 Remaining: 4.3 tpd</p>
<p>Control Measure Recommendation:</p> <p>States implement most stringent measure possible to achieve VOC reductions by 2009 from OTB projections in OTC states, with out disrupting state and county paving operations.</p>	
<p>Brief Rationale for Recommended Strategy:</p> <p>(1) Delaware already implements and complies with the most stringent proposed control strategy.</p> <p>(2) The control strategy is supported by the 1977 Control Techniques Document EPA-450/2-77-037.</p>	

CONTROL MEASURE SUMMARY FOR *Asphalt Production Plants*

Control Measure Summary: NOx emission reductions can be obtained through installation of low NOx burners and flue gas recirculation. SO2 can be reduced by reducing the sulfur in fuel limits for distillate oil to 500 ppm.	Emissions (tons/year) in Ozone Transport Region	
2002 existing measure: No existing limitations for this specific category have been identified.	2002 NOx Base: 2002 SO2 Base:	827 847
<p>Candidate Measure:</p> <p>Emission Reductions: NOx can be reduced between 35% to 50% with low NOx burners and flue gas recirculation (FGR). SO2 can be reduced 25% to 75% by reducing the sulfur in fuel limits for distillate oil to 500 ppm.</p> <p>The MANEVU data for this category is incomplete. Only major point sources are typically included in the point source database. Non-major source emissions are likely lumped into the area source inventory with other industrial/commercial boilers/heaters. The point source data projects only 800+ tons per year (TPY) of both NOx and SO2 actual emissions in 2002 for the entire region. New York actual emissions are over 600 TPY of NOx and 400 TPY of SO2. Therefore, it is unknown what the actual reductions will produce as no accurate baseline exists for both major and minor facilities.</p> <p>Control Cost: Costs for control are similar to those of small to midsize boilers or process heaters. Low NOx burners range from \$500 to \$1250 per ton. While Low NOx burners in combination with FGR range from \$1000 to \$2000 per ton.</p> <p>Projected cost increase from lowering sulfur in distillate oil is approximately 2 to 3 cents per gallon.</p> <p>Timing of Implementation: Similar to the NOx RACT procedures of 1994. Require a NOx compliance plan by the spring of 2008 with full implementation and compliance within one year (01/01/09).</p> <p>Unknown for sulfur-in-fuel reductions.</p> <p>Implementation Area: Region-wide</p>	<p style="text-align: center;">NOx</p> <p>2009 Base: 1,276 2009 Reduction: <u>-549</u> 2009 Remaining: 727</p> <p style="text-align: center;">SO2</p> <p>2009 Base: 1,266 2009 Reduction: <u>-950</u> 2009 Remaining: 316</p>	
Recommended Strategy: States should support rules that encourage a combination of Best Management Practices, Low NOx Burners and FGR in asphalt production plants to achieve a 20-35% reduction in NOx emissions from a 2002 base, and encourage the use of low-sulfur oil. Area source emissions from asphalt plants are not included in this summary.		

REFERENCES:

Note: The reductions estimated for this category only include emissions from point sources. Area source emissions from fuel combustion at asphalt production plants are not explicitly contained in the area source emissions. These emissions are likely lumped together in the general area source industrial and commercial fuel use category. Reductions from area source emissions at asphalt production plants are included in the ICI boiler source category.

Candidate Measure (Low NOx Burners plus FGR; low sulfur fuel oil):

The emission reduction estimates and cost-effectiveness data were provided by NYSDEC. These control efficiencies and cost-effectiveness estimates for Low NOx Burners plus FGR are generally consistent with the data presented in E.H. Pechan & Associates, Inc., *AirControlNET Version 4.1: Documentation Report*, September 2005. Information in this report for small oil-fired process heaters and ICI boilers provide similar levels of control and cost-effectiveness.

Candidate Measure (Best Management Practices)

Best Practices to Reduce Fuel Consumption and/or Lower Air Emissions: HMA industry leaders have identified a number of Best Practices that, if implemented, allow for substantial reduction in plant fuel consumption and the corresponding products of combustion including NOx. In today's business environment, there is significant incentive to reduce fuel usage. For this reason, implementing best practices to reduce fuel consumption and NOx emissions, forms the basis of a sustainable strategy.

Effective stockpile management to reduce aggregate moisture content: Current information indicates that effective stockpile management can reduce aggregate moisture content by about 25 percent, corresponding to a reduction in fuel consumption by approximately 10 - 15 percent. There are a number of ways to reduce aggregate moisture: covering stockpiles, paving under stockpiles, and sloping stockpiles are all ways that prevent aggregate from retaining moisture. Best Practices are plant- and geographic locale-specific.

Burner tune-ups: As identified in OTC Resolution 06-02 and companion control measures summaries, a burner tune-up may reduce NOx emissions by up to 10 percent. From a contractor's perspective, this also is helpful in reducing fuel consumption. In other words, there can be a direct pay-back to the business from regular burner tune-ups.

Lowering mix temperature: A Technical Working Group of FHWA is currently investigating a number of newer formulation technologies, to understand the practicality and performance of lowering mix temperatures. Substantial reductions in mix temperatures, on the order of 20 percent or more, appear to be plausible. Lowering mix temperatures, by this amount, may reduce fuel consumption, as less heat is needed to produce the mix.

Other maintenance and operational best practices: Additional practices can be employed throughout the plant to help optimize production and operations. For example, regular inspection of drum mixing flites and other measures can be taken – all in the effort to make a plant operate more efficiently, thereby using less fuel.

Plant Type	Emission Rate (lbs NOx/ton asphalt produced)	% Reduction
Area/Point Sources (State emissions option)		
Batch Mix Plant – Natural Gas	0.02	35
Batch Mix Plant – Distillate/Waste Oil	0.09	35
Drum Mix Plant – Natural Gas	0.02	35
Drum Mix Plant – Distillate/Waste Oil	0.04	35
Area/Point Sources (State technology option)		
Batch/Drum Mix Plant – Natural Gas	Low-NOx Burner Technology and/or Best Management Practices	
Batch/Drum Mix Plant – Distillate/Waste Oil	Low-NOx Burner Technology and/or Best Management Practices	

**CONTROL MEASURE SUMMARY FOR
Auto Refinish Coatings – Area Source**

Control Measure Summary: Limiting the concentration of solvents in Auto Refinishing Coatings in order to reduce VOC emissions. Encourage the use of high transfer-efficiency painting methods (e.g., high volume low pressure spray guns), and controls on emissions from equipment (e.g., spray gun) cleaning, housekeeping activities (e.g., use of sealed containers for clean-up rags), and operator training.	Emissions (tons/year) in Ozone Transport Region	
2002 existing measure: Federal Auto Body Refinishing rules 40CFR Part 59 Subpart B <i>Emission Reductions:</i> 37% reduction from Part 59 (from Pechan OTC Model Rule Report) due to Part 59 VOC content limits <i>Control Cost:</i> \$118 per ton for Part 59 rules <i>Timing of Implementation:</i> Part 59 compliance required by January 1999 <i>Implementation Area:</i> Part 59 – Nationwide;	VOC Uncontrolled: 2002 Reduction: 2002 Base:	50,759 <u>-18,781</u> 31,978
OTB Control Measure: OTC Model Rule for Mobile Equipment Repair and Refinishing <i>Emission Reductions:</i> 38% reduction from 2002 Levels in those States that adopted OTC model Rule (per Pechan March 31, 2001 OTC Model Rule Report) <i>Control Cost:</i> \$1,534 per ton of VOC <i>Timing of Implementation:</i> Assuming 2007 effective date of rule, emission reductions are achieved 01/01/09. <i>Implementation Area:</i> All counties in the OTR.	VOC: 2009 Reduction: 2009 Remaining:	-10,468 <u>21,510</u>
Candidate measure: CARB October 20, 2005 SCM Staff Report – Lowers VOC limits, combines coatings categories, simplifies recording. <i>Emission Reductions:</i> CARB estimates a 65% reduction in VOC emissions from a 2002 baseline; the OTC model rule is very similar to the CARB 2002 baseline, so a similar reduction would be expected in the OTR. <i>Control Cost:</i> \$2,860 per ton <i>Timing of Implementation:</i> Assuming 2007 effective date of rule, emission reductions are achieved in beginning 01/01/09. <i>Implementation Area:</i> All counties in the OTR.	VOC: 2009 Reduction: 2009 Remaining:	-13,981 <u>7,529</u>
REFERENCES: 2002 Existing Measure (Federal Part 59 Rules): E.H. Pechan & Associates, Inc., <i>AirControlNET Version 4.1: Documentation Report</i> , September 2005. Pages III-1364 shows the Federal Part 59 rule at a cost of \$118 per ton (1990\$) and a reduction of 37 percent from uncontrolled levels. 2009 On-the-Books Measure (OTC Model Rule): E.H. Pechan & Associates, Inc., <i>Control Measure Development Support Analysis of Ozone Transport Commission Model Rules</i> , March 31, 2001. Table II-6 shows 37% reduction for Federal Part 59 rule and 38% (OTC Model Rule beyond Federal rule). Page 17 presents cost of \$1,534 per ton based on estimates used for PA Rule 129.75.		

Candidate Measure (CARB 2005 Suggested Control Measure):

California Air Resources Board. *Staff Report for the Proposed Suggested Control Measure for Automotive Coatings*. October 2005. Table V-3 shows the estimated 65% reduction from 2002 baseline emissions for new automotive coatings limits. A similar reduction is expected for the OTR. Page VII-6 indicates that the cost-effectiveness of the SCM is estimated to be \$1.43 per pound of VOC reduced (\$2,860 per ton). The CARB SCM coating categories and VOC limits are:

Table ES-1 - Proposed Coating Categories and VOC Limits		
Coating Category	VOC regulatory limit as applied Effective January 1, 2009	
	grams/liter	(pounds per gallon*)
Adhesion Promoter	540	4.5
Clear Coating	250	2.1
Color Coating	420	3.5
Multi-Color Coating	680	5.7
Pretreatment Coating	660	5.5
Primer	250	2.1
Single-Stage Coating	340	2.8
Temporary Protective Coating	60	0.5
Truck Bed Liner Coating	310	2.6
Underbody Coating	430	(3.6
Uniform Finish Coating	540	4.5
Any other coating type	250	2.1

The OTC Model Rule coating categories and VOC limits are:

OTC Model Rule		Limit
Coating Type	Grams per Liter	Pounds per gallon
Automotive pretreatment primer	780	6.5
Automotive primer-surfacer	575	4.8
Automotive primer-sealer	550	4.6
Automotive topcoat:		
single stage-topcoat	600	5.0
2 stage basecoat/clearcoat	600	5.0
3 or 4-stage basecoat/clearcoat	625	5.2
Automotive Multi-colored Topcoat	680	5.7
Automotive specialty	840	7.0

CONTROL MEASURE SUMMARY FOR *Cement Kilns*

Control Measure Summary:	Emissions (tons/year) in Ozone Transport Region	
2002 existing measure: NSR; PSD; State RACT.	NO_x 2002 Base:	31,960
On the Books: NO_x SIP Call <i>Measure ID:</i> NO _x SIP Call <i>Emission Reductions:</i> The SIP Call requirements were estimated by EPA to result in NO _x reductions of approximately 25 percent from the cement industry. <i>Control Cost:</i> \$2,000 per ton <i>Timing of Implementation:</i> 2004 <i>Implementation Area:</i> OTR	NO_x 2009 Base: 2009 Reduction: 2009 Remaining:	31,960 <u>-7,990</u> 23,970
Candidate measure: Use of proven control technologies (such as SNCR) or other methods to meet recommended emission limits. <i>Emission Reductions:</i> source specific, varies from 0-63% based upon 2002 base rates. <i>Control Cost:</i> less than 2,500 per ton <i>Timing of Implementation:</i> 01/01/09 <i>Implementation Area:</i> OTR	NO_x 2009 Base: Candidate Reduction: 2009 Remaining:	31,960 <u>-13,231</u> 18,279
Policy Recommendation: It is recommended that a program be developed reduces NO _x emissions from existing cement kilns by requiring existing kilns to meet a NO _x emission rate of 3.88 lbs/ton clinker for wet kiln 3.44 lbs/ton clinker for long dry kiln 2.36 lbs/ton clinker for pre-heater kiln 1.52 lbs/ton clinker for pre-calciner kiln. Trading between facilities would not be permitted, but averaging at a facility would be permissible.		
Brief Rationale for Recommended Strategy: This limit is consistent with the emission reduction capabilities of SNCR. There are 18 full-scale SNCR installations in Europe.		
REFERENCES EC/R Incorporated. <i>NO_x Control Technologies for the Cement Industry</i> – Final Report. September 19, 2000. This report for EPA shows data for two SNCR technologies, biosolids injection and NOXOUT®. These technologies showed average emission reductions of 50 and 40 percent, respectively. For biosolids injection, “Cost effectiveness for this kiln is based on the annualized costs of (\$320,000/year), the emission reduction achieved at that facility (emissions decreased from 2.4 lb/ton of clinker to 1.2 lb/ton of clinker), a kiln capacity of 215 tons/hr, and an annual operation of 8,000 hr/yr. Cost effectiveness is a credit of (\$310/ton) for installing biosolids injection on this kiln” due to tipping fee for using biosolids (dewatered sewage sludge) For NOXOUT®, “40 percent NO _x reduction based on the available test data. Cost effectiveness for the two kilns, using urea as the reagent, is based on an uncontrolled emission rate of 3.8 lb NO _x /ton of clinker, kiln capacities of 92 and 130 tons/hr respectively, annual operation of 8,000 hr/yr, and a NO _x control efficiency of 40%. Cost effectiveness is \$1,000/ton for the smaller kiln and \$2,500/ton for the larger kiln.” European Commission. <i>Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques in the Cement and Lime Manufacturing Industries</i> . December 2001. These report indicates that there are 18 full-scale SNCR installation in Europe. Most SNCR installations are designed and/or operated for NO _x reduction rates of 10-50% which is sufficient to comply with current legislation in some countries. Two Swedish plants installed SNCR in 1996/97 and have achieved a reduction of 80-85% at both kilns.		

Emission Rates:

Table 4-5 of the EPA's *NOx Control Technologies for the Cement Industry, September 19, 2000* provides the following uncontrolled emission rates for the four types of cement kilns:

Kiln Type	Heat Input Requirement (mmBtu/ton of clinker)	Average NOx Uncontrolled Emission Rate (lb/ton of clinker)	Range of NOx Uncontrolled Emission Rate (lb/ton of clinker)
Wet	6.0	9.7	3.6 to 19.5
Long Dry	4.5	8.6	6.1 to 10.5
Preheater	3.8	5.9	2.5 to 11.7
Precalciner	3.8	3.8	0.9 to 7.0

The OTC Control Measure Summary Sheet calls for a 60% reduction from uncontrolled emissions. Using this percent reduction figure and the uncontrolled emission rates above, the following controlled emission rates were calculated:

Kiln Type	Percent Reduction from Uncontrolled	Low-End NOx Controlled Emission Rate (lb/ton of clinker)	Average NOx Controlled Emission Rate (lb/ton of clinker)	High-End NOx Controlled Emission Rate (lb/ton of clinker)
Wet	60	1.44	3.88	7.80
Long Dry	60	2.44	3.44	4.20
Preheater	60	1.00	2.36	4.68
Precalciner	60	0.36	1.52	2.80

The State/workgroup lead recommended the use of the the average NOx Controlled emission rates in the above table (expressed as lb/ton of clinker).

CONTROL MEASURE SUMMARY FOR *Chip Reflash*

Control Measure Summary: Upgrade the version of software in engine electronic control module (ECM) aka “Chip Reflash”. Software reprograms the vehicle's computer and reduces off-cycle NOx emissions. The installation process typically takes between one-half to one hour.	Emissions Reductions (tons/day)	
<p>2002 existing measure: No existing measure in the OTR other than the EPA program resulting from the consent decrees on 7 heavy duty engine manufacturers. The results of the EPA program thus far are significantly lower than the level originally projected by the Agency (less than 10% implementation). CARB implemented a voluntary program that did not achieve its expected results, so the Board’s backstop mandatory program was triggered. The CARB mandatory program is facing two separate legal challenges, alleging that CARB has breached its settlement agreement and alleging that CARB is illegally establishing different emissions standards on “new engines”.</p>		
<p>Candidate measure: <i>Measure ID:</i> Model rule for Mandatory Chip Reflash Program in the OTR</p> <p><i>Emission Reductions:</i> NOx reduction (TPD) from in-state registered vehicles <i>Control Cost:</i> Moderate – manufacturers must provide the rebuild kits free to any truck operator who requests it. The cost associated with the reflash has been estimated at \$20-\$30 per vehicle, which is borne by the engine manufacturer. There may be costs associated with potential downtime to the trucking firms, and record-keeping requirements on the dealer performing the reflash and the vehicle owner. For the MRPO, ENVIRON estimated cost effectiveness to be “\$1,800 to \$2,500 (depending on vehicle size) due to incremental “fuel penalty” of 2% increase in fuel consumption). However, in reality, no fuel penalty has been documented on vehicles that have already been reflashed.</p> <p><i>Timing of Implementation:</i> The kits are currently available, so once the states adopt the rule, retrofits can begin according to the schedule.</p> <p><i>Implementation Area:</i> All OTR and MRPO states (NOx reductions 109 TPD)</p>	<p>LADCO</p> <p>Northeast states</p> <p>Mid-Atlantic States</p> <p>Total OTR</p>	<p>46 TPD</p> <p>41 TPD</p> <p>22 TPD</p> <p>63 TPD</p>
<p>Policy Recommendation of State/Workgroup Lead: Expand scope of the model rule for the Northeast states to the entire OTR and MWRPO</p>		
<p>Brief Rationale for Recommended Strategy: While the EPA program provides a good platform for chip reflash retrofits, the federal program is not even achieving 10% of its estimated emission reductions. The kits are available and must be given to the truckers for free; yet without additional motivation, it is unlikely that the implementation rate will improve due to fuel consumption and/or performance perceptions and the ability to extend the time to next major rebuild/overhaul. The states in the OTR do not face the prospect of breach-of-settlement allegations that CARB did in adopting a mandatory program, since they did not participate in the negotiation of the CD settlements. And there are significant emission reductions that can be achieved through a mandatory program, even though installing the kits will not result in the engines operating at the same emission levels required for the EPA engine certification test. Nevertheless, this is a relatively simple fix for a problem that our states will face if they rely on the federal program alone to produce emission reductions from these sources.</p>		

CONTROL MEASURE SUMMARY FOR *Consumer Products*

Control Measure Summary: Consumer Products This control measure establishes limits on the VOC content of consumer products. It is based on the California Air Resources Board (CARB) consumer products rules, with some region specific modifications. It regulates categories such as hairspray, air fresheners, glass and general purpose cleaners, adhesives, anti-perspirants and deodorants, insecticides and automotive aftermarket products.	VOC Emissions in Ozone Transport Region	
2002 Existing Measure: The Federal Consumer Products Rule Part 59 <i>Emission Reductions:</i> 20 % reduction of the categories being regulated or 9.95 % reduction of the entire consumer products inventory (about 40 % of products were included in rule). <i>Control Cost:</i> \$237 per ton of VOC reduced <i>Timing of Implementation:</i> 12/98 <i>Implementation Area:</i> Nationwide	2002 Annual Uncontrolled: 258,537 tpy Reduction: <u>25,724</u> tpy Remaining: 232,813 tpy 2002 Summer Uncontrolled: 713.9 tpd Reduction: <u>71.0</u> tpd Remaining: 642.9 tpd	
2009 On-the-Books Measure: Adopt the 2001 OTC Model Rule for Consumer Products in all OTC states (this model rule was based on a series of five CARB consumer products rules). <i>Emission Reductions:</i> 14.2 % beyond federal rule or a total of 21 % from the uncontrolled state. <i>Control Cost:</i> \$800 per ton VOC reduced <i>Timing of Implementation:</i> 1/1/05 effective date of VOC limits (though some states were later and some have yet to adopt) <i>Implementation Area:</i> OTR	2009 Annual Reduction: <u>22,916</u> tpy Remaining: 209,897 tpy 2009 Summer Reduction: <u>63.4</u> tpd Remaining: 579.5 tpd	
Candidate Measure #1: Adopt the CARB amendments to their consumer products rule, adopted 7/20/05, with the exception of the 12/31/09 shaving gel, and 12/31/08 anti-static aerosol VOC limits. This rule sets new VOC limits for 11 categories, revises the existing VOC limit for 1 category and includes some additional requirements. See more detailed limits below. <i>Emission Reductions:</i> CARB estimates their rule will achieve a 6.3 ton/day reduction of VOC in California, which is equivalent to about 11.3 tons per day in the OTR or a 2% reduction beyond the on-the-books measure. <i>Control Cost:</i> \$4,800 per ton of VOC reduced <i>Timing of Implementation:</i> 01/01/09 <i>Implementation Area:</i> OTR	2009 Annual Reduction: <u>7,453</u> tpy Remaining: 202,444 tpy 2009 Summer Reduction: <u>20.6</u> tpd Remaining: 558.9 tpd	
Candidate Measure #2: Follow and adopt as appropriate CARB 's next round of amendments to their consumer products rule, to be developed and proposed by approximately late 2006/early 2007 with limits effective in 2010. <i>Emission Reductions:</i> The CONS-2 amendments are estimated by CARB to achieve VOC reductions of about 20-35 tpd in California by 2010 which is equivalent to about 36-63 tpd in the OTR (The mid-point of this range was used in the calculations, 49.5 tpd). <i>Control Cost:</i> Unknown at present; <i>Timing of Implementation:</i> 01/01/10 <i>Implementation Area:</i> OTR	VOC not modeled: 2009 Annual Reduction: <u>Not Available</u> Remaining: 2009 Summer Reduction: Remaining:	

Summary of Candidate Measure #1: The proposed VOC limits based on CARB's 7/20/05 amendments are as follows:

Summary of Candidate Measure #1: The proposed VOC limits based on CARB's 7/20/05 amendments are as follows:

PRODUCT CATEGORY	CARB VOC CONTENT LIMIT %	OTC PROPOSED CONTENT LIMIT%	CARB EFFECTIVE DATE	OTC PROPOSED EFFECTIVE DATE
Adhesive, Contact – General purpose *	55	55	12/31/2006	1/1/2009
Special Purpose*	80	80	12/31/2006	1/1/2009
Adhesive Remover - Floor or Wall covering	5	5	12/31/2006	1/1/2009
Gasket or Thread				
Locking	50	50	12/31/2006	1/1/2009
General Purpose	20	20	12/31/2006	1/1/2009
Specialty	70	70	12/31/2006	1/1/2009
Anti-static - non-aerosol	11	11	12/31/2006	1/1/2009
Electrical Cleaner	45	45	12/31/2006	1/1/2009
Electronic Cleaner	75	75	12/31/2006	1/1/2009
Fabric refresher – aerosol	15	15	12/31/2006	1/1/2009
non-aerosol	6	6	12/31/2006	1/1/2009
Footware or Leather Care - aerosol	75	75	12/31/2006	1/1/2009
Solid	55	55	12/31/2006	1/1/2009
all other forms	15	15	12/31/2006	1/1/2009
Graffiti Remover –aerosol	50	50	12/31/2006	1/1/2009
non-aerosol	30	30	12/31/2006	1/1/2009
Hair Styling Products – aerosol & pump sprays	6	6	12/31/2006	1/1/2009
all other forms	2	2	12/31/2006	1/1/2009
Shaving Gel	7	7	12/31/2006	1/1/2009
Toilet/Urinal Care – aerosol	10	10	12/31/2006	1/1/2009
non-aerosol	3	3	12/31/2006	1/1/2009
Wood Cleaner – aerosol	17	17	12/31/2006	1/1/2009
non-aerosol	4	4	12/31/2006	1/1/2009
* Change to an existing category				

References:

2002 Existing Measure (Federal Part 59 Rules):

E.H. Pechan & Associates, Inc., *Control Measure Development Support Analysis of Ozone Transport Commission Model Rules*, March 31, 2001.

E.H. Pechan & Associates, Inc., *AirControlNET Version 4.1: Documentation Report*, September 2005. Pages III-1377 shows the Federal Part 59 rule at a cost of \$237 per ton (1990\$).

2009 On-the-Books Measure (OTC Model Rule):

E.H. Pechan & Associates, Inc., *Control Measure Development Support Analysis of Ozone Transport Commission Model Rules*, March 31, 2001. Table II-6 shows 14.2% reduction (OTC Model Rule beyond Federal rule). Page 8 presents cost of \$800 per ton based on CARB's Sept. 1999 Initial Statement of Reasons for Proposed Amendments to the California Consumer Products Regulation.

Candidate Measure #1 (CARB 2005 and 2006/2007 Amendments):

California Air Resources Board. *Initial Statement of Reasons for Proposed Amendments, Volume 1: Executive Summary*. June 24, 2004. Table 2 of the Executive Summary shows that the CONS-1 amendments will achieve reductions of about 6.8 tons per day state wide (6.3 tons per day without the 12/31/09 Shaving gel, and 12/31/08 anti-static aerosol regs.. Page 21 states the cost of CONS-1 will be \$2.40 per pound (\$4,800 per ton). Since OTC's model rule is very similar to the CARB's rule, and emissions are proportional to population, CARB's 6.3 ton per day reduction was prorated to the OTC region based on the ratio of OTR 2002 population (63 million) to CA 2002 population (35 million) yielding approximately 11.3 tons per day in the OTR (4,139 tons per year).

Page 4 states that the estimated reductions from CONS-2 (not yet proposed) will achieve 20-35 tons per day statewide by 2010. Since OTC's model rule is very similar to the CARB's rule, and emissions are proportional to population, the mid-point of CARB's 20-35 ton per day reduction (i.e., 27.5 tons per day) was prorated to the OTC region based on the ratio of OTR 2002 population (63 million) to CA 2002 population (35 million) yielding approximately 49.5 tons per day in the OTR (18,068 tons per year).

CONTROL MEASURE SUMMARY FOR Glass/Fiberglass Furnaces

Control Measure Summary:	Emissions (tons/year) in Ozone Transport Region	
2002 existing measure: NSR; PSD; State RACT.	NO_x 2002 Base:	18,840
Candidate measure: Use of oxyfiring or other methods to meet recommended emission limits. <i>Emission Reductions:</i> source specific, varies from 0-85% depending upon 2002 base rates. <i>Control Cost:</i> \$ 924 to 2,232 per ton <i>Timing of Implementation:</i> 01/01/09 <i>Implementation Area:</i> OTR	NO_x 2009 projected: Reduction at full implementation: Remaining after full implementation:	21,893 <u>-13,474</u> 8,419
Control Measure Recommendation: Develop a control strategy that requires implementation of an “oxyfiring” program for each furnace at the next furnace rebuild. Alternatively, states may allow manufacturers to propose compliance methods based on California’s San Joaquin Valley Rule 4354 which allows a mix of control options to meet specified emission limits. Prior to furnace rebuild, owners/operators may be allowed, by the state, to meet emissions limits by purchasing a state specified number of NO _x allowances. Continuous emission monitoring systems would be used to determine emissions. This Measure should be modeled at 85% reduction.		
Brief Rationale for Recommended Strategy: Oxyfiring is best implemented, and provides the most effective NO _x emission reductions, with a complete furnace rebuild. This strategy not only reduces NO _x emissions by as much as 85 percent, but reduces energy consumption, increases production rates by 10-15%, and improves glass quality by reducing defects. Oxyfiring is demonstrated technology and has penetrated into all segments of the glass industry.		
REFERENCES European Commission, Integrated Pollution Prevention and Control (IPPC) Bureau. <i>Reference Document on Best Available Techniques in the Glass Manufacturing Industry</i> . December 2001. This document reports 75 to 85% reduction in NO _x and emission rates of 1.25 to 4.1 lbs NO _x /ton. The cost effectiveness was determined to be \$1,254 to \$2,542 depending on the size of the furnace. U.S. EPA <i>Alternative Control Techniques Document – NO_x Emissions from Glass Manufacturing</i> , EPA-453/R-94-037, June 1994. Oxyfiring reduction of 85%, cost-effectiveness of \$2,150 to \$5,300.		

Emission rates based on San Joaquin Valley Rule 4354

Type of Furnace	Block 24-hour Average	Rolling 30-day average
Container Glass	4.0 pounds of NO _x per ton of glass pulled	4.0 pounds of NO _x per ton of glass pulled
Fiberglass	4.0 pounds of NO _x per ton of glass pulled	4.0 pounds of NO _x per ton of glass pulled
Flat Glass	9.2 pounds of NO _x per ton of glass pulled	7.0 pounds of NO _x per ton of glass pulled

CONTROL MEASURE SUMMARY FOR
Industrial, Commercial, Institutional (ICI) Boilers – Jointly processed with MANE-VU
Addendum to OTC Resolution 06-02 Guidelines for ICI Boilers

ICI Boiler Size (mmBtu/hr)	Control Strategy/ Compliance Option	NOx Control Measure
5-25		Annual Boiler Tune-Up
25-100	Option #1	Natural Gas: 0.05 lb NOx/mmBtu #2 Fuel Oil: 0.08 lb NOx/mmBtu #4 or #6 Fuel Oil: 0.20 lb NOx/mmBtu Coal: 0.30 lb NOx/mmBtu**
	Option #2	50% reduction in NOx emissions from uncontrolled baseline
	Option #3	Purchase current year CAIR NOx allowances equal to reduced needed to achieve the required emission rates
100-250	Option #1	Natural Gas: 0.10 lb NOx/mmBtu #2 Fuel Oil: 0.20 lb NOx/mmBtu #4 or #6 Fuel Oil: 0.20 lb NOx/mmBtu Coal: Wall-fired 0.14 lb NOx/mm Btu Tangential 0.12 lb NOx/mm Btu Stoker 0.22 lb NOx/mm Btu Fluidized Bed 0.08 lb NOx/mm Btu
	Option #2	LNB/SNCR, LNB/FGR, SCR, or some combination of these controls in conjunction with Low NOx Burner technology
	Option #3	60% reduction in NOx emissions from uncontrolled baseline
	Option #4	Purchase current year CAIR NOx allowances equal to reduced needed to achieve the required emission rates
>250	Option #1	Purchase current year CAIR NOx allowances equal to reduced needed to achieve the required emission rates
	Option #2	Phase I – 2009 Emission rate equal to EGUs of similar size Phase II – 2012 Emission rate equal to EGUs of similar size

CONTROL MEASURE SUMMARY FOR *Industrial Surface Coatings Fabric Printing*

Control Measure Summary: This category includes several source types: Fabric, Printing, Coating and Dyeing; Large Appliances; Metal Can coating, Metal Coil coating; Metal Furniture coating; Misc. Metal Parts coating; Paper and Other Web coating; Plastic Parts coating; & Wood Building Products coating	Emissions (tons/year) in Ozone Transport Region	
<p>Fabric Printing, Coating and Dyeing - 2002 existing measures: NSPS; PSD/NSR; State RACT rules in 1-hour non-attainment counties EPA CTG RACT limit: 2.9 lbs VOC/gal coating [0.35 kg/liter] (minus H₂O & exempt solvents) Applicability: Sources 3 lbs/hour, 15 lb/day or 10 tons/year uncontrolled emissions OTC state RACT limits: MD, NJ, NH = 2.9 lbs/gal coating MA = 4.8 lbs VOC/gal of solids applied (equivalent to 2.9 lbs/gal coating)</p>	<p>VOC Actual 2002:</p>	<p>(not available)</p>
<p>Fabric Printing, Coating and Dyeing - 2009 On-the-Books measures: MACT Std. - Subpart OOOO (68 FR 32172, 5/29/03) EPA MACT limits <u>existing sources</u>: Coating and printing operations - 0.12 kg HAP/liter solids Dyeing and finishing operations - 0.016 kg HAP/liter solids Dyeing operations only - 0.016 kg HAP/liter solids Finishing operations only - 0.0003 kg HAP/liter solids <i>Emission Reductions:</i> Nationwide – 60% HAP reduction from 1997 baseline MACT Organic HAP control efficiency option: 97% for existing sources MACT Estimated VOC reduction 60% (Pechan Table) <i>Control Cost:</i> Nationwide –\$14.5 million/yr for 4,100 tons/yr = \$3,537/ton <i>Timing of Implementation:</i> Compliance Date (existing) May 29, 2006 <i>Implementation Area:</i> Nationwide</p>	<p>VOC Actual 2002: OTB 2009: Reduction from OTB:</p>	<p>(not available)</p>
<p>Fabric Printing, Coating and Dyeing Candidate measure 1: Adopt More Stringent RACT regulations; lower applicability thresholds, extend geographic coverage <i>Measure ID: Permanent Total Enclosure</i> <i>Emission Reductions: Estimated VOC reduction 95-97%</i> <i>(Air Control Net 3.0 Table)</i> <i>Control Cost: \$1,459-\$1,565/ton</i> <i>Timing of Implementation:</i> Assuming 2007 or 2008 effective date of rule, emission reductions in 2009 or 2010 <i>Implementation Area:</i> (1) 8-hr ozone nonattainment areas, (2) 8-hr ozone nonattainment areas plus adjacent counties, or (3) all counties</p>	<p>VOC OTB 2009: BOTW 2009: Reduction from BOTW:</p>	<p>(not available)</p>
<p>Policy Recommendation: Final recommendation not made as of June, 2006.</p>		
<p>Brief Rationale for Recommended Strategy: See additional discussion in briefing paper</p>		

CONTROL MEASURE SUMMARY FOR
Industrial Surface Coatings Large Appliances

Control Measure Summary: This category includes several source types: Fabric, Printing, Coating and Dyeing; Large Appliances; Metal Can coating, Metal Coil coating; Metal Furniture coating; Misc. Metal Parts coating; Paper and Other Web coating; Plastic Parts coating; & Wood Building Products coating	Emissions (tons/year) in Ozone Transport Region	
Large Appliances - 2002 existing measures: NSPS; PSD/NSR; State RACT rules in 1-hour non-attainment counties; EPA CTG RACT limit: 2.8 lbs VOC/gal coating [0.34 kg/liter] (minus H ₂ O & exempt solvents)	VOC Actual 2002:	(not available)
Large Appliances - 2009 On-the-Books measures: MACT Std. – Subpart NNNN (67 FR 48254, 7/23/02) EPA MACT limits <u>existing sources</u> : 0.13 kg HAP/liter solids <i>Emission Reductions:</i> Nationwide – 45% HAP reduction from 1995 baseline MACT Organic HAP control efficiency option: xx% for existing sources Estimated VOC reduction: 0% (Pechan Table) - 60%?? <i>Control Cost:</i> Nationwide – \$1.63 million/yr for 1,190 tons/yr = \$1,370/ton Timing of Implementation: Compliance Date (existing) July 23, 2005 <i>Implementation Area:</i> Nationwide	VOC Actual 2002: OTB 2009: Reduction from OTB:	(not available)
Large Appliances Candidate measure 1: Adopt More Stringent RACT regulations (e.g., ICAC letter 2/16/2001); lower applicability thresholds, extend geographic coverage <i>Measure ID:</i> ICAC Option 1 - Nationwide – 80% HAP reduction from 1995 baseline (Additional 250 tons/per HAP) ICAC Option 2 - Nationwide – 98% HAP reduction from 1995 baseline (Additional 1,190 tons/per HAP) <i>Emission Reductions:</i> <i>Control Cost:</i> <i>Timing of Implementation:</i> Assuming 2007 or 2008 effective date of rule, emission reductions in 2009 or 2010 <i>Implementation Area:</i> (1) 8-hr ozone nonattainment areas, (2) 8-hr ozone nonattainment areas plus adjacent counties, or (3) all counties	VOC OTB 2009: BOTW 2009: Reduction from BOTW:	(not available)
Policy Recommendation of: Final recommendation not made as of June, 2006.		
Brief Rationale for Recommended Strategy: See additional discussion in briefing paper		

CONTROL MEASURE SUMMARY FOR
Industrial Surface Coatings Metal Cans

Control Measure Summary: This category includes several source types: Fabric, Printing, Coating and Dyeing; Large Appliances; Metal Can coating, Metal Coil coating; Metal Furniture coating; Misc. Metal Parts coating; Paper and Other Web coating; Plastic Parts coating; & Wood Building Products coating	Emissions (tons/year) in Ozone Transport Region	
Metal Can - 2002 existing measures: NSPS; PSD/NSR; State RACT rules in 1-hour non-attainment counties; EPA CTG RACT limit: <u>lbs VOC/gal coating (minus H₂O&exempt solvents)</u> Sheet basecoat & over varnish		

<p>Metal Can (Continued)</p> <p>Candidate measure 1: Adopt More Stringent RACT regulations; lower applicability thresholds, extend geographic coverage <i>Measure ID: Permanent Total Enclosure</i></p> <p><i>Emission Reductions: Estimated VOC reduction 95% (Air Control Net 3.0 Table)</i></p> <p><i>Control Cost: \$7,947/ton</i></p> <p><i>Timing of Implementation:</i> Assuming 2007 or 2008 effective date of rule, emission reductions in 2009 or 2010</p> <p><i>Implementation Area:</i> (1) 8-hr ozone nonattainment areas, (2) 8-hr ozone nonattainment areas plus adjacent counties, or (3) all counties.</p>	<p>VOC</p> <p>OTB 2009: BOTW 2009: Reduction from BOTW:</p>	<p>(not available)</p>
<p>Policy Recommendation: Final recommendation not made as of June, 2006.</p>		
<p>Brief Rationale for Recommended Strategy: See additional discussion in briefing paper</p>		

CONTROL MEASURE SUMMARY FOR
Industrial Surface Coatings Metal Coils

Control Measure Summary: This category includes several source types: Fabric, Printing, Coating and Dyeing; Large Appliances; Metal Can coating, Metal Coil coating; Metal Furniture coating; Misc. Metal Parts coating; Paper and Other Web coating; Plastic Parts coating; & Wood Building Products coating	Emissions (tons/year) in Ozone Transport Region	
<p>Metal Coil - 2002 existing measures: NSPS; PSD/NSR; State RACT rules in 1-hour non-attainment counties; EPA CTG RACT limit: 2.6 lbs VOC/gal coating [0.31 kg/liter] (minus H₂O & exempt solvents) Applicability: Sources 10 tons/year uncontrolled emissions OTC state RACT limits: NH - same limits as CTG</p>	<p>VOC Actual 2002:</p>	<p>(not available)</p>
<p>Metal Coil – 2009 On-the-Books measures: MACT Std. – Subpart SSSS (67 FR 39794 , 6/10/02) EPA MACT limits <u>existing sources</u>: 0.046 kg HAP/liter solids <i>Emission Reductions:</i> Nationwide – 53% HAP reduction from current levels? MACT Organic HAP control efficiency option: xx% for existing sources Estimated VOC reduction 53% (Pechan Table) <i>Control Cost:</i> Nationwide – \$7.6 million/yr for 1,316 tons/yr = \$5,775/ton <i>Timing of Implementation:</i> Compliance Date (existing) June 10, 2005 <i>Implementation Area:</i> Nationwide</p>	<p>VOC Actual 2002: OTB 2009: Reduction from OTB:</p>	<p>(not available)</p>
<p>Metal Coil Candidate measure 1: Adopt More Stringent RACT regulations; lower applicability thresholds, extend geographic coverage <i>Measure ID:</i> <i>Emission Reductions:</i> <i>Control Cost:</i> <i>Timing of Implementation:</i> Assuming 2007 or 2008 effective date of rule, emission reductions in 2009 or 2010 <i>Implementation Area:</i> (1) 8-hr ozone nonattainment areas, (2) 8-hr ozone nonattainment areas plus adjacent counties, or (3) all counties.</p>	<p>VOC OTB 2009: BOTW 2009: Reduction from BOTW:</p>	<p>(not available)</p>
<p>Policy Recommendation: Final recommendation not made as of June, 2006.</p>		
<p>Brief Rationale for Recommended Strategy: See additional discussion in briefing paper</p>		

**CONTROL MEASURE SUMMARY FOR
Industrial Surface Coatings Metal Furniture**

Control Measure Summary: This category includes several source types: Fabric, Printing, Coating and Dyeing; Large Appliances; Metal Can coating, Metal Coil coating; Metal Furniture coating; Misc. Metal Parts coating; Paper and Other Web coating; Plastic Parts coating; & Wood Building Products coating	Emissions (tons/year) in Ozone Transport Region	
<p>Metal Furniture - 2002 existing measures: NSPS; PSD/NSR; State RACT rules in 1-hour non-attainment counties EPA CTG RACT limit: 3.0 lbs VOC/gal coating [0.36 kg/liter] (minus H₂O & exempt solvents) Applicability: Sources 10 tons/year uncontrolled emissions OTC state RACT limits: NH - same limits as CTG</p>	<p>VOC Actual 2002:</p>	<p>(not available)</p>
<p>Metal Furniture – 2009 On-the-Books measures: MACT Std. – Subpart RRRR (67 FR 28606 , 5/23/03) EPA MACT limits <u>existing sources</u>: 0.10 kg HAP/liter solids <i>Emission Reductions:</i> Nationwide – 73% HAP reduction from 1997/1998 baseline MACT Organic HAP control efficiency option: xx% for existing sources Estimated VOC reduction 0% (Pechan Table) <i>Control Cost:</i> Nationwide – \$14.8 million/yr for 16,300 tons/yr = \$908/ton <i>Timing of Implementation:</i> Compliance Date (existing) May 23, 2006 <i>Implementation Area:</i> Nationwide</p>	<p>VOC Actual 2002: OTB 2009: Reduction from OTB:</p>	<p>(not available)</p>
<p>Metal Furniture Candidate measure 1: Adopt More Stringent RACT regulations; lower applicability thresholds, extend geographic coverage <i>Measure ID: Permanent Total Enclosure</i> <i>Emission Reductions: Estimated VOC reduction 95% (Air Control Net 3.0 Table)</i> <i>Control Cost: \$20,115/ton</i> <i>Timing of Implementation:</i> Assuming 2007 or 2008 effective date of rule, emission reductions in 2009 or 2010 <i>Implementation Area:</i> (1) 8-hr ozone nonattainment areas, (2) 8-hr ozone nonattainment areas plus adjacent counties, or (3) all counties.</p>	<p>VOC OTB 2009: BOTW 2009: Reduction from BOTW:</p>	<p>(not available)</p>
<p>Policy Recommendation: Final recommendation not made as of June, 2006.</p>		
<p>Brief Rationale for Recommended Strategy: See additional discussion in briefing paper</p>		

CONTROL MEASURE SUMMARY FOR
Industrial Surface Coatings Miscellaneous Metal Parts

Control Measure Summary: This category includes several source types: Fabric, Printing, Coating and Dyeing; Large Appliances; Metal Can coating, Metal Coil coating; Metal Furniture coating; Misc. Metal Parts coating; Paper and Other Web coating; Plastic Parts coating; & Wood Building Products coating		Emissions (tons/year) in Ozone Transport Region	
Miscellaneous Metal Parts - 2002 existing measures: NSPS; PSD/NSR; State RACT rules in 1-hour non-attainment counties EPA CTG RACT limit: <u>lbs VOC/gal coating (minus H₂O&exempt solvents)</u> Clear or transparent top coat 4.3 [0.52 kg/l] Air dries Coatings 3.5 [0.42 kg/l] Coating used in extreme environmental conditions 3.5 [0.42 kg/l] All other coatings 3.0 [0.35 kg/l] Applicability: 10 tons/year uncontrolled emissions OTC state RACT limits: NH same limits as CTG		VOC Actual 2002:	(not available)
Miscellaneous Metal Parts – 2009 On-the Books measures: MACT Std. – Subpart MMMM (69 FR 130 , 1/2/04) EPA MACT limits <u>existing sources</u> : General use Coating 0.31 kg HAP/l solids High Performance Coating 3.30 kg HAP/l solids Rubber-to-Metal Coating 4.50 kg HAP/l solids Extreme Performance Fluoropolymer 1.5 kg HAP/l solids <i>Emission Reductions:</i> Nationwide – 48% HAP reduction from 1997 baseline MACT Organic HAP control efficiency option: xx% for existing sources <i>Estimated VOC reduction 0% (Pechan Table)</i> <i>Control Cost:</i> Nationwide – \$57.3 million/yr for 26,000 tons/yr = \$2204/ton <i>Timing of Implementation:</i> Compliance Date (existing) Jan. 2, 2007 <i>Implementation Area:</i> Nationwide		VOC Actual 2002: OTB 2009: Reduction from OTB:	(not available)
Miscellaneous Metal Parts Candidate measure 1: Adopt More Stringent RACT regulations; lower applicability thresholds, extend geographic coverage <i>Measure ID:</i> <i>Emission Reductions:</i> <i>Control Cost:</i> <i>Timing of Implementation:</i> Assuming 2007 or 2008 effective date of rule, emission reductions in 2009 or 2010 <i>Implementation Area:</i>		VOC OTB 2009: BOTW 2009: Reduction from BOTW:	(not available)
Policy Recommendation: Final recommendation not made as of June, 2006.			
Brief Rationale for Recommended Strategy: See additional discussion in briefing paper			

CONTROL MEASURE SUMMARY FOR
Industrial Surface Coatings Paper and Other Web

Control Measure Summary: This category includes several source types: Fabric, Printing, Coating and Dyeing; Large Appliances; Metal Can coating, Metal Coil coating; Metal Furniture coating; Misc. Metal Parts coating; Paper and Other Web coating; Plastic Parts coating; & Wood Building Products coating	Emissions (tons/year) in Ozone Transport Region	
<p>Paper & Other Web - 2002 existing measures: NSPS; PSD/NSR; State RACT rules in 1-hour non-attainment counties EPA CTG RACT limit: 2.9 lbs VOC/gal coating [0.35 kg/liter] (minus H₂O & exempt solvents) Applicability: Sources 3 lbs/hour, 15 lb/day or 10 tons/year uncontrolled emissions OTC state RACT limits: MD, NJ, NH = 2.9 lbs/gal coating MA = 4.8 lbs VOC/gal of solids (equivalent to 2.9 lbs/gal coating)</p>	<p>VOC Actual 2002:</p>	
<p>Paper & Other Web – 2009 On-the-Books measures: MACT Std. – Subpart JJJJ (67 FR 72330 , 12/4/02) EPA MACT limits <u>existing sources</u>: 0.2 kg organic HAP/kg coating solids <i>Emission Reductions:</i> Nationwide – 80% HAP reduction from current levels?? MACT Organic HAP control efficiency option: 95% for existing sources Estimated VOC reduction 80% (Pechan Table) <i>Control Cost:</i> Nationwide – \$64 million/yr for 34,500 tons/yr = \$1,855/ton <i>Timing of Implementation:</i> Compliance Date (existing) Dec. 5, 2005 <i>Implementation Area:</i> Nationwide</p>	<p>VOC Actual 2002: OTB 2009: Reduction from OTB:</p>	<p>(not available)</p>
<p>Paper & Other Web Candidate measure 1: Adopt More Stringent RACT regulations; lower applicability thresholds, extend geographic coverage <i>Measure ID:</i> <i>Emission Reductions:</i> <i>Control Cost:</i> <i>Timing of Implementation:</i> Assuming 2007 or 2008 effective date of rule, emission reductions in 2009 or 2010 <i>Implementation Area:</i></p>	<p>VOC OTB 2009: BOTW 2009: Reduction from BOTW:</p>	<p>(not available)</p>
<p>Policy Recommendation: Final recommendation not made as of June, 2006.</p>		
<p>Brief Rationale for Recommended Strategy: See additional discussion in briefing paper</p>		

CONTROL MEASURE SUMMARY FOR
Industrial Surface Coatings Plastic Parts

Control Measure Summary: This category includes several source types: Fabric, Printing, Coating and Dyeing; Large Appliances; Metal Can coating, Metal Coil coating; Metal Furniture coating; Misc. Metal Parts coating; Paper and Other Web coating; Plastic Parts coating; & Wood Building Products coating			Emissions (tons/year) in Ozone Transport Region																									
Plastic Parts - 2002 existing measures: NSPS; PSD/NSR; State RACT rules in 1-hour non-attainment counties EPA CTG RACT limit: <u>lbs VOC/gal coating (minus H₂O&exempt solvents)</u> <table><thead><tr><th></th><th><u>Auto Interior</u></th><th><u>Auto Exterior</u></th></tr></thead><tbody><tr><td>High Bake Prime</td><td>3.8 [0.46 kg/l]</td><td>--</td></tr><tr><td>High Bake Prime - Flexible</td><td>--</td><td>5.0 [0.60 kg/l]</td></tr><tr><td>High Bake Prime – Nonflexible</td><td>--</td><td>4.5 [0.54 kg/l]</td></tr><tr><td>High Bake Color</td><td>4.1 [0.49 kg/l]</td><td>4.6 [0.55 kg/l]</td></tr><tr><td>Low Bake Prime</td><td>3.5 [0.42 kg/l]</td><td>5.5 [0.66 kg/l]</td></tr><tr><td>Low Bake Color</td><td>3.5 [0.42 kg/l]</td><td>5.6 red or black</td></tr><tr><td>Low Bake Color</td><td>--</td><td>4.5 all others</td></tr></tbody></table> Applicability: NH - 50 tons/year uncontrolled emissions OTC state RACT limits: NH - same limits as CTG				<u>Auto Interior</u>	<u>Auto Exterior</u>	High Bake Prime	3.8 [0.46 kg/l]	--	High Bake Prime - Flexible	--	5.0 [0.60 kg/l]	High Bake Prime – Nonflexible	--	4.5 [0.54 kg/l]	High Bake Color	4.1 [0.49 kg/l]	4.6 [0.55 kg/l]	Low Bake Prime	3.5 [0.42 kg/l]	5.5 [0.66 kg/l]	Low Bake Color	3.5 [0.42 kg/l]	5.6 red or black	Low Bake Color	--	4.5 all others	VOC Actual 2002:	(not available)
	<u>Auto Interior</u>	<u>Auto Exterior</u>																										
High Bake Prime	3.8 [0.46 kg/l]	--																										
High Bake Prime - Flexible	--	5.0 [0.60 kg/l]																										
High Bake Prime – Nonflexible	--	4.5 [0.54 kg/l]																										
High Bake Color	4.1 [0.49 kg/l]	4.6 [0.55 kg/l]																										
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Low Bake Color	3.5 [0.42 kg/l]	5.6 red or black																										
Low Bake Color	--	4.5 all others																										
Plastic Parts - 2009 On-the Books measures: MACT Std. – Subpart PPPP (69 FR 20968 , 4/19/04) EPA MACT limits <u>existing sources</u> : General Use Coating - 0.16 kg HAP/kg <u>coating solids</u> Automotive Lamp Coating - 0.45 kg HAP/kg <u>coating solids</u> Thermoplastic Olefins - 0.26 kg HAP/kg <u>coating solids</u> New Assembled On-Road Vehicles - 1.34 kg HAP/kg <u>coating solids</u> <i>Emission Reductions:</i> <i>Nationwide – 80% HAP reduction from 1997 baseline</i> <i>Estimated VOC reduction 0% (Pechan Table)</i> <i>Control Cost:</i> <i>Nationwide – \$10.9 million/yr for 7,560 tons/yr = \$1,442/ton</i> <i>Timing of Implementation:</i> Compliance Date (existing) April 19, 2007 <i>Implementation Area:</i> Nationwide			VOC Actual 2002: OTB 2009: Reduction from OTB:	(not available)																								
Plastic Parts Candidate measure 1: Adopt More Stringent RACT regulations; lower applicability thresholds, extend geographic coverage <i>Measure ID:</i> <i>Emission Reductions:</i> <i>Control Cost:</i> <i>Timing of Implementation:</i> Assuming 2007 or 2008 effective date of rule, emission reductions in 2009 or 2010 <i>Implementation Area:</i>			VOC OTB 2009: BOTW 2009: Reduction from BOTW:	(not available)																								
Policy Recommendation: Final recommendation not made as of June, 2006.																												
Brief Rationale for Recommended Strategy: See additional discussion in briefing paper																												

CONTROL MEASURE SUMMARY FOR
Industrial Surface Coatings Wood Building Products

Control Measure Summary: This category includes several source types: Fabric, Printing, Coating and Dyeing; Large Appliances; Metal Can coating, Metal Coil coating; Metal Furniture coating; Misc. Metal Parts coating; Paper and Other Web coating; Plastic Parts coating; & Wood Building Products coating	Emissions (tons/year) in Ozone Transport Region																
Wood Building Products - 2002 existing measures: NSPS; PSD/NSR; State RACT rules in 1-hour non-attainment counties EPA CTG RACT limit: <u>lbs VOC/gal coating (minus H₂O&exempt solvents)</u>	VOC Actual 2002:	(not available)															
Wood Building Products - 2009 On-the-Books measures: MACT Std. – Subpart QQQQ (68 FR 31746 , 5/28/03) EPA MACT limits <u>existing sources</u> : <div style="text-align: right; margin-right: 100px;"><u>kg HAP/liter of solids (lb HAP/gal solids)</u></div> <table border="0" style="width: 100%;"> <tr> <td>Doors, Windows & Misc.</td><td style="text-align: right;">0.231</td><td style="text-align: right;">(1.93)</td></tr> <tr> <td>Flooring</td><td style="text-align: right;">0.093</td><td style="text-align: right;">(0.78)</td></tr> <tr> <td>Interior Wall Paneling & Tileboard</td><td style="text-align: right;">0.183</td><td style="text-align: right;">(1.53)</td></tr> <tr> <td>Other Interior Panels</td><td style="text-align: right;">0.020</td><td style="text-align: right;">(0.17)</td></tr> <tr> <td>Exterior Siding & Primed Door Skins</td><td style="text-align: right;">0.007</td><td style="text-align: right;">(0.06)</td></tr> </table> <i>Emission Reductions:</i> Nationwide – 63% HAP reduction from 1997 baseline MACT Organic HAP control efficiency option: xx% for existing sources <i>Estimated VOC reduction 63% (Pechan Table)</i> <i>Control Cost:</i> Nationwide –\$22.5 million/yr for 4,900 tons/yr = \$4,592/ton <i>Timing of Implementation:</i> Compliance Date (existing) May 28, 2006 <i>Implementation Area:</i> Nationwide	Doors, Windows & Misc.	0.231	(1.93)	Flooring	0.093	(0.78)	Interior Wall Paneling & Tileboard	0.183	(1.53)	Other Interior Panels	0.020	(0.17)	Exterior Siding & Primed Door Skins	0.007	(0.06)	VOC Actual 2002: OTB 2009: Reduction from OTB:	(not available)
Doors, Windows & Misc.	0.231	(1.93)															
Flooring	0.093	(0.78)															
Interior Wall Paneling & Tileboard	0.183	(1.53)															
Other Interior Panels	0.020	(0.17)															
Exterior Siding & Primed Door Skins	0.007	(0.06)															
Wood Building Products Candidate measure 1: Adopt More Stringent RACT regulations; lower applicability thresholds, extend geographic coverage <i>Measure ID:</i> <i>Emission Reductions:</i> <i>Control Cost:</i> <i>Timing of Implementation:</i> Assuming 2007 or 2008 effective date of rule, emission reductions in 2009 or 2010 <i>Implementation Area:</i>	VOC OTB 2009: BOTW 2009: Reduction from BOTW:	(not available)															
Policy Recommendation of State/Workgroup Lead: Final recommendation not made as of June, 2006.																	
Brief Rationale for Recommended Strategy: See additional discussion in briefing paper																	

Control Measure Summary: This category includes several source types: Fabric, Printing, Coating and Dyeing; Large Appliances; Metal Can coating, Metal Coil coating; Metal Furniture coating; Misc. Metal Parts coating; Paper and Other Web coating; Plastic Parts coating; & Wood Building Products coating	Emissions (tons/year) in Ozone Transport Region	
Industrial Surface Coatings Category Total - 2002 existing measures: NSPS: PSD/NSR; State RACT rules in 1-hour non-attainment counties	Total VOC Point &Area Actual 2002:	164,445
Industrial Surface Coatings Category Total - 2009 On-the-Books measures: MACT Std.s. – Subpart OOOO (68 FR 32172, 5/29/03) Subpart NNNN (67 FR 48254, 7/23/02) Subpart KKKK (68 FR 64432 , 11/13/03) Subpart SSSS (67 FR 39794 , 6/10/02) Subpart RRRR (67 FR 28606 , 5/23/03) Subpart MMMM (69 FR 130 , 1/2/04) Subpart JJJJ (67 FR 72330 , 12/4/02) Subpart PPPP (69 FR 20968 , 4/19/04) Subpart QQQQ (68 FR 31746 , 5/28/03) <i>Emission Reductions:</i> <i>OTC Regional – x,xxx from 2002 baseline</i> <i>Control Cost:</i> <i>OTC Regional –\$ xx.x million/yr for x,xxx tons/yr = \$4,592/ton</i> <i>Timing of Implementation:</i> Compliance Dates (existing) 5/29/06; (existing) 7/23/05; (existing) 11/13/06; (existing) 6/10/05; (existing) 5/23/06; (existing) 1/2/07; (existing) 12/5/05; (existing) 4/19/07; (existing) 5/28/06 <i>Implementation Area:</i> Ozone Transport Region	Total VOC Point & Area Actual 2002: Reduction from OTB: MANE-VU 2002 Point* MANE-VU 2002 Area* (Ed Sabo’s e-mail 01/06/06)	164,445 <u>-175,983</u> -11,448 24,931 139,512 From 10/04/05 draft emission inventory
Industrial Surface Coatings Category Total Candidate measure 1: Adopt More Stringent RACT regulations; lower applicability thresholds, extend geographic coverage <i>Measure ID:</i> <i>Emission Reductions:</i> <i>Control Cost:</i> <i>Timing of Implementation:</i> Assuming 2007 or 2008 effective date of rule, emission reductions in 2009 or 2010 <i>Implementation Area:</i>	VOC OTB 2009: BOTW 2009: Reduction from BOTW:	(not available)
Policy Recommendation: Final recommendation not made as of June, 2006.		
Brief Rationale for Recommended Strategy: See additional discussion in briefing paper		

Background Information

Industrial surface coatings are used during the manufacture of a wide variety of products including: fabrics, paper, large appliances, metal cans, metal coils, metal furniture, metal parts, plastic parts, and wood building materials. Surface coating is the process by which paints, inks, varnishes, adhesives or other decorative or functional coatings are applied to a substrate (e.g., fabric, metal, wood, or plastic) to protect or decorate the substrate. Industrial surface coatings can be applied by brushing, rolling, spraying, dipping, flow coating, electro-coating, or combinations and variations of these methods. The process used to coat a particular product is dependent on the composition of the coating, the substrate to which the coating is applied and the intended end use of the final product. After a coating is applied, it is dried or cured either by conventional curing through the use of thermal drying ovens, or through the use of radiation. During conventional curing, heat from thermal ovens is used to evaporate the solvents and/or water trapped in the coating and release them into the atmosphere. Two types of radiation curing processes currently in use are ultraviolet (UV) curing and electron beam (EB) curing.

Emissions are released by the evaporation of the solvents used in the coatings and the evaporation of any additional solvents used to dilute (thin) the coating prior to application and for cleaning the coating equipment after use. Emissions from surface preparation and coating applications are a function of the VOC content of product used. Emissions are also a function of the type of coating process used (rolling, dipping, spraying, etc.) and the transfer efficiency of the process. Transfer efficiency is the percentage of the coating solids that are applied (e.g., sprayed) which actually adhere to the surface being coated. Emissions from cleaning vary with the type of cleanup and the housekeeping practices used.

Industrial surface coating is estimated to account for approximately 164,000 tons per year of VOC emissions in the Mid-Atlantic/Northeast Visibility Union (MANE-VU) region in 2002 from both point and area sources. It is important to consider two aspects regarding the accuracy of this emissions estimate when assessing this category for additional controls:

- 1) The MANE-VU VOC emissions inventory for the industrial surface coating category includes emissions from both point and area sources. While the 2002 VOC emissions inventory for the MANE-VU region indicates that VOC emission from area sources in this category are substantial, the area source part of the emissions inventory is highly uncertain and may be substantially overestimated. The method used to estimate area source VOC emissions relies heavily on employee emission factors and employment data. These emission factors are based on data collected by EPA in the 1980s and may not accurately portray the types of coatings, the type of coating equipment, or the type of control technology currently in use.
- 2) At least nine types of industrial surface coating point sources are already controlled due to state specific VOC RACT regulations or will soon be controlled prior to 2009 as a result of the recently promulgated Maximum Achievable Control Technology (MACT) standards. Since the MACT standards were designed to control air toxic emissions and not necessarily VOC emissions the effectiveness of the MACT standards for controlling VOC emissions will vary with the industrial surface coating subcategory (e.g., metal cans, wood building products, etc.) and the type of coating equipment and the type of solvents used in that subcategory.

Regulatory History

Industrial surface coating processes are currently subject to multiple state and federal regulations pursuant to Titles I and III of the Clean Air Act. Title I imposes Standards of Performance for New Stationary Sources (NSPS) on new and modified large stationary sources. In the early 1990s, EPA promulgated NSPSs for various types of industrial surface coating operations. These regulations applied

to surface coating operations that were constructed or modified after effective dates specified in each NSPS. In general, surface coating operations constructed or modified after 1980 are subject to NSPS requirements. The NSPS generally established VOC emission rate limits that could be complied with using either compliant coatings or add-on capture and control equipment. For certain source categories the NSPS also set transfer efficiency requirements.

New and modified large stationary sources that increase their emissions can also be subject to the New Source Review (NSR) requirements of Title I. NSR requires a control technology review for large new plants and for modifications at existing plants that result in a significant increase in emissions, subjecting these sources to Best Available Control Technology (BACT) in attainment areas and Lowest Achievable Emission Rate (LAER) in nonattainment areas. BACT and LAER control requirements are updated over time to reflect improvements in control equipment and are reviewed on a case-by-case basis during state permitting process.

Criteria pollutants, which include VOCs, nitrogen oxides (NO_x), sulfur dioxide (SO₂), fine particulate matter (PM_{fine}), carbon monoxide (CO) and lead (Pb), are also regulated by the State Implementation Plans (SIPs) required by Title I. SIPs set forth the states' strategies for achieving reductions of criteria pollutants for which the state is currently out of attainment. SIPs must include requirements that all major stationary sources located in nonattainment areas must install reasonably available control technology (RACT). RACT levels must be based on the level of emissions reduction that can be reasonably achieved at a reasonable cost. The U.S. EPA has issued a series of Control Technology Guidelines (CTGs) and Alternative Control Technologies (ACT) documents to assist states in defining RACT for a number of industrial surface coating categories. For categories not covered by a CTG or ACT document, state regulations require that a case-by-case RACT determination be made. Most of the EPA's CTGs and ACT documents for the industrial surface coating category were developed prior to 1990. While specific RACT requirements will vary from state to state, some OTC states have already adopted RACT regulations that are more stringent than the CTG/ACT requirements.

Policy Recommendation

As can be noted from the background information, the regulatory history, and the information contained in summary tables, the industrial surface coatings category includes at least nine different major source types and multiple processes for each source type with regulations and emissions limits that vary not only by major source type, but also by individual process and individual product. In addition, the industrial surface coatings category is already subject to a variety of regulations (NSPS; PSD/NSR, state RACT, MACT, state specific rules on hazardous air pollutants) that were adopted to achieve different goals. Some regulations (e.g., RACT) were designed to reduce VOC emissions. Other regulations (e.g., MACT) were designed to reduce emissions of hazardous air pollutants but have the side benefit of reducing VOC emissions as well.

Analysis of the potential benefits and costs of adopting additional VOC control measures, Beyond On-The-Way (BOTW) measures) is further complicated by the following:

- 1) Uncertainty as to the accuracy of the current (2002) MANE-VU VOC emissions inventory for the industrial surface coatings category;
- 2) Difference in current VOC RACT limits among the OTC states;
- 3) Difference in the estimates of the potential VOC reductions from MACT standards; and
- 4) Difference in the source size and geographic area covered by a specific regulation.

The most recent version of the (2002) MANE-VU VOC emissions inventory for the MANE-VU region estimates total VOC emissions from the industrial surface coatings category to be 164,445 tons (24,931 tons of VOC from point sources and 139,512 tons from area sources). Further investigation into the amount of VOC emissions from area sources will most likely reveal that these VOC emissions are

substantially overestimated due in part to the emission factors and employment data used and in part to the cutpoints used by various states for distinguishing a point source from an area source.

A quick sampling of the current VOC RACT limits in the OTC states reveals differences not only in the limits for existing sources (lbs. VOC per gallon of coating minus water and exempt solvents), but also in the size of source to which these limits apply.

Several complications arise when trying to calculate the potential VOC reductions from a particular MACT standard including the following:

- 1) Not all toxics regulated under the MACT are VOCs;
- 2) MACT standards are expressed as kg HAP/liter of solids or lbs. HAP/gallon of solids not lbs. VOC/gallon of coating minus water and exempt solvent so the MACT limit applies to all HAPs not just VOCs; and
- 3) The specific types of processes and coatings regulated under the MACT standards are different than the types of processes and coatings regulated under the RACT standards.

These complications have lead to widely varying estimates of the potential additional VOC reductions from the application of a particular MACT requirement (from 0% to as much as 80% VOC reduction nationwide).

RACT standards and MACT standards apply to sources located in different geographic areas throughout the Ozone Transport Region. For some OTC states RACT standards apply only to sources located in 1-hour ozone nonattainment counties while in other OTC states RACT standards apply statewide. MACT standards are applicable nationwide and only to major HAP sources (10 tons/year of individual HAP or 25 tons/year of combined HAPs).

Given all of these uncertainties the following options are available:

- 1) OTC states that currently have higher VOC RACT limits than the EPA CTG/ACT VOC RACT limits can adopt more stringent RACT regulations;
- 2) OTC states can extend the geographic coverage for RACT limits to statewide;
- 3) OTC states can lower the RACT applicability thresholds
- 4) OTC states can adopt more stringent control requirements for specific industrial surface coating categories (e.g., permanent total enclosures for metal can coating processes).

Policy recommendations:

- 1) Due to uncertainty in current MANE-VU VOC emissions inventory for this category, develop an improved, state specific VOC emissions inventory for point and area sources for each subcategory of industrial surface coatings before requiring additional controls beyond MACT.

CONTROL MEASURE SUMMARY FOR *Lime Kilns*

Control Measure Summary: Good combustion practices and kiln operation for Lime Kilns. These kilns are used for the calcination of limestone. Lime kilns are also often associated with paper mills.	Emissions (tons/year) in Ozone Transport Region	
2002 existing measure: NSR; PSD; State RACT. <i>Emission Reductions:</i> <i>Control Cost:</i> <i>Timing of Implementation:</i> <i>Implementation Area:</i> OTR	NOx Uncontrolled: 2002 Reduction: 2002 Base:	 4,649 <u>0</u> 4,649
Candidate measure: Good combustion practices and kiln operation <i>Emission Reductions:</i> Under Evaluation <i>Control Cost:</i> less than \$2,000 per ton <i>Timing of Implementation:</i> 01/01/09 <i>Implementation Area:</i> OTR	NOx 2009 Base including growth: 2009 Reduction: 2009 Remaining:	 5,228 <u>TBD</u>
Policy Recommendation: Final recommendation not made as of June, 2006.		
Recommended Strategy: See additional discussion in briefing paper		
REFERENCES: European Commission, Integrated Pollution Prevention and Control (IPPC) Bureau. <i>Reference Document on Best Available Techniques in the Cement and Lime Manufacturing Industries</i> . December 2001. “The direct transfer of low-NOx burner technology from cement kilns to lime kilns is not straightforward. In cement kilns, flame temperatures are higher and low-NOx burners have been developed for reducing high initial levels of ‘thermal NOx’. In most lime kilns the levels of NOx are lower and the ‘thermal NOx’ is probably less important.” Northeast States for Coordinated Air Use Management. <i>Assessment of Control Technology Options for BART-Eligible Sources: Steam Electric Boilers, Industrial Boilers, Cement Plants, and Paper and Pulp Facilities</i> . March 2005. “Due to the design of the lime kiln, SNCRs and SCRs are not viable NOx reduction techniques. Installing low-NOx burners is also not a practical NOx reduction technique according to a BACT analysis conducted on a new lime kiln in 1997...combustion modification such as decreasing excess air is the best way to reduce NOx emissions”.		

CONTROL MEASURE SUMMARY FOR
Municipal Waste Combustors
(Only NOx reductions are evaluated under this strategy)

Control Measure Summary	Emissions (tons/year) in Ozone Transport Region	
2002 existing measure: Federal performance standards and emissions guidelines for large MWCs (40 CFR 60 Subparts Cb and Eb). No control technology is mandated to meet the emissions limitations. EPA approved state trading programs for NOx compliance are allowed as is facility-wide averaging for NOx compliance. <i>Emission Reductions:</i> 19,000 Mg NOx/yr nationally (increment over 1991 40 CFR 60 Subpart Ca standards). <i>Control Cost:</i> \$7.2 per Mg municipal solid waste combusted. <i>Timing of Implementation:</i> Compliance required December 19, 2000. <i>Implementation Area:</i> Nationwide.	NOx 2002 Base:	26,139
	SO2: 2002 Base	3,865
	VOC: 2002 Base	473
Implement Federal Rules: <i>Measure ID:</i> <i>Emission Reductions:</i> Varies per state depending on the number of MWC units, incinerator technology and chosen emissions limitations. In Connecticut, this measure resulted in NOx emissions reductions of 1.6 tons/summer day and 592 tons/year. <i>Control Cost:</i> \$0 to approximately \$1,500/MMBtu/hr depending on whether SNCR was installed in response to the federal emissions guidelines and whether SNCR is feasible. <i>Timing of Implementation:</i> Assuming timely adoption of state rule amendments, compliance with emissions limitations could be required by May 1, 2009. <i>Implementation Area:</i> Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York and Pennsylvania report operating MWC units (assuming state NOx emissions limitations are at the level of the federal emissions guidelines).	NOx 2009 Reduction: 2009 Remaining:	 -3,610 22,529
	SO2	***
	VOC	***
Policy Recommendation of State/Workgroup Lead: Individual states with operating MWCs should evaluate the possible reduction of state NOx emissions limitations to produce creditable emissions reductions. At the regional level, this strategy should not be emphasized as it is state-specific in nature (depending on the MWC population, current control level and current state standards); does not require regional implementation to maximize its effectiveness; emissions from MWCs are a minor portion of the regional inventory given MACT-based standards required under Section 129 of the Clean Air Act; and EPA has proposed more stringent NOx emission limits for MWCs that states will be required to adopt and implement as of April 2009.		
Recommended Strategy: MWCs are subject to stringent MACT emissions standards, including standards for NOx, under Section 129 of the Clean Air Act. To comply with these MACT standards, many MWC owners and operators installed control technologies, including SNCR, to comply with the federal deadline of December 19, 2000. Many MWCs may be operated to reduce emissions to a level below the current federal standards. For example, Connecticut includes a state NOx emission reduction credit (ERC) trading program in its MWC rule. Recognizing that the "excess emissions" produced in Connecticut's MWC NOx ERC trading program could yield creditable emissions reductions if the required NOx emissions limits were reduced, in October 2000, the Department amended the state MWC rule to require the MWC owners and operators to meet more stringent NOx emissions limits as of May 1, 2003. The resulting emissions reductions of 1.62 tons of NOx per summer day (248 tons per ozone season) were used for compliance with the "shortfall" emission reduction obligation		

needed for EPA approval of the attainment demonstration for the 1-hour ozone national ambient air quality standard.

Other states in the OTC region have operating MWC units that now comply with MACT-based state emissions limitations. Many MWC units now operate with SNCR to control NO_x emissions. For MWC units that do not now have SNCR, SNCR is likely a feasible RACT measure capable of reducing NO_x emissions below the state limits. Thus, the reduction of the state MWC NO_x limits may produce creditable NO_x emissions reductions. Furthermore, since MWCs are not subject to the Clean Air Interstate Rule (CAIR) and may not participate in a CAIR NO_x trading program, reduction of state MWC NO_x emissions limitations could be considered an equity measure that places MWC owners in a position similar to the owners of large electric generating units subject to CAIR. However, the amount of creditable emissions reductions a state may obtain from this strategy is limited given EPA's December 19, 2005 proposal of reduced emissions limitations for MWCs.

BACKGROUND INFORMATION

In December 1995, EPA adopted new source performance standards (NSPS) (40 CFR 60 subpart Eb) and emission guidelines (subpart Cb) for MWC units with a combustion capacity greater than 250 tons per day. Both the NSPS and emission guidelines require compliance with emission limitations for nine pollutants including NO_x that reflect the performance of maximum achievable control technology (MACT). The emission guidelines required compliance by December 2000 for all existing MWCs, while the NSPS apply to new MWCs. On December 19, 2005, EPA proposed revisions to the emissions guidelines to reflect the levels of performance achieved due to the installation of control equipment (70 FR 75348). This proposal includes reduced NO_x emissions limitations that states will be required to adopt and implement by April 2009, if the proposal is finalized. Selective non-catalytic reduction (SNCR) is considered MACT for NO_x under both the 1995 guidelines and the 2005 proposal.

Connecticut's MWC regulation, section 22a-174-38 of the Regulations of Connecticut State Agencies (R.C.S.A.) (Attachment A), was adopted in June 1999 with NO_x emissions limits equivalent to the federal emissions guidelines (Phase I NO_x limits). Owners and operators of the state's 15 MWC units were required to comply with the emissions limits no later than December 19, 2000. R.C.S.A. section 22a-174-38 was amended in October 2000 to include more stringent NO_x emissions limits (Phase II NO_x limits), for which compliance was required no later than May 1, 2003. The following NO_x emissions reductions, relative to emissions levels under the Phase I NO_x limits, are attributed to the Phase II NO_x limits in Connecticut:

- 592 tons per year;
- 248 tons per ozone season; and
- 1.62 tons per day during the ozone season.¹

EPA's December 19, 2005 proposal to update the 1995 emissions standards will substantially reduce the ability of other states to achieve the same level of emissions reductions that Connecticut achieved by implementing this measure in 2003.

Add-on NO_x Control

The number of NO_x-reduction technologies for MWCs are limited as these units use a heterogeneous, wet fuel; are less thermally efficient than fossil fuel-fired boilers of comparable heat input; and require larger amounts of excess air and less densely-packed heat recovery systems. Low-NO_x burners, fuel switching and load curtailment are not possible control options.

¹ Assumes 100% rule effectiveness, which is reasonable given that the MWCs are operated with continuous emissions monitoring.

The only generally applicable and feasible add-on control technology for reducing NO_x emissions from MWCs is SNCR.² SNCR is a chemical process for removing NO_x from flue gas. In the SNCR process, a reagent, typically liquid urea or anhydrous gaseous ammonia is injected within a boiler or in ducts in a region where the temperature is between 900 and 1100 degrees Celsius. The reaction converts NO_x to nitrogen gas and water vapor. SNCR performance depends on factors specific to each type of combustion equipment, including flue gas temperature, residence time for the reagent and flue gas, amount of reagent injected, reagent distribution, uncontrolled NO_x level and carbon monoxide and oxygen concentrations.

Some disadvantages arise from the use of SNCR including: the high operating temperatures required; ineffectiveness at high temperatures with low concentrations of NO_x; the need to accommodate enough residence time to complete the chemical reaction at high temperatures; and undesirable excess ammonia and urea emissions ("ammonia slip") that arise from an incomplete chemical reaction (Thermal Energy International, 2000).

All of Connecticut's large MWC units are equipped with SNCR, including nine mass burn/waterwall units and three refuse-derived fuel units. Two tire-fired units subject to the state MWC rule also operate with SNCR.³ Similarly, all of New Jersey's large MWC units are equipped with SCR to meet NO_x emissions limitations based on the federal emissions guidelines.

Cost

The capital cost of installing SNCR on a MWC unit is approximately \$1,500 MMBtu/hr (see, e.g., Institute of Clean Air Companies, 2000).⁴ Most of the cost of using SNCR is in operating expenses (Institute of Clean Air Companies, 2000), which EPA estimates as falling between 680 and 1,200 \$/MMBtu (1993 dollars). Thus, SNCR is well suited for seasonal control in that it may provide significant reductions in NO_x emissions but incurs little cost when the system is not in use. EPA has assigned an ozone season cost effectiveness to SNCR operated on MWC units of \$2,140 per ton of NO_x reduced (1990 dollars)(EPA, 1999, Table 16).

Emissions reductions

In Connecticut, MWC facility owners report emissions reductions of 25 to 50% from the operation of SNCR; a typical reduction of 35-40% could be assumed from the installation and operation of SNCR/ammonia injection to MWC units of similar size and type. Other combustors of varying technologies and capacities but with similar baseline NO_x emissions have reported reductions ranging from 35 - 75% from the operation of urea-based SNCR (Appendix 1, Institute of Clean Air Companies, 2000). EPA assigns a typical 45% emission reduction to the effectiveness of SNCR at MWCs (EPA, 1999, Table 16).

² The use of SCR to control NO_x emissions from MWCs in North American is limited to very few units (see, e.g., <http://www.region.peel.on.ca/pw/waste/facilities/algonquin-power.htm>) because the nature of municipal solid waste requires huge SCR reactor sizes and significant actions to prevent catalyst poisoning. These factors, combined with the relatively small size of most MWCs, makes the use of SCR prohibitively expensive (EPA 2005, comment by IWSA).

³ Connecticut also has three mass burn refractory units that are classified as small MWCs and do not use SNCR.

⁴ For comparison, EPA places the capital cost of SNCR between 1,600 and 3,300 \$/MMBtu (1993 dollars). In 2002, the 3-unit facility (140 MMBTU/hr per unit) owned by the Connecticut Resources Recovery Authority in Bridgeport, Connecticut installed SNCR on all three units at a capital cost of \$2.1 million.

REFERENCES

Institute of Clean Air Companies. May 2000. *Selective Non-Catalytic Reduction (SNCR) for Controlling NOx Emissions*. <http://www.fueltechnv.com/pdf/TPP-534.pdf>

Thermal Energy International Inc. 2000. *Thermal THERMALONox Competitive Advantages*.
<http://www.thermalenergy.com/solutions/solutions.html>

U.S. Environmental Protection Agency. November 1999. Nitrogen Oxides (NOx), *Why and How They are Controlled*. Clean Air Technology Center: EPA 456/F-99-006R.

U.S. Environmental Protection Agency. April 2005. *Corrected Response to Significant Public Comments on the Proposed Clean Air Interstate Rule*. Comment of IWSA.

U.S. Environmental Protection Agency. December 19, 2005. *Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Large Municipal Waste Combustors; Proposed Rule*. 70 FR 75348.

CONTROL MEASURE SUMMARY FOR
Printing and Graphic Arts

Control Measure Summary: This category includes categories of both heat set and non-heat set operations. It includes lithographic, gravure, flexographic and screen printing. It includes both point sources and area sources.	Emissions (tons/year) in Ozone Transport Region	
2002 existing measures: RACT, BACT, NSPS	VOC Point Actual 2002	5,501
2009 On-the-Books measures: MACT Std. - Subpart KK Publication rotogravure – limit organic HAP emissions to no more than 8% of volatile matter used each month. Either reformulation or 92% capture and control efficiency. Product and packaging rotogravure and wide-web flexo – limit organic HAP emissions to no more than 5% of volatile matter used each month. Either reformulation or 95% capture and control efficiency. <i>Emission Reductions:</i> <i>Control Cost:</i> <i>Timing of Implementation:</i> Compliance Date (existing) December 5, 2005 <i>Implementation Area:</i> Nationwide	VOC Point Actual 2002: 5,501 2009 Reduction: <u>-121</u> 2009 Remaining: 5,380 VOC Point Actual 2002: 31,738 2009 Reduction: <u>-0</u> 2009 Remaining: 31,738	
Candidate measure: Adopt the requirements of SCAQMD rule 1130 and 1130.1 <i>Emission Reductions:</i> Under evaluation <i>Control Cost:</i> Under evaluation <i>Timing of Implementation:</i> Assuming 2007 or 2008 effective date of rule, emission reductions in 2009 or 2010 <i>Implementation Area:</i> OTR	VOC OTB 2009: BOTW 2009: Reduction from BOTW:	Under review
Candidate measure: Same option as CM1, except potentially require that publication, packaging and product rotogravure and wide web flexo printers that are equipped with capture and control equipment, meet the capture and control efficiency requirement in the MACT standard for VOC reductions (this would apply to facilities not major for HAPs). <i>Implementation Area:</i> OTR	VOC OTB 2009: BOTW 2009: Reduction from BOTW:	Under review
Candidate measure: Adopt September 2006 CTGs. In September 2006, EPA determined that control technique guideline (CTG) documents will be substantially as effective as national regulations in reducing VOC emissions in ozone nonattainment areas from the following Group II product categories: lithographic printing materials, letterpress printing materials, and flexible packaging printing materials <i>Implementation Area:</i> OTR		Under Review
Policy Recommendation: Final recommendation not made as of June, 2006.		
Brief Rationale for Recommended Strategy:		

CONTROL MEASURE SUMMARY FOR *Portable Fuel Containers*

Control Measure Summary: Portable Fuel Containers This control measure establishes design and manufacturing specifications for portable fuel containers (PFCs) based on the California Air Resources Board (CARB) rules. PFCs are used to refuel residential and commercial equipment and vehicles. PFCs are used to refuel a broad range of small off-road engines and other equipment (e.g., lawnmowers, chainsaws, personal watercraft, motorcycles, etc.).	VOC Emissions in Ozone Transport Region	
2002 Existing Measure: None	2002 Annual: 2002 Summer:	99,919 tpy 315.3 tpd
2009 On-the-Books Measure: Adopt the OTC Model Rule for PFCs, which is based on the 2000 CARB rule for PFCs. <i>Emission Reductions:</i> Based on a CE=65%, RE=100%, RP=based on the number of years the rule has been in place based on the assumed 10-yr turnover of the sale of the cans, and Total control = 65% when fully implemented after 10 years. <i>Control Cost:</i> \$581 per ton <i>Timing of Implementation:</i> State specific with a 10% per year turnover, full reductions are achieved after 10 years. CARB, and the EPA, have estimated a 5 year turnover for the cans, but the OTC used a more conservative 10 year turnover in calculating emission reductions. <i>Implementation Area:</i> OTR	Annual: 2009 Reduction: 2009 Remaining: Summer: 2009 Reduction: 2009 Remaining:	 <u>33,055</u> tpy 66,864 tpy <u>107.1</u> tpd 208.2 tpd
2009 On-the-Way Measure: Proposed Federal HAP Mobile Source Reg (Feb 28, 2006) Rule – This rule proposes to regulate PFCs similar to CARBs 2006 rule amendments and will regulate permeability to 0.3 grams of HC per gallon per day (2001 OTC Model Rule has 0.4 grams per gallon per day). It does not contain CARBs amendments regarding kerosene containers and utility jugs. <i>Emission Reductions:</i> EPA estimates about a 9% reduction nationwide in 2009 and a 61% reduction when fully implemented after 5 years. <i>Control Cost:</i> \$180 per ton without fuel savings; over the long term, fuel savings outweigh costs. <i>Timing of Implementation:</i> Jan.1, 2009 effective date of rule and 20% per year turnover, full reductions are achieved after 5 years, in 2014. <i>Implementation Area:</i> Nationwide	Annual: 2009 Reduction: 2009 Remaining: Summer: 2009 Reduction: 2009 Remaining:	 <u>negligible</u> 66,864 tpy <u>negligible</u> 208.2 tpd
Candidate measure: Adopt the CARB 2006 amendments broadening PFC definition to include kerosene containers and utility jugs, increasing the permeability requirement from 0.3 grams of hydrocarbons per gallon per day to 0.4 grams of hydrocarbons per gallon per day, and other changes needed to make the OTC Model Rule consistent with CARB <i>Emission Reductions:</i> CARB estimates their amendments are expected to reduce ROG emissions by 58% after full penetration into the marketplace, assumed to be 5 years. <i>Control Cost:</i> CARB estimate is \$800 to \$1,400 per ton reduced <i>Timing of Implementation:</i> State specific with a 10% per year turnover, full reductions are achieved after 10 years <i>Implementation Area:</i> OTR	Annual: 2009 Base: 2009 Reduction: 2009 Remaining: Summer: 2009 Base: 2009 Reduction: 2009 Remaining:	 66,864 tpy <u>4,152</u> tpy 62,712 tpy 208.2 tpd <u>12.8</u> tpd 195.4 tpd

Summary of Candidate Measure:

The California Air Resources Board (CARB) 2000 PFC regulation establishes design and manufacturing specifications for PFCs. PFC emissions are calculated by accounting for emissions from five different components related to gas container use: permeation, diurnal, transport-spillage, refueling spillage and refueling vapor displacement emissions. The permeation, diurnal emissions (associated with storage) and transport-spillage emissions are included in the area source inventory. The equipment refueling spillage and refueling vapor displacement emissions are calculated from the non-road model and are included in the non-road inventory. After four years of implementation and a comprehensive assessment of the program, CARB staff identified some problems with the rule related to consumer acceptance and reducing anticipated emission reductions. Their 2006 amendments address these issues, as well as expanding on the regulation to increase emission reductions. The amendments include the following:

1. Eliminate the requirement for an auto shutoff.
2. Eliminate fuel flow rate and fill level standards.
3. Eliminate one opening standard.
4. Reduce pressure standard from 10 psig to 5 psig.
5. Establish a certification program for PFCs.
6. Expand the definition of a PFC to include utility jugs and kerosene containers. CARB staff determined that consumers were using these containers for gasoline.
7. Change permeability standard from 0.4 grams ROG /gallon-day to 0.3 grams/gallon-day.
8. Combine the evaporation and permeation standards into a new diurnal standard to simplify certification and compliance testing.
9. Adopt new PFC test procedures.
10. Include a voluntary Consumer Acceptance Program to support and encourage user-friendly PFC designs (i.e., allowing the use of the ARB Star Rating system to clearly identify superior designs as determined by users).

While ARB staff does not expect these changes to affect the cost of gasoline cans, the price of kerosene cans could rise to as much as \$8.50 per container once the regulations are implemented. CARB also estimates the cost-effectiveness to be between \$0.40 to \$0.70 per pound.

Recommended Strategy: CARB, through their comprehensive history of research and multiple product surveys, have the best technical data available to create rules to regulate portable fuel containers. Most portable fuel container manufacturers market their products nationally, therefore many will be selling the new products nationally after they have produced cans that conform with the CARB rules. The CARB rule contains some revisions to their original rule to ease consumer acceptance of the cans, for states that have adopted the original OTC model rule. In addition the CARB rule amendments regulate kerosene cans and utility jugs, which the Federal rule proposal does not.

References:**2009 On-the-Books Measure (OTC Model Rule):**

E.H. Pechan & Associates, Inc., *Control Measure Development Support Analysis of Ozone Transport Commission Model Rules*, March 31, 2001. Much of the analysis in this report was based on CARB's analysis for CARB's original 1999 PFC rule, which estimated a 75% reduction that would be fully achieved after 5 years (CARB's assumed life cycle for PFCs). The OTC used a more conservative 10-year turnover rate in its analysis. Table II-5 of the Pechan report shows the cost of compliance to be \$581/ton.

2009 On-the-Way Measure (Proposed 2/28/06 Federal Rule):

U.S. EPA Office of Transportation and Air Quality. *Estimating Emissions Associated with Portable Fuel Containers (PFCs), Draft Report*, EPA420-D-06-003, February 2006.

U.S. EPA Office of Transportation and Air Quality. *Draft Regulatory Impact Analysis: Control of Hazardous Air Pollutants from Mobile Sources*, EPA420-D-06-004, February 2006.

Candidate Measure (CARB 2006 Amendments):

California Air Resources Board. *Final Statement of Reasons for Rulemaking, Including Summary of Comments and Agency Response: PUBLIC HEARING TO CONSIDER AMENDMENTS TO THE PORTABLE FUEL CONTAINER REGULATIONS*. September 15, 2005.

California Air Resources Board. *Initial Statement of Reasons for Proposed Amendments to the Portable Fuel Container Regulations*. July 29, 2005. Table 5.1 shows the cost-effectiveness of the proposed amendments to be \$0.40 to \$0.70 per pound (\$800 to \$1,400 per ton)

CONTROL MEASURE SUMMARY FOR *Regional Fuel*

Control Measure Summary: The OTR proposes a common fuel standard for the OTR states that does not require MTBE or Ethanol, but exhibits Environmentally Beneficial Combustion Properties.	NOx Emissions (tons/summer day) in OTR	
2002 existing measure: Federal program in the CAA requiring RFG in certain non-attainment areas and allowing other states with non-attainment areas to opt-in. All but two states in the OTR are participating, in whole or in part, with the federal program, however nearly 1/3 of the gasoline sold in the OTR is not RFG.		
Candidate measure: <i>Measure ID:</i> OTR-wide Regional Fuel <i>Emission Reductions:</i> <i>Control Cost:</i> unknown at this time <i>Timing of Implementation:</i> <i>Implementation Area:</i> All states in the OTR	NOx VOC	~ 4.8 tpsd ~ 139.4 tpsd
Policy Recommendation: Continue to examine the potential for a regional fuel, keeping in mind that some states like PA may have statutory/legislative constraints.		
Brief Rationale for Recommended Strategy: The Energy Policy Act of 2005 provides the opportunity for the OTR to achieve a single clean-burning gasoline without MTBE, as it also eliminates the oxygen content requirement for RFG. The authority provided in Energy Act is consistent with what states promoted through the long debate over MTBE/ethanol/RFG. Approximately one-third of the gasoline currently sold in the OTR is not RFG; most is conventional gasoline. The new authority plus the potential for emission reductions from the amount of non-RFG sold in the OTR provides an opportunity for additional emission reductions in the region as well as for a reduced number of fuels, and possibly a single fuel, to be utilized throughout the region.		

Appendix D – VOC Emissions by County for 2002 and 2009

Table D-1 Adhesives and Sealants VOC Area Source Emission Summary for 2002 and 2009 by County

Table D-2 Adhesives and Sealants VOC Point Source Emission Summary for 2002 and 2009 by County

Table D-3 Cutback and Emulsified Asphalt Paving VOC Area Source Emission Summary for 2002 and 2009 by County

Table D-4 Consumer Products VOC Area Source Emission Summary for 2002 and 2009 by County

Table D-5 Portable Fuel Containers VOC Area Source Emission Summary for 2002 and 2009 by County

Table D-6 Portable Fuel Containers VOC Nonroad Source Emission Summary for 2002 and 2009 by State

Table D-7 Reformulated Gasoline Emission Summary by State

Due to their large size, these tables are being transmitted electronically in the spreadsheet named Appendix_D_VOC_2009.xls. There are separate tabs for each of the tables listed above.

Appendix E – NOx Emissions by County for 2002 and 2009

Table E-1 Reformulated Gasoline Emission Summary by State

Table E-2 Chip Reflash Emission Summary by State

Table E-3 Asphalt Production Plant NOx Emission Summary for 2002 and 2009 by
County

Table E-4 Cement Kiln NOx Emission Summary for 2002 and 2009 by County

Table E-5 Glass and Fiberglass Furnace NOx Emission Summary for 2002 and 2009 by
County

Table E-6 ICI Boiler NOx Area Source Emission Summary for 2002 and 2009 by State

Table E-7 ICI Boiler NOx Point Source Emission Summary for 2002 and 2009 by State

Due to their large size, these tables are being transmitted electronically in the spreadsheet named Appendix_E_NOx_2009.xls. There are separate tabs for each of the tables listed above.

Appendix F – State ICI Boiler Regulations

Due to their large size, these tables are being transmitted electronically in the spreadsheet named Appendix F State ICI Regs.xls. There are separate tabs for each state. In the final report, these tables will be provided in electronic format

APPENDIX G-2

OZONE TRANSPORT COMMISSION Initial List of Control Measures: Appendix B of OTC Control Measures TSD

**Bureau of Air Quality
Department of Environmental Protection**

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Appendix B – Initial List of Control Measures

Measure	Pollutant	Description	Source	Source Code
"CashforClunkers"lawn&gardenprogram		Offer \$75 for owners to turn in old, 2 and 4-stroke lawn & garden equipment and purchase electric or push mower	Non-road	DC RACM - 2003
"Southern"reformulatedgasoline(verylowRVP)	VOC	Very Low RVP	On-road	MA Strategies - 2004
1RegenerativeThermalOxidizer	VOC	Process vent gas treatment	Stationary	NEET Database - ongoing
1ThermalOxidizers	VOC	Process vent gas treatment	Stationary	NEET Database - ongoing
3RCleanMultiFuels-CLEANCOAL	VOC	Work practices (general)	Pollution Prevention	NEET Database - ongoing
3RMultiVenturiOffgasScrubber		Emission capture systems	Stationary	NEET Database - ongoing
4DayWorkWeek/FlexibleWorkSchedules		Encourage employers to adopt a shorter work week, with employees working 4 10-hour days	Mobile	DC RACM - 2003
AcceleratedimplementationofEnhancedI/M	VOC			MA Strategies - 2004
AcceleratedVehicleRetirement	NOx/VOC	Implement an accelerated vehicle retirement, or "scrappage" program in conjunction with an I/M program.	Mobile	EPA Measures - 1999
AccessToJobsProgram		Identifies gaps in transit service between places of residence and places of work for low wage workers	Mobile	DC RACM - 2003
AcetalResinsProduction	VOC		Stationary	EPA Measures - 1999
AcrylicFibers/MonoacrylicFibersProduction	VOC	See Website - http://www.epa.gov/ttn/uatw/gmact/gmactpg.html	Stationary	EPA Measures - 1999
Acrylicplastisols2	VOC	Acrylic plastisols are being investigated as a new type of low-solvent industrial coating. Acrylic polymers offer a number of distinct advantages over polyvinyl chloride such as superior exterior durability and a more favorable environmental image.	Stationary	Regulatory Impact Analysis - 1997
Acrylonitrile-Butadiene-StyreneProduction	VOC	See Website - http://www.epa.gov/ttn/uatw/pr4/pr4pg.html	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
AdaptiveControlTechniquesforEngineManagemen t25	NOx/VOC	Non-linear adaptive control techniques control air/fuel ratios more precisely over a wider range of operating conditions and operate catalytic converters over the narrow range in which they are efficient. Adapts to aging or faulty engines and to varying fuel properties such as volatility.		Regulatory Impact Analysis - 1997
AdditionalTransitStores		Establish additional stationary transit stores in the region	Mobile	DC RACM - 2003
Addzonealerttountywebsite				EACs - 2004
Addselectivecatalyticreduction(SCR)	NOx/PM		Diesel locomotives	Regulatory Impact Analysis - 1997
AdhesiveApplications	VOC	VOC content limits for compliant adhesives + Emission capture and control system for non-compliant adhesives + Transfer efficiency requirements for adhesive applicators + Solvent cleaning, storage and disposal comply with Rule 1171	Stationary	EPA Measures - 1999
Adhesives-industrial	VOC	SCAQMD Rule 1168	Stationary	EPA Measures - 1999
AdipicAcidManufacturing	NOx	Thermal Reduction	Stationary	EPA Measures - 1999
AdipicAcidManufacturing	NOx	Extended Absorption	Stationary	EPA Measures - 1999
Adoptaschoolbusprogram				EACs - 2004
Adoptlocalcleanairpolicy				EACs - 2004
Adoptmeasurestoreducelawnareaandmowerusaget hroughxeriscaping	NOx		Landuse	SAQMD Clean Air Plan - 2003
AdvancedAcetylenicGlycol(AAG)technology9	VOC	To address the need for substrate wetting in waterborne systems, a new-generation surfactant has been developed based on Advanced Acetylenic Glycol (AAG) technology. The AAG technology provides greater flexibility and mobility, as well as other benefits.		Regulatory Impact Analysis - 1997
AdvancedAirfoilRetrofit	NOx/VOC	Rather than using airfoils designed originally for		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
		the airline industry, systems using airfoils designed specifically for wind towers offer substantial savings. One estimate is that substitution of such airfoils onto existing towers causes a 20 - 30 percent increase in electricity generation.		
Aerodynamic devices	NOx		Non-road	Regulatory Impact Analysis - 1997
Acrylonitrile-Butadiene-Styrene Production	VOC	See Website - http://www.epa.gov/ttn/uatw/pr4/pr4pg.html	Stationary	EPA Measures - 1999
Adaptive Control Techniques for Engine Management	NOx/VOC	Non-linear adaptive control techniques control air/fuel ratios more precisely over a wider range of operating conditions and operate catalytic converters over the narrow range in which they are efficient. Adapts to aging or faulty engines and to varying fuel properties such as volatility.		Regulatory Impact Analysis - 1997
Additional Transit Stores		Establish additional stationary transit stores in the region	Mobile	DC RACM - 2003
Add ozone alert to county website				EACs - 2004
Add selective catalytic reduction (SCR)	NOx/PM		Diesel locomotives	Regulatory Impact Analysis - 1997
Adhesive Applications	VOC	VOC content limits for compliant adhesives + Emission capture and control system for non-compliant adhesives + Transfer efficiency requirements for adhesive applicators + Solvent cleaning, storage and disposal comply with Rule 1171	Stationary	EPA Measures - 1999
Adhesives-industrial	VOC	SCAQMD Rule 1168	Stationary	EPA Measures - 1999
Adipic Acid Manufacturing	NOx	Thermal Reduction	Stationary	EPA Measures - 1999
Adipic Acid Manufacturing	NOx	Extended Absorption	Stationary	EPA Measures - 1999
Adopt a school bus program				EACs - 2004
Adopt local clean air policy				EACs - 2004

Measure	Pollutant	Description	Source	Source Code
Adoptmeasurestoreducelawnareaandmowerusaget hroughxeriscaping	NOx		Landuse	SAQMD Clean Air Plan - 2003
AdvancedAcetylenicGlycol(AAG)technology9	VOC	To address the need for substrate wetting in waterborne systems, a new-generation surfactant has been developed based on Advanced Acetylenic Glycol (AAG) technology. The AAG technology provides greater flexibility and mobility, as well as other benefits.		Regulatory Impact Analysis - 1997
AdvancedAirfoilRetrofit	NOx/VOC	Rather than using airfoils designed originally for the airline industry, systems using airfoils designed specifically for wind towers offer substantial savings. One estimate is that substitution of such airfoils onto existing towers causes a 20 - 30 percent increase in electricity generation.		Regulatory Impact Analysis - 1997
Aerodynamicdevices	NOx		Non-road	Regulatory Impact Analysis - 1997
AerosolMetalsMonitor		Ambient Monitoring	Monitoring	NEET Database - ongoing
AerosolPaints	VOC	Bay Area Air Quality Management District's (BAAQMD's) rule + additional reductions from standards similar to those of SCAQMD.	Stationary	EPA Measures - 1999
AerospaceAssemblyandComponentManufacturing Operations	VOC	VOC content limits for coatings, adhesives, and maskents + Cleaning operations and solvent storage and disposal comply with Rule 1171	Stationary	EPA Measures - 1999
AerospaceIndustries	VOC	See Website - http://www.epa.gov/ttn/uatw/aerosp/aeropg.html	Stationary	EPA Measures - 1999
AerospaceManufacturingandRework	VOC	EPA's National Emission Standard for Hazardous Air Pollutant (NESHAP) + area-specific limits for specialty coatings to reflect local plant operations.	Stationary	EPA Measures - 1999
AgriculturalBurning	NOx	Seasonal Ban (Ozone Season)	Stationary	EPA Measures - 1999
Agriculturaldieselengineelectrification	NOx		Offroad	SAQMD Clean Air Plan - 2003
Agriculturaldieselengineelectrification	VOC		Offroad	SAQMD Clean Air Plan - 2003
Agriculturalequipmentretrofits		Require agricultural equipment to be retrofitted	Non-road	DC RACM - 2003

Measure	Pollutant	Description	Source	Source Code
		with emissions controls		
Agriculturalequipmentuserrestrictions		Mandatory restrictions on use of agricultural equipment during Code Red Ozone Action Days	Non-road	DC RACM - 2003
Agriculture:Ammoniarestrictionsonconfinedanima lfeedingoperations	PM2.5		Area	CT Memo - 2005
AIMSurfaceCoatings				CT RACM - 2001
Aircraft:ReduceEmissionsbyAlteringOperations(e. g.,Taxiing)	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
AircraftNon-GateIdling		Sign MOUs with airlines to limit idling of aircraft while taxiing	Area	DC RACM - 2003
AircraftNon-GateIdling				EACs - 2004
Aircraftsurfacecoating	VOC	MACT	Stationary	EPA Measures - 1999
Aircurtaindestructor-landclearing				EACs - 2004
AirportCleanAirPlan				EACs - 2004
AirportCongestionPricing		Charge higher aircraft landing fees during busy times of day to reduce airport delays and congestion	Area	DC RACM - 2003
AirQualityOutreachandActionDays				EACs - 2004
AirStripping/SoilDecontamination	VOC		Stationary/Are a	SAQMD Clean Air Plan - 2003
Aliphaticisocyanates17	VOC	Urethane technology provides strong linkage for molecules in coatings, and is finding its way into high-solid, powder, and waterborne technologies. For example, isophorone diisocyanate is gathering strength in the powder coatings market, while use of hexamethylene diisocyanate in waterbased coatings is expected to grow. A family of low-temperature unblocking isocyanates as also been developed, and is being marketed to the painting		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
		and coating industry.		
AlkalineFuelCells(AFC)6	NOx/VOC	Long used by NASA on space missions, these cells can achieve power generating efficiencies of up to 70 percent. They use alkaline potassium as the electrolyte. Until recently they were too costly for commercial applications, but several companies are examining ways to reduce costs and improve operating flexibility.		Regulatory Impact Analysis - 1997
AllowDistricttoOptintoTest-onlyProgram	NOx		On-Road Mobile	SAQMD Clean Air Plan - 2003
Alternatecommuteinfrastructure				EACs - 2004
Alternateworkschedules				EACs - 2004
Alternativefuelforcountyfleets				EACs - 2004
alternativefuelshuttlebuses	NOx		Landuse	SAQMD Clean Air Plan - 2003
Alternativefuelvehicles				EACs - 2004
AluminumRollingMills	VOC	Add-on controls achieving a 95-percent reduction in VOC emissions and/or VOC-content standards for lubricants	Stationary	EPA Measures - 1999
AmbientEngineeringBiofilters	VOC	Emission capture systems	Stationary	NEET Database - ongoing
AminoResinsProductions	VOC	See Website - http://www.epa.gov/ttn/uatw/amino/aminopg.html	Stationary	EPA Measures - 1999
Ammonia-NaturalGas-FiredReformers	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
Ammonia-NaturalGas-FiredReformers	NOx	Oxygen Trim + Water Injection	Stationary	EPA Measures - 1999
Ammonia-NaturalGas-FiredReformers	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
Ammonia-NaturalGas-FiredReformers	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
Ammonia-NaturalGas-FiredReformers	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
AmmoniaPlants	NOx	Controls based on those for process heaters and industrial boilers	Stationary	EPA Measures - 1999
AmmoniaProduction;FeedstockDesulfurization	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
Amorphoussilicon(a-Si)	NOx/VOC	A solar film on which research efforts is focused because of its potential for increased unit efficiency and ease of manufacturing. Efficiency gains are evident: from less than one percent in 1974 to 10.2 percent in 1994. Researchers are currently seeking laboratory efficiency ratings of 13 percent. Lower efficiency ceiling of a-Si compared to crystalline silicon offset by lower manufacturing costs.		Regulatory Impact Analysis - 1997
Announceozoneactiondaysonradio				EACs - 2004
AnnualGasolineVehiclePollutionFee		Levy an annual fee on petroleum-powered vehicles based on mileage driven and emission rates.	Mobile	DC RACM - 2003
Anti-idlingprovisions-dieselengines-				EACs - 2004
Applicationofagriculturalpesticides	VOC	Water based carriers for pesticides	Stationary	EPA Measures - 1999
AppointOzoneActionCoordinator-				EACs - 2004
Askgaragestoplimitidling				EACs - 2004
Asphalt/CoalTarApplications-MetalPipes	VOC	Pending	Stationary	EPA Measures - 1999
AsphalticConcrete;RotaryDryer;ConversionPlant	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
AsphaltProcessing	VOC	Pending	Stationary	EPA Measures - 1999
AsphaltRoofingManufacturing	VOC	Pending	Stationary	EPA Measures - 1999
AugmenttruckandBusInspectionswithCommunity-basedInspections	NOx		On-Road Mobile	SAQMD Clean Air Plan - 2003
AutoandLightDutyTruck(SurfaceCoating)	VOC	Pending	Stationary	EPA Measures - 1999
AutobodyRefinishing	VOC	High-volume, low pressure (HVL) spray systems + gun-cleaning equipment + proper disposal for clean-up solvents + California's Best Available Retrofit Control Technology limits.	Stationary	EPA Measures - 1999
AutobodyRefinishingControls				EACs - 2004
AutomatedElectricVehicleChargingSystem15	NOx/VOC	Development of an automated system that would dock, or couple, an EV to a battery charging system. The project will address inductively and		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
		conductively coupled systems. This project is expected to build on previous research into such an automated system, resulting in a prototype test unit of a commercially viable system. This project, if successful, will improve the perceived convenience and, thus, commercial viability of EVs.		
Automatespeedenforcementandlowerthespeedlimit to55mphforheavydutyvehicles	NOx		On-Road Mobile	SAQMD Clean Air Plan - 2003
AutomaticVehicleLocatorSystem		System would provide bus location information to WMATA dispatchers. This would decrease wait time and improve on-time arrival/departure.	Mobile	DC RACM - 2003
AutomobileandLight-dutytrucksurfacecoatingoperations	VOC	Low solvent coatings	Stationary	EPA Measures - 1999
AutomobileAssembly	VOC	Spray booth abatement at 5.8 lbs/gal solids applied + without spray booth abatement, a 10-lbs/gal level	Stationary	EPA Measures - 1999
AutomobileInsuranceisChargedatthepumporinsuranceismileagebased	NOx			SAQMD Clean Air Plan - 2003
Automobilerefinishing	VOC	Federal Rule	Stationary	EPA Measures - 1999
Automobilerefinishing	VOC	FIP Rule (VOC content & TE)	Stationary	EPA Measures - 1999
Automobilerefinishing	VOC	CARB BARCT limits	Stationary	EPA Measures - 1999
Availability/ExtentofNOxControls	NOx		Stationary	EPA Measures - 1999
BACTandoffsetsfornewormodifiedpointsources				EACs - 2004
Bakeries		Adopt SCAQMD Rule 1153: Commercial Bakery Ovens	Area	DC RACM - 2003
Banactivitiessuchas2-strokeengines	NOx		Offroad	SAQMD Clean Air Plan - 2003
Banactivitiessuchas2-strokeengines	VOC		Offroad	SAQMD Clean Air Plan - 2003
Banopenburningduringozoneaction				EACs - 2004
Banorlimitopenburning				EACs - 2004
Banorrestrictuseofrecreationalvehicles	NOx		Offroad	SAQMD Clean Air Plan - 2003

Measure	Pollutant	Description	Source	Source Code
Banorrestrictuseofrecreationalvehicles	VOC		Offroad	SAQMD Clean Air Plan - 2003
BantheuseofVOC-bornepesticidesonspare-the-airdays	VOC		Area	SAQMD Clean Air Plan - 2003
Bantransfersystems inPetroleumDryCleaning	VOC		Stationary/Area	SAQMD Clean Air Plan - 2003
BanVehiclesfromDowntownStreets		Restrict private vehicle use in certain downtown areas during business hours , encouraging pedestrian and bicycle use instead.	Mobile	DC RACM - 2003
BatchProcesses	VOC	Current technologies achieving 98-percent control efficiency with exemptions based on considerations of volatility, annual emissions and flow rate.	Stationary	EPA Measures - 1999
BEPs				EACs - 2004
BestAvailableRetrofitControlTechnology(BARCT)for10tpyVOCsources	VOC			MA Strategies - 2004
Bestmgtpactices-engines				EACs - 2004
Bestpracticesforfueling				EACs - 2004
BeverageCanCoating	VOC	Incineration	Stationary	EPA Measures - 1999
Beveragecansurfacecoatingindustry	VOC	Low solvent inks or Incineration	Stationary	EPA Measures - 1999
Biodiesel(On-Road)		Require regional use of biodiesel fuel for on-road vehicles	Mobile	DC RACM - 2003
Biodieselreadytrucks				EACs - 2004
Bio-dieselsolidwastetrucks				EACs - 2004
BiofiltrationofGaseousEffluents	VOC	Process vent gas treatment	Stationary	NEET Database - ongoing
Biomimeticcoatings1	VOC	Synthetic routes are being developed for new water soluble polymers to enable the formulation of effective and durable waterborne protective coatings. The aim is to develop novel water-soluble polymers which on evaporation of water undergo a phase transformation similar to protein		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
		molecules where hydrophobic moieties, present in the polymer, form the matrix of the film. This approach to produce zero-VOC solvent systems avoids the water sensitivity and reductions in performance and durability experienced by the current generation of water-based coatings.		
Blowdowncontrolsatnaturalgaspipelinecompressor stations	NOx/VOC		Stationary	CT Memo - 2005
BoatManufacturing	VOC	Pending	Stationary	EPA Measures - 1999
BoilersandProcessHeatersinPetroleumRefineries	NOx	NOx emission limit + Approved Alternative Emission Control Plan + Continuous NOx stack monitoring	Stationary	EPA Measures - 1999
BoseAnti-AirPollutantandEnergyConservationSystem		Fund trial of Bose system in local vehicle fleets. The Bose system is a mechanical system that uses high-speed centrifugal separation to remove light combustible gases from the exhaust stream. The system can be used with all types of fuel.	Mobile	DC RACM - 2003
Brownfielddevelopment				EACs - 2004
BuildPark&RideLotsatMajorIntersectionsofCommuterHighways		Construct new park & ride commuter lots along HOV facilities	Mobile	DC RACM - 2003
Bulkgasolineterminals	VOC	Vapor collection systems + Vapor tight tank trucks, Water-based cements	Stationary	EPA Measures - 1999
BulkTerminals	VOC	Balanced/Adsorber/Testing	Stationary	EPA Measures - 1999
burningduringtheozoneseason	NOx		Area	SAQMD Clean Air Plan - 2003
burningduringtheozoneseason	VOC		Area	SAQMD Clean Air Plan - 2003
BusTraffic-SignalPre-emption	NOx		Landuse	SAQMD Clean Air Plan - 2003
ButylRubberProduction	VOC	See Website - http://www.epa.gov/ttn/uatw/pr1/pr1pg.html	Stationary	EPA Measures - 1999
Buyinbulk;lesspackaging				EACs - 2004
By-ProductCokeManufacturing;OvenUnderfiring	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
C.G.S.section29-252			Stationary	CT Memo - 2005
Cadmiumtelluride	NOx/VOC	A solar film on which research effort is focused due to its likely ease of production, likely improved efficiency and ability to compete with crystalline silicon modules. Laboratory efficiency ratings have reached 16 percent with commercial efficiency of 6 percent. Research indicates manufacturing techniques are likely very low cost, including electrodeposition, spraying, and high rate evaporation.		Regulatory Impact Analysis - 1997
CaliforniaLowEmissionVehiclePhase2(CALEV2)	NOx/VOC		Mobile	CT Memo - 2005
CaliforniaLow-EmissionVehicles	NOx/VOC	Adopt the California low-emission vehicle program	Mobile	EPA Measures - 1999
Californiaperiodicheavy-dutydieselvehiclefleetinspectionprogram	PM2.5		Mobile	CT Memo - 2005
CaliforniaSpark-IgnitionEngines(Dec2000)				TX SIP - 2000-2004
CANSOLVRegenerableSO2ControlTechnology	PM	Emission capture systems	Stationary	NEET Database - ongoing
CapandTradeEmissionsReductionProgramsimilartoRECLAIM	NOx		Stationary	SAQMD Clean Air Plan - 2003
CapandTradeEmissionsReductionProgramsimilartoRECLAIM	VOC		Stationary	SAQMD Clean Air Plan - 2003
CARBDieselFuel(On-Road)		Implement CARB diesel fuel standards	Mobile	DC RACM - 2003
CarbonBlackManufacture	VOC	Flare	Stationary	EPA Measures - 1999
CarbonBlackProduction	VOC	Pending	Stationary	EPA Measures - 1999
CarbonylSulfideProduction(Misc.OrganicNESHA P)	VOC	Pending	Stationary	EPA Measures - 1999
CARBsetstighterrequirementsformanufacturerstocertifyemissionsfromnewpassengervehicles	NOx		On-Road Mobile	SAQMD Clean Air Plan - 2003
CARBsetstighterrequirementsfornewpassengervehicles(LEVIII)	NOx		On-Road Mobile	SAQMD Clean Air Plan - 2003

Measure	Pollutant	Description	Source	Source Code
Cargohandlingequipmentatshipbuildersandports	PM2.5		Mobile	CT Memo - 2005
CarSharingProgram		Fund incentives for new car sharing customers (I.e. Flexcar or Zipcar services)	Mobile	DC RACM - 2003
CarSharingPrograms	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
CatalyticOxidationwithHeatrecovery	VOC	Emission capture systems	Stationary	NEET Database - ongoing
CelluloseAcetateManufacture	VOC	Carbon Adsorption	Stationary	EPA Measures - 1999
CelluloseFoodCasingManufacturing	VOC	Pending	Stationary	EPA Measures - 1999
Cement	NOx	Production procedures + SCR -2.8lb/ton	Stationary	EPA Measures - 1999
CementKilnEmissionLimits(March2003)				TX SIP - 2000-2004
CementKilns	NOx	Continuous monitoring and recording of NOx emissions + NOx emission limit	Stationary	EPA Measures - 1999
CementKilns	NOx	Require combustion controls and post-combustion controls (SNCR) to achieve reductions of up to 70 percent on certain processes	Stationary	EPA Measures - 1999
CementManufacturing-Dry	NOx	Selective Non-Catalytic Reduction - NH3 Based	Stationary	EPA Measures - 1999
CementManufacturing-Dry	NOx	Mid-Kiln Firing	Stationary	EPA Measures - 1999
CementManufacturing-Dry	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
CementManufacturing-Dry	NOx	Selective Non-Catalytic Reduction - Urea Based	Stationary	EPA Measures - 1999
CementManufacturing-Dry	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
CementManufacturing-Wet	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
CementManufacturing-Wet	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
CementManufacturing-Wet	NOx	Mid-Kiln Firing	Stationary	EPA Measures - 1999
CeramicClayManufacturing;Drying	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
CeramicTechnologyforAdvancedHeatEngines4		Ceramic engine components are desirable for their durability and longevity.		Regulatory Impact Analysis - 1997
Certainfinalrecommendedmeasuresforresidential,commercialandindustrialsector			Stationary	CT Memo - 2005

Measure	Pollutant	Description	Source	Source Code
Cetaneadditivestodieselfuel				EACs - 2004
Changeworkschedule				EACs - 2004
ChangeZoningOrdinancestoEncourageIn-fill	NOx		Landuse	SAQMD Clean Air Plan - 2003
CHANoxRemovalSystem34	NOx	This system removes NOx pollutants from small stationary diesel engines. There are currently no feasible controls for these engines.		Regulatory Impact Analysis - 1997
CharcoalManufacturing	VOC	Incineration	Stationary	EPA Measures - 1999
CleanAirPartnersProgram		This program motivates individuals to take voluntary actions to reduce emissions on Ozone Action Days	Mobile	DC RACM - 2003
CleanFuelsfromMunicipalSolidWaste,Biomass,an dOtherWasteFuels22	NOx/VOC	Development and demonstration of technologies and/or production processes to synthesize clean alternative fuels from various energy-rich, renewable sources, such as biomass, municipal solid waste, landfill gas, and other low cost or “free” waste fuels. The project is expected to result in pilot-scale production demonstrations, scale-up process design and cost analysis, overall environmental impact analysis, and projections for ultimate clean fuel costs and availability, for alternative fuels that are determined to offer the most promise		Regulatory Impact Analysis - 1997
Cleaningsolvents	VOC	Disposal practices for waste solvents	Stationary	EPA Measures - 1999
Clearcoatpowder21	VOC	The Low Emission Paint Consortium is researching the development of a powder clearcoat, although this type of coating has many difficulties to overcome in terms of durability and appearance in comparison with current methods. A trade-off with powder coatings is that powder requires higher bake requirements and new equipment and application systems.		Regulatory Impact Analysis - 1997
Clusterdevelopment,SmartGrowth,				EACs - 2004

Measure	Pollutant	Description	Source	Source Code
CNGRefuseHaulers		Purchase new CNG powered trash trucks instead of conventional diesel vehicles	Mobile	DC RACM - 2003
CNGRentalCars		Purchase CNG rental cars for use in the region	Mobile	DC RACM - 2003
CNGTaxicabs		Replace regional taxicabs 7 years or older with CNG or other alternative fuel vehicles	Mobile	DC RACM - 2003
CoalCleaning-ThermalDryer;FluidizedBed	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
CoatingofMetalPartsandProducts	VOC	VOC content limits for coatings + Solvent cleaning and storage comply with Rule 1171 + Emission collection and control system for non-compliant coatings	Stationary	EPA Measures - 1999
Coemployees-restrictmowingduring				EACs - 2004
CokeBy-ProductPlants	VOC	Pending	Stationary	EPA Measures - 1999
CokeOvens:Pushing,QuenchingandBatteryStacks	VOC	Pending	Stationary	EPA Measures - 1999
CokeOvens:TopSideandDoorLeaks	VOC	Established MACT and LAER emission limits for coke batteries	Stationary	EPA Measures - 1999
Coldcleaning	VOC	NESHAP/MACT	Stationary	EPA Measures - 1999
Coldcleaning	VOC	Airtight degreasing system	Stationary	EPA Measures - 1999
Coldcleaning	VOC	SCAQMD 1122 (VOC content limit)	Stationary	EPA Measures - 1999
Coldlensblockingmethods("LoctiteColdBloc")6	VOC	New uv-curing "cold" blocking adhesive enables optical manufacturers to produce lens surfaces that are practically distortion free, and virtually eliminates the environmental concerns (solvents) of the current technique. This technique facilitates easy debonding using a variety of debonding agents and techniques. The adhesive is a significant advance in the lens blocking process, as it eliminates heat-induced blocking strain, which is the most significant problem encountered with current hot pitch blocking methods. Process reduces costly processing time, and is compatible with existing tooling.		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
Combifilter-ActiveDieselParticulateFilter	VOC/PM	Emission capture systems	Stationary	NEET Database - ongoing
CombustionTurbines	VOC	Pending	Stationary	EPA Measures - 1999
Commercial,InstitutionalIncinerators	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
CommercialEthyleneOxideSterilization	VOC	Control emissions from the main sterilizer vent and vacuum pump drains at 99-percent from ethylene oxide (EtO) sterilizers using greater than 600 pounds of EtO per year.	Stationary	EPA Measures - 1999
Community-basedshuttlesystem	NOx		Landuse	SAQMD Clean Air Plan - 2003
Commuteemissionreductionprogram				EACs - 2004
CommuterChoiceProgram				EACs - 2004
CommuterChoiceTaxCredit		Employers subsidize employees' monthly transit or vanpool costs and receive a tax credit for incurred expenses.	Mobile	DC RACM - 2003
Commutesolutionsprograms-				EACs - 2004
Compatibleinnovativecoatings27	VOC	Ciba is working on developing compatible powder, high solid and waterborne epoxy systems. Examples of areas of research include: new high flow solid epoxy resin for powder coating applications with smoother appearance; and new waterborne epoxy resins and epoxy hardeners with environmental advantages.		Regulatory Impact Analysis - 1997
comprees;carpool,flexible,etc				EACs - 2004
ComputerizedTrafficSignals	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
Congestionmitigation-trafficssignal				EACs - 2004
CongestionPricingonLowOccupancyVehicles		Impose a fee on vehicles containing two or fewer persons that use designated roadways during the peak AM period	Mobile	DC RACM - 2003
Conserveenergyincountyproperty				EACs - 2004
Constructionequipment				EACs - 2004

Measure	Pollutant	Description	Source	Source Code
Construction equipment retrofits with oxidation catalysts and particulate filters	NOx/VOC		Mobile	CT Memo - 2005
Construction equipment user restrictions		Restrict use of construction equipment during expected ozone exceedance days	Non-road	DC RACM - 2003
Construction retrofits		Require construction equipment operating on state and local contracts to be retrofitted with particulate filters and/or oxidation catalysts	Non-road	DC RACM - 2003
Consumer & commercial products				CT RACM - 2001
Contract incentives for low emission vehicles				EACs - 2004
Control of Power Electronics	NOx/VOC	Manual adjustment of individual controls on individual tower systems is expensive and time consuming. By using computers and electronic components on the systems it becomes possible to manipulate an entire farm in real time. It is expected that systems would also be able to adjust to extreme weather conditions independently, thus avoiding catastrophic failures.		Regulatory Impact Analysis - 1997
Control of Extended Idling of Buses and Trucks		Step-up enforcement of existing regulations to prevent extended vehicle idling	Mobile	DC RACM - 2003
Control of Engines > 500 HP				EACs - 2004
Control of Gaseous Emissions from Active Landfills	VOC	Landfill sampling and monitoring requirements + Collection system with treatment and control device for VOC	Stationary	EPA Measures - 1999
Control of Parking at Schools		Restrict high school students from driving to and parking at high schools when bus service is available.	Mobile	DC RACM - 2003
Controls on Power Plants Outside Nonattainment Area		Require power plants operating in counties adjacent to Washington nonattainment area to install nonattainment area controls	Stationary	DC RACM - 2003
Conversion of Product; Acid Cleaning Bath	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
Convenience Commercial Centers in Residential Area		Change zoning ordinances to allow neighborhood-	Mobile	DC RACM - 2003

Measure	Pollutant	Description	Source	Source Code
s		serving retail establishments in residential areas		
ConversiontoAlternativeFueledVehiclesProgram	NOx/VOC	Tax credits or deductions to for conversion to or purchase of alternative fueled vehicles and alternative fuel stations	Mobile	EPA Measures - 1999
Convertoff-roaddieselequipmenttozeroemission,e.g.,electrification,battery,solar,orfuelcell	NOx		Offroad	SAQMD Clean Air Plan - 2003
Convertoff-roaddieselequipmenttozeroemission,e.g.,electrification,battery,solar,orfuelcell	VOC		Offroad	SAQMD Clean Air Plan - 2003
Converttouseoflow-sulfurgasoline				EACs - 2004
Coolcitiesprogram				EACs - 2004
Copperindiumdiselenide(CIS)	NOx/VOC	A solar film on which research effort is focused due to its ability to withstand outdoor exposure without significant deterioration. This film also appears easier to produce and gain efficiencies than alternatives. In 1995, a laboratory efficiency rate of 17.1 percent was recorded with 10.2 percent for a production prototype module.		Regulatory Impact Analysis - 1997
CRT(R)Filter	PM		Mobile	NEET Database - ongoing
CrystallineSilicon	NOx/VOC	Silicon crystals were the first technology explored and applied to market devices. Research continues because it is the only technology with demonstrated long term reliability, competitive cost, and high efficiency. Newer cells have demonstrated a 24% efficiency rating. Commercial production modules are expected with an efficiency of 14%.		Regulatory Impact Analysis - 1997
CTNOx“RACT”Regulation	NOx		Stationary	CT Memo - 2005
CutbackAsphalt	VOC	VOC content limit	Stationary	EPA Measures - 1999
CutbackAsphalt	VOC	Switch to emulsified asphalts	Stationary	EPA Measures - 1999
CutbackAsphalt				EACs - 2004

Measure	Pollutant	Description	Source	Source Code
CutbackAsphalt:IncreasedRuleEffectiveness	VOC		Stationary	CT Memo - 2005
DecliningCapRule	VOC	Cap and Trade program with an allowable emissions cap for major VOC sources set below a baseline. Emission allotments for each cap can be sold and traded for emission reductions below the assigned cap.	Stationary	EPA Measures - 1999
Degreasing	VOC	Alternative cleaners or cleaning processes.	Stationary	EPA Measures - 1999
Delay/reschedulelandscaping				EACs - 2004
DemonstrationoftheUseofFastChargedElectricGro undSupportEquipmentasaMeansofReducingAirpor tEmissions	NOx/PM	Fugitive emission controls	Stationary	NEET Database - ongoing
Developandfundaprogramforneighborhoodelectric vehicles	NOx		On-Road Mobile	SAQMD Clean Air Plan - 2003
Developastationcar/lowemissionvehicleshareprogr am	NOx		On-Road Mobile	SAQMD Clean Air Plan - 2003
DiaphragmSensors(FiberOptics)26				Regulatory Impact Analysis - 1997
DieselandGasolineTrucksandBusesRetrofitwith3- waycatalystsongasoline- burningheavydutytrucksthatcurrentlyhave2- waycatalystsornocatalysts	NOx		Mobile	SAQMD Clean Air Plan - 2003
DirectInjection(DI)DieselV66	VOC	Targeted for the executive car, minivan, multipurpose, and sport utility market, cost effective features include electronic rotary fuel injection, fixed-geometry inlet prot, conventional wastegated turbocharger, cooled EGR, with advanced control algorithms, and an oxidation catalyst. As with the CIDI engine, the V6 DI engine will benefit from current DI engine research of light weight engines and parts and emission control technologies.		Regulatory Impact Analysis - 1997
DiscountMulti-TripBusFares		Introduce discount programs reducing cost of multiple bus rides through purchase of pass books	Mobile	DC RACM - 2003

Measure	Pollutant	Description	Source	Source Code
		(e.g. 10-trip tickets)		
Distributedgenerators--R.C.S.A.section22a-174-42	NOx/VOC		Stationary	CT Memo - 2005
Downtownshuttles;rapidtransitbus				EACs - 2004
Drive-throughfacilitiesonozone				EACs - 2004
drivingtoschool				EACs - 2004
DryCleaning-Perchloroethylene	VOC	MACT (condensers/adsorbers)	Stationary	EPA Measures - 1999
Drycleaning-petroleum	VOC	MACT	Stationary	EPA Measures - 1999
Dual-curephotocatalysttechnology12	VOC	Low-solvent, low-VOC coatings are being developed that use photocatalysts to react with the coating material and accelerate the curing process. These photocatalysts allow the coatings to cure from liquids to solids quickly under UV or visible light. A family of such photocatalysts is being developed and tested. Major uses include tape adhesives and protective topcoats for aircraft. Development of solventless backing saturants for electrical tape backings has essentially been completed. Optimal dual cure resin formulations have been identified and utilized in preparing complete tape constructions.		Regulatory Impact Analysis - 1997
Dual-curephotocatalysttechnology4	VOC	Dual-cure photocatalyst technology is being researched for a variety of coating and adhesive uses, such as aerospace topcoats, aerospace primers, and solventless manufacture of tape backings. Significant progress has been made in improving the performance of the urethane/acrylate formulation being used for the aerospace topcoat application. Technical challenges have continued with the aerospace primer formulation.		Regulatory Impact Analysis - 1997
Dualfueldiesel/LNGpower	NOx		Diesel locomotives	Regulatory Impact Analysis - 1997
EarlyBusEngineReplacement		Replaces high-polluting diesel engines in	Mobile	DC RACM - 2003

Measure	Pollutant	Description	Source	Source Code
		WMATA buses with new diesel engines		
EastmanAQ1350polymer2	VOC	A new water-dispersible hot-melt adhesive raw material, which can form the basis for use in a variety of applications including nonwoven products such as disposable diapers, packaging, bookbinding and labels. Products containing the water-dispersible adhesive are more easily repulped or recycled.		Regulatory Impact Analysis - 1997
EB-curableepoxyresinsforcomposites9	VOC	Major advancement in the formulation of epoxy resin systems capable of being cured (cross-linked) by ionizing radiation. This development could be the link in making polymer matrix composites and adhesives a cost-effective system for manufacturing a broad range of products in both high-tech and high-volume commercial applications. Further optimization of these resin systems is currently being performed for specific aircraft, aerospace, and defense applications. Substantially reduced manufacturing costs (25-65% less expensive) and curing times; and improvements in part quality and performance.		Regulatory Impact Analysis - 1997
ECMBfundedenergyefficiencyandrenewableenergy measures	NOx/VOC		Stationary	CT Memo - 2005
EDV®WetScrubbingSystem	NOx/PM	Emission capture systems	Stationary	NEET Database - ongoing
EK35®	PM	Fugitive emission controls	Stationary	NEET Database - ongoing
Electrical/electroniccoating	VOC	SCAQMD Rule	Stationary	EPA Measures - 1999
Electrical/electroniccoating	VOC	MACT	Stationary	EPA Measures - 1999
Electricforklifts-county				EACs - 2004
Electricnewforkliftpurchasesandforkliftrentals	NOx		Offroad	SAQMD Clean Air Plan - 2003
Electricnewforkliftpurchasesandforkliftrentals	VOC		Offroad	SAQMD Clean Air Plan - 2003
Electrificationandsingleenginetaxiing	NOx		Offroad	SAQMD Clean Air Plan - 2003

Measure	Pollutant	Description	Source	Source Code
Electrification or Use of Alternate Fuels in Airport Service Equipment	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
Electron Beam (EB) curing	VOC	EB curing with existing technology has already been shown to dramatically reduce or eliminate solvent emissions in wood finishing. Currently, new advances in EB equipment and processes are being developed, including a new, lower-energy EB system and a new transport system for the EB treatment of powders. EB processes result in improved product performance and higher productivity, but require different curing equipment, and in some cases, application may be more difficult.		Regulatory Impact Analysis - 1997
Electronic Fuel Injection for CNG, LNG, LPG, Hydrogen	NOx/VOC		Mobile	NEET Database - ongoing
Eliminate Timed Parking	NOx		Land use	SAQMD Clean Air Plan - 2003
Eliminate vehicle emission control				EACs - 2004
Emission-based parking fees	NOx		Land use	SAQMD Clean Air Plan - 2003
Emission-based registration fees	NOx		Land use	SAQMD Clean Air Plan - 2003
Emissions from Decontamination of Soil	VOC	Approved VOC mitigation plan + Monitor for VOC contamination	Stationary	EPA Measures - 1999
Emissions from Petroleum Storage Tanks		Adopt SCAQMD Rule 1178: Further Reductions of VOC Emissions from Storage Tanks at Petroleum Facilities	Area	DC RACM - 2003
Employee Commute Options	NOx/VOC	In areas not already required to implement an ECO program, evaluate the potential emission reductions to be achieved by implementing such a program and consider its implementation to achieve additional reductions and stabilize mobile source emissions.	Mobile	EPA Measures - 1999
Employer Metro Shuttle Bus Services		Provide incentives for businesses to provide employee shuttle service to the nearest rail or	Mobile	DC RACM - 2003

Measure	Pollutant	Description	Source	Source Code
		transit stop		
EmployerOutreach(PrivateSector)		Provide regional outreach to encourage large private-sector employers to voluntarily implement alternative commute strategies to reduce vehicle trips to work sites	Mobile	DC RACM - 2003
EmployerOutreach(PublicSector)		Provide regional outreach to encourage public-sector employers to voluntarily implement alternative commute strategies to reduce vehicle trips to work sites	Mobile	DC RACM - 2003
EmptytheERCbank	VOC			MA Strategies - 2004
EmulsifiedAsphalt	VOC	VOC content limit	Stationary	EPA Measures - 1999
Encourage55duringpeakozone				EACs - 2004
Energizer-reducevehiclefleet;90%offorklifts-battery				EACs - 2004
Energyconservation-33citybuildings				EACs - 2004
Energyconservationatcobldgs				EACs - 2004
Energyconservationplan				EACs - 2004
Energyefficientbuildings				EACs - 2004
Energyefficientpublicbuildings				EACs - 2004
Energyefficiencyprograms				EACs - 2004
Energyreduction-LNB;waterbasedpaints				EACs - 2004
EngineTestFacilities	VOC	Pending	Stationary	EPA Measures - 1999
EnhancedRuleComplianceatExistingStationarySources	NOx	Step up enforcement of and compliance with existing rules for emissions control by stationary sources	Stationary	DC RACM - 2003
EnhancedRuleEffectiveness				CT RACM - 2001
Enhancerealtimetrafficinformationtoallowdriverstomakebetterdecisionsaboutwhenandwheretotravel	NOx		Landuse	SAQMD Clean Air Plan - 2003

Measure	Pollutant	Description	Source	Source Code
Ensure emission reductions in SEPs,				EACs - 2004
EnviroKleen®	PM	Adhesives and sealants	Pollution Prevention	NEET Database - ongoing
EOLYSSystem33	PM	Combines the use of a particulate trap with the action of the catalytic additive to ensure that particulates are destroyed during combustion.		Regulatory Impact Analysis - 1997
EPANOxSIPcall				CT RACM - 2001
EpichlorohydrinElastomersProduction	VOC	See Website - http://www.epa.gov/ttn/uatw/pr1/pr1pg.html	Stationary	EPA Measures - 1999
EpoxyResinsProduction	VOC	See Website - http://www.epa.gov/ttn/uatw/pr2/pr2pg.html	Stationary	EPA Measures - 1999
EquipmentleaksforVOCinthesyntheticorganicchemicalmanufacturingindustry	VOC	Monitoring and repair	Stationary	EPA Measures - 1999
EquipmentleaksofVOCfromon-shorenaturalgasprocessingplants	VOC	Inspection and repair	Stationary	EPA Measures - 1999
EquipmentleaksofVOCinpetroleumrefineries	VOC	Inspection and repair	Stationary	EPA Measures - 1999
EstablishaHeavy-DutySmogCheckProgram	NOx		On-Road Mobile	SAQMD Clean Air Plan - 2003
Establishcleanairlabeling,energyconservationandpubliceducationprograms	NOx		Offroad	SAQMD Clean Air Plan - 2003
EstablishCleanFleetRequirementsforpublicfleets	NOx		On-Road Mobile	SAQMD Clean Air Plan - 2003
Ethanolalternativefuelvehicles				EACs - 2004
EthyleneProcesses	VOC	Pending	Stationary	EPA Measures - 1999
Ethylene-PropyleneRubberProduction	VOC	See Website - http://www.epa.gov/ttn/uatw/pr1/pr1pg.html	Stationary	EPA Measures - 1999
ExhaustGasRecirculation27	NOx	This specific technology makes EGR more effective by ensuring EGR is applied at the high loads heavy-duty diesel engines (HDDEs) often run at, and providing an acceptable air flow to ensure		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
		the fuel is being burnt efficiently. Continuing work includes assessments of EGR on engine durability, particulate emissions improvements, and transient engine performance.		
ExplosivesProduction	VOC	Pending	Stationary	EPA Measures - 1999
Extendenergyefficiencyrequirements				EACs - 2004
ExtendRampMetering		Install signals to control flow of vehicles at selected freeway ramp entrances to maintain level of service	Mobile	DC RACM - 2003
FabricCoating	VOC	Incineration	Stationary	EPA Measures - 1999
FederalMotorVehicleControlprogram				CT RACM - 2001
FederalNon-roadGasolineEngines				CT RACM - 2001
FederalNon-roadHeavyDutydieselengines				CT RACM - 2001
FerroalloysProduction:SilicomanganeseandFerroManganese	VOC	National emission standards for hazardous air pollutants (NESHAP) for production of ferroalloys	Stationary	EPA Measures - 1999
FiberglassManufacturing;Textile-TypeFiber;RecupFurnaces	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
Flares	VOC	Fugitive emission controls	Stationary	NEET Database - ongoing
FlexiblePolyurethaneFoamFabricationOperations	VOC	Pending	Stationary	EPA Measures - 1999
FlexiblePolyurethaneFoamProduction	VOC	See Website - http://www.epa.gov/ttn/uatw/foam/foampg.html	Stationary	EPA Measures - 1999
FlexibleVinylandUrethaneCoatingandPrinting	VOC	Low solvent coatings or Incineration	Stationary	EPA Measures - 1999
FluidCatalyticCrackingUnits;CrackingUnit	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
Foam-controlagents11	VOC	More sophisticated foam-control agents are being developed and used as formulators move from solvent-based to waterborne coating systems. Foam is a common problem in waterborne systems, and it can adversely affect the coating's appearance and durability. Prudent use of foam control agents can minimize or eliminate the adverse effects of		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
		foam without impacting other surface properties.		
Formregionalstakeholdersgroup				EACs - 2004
FuelCellTechnologies7	NOx/VOC	Development and demonstration of fuel cell technologies for on- and off-road mobile sources to improve the commercial viability of fuel cells, including improvements in power density, fuel storage, reformer efficiency, system integration, and cost reduction. This program is expected to result in several projects that would support promising fuel cell technologies for on- and off-road vehicles. Fuel cell technologies that will be considered include proton exchange membrane, solid oxide, direct methanol, phosphoric acid, and molten carbonate. Mobile source applications that will be considered in this category include light-, medium-, and heavy-duty on-road vehicles, locomotives, ships, utility vehicles, neighborhood electric vehicles, and other off-road equipment applications. Peripheral technologies involving fuel infrastructure, on-board fuel storage, and hydrogen reforming shall be included if they have potential to advance the commercial viability of fuel cell applications.		Regulatory Impact Analysis - 1997
FuelCellVehicle8	NOx/VOC	Chrysler is teaming with Delphi Energy and Engine Management Systems to build within two years a “proof of concept” fuel cell vehicle that runs on gasoline. The technology will be a five-step process to refine gasoline on-board a vehicle. This could improve fuel efficiency by 50 percent, provide up to 400 miles range, be at least 90 percent cleaner, and cost no more than a current mid-size car.		Regulatory Impact Analysis - 1997
FuelFiredEquipment;ProcessHeaters,PropaneGas	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
FugitiveEmissions:Oil&GasProductionFacilities&	VOC	Identify all major & critical equipment + I & M	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
ConveyingStations		Program		
Galliumarsenide	NOx/VOC	It is possible to increase any solar cell's efficiency by focusing a more direct source of solar energy on it. In application, cells need to withstand extreme conditions in order to see an efficiency increase. This alloy demonstrated an efficiency of 28 percent under concentrated sunlight.		Regulatory Impact Analysis - 1997
Garbagetruckregulation	PM2.5		Mobile	CT Memo - 2005
GasChromatograph	VOC	Ambient Monitoring	Monitoring	NEET Database - ongoing
Gascollectionsystem-solidwastelandfill				EACs - 2004
Gaseous-andLiquid-FueledInternalCombustionEngines	VOC	VOC and NOx emission limits for stationary and portable engines	Stationary	EPA Measures - 1999
Gas-firedWaterHeaters,SmallBoilers,andProcessHeaters(Dec2002)				TX SIP - 2000-2004
GasolineDistribution(Stage1)	VOC	Improved seals on storage tanks and performing leak detection and repair of vapor and liquid leaks from equipment used to transfer gasoline Vapor processors are to collect and treat or recover vapors displaced during cargo tank loading operations.	Stationary	EPA Measures - 1999
GasolineLoadingRacks:IncreasedRuleEffectiveness	VOC		Stationary	CT Memo - 2005
GasProductionandfromPetroleumProduction	VOC		Industrial Process	SAQMD Clean Air Plan - 2003
GasTaxIncrease		Increase state and local gas taxes to add 10% to purchase price of gasoline. Use proceeds to fund regional transit operations.	Mobile	DC RACM - 2003
GasTurbines	NOx	Detailed equations 40 CFR 60.332	Stationary	EPA Measures - 1999
GasTurbines	NOx	Limits for turbines burning natural gas at 25-42 ppm and as low as 9-15 ppm.+ limits for turbines burning distillate oil at 65 ppm or below, and as	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
		low as 25-42 ppm..		
GasTurbines	NOx	Turbines >25 MW: Wet injection + SCR - 9 ppm (0.04 lb/mm Btu & 8-25 MW: Low NOx combustion - 42 ppm	Stationary	EPA Measures - 1999
GasTurbines-JetFuel	NOx	Selective Catalytic Reduction + Water Injection	Stationary	EPA Measures - 1999
GasTurbines-JetFuel	NOx	Water Injection	Stationary	EPA Measures - 1999
GasTurbines-NaturalGas	NOx	Steam Injection	Stationary	EPA Measures - 1999
GasTurbines-NaturalGas	NOx	Selective Catalytic Reduction + Low NOx Burners	Stationary	EPA Measures - 1999
GasTurbines-NaturalGas	NOx	Selective Catalytic Reduction + Steam Injection	Stationary	EPA Measures - 1999
GasTurbines-NaturalGas	NOx	Selective Catalytic Reduction + Water Injection	Stationary	EPA Measures - 1999
GasTurbines-NaturalGas	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
GasTurbines-NaturalGas	NOx	Water Injection	Stationary	EPA Measures - 1999
GasTurbines-Oil	NOx	Selective Catalytic Reduction + Water Injection	Stationary	EPA Measures - 1999
GasTurbines-Oil	NOx	Water Injection	Stationary	EPA Measures - 1999
Gearbox	NOx/VOC	The turbine blades' rotation causes wear on a system's gearbox. By using improved gearboxes, it is possible to lower total system cost (gearboxes are approximately 20 percent of total system cost). If as projected, infinitely variable speed tower systems become available, then it would no longer be necessary to maintain a gearbox in a tower system. Improved design and use of composite materials will reduce system cost by increasing the system's life span.		Regulatory Impact Analysis - 1997
Glass	NOx	Pressed / blown - LNB 13 lb/ton & Container - LNB 6 lb/ton & Flat - SNCR 9.5 lb.ton	Stationary	EPA Measures - 1999
GlassForming	VOC	Silicon-water emulsions replacement for petroleum-based lubricants	Stationary	EPA Measures - 1999
GlassFurnaces	NOx	Combustion modifications, process changes and post-combustion controls (SNCR) + RACT limits	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
		of 5.3-5.5 lbs NOx/ton of glass removed with limits as low as 4.0 lb NOx/ton of glass removed + coordinate installation of controls with routine furnace rebuilds		
GlassMeltingFurnaces	NOx	NOx emission limit + Continuous NOx monitoring from unit + Alternative Emission Control Plan	Stationary	EPA Measures - 1999
GraphicArts	VOC	VOC content of graphic art materials + VOC content limit for fountain solutions + Emission control system for non-compliant materials + Solvent cleaning and storage and disposal of VOC-containing materials comply with Rule 1171	Stationary	EPA Measures - 1999
GraphicArts-RotogravureandFlexographicPrinting	VOC	Permanent total enclosures, where possible + VOC limits for inks + low-solvent clean-up solutions	Stationary	EPA Measures - 1999
HazardousOrganicNESHAP(CoveringManufactureOfSeveralOrganicCompounds)	VOC	See Website - http://www.epa.gov/ttn/uatw/hon/honpg.html	Stationary	EPA Measures - 1999
Heavy-DutyDieselEngineStandards--R.C.S.A.section22a-174-36a	NOx/VOC		Mobile	CT Memo - 2005
heavydutydieselstrategies				EACs - 2004
Heavy-DutyDieselVehicleControlsandFuels	VOC		Mobile	CT Memo - 2005
Heavy-DutyDieselVehicles:FuelAdditivesToReduceEmissions	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
Heavy-DutyDieselVehicles:IntermodalFreightEfficiency	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
Heavy-DutyDieselVehicles:PreventiveMaintenance/RebuildRequirementsatSpecificMileage	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
Heavy-DutyDieselVehicles:ReduceTruckIdling	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
Heavy-DutyDieselVehicles:RequireLowSulfurDieselFuelEarlierThanEPAMayRequire	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
Heavy-DutyDieselVehicles:RequireUseOfOxydieselFuel	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
Heavy-DutyDieselVehicles:Upgrading/RetrofitEquipment	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
Heavy-DutyEngineECMRecalibration	NOx		On-Road Mobile	SAQMD Clean Air Plan - 2003
HeavyTransitRail	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
HighAirFlowBio-airVENT	VOC	Process vent gas treatment	Stationary	NEET Database - ongoing
Highcetanedieselfuelforonroadvehicles		Require onroad diesel vehicles to use high cetane fuel	Mobile	DC RACM - 2003
Highsolidsaliphaticpolyurethanecoatings16	VOC	Three novel approaches to high solids aliphatic polyurethane coatings have been developed: a 100% solids, VOC free, instant setting, aliphatic polyurethane coating system; a high solids mix-and-apply aliphatic polyurethane coating system; and a high solids single component aliphatic polyurethane coating system.		Regulatory Impact Analysis - 1997
HighwayPaints	VOC	VOC content limits	Stationary	EPA Measures - 1999
HighwayVehicles-Gasoline	NOx/VOC	Transportation Control Package	Mobile	EPA Measures - 1999
HighwayVehicles-Gasoline	NOx/VOC	Federal Reformulated Gasoline	Mobile	EPA Measures - 1999
HighwayVehicles-LDGasoline	NOx/VOC	High Enhanced I/M	Mobile	EPA Measures - 1999
HighwayVehicles-LDGasoline	NOx/VOC	Fleet ILEV	Mobile	EPA Measures - 1999
HighwayVehicles-LDGasTrucks	NOx/VOC	Tier 2 Standards	Mobile	EPA Measures - 1999
Homeheatingoilsulfurreductions	PM2.5		Mobile	CT Memo - 2005
Hotmeltspraytool1	VOC	A newly-redesigned, solvent-free, hot melt spray tool is under to development to reduce VOC emissions. Further details not available.		Regulatory Impact Analysis - 1997
HOVlanes-I-24,40				EACs - 2004
HRVOCWebpage(Dec2004)				TX SIP - 2000-2004

Measure	Pollutant	Description	Source	Source Code
Hybridvehicles				EACs - 2004
HydrazineProduction	VOC	Pending	Stationary	EPA Measures - 1999
Hyper-immobilizingAbsorbentDeactivatingPowder	VOC	Manufacturing (general)	Pollution Prevention	NEET Database - ongoing
HazardousOrganicNESHAP(CoveringManufactureOfSeveralOrganicCompounds)	VOC	See Website - http://www.epa.gov/ttn/uatw/hon/honpg.html	Stationary	EPA Measures - 1999
Heavy-DutyDieselEngineStandards--R.C.S.A.section22a-174-36a	NOx/VOC		Mobile	CT Memo - 2005
heavydutydieselstrategies				EACs - 2004
Heavy-DutyDieselVehicleControlsandFuels	VOC		Mobile	CT Memo - 2005
Heavy-DutyDieselVehicles:FuelAdditivesToReduceEmissions	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
Heavy-DutyDieselVehicles:IntermodalFreightEfficiency	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
Heavy-DutyDieselVehicles:PreventiveMaintenance/RebuildRequirementsatSpecificMileage	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
Heavy-DutyDieselVehicles:ReduceTruckIdling	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
Heavy-DutyDieselVehicles:RequireLowSulfurDieselFuelEarlierThanEPAMayRequire	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
Heavy-DutyDieselVehicles:RequireUseOfOxydieselFuel	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
Heavy-DutyDieselVehicles:Upgrading/RetrofitEquipment	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
Heavy-DutyEngineECMRecalibration	NOx		On-Road Mobile	SAQMD Clean Air Plan - 2003
HeavyTransitRail	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
HighAirFlowBio-airVENT	VOC	Process vent gas treatment	Stationary	NEET Database - ongoing
Highcetanediesel fuel for on road vehicles		Require on road diesel vehicles to use high cetane fuel	Mobile	DC RACM - 2003
High solids aliphatic polyurethane coatings 16	VOC	Three novel approaches to high solids aliphatic polyurethane coatings have been developed: a 100% solids, VOC free, instant setting, aliphatic polyurethane coating system; a high solids mix-and-apply aliphatic polyurethane coating system; and a high solids single component aliphatic polyurethane coating system.		Regulatory Impact Analysis - 1997
Highway Paints	VOC	VOC content limits	Stationary	EPA Measures - 1999
Highway Vehicles-Gasoline	NOx/VOC	Transportation Control Package	Mobile	EPA Measures - 1999
Highway Vehicles-Gasoline	NOx/VOC	Federal Reformulated Gasoline	Mobile	EPA Measures - 1999
Highway Vehicles-LD Gasoline	NOx/VOC	High Enhanced I/M	Mobile	EPA Measures - 1999
Highway Vehicles-LD Gasoline	NOx/VOC	Fleet ILEV	Mobile	EPA Measures - 1999
Highway Vehicles-LD Gas Trucks	NOx/VOC	Tier 2 Standards	Mobile	EPA Measures - 1999
Home heating oils sulfur reductions	PM2.5		Mobile	CT Memo - 2005
Hot melt spray tool 1	VOC	A newly-redesigned, solvent-free, hot melt spray tool is under development to reduce VOC emissions. Further details not available.		Regulatory Impact Analysis - 1997
HOV lanes-I-24,40				EACs - 2004
HR VOC Webpage (Dec 2004)				TX SIP - 2000-2004
Hybrid vehicles				EACs - 2004
Hydrazine Production	VOC	Pending	Stationary	EPA Measures - 1999
Hyper immobilizing Absorbent Deactivating Powder	VOC	Manufacturing (general)	Pollution Prevention	NEET Database - ongoing
I/M for heavy-duty diesel vehicles	PM2.5		Mobile	CT Memo - 2005
IC Engines	NOx	Lean burn - LEC 2 gm/bhp-hr & Rich Burn - SNCR 2 gm/bhp-hr & Diesel - SCR 2 gm/bhp-hr	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
ICEngines-Gas,Diesel,LPG	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ICEngines-Gas,Diesel,LPG	NOx	Ignition Retard	Stationary	EPA Measures - 1999
ICBoilers-Coal/Cyclone	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ICBoilers-Coal/Cyclone	NOx	Natural Gas Reburn	Stationary	EPA Measures - 1999
ICBoilers-Coal/Cyclone	NOx	Coal Reburn	Stationary	EPA Measures - 1999
ICBoilers-Coal/Cyclone	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ICBoilers-Coal/FBC	NOx	Selective Non-Catalytic Reduction - Urea	Stationary	EPA Measures - 1999
ICBoilers-Coal/Stoker	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ICBoilers-Coal/Wall	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ICBoilers-Coal/Wall	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ICBoilers-Coal/Wall	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ICBoilers-Coke	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ICBoilers-Coke	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ICBoilers-Coke	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ICBoilers-DistillateOil	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
ICBoilers-DistillateOil	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ICBoilers-DistillateOil	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ICBoilers-DistillateOil	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ICBoilers-LiquidWaste	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ICBoilers-LiquidWaste	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ICBoilers-LiquidWaste	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ICBoilers-LiquidWaste	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
ICBoilers-LPG	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
ICBoilers-LPG	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ICBoilers-LPG	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
ICIBoilers-LPG	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-MSW/Stoker	NOx	Selective Non-Catalytic Reduction - Urea	Stationary	EPA Measures - 1999
ICIBoilers-NaturalGas	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-NaturalGas	NOx	Oxygen Trim + Water Injection	Stationary	EPA Measures - 1999
ICIBoilers-NaturalGas	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
ICIBoilers-NaturalGas	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-NaturalGas	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ICIBoilers-ProcessGas	NOx	Oxygen Trim + Water Injection	Stationary	EPA Measures - 1999
ICIBoilers-ProcessGas	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-ProcessGas	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
ICIBoilers-ProcessGas	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ICIBoilers-ResidualOil	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
ICIBoilers-ResidualOil	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-ResidualOil	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ICIBoilers-ResidualOil	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-Wood/Bark/Stoker	NOx	Selective Non-Catalytic Reduction - Urea	Stationary	EPA Measures - 1999
I/Mforheavy-dutydieselvehicles	PM2.5		Mobile	CT Memo - 2005
ICEngines	NOx	Lean burn - LEC 2 gm/bhp-hr & Rich Burn - SNCR 2 gm/bhp-hr & Diesel -SCR 2 gm/bhp-hr	Stationary	EPA Measures - 1999
ICEngines-Gas,Diesel,LPG	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ICEngines-Gas,Diesel,LPG	NOx	Ignition Retard	Stationary	EPA Measures - 1999
ICIBoilers-Coal/Cyclone	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-Coal/Cyclone	NOx	Natural Gas Reburn	Stationary	EPA Measures - 1999
ICIBoilers-Coal/Cyclone	NOx	Coal Reburn	Stationary	EPA Measures - 1999
ICIBoilers-Coal/Cyclone	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-Coal/FBC	NOx	Selective Non-Catalytic Reduction - Urea	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
ICIBoilers-Coal/Stoker	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-Coal/Wall	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-Coal/Wall	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-Coal/Wall	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ICIBoilers-Coke	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-Coke	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ICIBoilers-Coke	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-DistillateOil	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
ICIBoilers-DistillateOil	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ICIBoilers-DistillateOil	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-DistillateOil	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-LiquidWaste	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ICIBoilers-LiquidWaste	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-LiquidWaste	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-LiquidWaste	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
ICIBoilers-LPG	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
ICIBoilers-LPG	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ICIBoilers-LPG	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-LPG	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-MSW/Stoker	NOx	Selective Non-Catalytic Reduction - Urea	Stationary	EPA Measures - 1999
ICIBoilers-NaturalGas	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-NaturalGas	NOx	Oxygen Trim + Water Injection	Stationary	EPA Measures - 1999
ICIBoilers-NaturalGas	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
ICIBoilers-NaturalGas	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-NaturalGas	NOx	Low NOx Burners	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
ICIBoilers-ProcessGas	NOx	Oxygen Trim + Water Injection	Stationary	EPA Measures - 1999
ICIBoilers-ProcessGas	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-ProcessGas	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
ICIBoilers-ProcessGas	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ICIBoilers-ResidualOil	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
ICIBoilers-ResidualOil	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-ResidualOil	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ICIBoilers-ResidualOil	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ICIBoilers-Wood/Bark/Stoker	NOx	Selective Non-Catalytic Reduction - Urea	Stationary	EPA Measures - 1999
Idlingrestriction-heavy-dutydiesel				EACs - 2004
Idlingrestrictionsforconstructionequipment		Limit idling by construction equipment	Non-road	DC RACM - 2003
Idlingrestrictionsforlawn&gardenequipment		Limit idling by commercial lawn & garden equipment	Non-road	DC RACM - 2003
Implementaprogramtoreplacecatalystsinlightdutyvehiclesandtrucks,includingSUVs	NOx		On-Road Mobile Light Duty Vehicle Technology Control Measures	SAQMD Clean Air Plan - 2003
ImplementNOxRACTBeyondNonattainmentArea		Take credit for reductions due to implementation of NOx RACT rules beyond nonattainment area	Area	DC RACM - 2003
ImplementOTCBeyondNonattainmentArea		Take credit for reductions due to implementation of OTC measures beyond nonattainment area	Area	DC RACM - 2003
Implementregistrationandinspectionprogramforheavy-duty(>50hp)off-road diesele engines	NOx		Offroad	SAQMD Clean Air Plan - 2003
Implementregistrationandinspectionprogramforheavy-duty(>50hp)off-road diesele engines	VOC		Offroad	SAQMD Clean Air Plan - 2003
Implementsteps-purchasealternative				EACs - 2004

Measure	Pollutant	Description	Source	Source Code
Implement toll booths and pay-to-drive roads	NOx		Land use	SAQMD Clean Air Plan - 2003
Implement traffic calming measures to reduce vehicle speed and encourage bicycle and pedestrian activity	NOx		Land use	SAQMD Clean Air Plan - 2003
Implement VOC RACT Beyond Nonattainment Area		Take credit for reductions due to implementation of VOC RACT rules beyond nonattainment area	Area	DC RACM - 2003
Improved Airfoil Materials	NOx/VOC	Utilization of wind power necessitates a device (airfoil) which will capture wind energy. By using newer materials and changing the number of blades, improved energy generation and lower costs may be achieved. Improved airfoil design using composite materials (fiberglass, wood/epoxy) and fewer blades (2-3) will reduce system cost while increasing energy conversions/efficiencies.		Regulatory Impact Analysis - 1997
Incident mgmt/Intelltrans.System				EACs - 2004
Include fuel efficiency/emission				EACs - 2004
Include NOx screening in the Heavy-Duty Vehicle Inspection Program	NOx		On-Road Mobile	SAQMD Clean Air Plan - 2003
Increased compliance with the anti-idling restriction; school bus and truck stop signage; state and local police enforcement	PM2.5		Mobile	CT Memo - 2005
Increase the price of gasoline to pay for damages of pollution, cost of global warming (greenhouse gases), and cost of petroleum dependency	NOx		Land use	SAQMD Clean Air Plan - 2003
Increase Vehicle Registration Fee and Traffic and Parking Violation Fines	NOx		Land use	SAQMD Clean Air Plan - 2003
Industrial, Institutional and Commercial Boilers, Steam Generators, and Process Heaters	NOx	NOx emission limit, methods to meet the limit is not specified	Stationary	EPA Measures - 1999
Industrial and Commercial Boilers	NOx	Limits for boilers larger than 100 mmBtu/hr at levels of 0.15 lb/mmBtu or below for coal and 0.05 lb/mmBtu for oil and gas + limits for mid-size boilers between 50-100 mmBtu/hr at 0.10	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
		lb/mmBtu for gas, 0.12 lb/mmBtu for distillate oil and 0.30 lb/mmBtu for residual oil, 0.38 lb/mmBtu for coal + boilers smaller than 50 mmBtu/hr make annual "tune-ups" to minimize excess air		
IndustrialBoilers	VOC	Pending	Stationary	EPA Measures - 1999
IndustrialCoalCombustion	NOx	RACT to 50 tpy (Low NOx Burners)	Stationary	EPA Measures - 1999
IndustrialCoalCombustion	NOx	RACT to 25 tidy (Low NOx Burners)	Stationary	EPA Measures - 1999
Industrialequipmentretrofits		Require industrial equipment to be retrofitted with emissions controls	Non-road	DC RACM - 2003
IndustrialIncinerators	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
Industrialmaintenancecoating	VOC	AIM Coating Federal Rule	Stationary	EPA Measures - 1999
Industrialmaintenancecoating	VOC	South Coast Phase II	Stationary	EPA Measures - 1999
Industrialmaintenancecoating	VOC	South Coast Phase I	Stationary	EPA Measures - 1999
Industrialmaintenancecoating	VOC	South Coast Phase III	Stationary	EPA Measures - 1999
IndustrialNaturalGasCombustion	NOx	RACT to 25 tpy (Low NOx Burners)	Stationary	EPA Measures - 1999
IndustrialNaturalGasCombustion	NOx	RACT to 50 tpy (Low NOx Burners)	Stationary	EPA Measures - 1999
IndustrialOilCombustion	NOx	RACT to 25 tpy (Low NOx Burners)	Stationary	EPA Measures - 1999
IndustrialOilCombustion	NOx	RACT to 50 tpy (Low NOx Burners)	Stationary	EPA Measures - 1999
IndustrialProcessCoolingTowers	VOC	See Website - http://www.epa.gov/ttn/uatw/mactfnl.html	Stationary	EPA Measures - 1999
Industrialsurfacecoating:Largeappliances	VOC	Low solvent coatings	Stationary	EPA Measures - 1999
Industrialsurfacecoating:surfacecoatingofplasticpartsforbusinessmachines	VOC	Low VOC coatings	Stationary	EPA Measures - 1999
IndustrialWastewaterTreatment	VOC	Wastewater stream enclosed to point of treatment + require 95-percent control of volatiles + regulations on wastewater streams with lower VOC concentration than those identified in EPA's Control Techniques Guideline (CTG)	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
IndustrialWastewaterTreatment/PubliclyOwnedTreatmentWorks	NOx/VOC		Area	CT Memo - 2005
Injector/IntensifierSystem24	NOx	This system is designed to reduce NOx emissions from heavy-duty diesel vehicles through a new natural gas fuel injector system. The natural gas injector system will be fabricated installed and certified.		Regulatory Impact Analysis - 1997
In-Process;BituminousCoal;CementKiln	NOx	Selective Non-Catalytic Reduction - Urea based	Stationary	EPA Measures - 1999
In-Process;BituminousCoal;LimeKiln	NOx	Selective Non-Catalytic Reduction - Urea based	Stationary	EPA Measures - 1999
In-Process;ProcessGas;CokeOven/BlastFurnaces	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
In-Process;ProcessGas;CokeOvenGas	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
In-ProcessFuelUse;BituminousCoal;General	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
In-ProcessFuelUse;NaturalGas;General	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
In-ProcessFuelUse;ResidualOil;General	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
Installpassivegasvents-landfill				EACs - 2004
InstallRemoteSensingtoIdentifyHigh-EmittingVehicles	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
Institutional/CommercialBoilers	VOC	Pending	Stationary	EPA Measures - 1999
IntegratedIronandSteelManufacture	VOC	Pending	Stationary	EPA Measures - 1999
IntellidyneFuelEconomizer	NOx/VOC	Other	Stationary	NEET Database - ongoing
InternalCombustionEngines-Gas	NOx	Ignition Retard	Stationary	EPA Measures - 1999
InternalCombustionEngines-Gas	NOx	Air-to-Fuel Ratio	Stationary	EPA Measures - 1999
InternalCombustionEngines-Gas	NOx	Air-to-Fuel Ratio + Ignition Retard	Stationary	EPA Measures - 1999
InternalCombustionEngines-Gas	NOx	L-E (Medium Speed)	Stationary	EPA Measures - 1999
InternalCombustionEngines-Gas	NOx	L-E (Low Speed)	Stationary	EPA Measures - 1999
InternalCombustionEngines-Gas	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
InternalCombustionEngines-Oil	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
InternalCombustionEngines-Oil	NOx	Ignition Retard	Stationary	EPA Measures - 1999
IntroducelowNOxenginesearly	NOx		M3 On-road heavy duty diesel	Regulatory Impact Analysis - 1997
Iron&SteelMills-Annealing	NOx	Low NOx Burners + Selective Catalytic Reduction	Stationary	EPA Measures - 1999
Iron&SteelMills-Annealing	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
Iron&SteelMills-Annealing	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
Iron&SteelMills-Annealing	NOx	Low NOx Burners + Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
Iron&SteelMills-Annealing	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
Iron&SteelMills-Annealing	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
Iron&SteelMills-Galvanizing	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
Iron&SteelMills-Galvanizing	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
Iron&SteelMills-Reheating	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
Iron&SteelMills-Reheating	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
Iron&SteelMills-Reheating	NOx	LEA	Stationary	EPA Measures - 1999
IronandSteelIndustry/SinterPlants	VOC	Deoiling control limit on oil and grease for mill scale.	Stationary	EPA Measures - 1999
IronandSteelFoundries	VOC	SCAQMD's rule for combustion gas limiting the discharge of carbon monoxide	Stationary	EPA Measures - 1999
IronandSteelMills	NOx	Low NOx burners and FGR for reheat furnaces + SCR and low NOx burners for annealing furnaces + low NOx burners and FGR for galvanizing furnaces	Stationary	EPA Measures - 1999
IronFoundries	VOC	Pending	Stationary	EPA Measures - 1999
IronProduction;BlastFurnace;BlastHeatingStoves	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
KraftPulpMills	NOx	Industrial boilers regulated same as Industrial and Commercial Boilers + SNCR for recovery boilers + lime kilns regulated same as Cement Kilns	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
LABSORB(tm)RegenerativeSO2scrubbing	PM	Emission capture systems	Stationary	NEET Database - ongoing
LandDeveelopmentCode/Tree				EACs - 2004
LandfillGases	VOC	New Source Performance Standard + lower size cutoff based on area's major source definition + regulating landfills with more than 500,000 tons in place.	Stationary	EPA Measures - 1999
Landscape/treeordinances				EACs - 2004
Landscapeordinance-noresid				EACs - 2004
LargeAppliance(SurfaceCoating)	VOC	Pending	Stationary	EPA Measures - 1999
LargeWaterHeatersandSmallBoilers	NOx	NOx emission limit + Compliance Certification Program for equipment manufacturers + Retrofit Compliance Certification Program	Stationary	EPA Measures - 1999
LaserRemoteSensing	NOx	Real-time monitoring/information display	Models and Environmental Software	NEET Database - ongoing
LaserRemoteSensing	NOx	Ambient modeling/simulation	Models and Environmental Software	NEET Database - ongoing
LasIR	NOx	Emissions Monitoring	Monitoring	NEET Database - ongoing
Lawn&gardenequipmen:				EACs - 2004
Lawnandgardenequipmentbuybackandscrappageprograms	NOx/VOC		Mobile	CT Memo - 2005
LawnMowerandGardenReplacementProgram	NOx/VOC	Voluntary program to replace gasoline powered lawn and garden equipment with electric powered equipment	Mobile	EPA Measures - 1999
LeanBurnCatalysts31	NOx	Major challenges in this project are the development of a catalyst with the three following attributes: 1) Sufficient and selective lean NOx activity; 2) Robustness, particularly hydrothermal durability; and 3) economically practical.		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
		Development of a lean burn catalyst is critical for the commercialization of the lean burn engine.		
LeatherTanningandFinishingOperations	VOC	Pending	Stationary	EPA Measures - 1999
LimeKilns	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
LimeKilns	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
LimeKilns	NOx	Selective Non-Catalytic Reduction - Urea Based	Stationary	EPA Measures - 1999
LimeKilns	NOx	Selective Non-Catalytic Reduction - NH3Based	Stationary	EPA Measures - 1999
LimeKilns	NOx	Mid-Kiln Firing	Stationary	EPA Measures - 1999
Limitingpleasurecraft/vehicleuseabove100F	VOC		Offroad	SAQMD Clean Air Plan - 2003
LNGCombustionTechnologyforLocomotives23	NOx/VOC	Develop and demonstrate, via the GasRail USA program, LNG combustion technology for locomotives capable of reducing NOx emissions by 75% or more compared to conventional diesel technology. In partnership with Southwest Research Institute, the project would optimize a newly developed combustion technology in a multi-cylinder locomotive engine. This will be followed by integration of the combustion system into one or more Metrolink passenger locomotives for operation in the SCAQMD Basin.		Regulatory Impact Analysis - 1997
LongerTermEngineRetrofitforAftertreatment	NOx		Offroad	SAQMD Clean Air Plan - 2003
LoTOx(tm)Technology	NOx	Emission capture systems	Stationary	NEET Database - ongoing
LowEmission,AlternativeFuelTechnologiesforOn-RoadApplications21	NOx/VOC	Development and demonstration of low-emission, alternative fuel technologies for light-, medium-, and heavy-duty mobile sources. Alternative clean fuels that will be considered include, but are not necessarily limited to, natural gas, propane, methanol, ethanol, hydrogen, and Hythane. In addition, reformulated gasoline and diesel fuels have been developed that produce lower emissions. When used in conjunction with advanced emission controls, additives, and new engine technologies,		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
		these appear to have promise to meet some CARB LEV standards.		
Low-EmissionAsphalt		Adopt SCAQMD Rules 1108: Cutback Asphalt (less than 0.5% VOC evaporating at 260F) and 1108.1: Emulsified Asphalt (less than 3% VOC evaporating at 260F)	Area	DC RACM - 2003
Lowemissiondieselforfleets				EACs - 2004
Low-EmissionFurnaces		Adopt SCAQMD Rule 1111: NOx Emissions from Natural Gas Fired, Fan-Type Central Furnaces (no more than 40 nanograms of NOx per joule of useful heat)	Area	DC RACM - 2003
Low-emissionsagriculturalequipment		Require sale of low-emissions agricultural equipment in region	Non-road	DC RACM - 2003
Low-emissionsconstructionequipment		Require sale of low-emissions construction equipment in region	Non-road	DC RACM - 2003
Low-EmissionWaterHeaters		Adopt SCAQMD Rule 1121: Control of NOx from Residential Type Natural Gas Fired Water Heaters	Area	DC RACM - 2003
Loweremissionstandardsforgasolinetrucks	NOx		On-Road Mobile	SAQMD Clean Air Plan - 2003
Lowerspeedlimit-55fortrucksduring				EACs - 2004
Low-NOxDieselFuel(On-Road)		Require regional use of low-NOx fuel for on-road diesel vehicles	Mobile	DC RACM - 2003
lowNOxlimitsforboilers/heatersintheheatinputrange of 75,000 to 2,000,000 Btu/hr	NOx		Stationary	SAQMD Clean Air Plan - 2003
LowReidVaporPressureGas				EACs - 2004
LowSfuels-asap				EACs - 2004
Low-SulfurFuelforElectricGeneratingUnits--R.C.S.A.section22a-174-19a	PM2/5		Stationary	CT Memo - 2005
LowSulfurFuelOil(340ppm);80percentReductionin SOx Emissions	NOx		Marine (commercial)	Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
Low-sulfurTypeIIfuelsinallvehicles				EACs - 2004
LowVOCstrippingmaterial				EACs - 2004
LABSORB(tm)RegenerativeSO2scrubbing	PM	Emission capture systems	Stationary	NEET Database - ongoing
LandDevevelopmentCode/Tree				EACs - 2004
LandfillGases	VOC	New Source Performance Standard + lower size cutoff based on area's major source definition + regulating landfills with more than 500,000 tons in place.	Stationary	EPA Measures - 1999
Landscape/treeordinances				EACs - 2004
Landscapeordinance-noresid				EACs - 2004
LargeAppliance(SurfaceCoating)	VOC	Pending	Stationary	EPA Measures - 1999
LargeWaterHeatersandSmallBoilers	NOx	NOx emission limit + Compliance Certification Program for equipment manufacturers + Retrofit Compliance Certification Program	Stationary	EPA Measures - 1999
LaserRemoteSensing	NOx	Real-time monitoring/information display	Models and Environmental Software	NEET Database - ongoing
LaserRemoteSensing	NOx	Ambient modeling/simulation	Models and Environmental Software	NEET Database - ongoing
LasIR	NOx	Emissions Monitoring	Monitoring	NEET Database - ongoing
Lawn&gardenequipmen:				EACs - 2004
Lawnandgardenequipmentbuybackandscrappageprograms	NOx/VOC		Mobile	CT Memo - 2005
LawnMowerandGardenReplacementProgram	NOx/VOC	Voluntary program to replace gasoline powered lawn and garden equipment with electric powered equipment	Mobile	EPA Measures - 1999
LeanBurnCatalysts31	NOx	Major challenges in this project are the development of a catalyst with the three following attributes: 1) Sufficient and selective lean NOx		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
		activity; 2) Robustness, particularly hydrothermal durability; and 3) economically practical. Development of a lean burn catalyst is critical for the commercialization of the lean burn engine.		
LeatherTanningandFinishingOperations	VOC	Pending	Stationary	EPA Measures - 1999
LimeKilns	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
LimeKilns	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
LimeKilns	NOx	Selective Non-Catalytic Reduction - Urea Based	Stationary	EPA Measures - 1999
LimeKilns	NOx	Selective Non-Catalytic Reduction - NH3Based	Stationary	EPA Measures - 1999
LimeKilns	NOx	Mid-Kiln Firing	Stationary	EPA Measures - 1999
Limitingpleasurecraft/vehicleuseabove100F	VOC		Offroad	SAQMD Clean Air Plan - 2003
LNGCombustionTechnologyforLocomotives23	NOx/VOC	Develop and demonstrate, via the GasRail USA program, LNG combustion technology for locomotives capable of reducing NOx emissions by 75% or more compared to conventional diesel technology. In partnership with Southwest Research Institute, the project would optimize a newly developed combustion technology in a multi-cylinder locomotive engine. This will be followed by integration of the combustion system into one or more Metrolink passenger locomotives for operation in the SCAQMD Basin.		Regulatory Impact Analysis - 1997
LongerTermEngineRetrofitforAftertreatment	NOx		Offroad	SAQMD Clean Air Plan - 2003
LoTOx(tm)Technology	NOx	Emission capture systems	Stationary	NEET Database - ongoing
LowEmission,AlternativeFuelTechnologiesforOn-RoadApplications21	NOx/VOC	Development and demonstration of low-emission, alternative fuel technologies for light-, medium-, and heavy-duty mobile sources. Alternative clean fuels that will be considered include, but are not necessarily limited to, natural gas, propane, methanol, ethanol, hydrogen, and Hythane. In addition, reformulated gasoline and diesel fuels have been developed that produce lower emissions.		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
		When used in conjunction with advanced emission controls, additives, and new engine technologies, these appear to have promise to meet some CARB LEV standards.		
Low-EmissionAsphalt		Adopt SCAQMD Rules 1108: Cutback Asphalt (less than 0.5% VOC evaporating at 260F) and 1108.1: Emulsified Asphalt (less than 3% VOC evaporating at 260F)	Area	DC RACM - 2003
Lowemissiondieselforfleets				EACs - 2004
Low-EmissionFurnaces		Adopt SCAQMD Rule 1111: NOx Emissions from Natural Gas Fired, Fan-Type Central Furnaces (no more than 40 nanograms of NOx per joule of useful heat)	Area	DC RACM - 2003
Low-emissionsagriculturalequipment		Require sale of low-emissions agricultural equipment in region	Non-road	DC RACM - 2003
Low-emissionsconstructionequipment		Require sale of low-emissions construction equipment in region	Non-road	DC RACM - 2003
Low-EmissionWaterHeaters		Adopt SCAQMD Rule 1121: Control of NOx from Residential Type Natural Gas Fired Water Heaters	Area	DC RACM - 2003
Loweremissionstandardsforgasolinetrucks	NOx		On-Road Mobile	SAQMD Clean Air Plan - 2003
Lowerspeedlimit-55fortrucksduring				EACs - 2004
Low-NOxDieselFuel(On-Road)		Require regional use of low-NOx fuel for on-road diesel vehicles	Mobile	DC RACM - 2003
lowNOxlimitsforboilers/heatersintheheatinputrang eof75,000to2,000,000Btu/hr	NOx		Stationary	SAQMD Clean Air Plan - 2003
LowReidVaporPressureGas				EACs - 2004
LowSfuels-asap				EACs - 2004
Low-SulfurFuelforElectricGeneratingUnits-- R.C.S.A.section22a-174-19a	PM2/5		Stationary	CT Memo - 2005

Measure	Pollutant	Description	Source	Source Code
LowSulfurFuelOil(340ppm);80percentReductioninSOxEmissions	NOx		Marine (commercial)	Regulatory Impact Analysis - 1997
Low-sulfurTypeIIfuelsinallvehicles				EACs - 2004
LowVOCstrippingmaterial				EACs - 2004
Magneticallycontrolleddepositionofmetalsusinggas plasma ⁷	VOC	Methods of spraying materials on a substrate in a controlled manner are being researched in an attempt to eliminate the waste inherent in the present process. Thin layers of secondary material are plated on substrates either by plating or spraying processes. Plating operations produce large amounts of hazardous liquid waste. Spraying, while one of the less waste intensive methods, produces 'over spray' which is waste that is a result of the uncontrolled nature of the spray stream. In many cases the over spray produces a hazardous waste.		Regulatory Impact Analysis - 1997
MagneticTapes(SurfaceCoating)	VOC	See Website - http://www.epa.gov/ttn/uatw/magtape/magtappg.html	Stationary	EPA Measures - 1999
MagnetWireCoatingOperations	VOC	VOC content limits for compliant coatings + Emission capture and control system for non-compliant coatings + Cleaning operations and solvent storage and disposal comply with Rule 1171	Stationary	EPA Measures - 1999
Mandatorychipreflashingforheavy-dutydieseltrucks	NOx/VOC		Mobile	CT Memo - 2005
MandatoryFacilityReductiononSpareAirDays	NOx		Stationary	SAQMD Clean Air Plan - 2003
MandatoryFacilityReductiononSpareAirDays	VOC		Stationary	SAQMD Clean Air Plan - 2003
ManufactureOfPaints,Coatings,andAdhesives	VOC	Pending	Stationary	EPA Measures - 1999
ManufactureofPolymericCellularProducts(Foam)	VOC	Discontinue use of VOC blowing agents in non-expandable molding operations + Quantity limitations on blowing agents in expandable	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
		molding operations		
ManufacturingOfNutritionalYeast	VOC	Pending	Stationary	EPA Measures - 1999
ManufacturingTechniques	NOx/VOC	The manufacture of wind tower components is to date a labor intensive process (airfoils are traditionally hand laid). Development and use of computerized mass production techniques promises to reduce lay-up times and increase orders.		Regulatory Impact Analysis - 1997
MarinaGasolineRefueling	VOC	Stage I and II vapor recovery at marinas that dispense more than 10,000 gallons per month.	Stationary	EPA Measures - 1999
MarineCoatingOperations	VOC	VOC content limits for marine coatings + Solvent cleaning and storage comply with Rule 1171 + Emission collection and control system for non-compliant coatings	Stationary	EPA Measures - 1999
MarineEngines:OperatingRestrictions	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
MarineEngines:Refueling/Fuels	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
Marinesurfacecoating	VOC	Add-on control levels	Stationary	EPA Measures - 1999
Marinesurfacecoating	VOC	MACT	Stationary	EPA Measures - 1999
MarineVesselLoadingOperations	VOC	Sets standards and requires RACT for VOC and HAP emissions from new and existing marine tank vessel loading operations Sets NESHAP and requires MACT for existing and new major marine tank vessel loading operations	Stationary	EPA Measures - 1999
Mechanical,electric,railroadcoating	VOC	MACT level of control	Stationary	EPA Measures - 1999
Mechanical,electric,railroadcoating	VOC	SCAQMD Limits	Stationary	EPA Measures - 1999
Media/publicrelationsprogram				EACs - 2004
MedicalWasteIncinerators	NOx	250 ppmv	Stationary	EPA Measures - 1999
MedicalWasteIncinerators	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
MedicalWasteIncinerators	NOx	Controls similar to those for municipal waste combustors	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
Medium-DutyCNGEngineConversionKit18	NOx/VOC	Support for field demonstration of improved software and hardware for a medium-duty CNG engine conversion kit to support the existing medium-duty vehicle population. The SCAQMD previously supported field demonstration of the first generation kit in a contract with Thermo Power Corporation. This kit has operated well in the field. However, improvements in performance and fuel economy are needed if the kit is to be commercially viable. Hardware and software modifications to achieve improved performance and fuel economy are currently being developed. The proposed project would support field demonstration of the second generation kit.		Regulatory Impact Analysis - 1997
MetalCan(SurfaceCoating)	VOC	Pending	Stationary	EPA Measures - 1999
Metalcoil&cancoating	VOC	Incineration	Stationary	EPA Measures - 1999
Metalcoil&cancoating	VOC	MACT	Stationary	EPA Measures - 1999
Metalcoil&cancoating	VOC	BAAQMD Rule 11 Amended	Stationary	EPA Measures - 1999
MetalCoil(SurfaceCoating)	VOC	Pending	Stationary	EPA Measures - 1999
Metalcoilsurfacecoating	VOC	Incineration	Stationary	EPA Measures - 1999
MetalContainer,Closure,andCoilCoatingOperations	VOC	VOC content limits for compliant coatings + Emission capture and control system for non-compliant coatings + Cleaning operations and solvent storage and disposal comply with Rule 1171	Stationary	EPA Measures - 1999
Metalfurniture,appliances,parts	VOC	SCAQMD Limits	Stationary	EPA Measures - 1999
Metalfurniture,appliances,parts	VOC	MACT	Stationary	EPA Measures - 1999
Micro-emulsionstechnology15	VOC	New microemulsion technology creates an effective way to decrease VOC levels up to 50% or more and still maintain effective paint-stripping performance. This solvent technology allows water to be incorporated into hydrocarbon-based paint strippers		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
		while making minimal performance sacrifices.		
MiscellaneousMetalPartsandProducts(SurfaceCoating)	VOC	Pending	Stationary	EPA Measures - 1999
Mobilezonesprayboothventilationsystem6	VOC	New process design endeavors to reduce the volume of air to be treated from spray paint booths, thereby increasing efficiency and improving air pollution abatement (in particular, reducing VOC emissions). Most of the ventilation air is recycled through the booth to maintain laminar flow; the machinery is located on the supply side of the booth rather than on the exhaust side. 60 to 95% reduction in spray booth exhaust rate should result.		Regulatory Impact Analysis - 1997
MobotecSystem	NOx/PM	Emission capture systems	Stationary	NEET Database - ongoing
MoleculeQuantumMechanicAirPurification	NOx/VOC	Other	Stationary	NEET Database - ongoing
MoltenCarbonateFuelCell(MCFC)4	NOx/VOC	The molten carbonate fuel cell uses an electrolyte of lithium and potassium carbonates and operates at approximately 650C (1200F). Due to the high temperature involved, noble metal catalysts are not required for the cell electrochemical oxidation and reduction process.		Regulatory Impact Analysis - 1997
Moreefficienttraffickingsystems				EACs - 2004
MotorVehicleandMobileEquipmentNon-AssemblyLineCoatingOperations	VOC	VOC content limits for compliant coatings + Emission capture and control system for non-compliant coatings + Cleaning operations and solvent storage and disposal comply with Rule 1171	Stationary	EPA Measures - 1999
MotorVehicleAssemblyLineCoatingOperations	VOC	VOC content limit for compliant coatings + Solvent cleaning and storage comply with Rule 1171 + Emission capture and control system for non-compliant coatings	Stationary	EPA Measures - 1999
Motorvehiclecoating	VOC	MACT	Stationary	EPA Measures - 1999
Motorvehiclecoating	VOC	Incineration	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
Multi-junctioncells(galliumarsenideandIII-Valloys)	NOx/VOC	It is possible to increase any solar cell's efficiency by focusing a more direct source of solar energy on it. In application, cells need to withstand extreme conditions in order to see an efficiency increase. This alloy demonstrated an efficiency in excess of 30 percent under concentrated sunlight. The expectation is to exceed 32 percent efficiency.		Regulatory Impact Analysis - 1997
Municipalsolidwastelandfill	VOC	RCRA standards	Stationary	EPA Measures - 1999
MunicipalWasteCombustorControls	NOx		Stationary	CT Memo - 2005
MunicipalWasteCombustors	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
MunicipalWasteCombustors	NOx	EPA's regulation for large, existing MWCs emitting more than 250 tons/day + more stringent limits (e.g., 30-50 ppmv) or shorter averaging periods (e.g., 8-hr average).	Stationary	EPA Measures - 1999
MunicipalWasteCombustors(Beganoperationbetween12/20/89and9/20/94)	NOx	180 ppm at 7% oxygen	Stationary	EPA Measures - 1999
Natural-Gas-Fired,Fan-TypeCentralFurnaces	NOx	NOx emission limit	Stationary	EPA Measures - 1999
NaturalGasFuelSpecifications	NOx		Area	SAQMD Clean Air Plan - 2003
Naturalgasprocessingplant-reduceNoxandVOCemissionsby90%				EACs - 2004
NaturalGasProduction;Compressors	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
NaturalGasTransmissionandStorage	VOC	Pending	Stationary	EPA Measures - 1999
NeopreneProduction	VOC	See Website - http://www.epa.gov/ttn/uatw/pr1/pr1pg.html	Stationary	EPA Measures - 1999
Newinfrastructure-rideshareprogram				EACs - 2004
Newlatexpolymerapplicationmethod5	VOC	New latex polymer application method eliminates the acetate rinse-out and the resultant solvent-contaminated water waste stream and distillation air emissions.		Regulatory Impact Analysis - 1997
Newphotoinitiatorsystems25	VOC	Ciba is working on advanced photoinitiator systems		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
		that enable paints and coatings to dry rapidly without the need for heating or the release of solvents into the atmosphere. Key future research is targeting extending the range of photoinitiators for paints and coatings.		
NewUV-curetechnologyapplications7	VOC	New UV-cure applications are being developed for use in the automotive industry. These applications include coatings for metal and plastics, interior and exterior applications, adhesives, and gasketing.		Regulatory Impact Analysis - 1997
Newvehiclespowered	NOx		M4 On-road heavy duty diesel	Regulatory Impact Analysis - 1997
Nitric/adipicacids	NOx	Nitric acid - 2.3 lb/ton extended adsorption; Adipic acid - 7.4 lb/ton extended adsorption	Stationary	EPA Measures - 1999
NitricAcidManufacturing	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
NitricAcidManufacturing	NOx	Extended Absorption	Stationary	EPA Measures - 1999
NitricAcidManufacturing	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
NitricAcidPlants	NOx	3.0 lb/ton of acid produced	Stationary	EPA Measures - 1999
NitricandAdipicAcidPlants	NOx	Consider a standard of 2.0 lbs NOx/ton of nitric acid produced, representing approximately 95-percent control. Even lower standards are achievable using SCR. The nation's four adipic acid plants are already regulated at over 80-per-cent efficiency.	Stationary	EPA Measures - 1999
NitrileButadieneRubberProduction	VOC	See Website - http://www.epa.gov/ttn/uatw/pr1/pr1pg.html	Stationary	EPA Measures - 1999
NitrogenOxides(NOx)EmissionControl	NOx	Process vent gas treatment	Stationary	NEET Database - ongoing
Non-acrylateSystems10	VOC	In the research development of UV and EB curable alternatives to acrylates, a number of "new" systems have been developed that reduce emissions, such as cationic systems, alternating free radical induced copolymerization of donor/acceptor		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
		type monomers, various hybrid systems, and photoinduced addition reactions for the formation of polymeric networks.		
Non-majorVOCsourcebakeries	NOx/VOC		Stationary	CT Memo - 2005
Non-NylonPolyamidsProduction	VOC	See Website - http://www.epa.gov/ttn/uatw/pr2/pr2pg.html	Stationary	EPA Measures - 1999
Non-ozonedepletingsealantsforammunitionapplications 22	VOC	Research program aimed at investigating solvent-free or solvent-safe case mouth sealants for military ammunition by evaluating state-of-the-art, commercially-available non-ozone depleting sealants. Economic benefits include reduced costs (elimination of toxic ozone-depleting chemicals environmental protection activities), increased production rates, and reduced lot rejection rate (which currently averages 6% per year).		Regulatory Impact Analysis - 1997
Non-RoadEngineStandards8	VOC		Mobile	CT Memo - 2005
NonroadGasolineEngines	NOx/VOC	Federal Reformulated Gasoline	Mobile	EPA Measures - 1999
Non-RoadVehiclesandEngines	NOx/VOC	Achieve reductions from lawn and garden equipment and recreational vessels	Mobile	EPA Measures - 1999
Non-ThermalPlasmaReactor30	NOx/VOC	"Packed-bed reactor" transforms exhaust gas pollutants into less harmful constituents. Simultaneous particulate and NOx removal in diesel engine exhaust		Regulatory Impact Analysis - 1997
NonutilityBoilers	NOx	Natural Gas and Distillate Oil- Low heat release rate - 0.10 lb/mmBtu; High heat -0.20 lb/mmBtu Residual Oil- Low heat release rate - 0.3 lb/mmBtu; High heat release rate - 0.4 lb/mmBtu Coal- Mass Feed Stoker - 0.5 lb/mmBtu; Spreader Stoker and FBC - 0.6 lb/mmBtu; Pulverized Coal - 0.7 lb/mmBtu; Lignite - 0.6 lb/mmBtu	Stationary	EPA Measures - 1999
NOxAnalyzers	NOx	Emissions Monitoring	Monitoring	NEET Database - ongoing
NOxBudgetProgram(EPANOxSIPCall)	NOx		Stationary	CT Memo - 2005

Measure	Pollutant	Description	Source	Source Code
NOxControlsonCommercialPowerGeneratingEquipment		Adopt OTC Additional NOx Controls Rule throughout nonattainment area (applies to industrial boilers, stationary combustion turbines and reciprocating engines, emergency generators, load shavers and cement kilns)	Stationary	DC RACM - 2003
NOxemissionlimitsonasphalticconcreteproductionfacilities	NOx		Stationary	SAQMD Clean Air Plan - 2003
NOxemissionlimitsonasphalticconcreteproductionfacilities	VOC		Stationary	SAQMD Clean Air Plan - 2003
NOxLimitForPowerPlants		Cap the emission rate from each utility boiler and turbine below NOx SIP Call limits	Stationary	DC RACM - 2003
NOxRACTRules	NOx	States' NOx RACT rules	Stationary	EPA Measures - 1999
off-roadvehiclereplacements				EACs - 2004
Offsetlithography	VOC	Low solvent inks and fountain solutions	Stationary	EPA Measures - 1999
Off-SiteWasteandRecoveryOperations	VOC	Pending	Stationary	EPA Measures - 1999
Oilandnaturalgasproduction	VOC	Equipment and maintenance	Stationary	EPA Measures - 1999
OilandNaturalGasProduction	VOC	For major oil and natural gas production facilities, the rule requires controls at the following emission points: (1) process vents at certain size glycol dehydration units; (2)tanks with flashing emission potential; and (3) certain fugitive emission sources at natural gas processing plants. For natural gas transmission and storage facilities that are major sources of hazardous air pollutants, the rule requires emission controls at process vents at certain size glycol dehydration units.	Stationary	EPA Measures - 1999
On-boardRefuelingVaporRecovery	VOC		Mobile	CT Memo - 2005
On-boardRefuelingVaporRecovery				CT RACM - 2001
On-roadvehiclereplacement				EACs - 2004
OpenBurning	NOx	Episodic Ban (Daily Only)	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
Openburning	VOC	Episodic ban	Stationary	EPA Measures - 1999
OpenBurning		Eliminate open burning in counties adjacent to nonattainment area	Area	DC RACM - 2003
OpenBurning				EACs - 2004
Openburningban-expanded				EACs - 2004
Opentopdegreasing	VOC	SCAQMD 1122 (VOC content limit)	Stationary	EPA Measures - 1999
Opentopdegreasing	VOC	Airtight degreasing system	Stationary	EPA Measures - 1999
Opentopdegreasing	VOC	MACT	Stationary	EPA Measures - 1999
Optimizedautomobilecatalyst35	NOx/VOC	Airflow Catalysts is attempting to reengineer the traditional automobile catalyst. The redesign is an effort to minimize costs by reducing the amounts of costly rare metals in the catalyst. The new design will seek to react all contaminants (NOx, HC, CO) in the same area of the converter, rather than in three separate areas. The company is also seeking to minimize the need for air injection for NOx control.		Regulatory Impact Analysis - 1997
OrganicAcidsManufacture	VOC	RACT Extended to Other Areas	Stationary	EPA Measures - 1999
OrganicChemicalPlants	NOx	Controls on industrial boilers and process heaters for these sources	Stationary	EPA Measures - 1999
OrganicLiquidsDistribution(Non-Gasoline)	VOC	Pending	Stationary	EPA Measures - 1999
Organicprotectivecoatingsandapplicationtechnolog y3	VOC	High performance, non-toxic, low VOC content coatings for Navy use are being developed, including investigation of low VOC polymer technology to produce low VOC binder systems. Reactive monomers and diluents and low molecular weight resins have been used to develop low viscosity binder systems for future near-zero VOC aircraft coatings. In addition, recent advances in water-borne resin technology has allowed for the development of a high performance water-borne		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
		topcoat which goes beyond mere compliance with environmental regulations. Non-toxic inhibitor systems have been developed and formulated into non-toxic aircraft corrosion inhibiting primers. Coating corrosion resistance, physical performance properties and VOC content were evaluated in the development of the best materials. The non-toxic inhibited primers have been optimized, and service evaluation at Navy maintenance facilities is in progress.		
OTC-architecturalandindmain				EACs - 2004
OTC-consumerproducts				EACs - 2004
OTC-lowemissionspaint				EACs - 2004
OTCPhaseIINOxMOU		Require reductions in emissions from regional power plants through the OTC Phase II NOx MOU	Stationary	DC RACM - 2003
OTC-portablefuelcontainers				EACs - 2004
OxygenEnrichmentMembrane32	NOx/VOC	Membrane system uses DuPont Teflon AF fiber as the oxygen exchange mechanism for a underhood module to feed oxygen-enriched air directly to the engine chamber. The membrane separates ambient air into oxygen-rich and nitrogen-rich streams. The oxygen rich stream is directed to the manifold to improve combustion, while the nitrogen rich stream can be fed into the exhaust as a plasma to reduce NOx emissions.		Regulatory Impact Analysis - 1997
PahlmanProcess	NOx/PM	Emission capture systems	Stationary	NEET Database - ongoing
PaintStrippingOperations	VOC	Pending	Stationary	EPA Measures - 1999
Paper,Fabric,andFilmCoatingOperations	VOC	VOC content limits for compliant coatings + Coating applicator transfer efficiency + Emission capture and control system for non-compliant coatings	Stationary	EPA Measures - 1999
PaperandOtherWebs(SurfaceCoating)	VOC	Pending	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
Papersurfacecoating	VOC	Incineration	Stationary	EPA Measures - 1999
ParkingLotTreePlantingToReduceVehicleTemperaturesAnd,Thereby,EvaporativeEmissions	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
PartnershipforNewGenerationVehicle1	NOx/VOC	Multi-agency Federal partnership with US automakers and suppliers, and universities to develop advanced manufacturing technologies, near-term vehicle improvements, and prototypes with up to triple efficiency. The partnership is evaluating many of the individual technologies listed below such as lean NOx catalysts, CIDI engine, reformulated or alternative fuels for CIDI, CIDI fuel injection, EGR in addition to improved manufacturing processes that would allow higher temperatures or reduced weight. Other goals include reducing the vehicle weight, aerodynamics, rolling resistance, accessory energy use, and regenerative braking that increase vehicle efficiency and reduce emissions.		Regulatory Impact Analysis - 1997
PesticideActiveIngredientProduction	VOC	See Website - http://www.epa.gov/ttn/uatw/pest/pestpg.html	Stationary	EPA Measures - 1999
PesticideApplication	VOC	Reformulation - FIP rule	Stationary	EPA Measures - 1999
PesticideApplication	VOC	Ozone season limits on pesticide application and prohibition of solvent-containing fumigants + emissions regulations for fumigation chambers + lowest VOC-emitting alternative	Stationary	EPA Measures - 1999
PetroGuard	VOC	Petroleum, oils, and lubricants	Pollution Prevention	NEET Database - ongoing
Petroleumdrycleaners	VOC	Carbon adsorption	Stationary	EPA Measures - 1999
PetroleumDryCleaning				EACs - 2004
PetroleumRefineries	NOx	Regulate refinery boilers and process heaters like other industries + regulate fluid catalytic cracking units by controlling CO boilers + SNCR or low	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
		NOx burners on tail gas incinerators		
PetroleumRefineries- CatalyticCracking(FluidandOther)Units,CatalyticR eformingUnits,andSulfurPlantUnits	VOC	Controls for emissions of air toxics from storage tanks,equipment leaks, process vents, and wastewater collection and treatment systems. Provides emissions averaging across operations and across refineries.	Stationary	EPA Measures - 1999
PetroleumRefineries- OtherSourcesNotDistinctlyListed	VOC	Controls for emissions of air toxics from other nonspecific refinery sources, processes, and systems. Provides emissions averaging across operations and across refineries.	Stationary	EPA Measures - 1999
Petroleumrefineryfugitives	VOC	Equipment and maintenance	Stationary	EPA Measures - 1999
Petroleumrefinerywastewatersystems	VOC	Covers, Floating roofs, Combustion devices or Carbon adsorption	Stationary	EPA Measures - 1999
PetroleumSolventDryCleaners	VOC	Operating practices + Leak controls + Tight storage containers + Waste stream filtration system + Emission control devices	Stationary	EPA Measures - 1999
PharmaceuticalsandCosmeticsManufacturingOper ations	VOC	Surface condensers on equipment vents + Control devices on VOC transfer to storage operations + Control devices on drying operations	Stationary	EPA Measures - 1999
PharmaceuticalsProduction	VOC	See Website - http://www.epa.gov/ttn/uatw/pharma/pharmpg.html	Stationary	EPA Measures - 1999
PhaseIIMARAMA/NESCAUMUtilityBoiler	NOx		Stationary	EPA Measures - 1999
PhosphoricAcidFuelCell(PAFC)3	NOx/VOC	This is the most commercially developed type of fuel cell. It is already being used in such diverse applications as hospitals, nursing homes, hotels, office buildings, schools, utility power plants, and an airport terminal. Phosphoric acid fuel cells generate electricity at more than 40% efficiency, and nearly 85% if steamthat the fuel cell produces is used for cogeneration, compared to 30% for the most efficient internal combustion engine. Operating temperatures are in the range of 400		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
		degrees F. These fuel cells also can be used in larger vehicles, such as buses and locomotives.		
PhotographicChemicalProduction	VOC	Pending	Stationary	EPA Measures - 1999
PhotovoltaicsforMilitaryApplications		This technology involves demonstrating the use of photovoltaic technology, reducing the amount of pollutants from fossil-fueled electrical gensets within DOD, and enhancing energy security. The focus will be to develop a modular, standardized power processing center (PPC) that will service multiple source photovoltaic/engine hybrid and demand reduction applications.		Regulatory Impact Analysis - 1997
PhthalatePlasticizersProduction	VOC	Pending	Stationary	EPA Measures - 1999
Planningforfuturegreenspaces				EACs - 2004
PlasmaEnhancedESP		Emission capture systems	Stationary	NEET Database - ongoing
PlasmaTreatmentofAutomotiveExhaust28	NOx/VOC	Plasma (ionized gas) treatment of lean-burn exhaust emissions in both gasoline and diesel lean-burn engines. Current plasma systems (gas-phase plasma discharges) appear to have low NOx conversion and/or high energy consumption. An alternative approach is being pursued to improve emission reduction and energy consumption.		Regulatory Impact Analysis - 1997
Plastic,Rubber,andGlassCoatings	VOC	VOC content limits for compliant coatings + Coating applicator transfer efficiency + Emission capture and control system for non-compliant coatings	Stationary	EPA Measures - 1999
PlasticPartsandProducts(SurfaceCoating)	VOC	Pending	Stationary	EPA Measures - 1999
PlasticsProducts;Specific;(ABS)Resin	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
PleasureCraftCoatingOperations	VOC	VOC content limits for applicable coatings + Solvent cleaning and storage comply with Rule 1171	Stationary	EPA Measures - 1999
PlywoodandCompositeWoodProducts	VOC	Pending	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
PM10AmbientAirSampling		Ambient Monitoring	Monitoring	NEET Database - ongoing
PolyesterResinOperations	VOC	Polyester residual monomer content limit + Process requirements to limit VOC loss + Spray applicator requirements + Solvent cleaning operations comply with Rule 1171 + Emission control system for non-compliant polyester materials	Stationary	EPA Measures - 1999
PolyetherPolyolsProduction	VOC	See Website - http://www.epa.gov/ttn/uatw/polyol/polyolpg.html	Stationary	EPA Measures - 1999
PolyethyleneTerephthalateProduction	VOC	See Website - http://www.epa.gov/ttn/uatw/pr4/pr4pg.html	Stationary	EPA Measures - 1999
Polymericcoatingofsupportingsubstratesfacilities	VOC	Carbon adsorption or Incineration	Stationary	EPA Measures - 1999
Polyolresins,crosslinkersandreactivediluents14	VOC	Recent developments with polyol resins, crosslinkers and reactive diluents will enable the future formulation of higher-solids, ultralow-VOC coatings and, ultimately, of solventless liquid coatings. In spite of the increasing popularity of waterborne and powder coatings, many companies see a future for higher-solids coatings and are investing in new technology, particularly for industrial (original equipment manufacturer) and special-purpose applications.		Regulatory Impact Analysis - 1997
PolystyreneProduction	VOC	See Website - http://www.epa.gov/ttn/uatw/pr4/pr4pg.html	Stationary	EPA Measures - 1999
Polyurethanereactive(PUR)technology3	VOC	New, accelerated-cure versions of hot-melt adhesives technology for recreational vehicle and building components customers has been developed. Also applicable to the profile wrapping segment of the woodworking industry, which can use the adhesives to make window and door components that withstand hot and cold temperatures, rain and snow. Users can increase process speeds, while at the same time produce		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
		stronger products in a solvent-free environment.		
pooling;flexschedules;alternatefuel				EACs - 2004
Port/harborelectrification	NOx/VOC		Mobile	CT Memo - 2005
Portablefuelcontainerbuybackpromotions	NOx/VOC		Stationary	CT Memo - 2005
PortableToxicChemicalDetector		Fugitive emission controls	Stationary	NEET Database - ongoing
Powder-basedprimers20	VOC	GM is working on a prototype powder primer to try on one of its vehicle lines; such a primer would contain no VOCs. New chemistry research is being conducted on both epoxy and polyester powder primers.		Regulatory Impact Analysis - 1997
PP3-FFuelOilTreatment,		Fuels and fuel additives	Pollution Prevention	NEET Database - ongoing
PP-CCylinderoiladditive		Petroleum, oils, and lubricants	Pollution Prevention	NEET Database - ongoing
Preconditioningofdieselengines	NOx		Offroad	SAQMD Clean Air Plan - 2003
Prepolymersandultralow-viscosityreactivediluentstechnologies10	VOC	Two technologies have been developed to help solve formulation problems with decreased levels of VOCs in two-part, solventborne polyurethane coatings. One technology is a process to make narrow-molecular-weight-distribution, isocyanate-terminated polyurethane prepolymers. The other technology is the creation of ultralow-viscosity oxazolidine and aldimine/oxazolidine reactive diluents. Use of these materials achieves low-VOC formulations, controlled reactivity of low-VOC systems and enhanced coating performance, as well as formulation flexibility and ease of use.		Regulatory Impact Analysis - 1997
PrimaryCopperSmelters;ReverbSmeltingFurnace	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
Printing,Coating,andDyeingOfFabrics	VOC	Pending	Stationary	EPA Measures - 1999
Printing/Publishing(SurfaceCoating)	VOC	See Website - http://www.epa.gov/ttn/uatw/print/printpg.html	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
Printing-Letterpress	VOC	Carbon Adsorption	Stationary	EPA Measures - 1999
Printing-Lithographic	VOC	New CTG to Other Areas	Stationary	EPA Measures - 1999
ProcessHeaters	NOx	Limits of 0.036 lb/mmBtu for gas and 0.05 lb/mmBtu for other liquid fuels+ limits same as mid-sized industrial boilers for gas, distillate oil and residual oil-fired units	Stationary	EPA Measures - 1999
ProcessHeaters	VOC	Pending	Stationary	EPA Measures - 1999
Processheaters(revised)	NOx	NG - ULNB 0.05 lb/mm Btu / Oil - ULNB 0.14 lb/mm Btu	Stationary	EPA Measures - 1999
ProcessHeaters-DistillateOil	NOx	Low NOx Burners + Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-DistillateOil	NOx	Low NOx Burners + Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-DistillateOil	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ProcessHeaters-DistillateOil	NOx	Ultra Low NOx Burners	Stationary	EPA Measures - 1999
ProcessHeaters-DistillateOil	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-DistillateOil	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-DistillateOil	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
ProcessHeaters-LPG	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ProcessHeaters-LPG	NOx	Ultra Low NOx Burners	Stationary	EPA Measures - 1999
ProcessHeaters-LPG	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-LPG	NOx	Low NOx Burners + Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-LPG	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-LPG	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
ProcessHeaters-LPG	NOx	Low NOx Burners + Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-NaturalGas	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-NaturalGas	NOx	Ultra Low NOx Burners	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
ProcessHeaters-NaturalGas	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-NaturalGas	NOx	Low NOx Burners + Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-NaturalGas	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ProcessHeaters-NaturalGas	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
ProcessHeaters-NaturalGas	NOx	Low NOx Burners + Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-OtherFuel	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
ProcessHeaters-OtherFuel	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ProcessHeaters-OtherFuel	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-OtherFuel	NOx	Ultra Low NOx Burners	Stationary	EPA Measures - 1999
ProcessHeaters-OtherFuel	NOx	Low NOx Burners + Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-OtherFuel	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-OtherFuel	NOx	Low NOx Burners + Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-ProcessGas	NOx	Low NOx Burners + Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-ProcessGas	NOx	Low NOx Burners + Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-ProcessGas	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
ProcessHeaters-ProcessGas	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ProcessHeaters-ProcessGas	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-ProcessGas	NOx	Ultra Low NOx Burners	Stationary	EPA Measures - 1999
ProcessHeaters-ResidualOil	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
ProcessHeaters-ResidualOil	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-ResidualOil	NOx	Low NOx Burners + Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-ResidualOil	NOx	Ultra Low NOx Burners	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
ProcessHeaters-ResidualOil	NOx	Low NOx Burners + Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ProcessHeaters-ResidualOil	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
ProcessHeaters-ResidualOil	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
ProheatGen4			Mobile	NEET Database - ongoing
Propane/ButaneFuelBlends19	NOx/VOC	Emissions testing on multiple light-duty vehicles using propane/butane blends, which may be cost-effective low-emission alternative fuels for light-, medium-, and heavy-duty vehicles. It is expected that the proposed project will result in emission benefits and help AQMD, ARB, the petroleum industry, and automobile manufacturers identify a potentially clean, cost-effective alternative fuel with capability for wide-scale application to all types of internal combustion engines. Generate data on emissions, lubricant compatibility, combustion chamber and intake valve deposits, component durability, and catalyst durability. Operate and evaluate three or more new vehicles for a minimum of 50,000 miles using selected butane/propane blends. Conduct periodic emission tests during mileage accumulation to determine the effects of operation on regulated emissions, speciated hydrocarbons, and the specific reactivity (ozone-forming potential) of exhaust emissions. At test completion dismantle engines and quantify and rate deposits.		Regulatory Impact Analysis - 1997
Protectnaturalareas;minimizeuseof				EACs - 2004
ProteinExchangeMembraneFuelCell(PEMFC)9	NOx/VOC	These cells operate at relatively low temperatures (about 200 F), have high power density, can vary their output quickly to meet shifts in power demand, and are suited for applications, such as in automobiles, where quick startup is required. According to the U.S. DOE, "they are the primary candidates for light-duty vehicles, for buildings,		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
		and potentially for much smaller applications such as replacements for rechargeable batteries in video cameras." Fueling stations are a large obstacle in introducing hydrogen powered vehicles to the public on a large scale. From the best calculations available, fueling stations are cost effective, and they are starting to be built across the country. A fueling station will cost \$4.5 million to build, but will produce as well as dispense the fuel. Hydrogen fuel costs 3.8 cents per mile, while gas costs 4.5 cents per mile. 11 pounds of hydrogen would provide a 400 mile driving range for a mid-sized car. The tank for this fuel is 3 times the size of a gas tank, and fueling would take about ten minutes.		
ProtonExchangeMembraneFuelCells(PEMFC)5	NOx/VOC	These cells operate at relatively low temperatures (about 200 degrees F), have high power density, can vary their output quickly to meet shifts in power demand, and are suited for applications, such as automobiles, where quick startup is required. According to DOE, "they are the primary candidates for light-duty vehicles, for buildings, and potentially for much smaller applications such as replacements for rechargeable batteries in video cameras."		Regulatory Impact Analysis - 1997
Providefreepublictransit	NOx		Landuse	SAQMD Clean Air Plan - 2003
Providefreepublictransitduringepisodes	NOx		Landuse	SAQMD Clean Air Plan - 2003
Providefreereplacementgascapstolight-andmedium-dutyvehicleowners	NOx		On-Road Mobile	SAQMD Clean Air Plan - 2003
Provideincentivesformicroturbineenginesinsmallpowergenerationapplications	VOC		Offroad	SAQMD Clean Air Plan - 2003
ProvideTruckstopElectrificationForIn-TruckServices	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
Publicawarenessprogram				EACs - 2004
PublicEducationonNOxandROGsourcesinSchoolsandSmallBusinesses	NOx		Landuse	SAQMD Clean Air Plan - 2003
PubliclyOwnedTreatmentWorks	VOC	Source reduction approaches requiring industrial pretreatment controlling VOCs where they are most concentrated	Stationary	EPA Measures - 1999
PubliclyOwnedTreatmentWorks(POTW)Emissions	VOC	See Website - http://www.epa.gov/ttn/uatw/potw/potwpg.html	Stationary	EPA Measures - 1999
PulpandPaper	VOC	Maximum Achievable Control Technology standards for the integrated pulp and paper industry	Stationary	EPA Measures - 1999
PulpandPaperProduction	VOC	Pending	Stationary	EPA Measures - 1999
Purchase15CNGvehicles				EACs - 2004
Purchase1hybridelectricbus				EACs - 2004
Purchase2alternativefuelvehicles				EACs - 2004
PVManufac-turing(PVMat)	NOx/VOC	One of the primary hindrances to PV market acceptance is the difficulty in taking laboratory results and replicating them under real world conditions. A public-private partnership, funded for 5 years at \$118 million, sought to address this problem by improving PV manufacturing processes, module development, and balance of system (BOS) components. For example, BOS components account for 50% of the system cost but 99% of repair issues. The goal was to increase PV module supply [currently demand outstrips supply (as of May, firms are taking no further orders for 1997)] and ensure that the U.S. production remains internationally competitive.		Regulatory Impact Analysis - 1997
QC-TILDAS		Other	Stationary	NEET Database - ongoing
QuaternaryAmmoniumCompoundsProduction	VOC	Pending	Stationary	EPA Measures - 1999
RACTatmajorsources				EACs - 2004

Measure	Pollutant	Description	Source	Source Code
RayonProduction	VOC	Pending	Stationary	EPA Measures - 1999
RCL®CatalyticCombustion		Combustion	Pollution Prevention	NEET Database - ongoing
ReasonablyAvailableControlTechnology(RACT)for25tpyVOCsources	VOC			MA Strategies - 2004
ReciprocatingInternalCombustionEngines	NOx	Limits for rich-burn gas-fired engines between 0.4-0.8 g/bhp-hr, for lean-burn engines as low as 0.5-0.6 g/bhp-hr and for diesel engines at 0.5-1.1 g/bhp-hr.	Stationary	EPA Measures - 1999
ReciprocatingInternalCombustionEngines	VOC	Pending	Stationary	EPA Measures - 1999
Reducedenginetaxi,aircrafttowing,congestionreduction	NOx		M15 Airports	Regulatory Impact Analysis - 1997
Reducedidlingscenario	NOx		Airports	Regulatory Impact Analysis - 1997
Reducelocomotiveidling				EACs - 2004
ReduceParkingFeesatFacilitiesOutsidetheBeltwayAdjacenttoMetro		Reduce parking fees at Metro parking facilities or county/city managed facilities outside of the Beltway that are located near Metro stations.	Mobile	DC RACM - 2003
ReducethenumberofpublicparkingspacesintheCityofSacramentoby25%	NOx		Landuse	SAQMD Clean Air Plan - 2003
ReductionsonNOxRACTfornon-NOxBudgetunits	NOx/VOC		Stationary	CT Memo - 2005
RefineryFlares	NOx	Adoption of a Flare Monitoring and Recording Plan	Stationary	EPA Measures - 1999
ReformulatedGasoline	NOx/VOC	Opt into the federal reformulated gasoline program	Mobile	EPA Measures - 1999
ReformulatedGasoline				CT RACM - 2001
ReformulatedGasoline-PhaseI3	VOC		Mobile	CT Memo - 2005
Reformulationsofaerosolproducts(suchasspraypaint,rustproofing,andWD-40)	VOC			MA Strategies - 2004
RegenerativeThermalOxidizer		Emission capture systems	Stationary	NEET Database - ongoing
RegulatesmallICEengines				EACs - 2004

Measure	Pollutant	Description	Source	Source Code
Regulation of additional printing operations	NOx/VOC		Stationary	CT Memo - 2005
Removal of exemption on cutback asphalt use	NOx/VOC		Area	CT Memo - 2005
Renewable Portfolio Standards (DPUC)-- C.G.S. section 16-245a	NOx/VOC		Stationary	CT Memo - 2005
Replace/retrofit construction equipment				EACs - 2004
Repower heavy-duty diesel vehicles with newer, lower emitting engines	NOx		On-Road	SAQMD Clean Air Plan - 2003
Repower old units with 2004 standard certified engines	NOx/VOC		M6 On-road heavy duty diesel	Regulatory Impact Analysis - 1997
Repower with natural gas engines	NOx		M5 On-road heavy duty diesel	Regulatory Impact Analysis - 1997
Require surcharge to be paid by drivers during the summer season based on the number of driving miles	NOx		Land use	SAQMD Clean Air Plan - 2003
Require capture efficiency testing at all major sources of VOC, and more stringent reporting requirements, including on-line CEMs.	VOC			MA Strategies - 2004
Require low-NOx fuel for agricultural equipment		Require agricultural equipment to use low-NOx fuel during ozone season	Non-road	DC RACM - 2003
Require On-Board Diagnostics on New Diesel and Gasoline Trucks and Buses	NOx		Mobile	SAQMD Clean Air Plan - 2003
Require passenger vehicles not meeting the standards of passenger car to pay an annual fee and/or a fee upon purchase	NOx		Land use	SAQMD Clean Air Plan - 2003
Require SNCR at all major NOx sources (50 tpy+)	NOx			MA Strategies - 2004
Require that Congestion Mitigation Air Quality (CMAQ) funds be used only for projects that significantly improve air quality	NOx			SAQMD Clean Air Plan - 2003

Measure	Pollutant	Description	Source	Source Code
RescindRestrictedEmissionStatuspermitsandrequiremissionrateswithRACTorBARCT	VOC			MA Strategies - 2004
ResidentialFuelCells7	NOx/VOC	Fuel cell that is small enough to fit into a closet and capable of generating 2-10 kW of power.		Regulatory Impact Analysis - 1997
ResidentialLNBwaterheater				EACs - 2004
ResidentialSpaceandWaterHeaters	NOx	Set limit on new sources of 0.09 lbs/mmBtu of heat output + incentives to replace older space and water heaters	Stationary	EPA Measures - 1999
Restrictionsonoutdoorwoodburningfurnaces	NOx/VOC		Stationary	CT Memo - 2005
RestrictionsonwoodstovesnotsubjecttoNSPS;noburndays	NOx/VOC		Stationary	CT Memo - 2005
Restrictorbancertainoff-roadengineuse--e.g.,target2-strokeenginesunder5horsepower(limitsorbansonlawnmowers,jetskis,ORVs,chainsaws,weedwackers,andleafblowers)	VOC			MA Strategies - 2004
RetrofitenginesforNOx:	NOx		M9 Non-road diesel	Regulatory Impact Analysis - 1997
RetrofitenginesforNOx:waterinjection/emulsion	NOx		M9 Non-road diesel	Regulatory Impact Analysis - 1997
ReviseallexistingAirPermitsfor25tpyorhigherVOC sourcestorequirestrictermonitoring,recordkeepingandcontrollevels(wouldhitthelargestdozenorsoemitterse.g.,Rexam,Globe)	VOC			MA Strategies - 2004
RocketTestingFacilities	VOC	Pending	Stationary	EPA Measures - 1999
RotaryRegenerativeOxidizerwithElectricDriveandFullFlowOn-LineBake-out		Emission capture systems	Stationary	NEET Database - ongoing
Rotary ValveRTO(RL)		Process vent gas treatment	Stationary	NEET Database - ongoing
RTIDryRegenerableAlkaliCarbonateProcess		Emission capture systems	Stationary	NEET Database - ongoing
Rubberandplasticsmanufacturing	VOC	SCAQMD o low VOC	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
RubberTireManufacturing	VOC	Pending	Stationary	EPA Measures - 1999
Rubbertiremanufacturingindustry	VOC	VOC capture systems + Control devices	Stationary	EPA Measures - 1999
SafeYellowIC8	VOC	A product has been developed for enhancing powder coatings by increasing the flow of the resins, eliminating orange peel and allowing the replacement of more expensive organic pigment on a one for one basis. The manufacturers of this product say it is an improved coating with lower costs.		Regulatory Impact Analysis - 1997
Sand/Gravel;Dryer	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
Schoolbusengineretrofit				EACs - 2004
Schoolbusretrofits,newlow-emissionschoolbusesanduseofultralowsulfurdiesel fuel	NOx/VOC		Mobile	CT Memo - 2005
ScreenPrintingOperations	VOC	VOC content of screen printing materials + Solvent cleaning and storage and disposal of VOC-containing materials comply with Rule 1171	Stationary	EPA Measures - 1999
season-EACareas				EACs - 2004
SecondaryAluminumProduction;SmeltingFurnaces /Reverb	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
Selectivecatalyticreduction(SCR)	NOx		M11 Diesel locomotives	Regulatory Impact Analysis - 1997
SemiconductorManufacturing	VOC	Solvent cleaning station requirements + Emission control system on photoresist operations +C content limits for cleanup solvents	Stationary	EPA Measures - 1999
SemiconductorManufacturing	VOC	Pending	Stationary	EPA Measures - 1999
ServiceStations-StageI	VOC	Vapor Balance	Stationary	EPA Measures - 1999
Setloweremissionsstandardsfornewhandheldandnon-handheldlawnandgardenequipment/State/Federal	NOx		Offroad	SAQMD Clean Air Plan - 2003
Setloweremissionstandardsfornewoff-roadspark-	NOx		Offroad	SAQMD Clean Air Plan - 2003

Measure	Pollutant	Description	Source	Source Code
ignited engines (<25hp)				
Set more stringent emission standards for new marine vessels and pursue approaches to reduce land-based port emissions	VOC		Offroad	SAQMD Clean Air Plan - 2003
Set New Consumer Products Limits for 2006	VOC		Area	SAQMD Clean Air Plan - 2003
Set New Consumer Products Limits for 2008–2010	VOC		Area	SAQMD Clean Air Plan - 2003
Set user restrictions for each on-road vehicle type during episodes	NOx		Land use	SAQMD Clean Air Plan - 2003
Set VOC/ROG/NOx standard for diesel fueled refrigeration units on trucks	NOx		On-Road Mobile	SAQMD Clean Air Plan - 2003
Shell Global Solutions Third Stage Separator (TSS)		Emission capture systems	Stationary	NEET Database - ongoing
Shift electric load profile				EACs - 2004
Shipbuilding and Ship Repair	VOC	Enhanced application techniques achieving a minimum 65-percent transfer efficiency + California's general limit of 340 grams per liter for marine coatings.	Stationary	EPA Measures - 1999
Shipbuilding and Ship Repair (Surface Coating)	VOC	See Website - http://www.epa.gov/ttn/uatw/shipb/shipbpg.html	Stationary	EPA Measures - 1999
Sidel SRU flue gas condensers		Emission capture systems	Stationary	NEET Database - ongoing
Small Compression Ignition Direct Injection (CIDI) Diesel Engines	VOC	Research is being conducted into lightweight engine materials, alternative fuels, and catalytic converters in an effort to apply the advantages of CIDI engines (high thermal efficiency, operating flexibility, low start-up emissions) to passenger cars, while controlling negative characteristics (heavy engine components and production of sub-optimal levels of NOx and particulate emissions).		Regulatory Impact Analysis - 1997
Small Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters	NOx	NOx emission limit, methods to meet the limit is not specified	Stationary	EPA Measures - 1999
Small Source BACT			Stationary	CT Memo - 2005

Measure	Pollutant	Description	Source	Source Code
Smokingvehicleban				EACs - 2004
SOCMIbatchprocesses	VOC	Vapor collection system + incineration	Stationary	EPA Measures - 1999
SOCMIbatchreactorprocesses	VOC	New CTG	Stationary	EPA Measures - 1999
SOCMI-Distillation	VOC	New CTG level control	Stationary	EPA Measures - 1999
SOCMI-fugitives	VOC	Equipment and maintenance	Stationary	EPA Measures - 1999
SOCMI-ReactorProcesses	VOC	New CTG level control	Stationary	EPA Measures - 1999
sodiumbicarbonateinjection		Emission capture systems	Stationary	NEET Database - ongoing
Solae-switchtoalternativefuel				EACs - 2004
SolidOxideFuelCell(SOFC)2	NOx/VOC	The solid oxide fuel cell generates power electrochemically, avoiding the air pollutants and efficiency losses associated with combustion processes. Fuels cells operate continuously, generating power as long as natural gas, coal-derived gas, or other hydrocarbon fuels are supplied. The solid electrolyte allows for the simplest of fuel cell plant designs, and requires no external fuel reforming. Capable of using either natural gas or cleaned coal gas, it emits no sulfur pollutants and as much as 60 to 65 percent less carbon dioxide than a conventional coal-burning plant.		Regulatory Impact Analysis - 1997
SolidWasteDisposal;Government;OtherIncinerator ;Sludge	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
SolventCleaningOperations	VOC	Compliant solvent requirement by cleaning application + Cleaning devices and methods requirement + Storage and disposal requirements + Emission control system for non-compliant solvents and cleaning procedures	Stationary	EPA Measures - 1999
SolventCleaningOperations– Cleaningofcoatings/adhesivesapplicationequipmen t	VOC	VOC-content specifications for solvents based on vapor pressure or emission capture and control systems	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
SolventCleaningOperations– Cleaningofinkapplicationequipment	VOC	VOC-content specifications for solvents based on vapor pressure or emission capture and control systems	Stationary	EPA Measures - 1999
SolventCleaningOperations– Cleaningofpolyesterresinapplicationequipment	VOC	VOC-content specifications for solvents based on vapor pressure or emission capture and control systems	Stationary	EPA Measures - 1999
SolventCleaningOperations– Repair&maintenancecleaning	VOC	VOC-content specifications for solvents based on vapor pressure or emission capture and control systems	Stationary	EPA Measures - 1999
SolventCleaningOperations– Surfacecleaningformfg,&surfaceprepforcoating,adhesive,orinkapplication	VOC	VOC-content specifications for solvents based on vapor pressure or emission capture and control systems	Stationary	EPA Measures - 1999
SolventCleaningOperations– Ultravioletinkremovalfromgraphicarts	VOC	VOC-content specifications for solvents based on vapor pressure or emission capture and control systems	Stationary	EPA Measures - 1999
SolventDegreasers	VOC	Operating practice requirements + VOC content limits of solvents + Clean Air Solvent Certificates	Stationary	EPA Measures - 1999
SpaceHeaters-DistillateOil	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
SpaceHeaters-DistillateOil	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
SpaceHeaters-DistillateOil	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
SpaceHeaters-DistillateOil	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
SpaceHeaters-NaturalGas	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
SpaceHeaters-NaturalGas	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
SpaceHeaters-NaturalGas	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
SpaceHeaters-NaturalGas	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
SpaceHeaters-NaturalGas	NOx	Oxygen Trim + Water Injection	Stationary	EPA Measures - 1999
SpandexProduction	VOC	Pending	Stationary	EPA Measures - 1999
Stage1vaporrecovery				EACs - 2004
Stage1vaporrecovery				EACs - 2004

Measure	Pollutant	Description	Source	Source Code
StageI VaporRecovery>25,000				EACs - 2004
StageI vaporrecovery-EACareas				EACs - 2004
StageIIVaporRecovery	VOC	Rules to achieve a 95-percent level of control efficiency + require California certification of equipment + limit exemptions to facilities with throughputs below 10,000 gallons per month + semi-annual inspections.+ Stage II program in Moderate nonattainment areas	Stationary	EPA Measures - 1999
StageIIVaporRecovery				CT RACM - 2001
StageIIVaporRecovery:Pressure-VentValves	VOC		Stationary	CT Memo - 2005
StageI-truckunloading	VOC	Vapor balance	Stationary	EPA Measures - 1999
StageI-truckunloading	VOC	Vapor balance + PN valves	Stationary	EPA Measures - 1999
StageIVaporRecovery				EACs - 2004
StageIVaporRecoveryatGasolineServiceStations	VOC		Stationary	CT Memo - 2005
Stakeholderdevelopment				EACs - 2004
StarchManufacturing;CombinedOperations	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
State&LocalFleetReplacement		Replace public sector gasoline-fueled automobile fleet with hybrid vehicles (i.e. Toyota Prius)	Mobile	DC RACM - 2003
StationaryGasTurbines	NOx	Continuous in-stack NOx and oxygen monitoring system + Selective Catalytic Reduction	Stationary	EPA Measures - 1999
StationaryInternalCombustionEngines	NOx	NOx emission limit	Stationary	EPA Measures - 1999
StationCarsToPromoteUserFriendlinessOfMassTransportation	NOx/VOC	Voluntary measures	Mobile	EPA Measures - 1999
SteelFoundries	VOC	Pending	Stationary	EPA Measures - 1999
SteelFoundries;HeatTreatingFurnaces	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
SteelProduction;SoakingPits	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
StorageTankDegassing	VOC	Degassing procedures required + Control device to capture VOCs displaced from tanks	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
StorageVesselsforPetroleumLiquids	VOC	Floating roofs	Stationary	EPA Measures - 1999
Strictercontrolsonillegalburning				EACs - 2004
Styrene-AcrylonitrileProduction	VOC	See Website - http://www.epa.gov/ttn/uatw/pr4/pr4pg.html	Stationary	EPA Measures - 1999
SubsidizePurchaseofBikeAccessories	NOx		Landuse	SAQMD Clean Air Plan - 2003
SulfatePulping-RecoveryFurnaces	NOx	Low NOx Burners + Flue Gas Recirculation	Stationary	EPA Measures - 1999
SulfatePulping-RecoveryFurnaces	NOx	Selective Non-Catalytic Reduction	Stationary	EPA Measures - 1999
SulfatePulping-RecoveryFurnaces	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
SulfatePulping-RecoveryFurnaces	NOx	Oxygen Trim + Water Injection	Stationary	EPA Measures - 1999
SulfatePulping-RecoveryFurnaces	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
SupercriticalCO2asapaintsolvent30	VOC	Supercritical CO2 is being investigated as a replacement for traditional paint solvents, eliminating VOC emissions.		Regulatory Impact Analysis - 1997
SuperplasticAdvancedManifolds3	VOC	Double-wall +manifold offers the potential for substantial reductions in cold-start emissions by allowing the inner tube to heat quickly, resulting in a quicker "light-off" of the catalytic converter, thereby reducing hydrocarbon emissions.		Regulatory Impact Analysis - 1997
Supportcetanedieselfueladditive				EACs - 2004
Surfacecoatingofmetalfurniture	VOC	Low solvent coatings	Stationary	EPA Measures - 1999
SurfaceCoatingofPlasticParts	VOC	HVLP spray or other techniques achieving a minimum transfer efficiency of 65 percent + VOC-content limits	Stationary	EPA Measures - 1999
SurfaceCoatingOperation;CoatingOvenHeater;NaturalGas	NOx	Low NOx Burners	Stationary	EPA Measures - 1999
Switchvehiclestobio-diesel				EACs - 2004
Syntheticfibermanufacture	VOC	Carbon Adsorber	Stationary	EPA Measures - 1999
SyntheticFiberProduction	VOC	Solvent recovery systems including carbon adsorption	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
SyntheticOrganicChemicalManufacturing	VOC	See Website - http://www.epa.gov/ttn/uatw/hon/honpg.html	Stationary	EPA Measures - 1999
SyntheticOrganicChemicalManufacturingIndustry(SOCMI)ReactorandDistillationProcesses	VOC	98-percent reduction in emissions from SOCMI sources + exemptions based on EPA's CTG with a more stringent total resource effectiveness (TRE) cutoff for exemptions	Stationary	EPA Measures - 1999
TD-4100On-LineHydrocarbonMonitor		Emissions Monitoring	Monitoring	NEET Database - ongoing
TerephthalicAcidManufacture	VOC	Incineration	Stationary	EPA Measures - 1999
Testo350		Emissions Monitoring	Monitoring	NEET Database - ongoing
TextileFinishing	VOC	Add-on controls of 95 percent or better control efficiency + capture efficiency based on best engineering practices + possible exemption of low-solvent inks	Stationary	EPA Measures - 1999
thecaptureandcontrolofVOCemissionsfromlivestockwaste	VOC		Stationary	SAQMD Clean Air Plan - 2003
TheExpertFurnaceSystemOptimizationProcess(EFSOP)forEAFs		Combustion	Pollution Prevention	NEET Database - ongoing
Thegraphicartsindustry;Publicationrotogravureprinting	VOC	Carbon adsorption	Stationary	EPA Measures - 1999
ThermalOxidizers		Emission capture systems	Stationary	NEET Database - ongoing
ThermalOxidizerwithEnergyRecovery		Process vent gas treatment	Stationary	NEET Database - ongoing
ThermoPV(TPV)	NOx/VOC	Using superconducting materials to turn solar energy into heat to create steam to then generate electricity.		Regulatory Impact Analysis - 1997
Thin-layercrystallinesilicon	NOx/VOC	A solar film on which research effort is focused because it is likely to blend the production ease of other film technologies with the efficiency of silicon crystals.		Regulatory Impact Analysis - 1997
Tightenstandardsforbulkterminalgasolinestorageandtransferin7.24(2)--	VOC			MA Strategies - 2004

Measure	Pollutant	Description	Source	Source Code
suchthatthevaporrecoveryunitsarerequiredtooperateatloweremissionrates.				
Tighteremissionstandardsforpleasurecraft/State/Federal	VOC		Offroad	SAQMD Clean Air Plan - 2003
TORBEDTM-ProcessReactorTechnologies		Other	Stationary	NEET Database - ongoing
Trafficmarkings	VOC	South Coast Phase III	Stationary	EPA Measures - 1999
Trafficmarkings	VOC	South Coast Phase I	Stationary	EPA Measures - 1999
Trafficmarkings	VOC	South Coast Phase II	Stationary	EPA Measures - 1999
Trafficmarkings	VOC	AIM Coating Federal Rule	Stationary	EPA Measures - 1999
TransitPrioritization--QueueJumps		Provide queue jumps for buses at over-capacity signalized intersections throughout the region. Queue jumps allow buses to use a shoulder or other designated lane to bypass intersection queues and move forward towards the stop line.	Mobile	DC RACM - 2003
Transitprograms				EACs - 2004
TransportRefrigerationUnits(TRUs)	PM2.5		Mobile	CT Memo - 2005
TreatmentStorageandDisposalFacilities	VOC	Expedited process for upgrading permits + air pollution control regulations for TSDFs modeled after EPA's hazardous waste rules	Stationary	EPA Measures - 1999
Treeplantingprogram				EACs - 2004
Truckstoelectrification	PM2.5		Mobile	CT Memo - 2005
Truckstoelectrification				EACs - 2004
TSDFs	VOC	Phase I & II rules	Stationary	EPA Measures - 1999
UltraFiltration24	VOC	Decorative Coatings' technology center at Montataire, France is developing new technologies to improve waterborne paint waste reuse, thereby reducing new paint production and associated emissions. One of its initiatives is wastewater treatment by Ultra Filtration (UF). This is a major project, because up to 12 European sites may be		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
		involved. UF is a nonchemical membrane separation process, which separates the effluent into two streams: permeate (the treated water) and concentrate (UF sludge). The pollution level of the permeate is equivalent to that obtained after conventional treatment, but it is completely free of paint solids, which are held in the concentrate. So far, UF has proved to be an efficient solution for treating effluent from waterborne paint production. Industrial application of UF is economical provided that the concentrate is reused in making paint.		
UndergroundStorageTankVents	VOC	Pressure-vacuum valves on open vent pipes of storage tanks equipped with Stage I vapor recovery	Stationary	EPA Measures - 1999
Updateddevelopmentregulations				EACs - 2004
UpgradeVOCRACT	NOx/VOC		Stationary	CT Memo - 2005
UreaResins-General	VOC	RACT Extended to Other Areas	Stationary	EPA Measures - 1999
usage;restrictvehicleidletimes				EACs - 2004
Uselandfillgas;supportNCGreenPower				EACs - 2004
Useremotesensorsandlicenseplatephotostoidentifysmokingvehicles	NOx		On-Road Mobile	SAQMD Clean Air Plan - 2003
UtilityBoilers	NOx	Selective Catalytic Reduction	Stationary	EPA Measures - 1999
UtilityBoilers	NOx	T-fired and wall-fired coal units emissions of 0.15 lb/mmBtu or below + oil and gas units emissions of 0.05 lb/mmBtu + emission rates based on energy output	Stationary	EPA Measures - 1999
Utilityboilers	NOx	Gas / oil - SCR 0.08 lb/mmBtu	Stationary	EPA Measures - 1999
UtilityBoilers	NOx	Natural Gas- 0.2lb/mmBtu; Liquid Fossil Fuel - 0.3 lb/mmBtu; Subituminous Coal - 0.5 lb/mmBtu; Lignite- 0.8 lb/mmBtu; Bituminous Coal- 0.6 lb/mmBtu	Stationary	EPA Measures - 1999
UV/ozoneoxidationtechnique23	VOC	Technology development and demonstration		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
		activity targeted for Department of Defense painting operations to validate the recirculation/partitioning concept used with a novel UV/ozone oxidation technique to eliminate HAP and VOC discharges from paint spray booths and other booth designs. Preliminary results suggest that booth discharge flow reductions of up to 75% can be achieved.		
VacuumInsulatedCatalyticConverter29	NOx/VOC	Using a form of vacuum insulation and phase-change heat storage technology, the converter remains at operating temperatures for more than 24 hours after the engine has been turned off. Potential exists to reduce automotive emissions to ultra-low emission vehicle (ULEV) levels, or even to equivalent zero emission vehicle (EZEV) standards in some cases.		Regulatory Impact Analysis - 1997
VariousMiscellaneousPolymerChemicalsProduction	VOC	Pending	Stationary	EPA Measures - 1999
VegetableOilProduction	VOC	Pending	Stationary	EPA Measures - 1999
VehicleI/Mprogram				EACs - 2004
Vehicleinspectionincludingdiesel				EACs - 2004
VinylChlorideEmissions	VOC	Emission control system with continuous stack monitor	Stationary	EPA Measures - 1999
VOCemissionlimitsformarinecoatings	VOC		Stationary/Area	SAQMD Clean Air Plan - 2003
VOCemissionlimitsforCommercialCookingsuchasharbroilersanddeepfatfryers	VOC		Area	SAQMD Clean Air Plan - 2003
VOCemissionsformthepolymermanufacturingindustry	VOC	Incineration of emissions in boiler or flare	Stationary	EPA Measures - 1999
VOClimitsforMetalPartsandProductsinDistrictswhere rules are not adopted	VOC		Stationary/Area	SAQMD Clean Air Plan - 2003

Measure	Pollutant	Description	Source	Source Code
			a	
VOClimitsforunregulatedcoatings	VOC		Stationary/Area	SAQMD Clean Air Plan - 2003
VOCRACTpursuanttosections182(a)(2)(A)and182(b)(2)(B)ofCleanAirAct				CT RACM - 2001
VolatileOrganicLiquidsStorage	VOC	Volatile organic liquid storage CTG + enhanced test methods, monitoring specifications and equipment specifications based on HON rule + lower vapor pressure limits for exemptions in current rules	Stationary	EPA Measures - 1999
Volatileorganicliquidstorage	VOC	Floating roof tops for tanks	Stationary	EPA Measures - 1999
Volatileorganicliquidstorage	VOC	Floating roofs	Stationary	EPA Measures - 1999
VoluntaryMobileEmissionsReductionProgram(VMEP)				TX SIP - 2000-2004
W15-590DieselFuelAdditive		Fund trial of the fuel additive W15-590 to reduce NOX emissions. The additive can be mixed with the fuel before or after delivery from the distribution center.	Mobile	DC RACM - 2003
WasteBurning--AgriculturalorOpenBurning(defined:p804ofCAFIP)	VOC	Agricultural and open burning are prohibited on a “no-burn day” which is a day declared by EPA, CARB, or local air district if an ozone exceedance (0.09 ppm) is predicted	Stationary	EPA Measures - 1999
Water-based,solvent-freeandultrahigh-solidscoatings12	VOC	Water-based, solvent free and ultrahigh-solids coatings are being considered for development for the metal office furniture industry.		Regulatory Impact Analysis - 1997
Water-basedaerosoladhesive11	VOC	Based on new technology, a water-based low VOC spray adhesive has been developed that offers bonding strength and heat resistance comparable to many typical solvent-based aerosol products. This adhesive can be used to bonds a range of substrates, including paper, fabrics, plastics, wood, and		Regulatory Impact Analysis - 1997

Measure	Pollutant	Description	Source	Source Code
		aluminum.		
Water-basedcoatings13	VOC	Morton's Water-Based Polymers Technology Group is involved in developing new and improving on existing Morton waterborne products such as: a new water-based, lead-free highway paint; a zero-VOC, waterborne color dispersion paint component; and water-based automotive plastic coatings.		Regulatory Impact Analysis - 1997
Water-basedsoldermask26	VOC	Probimer7 water-based solder masks can help cut down on the use of solvents; these water-based coatings are used on printed wiring boards in the computer industry. In addition, the division's powder coating systems are applied to buildings and cars using electrostatic charge - avoiding the need for a solvent.		Regulatory Impact Analysis - 1997
Waterborneclearcoats19	VOC	Water-based clearcoats are under investigation at Ford.		Regulatory Impact Analysis - 1997
Waterborneprimers18	VOC	Waterborne primers will be studied at three Ford truck plants and a BMW plant.		Regulatory Impact Analysis - 1997
WebOffsetLithography	VOC	New CTG	Stationary	EPA Measures - 1999
WetESP		Emission capture systems	Stationary	NEET Database - ongoing
WMATABusInformationDisplayswithMaps		Install additional information boxes with maps and schedule information. Would include schedules in languages other than English in neighborhoods where most residents speak another language	Mobile	DC RACM - 2003
WoodFlatStockCoatingOperations	VOC	VOC content limits for coatings, inks, and adhesives + Applicator requirements + Emission collection and control system for non-compliant coatings	Stationary	EPA Measures - 1999
WoodFurniture(SurfaceCoating)	VOC	See Website - http://www.epa.gov/ttn/uatw/wood/riwood.html	Stationary	EPA Measures - 1999
WoodFurnitureCoating	VOC	Incineration	Stationary	EPA Measures - 1999

Measure	Pollutant	Description	Source	Source Code
WoodFurnitureCoating	VOC	Negotiated regulatory rules	Stationary	EPA Measures - 1999
WoodFurnitureProducts(SurfaceCoating)	VOC	Pending	Stationary	EPA Measures - 1999
Woodfurnituresurfacecoating	VOC	New CTG	Stationary	EPA Measures - 1999
Woodfurnituresurfacecoating	VOC	MACT	Stationary	EPA Measures - 1999
Woodfurnituresurfacecoating	VOC	Add-On Controls	Stationary	EPA Measures - 1999
WoodProductsCoatings	VOC	VOC content limits of coatings and strippers + Coating applicator transfer efficiency + Approved emission control system for non-compliant coatings	Stationary	EPA Measures - 1999
Woodproductsurfacecoating	VOC	MACT	Stationary	EPA Measures - 1999
Woodproductsurfacecoating	VOC	SCAQMD Rule 1104	Stationary	EPA Measures - 1999
Woodproductsurfacecoating	VOC	Incineration	Stationary	EPA Measures - 1999
WorkwithSEQLproject				EACs - 2004
XactMulti-MetalsCEM		Emissions Monitoring	Monitoring	NEET Database - ongoing
XononCoolCombustion®		Combustion	Pollution Prevention	NEET Database - ongoing
ZeroI/Mwaiversandexemptions		Eliminate all waivers and exemptions in the I/M program	Mobile	DC RACM - 2003
Zero-VOCIndustrialMaintenanceMetalCoating31	VOC	This zero-VOC coating technology is intended for use as a topcoat on metal furniture. The resin formulation for the coating will be adjusted to provide acceptable drying times, flexibility and hardness, and ultraviolet, chemical and salt spray resistance.		Regulatory Impact Analysis - 1997
ZEVbusdemonstrationandpurchase	NOx		TCM	SAQMD Clean Air Plan - 2003
ZEVprogram		Adopt California ZEV program	Mobile	DC RACM - 2003
Zoningordinance-landscapebuffers				EACs - 2004

APPENDIX G-3

Assessment of Reasonable Progress for Regional Haze in MANE-VU Class I Areas

**Bureau of Air Quality
Department of Environmental Protection**

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FINAL

**Assessment of Reasonable Progress for Regional Haze
In MANE-VU Class I Areas**

**Methodology for Source Selection, Evaluation of Control Options, and
Four Factor Analysis**

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List of Acronyms

AFGD	Advanced Flue Gas Desulfurization
BACM	Best Available Control Measure
BART	Best Available Retrofit Technology
BLM	Bureau of Land Management
BTU	British Thermal Unit
CAA	Clean Air Act
CAIR	Clean Air Interstate Rule
CFB	Circulating Fluidized Bed
CHP	Combined Heat and Power
CO ₂	carbon dioxide
DOE	Department of Energy
EGU	Electric Generating Unit
EIA	Energy Information Administration
EPA	Environmental Protection Agency
ESP	Electrostatic Precipitator
FGD	Flue Gas Desulfurization
HAP	Hazardous Air Pollutant
ICI	Industrial, Commercial, Institutional
IPM [®]	Integrated Planning Model
kW	kilowatt
kWh	kilowatt-hour
LADCO	Lake Michigan Air Directors Consortium
LAER	Lowest Achievable Emission Rate
LNB	Low NO _x Burner
LSD	Lime Spray Drying // Low Sulfur Diesel
LSFO	Limestone Forced Oxidation

List of Acronyms - continued

MACT	Maximum Achievable Control Technology
MANE-VU	Mid-Atlantic/Northeast Visibility Union
MARAMA	Mid-Atlantic Regional Air Management Association
MEL	Magnesium Enhanced Lime
MM	million
MMBTU	Million British Thermal Units
MRPO	Midwest Regional Planning Organization
MW	Megawatt
NESCAUM	Northeast States for Coordinated Air Use Management
NO _x	nitrogen oxides
NSPS	New Source Performance Standard
NSR	New Source Review
O&M	Operation and Maintenance
OFA	Over-fire Air
PADD	Petroleum Administration for Defense District
PM	Particulate Matter
PM ₁₀	Particulate Matter with diameter 10 micrometers or less
PM _{2.5}	Particulate Matter with diameter 2.5 micrometers or less
PSD	Prevention of Significant Deterioration
RACM	Reasonably Available Control Measure
RACT	Reasonably Available Control Technology
RWC	Residential Wood Combustion
SACR	Selective Auto-catalytic Reduction
SCC	Source Classification Code
SCR	Selective Catalytic Reduction
SIP	State Implementation Plan
SNCR	Selective Non-catalytic Reduction
SO ₂	sulfur dioxide
SOFA	Separated Over-fire Air
ULSD	Ultra Low Sulfur Diesel

EXECUTIVE SUMMARY

The Regional Haze regulations set forth under 40 CFR 51.308(d)(1) require States to achieve reasonable progress toward natural visibility conditions. The national visibility goal in Class I areas is defined in the CAA Section 169A(a)(1) as “the prevention of any future, and the remedying of any existing, impairment of visibility...”, and is expected to be satisfied by 2064 with a return to natural visibility conditions. States containing Class I areas must set Reasonable Progress Goals (RPGs) to define future visibility conditions that are expected (but not required) to be equal to, or better, than visibility conditions expected by the uniform rate of progress at any future year until natural conditions are achieved. RPGs are to be established for the final year in the planning period, which in the case of the first SIP is 2018.

Following draft guidance from EPA in establishing RPGs, States must set a baseline from which reasonable progress towards visibility improvement will be measured. The MANE-VU baseline year for the emission inventory is 2002 and for monitoring is 2000-2004. The next task is to identify key pollutants affecting visibility impairment at each Class I area. The major pollutant contributing to visibility impairment in MANE-VU has been shown to be sulfate.

In order to determine the key source regions and source types affecting visibility impairment at each Class I area, a contribution assessment was prepared by NESCAUM for MANE-VU. Major contributors were identified by ranking emissions sources, comparing Q/d (emission impact over distance), and modeling visibility impacts. Source apportionment and other analyses documented in MANE-VU’s contribution assessment showed that several source categories have impacts on visibility at MANE-VU Class I areas.

The largest contribution to visibility impairment at most sites was from burning of coal, primarily utility and industrial combustion sources in MANE-VU and nearby States. At forested rural sites, biogenic organics are a moderate to large contributor to visibility impairment, but other sources of secondary organics also contribute. Wood smoke and ammonium nitrate were identified as small to moderate contributors.

Based on information from the contribution assessment and additional emissions inventory analysis, MANE-VU selected the following source categories for analysis in this project:

- Coal and oil-fired Electric Generating Units, (EGUs);
- Point and area source industrial, commercial and institutional boilers;
- Cement kilns;
- Lime kilns;
- The use of heating oil; and
- Residential wood combustion

This document presents the results of an analysis of the economic and environmental impacts of potential control scenarios that could be implemented by MANE-VU States to reduce emissions from the above source categories in order to make reasonable progress toward meeting visibility improvement goals. The purpose of this analysis is to present information that can be used by States to develop policies and implementation plans to address reasonable progress goals. Control technologies to achieve reasonable progress goals are evaluated with respect to four factors listed in the Clean Air Act (Section 169A):

- Cost,
- Compliance timeframe,
- Energy and non-air quality environmental impacts, and
- Remaining useful life for affected sources.

The “four factor” analysis was applied to control options identified for each of the selected source categories. Cement kilns and lime kilns are analyzed together due to the similarity of the two source categories.

The table below presents a summary of the four factor analysis for the source categories analyzed. Detailed information on control technologies assessed in this effort is presented in the main body of this document.

Table I Summary of Results from the Four Factor Analysis

Source Category	Primary Regional Haze Pollutant	Average Cost in 2006 dollars (per ton of pollutant reduction)	Compliance Timeframe	Energy and Non-Air Quality Environmental Impacts	Remaining Useful Life
Electric Generating Units	SO ₂	IPM* v.2.1.9 predicts \$775-\$1,690 \$170-\$5,700 based on available literature	2-3 years following SIP submittal	Fuel supply issues, potential permitting issues, reduction in electricity production capacity, wastewater issues	50 years or more
Industrial, Commercial, Institutional Boilers	SO ₂	\$130-\$11,000 based on available literature	2-3 years following SIP submittal	Fuel supply issues, potential permitting issues, control device energy requirements, wastewater issues	10-30 years
Cement and Lime Kilns	SO ₂	\$1,900-\$73,000 based on available literature	2-3 years following SIP submittal	Control device energy requirements, wastewater issues	10-30 years
Heating Oil	SO ₂	\$550-\$750 based on available literature. There is a high uncertainty associated with this cost estimate.	Currently feasible. Capacity issues may influence timeframe for implementation of new fuel standards	Increases in furnace/boiler efficiency, Decreased furnace/boiler maintenance requirements	18-25 years
Residential Wood Combustion	PM and VOC	\$0-\$10,000 based on available literature	Several years - dependent on mechanism for emission reduction	Reduce greenhouse gas emissions, increase efficiency of combustion device	10-15 years

* Integrated Planning Model (IPM[®]) application by ICF for MANE-VU

This report also contains information on current and planned controls at 20 specific non-EGU sources and 30 specific EGU sources identified by MANE-VU to consider control strategies already in place or planned by 2018.

CHAPTER 1

INTRODUCTION

BACKGROUND

The Regional Haze regulations set forth under 40 CFR 51.308(d)(1) require States to achieve reasonable progress toward natural visibility conditions. The national visibility goal in Class I areas is defined in the CAA Section 169A(a)(1) as “the prevention of any future, and the remedying of any existing, impairment of visibility...”, and is expected to be satisfied by 2064 with a return to natural visibility conditions. States containing Class I areas must set Reasonable Progress Goals (RPGs) to define future visibility conditions that are expected (but not required) to be equal to, or better, than visibility conditions expected by the uniform rate of progress at any future year until natural conditions are achieved. RPGs are to be established for the final year in the planning period, which in the case of the first SIP is 2018.

Following draft guidance from EPA in establishing RPGs, States must set a baseline from which reasonable progress towards visibility improvement will be measured. The MANE-VU baseline year for the emission inventory is 2002 and for monitoring is 2000-2004. The next task is to identify key pollutants affecting visibility impairment at each Class I area. The major pollutant contributing to visibility impairment in MANE-VU has been shown to be sulfate.

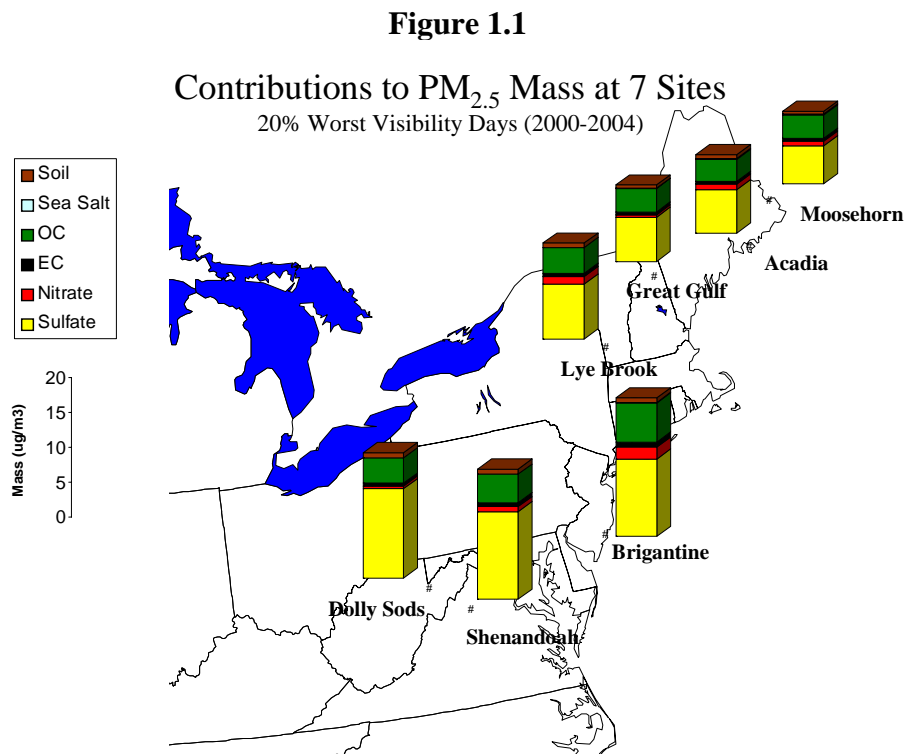
In addition to the planned reductions that will be included as part of the State SIPs for regional haze, federal programs will also have significant benefits in reducing regional haze by 2018 and beyond. A list of EPA’s national and regional rules as well as voluntary programs that will assist in the reduction of fine particle pollution are as follows:

- Clean Air Interstate Rule (CAIR)
- The Acid Rain Program
- NO_x SIP Call
- 2004 Clean Air Nonroad Diesel Rule
- 2007 Clean Diesel Trucks and Buses Rule
- Tier 2 Vehicle Emission Standards and Gasoline Sulfur Program
- Emission standards for other engines (highway and non-highway use)
- National Clean Diesel Campaign
- The Great American Woodstove Changeout

More information and links to the programs listed above can be found on the following website:
<http://www.epa.gov/pm/reducing.html>

DETERMINATION OF EMISSION SOURCE CATEGORIES AND INDIVIDUAL SOURCES MOST RESPONSIBLE FOR REGIONAL HAZE IN MANE-VU CLASS I AREAS

Particles in the $PM_{2.5}$ size range are directly responsible for visibility reduction. Figure 1.1 generated by NESCAUM from analysis of monitoring data shows the components of $PM_{2.5}$ mass at the seven Class I areas of concern on the 20% worst visibility days during the period from 2000-2004. These components of $PM_{2.5}$ are directly responsible for visibility reduction.



NESCAUM, 2006. "2000-2004 Visibility Rankings and Glide Paths.ppt." PowerPoint Presentation developed by Gary Kleiman.

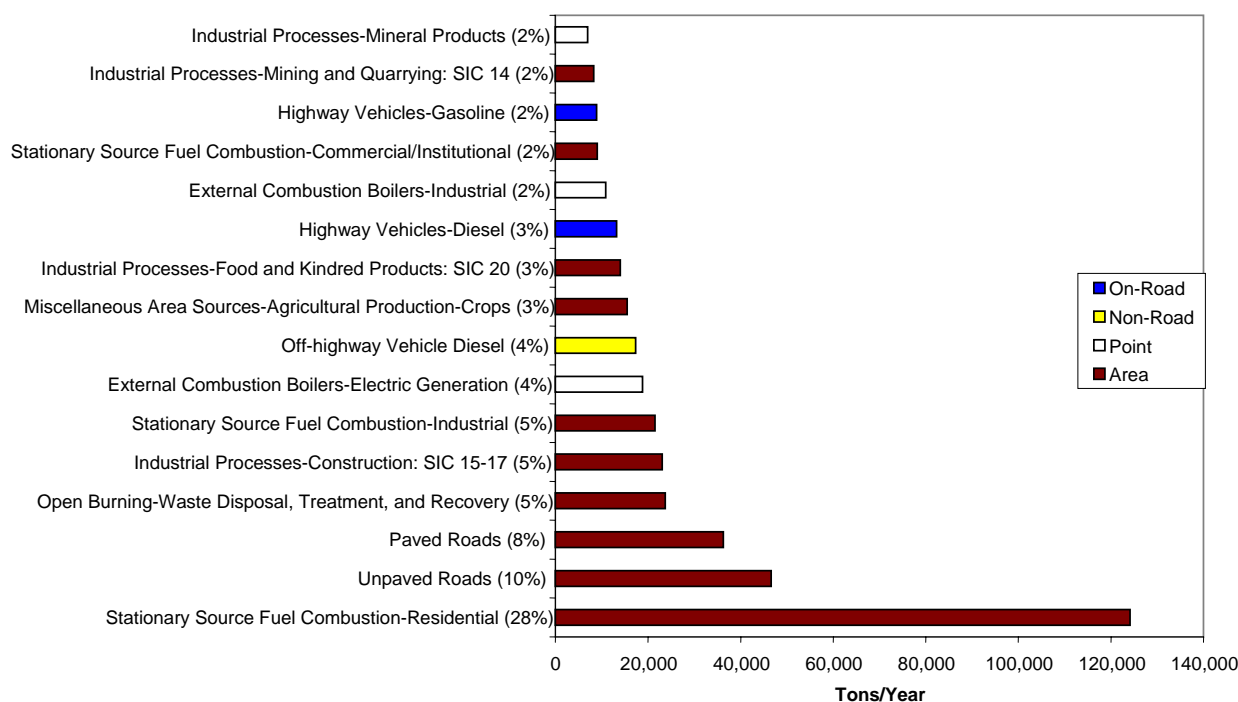
From Figure 1.1, it is apparent that sulfate is the largest contributor to $PM_{2.5}$ mass at the Class I areas of concern. The second largest contributor to $PM_{2.5}$ mass is organic carbon (OC). Nitrates, elemental carbon (EC), soil, and sea salt also contribute to $PM_{2.5}$ mass.

Source apportionment and other analyses documented in MANE-VU's contribution assessment indicated that a number of source categories have impacts on visibility at MANE-VU Class I areas. The largest contribution to visibility impairment at most sites was SO_2 from coal-combustion, primarily utility and industrial sources in MANE-VU and nearby States. At forested rural sites, biogenic organics are a moderate to large contributor to visibility impairment but other sources of secondary organics also contribute. Wood smoke and ammonium nitrate were identified as small to moderate contributors (see Appendix B of the Contribution Assessment).

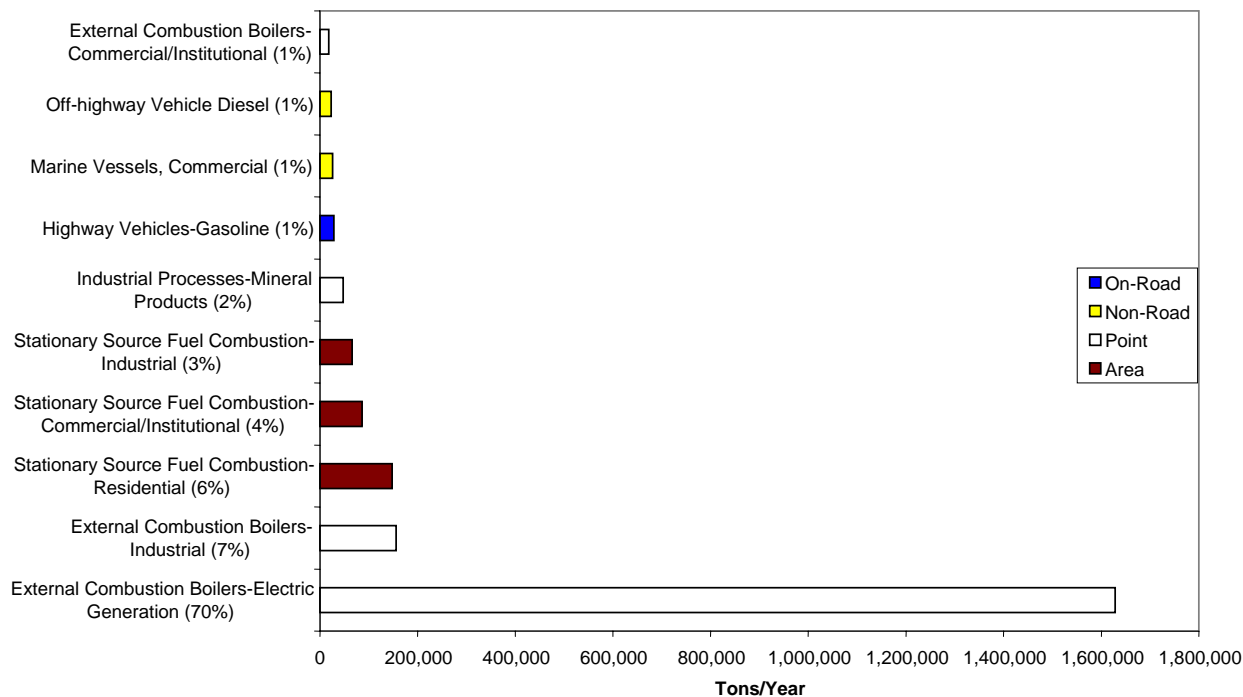
The contribution assessment also included an analysis of haze-associated pollutant emissions. “SO₂ is the primary precursor pollutant for sulfate particles. Sulfate particles commonly account for more than fifty percent of particle light extinction at northeastern Class I areas on the clearest days and for as much as or more than eighty percent on the haziest days.” The assessment noted that point sources dominate SO₂ emissions in the MANE-VU region. Point source emissions sources primarily consist of stationary combustion sources for generating electricity, industrial power, and heat. Commercial and residential heating constitute another important source category in MANE-VU States. An analysis of the largest sources in the region also indicates that a few large kilns are among the largest SO₂ sources in the region.

Figures 1.2 and 1.3 show the top emissions source categories of PM_{2.5} and SO₂ from Version 3 of the 2002 MANE-VU emissions inventory. The largest SO₂ source categories are the largest contributors to visibility impairment in MANE-VU.

**Figure 1.2 MANE-VU 2002 Version 3 Annual Emissions Inventory
 Top PM_{2.5} Primary Source Categories**



**Figure 1.3 MANE-VU 2002 Version 3 Annual Emissions Inventory
Top SO₂ Source Categories**



Description of Individual Source Identification Process and Modeling

The following discussion describes the data and procedures that were used to identify the individual sources with the greatest impact on regional haze in MANE-VU Class I areas. The individual sources included in this report (see Chapters 3, 5, and 7) were determined by identifying the sources with the maximum predicted 24-hour sulfate ion impact.

From 2004 to 2006, the Vermont Department of Environmental Conservation (VTDEC) participated in MANE-VU RPO planning activities by performing regional scale screening modeling of pollutants known to contribute to regional haze at Class I areas in the MANE-VU region. The model used by VTDEC was the CALPUFF model run on a domain including most of the eastern United States. Both point and area sources were modeled for the entire year 2002, and variable hourly CEMS emission data were used for all the largest 750+ EGUs in the domain. Model results were primarily intended to be used in conjunction with other source/receptor modeling methods as part of the technical underpinning of the document, *Contributions to Regional Haze in the Northeast and Mid-Atlantic United States: Mid-Atlantic/Northeast Visibility Union (MANE-VU) Contribution Assessment*, prepared by NESCAUM for MANE-VU and dated August 2006. This document contains more detailed discussion of the approach used to develop inputs for the modeling platform, the model setup, and its validation. It can be found at the following link: <http://www.manevu.org/Document.asp?fview=Reports#>

Starting in 2006, through its participation on two MANE-VU RPO workgroups, (the BART Workgroup and the Reasonable Progress Workgroup), which were charged with developing technical support information for regional haze plans for the MANE-VU Class I areas, VTDEC made available some of the EGU source modeling results previously generated during its work on the contribution assessment report cited above. VTDEC also performed new point source modeling with the same CALPUFF modeling platform for a number of additional large point sources identified by the workgroups, primarily non-EGUs. The new point source modeling was performed for sources that did not have CEMS hourly emission data. This new modeling performed specifically for the workgroups differed in this fundamental way from the modeling of large EGUs with available CEMS hourly emission data which had been done for the contribution assessment. All new non-EGU point source modeling performed with CALPUFF by VTDEC for the BART and Reasonable Progress Workgroups utilized a constant average hourly emission rate (annual tons/8760) for the year 2002 based on emissions provided by the individual States in which the sources were located. Except for a more complete set of discrete receptors covering each Class I area, all other inputs and settings of the CALPUFF modeling system, including the NWS Observation-based CALMET created wind-fields, were exactly the same as used in the contribution assessment modeling work.

For the Reasonable Progress Workgroup, VTDEC assembled the results of its earlier individual CEMS-based stack modeling of EGUs into tables which listed the maximum 24-hr (calendar day) sulfate ion impact predicted at any receptor in each Class I area due to the emissions from each individual EGU modeled (more than 750). Because the largest contributing pollutant to visibility impairment in all the MANE-VU Class I areas is the sulfate ion, the Reasonable Progress Workgroup felt that ranking point sources based on this maximum 24-hour impact alone would be an appropriate way to prioritize their relative potential for improving visibility and making reasonable progress at these areas. Once the maximum 24-hr sulfate ion impacts modeled for 2002 were ranked from greatest to smallest by EGU, the top impacting EGUs were identified for each of the Class I areas.

In order to examine and prioritize potentially controllable non-EGU large point sources of SO₂ located both within MANE-VU and external to MANE-VU, the Reasonable Progress Workgroup examined the 2002 NEI based on SIC code selections. Selected stack points for sources selected were modeled individually using the stack parameters and the constant annual average emission rate of SO₂ only. VTDEC converted the annual total tons of SO₂ reported by the state to the NEI for that stack point into an average hourly emission rate and ran the CALPUFF model for the 194 largest points identified in three lists supplied by Delaware. The selection of points to model was based first on a selection of the top 100 emitting points modeled from a group of several hundred ICI boilers (list 1) and Cement and Lime Kilns (list 2) identified by SCC code and extracted from the 2002 NEI database. Later this list of 100 stack emission points to model was expanded by adding the top 94 stack points not previously included in the ICI and kiln lists, but identified by more inclusive selection criteria based on SCC codes (list 3) and ranked by annual SO₂ emissions.

The maximum predicted 24-hour sulfate ion impact from each of the 194 non-EGUs modeled were combined into an ordered table showing the largest impacting non-EGU at top and the least impacting non-EGU at the bottom for each Class I area. A similar ordered table was created

showing the annual average sulfate ion impacts of these 194 non-EGU stack points. The top non-EGUs impacting each Class I area were then selected from the top of each list.

The ranked listings for EGUs represent the EGUs most likely to produce the largest sulfate ion impact at each Class I area on a 24-hour basis. The EGU modeled results were based on variable hourly SO₂ emissions from the CEMS data submitted by the sources themselves. For the EGUs, the modeled stack ID for which the hourly SO₂ emission was reported might be a single electric generating unit or it might be a combination of two or more individual electric generating units operating at a plant and emitting from the same stack. The CALPUFF modeling was done on the emission rate supplied for the particular hour of the year 2002 and did not determine whether that emission was from a single EGU or from a combination of several at a plant. Therefore, to identify which particular unit at a plant reporting multiple units emitting from a single stack is responsible for the specific impact due to that hourly emission, would require more information than was available to VTDEC. The reported impact is from the stack and the distribution among units combined in that stack's CEMs data cannot be determined from the modeling results.

For the non-EGU points modeled, there is a slight probability that emissions modeled may have been only from a particular "process" level in the NEI database structure. There may have been more than one process reported for the same emission point during the year 2002 so that a sum of two or more process annual emissions should be modeled and summed for the entire unit level emission control potential to be identified. The top modeled impacts are simply the top for each area based on the 194 separate stack points modeled with each individual annual average emission rate supplied from one of the three NEI selected listings VTDEC received.

APPROACH TO DEMONSTRATING REASONABLE PROGRESS

Based on the contribution assessment, including modeling and emissions inventory analysis, MANE-VU selected the following source categories for analysis in this project:

- Coal and oil-fired Electric Generating Units, (EGUs);
- Point and area source industrial, commercial and institutional boilers;
- Cement kilns;
- Lime kilns;
- The use of heating oil; and
- Residential wood combustion

This document presents the results of an analysis of the economic and environmental impacts of potential control scenarios that could be implemented by MANE-VU States to demonstrate reasonable progress toward meeting visibility improvement goals. The purpose of this analysis is to present information that can be used by States to develop policies and implementation plans to address reasonable progress goals. Control technologies to achieve reasonable progress goals are evaluated with respect to four factors listed in the Clean Air Act (Section 169A):

- Cost,
- Compliance timeframe,
- Energy and non-air quality environmental impacts, and
- Remaining useful life for affected sources.

The “four factor” analysis is applied to control options identified for the selected source categories. The analysis of cement kilns and lime kilns was combined into one section due to the similarity of the two sources.

Category analyses are presented for electric generating units (EGUs), industrial, commercial, and institutional (ICI) boilers, cement kilns, lime kilns, distillate-oil fired heating units, and residential wood combustion. Only sulfur dioxide (SO₂) emissions are considered for the first five categories. The SO₂ emitted from sources in these five source categories comprised approximately 90% of all SO₂ emitted from within MANE-VU in 2002. For residential wood combustion, the analysis is presented for particulate matter. PM_{2.5} emissions from this source were 28% of the total PM_{2.5} emitted from within MANE-VU in 2002. Biomass burning causes both direct emissions of primary particles and emissions of volatile organics which can contribute to the formation of secondary organic carbon particles. Organic carbon is typically the second-largest contributor to regional haze in the MANE-VU region.

For EGUs, ICI boilers, and kilns control options include fuel switching, fuel preparation, *in-situ* modifications, and add-on controls. Because of the similarity in available control options, cement and lime kilns have been combined into one category. For oil-fired heating oil, the only control option considered is reduction in sulfur content in the fuel oil. For residential wood combustion and outdoor wood-fired boilers, we have included descriptions of alternative technologies for replacement and emission reduction.

Additionally, we have assembled current and planned controls for the 20 specific non-EGU and 30 EGU sources based on information from State agencies and Integrated Planning Model (IPM[®]). The purpose of selecting these sources is to find out whether the sources that have the greatest impacts on Class I areas near MANE-VU in 2002 are already controlled or will be controlled by 2018. In many cases, States have supplied a schedule of planned controls for these facilities, which we have included in tabular form in this report. In the case of EGUs, we obtained information from the States and from modeled projections developed using Integrated Planning Model (IPM[®]).

REFERENCES

NESCAUM, 2006. *2000-2004 Visibility Rankings and Glide Paths.ppt*. PowerPoint Presentation developed by Gary Kleiman.

EPA. Information accessed on the web April 6, 2007. <http://www.epa.gov/pm/reducing.html>

Vermont Air Quality Planning. Personal communications regarding description of the source identification and modeling process from Paul Wishinski (802-241-3862, paul.wishinski@state.vt.us) via E-mail on April 4, 2007.

NESCAUM, 2006. *Contributions to Regional Haze in the Northeast and Mid-Atlantic United States*. Prepared by NESCAUM for MANE-VU, August, 2006.

CHAPTER 2

SOURCE CATEGORY ANALYSIS: ELECTRIC GENERATING UNITS (EGUs)

SOURCE CATEGORY DESCRIPTION

The MANE-VU contribution assessment demonstrated that the principal contributor to visibility impairment in Class I MANE-VU areas and Class I areas affected by emissions from sources within MANE-VU is SO₂ from EGUs. Roughly 70% of the 2.3 million tons of SO₂ emissions in the 2002 emissions inventory (2002 MANE-VU Emissions Inventory Version 3) were from EGUs, making them the largest source category contributing to regional haze in terms of total visibility impairing emissions and in terms of number of facilities.

Boilers at EGUs burn various fuels to produce heat for steam production which is then used to drive turbine generators for electricity production. The primary fuel combusted in EGU boilers in the eastern United States is coal from mines in the Midwest and Appalachia. Coal from this region generally contains 2-4% sulfur. The sulfur contained in the coal is emitted as SO₂ from the boiler. Coal obtained from western States is generally lower in sulfur, with a sulfur content of <1%.

Nationally, 90% of the SO₂ emissions from the EGUs are from coal-fired electric utility boilers. These coal-fired utility boilers are also the largest sources of NO_x and PM emissions, which also contribute to regional haze. All coal-fired electric utility power plants in the United States use control devices to reduce PM emissions. Additionally, many of the boilers are required to use controls for SO₂ or NO_x emissions depending on site-specific factors such as the properties of the coal burned, when the power plant was built, and the area where the power plant is located. According to the EPA Clean Air Markets Division, (Personal communication with Mr. Peter Kokopeli, EPA – CAMD on April 3, 2007), as of January 1, 2006, the percentage of coal-fired EGU capacity in the United States with SO₂ and/or NO_x control devices (as a percentage of heat input), were as follows:

- 2% of coal-fired EGU capacity had SO₂ control only;
- 57% of coal-fired EGU capacity had NO_x control only;
- 32% of coal-fired EGU capacity had SO₂ and NO_x controls;
- 9% of coal-fired EGU capacity had no SO₂ or NO_x controls.

As 66% of coal-fired EGU capacity, (as a percentage of heat input), have no SO₂ controls, there is room for significant reductions in emissions of SO₂. There is currently a trend towards improving control of SO₂ through installation of additional controls and making other process and fuel changes. The four factor analysis of potential control scenarios for EGUs contained in this chapter addresses the control options and costs, time requirements, energy and non-air impacts, and source life associated with these controls.

Although PM and NO_x from coal-fired utility boilers contribute to regional haze, the MANE-VU contribution assessment conducted by NESCAUM determined that SO₂ from power plants was the largest contributor to regional haze in the MANE-VU Class I areas. Therefore, the focus of this control option analysis for coal-fired boilers is on SO₂ controls. Effects of the SO₂ control

options on PM and NO_x emissions are addressed where applicable, to ensure that the impact on emissions of these pollutants is considered for planning purposes.

In addition to coal combustion, some EGUs in MANE-VU States also burn fuel oil and/or natural gas. However, the EGU sources with the greatest impact on MANE-VU Class I areas were all coal-fired units. Emissions of SO₂ from natural gas combustion are negligible, but SO₂ emissions from fuel oil combustion are directly proportional to the sulfur content of the fuel. The cost of switching from a high sulfur distillate fuel oil to a lower sulfur distillate fuel oil is addressed in Chapter 8 of this report.

The SCCs applicable to coal-fired utility boilers include SCCs beginning 1-01-001-XX, 1-01-002-XX, and 1-01-003-XX.

EVALUATION OF CONTROL OPTIONS

Effective post-combustion SO₂ controls for EGUs and particularly coal-fired boilers are well understood and have been applied to a large number of sources over the years in response to regulations in the form of NSPS, PSD/NSR, State RACT Rules and the Title IV Acid Rain Program. Additional SO₂ reductions are anticipated as a result of the Clean Air Interstate Rule (CAIR), which was finalized on May 12, 2005.

In addition to post-combustion controls that can be applied to reduce emissions of SO₂ from coal-fired boilers, there are other strategies that can be used to reduce emissions of SO₂. Examples of such strategies include switching to a fuel with a lower sulfur content, and coal cleaning prior to combustion. Methods of SO₂ control applicable to coal-fired boilers are listed in Table 2.1 with a brief description of the control option, applicability, and range of performance. A more detailed description of the control option and an analysis of the four factor assessment for reasonable progress follow the table.

MACTEC assembled the list of available SO₂ control options for the EGU source category given in Table 2.1 from available documentation. Note that the estimated performance of each control option varies greatly and depends on a variety of site specific factors, including the boiler type. Examples of three major types of coal-fired boiler include fluidized bed combustors, stoker boilers, and pulverized coal boilers. In addition to these three types of coal-fired boilers there are many subcategories of boilers, characterized by their specific design. Control devices designed for these types of boilers vary in terms of cost as well as estimated performance.

Table 2.1 SO₂ Control Options for Coal-fired EGU Boilers

Technology	Description	Applicability	Performance
Switch to a Low Sulfur Coal (generally <1% sulfur)	Replace high-sulfur bituminous coal combustion with lower-sulfur coal	Potential control measure for all coal-fired EGUs currently using coal with high sulfur content	50-80% reduction in SO ₂ emissions by switching to a lower-sulfur coal
Switch to natural gas (virtually 0% sulfur)	Replace coal combustion with natural gas	Potential control measure for all coal-fired EGUs	Virtually eliminate SO ₂ emissions by switching to natural gas
Coal Cleaning	Coal is washed to remove some of the sulfur and ash prior to combustion	Potential control measure for all coal-fired EGUs	20-25% reduction in SO ₂ emissions
Flue Gas Desulfurization (FGD) - Wet	SO ₂ is removed from flue gas by dissolving it in a lime or limestone slurry. (Other alkaline chemicals are sometimes used)	Applicable to all coal-fired EGUs	30-95%+ reduction in SO ₂ emissions
Flue Gas Desulfurization (FGD) – Spray Dry	A fine mist containing lime or other suitable sorbent is injected directly into flue gas	Applicable primarily for boilers currently firing low to medium sulfur fuels	60-95%+ reduction in SO ₂ emissions
Flue Gas Desulfurization (FGD) –Dry	Powdered lime or other suitable sorbent is injected directly into flue gas	Applicable primarily for boilers currently firing low to medium sulfur fuels	40-60% reduction in SO ₂ emissions

Table references:

1. *Assessment of Control Technology Options for BART-Eligible Sources*, NESCAUM, March 2005.
2. *Controlling Fine Particulate Matter Under the Clean Air Act: A Menu of Options*, STAPPA-ALAPCO, March 2006.

Switch to Low Sulfur Coal

Fuel switching encompasses several different control options. Often it is not possible to completely switch from one type of fuel to another. One option is blending lower-polluting fuels with baseline fuels to reduce overall emissions. For example, many coal-fired boiler operators blend lower sulfur subbituminous coals with high sulfur bituminous coals to reduce SO₂ emissions. In other cases, bituminous coals with a lower sulfur content can be substituted for high sulfur bituminous coal.

The feasibility of fuel switching depends partly on the characteristics of the plant and the particular type of fuel change being considered. Many plants will be able to switch from high-sulfur to low-sulfur bituminous coal without serious difficulty, but switching from bituminous to subbituminous coal may present greater challenges and costs. In some instances, fuel switching will require significant investment and modifications to an existing plant. Switching to a lower sulfur coal can affect coal handling systems, boiler performance, PM control effectiveness and ash handling systems. In any case, fuel switching or blending has been

a key strategy used by EGUs to comply with the federal Acid Rain Program. Overall SO₂ reductions estimated from switching to low-sulfur coal range from 50-80%.

Switch to Natural Gas

Switching from coal combustion to natural gas combustion virtually eliminates SO₂ emissions, but it is currently uneconomical to consider this option for base load EGUs due to the fuel quantity necessary and the price of natural gas. The price of natural gas and coal are variable, but in terms of heating value, the price of natural gas over the past several years has been several times higher than coal. According to information published on the EIA website, in January 2007 the price of natural gas was approximately four times higher than coal according to average monthly costs of fuel delivered to electricity producers during that month.

Coal Cleaning

According to the 2006 STAPPA-ALAPCO document on control technologies titled *Controlling Particulate Matter Under the Clean Air Act: A Menu of Options*, coal cleaning or washing is a widely practiced method of reducing impurities in coal, particularly sulfur. Reducing the sulfur content of the fuel used in the boiler reduces the SO₂ emissions proportionally. Coal cleaning has been shown to reduce SO₂ emissions by 20-25%, while increasing the heating value of the fuel. Additional removal can be achieved through advanced chemical washing techniques, but no detailed information on these techniques was available.

Conventional (physical) coal washing techniques remove ash and sulfur from coal by crushing the fuel and separating the components in a liquid bath, such as water. The lighter coal particles float to the top of the bath for recovery, while the heavier impurities sink to the bottom for removal.

Coal sulfur exists in two forms, inorganic and organic. The inorganic sulfur in coal called pyrite is primarily in the form of ferrous sulfate (FeSO₄). Because it is not chemically bound within the coal, 40-50% of this pyrite can be removed through coal washing. The organic form of sulfur is chemically bound in the molecular structure of the coal itself and cannot be physically washed out. Organic sulfur accounts for between 35-75% of the total sulfur in Illinois Basin coals in the example given by STAPPA-ALAPCO. Depending on the percentage of the sulfur in a given coal sample which exists in the form of pyrite, varying amounts of the total sulfur can be removed.

Although there are benefits associated with coal washing, there are limitations associated with this technology. The 20-25% SO₂ reduction is beneficial, but post-combustion controls have been shown to reduce SO₂ emissions by greater percentages. Also, solid and liquid wastes are generated using the washing process and must be addressed.

Flue Gas Desulfurization (FGD) - Wet

There are three types of FGD scrubbers: wet, spray dry, and dry. According to the 2006 STAPPA-ALAPCO document on control technologies titled *Controlling Particulate Matter Under the Clean Air Act: A Menu of Options*, EPA reports that 85% of the FGD systems in the

United States are wet systems. Twelve percent of the FGD systems are spray dry systems, and 3% are dry systems. The operating parameters, impacts on capacity factor, and costs of each SO₂ removal method are different. Capacity factor is the amount of energy a facility generates in one year divided by the total amount it could generate if it ran at full capacity.

SO₂ in the flue gas can be removed by reacting the sulfur compounds with a solution of water and an alkaline chemical to form insoluble salts that are removed in the scrubber effluent. These processes are called “wet FGD systems”. Most wet FGD systems are based on using either limestone or lime as the alkaline source. At some of these facilities, fly ash is mixed with the limestone or lime. Several other scrubber system designs (e.g., sodium carbonate, magnesium oxide, dual alkali) are used by a small percentage of the total number of boilers.

The basic wet limestone scrubbing process is simple and is the type most widely used for control of SO₂ emissions from coal-fired electric utility boilers. Limestone sorbent is inexpensive and generally available throughout the United States. In a wet limestone scrubber, the flue gas containing SO₂ is brought into contact with limestone/water slurry. The SO₂ is absorbed into the slurry and reacts with limestone to form an insoluble sludge. The sludge, mostly calcium sulfite hemihydrate and gypsum, is disposed of in a pond specifically constructed for the purpose or is recovered as a salable byproduct. Integrated Planning Model (IPM[®]) used by EPA to predict future EGU control strategies assumes that this technology will be used to control SO₂ from coal-fired boilers that are 100 MW or larger, that combust bituminous coal with 2% or higher sulfur content by weight. Integrated Planning Model (IPM[®]) documentation refers to the specific scrubber technology as Limestone Forced Oxidation, (LSFO), and assumes 95% SO₂ removal using this technology. Data and documentation obtained for use in this report are from Integrated Planning Model (IPM[®]) version 2.1.9.

The wet lime scrubber operates in a similar manner to the wet limestone scrubber. In a wet lime scrubber, flue gas containing SO₂ is contacted with hydrated lime/water slurry; the SO₂ is absorbed into the slurry and reacts with hydrated lime to form an insoluble sludge. The hydrated lime provides greater alkalinity (higher pH) and reactivity than limestone. However, lime-scrubbing processes require disposal of large quantities of waste sludge.

Another wet scrubber technology used to control emissions of SO₂ from EGUs is Magnesium Enhanced Lime, (MEL). This technology is available to coal-fired boilers from 100 MW to 550 MW in capacity, that combust bituminous, sub-bituminous or lignite coal with less than 2.5% sulfur content by weight. Integrated Planning Model (IPM[®]) assumes that MEL provides 96% SO₂ removal.

The SO₂ removal efficiencies of existing wet limestone scrubbers range from 31-97%, with an average of 78%. The SO₂ removal efficiencies of existing wet lime scrubbers range from 30 to 95%. For both types of wet scrubbers, operating parameters affecting SO₂ removal efficiency include liquid-to-gas ratio, pH of the scrubbing medium, and the ratio of calcium sorbent to SO₂. Periodic maintenance is needed because of scaling, erosion, and plugging problems. Recent advancements include the use of additives or design changes to promote SO₂ absorption or to reduce scaling and precipitation problems.

Flue Gas Desulfurization (FGD) – Spray Dry

A spray dryer absorber (sometimes referred to as wet-dry or semi-dry scrubber) operates by the same principle as wet lime scrubbing, except that the flue gas is contacted with a fine mist of lime slurry instead of a bulk liquid (as in wet scrubbing). For the spray dryer absorber process, the combustion gas containing SO₂ is contacted with fine spray droplets of hydrated lime slurry in a spray dryer vessel. This vessel is located downstream of the air heater outlet where the gas temperatures are in the range of 120 to 180 °C (250 to 350 °F). The SO₂ is absorbed in the slurry and reacts with the hydrated lime reagent to form solid calcium sulfite and calcium sulfate sludge as in a wet lime scrubber. The water is evaporated by the hot flue gas and forms dry, solid particles containing the reacted sulfur. These particles are entrained in the flue gas, along with fly ash, and are collected in a PM collection device. Most of the SO₂ removal occurs in the spray dryer vessel itself, although some additional SO₂ capture has also been observed in downstream particulate collection devices, especially fabric filters. This process produces dry reaction waste products for easy disposal.

The primary operating parameters affecting SO₂ removal are the calcium-reagent-to-sulfur stoichiometric ratio and the approach to saturation in the spray dryer. To increase overall sorbent use, the solids collected in the spray dryer and the PM collection device may be recycled. The SO₂ removal efficiencies of existing lime spray dryer systems range from 60-95%.

Lime Spray Drying (LSD) is a dry SO₂ scrubber technology applied in Integrated Planning Model (IPM[®]) runs for coal-fired boilers 550 MW or larger that combust bituminous, subbituminous or lignite coal with sulfur content between 0.4% and 2% sulfur by weight. Integrated Planning Model (IPM[®]) assumes that LSD provides 90% SO₂ removal.

Flue Gas Desulfurization (FGD) –Dry

For the dry injection process, dry powdered lime (or another suitable sorbent) is directly injected into the ductwork upstream of a PM control device. Some systems use spray humidification followed by dry injection. This dry process eliminates the slurry production and handling equipment required for wet scrubbers and spray dryers, and produces dry reaction waste products for easier disposal. The SO₂ is adsorbed and reacts with the powdered sorbent. The dry solids are entrained in the combustion gas stream, along with fly ash, and collected by the PM control device. The SO₂ removal efficiencies of existing dry injection systems range from 40-60%.

FOUR FACTOR ANALYSIS OF POTENTIAL CONTROL SCENARIOS FOR EGUs

Each of the control options presented in Table 2.1 is evaluated in this section according to the four factors for determining reasonable progress as required by Section 169A(g)(1) of the Clean Air Act and 40 CFR 51.308(d)(1)(i)(A). The information provided in this section is intended to be used by the States in setting Reasonable Progress Goals for reducing regional haze in the MANE-VU Class I areas.

Cost of Compliance

For EGUs, EPA used Integrated Planning Model (IPM[®]) to predict which units will install controls at what costs and which units will buy credits. Integrated Planning Model (IPM[®]) predicts a least-cost solution to meet power production demands within emissions constraints. Emissions may be reduced by fuel-switching, use of controls or by using power from a cleaner unit. The RPOs made some Integrated Planning Model (IPM[®]) runs to determine which units will install controls to comply with the EPA CAIR rule. Additionally, MANE-VU investigated an even more stringent “CAIR Plus” strategy using Integrated Planning Model (IPM[®]). In Chapter 3, the parsed results (projections disaggregated to the unit level), available for the CAIR Plus strategy are used to help estimate costs for specific EGUs. It should be noted that Integrated Planning Model (IPM[®]) is an industry-wide model, and the control costs output from the model represent the industry-wide average cost of control that can be expected based on a set industry-wide emission reduction. Integrated Planning Model (IPM[®]) results can also be viewed as the predicted cost of control at a model plant. The costs of control at individual facilities are dependent on a number of factors and cannot be determined for any specific individual facility from Integrated Planning Model (IPM[®]) results.

Table 2.2 contains the marginal costs of SO₂ emission reductions, also known as the SO₂ allowance price, for MANE-VU Base Case CAIR, (MARAMA_5c), and CAIR Plus, (MARAMA 4c), Integrated Planning Model (IPM[®]) runs. These costs include the capital costs of new investments, fuel costs, and the operation and maintenance costs of power plants. For both the CAIR and CAIR Plus run, Integrated Planning Model (IPM[®]) installed scrubbers to meet the demand for SO₂ reduction while meeting the demand for electricity. Integrated Planning Model (IPM[®]) also installed NO_x controls, but the cost of achieving the NO_x emissions reductions was provided independently from SO₂ controls. Application of SO₂ controls such as use of cleaner and lower-sulfur coals or post combustion controls such as wet scrubbers generally help to reduce PM emissions in addition to SO₂. SO₂ controls generally do not affect PM or NO_x emissions.

Table 2.2 Marginal Costs of Emission Reductions (Allowance Prices) Calculated by Integrated Planning Model (IPM[®]) for the CAIR Base Case and CAIR Plus Runs (2006 \$/ton)

Pollutant	CAIR Base Case (MARAMA_5c)						CAIR Plus Policy Case (MARAMA_4c)					
	2008	2009	2010	2012	2015	2018	2008	2009	2010	2012	2015	2018
SO ₂	774	837	905	979	1,141	1,338	975	1,055	1,139	1,233	1,437	1,684

Table reference:

Final Draft Report - Comparison of CAIR and CAIR Plus Proposal Using the Integrated Planning Model (IPM[®]), ICF Resources; May 30, 2007.

Note – A conversion factor of 1.2101 was used to convert the dollar values from 1999 to 2006

www.inflationdata.com

The CAIR Plus strategy requires additional SO₂ and NO_x control beyond EPA’s CAIR program. ICF’s report on the CAIR and CAIR Plus Integrated Planning Model (IPM[®]) runs titled: *Final Draft Report - Comparison of CAIR and CAIR Plus Proposal Using the Integrated Planning*

Model (IPM[®]), states that the power sector opts for a technology strategy for complying with the CAIR Plus proposal requirements. In the CAIR Plus analysis, the CAIR Plus region requires the installation of an additional 19.5 GW of scrubbers and 77.8 GW of SCR by 2012. These controls represent a 30% increase in scrubbers and 185% increase in SCRs in 2012 compared to the Integrated Planning Model (IPM[®]) CAIR run. By 2018, the cumulative installation of scrubbers is 17% higher and the installation of SCR is 98% higher for the CAIR Plus run compared to the CAIR run. The resulting SO₂ and NO_x emissions from the CAIR and CAIR Plus Integrated Planning Model (IPM[®]) runs are listed for MANE-VU in Table 2.3.

**Table 2.3 NO_x and SO₂ Emissions from the Electric Power Sector
 (Thousand Tons)**

	2008	2009	2010	2012	2015	2018
	SO ₂ NO _x	SO ₂ NO _x	SO ₂ NO _x	SO ₂ NO _x	SO ₂ NO _x	SO ₂ NO _x
CAIR Base Case (MARAMA_5c)	802 386	650 272	518 213	463 209	410 202	394 199
CAIR Plus Policy Case (MARAMA_4c)	735 376	556 228	396 159	376 162	312 153	271 146

Table reference:

Final Draft Report - Comparison of CAIR and CAIR Plus Proposal Using the Integrated Planning Model (IPM[®]), ICF Resources; May 30, 2007.

Cost of Switching to Low Sulfur Coal

Switching to a low-sulfur coal or blending a lower sulfur coal can impact cost due to the following two main reasons:

1. The cost of low-sulfur coal compared to higher sulfur coal
2. The cost of necessary boiler or coal handling equipment modifications

The cost of low-sulfur coal compared to higher sulfur coal is not only related to the “dollar per ton” cost of the coal, but also related to the heating value of the coal.

Recent data from the Energy Information Administration show the average price of coals from various locations together with estimated heating values and sulfur content. The prices of coal indicated in Tables 2.4 and 2.5 do not include the cost of delivery.

The energy-based cost of each of the coals listed in Table 2.4 is approximately the same, with the exception of coal from the Powder River Basin. Powder River Basin coal has a significantly lower heating value than the other four varieties of coal, but on an energy basis, it is still approximately one third the cost of the other coals listed. Since Powder River Basin coal contains significantly less sulfur, it would seem that this coal would be the best fuel for boilers trying to incorporate a lower sulfur coal. Unfortunately, due to the lower heating value of the coal, boilers that are configured to burn coal with a higher heating value can only use a small percentage of this low-sulfur coal (no higher than 15% Powder River Basin coal). The only way to burn higher percentages of the Powder River Basin coal would be to extensively retrofit the boilers or suffer from poor boiler performance and other operating difficulties. Such retrofits should be reviewed in light of current Prevention of Significant Deterioration (PSD) permitting

regulations to ensure that all such requirements are met and that emissions do not increase. The coal prices included in Table 2.4 do not reflect the cost of boiler retrofits required to combust low sulfur coal.

Table 2.4 Recent Average Coal Prices from Various Locations in the U.S. (12/2006)
 (\$/ton)

	Central Appalachia (Bituminous)	Northern Appalachia (Bituminous)	Illinois Basin (Bituminous)	Powder River Basin (Subbituminous)	Uinta Basin (Low-S Bituminous)
Coal Heating Value (BTU/lb)	12,500	13,000	11,000	8,800	11,700
Sulfur Content (%)	1.2	<3	5	0.8	0.8
Cost/ton (\$)	\$47.25	\$43.00	\$33.33	\$9.85	\$36.00

Table reference:

EIA website accessed on 2/20/07: <http://www.eia.doe.gov/cneaf/coal/page/coalnews/coalmar.html>

The two types of coal used for fuel in EGU boilers in the United States are bituminous and subbituminous coals. Bituminous coals have varying amounts of sulfur, but the sulfur content of bituminous coal is generally higher than subbituminous coal. Traditionally, many EGU boilers have been designed to combust bituminous coal because of the higher carbon content and heating value.

Table 2.5 shows the average 2005 cost data from the Energy Information Administration for bituminous and subbituminous coal. The purpose of this information is to demonstrate the difference in cost of these coals based on their heating value. Assuming a heat content for bituminous coal of 12,000 BTU/lb and 10,000 BTU/lb for subbituminous coal allows the calculation of the cost of the coal on an energy basis. The coal prices included in Table 2.5 do not reflect the cost of boiler retrofits required to combust low sulfur coal.

Table 2.5 Average U.S. Bituminous and Subbituminous Coal Prices
 (2006 dollars/ton)

Fuel	Average Price per Ton	Average Price per MMBTU
Bituminous Coal	\$38.00	\$1.58
Subbituminous Coal	\$8.96	\$0.44

Table reference:

EIA website accessed on 2/20/07: <http://www.eia.doe.gov/cneaf/coal/page/acr/table31.html>

Note – A conversion factor of 1.0323 was used to convert the dollar values from 2005 to 2006
www.inflationdata.com

Switching to subbituminous coal can reduce SO₂ emissions by up to 80%, but changes must be made to the boilers to compensate for the lower heating value of the subbituminous coal. Much of the difference in fuel price is due to the difficulty in using subbituminous coal in boilers

designed to combust bituminous coal. The 2006 STAPPA-ALAPCO document, *Controlling Fine Particulate Matter Under the Clean Air Act*, states that “fuel substitution is not feasible for sources where the substitution would require excessive retrofits or would entail substantial performance losses.”

Cost of Coal Cleaning

The World Bank reports that the cost of physically cleaning coal varies from \$1 to \$10 per ton of coal cleaned, depending on the coal quality, the cleaning process used, and the degree of cleaning desired. In most cases the costs were found to be between \$1 and \$5 per ton of coal cleaned. Based on the recent prices of coal from Tables 2.4 and 2.5, this cost represents a 2-15% increase in the cost of coal.

In addition to lowering the emissions from coal combustion, coal cleaning also increases the heating value of the fuel. This lowers the transportation cost of the fuel per unit of energy, offsetting the costs associated with the coal washing. It is not clear whether this has been taken into account in the cost information provided by the World Bank.

Cost of Flue Gas Desulfurization (FGD) – Wet

The cost of flue gas desulfurization varies depending on a number of factors including the size of the boiler, SO₂ reduction requirements, boiler capacity factor, and fuel sulfur content. Taking these factors into account, the typical cost effectiveness of a 1,000 MMBTU/hr (~300MW) coal-fired boiler equipped with wet FGD is around \$410 per ton of SO₂ reduced when combusting high-sulfur coal. This cost is based on a boiler capacity factor of 83% and SO₂ removal efficiency of 90%. Assuming the same boiler and SO₂ control efficiency, but firing low-sulfur coal, the cost per ton is slightly more expensive at \$510 per ton of SO₂ controlled. (*Controlling Fine Particulate Matter Under the Clean Air Act: A Menu of Options*, STAPPA-ALAPCO, March 2006) (Converted from 2003 to 2006 dollars using a conversion factor of 1.0959 www.inflationdata.com)

A similar cost estimation from the same STAPPA-ALAPCO document provides information for boilers in the size range of >4,000 MMBTU/hr (~ 1,200 MW) and <4,000 MMBTU/hr achieving >90% SO₂ removal efficiency. These cost estimates demonstrate the initial and ongoing costs of installing wet scrubbers. For units >1,200 MW, the capital costs are between \$380-\$850/MW; operation and maintenance costs (O&M) range from \$7-\$27/MW; and the ultimate cost effectiveness is shown to be from \$230-\$570/ton SO₂ removed. For boilers <1,200 MW, the capital costs are between \$850-\$5,100/MW; operation and maintenance costs (O&M) range from \$28-\$68/MW; and the ultimate cost effectiveness is shown to be from \$570-\$5,700/ton SO₂ removed. This information demonstrates a strong cost effectiveness advantage realized by installing control devices on the larger emission units. (Converted from 2001 to 2006 dollars using a conversion factor of 1.1383 www.inflationdata.com)

In another independent analysis of control costs, Integrated Planning Model (IPM[®]) background documentation defines a range of control efficiencies, costs, and applicability based on unit size and coal type. (<http://www.epa.gov/airmarkets/progsregs/epa-ipm/past-modeling.html>) Two wet scrubber (wet FGD) control technologies are discussed in Integrated Planning Model (IPM[®])

background documentation; (1) Limestone Forced Oxidation (LSFO), and (2) Magnesium Enhanced Lime (MEL). Both of the scrubber control technologies are applicable to distinct unit sizes and coal types, but there is no indication in the parsed Integrated Planning Model (IPM[®]) results as to which type of scrubber has been applied by the model. Both scrubber technologies are assumed to achieve a SO₂ removal percentage of 95% or greater. According to Integrated Planning Model (IPM[®]) documentation, the costs used by Integrated Planning Model (IPM[®]) for these control technologies were developed by EPA and presented in a document titled *Emissions: A Review of Technologies*, (EPA-600/R-00-093), October 2000 prepared by EPA's Office of Research and Development. The cost and performance calculations were primarily a function of heat rate, capacity, and sulfur content. The range of various scrubber costs is included in Attachment 1. Using the data in Attachment 1 and applying a standard engineering economics analysis (Attachment 2), the costs of SO₂ removal using these control technologies vary from approximately \$300-\$1,100 per ton of SO₂ removal, (Converted from 1999 to 2006 dollars using a conversion factor of 1.2101 www.inflationdata.com).

Cost of Flue Gas Desulfurization (FGD) – Spray Dry

The cost of flue gas desulfurization varies depending on a number of factors including the size of the boiler, SO₂ reduction requirements, boiler capacity factor, and fuel sulfur content. Taking these factors into account, the typical cost effectiveness of a 1,000 MMBTU/hr (~300MW) coal-fired boiler equipped with spray dry FGD is around \$420 per ton of SO₂ reduced. This cost is based on a boiler capacity factor of 83% and SO₂ removal efficiency of 90%. (*Controlling Fine Particulate Matter Under the Clean Air Act: A Menu of Options*, STAPPA-ALAPCO, March 2006) (Converted from 2003 to 2006 dollars using a conversion factor of 1.0959 www.inflationdata.com)

EPA reports in a 2005 document titled *Multipollutant Emission Control Technology Options for Coal-fired Power Plants*, that conventional Spray Dry FGD systems can cost from \$155-\$237 per kW, have fixed operation and maintenance costs ranging from \$1.55-\$7.25 per kW-yr, and variable operation and maintenance costs from 0.2-0.7 mills/kWh. These costs are associated with a 300 MW plant. (Converted from 2005 to 2006 dollars using a conversion factor of 1.0322 www.inflationdata.com)

A similar cost estimation from STAPPA-ALAPCO, 2006 provides information for boilers in the size range of >2,000 MMBTU/hr (~600 MW) and <2,000 MMBTU/hr achieving from 80-90% SO₂ removal efficiency. These cost estimates provide the initial and ongoing costs of installing wet scrubbers. For units >600 MW, the capital costs are between \$140-\$510/MW; operation and maintenance costs range from \$14-\$34/MW; and the ultimate cost effectiveness is shown to be from \$170-\$340/ton SO₂ removed. For boilers <600 MW per hour, the capital costs are between \$510-\$5,100/MW; operation and maintenance costs (O&M) range from \$34-\$1,020/MW; and the ultimate cost effectiveness is shown to be from \$570-\$4,550/ton removed. As was the case with wet scrubbers, this information demonstrates a strong cost effectiveness advantage realized by installing control devices on the larger emission units. (Converted from 2001 to 2006 dollars using a conversion factor of 1.1383 www.inflationdata.com)

Integrated Planning Model (IPM[®]) background documentation defines a range of control efficiencies, costs, and applicability based on unit size and coal type.

(<http://www.epa.gov/airmarkets/progsregs/epa-ipm/past-modeling.html>) Lime Spray Dry (LSD) technology is one form of SO₂ control applied by Integrated Planning Model (IPM[®]). LSD is assumed to achieve a SO₂ removal percentage of 90%. According to Integrated Planning Model (IPM[®]) documentation, the costs used by Integrated Planning Model (IPM[®]) for these control technologies were developed by EPA and presented in a document titled *Emissions: A Review of Technologies*, (EPA-600/R-00-093), October 2000 prepared by EPA's Office of Research and Development. The cost and performance calculations were primarily a function of heat rate, capacity, and sulfur content. The range of various scrubber costs is included in Attachment 1. Depending on boiler size, boiler capacity factor, and coal sulfur content, the fixed capital costs range from \$142 to \$183/kW, while fixed operation and maintenance costs (O&M) range from \$5 to \$7/kW-yr and variable O&M costs range from 1.9 to 2.4 mills/kWh. Assuming the typical costs in Attachment 1, an EGU rated 800 MW, a capital cost investment of \$156/kW or \$125 million would be expected. Fixed O&M and variable O&M costs would be approximately \$6/kW-yr and 2.2 mills/kWh respectively and would depend on the EGU annual output. This cost could be expected to reduce SO₂ emissions by 90%. The cost and performance calculations were primarily a function of heat rate, capacity, and sulfur content. Using the data in Attachment 1 and applying a standard engineering economics analysis (Attachment 2), the costs of SO₂ removal using this control technology varies from approximately \$480-\$600 per ton of SO₂ removal, (Converted from 1999 to 2006 dollars using a conversion factor of 1.2101 www.inflationdata.com).

Cost of Flue Gas Desulfurization (FGD) – Dry

The cost of flue gas desulfurization varies depending on a number of factors including the size of the boiler, SO₂ reduction requirements, boiler capacity factor, and fuel sulfur content. Taking these factors into account, the typical cost effectiveness of a 1,000 MMBTU/hr (~300MW) coal-fired boiler equipped with dry FGD is around \$693 per ton of SO₂ reduced when combusting high-sulfur coal. This cost is based on a boiler capacity factor of 83% and SO₂ removal efficiency of 40%. Assuming the same boiler and SO₂ control efficiency, but firing low-sulfur coal, the cost per ton is slightly higher at \$764 per ton of SO₂ controlled. (*Controlling Fine Particulate Matter Under the Clean Air Act: A Menu of Options*, STAPPA-ALAPCO, March 2006) (Converted from 2003 to 2006 dollars using a conversion factor of 1.0959 www.inflationdata.com)

The 2005 EPA document titled, *Multipollutant Emission Control Technology Options for Coal-fired Power Plants*, shows that advanced dry FGD systems can cost from \$50-\$150 per kW, have fixed operation and maintenance costs ranging from <\$1 -\$3 per kW-yr, (based on 1-2% of capital), and variable operation and maintenance costs from 0.2-0.7 mills/kWh. Assuming an SO₂ reduction percentage of 40%, capacity factor of 85%, coal sulfur content of 1.5%, and coal heat content of 12,000 BTU/lb and applying a standard engineering economics analysis (Attachment 2), the costs of SO₂ removal using this control technology varies from approximately \$250-\$850 per ton (Converted from 2005 to 2006 dollars using a conversion factor of 1.0322 www.inflationdata.com)).

Summary of SO₂ Reduction Costs

The cost of SO₂ reductions on a per ton basis for EGUs is dependent on the cost (and availability) of fuels, boiler size and type, equipment retrofit costs, the desired emission reduction, and other site specific factors. Although these factors can cause the cost of the reductions to be well above or below the industry average, a summary of estimated ranges for SO₂ reductions is included in Table 2.6 for FGDs. Sufficient data were not available to calculate a range of costs with reasonable certainty for fuel switching or coal cleaning. Within the range of estimated costs for a given boiler size, the low end of the SO₂ reduction cost is generally associated with a high boiler capacity factor. The reason for this is due to the high capital costs and fixed operation and maintenance costs of the control device. With higher boiler capacity factors, the control device is able to reduce more tons of SO₂, which effectively reduces the per ton cost of the reduction.

**Table 2.6 Estimated Cost Ranges for SO₂ Control Options for Coal-fired EGU Boilers
 (2006 dollars/ton of SO₂ Reduced)**

Technology	Description	Performance	Cost Range (2006 dollars/ton of SO₂ Reduced)
Switch to a Low Sulfur Coal (generally <1% sulfur)	Replace high-sulfur bituminous coal combustion with lower-sulfur coal	50-80% reduction in SO ₂ emissions by switching to a lower-sulfur coal	Potential reduction in coal costs, but possibly offset by expensive retrofits and loss of boiler efficiency
Switch to natural gas (virtually 0% sulfur)	Replace coal combustion with natural gas	Virtually eliminate SO ₂ emissions by switching to natural gas	Unknown – cost of switch is currently uneconomical due to price of natural gas
Coal Cleaning	Coal is washed to remove some of the sulfur and ash prior to combustion	20-25% reduction in SO ₂ emissions	2-15% increase in fuel costs based on current prices of coal
Flue Gas Desulfurization (FGD) – Wet	SO ₂ is removed from flue gas by dissolving it in a lime or limestone slurry. (Other alkaline chemicals are sometimes used)	30-95%+ reduction in SO ₂ emissions	\$570-\$5,700 for EGUs <1,200 MW \$330-\$570 for EGUs >1,200 MW
Flue Gas Desulfurization (FGD) – Spray Dry	A fine mist containing lime or other suitable sorbent is injected directly into flue gas	60-95%+ reduction in SO ₂ emissions	\$570-\$4,550 for EGUs <600 MW \$170-\$340 for EGUs >600 MW
Flue Gas Desulfurization (FGD) –Dry	Powdered lime or other suitable sorbent is injected directly into flue gas	40-60% reduction in SO ₂ emissions	\$250-\$850 for EGUs ~300 MW

Table references:

1. EIA website accessed on 2/20/07: <http://www.eia.doe.gov/cneaf/coal/page/coalnews/coalmar.html>
2. EIA website accessed on 2/20/07: <http://www.eia.doe.gov/cneaf/coal/page/acr/table31.html>
3. STAPPA-ALAPCO. *Controlling Fine Particulate Matter Under the Clean Air Act: A Menu of Options*; March 2006.

4. U.S. EPA. EPA-600/R-05/034; *Multipollutant Emission Control Technology Options for Coal-fired Power Plants*; March 2005.
5. U.S. EPA. Integrated Planning Model (IPM[®]) background documentation located on website:
<http://www.epa.gov/airmarkets/progsregs/epa-ipm/past-modeling.html>
6. *Final Draft Report - Comparison of CAIR and CAIR Plus Proposal Using the Integrated Planning Model (IPM[®])*, ICF Resources; May 30, 2007.
7. World Bank Organization. Information located on website:
<http://www.worldbank.org/html/fpd/em/power/EA/mitigatn/aqsocc.stm>

Time Necessary for Compliance

Generally, sources are given a 2-4 year phase-in period to comply with new rules. Under the previous Phase I of the NO_x SIP Call, EPA provided a compliance date of about 3½ years from the SIP submittal date. Most MACT standards allow a 3-year compliance period. Under Phase I of the NO_x SIP Call, EPA provided a 2-year period after the SIP submittal date for compliance. States generally provided a 2-year period for compliance with RACT rules. For the purposes of this review, we have assumed that a maximum of 2 years after SIP submittal is adequate for pre-combustion controls (fuel switching or cleaning) and a maximum of 3 years is adequate for the installation of post combustion controls.

For post-combustion controls, site-specific information must be supplied to vendors in order to determine the actual time needed for installation of a given control. Large scale implementation of control devices within the EGU sector, particularly in a short time period, may require consideration of impacts on regional electricity demands. Integrated Planning Model (IPM[®]) has allowed for these and other impacts in determining the least cost approach to emission reductions, however, there is a great deal of uncertainty associated with modeled results in comparison to real-world applications of control strategies.

For BART control measures, the proposed BART guidelines require States to establish enforceable limits and require compliance with the BART emission limitations no later than 5 years after EPA approves the regional haze SIP.

Energy and Non-Air Impacts

Fuel switching and cleaning may add to transportation issues and secondary environmental impacts from waste disposal and material handling operations (e.g. fugitive dust). Additionally, these SO₂ control methods can create fuel supply problems if several large customers of various types of coal suddenly make changes in purchasing patterns. The main impact would be on the stability of fuel prices. It is not likely that this would be a persistent problem.

Another impact of fuel switching is that the modifications required for switching from one fuel to another may require a unit to be examined for major NSR permitting requirements. This is true even for modifications required for addition of controls since the modifications could trigger the definition of a “significant modification” under NSR/PSD.

Fuel switching between types and geographic sources of coal and installation of control devices can significantly effect mercury emissions. Data from EPA's Mercury Information Collection Request (ICR) revealed that many power plants have existing mercury capture as a co-benefit of air pollution control technologies for NO_x, SO₂ and PM. This includes capture of particulate-bound mercury in PM control equipment and capture of soluble ionic mercury in wet FGD

systems. Additional data have also shown that the use of SCR for NO_x control enhances oxidation of elemental mercury to the soluble ionic form, resulting in increased removal in the wet FGD system for units burning bituminous coal. Overall the ICR data revealed higher levels of Hg capture for bituminous coal-fired plants as compared to subbituminous coal-fired plants. Other factors that influence mercury emissions from coal combustion are chlorine content of the coal and fly ash composition.

FGD systems typically operate with high pressure drops across the control equipment, resulting in a significant amount of electricity required to operate blowers and circulation pumps. In addition, some combinations of FGD technology and plant configuration may require flue gas reheating to prevent physical damage to equipment, resulting in higher fuel usage. According to Integrated Planning Model (IPM[®]) background documentation, wet FGD systems reduce the capacity of the EGU by 2.1%. This means that the scrubber reduces the amount of electricity for sale to the grid by 2.1%. The main effect of this reduction is the increased cost of energy production.

The primary environmental impact of FGD systems is the generation of wastewater and sludge from the SO₂ removal process. When the exhaust gas from the boiler enters the FGD the SO₂, metals, and other solids are removed from the exhaust and collected in the FGD liquid. The liquid slurry collects in the bottom of the FGD in a reaction tank. The slurry is then dewatered and a portion of the contaminant-laden water is removed from the system as wastewater. Waste from the FGD systems will increase sulfate, metals, and solids loading in a facility's wastewater, potentially impacting community wastewater treatment facilities for smaller units that do not have self contained water treatment systems. In some cases FGD operation necessitates installation of a clarifier on site to remove excessive pollutants from wastewater. This places additional burdens on a facility or community wastewater treatment and solid waste management capabilities. These impacts will need to be analyzed on a site-specific basis. If lime or limestone scrubbing is used to produce calcium sulfite sludge, the sludge must be stabilized prior to land filling. If a calcium sulfate sludge is produced, dewatering alone is necessary before land filling, however, SO₂ removal costs are higher due to increased equipment costs for this type of control system. In some cases calcium sulfate sludge can be sold for use in cement manufacturing.

With wet FGD technologies a significant visible plume is present from the source due to condensation of water vapor as it exits the smoke stack. Although the water eventually evaporates and the plume disappears, community impact may be significant.

Remaining Useful Life of the Source

Available information for remaining useful life estimates of EGU boilers indicates a wide range of operating lifetimes, depending on size of the unit, capacity factor, and level of maintenance performed. Typical life expectancies range to 50 years or more. Additionally, implementation of regulations over the years has resulted in retrofitting that has ultimately increased the expected life span of many EGUs. The lifetime of an EGU may be extended through repair, repowering, or other strategies if the unit is more economical to run than to replace with power from other sources. This may be particularly likely if the unit serves an area which has limited transmission capacity available to bring in other power.

REFERENCES

2002 MANE-VU Emissions Inventory Version 3.

EPA Clean Air Markets Division, (CAMD). Personal communication regarding control at coal-fired EGUs in the United States from Mr. Peter Kokopeli (202-343-9085), (kokopeli.peter@epa.gov) via E-mail on April 3 and April 10, 2007.

NESCAUM. *Assessment of Control Technology Options for BART-Eligible Sources*; March, 2005.

Midwest RPO. *Candidate Control Measures – Source Category: Electric Generating Units*; 12/09/2005.

STAPPA-ALAPCO. *Controlling Fine Particulate Matter Under the Clean Air Act: A Menu of Options*; March 2006.

Evans, David A; Hobbs, B.F.; Oren, C.; Palmer, K.L. *Modeling the Effects of Changes in New Source Review on National SO₂ and NO_x Emissions from Electricity-Generating Units*.

U.S. EPA. EPA-600/R-05/034; *Multipollutant Emission Control Technology Options for Coal-fired Power Plants*; March 2005.

U.S. EPA. Integrated Planning Model (IPM[®]) background documentation located on website: (<http://www.epa.gov/airmarkets/progsregs/epa-ipm/past-modeling.html>)

ICF Resources. *Final Draft Report - Comparison of CAIR and CAIR Plus Proposal Using the Integrated Planning Model (IPM[®])*, May 30, 2007.

GE Water & Process Technologies. Information accessed on web March 27, 2007: http://www.zenon.com/applications/FGD_wastewater_treatment.shtml

Energy Information Administration (EIA). Information located on website: <http://www.eia.doe.gov/cneaf/coal/page/coalnews/coalmar.html>

Energy Information Administration (EIA). Information located on website: <http://www.eia.doe.gov/cneaf/coal/page/acr/table31.html>

Energy Information Administration (EIA). Information located on website: http://www.eia.doe.gov/cneaf/electricity/epm/epm_sum.html

World Bank Organization. Information located on website: <http://www.worldbank.org/html/fpd/em/power/EA/mitigatn/aqsocc.stm>

CHAPTER 3

ANALYSIS OF SELECTED ELECTRIC GENERATING UNITS (EGUs)

EGU FACILITY CONTROLS

The Vermont Department of Environmental Conservation (VTDEC) used the CALPUFF model to estimate sulfate ion impacts from large EGUs and determine the major EGUs and process units (boilers) at the EGUs that contribute to visibility impairment in Class I MANE-VU areas and Class I areas affected by emissions from sources within MANE-VU (See Chapter 1, for more details). Modeling was based on 2002 SO₂ emissions, and the results of the modeling showed the SO₂ emissions of the 100 highest emitting EGUs and the contribution of these sources toward the SO₂ concentration in each of the Class I areas. Proximity of the individual sources to Class I areas and variations in meteorology on the 20% worst visibility days resulted in varying impacts from individual sources on each Class I area. In subsequent discussions with MARAMA and the Reasonable Progress Workgroup, MACTEC was directed to focus on the emissions from the top 30 individual sources for this analysis. The 30 individual sources are located at 23 distinct facilities. The location of the 23 EGU facilities of interest is included in Figure 3.1.

Since EGUs are the largest emitters of SO₂ in the United States and have the greatest impact on haze in the MANE-VU Class I areas, it is particularly useful to determine what controls have recently been applied at these facilities (since the 2002 emission inventory). Also important is information about controls that are currently being applied at facilities, or are planned for addition in the future.

MACTEC gathered information from two primary sources of data for analysis of controls to be applied at the 30 EGUs.

1. Integrated Planning Model (IPM[®]) results from the MANE-VU CAIR Plus (MARAMA 4c) run.
2. Information from State agencies with facilities in the list of the top 30 individual sources. We requested EGU permit information, information about SO₂ controls recently implemented or planned at the facility and any available information on BART, consent decrees, or other regulations that will impact EGU control devices.

The MANE-VU CAIR Plus model results represent an estimate of the additional controls that might be installed under a more stringent cap and trade program in the Eastern U.S. The comparison of this estimate to the known planned controls for these 30 key EGUs is intended to give an idea of whether a stricter cap would in fact result in great controls at these sources.

Figure 3.1

EGU Facilities with the Greatest Visibility Impacts
in Mid-Atlantic North Eastern Class I Areas



Note: Some facilities are too close to differentiate on the map

INTEGRATED PLANNING MODEL (IPM[®]) ANALYSIS

For EGUs, EPA used the Integrated Planning Model (IPM[®]) to estimate which units will install controls at what costs and which units will buy credits. The RPOs also made some Integrated Planning Model (IPM[®]) runs to determine which units will install controls to comply with the EPA CAIR rule. Additionally, an even more stringent “CAIR Plus” strategy was investigated using the Integrated Planning Model (IPM[®]). The parsed results which include modeled control scenarios for individual EGUs were used to help determine costs for EGUs, and ultimately estimate the marginal cost of SO₂ reductions for the model planning years of 2009, 2012, and 2018.

MACTEC obtained information from the CAIR Plus Policy Case, (MARAMA_4c) for the years 2009, 2012, and 2018 for the 30 EGUs. The information obtained included unit design capacity, SO₂ emissions, assumed existing controls, and controls to be applied as calculated by the Integrated Planning Model (IPM[®]). The information was available for each of the individual years, (2009, 2012, and 2018). Also available were the resulting changes in design capacity due to controls, production output, or other factors from Integrated Planning Model (IPM[®]). The parsed model data do not supply specific design information pertaining to the scrubber size,

costs, or other related information for individual units. It is only possible to determine the year that the scrubber is due to be installed on individual process units. Information from the CAIR Plus Integrated Planning Model (IPM[®]) run is included in Table 3.1. Integrated Planning Model (IPM[®]) projections in Table 3.1 are not intended to be interpreted literally, but only as an example of the least-cost results from one set of inputs to the model. Also, the controls applied by Integrated Planning Model (IPM[®]) may differ from planned controls at the facility. For information on planned controls at these facilities, please see Table 3.2

Table 3.1 Integrated Planning Model (IPM® version 2.1.9) CAIR Plus Projections for the Top 30 EGUs Responsible for Visibility Impairment in MANE-VU Class I Areas

State	Facility ID	Facility	Primary Emissions Point Descriptions	Point #	2002 SO ₂ Total (Tons) ¹	2018 SO ₂ Total (Tons) ²	SO ₂ Reduction (2002-2018) (Tons/Year) ³	% SO ₂ Reduction (2002-2018) ³	Design Capacity ⁴	Existing Control ⁴	MANE_VU CAIR Plus Projection ⁵
TN	D03406C10	Johnsonville	Coal - wall fired; dry bottom boiler	10	108,789	46,000	63,000	58%	15,688 MMBTU	Cold-side ESP; LNB	SCR by 2012
OH	D028404	Conesville	Coal - tangential; dry bottom boiler	4	92,340	7,000	85,000	92%	764 MW	Cold-side ESP; LNB + OFA + BOOS	SCR and Scrubber by 2009
PA	D031361	Keystone	Coal - tangential; dry bottom boiler	1	87,709	5,000	83,000	94%	8,010 MMBTU	Cold-side ESP + SCR; LNB; OFA	Scrubber by 2009
OH	D02872C04	Muskingum River	Coal - cyclone; wet bottom boiler	4	24,484	1,000	23,000	96%	205 MW to 201 MW by 2012	Cold-side ESP; OFA	SCR and Scrubber by 2012
PA	D03179C01	Hatfield's Ferry	Coal - wall fired; dry bottom boiler	1	55,695	13,000	43,000	77%	5,766 MMBTU	Cold-side ESP + SNCR; LNB	None
OH	D02876C01	Kyger Creek	Coal - wall fired; wet bottom boiler	1	13,789	1,000	13,000	93%	13,789 MMBTU	Cold-side ESP + SCR; OFA	Scrubber by 2012
WV	D03935C02	John E. Amos	Coal - wall fired; dry bottom boiler	2	31,465	6,000	25,000	81%	7,020 MMBTU	Cold-side ESP + SCR; LNB	Scrubber
PA	D031362	Keystone	Coal - tangential; dry	2	62,890	4,000	59,000	94%	8,010 MMBTU	Cold-side ESP + SCR; LNB; OFA	Scrubber by 2009
IN	D01010C05	Wabash River	Coal - wall fired; dry bottom boiler	5	9,380	1,000	8,000	89%	95 MW	Cold-side ESP + Cyclone; LNB + OFA	SNCR by 2009
PA	D031491	Montour	Coal - tangential; dry bottom boiler	1	61,005	4,000	57,000	93%	744 MW	Cold-side ESP + SCR; LNB + OFA	Scrubber by 2009
NC	D080421	Belews Creek	Coal - wall fired; dry bottom boiler	1	57,848	3,000	55,000	95%	1,096 MW	Cold-side ESP + SCR; LNB	Mercury control
WV	D03948C02	Mitchell	Coal - wall fired; dry bottom boiler	2	29,532	6,000	24,000	80%	7,020 MMBTU	Cold-side ESP + SCR + Wet Scrubber; LNB	None
PA	D031222	Homer City	Coal - wall fired; dry bottom boiler	2	55,346	3,000	52,000	95%	6,792 MMBTU	Cold-side ESP + SCR; LNB + OFA	Scrubber by 2009
PA	D031492	Montour	Coal - tangential; dry bottom boiler	2	50,441	4,000	46,000	92%	729 MW	Cold-side ESP + SCR; LNB + OFA	Scrubber by 2009
MD	D01571CE2	Chalk Point	Coal - wall fired; dry bottom boiler	2	23,537	2,000	22,000	92%	335 MW	Cold-side ESP; LNB	SCR and Scrubber by 2009
MI	D01733C12	Monroe	Coal - cell fired; dry bottom boilers	1 & 2	48,563	28,000	21,000	42%	770, 785 MW	Cold-side ESP + SCR; LNB	None
PA	D031221	Homer City	Coal - wall fired; dry bottom boiler	1	45,745	3,000	43,000	93%	607 MW	Cold-side ESP + SCR; LNB + OFA	Scrubber by 2009
NC	D080422	Belews Creek	Coal - wall fired; dry bottom boiler	2	45,236	3,000	42,000	93%	1,096 MW	Cold-side ESP + SCR; LNB	Mercury control
WV	D039432	Fort Martin	Coal - wall fired; dry bottom boiler	2	45,890	5,000	41,000	89%	4,634 MMBTU	Cold-side ESP + SNCR; LNB + OFA	Scrubber by 2012
WV	D039431	Fort Martin	Coal - tangential; dry bottom boiler	1	45,228	5,000	40,000	89%	4,460 MMBTU	Cold-side ESP + SNCR; LNB + OFA	Scrubber by 2012
WV	D039353	John E. Amos	Coal - wall fired; dry bottom boiler	3	44,030	9,000	35,000	80%	11,900 MMBTU	Cold-side ESP + SCR; LNB	Scrubber

Table 3.1 Integrated Planning Model (IPM[®] version 2.1.9) CAIR Plus Projections for the Top 30 EGUs Responsible for Visibility Impairment in MANE-VU Class I Areas

State	Facility ID	Facility	Primary Emissions Point Descriptions	Point #	2002 SO ₂ Total (Tons) ¹	2018 SO ₂ Total (Tons) ²	SO ₂ Reduction (2002-2018) (Tons/Year) ³	% SO ₂ Reduction (2002-2018) ³	Design Capacity ⁴	Existing Control ⁴	MANE_VU CAIR Plus Projection ⁵
OH	D0283612	Avon Lake	Coal - wall fired; dry bottom boiler	12	41,872	6,000	36,000	86%	6,040 MMBTU	Cold-side ESP	Scrubber by 2009; SCR by 2012
VA	D037976	Chesterfield	Coal - tangential; dry bottom boiler	6	40,923	4,000	37,000	90%	6,650 MMBTU	Cold-side ESP; LNB + OFA	SCR and Scrubber by 2012
PA	D082261	Cheswick	Coal - tangential; dry bottom boiler	1	42,018	5,000	37,000	88%	550 MW	Cold-side ESP + SCR ; LNB + OFA	Scrubber by 2009
OH	D028281	Cardinal	Coal - cell fired; dry bottom boilers	1	39,894	2,000	38,000	95%	600 MW to 587 MW in 2012	Cold-side ESP + SCR; LNB	Scrubber by 2012
MD	D015731	Morgantown	Coal - tangential; dry bottom boiler	1	37,757	3,000	35,000	92%	570 MW	Cold-side ESP; LNB +OFA	SCR and Scrubber by 2009
OH	D028667	W H Sammis	Coal - wall fired; dry bottom boiler	7	33,720	3,000	31,000	91%	593 MW to 818 MW in 2012	Cold-side ESP + SNCR; LNB	Scrubber in 2009; Coal to IGCC in 2012
MD	D015732	Morgantown	Coal - tangential; dry bottom boiler	2	32,587	3,000	30,000	91%	570 MW	Cold-side ESP; LNB +OFA	SCR and Scrubber by 2009
MA	D016193	Brayton Point	Coal - wall fired; dry bottom boiler	3	19,451	3,000	16,000	85%	5,800 MMBTU	Cold-side ESP; LNB + OFA	SCR, Scrubber, Mercury Control by 2009
NJ	D023781	B L England	Coal - cyclone; wet bottom boiler	1	10,080	1,000	9,000	90%	129 MW	Cold-side ESP; + SNCR; OFA	None

Note: CEMS hourly data was used in the modeling of the emission units, not annual emissions. Also, a single emission unit at a generating plant may represent two or more emission units at that plant emitting from the same stack point. (Refer to the detailed explanation in the Introduction section of this report).

Table references:

1. 2002 SO₂ total for the emission point from RPO emission inventory
2. Integrated Planning Model (IPM[®]) CAIR Plus projected 2018 SO₂ total for the emission point (rounded to nearest 1,000 tons)
3. Approximate reduction in SO₂ emissions for 2018 Integrated Planning Model (IPM[®]) versus 2002 RPO emission inventory (rounded to nearest 1,000 tons)
4. Information from Integrated Planning Model (IPM[®]) and RPO emission inventories
5. Information from Integrated Planning Model (IPM[®]) CAIR Plus Scenario

Integrated Planning Model (IPM[®]) background documentation defines a range of control efficiencies, costs, and applicability based on unit size and coal type. (<http://www.epa.gov/airmarkets/progsregs/epa-ipm/past-modeling.html>) Three scrubber control technologies are discussed briefly in Integrated Planning Model (IPM[®]) background documentation; 1. Limestone Forced Oxidation (LSFO), 2. Magnesium Enhanced Lime (MEL) and 3. Lime Spray Dryer (LSD). Each of the three scrubber control technologies are applicable for distinct unit sizes and coal types, but there is no indication in the parsed Integrated Planning Model (IPM[®]) results as to which type of scrubber has been applied by the model. All three scrubber technologies are assumed to achieve a SO₂ removal percentage of 90% or greater. The range of various scrubber costs is included in Attachment 1. Depending on boiler size, boiler capacity factor, and coal sulfur content, the fixed capital costs range from \$140 to \$580/kW, while fixed operation and maintenance costs (O&M) range from \$5 to \$24/kW-yr and variable O&M costs range from 1.0 to 2.4 mills/kWh. Assuming the typical costs in Attachment 1, an EGU rated 500 MW, (the approximate average of the 30 units included in this analysis), a capital cost investment of \$216/kW or \$110 million would be expected. Fixed O&M and variable O&M costs would be approximately \$11/kW-yr and 2.0 mills/kWh, respectively and would depend on the EGU annual output. This cost could be expected to reduce SO₂ emissions by greater than 90%. A typical SO₂ reduction from a 500 MW unit (assuming a minimum of 90% reduction), based on the 30 units included in this analysis would be from 4,000 to 40,000 tons annually. (Converted from 1999 to 2006 dollars using a conversion factor of 1.2101 www.inflationdata.com)

INFORMATION OBTAINED FROM STATE AGENCIES

The 30 EGUs analyzed here are already subject to a variety of existing emission control requirements, including CAIR, BART, mercury controls, the NO_x SIP call, and EPA's acid rain control program. Therefore, it is expected that at least some of the 30 EGUs will already be adding control by 2018.

To investigate this possibility, MACTEC contacted State agencies with facilities in the list of the top 30 individual sources. We requested EGU permit information, information about SO₂ controls recently implemented or planned at the facility, and any available information on BART, consent decrees, or other regulations that will impact EGU control devices. The information we have obtained is included in Table 3.2.

Table 3.2 Point Source Information for the Top 30 EGUs Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	2002 SO ₂ Total (tons) ^a	Primary Emissions Point Description	Point ID (Permit ID No.)	Design Capacity	Existing Control(s)	Proposed/Planned Control(s)	Additional Information
Johnsonville ^{1, 2, 3}	TN	108,789	Coal-fired Boilers 01-10 for steam & electricity generation. The units are pulverized coal, dry-bottom boilers without fly ash reinjection. Units 1-6 are Combustion Engineering tangentially-fired boilers. Units 7-10 are Foster Wheeler wall fired boilers. All boilers exhaust through a common stack.	43-0011-01-10	15,688 MMBTU/hr	ESP	Combustion of low-sulfur fuel (since 2002) SCR by 2018	2018 SO ₂ emissions will be approximately 51,000 tpy
Conesville ⁴	OH	92,340	Unit 4 Main Boiler - Combustion Engineering model 7868 pulverized coal-fired, dry-bottom boiler	B004	7,960 MMBTU/hr	ESP	FGD and SCR by 8/18/09	N/A
Keystone (aka Reliant Energy Northeast Mgmt/Keystone Power Plant) ⁵	PA	87,709	Boiler 1 w/low NO _x burner	1 (031)	8,717 MMBTU/hr	Cold-side ESP SCR	FGD	Alternate operation: SCR System Boiler 1
Muskingum River ⁶	OH	24,484	Unit 3 Main Boiler - Babcock and Wilcox model RB-248 (custom) coal-fired, cyclone boiler	B004	2,150 MMBTU/hr	ESP	None planned	N/A

Table 3.2 Point Source Information for the Top 30 EGUs Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	2002 SO ₂ Total (tons) ^a	Primary Emissions Point Description	Point ID (Permit ID No.)	Design Capacity	Existing Control(s)	Proposed/Planned Control(s)	Additional Information
Hatfield's Ferry ⁵	PA	55,695	Babcock & Wilcox Boiler #1 that burns bituminous coal (227 tons/hr) and No. 2 fuel oil (1,384 gal/hr)	1 (031)	5,766 MMBTU/hr	Cold-side ESP	FGD	N/A
Kyger Creek ⁶	OH	13,789	Unit #1 Boiler- Babcock and Wilcox pulverized coal-fired, wet-bottom boiler	B001	1,850 MMBTU/hr	ESP	SCR, FGD operational by 1/01/09	N/A
John E. Amos ^{7,8}	WV	31,465	Dry-bottom wall-fired coal boiler	2	800 MW, 7,020 MMBTU/hr	ESP Low NO _x burners SCR	FGD (12/2008)	Vents through CS012
Keystone (aka Reliant Energy Northeast Mgmt/Keystone Power Plant) ⁵	PA	62,890	Boiler 2 w/low NO _x burner	2 (032)	8,717 MMBTU/hr	Cold-side ESP SCR	FGD	Alternate operation: SCR System Boiler 2
Wabash (aka Duke Energy Indiana, Inc. - Wabash River Generating Station) ^{9, 10}	IN	9,380	Wall fired coal electric utility boiler (pulverized – dry bottom) constructed in 1956 using No. 2 fuel oil as ignition fuel	5	1,096.2 MMBTU/hr	Low- NO _x burner (NO _x) ESP (PM)	None	Stack is equipped with CEM for SO ₂

Table 3.2 Point Source Information for the Top 30 EGUs Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	2002 SO ₂ Total (tons) ^a	Primary Emissions Point Description	Point ID (Permit ID No.)	Design Capacity	Existing Control(s)	Proposed/Planned Control(s)	Additional Information
Montour (aka PPL Montour, LLC – Montour Steam Electric Station) ⁵	PA	61,005	CE Boiler – Unit #1 that burns bituminous coal and No. 2 fuel oil	1 (031)	7,317 MMBTU/hr	Cold-side ESP SCR	FGD	N/A
Belews Creek (aka Duke Power's Belews Creek Plant) ¹¹	NC	57,848	Coal-fired electric utility boiler constructed in 1974	1	1,120 MW	None	Scrubbers (2008)	Expected rate under their compliance plan for the Clean Smokestacks Act is 0.150 lbs SO ₂ /MMBTU. Expected emissions SO ₂ for 2013 and later is 5,512 tpy.
Mitchell ^{7, 12}	WV	29,532	Dry-bottom wall-fired coal boiler	2	800 MW, 7,020 MMBTU/hr	ESP Low NO _x burners	FGD (1/2007); SCR (4/2007)	Vents through CS012
Homer City (aka Homer City OL/Homer City Generation Station) ¹³	PA	55,346	Boiler No. 2 (Unit 2)	2 (032)	6,792 MMBTU/hr	Cold-side ESP SCR	FGD	N/A
Montour (aka PPL Montour, LLC – Montour Steam Electric Station) ⁵	PA	50,441	CE Boiler – Unit #2 that burns bituminous coal and No. 2 fuel oil	2 (032)	1,239 MMBTU/hr	Cold-side ESP SCR	FGD	N/A

Table 3.2 Point Source Information for the Top 30 EGUs Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	2002 SO ₂ Total (tons) ^a	Primary Emissions Point Description	Point ID (Permit ID No.)	Design Capacity	Existing Control(s)	Proposed/Planned Control(s)	Additional Information
Chalk Point ^{15, 16}	MD	23,537	Steam Unit 2 is a wall fired, dry bottom, supercritical boiler base loaded unit. The primary fuel is coal with natural gas and No. 2 oil used for ignition.	2	342 MW	Low NO _x burners ESP SACR LNBs & SOFA (NO _x)	SCR and FGD (2009/2010 timeframe)	Unit covered under the MD Healthy Air Act
Monroe (aka Detroit Edison – Monroe Power Plant) ¹⁶	MI	48,563	4 cell burner boilers (Boiler Unit Nos. 1, 2, 3, and 4) constructed in the late 1960s (1968-1969) and modified in 1994	EG01 EG02 EG03 EG04	3,000 MW (total)	Dry wire ESP (SO ₃) FGD (Units 3 & 4) @ 97% CE	May put scrubbers on Units 1 & 2 later	If additional scrubbers are added, a SO ₂ reduction of 97% is anticipated
Homer City (aka Homer City OL/Homer City Generation Station) ¹³	PA	45,745	Boiler No. 1 (Unit 1)	1 (031)	6,792 MMBTU/hr	Cold-side ESP SCR	FGD	N/A
Belews Creek (aka Duke Power's Belews Creek Plant) ¹¹	NC	45,236	Coal-fired electric utility boiler constructed in 1975	2	1,120 MW	None	Scrubbers (2008)	Expected rate under their compliance plan for the Clean Smokestacks Act is 0.150 lbs SO ₂ /MMBTU. Expected emissions SO ₂ for 2013 and later is 4,639 tpy.

Table 3.2 Point Source Information for the Top 30 EGUs Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	2002 SO ₂ Total (tons) ^a	Primary Emissions Point Description	Point ID (Permit ID No.)	Design Capacity	Existing Control(s)	Proposed/Planned Control(s)	Additional Information
Fort Martin ^{7,8}	WV	45,228	Tangentially-fired coal boiler	1	552 MW, 4,460 MMBTU/hr	ESP Low NO _x burners SNCR Trim	FGD (4Q 2009)	N/A
Fort Martin ^{7,8}	WV	45,890	Wall-fired coal boiler	2	55 MW, 4,634 MMBTU/hr	ESP Low NO _x burners SNCR Trim	FGD (1Q 2010)	N/A
John E. Amos ^{7,8}	WV	44,030	Dry-bottom wall-fired coal boiler	3	1,300 MW, 11,900 MMBTU/hr	ESP Low NO _x burners SCR	FGD (12/2007)	N/A
Avon Lake ⁶	OH	41,872	Boiler #12 - Pulverized coal-fired, dry bottom, boiler	B012	6,040 MMBTU/hr	ESP	SCR and FGD operational by 2010	N/A
Chesterfield (aka Chesterfield Power Station) ¹⁷	VA	40,923	Combustion Engineering tangentially-fired coal boiler equipped with startup burners	6 (ES-6A)	6,650 MMBTU/hr	SCR ESP Stage combustion coal burners	FGD (95% CE under construction, operational 2008)	The unit is restricted to burn 2,330,160 tons/yr of coal at an annual average heating value of 12,500 BTU/lbs
Cheswick (aka Cheswick Power Station) ¹⁸	PA	42,018	Tangentially-fired "main" boiler that burns bituminous coal (primary fuel), natural gas, and synfuel	1	5,500 MMBTU/hr (coal & synfuel) 1,000 MMBTU/hr (NG)	Low NO _x burners SCR ESP w/flue gas conditioning (PM)	FGD (98% CE planned)	N/A

Table 3.2 Point Source Information for the Top 30 EGUs Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	2002 SO ₂ Total (tons) ^a	Primary Emissions Point Description	Point ID (Permit ID No.)	Design Capacity	Existing Control(s)	Proposed/Planned Control(s)	Additional Information
Cardinal ^{6, 12}	OH	39,894	Unit 1 Main Boiler - Babcock and Wilcox, pulverized coal-fired, dry bottom, cell burner boiler	B001	527 MMBTU/hr	ESP	FGD (2/2008)	N/A
Morgantown ^{14, 15}	MD	37,757	Combustion Engineering, Inc., Unit Boiler No. 1 - steam generating coal-fired utility boiler installed in 1967 which primarily combusts Eastern Bituminous coal containing no more than 2% sulfur by weight and secondary fuel is No. 6 oil containing no more than 2% sulfur by weight	1 (F-1)	5,317 MMBTU/hr	ESP SO ₃ injection Low NO _x burners	SCR and FGD (2009/2010 timeframe)	Stacks equipped with SO ₂ , NO _x , CO ₂ , and ultrasonic flow monitors. Unit covered under the MD Healthy Air Act.
W H Sammis ⁶	OH	33,720	Coal Fired Boiler No.1 - Foster-Wheeler pulverized coal-fired, dry-bottom boiler	B007	1,822 MMBTU/hr	Fabric filter	ESP FGD operational 12/31/09 SNCR Operational 06/06	N/A

Table 3.2 Point Source Information for the Top 30 EGUs Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	2002 SO ₂ Total (tons) ^a	Primary Emissions Point Description	Point ID (Permit ID No.)	Design Capacity	Existing Control(s)	Proposed/Planned Control(s)	Additional Information
Morgantown ^{14, 15}	MD	32,587	Combustion Engineering, Inc., Unit Boiler No. 2 - steam generating coal-fired utility boiler installed in 1967 primarily combusts Eastern Bituminous coal w/ no more than 2% sulfur by weight and secondary fuel is No. 6 oil w/ no more than 2% sulfur by weight	1 (F-2)	5,317 MMBTU/hr	ESP SO ₃ injection Low NO _x burners	SCR and FGD (2009/2010 timeframe)	Stacks equipped with SO ₂ , NO _x , CO ₂ , and ultrasonic flow monitors. Unit covered under the MD Healthy Air Act.
Brayton Point ¹⁹	MA	19,451	Water tube boiler	3 (EU3)	5,655 MMBTU/hr	ESP w/flue gas conditioning (PCD-3)	Fuel sulfur content (2011) FGD (2011)	BART recommended controls for SO ₂ are 95% control or 0.15 lb/MMBTU (coal), 0.33 lb/MMBTU (0.3% fuel sulfur limit) (oil)
B L England ^{20, 21}	NJ	10,080	Wet-bottom, cyclone coal boiler	1	129 MW	ESP SNCR	None	The facility will either close by 2012 or install scrubbers on all coal-fired units. One scrubber is already installed and the other unit would get a 95% CE –minimum, but unclear if this unit is already controlled.

^a 2002 SO₂ total for the emission point from RPO emission inventory.

- ¹ Tennessee Department of Environment and Conservation, Division of Air Pollution Control. Personal communication regarding Johnsonville facility from Ms. Julie Aslinger (615-532-0587, Julie.Aslinger@state.tn.us) via E-mail on March 1, 2007.
- ² MACTEC Federal Programs, Inc., “Revised Draft Final, Assessing Reasonable Progress for Regional Haze in the Mid-Atlantic North Eastern Class I Areas”, March 8, 2007. Comment regarding Johnsonville facility received from Ms. Julie Aslinger (615-532-0587, Julie.Aslinger@state.tn.us) via E-mail on March 30, 2007.
- ³ MACTEC, Inc., “Documentation of the Base G 2002 Base Year, 2009 and 2018 Emission Inventories for VISTAS”, January, 2007.
- ⁴ Ohio Environmental Protection Agency, Division of Air Pollution Control. Personal communications regarding Conesville facility from Mr. William Spires (614-644-3618, bill.spires@epa.state.oh.us) via E-mail on February 20 and 21, 2007.
- ⁵ Pennsylvania Department of Environmental Protection, Bureau of Air Quality. Personal communications regarding Keystone, Hatfield’s Ferry, and Montour facilities from Ms. Nancy Herb (717-783-9269, nherb@state.pa.us) via E-mail on January 31 and February 7, 2007.
- ⁶ Ohio Environmental Protection Agency, Division of Air Pollution Control. Personal communication regarding Muskingum, Kyger Creek, Avon Lake, Cardinal, and WH Sammis facilities from Mr. William Spires (614-644-3618, bill.spires@epa.state.oh.us) via E-mail on February 20, 2007.
- ⁷ West Virginia Division of Air Quality. Personal communication regarding John. E. Amos, Mitchell, and Fort Martin facilities from Ms. Laura Crowder (304-926-0499 Ext. 1247, LCROWDER@wvdep.org) via E-mail on February 17, 2007.
- ⁸ MACTEC Federal Programs, Inc., “Revised Draft Final, Assessing Reasonable Progress for Regional Haze in the Mid-Atlantic North Eastern Class I Areas”, March 8, 2007. Comments regarding John E. Amos, Mitchell, and Fort Martin and facilities received from Ms. Laura Crowder (304-926-0499 Ext. 1247, LCROWDER@wvdep.org) via E-mail on March 30, 2007.
- ⁹ Indiana Department of Environmental Management, Office of Air Quality. Personal communication regarding Wabash facility between Mr. Jay Koch (317-233-0581, JKOCH@idem.IN.gov) and Ms. Lori Cress, MACTEC Federal Programs, Inc. on January 31, 2007.
- ¹⁰ Indiana Department of Environmental Management, Office of Air Quality. Personal communications regarding Wabash facility from Mr. Jay Koch (317-233-0581, JKOCH@idem.IN.gov) via E-mail on February 1 and 5, 2007.
- ¹¹ North Carolina Department of Environment and Natural Resources, Division of Air Quality. Personal communications regarding Belews Creek facility from Ms. Sheila Holman (919-715-0971, sheila.holman@ncmail.net) via E-mail on February 1 and 2, 2007.
- ¹² MACTEC Federal Programs, Inc., “Revised Draft Final, Assessing Reasonable Progress for Regional Haze in the Mid-Atlantic North Eastern Class I Areas”, March 8, 2007. Comments regarding Mitchell and Cardinal facilities received from Mr. David J. Long, P.E. of American Electric Power (614-716-1245, djlong@aep.com) via E-mail on March 29, 2007.
- ¹³ Pennsylvania Department of Environmental Protection, Bureau of Air Quality. Personal communications regarding Homer City facility from Ms. Nancy Herb (717-783-9269, nherb@state.pa.us) via E-mail on January 31 and February 7 and 8, 2007.
- ¹⁴ Maryland Department of the Environment. Personal communication regarding Chalk Point and Morgantown facilities from Mr. Andy Heltibridge (410-537-4218, aheltibridge@mde.state.md.us) via U.S. mail on February 9, 2007.
- ¹⁵ MACTEC Federal Programs, Inc., “Revised Draft Final, Assessing Reasonable Progress for Regional Haze in the Mid-Atlantic North Eastern Class I Areas”, March 8, 2007. Comments regarding Chalk Point and Morgantown facilities received from Mr. Brian Hug (410-537-4125, bhug@mde.state.md.us) via E-mail on March 14, 2007.
- ¹⁶ Michigan Department of Environmental Quality, Air Quality Division. Personal communication regarding Monroe facility from Ms. Teresa Walker (517-335-2247, walkertr@michigan.gov) via E-mail on February 7, 2007.
- ¹⁷ Virginia Department of Environmental Quality, Division of Air Quality. Personal communication regarding Chesterfield facility from Ms. Doris McLeod (504-698-4197, damcleod@deq.virginia.gov) via E-mail on February 9, 2007.
- ¹⁸ Allegheny County Health Department. Personal communications regarding Cheswick facility from Ms. Jayme Graham (412-578-8129, JGraham@achd.net) via E-mail on February 2, 2007.
- ¹⁹ Massachusetts Department of Environmental Protection. Personal communications regarding Brayton Point facility from Mr. Donald Squires (617-292-5618, Donald.Squires@state.ma.us) via E-mail on February 2 and 7, 2007.
- ²⁰ New Jersey Department of Environmental Protection, Division of Air Quality. Personal communications regarding B.L. England facility between Mr. Ray Papalski (609-633-7225, Ray.Papalski@dep.state.nj.us) and Ms. Lori Cress, MACTEC Federal Programs, Inc. on January 31, 2007.
- ²¹ New Jersey Department of Environmental Protection, Division of Air Quality. Personal communications regarding B.L. England facility from Mr. Ray Papalski (609-633-7225, Ray.Papalski@dep.state.nj.us) via E-mail on February 1, 2007.

Table 3.3 presents a side by side comparison of the predicted control information from Tables 3.1 and 3.2. The existing control information available from Integrated Planning Model (IPM[®]) data was in disagreement with the information reported by the States for many of the EGUs. Since controls at the EGUs may have changed recently [since Integrated Planning Model (IPM[®] v.2.1.9)], Table 3.3 reports existing control information obtained from the States for this report. The information on proposed or planned controls obtained from the States reflects that 26 of the 30 EGUs included in this study plan to install SO₂ control (FGD/scrubber), or switch to a lower sulfur coal prior to 2018. SO₂ reduction estimates from the States were only available for some of the EGUs, but reflect a significant reduction in SO₂ for those units for which an estimate was supplied.

Regarding the control information from Integrated Planning Model (IPM[®]) CAIR Plus results, Integrated Planning Model (IPM[®]) predicts that 21 of the 30 EGUs will install SO₂ in the CAIR Plus scenario. Additionally, Integrated Planning Model (IPM[®]) predicts a reduction in SO₂ at all 30 EGUs included in this study, including the 9 units for which no SO₂ control is added. The SO₂ reductions estimated by Integrated Planning Model (IPM[®]) are said to be achieved through a number of compliance strategies in addition to control, such as fuel switching, plant retirements, plant dispatch, and new builds. Additional information on all Integrated Planning Model (IPM[®]) compliance strategies and well as information on NO_x reductions are available in Integrated Planning Model (IPM[®]) documentation available on EPA's website and in the ICF report titled: *Final Draft Report – Comparison of CAIR and CAIR Plus Proposal Using the Integrated Planning Model (IPM[®])*.

Table 3.3 Comparison of Controls Predicted by Integrated Planning Model (IPM[®]) CAIR Plus Results versus Proposed/Planned Control Additions by the State/Facility (by 2018) at the Top 30 EGUs Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	Point #	2002 SO ₂ (tons)	Existing Controls (based on information from State)	Facility/State Proposed/Planned Controls { % SO ₂ reduction }	IPM [®] Predicted Controls (CAIR Plus) { % SO ₂ reduction }
Johnsonville	TN	10	108,789	ESP	Low sulfur fuel since 2002; SCR by 2018 { 53% reduction in SO ₂ }	SCR by 2012 { 58% reduction in SO ₂ }
Conesville	OH	4	92,340	ESP	FGD and SCR by 8/18/09 { SO ₂ reduction unavailable }	SCR and Scrubber by 2009 { 92% reduction in SO ₂ }
Keystone	PA	1	87,709	Cold-side ESP; SCR	FGD { SO ₂ reduction unavailable }	Scrubber by 2009 { 94% reduction in SO ₂ }
Muskingum River	OH	4	24,484	ESP	None planned { SO ₂ reduction assumed 0% }	SCR and Scrubber by 2012 { 96% reduction in SO ₂ }
Hatfield's Ferry	PA	1	55,695	Cold-side ESP	FGD { SO ₂ reduction unavailable }	None { 77% reduction in SO ₂ }
Kyger Creek	OH	1	13,789	ESP	SCR, FGD operational by 1/01/09 { SO ₂ reduction unavailable }	Scrubber by 2012 { 93% reduction in SO ₂ }
John E. Amos	WV	2	31,465	ESP; Low NO _x burners; SCR	FGD by 12/2008 { SO ₂ reduction unavailable }	Scrubber { 81% reduction in SO ₂ }

Table 3.3 Comparison of Controls Predicted by Integrated Planning Model (IPM[®]) CAIR Plus Results versus Proposed/Planned Control Additions by the State/Facility (by 2018) at the Top 30 EGUs Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	Point #	2002 SO ₂ (tons)	Existing Controls (based on information from State)	Facility/State Proposed/Planned Controls { % SO ₂ reduction }	IPM [®] Predicted Controls (CAIR Plus) { % SO ₂ reduction }
Keystone	PA	2	62,890	Cold-side ESP; SCR	FGD { SO ₂ reduction unavailable }	Scrubber by 2009 { 94% reduction in SO ₂ }
Wabash River	IN	5	9,380	Low NO _x burners; ESP	None planned { SO ₂ reduction assumed 0% }	SNCR by 2009 { 89% reduction in SO ₂ }
Montour	PA	1	61,005	Cold-side ESP; SCR	FGD { SO ₂ reduction unavailable }	Scrubber by 2009 { 93% reduction in SO ₂ }
Belews Creek	NC	1	57,848	None	Scrubbers (2008) { 90% reduction in SO ₂ }	Mercury control { 95% reduction in SO ₂ }
Mitchell	WV	2	29,532	ESP; Low NO _x burners	FGD (1/2007); SCR (4/2007) { SO ₂ reduction unavailable }	None { 80% reduction in SO ₂ }
Homer City	PA	2	55,346	Cold-side ESP; SCR	FGD { SO ₂ reduction unavailable }	Scrubber by 2009 { 95% reduction in SO ₂ }
Montour	PA	2	50,441	Cold-side ESP; SCR	FGD { SO ₂ reduction unavailable }	Scrubber by 2009 { 92% reduction in SO ₂ }
Chalk Point	MD	2	23,537	Low NO _x burners; ESP; SACR LNBs & SOFA	SCR and FGD (2009/2010 timeframe) { SO ₂ reduction unavailable }	SCR and Scrubber by 2009 { 92% reduction in SO ₂ }
Monroe	MI	1 & 2	48,563	Dry wire ESP; FGD	Possible addition of scrubbers { 97% SO ₂ reduction if controlled }	None { 42% reduction in SO ₂ }
Homer City	PA	1	45,745	Cold-side ESP; SCR	FGD { SO ₂ reduction unavailable }	Scrubber by 2009 { 93% reduction in SO ₂ }
Belews Creek	NC	2	45,236	None	Scrubbers (2008) { 90% reduction in SO ₂ }	Mercury control { 93% reduction in SO ₂ }
Fort Martin	WV	2	45,890	ESP, Low NO _x burners; SNCR Trim	FGD (4Q 2009) { SO ₂ reduction unavailable }	Scrubber by 2012 { 89% reduction in SO ₂ }
Fort Martin	WV	1	45,228	ESP, Low NO _x burners; SNCR Trim	FGD (1Q 2010) { SO ₂ reduction unavailable }	Scrubber by 2012 { 89% reduction in SO ₂ }
John E. Amos	WV	3	44,030	ESP, Low NO _x burners; SCR	FGD (12/2007) { SO ₂ reduction unavailable }	Scrubber { 80% reduction in SO ₂ }
Avon Lake	OH	12	41,872	ESP	SCR and FGD operational by 2010 { SO ₂ reduction unavailable }	Scrubber by 2009; SCR by 2012 { 86% reduction in SO ₂ }
Chesterfield	VA	6	40,923	SCR; ESP; Stage combustion burners	FGD operational 2008 { 95% reduction in SO ₂ }	SCR and Scrubber by 2012 { 90% reduction in SO ₂ }
Cheswick	PA	1	42,018	Low NO _x burners; SCR; ESP w/flue gas conditioning	None { SO ₂ reduction assumed 0% }	Scrubber by 2009 { 88% reduction in SO ₂ }
Cardinal	OH	1	39,894	ESP	FGD (2/2008) { SO ₂ reduction unavailable }	Scrubber by 2012 { 95% reduction in SO ₂ }

Table 3.3 Comparison of Controls Predicted by Integrated Planning Model (IPM[®]) CAIR Plus Results versus Proposed/Planned Control Additions by the State/Facility (by 2018) at the Top 30 EGUs Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	Point #	2002 SO ₂ (tons)	Existing Controls (based on information from State)	Facility/State Proposed/Planned Controls { % SO ₂ reduction }	IPM [®] Predicted Controls (CAIR Plus) { % SO ₂ reduction }
Morgantown	MD	1	37,757	ESP; SO ₃ injection; Low NO _x burners	SCR and FGD (2009/2010 timeframe) { SO ₂ reduction unavailable }	SCR and Scrubber by 2009 { 92% reduction in SO ₂ }
W H Sammis	OH	7	33,720	Fabric filter	ESP and FGD operational 12/31/09; SNCR operational 6/06 { SO ₂ reduction unavailable }	Scrubber in 2009; Coal to IGCC in 2012 { 91% reduction in SO ₂ }
Morgantown	MD	2	32,587	ESP; SO ₃ injection; Low NO _x burners	SCR and FGD (2009/2010 timeframe) { SO ₂ reduction unavailable }	SCR and Scrubber by 2009 { 91% reduction in SO ₂ }
Brayton Point	MA	3	19,451	ESP w/flue gas conditioning (PCD-3)	Fuel sulfur content (2011); FGD 2011 { 95% reduction in SO ₂ }	SCR, Scrubber, Mercury Control by 2009 { 85% reduction in SO ₂ }
B L England	NJ	1	10,080	ESP;SNCR	Facility will either close or install scrubbers by 2012 { 95% reduction in SO ₂ }	None { 90% reduction in SO ₂ }

Table Reference: See full reference information for Integrated Planning Model (IPM[®]) and State agency contacts associated with Tables 3.1 and 3.2.

REFERENCES

2002 MANE-VU Emissions Inventory Version 3.

NESCAUM. *Assessment of Control Technology Options for BART-Eligible Sources*; March, 2005.

Midwest RPO. *Candidate Control Measures – Source Category: Electric Generating Units*; 12/09/2005.

STAPPA-ALAPCO. *Controlling Fine Particulate Matter Under the Clean Air Act: A Menu of Options*; March 2006.

Evans, David A; Hobbs, B.F.; Oren, C.; Palmer, K.L. *Modeling the Effects of Changes in New Source Review on National SO₂ and NO_x Emissions from Electricity-Generating Units*.

ICF Resources. *Final Draft Report - Comparison of CAIR and CAIR Plus Proposal Using the Integrated Planning Model (IPM[®])*, May 30, 2007.

U.S. EPA. EPA-600/R-05/034; *Multipollutant Emission Control Technology Options for Coal-fired Power Plants*; March 2005.

U.S. EPA. Integrated Planning Model (IPM[®]) background documentation located on website: (<http://www.epa.gov/airmarkets/progsregs/epa-ipm/past-modeling.html>)

Energy Information Administration (EIA). Information located on website: <http://www.eia.doe.gov/cneaf/coal/page/coalnews/coalmar.html>

Energy Information Administration (EIA). Information located on website: <http://www.eia.doe.gov/cneaf/coal/page/acr/table31.html>

World Bank Organization. Information located on website: <http://www.worldbank.org/html/fpd/em/power/EA/mitigatn/aqsocc.stm>

Attachment 1. Illustrative Scrubber Costs (1999 \$) for Representative MW and Heat Rates under the Assumptions in EPA Base Case 2004

Scrubber Type	Capacity (MW)	Heat Rate (BTU/kWh)			Cost
		9,000	10,000	11,000	
LSFO Min. Cutoff: >= 100 MW Max. Cutoff: None Assuming 3.0% Sulfur Content Coal (by weight) with Heating Value of 11,900 BTU/lb	100	456	469	481	Cap.Cost (\$/kW)
		19	19	20	Fix. O&M \$/kW-yr
		1.6	1.7	1.9	Var. O&M mills/kWh
	300	225	234	243	Cap.Cost (\$/kW)
		11	11	20	Fix. O&M \$/kW-yr
		1.6	1.7	1.9	Var. O&M mills/kWh
	500	173	180	187	Cap.Cost (\$/kW)
		9	9	9	Fix. O&M \$/kW-yr
		1.6	1.7	1.9	Var. O&M mills/kWh
	700	142	149	155	Cap.Cost (\$/kW)
		8	8	8	Fix. O&M \$/kW-yr
		1.6	1.7	1.9	Var. O&M mills/kWh
	1,000	157	166	174	Cap.Cost (\$/kW)
		7	8	8	Fix. O&M \$/kW-yr
		1.6	1.7	1.9	Var. O&M mills/kWh
MEL Min. Cutoff: >= 100 MW Max. Cutoff: <500 MW Assuming 1.5% Sulfur Content Coal (by weight) with Heating Value of 11,900 BTU/lb	100	340	351	362	Cap.Cost (\$/kW)
		17	17	17	Fix. O&M \$/kW-yr
		0.8	0.9	1	Var. O&M mills/kWh
	200	224	233	241	Cap.Cost (\$/kW)
		12	12	12	Fix. O&M \$/kW-yr
		0.8	0.9	1	Var. O&M mills/kWh
	300	224	235	245	Cap.Cost (\$/kW)
		11	11	12	Fix. O&M \$/kW-yr
		0.8	0.9	1	Var. O&M mills/kWh
	400	200	210	220	Cap.Cost (\$/kW)
		10	10	10	Fix. O&M \$/kW-yr
		0.8	0.9	1	Var. O&M mills/kWh
	500	178	187	196	Cap.Cost (\$/kW)
		9	9	9	Fix. O&M \$/kW-yr
		0.8	0.9	1	Var. O&M mills/kWh
LSD Min. Cutoff: >= 550 MW Max. Cutoff: None Assuming 1.5% Sulfur Content Coal (by weight) with Heating Value of 11,900 BTU/lb	600	137	144	151	Cap.Cost (\$/kW)
		5	5	6	Fix. O&M \$/kW-yr
		1.6	1.8	2	Var. O&M mills/kWh
	700	127	134	140	Cap.Cost (\$/kW)
		5	5	5	Fix. O&M \$/kW-yr
		1.6	1.8	2	Var. O&M mills/kWh
	800	124	130	135	Cap.Cost (\$/kW)
		5	5	5	Fix. O&M \$/kW-yr
		1.6	1.8	2	Var. O&M mills/kWh
	900	125	131	137	Cap.Cost (\$/kW)
		4	4	4	Fix. O&M \$/kW-yr
		1.6	1.8	2	Var. O&M mills/kWh
	1,000	118	124	130	Cap.Cost (\$/kW)
		4	4	4	Fix. O&M \$/kW-yr
		1.6	1.8	2	Var. O&M mills/kWh

Table reference: Copy of Table 5.3 from EPA Integrated Planning Model (IPM[®]) documentation (<http://www.epa.gov/airmarkets/progsregs/epa-ipm/docs/bc5emission.pdf>). (Note: To adjust cost data from 1999 to 2006, multiply by 1.2101 www.inflationdata.com)

Attachment 2. Engineering Methodology Used to Calculate \$/ton Pollutant Reduction

Calculation of Cost per ton of SO₂ of scrubbing

First, calculate annual cost of a scrubber (\$/kW/yr)

Cost data

	Cap	Fix O&M	Var O&M	
	469	19	1.7	
	\$/Kw	\$/KW-yr	\$/kWh	
Assume	Cap Rec Factor	CapacFact		
	0.15	0.85		
	1/yr		dimensionless	
			8760 h/yr	
				TOTAL
Implies	70.35	19	12.6582	102.01
	\$/KW-yr	\$/KW-yr	\$/KW-yr	\$/KW-yr

This is the annual cost per kW for a scrubber

Then calculation annual emissions reduction from the scrubber

Calculate emissions rate (lb/MBTU) based on coal S content

Fraction S	SO ₂ /S		Heat Content		SO ₂ Emissions rate
3%	2	divided by	0.012	=	5
dimensls	dimesnlss		MBTU/lb		lb/MBTU

Use emissions rate and assumed plant efficiency/operating hours to get emissions/kw/yr

UnconSO ₂ Reduction	Heat Rate	Cap Factor	Hr/yr		tons/lb	
5	0.9	0.01	0.85	8760	0.0005	=
lb/MBTU	dimensionl	MBTU/kWh	dimensls	hr/yr	tons/lb	tons/kw-yr

Check of units:

lb	mbtu	hr	ton
mbtu	kW	hr	lb

Result: Get \$/ton of reduction

divide cost/kw/yr by ton/kw/yr =	608.877	=	102.01	divided by	0.167535
			\$/KW-yr		tons/kw-yr

CHAPTER 4

SOURCE CATEGORY ANALYSIS: INDUSTRIAL, COMMERCIAL, AND INSTITUTIONAL BOILERS

SOURCE CATEGORY DESCRIPTION

The MANE-VU contribution assessment has demonstrated that SO₂ emissions are the principal contributor to visibility impairment in Class I areas in the northeast. After electric generation units, Industrial, Commercial, and Institutional (ICI) boilers and heaters are the next largest class of pollution sources that contribute to SO₂ emissions. Typical industrial applications include chemical, refining, manufacturing, metals, paper, petroleum, food production and a wide variety of other small industries and commercial heating applications. Commercial and institutional boilers are normally used to produce steam and hot water for space heating in office buildings, hotels, apartment buildings, hospitals, universities, and similar facilities. Most commercial and institutional boilers are small, with 80% of the population smaller than 15 million British Thermal Units per hour (MMBTU/hr). A fairly wide range of fuels are used by ICI boilers, ranging from coal, petroleum coke, distillate and residual fuel oils, natural gas, wood waste or other class of waste products. Boilers aggregated under the ICI classification are generally smaller than boilers in the electric power industry, and typically have a heat input in the 10 to 250 MMBTU/hr range; however, industrial boilers can be as large as 1,000 MMBTU/hr or as small as 0.5 MMBTU/hour.

The process that a particular unit serves strongly influences the boiler fuel choice. For example, the iron and steel industry uses coal to generate blast furnace gas or coke oven gas that is used in boilers, resulting in sulfur emissions. Pulp and paper processing may use biomass as a fuel, resulting in high PM emissions. Units with short duty cycles may utilize oil or natural gas as a fuel. The use of a wide variety of fuels is an important characteristic of the ICI boiler category. While many boilers are capable of co-firing liquid or gaseous fuels in conjunction with solid fuels, boilers are usually designed for optimum combustion of a single specific, fuel. Changes to the fuel type may, therefore, reduce the capacity, duty cycle, or efficiency of the boiler.

Boiler design also plays a role in the uncontrolled emission rate. Most ICI boilers are of three basic designs: water tube, fire tube, or cast iron. The fuel-firing configuration is a second major identifier of boiler design for solid fuels. Stoker boilers are the oldest technology and are still widely used for solid-fueled boilers. Pulverized coal boilers succeeded stokers as a more efficient method of burning coal and are used in larger boiler designs. Circulating fluidized bed (CFB) boilers are the most recent type of boiler for solid fuel combustion and are becoming more commonplace. CFB boilers are capable of burning a variety of fuels, and are more efficient and less polluting than stoker or pulverized coal boilers. Combined heat and power (CHP) or cogeneration technologies are also used to produce electricity and steam or hot water from a single unit. Some ICI boilers are used only in the colder months for space heating, while others have high capacity utilization year round.

Clean Air Act Regulations Controlling ICI Boilers

Emissions from ICI boilers are currently governed by multiple State and federal regulations under the Titles I, III, and IV of the Clean Air Act. Each of these regulatory programs is discussed in the following paragraphs. Title I regulates criteria pollutants by requiring local governments to adopt State Implementation Plans (SIPs) that set forth their strategy for achieving reductions in the particular criteria pollutant(s) for which they are out of attainment. The SIP requirements includes Reasonably Available Control Technology (RACT) requirements, but more stringent requirements may be imposed depending on the locale's degree of non-attainment with ambient air standards.

Title I also imposes New Source Performance Standards (NSPS) on certain specified categories of new and modified large stationary sources. In 1986, EPA codified the NSPS for industrial boilers (40 CFR part 60, subparts Db and Dc) and revised portions of them in 1998 to reflect improvements in control methods for the reduction of NO_x emissions. Subpart Db applies to fossil fuel-fired ICI units greater than 100 MMBTU per hour that were constructed or modified after June 19, 1984. Subpart Dc applies to fossil fuel-fired ICI units from 10 to 100 MMBTU per hour that were constructed or modified after June 9, 1989.

In addition, Title I subjects new and modified large stationary sources that increase their emissions to permitting requirements that impose control technologies of varying levels of stringency (known as New Source Review, or NSR). NSR prescribes control technologies for new plants and for plant modifications that result in a significant increase in emissions, subjecting them to Best Available Control Technology (BACT) in attainment areas and to the Lowest Achievable Emission Rate (LAER) in non attainment areas. Control strategies that constitute BACT and LAER evolve over time and are reviewed on a case by case basis in State permitting proceedings.

On September 13, 2004, EPA published a final rule under Title III of the CAA to substantially reduce emissions of toxic air pollutants from ICI boilers. These Maximum Achievable Control Technology (MACT) standards apply to ICI boilers located at major sources of hazardous air pollutants (HAPs). There are many options for complying with the MACT standards, ranging from continued use of existing control systems to fuel switching to the installation of a fabric filter and wet scrubber technologies. Thus, the control technologies used to reduce the level of HAP emitted from affected sources are also expected to reduce emissions of PM, and to a lesser extent, SO₂ emissions.

Title IV of the CAA addresses acid rain by focusing primarily on power plant emissions of SO₂. Title IV includes an Opt-in Program that allows sources not required to participate in the Acid Rain Program the opportunity to enter the program on a voluntary basis and receive their own acid rain allowances. The Opt-in Program offers sources such as ICI boilers a financial incentive to voluntarily reduce its SO₂ emissions. By reducing emissions below allowance allocation, an opt-in source will have unused allowances, which it can sell in the SO₂ allowance market.

The regulation of ICI boilers by various CAA programs has resulted in a variety of unit level emission limits resulting from SIP, NSPS, NSR, or MACT requirements. Overlaid on these unit level requirements are system-wide allowances of the NO_x SIP call and the Acid Rain SO₂ opt-in

program. Thus, the specific emission limits and control requirements for a given ICI boiler vary and depend on boiler age, size, and geographic location.

EVALUATION OF CONTROL OPTIONS

An undesirable by-product of the combustion of sulfur, SO₂ is associated with the combustion of most fossil fuels. Coal deposits contain sulfur in amounts ranging from trace quantities to as high as 8% or more. Distillate oils typically have sulfur contents less than 0.5% while residual oil can have 1-2% sulfur by weight. Petroleum coke, a byproduct of the oil refining process, may have as much as 6% sulfur. Pipeline quality natural gas contains virtually no sulfur, while landfill gas may contain varying amounts of sulfur depending on the materials contained in the landfill. A variety of air pollution control technologies are employed to meet requirements for sulfur dioxide control and are dependant on a number of factors to determine which technique is utilized for a given facility.

Air pollution reduction and control technologies for ICI boilers have advanced substantially over the past 25 years. In addition, advances in power generation technologies, renewable energy, and energy efficiency have the potential to further reduce emissions from these facilities. The focus of this evaluation is on the first category mentioned above - emission control technologies. The timing and magnitude of reductions from the other strategies – improved technologies, demand reduction/energy efficiency, and clean power should be considered as part of a longer-term solution.

Control techniques may be classified into three broad categories: fuel treatment/substitution, combustion modification, and post-combustion control. Fuel treatment primarily reduces SO₂ and includes coal cleaning using physical, chemical, or biological processes. Fuel substitution involves burning a cleaner fuel or renewable fuel. Combustion modification includes any physical or operational change in the furnace or boiler and is sometimes discussed in conjunction with post-combustion control technologies. Post-combustion control employs a device after the combustion of the fuel and is applied to control emissions of SO₂. It should be noted that physical or operational changes to a furnace or boiler may require that the unit be examined for applicability under the Prevention of Significant Deterioration (PSD) program.

There are a wide variety of proven control technologies for reducing SO₂ emissions from ICI boilers. The method of SO₂ control appropriate for any individual ICI boiler is dependent upon the type of boiler, type of fuel, capacity utilization, and the types and staging of other air pollution control devices. However, cost effective emissions reduction technologies for SO₂ are available and are effective in reducing emissions from the exhaust gas stream of ICI boilers.

Effective post-combustion SO₂ controls for boilers, and particularly coal-fired boilers, are well understood and have been applied to a number of sources over the years in response to regulations in the form of NSPS, PSD/NSR, State RACT Rules and the Title IV SO₂ program. Additional SO₂ reductions are anticipated as a result of regional pollution control initiatives prompted by the Clean Air Interstate Rule (CAIR), which was passed on May 12, 2005.

In addition to post-combustion controls that can be applied to reduce emissions of SO₂ from fossil fuel fired boilers, there are other strategies that can be used to reduce emissions of SO₂.

Examples of such strategies include switching to a fuel with a lower sulfur content, or coal cleaning prior to combustion. Methods of SO₂ control applicable to ICI boilers are listed in Table 4.1 with a brief description of the control option, applicability, and range of performance. After the table, a more detailed description of the control option and an analysis of the four factor assessment for reasonable progress is presented.

SO₂ Control Option Descriptions

Almost all SO₂ emission control technologies fall in the category of reducing SO₂ after its formation, as opposed to minimizing its formation during combustion. The exception to the nearly universal use of post-combustion controls is found in fuel switching and, more significantly, in fluidized bed boilers, in which limestone is added to the fuel in the combustion chamber.

Post-combustion SO₂ control is accomplished by reacting the SO₂ in the gas with a reagent (usually calcium- or sodium-based) and removing the resulting product (a sulfate/sulfite) for disposal or commercial use depending on the technology used. SO₂ reduction technologies are commonly referred to as Flue Gas Desulfurization (FGD) and are usually described in terms of the process conditions (wet versus dry), byproduct utilization (throwaway versus saleable) and reagent utilization (once-through versus regenerable).

Within each technology category, multiple variations are possible and typically involve the type and preparation of the reagent, the temperature of the reaction (for dry processes), the use of enhancing additives, etc. Because these variations mostly involve complex process chemistry, but are fundamentally similar, this summary focuses on the major categories of SO₂ control technologies, their applicability, performance and cost. Descriptions of available SO₂ control technology options are in Table 4.1. A brief discussion of these techniques follows.

Table 4.1 Available SO₂ Control Options For ICI Boilers

Technology	Description	Applicability	Performance
Switch to a Low Sulfur Coal (generally <1% sulfur)	Replace high-sulfur bituminous coal combustion with lower-sulfur coal	Potential control measure for all coal-fired ICIs currently using coal with high sulfur content	50-80% reduction in SO ₂ emissions by switching to a lower-sulfur coal
Switch to Natural Gas (virtually 0% sulfur)	Replace coal combustion with natural gas	Potential control measure for all coal-fired ICIs	Virtually eliminate SO ₂ emissions by switching to natural gas
Switch to a Lower Sulfur Oil	Replace higher-sulfur residual oil with lower-sulfur distillate oil. Alternatively, replace medium sulfur distillate oil with ultra-low sulfur distillate oil	Potential control measure for all oil-fired ICIs currently using higher sulfur content residual or distillate oils	50-80% reduction in SO ₂ emissions by switching to a lower-sulfur oil
Coal Cleaning	Coal is washed to remove some of the sulfur and ash prior to combustion	Potential control measure for all coal-fired ICI boilers	20-25% reduction in SO ₂ emissions
Combustion Control	A reactive material, such as limestone or bi-carbonate, is introduced into the combustion chamber along with the fuel	Applicable to pulverized coal-fired boilers and circulating fluidized bed boilers	40%-85% reductions in SO ₂ emissions
Flue Gas Desulfurization (FGD) - Wet	SO ₂ is removed from flue gas by dissolving it in a lime or limestone slurry. (Other alkaline chemicals are sometimes used)	Applicable to all coal-fired ICI boilers	30-95%+ reduction in SO ₂ emissions
Flue Gas Desulfurization (FGD) – Spray Dry	A fine mist containing lime or other suitable sorbent is injected directly into flue gas	Applicable primarily for boilers currently firing low to medium sulfur fuels	60-95%+ reduction in SO ₂ emissions
Flue Gas Desulfurization (FGD) –Dry	Powdered lime or other suitable sorbent is injected directly into flue gas	Applicable primarily for boilers currently firing low to medium sulfur fuels	40-60% reduction in SO ₂ emissions

Table references:

1. *Assessment of Control Technology Options for BART-Eligible Sources*, NESCAUM, March 2005.
2. *Controlling Fine Particulate Matter Under the Clean Air Act: A Menu of Options*, STAPPA-ALAPCO, March 2006.

Switch to Coal with Lower Sulfur Content

Switching from a high sulfur fuel to one with sufficiently low sulfur content is the first option available for SO₂ reduction in this category for pre-combustion control of SO₂. Fuels naturally low in sulfur content are readily available for solid (coal) and liquid (oil) fired boilers. For coal-fired boilers, low-sulfur fuels may be obtained directly or, alternatively, the sulfur content of coal fired in the boiler may be lowered first by cleaning the coal or blending coals obtained from several sources.

However, burning low-sulfur fuel may not be a technically feasible or economically practical SO₂ control alternative for all boilers. In some cases, a fuel with the required sulfur content to meet the applicable emission reduction may not be available or cannot be fired satisfactorily in a given boiler unit design. Even if such a fuel is available, use of the lower-sulfur fuel that must be transported long distances from the supplier may not be cost competitive with burning higher sulfur fuel supplied by near-by suppliers and using a post-combustion control device. The feasibility of fuel switching depends partly on the characteristics of the plant and the particular type of fuel change being considered. Many plants will be able to switch from high-sulfur to low-sulfur bituminous coal without serious difficulty, but switching from bituminous to sub-bituminous coal may present greater challenges and costs. In some instances, fuel switching will require significant investment and modifications to an existing plant. Switching to a lower sulfur fuel, either coal or oil, can affect fuel handling systems, boiler performance, PM control effectiveness and ash handling systems. Overall SO₂ reductions estimated from switching to low-sulfur fuels range from 50-80%.

Switch to Natural Gas

Switching from coal combustion to natural gas combustion virtually eliminates SO₂ emissions. It is technically feasible to switch from coal to natural gas, but it is currently uneconomical to consider this option for large ICIs due to the fuel quantity necessary and the price of natural gas. The price of natural gas is roughly seven times the price of coal in terms of heating value.

Reduced Sulfur Oil

Oil-fired boilers may opt for lower sulfur distillate fuels or, if available, ultra-low sulfur distillate fuel. Number 2 distillate fuel oil, heating oil, and highway diesel fuel oil are the same refinery-produced liquid, and are only differentiated for tax purposes. This differentiation is accomplished through addition of a red dye in the fuels supplied for non-transportation related use. Currently, the sulfur content in Number 2 oil varies between 15 and 20,000 ppm. Beginning in 2006, the permissible level of sulfur in highway diesel fuel (ultra low sulfur diesel, or ULSD) was reduced to 15 ppm. Prior to that, highway low sulfur diesel fuel was refined to contain 500 ppm sulfur (Low Sulfur Diesel, or LSD). Consequently, refineries have already performed the capital investments required for the production of LSD and ULSD fuel oil. Based on EIA data for the week of Feb 23, 2007 domestic production of ULSD fuel oil accounted for about 45% of all distillate oil in the United States and LSD fuel oil accounted for slightly over 17% of domestic production (See Chapter 8).

Coal Cleaning

According to the 2006 STAPPA-ALAPCO document on control technologies titled *Controlling Particulate Matter Under the Clean Air Act: A Menu of Options*, coal cleaning or washing is a widely practiced method of reducing impurities in coal, particularly sulfur. Reducing the sulfur content of the fuel used in the boiler reduces the SO₂ emissions proportionally. Coal cleaning has been shown to reduce SO₂ emissions by 20-25%, while increasing the heating value of the fuel. Additional removal can be achieved through advanced chemical washing techniques, but no detailed information on these techniques was available.

Conventional (physical) coal washing techniques remove ash and sulfur from coal by crushing the fuel and separating the components in a liquid bath, such as water. The lighter coal particles float to the top of the bath for recovery, while the heavier impurities sink to the bottom for removal.

Although there are benefits associated with coal washing, there are limitations associated with this technology. The 20-25% SO₂ reduction is beneficial, but post-combustion controls have been shown to reduce SO₂ emissions by greater percentages. Also, solid and liquid wastes are generated using the washing process and must be addressed.

Combustion Control

SO₂ reduction is also possible through combustion related control technologies. One such technology that has been demonstrated and is currently available is the use of fluidized bed boilers.

Fluidized bed boilers generally operate at lower temperatures than other combustion systems, 800° to 870° C (1500° F to 1600° F). The lower temperatures allow the use of limestone or dolomite to be added to the bed to capture sulfur. Limestone (CaCO₃) is converted to CaO at approximately 800° C (1500° F). SO₂ released from the fuel reacts with CaO to form CaSO₄, which is thermodynamically stable at bed temperatures. By recycling some of the solids leaving the bed up to 90% removal of SO₂ can be achieved with Ca/S molar ratios of 2 to 2.5 in circulating fluidized beds. Higher Ca/S ratios are required in bubbling beds. In either case, the sorbent is removed with the ash from the bed and sent to disposal.

Flue Gas Desulfurization (FGD)

There are three types of FGD scrubbers: wet, spray dry, and dry. According to the 2006 STAPPA-ALAPCO document on control technologies titled *Controlling Particulate Matter Under the Clean Air Act: A Menu of Options*, EPA reports that 85% of the FGD systems in use in the United States are wet systems. Twelve percent of the FGD systems are spray dry systems, and 3% are dry systems. The operating parameters, efficiency, and costs of each SO₂ removal method are different.

SO₂ in the flue gas can be removed by reacting the sulfur compounds with a solution of water and an alkaline chemical to form insoluble salts that are removed in the scrubber effluent. These processes are called “wet FGD systems”. Most wet FGD systems for control of SO₂ emissions

are based on using either limestone or lime as the alkaline source. At some of these facilities, fly ash is mixed with the limestone or lime. Several other scrubber system designs (e.g., sodium carbonate, magnesium oxide, dual alkali) are used by a small number of boilers.

The basic wet limestone scrubbing process is simple and is the type most widely used for control of SO₂ emissions from coal-fired electric utility boilers. Limestone sorbent is inexpensive and generally available throughout the United States. In a wet limestone scrubber, the flue gas containing SO₂ is brought into contact with limestone/water slurry. The SO₂ is absorbed into the slurry and reacts with limestone to form an insoluble sludge. The sludge, mostly calcium sulfite hemi-hydrate and gypsum, is disposed of in a pond specifically constructed for the purpose or is recovered as a salable byproduct.

The wet lime scrubber operates in a similar manner to the wet limestone scrubber. In a wet lime scrubber, flue gas containing SO₂ is contacted with hydrated lime/water slurry; the SO₂ is absorbed into the slurry and reacts with hydrated lime to form an insoluble sludge. The hydrated lime provides greater alkalinity (higher pH) and reactivity than limestone. However, lime-scrubbing processes require disposal of large quantities of waste sludge.

The SO₂ removal efficiencies of existing wet limestone scrubbers range from 31-97%, with an average of 78%. The SO₂ removal efficiencies of existing wet lime scrubbers range from 30 to 95%. For both types of wet scrubbers, operating parameters affecting SO₂ removal efficiency include liquid-to-gas ratio, pH of the scrubbing medium, and the ratio of calcium sorbent to SO₂. Periodic maintenance is needed because of scaling, erosion, and plugging problems. Recent advancements include the use of additives or design changes to promote SO₂ absorption or to reduce scaling and precipitation problems.

A spray dryer absorber (sometimes referred to as wet-dry or semi-dry scrubbers) operates by the same principle as wet lime scrubbing, except that the flue gas is contacted with a fine mist of lime slurry instead of a bulk liquid (as in wet scrubbing). For the spray dryer absorber process, the combustion gas containing SO₂ is contacted with fine spray droplets of hydrated lime slurry in a spray dryer vessel. This vessel is located downstream of the air heater outlet where the gas temperatures are in the range of 120 to 180 °C (250 to 350 °F). The SO₂ is absorbed in the slurry and reacts with the hydrated lime reagent to form solid calcium sulfite and calcium sulfate as in a wet lime scrubber. The water is evaporated by the hot flue gas and forms dry, solid particles containing the reacted sulfur. These particles are entrained in the flue gas, along with fly ash, and are collected in a PM collection device. Most of the SO₂ removal occurs in the spray dryer vessel itself, although some additional SO₂ capture has also been observed in downstream particulate collection devices, especially fabric filters. This process produces dry reaction waste products for easy disposal.

The primary operating parameters affecting SO₂ removal are the calcium-reagent-to-sulfur stoichiometric ratio and the approach to saturation in the spray dryer. To increase overall sorbent use, the solids collected in the spray dryer and the PM collection device may be recycled. The SO₂ removal efficiencies of existing lime spray dryer systems range from 60-95%.

For the dry injection process, dry powdered lime (or another suitable sorbent such as trona) is directly injected into the ductwork upstream of a PM control device. Some systems use spray

humidification followed by dry injection. This dry process eliminates the slurry production and handling equipment required for wet scrubbers and spray dryers, and produces dry reaction waste products for easier disposal. The SO₂ is adsorbed and reacts with the powdered sorbent. The dry solids are entrained in the combustion gas stream, along with fly ash, and collected by the PM control device. The SO₂ removal efficiencies of existing dry injection systems range from 40 to 60%.

FOUR FACTOR ANALYSIS OF POTENTIAL CONTROL SCENARIOS FOR ICI BOILERS

Each of the control options presented in Table 4.1 is reviewed in this section utilizing a four factor analysis approach for determining reasonable progress as required by Section 169A(g)(1) of the Clean Air Act and Section 51.308(d)(1)(i)(A). The information provided in this section is intended to be used by the States in setting Reasonable Progress Goals (RPGs) for reducing regional haze in Class I areas in MANE-VU Class I areas.

Cost of Compliance

To compare the various control options, information has been compiled on the cost-effectiveness of retrofitting controls. In general, cost-effectiveness increases as boiler size and capacity factor (a measure of boiler utilization) increases.

Cost of Switching to Low Sulfur Coal, Distillate Oil, or Natural Gas

Switching to a low-sulfur coal or blending a lower sulfur coal can impact cost due to the following two main reasons:

1. The cost of low-sulfur coal compared to higher sulfur coal.
2. The cost of boiler or coal handling equipment modifications necessary

The cost of low-sulfur coal compared to higher sulfur coal is not only related to the “dollar per ton” cost of the coal, but the heating value of the coal also impacts the cost analysis.

Table 4.2 reflects the potential sulfur reduction possible by switching fuels:

Table 4.3 shows the average 2004 and 2005 cost data from the Energy Information Administration for various fuels.

Refineries were required to make significant capital investments to meet the LSD and ULSD highway fuel sulfur requirement. To achieve the LSD and ULSD sulfur goals, refineries were required to implement diesel desulfurization technologies. Estimates for the capital costs were developed in 2001 by the Energy Information Administration (EIA) and are based on calendar year 1999. Table 4.4 presents the capital costs for desulfurization technologies presented by the EIA. The EIA developed estimates for new and revamped desulfurization technologies at existing refineries.

Table 4.2 Potential SO₂ Reductions Through Fuel Switching

Original Fuel	Sub-bituminous Coal (% Reduction)	Distillate oil (% Reduction)	Natural Gas (% Reduction)
Bituminous Coal	72.9	91.2	99.9
Sub-bituminous coal	-	69.5	99.9
Residual Oil	-	91.5	99.9
Distillate Oil	-	-	99.7

Calculations based on typical fuel sulfur content listed in Department of Energy EIA analysis for 2000. *Energy Policy Act Transportation Rate Study: Final Report on Coal Transportation*

In its highway diesel fuel rulemaking, EPA also developed cost estimates for the deployment and implementation of desulfurization technologies at refineries. EPA estimated that it would cost existing refineries an estimated \$50 million per refinery to install desulfurization technologies. No estimates were made for the costs associated with new refineries as none are currently being constructed in the United States. The EPA analysis spread the investment cost over a 2-year period. Consequently, it was estimated that the US refinery-wide investment for calendar year 2004 was \$2.45 billion and \$2.83 billion for calendar year 2005 (EIA 2001) (Converted from 2001 to 2006 dollars using a conversion factor of 1.1383 www.inflationdata.com).

Using the most recently available EIA price information for 2006 No. 2 Distillate oil for industrial, commercial, and institutional facilities in the northeast (excluding taxes), a cost per ton of SO₂ removed was calculated to be \$734/ton SO₂ by switching to 500 ppm LSD and \$554/ton SO₂ by switching to ULSD fuel oils. (See the discussion of fuel oil prices in Chapter 7 – Heating Oil.)

Cost of Coal Cleaning

The World Bank, an organization which assists with economic and technological needs in developing countries reports that the cost of physically cleaning coal varies from \$1 to \$10 per ton of coal cleaned, depending on the coal quality, the cleaning process used, and the degree of cleaning desired. In most cases the costs were found to be between \$1 and \$5 per ton of coal cleaned.

Cost of Combustion Control

Dry sorbent injection, (DSI), systems have lower capital and operation costs than post-combustion FGD systems due to: simplicity of design, lower water use requirements, and smaller land use requirements. Table 4.3 presents the estimated costs of adding DSI based SO₂ controls to ICI boilers based on boiler size, fuel type, and capacity factor. Capacity factor is the amount of energy a boiler generates in one year divided by the total amount it could generate if it ran at full capacity.

Table 4.3 Estimated Dry Sorbent Injection (DSI) Costs For ICI Boilers (2006 dollars)

Fuel	SO ₂ Reduction (%)	Capacity Factor (%)	Cost Effectiveness (\$/Ton of SO ₂)		
			100 MMBTU/hr	250 MMBTU/hr	1,000 MMBTU/hr
2%-sulfur coal	40	14	4,686	3,793	2,979
		50	1,312	1,062	834
		83	772	624	490
3.43%-sulfur coal	40	14	2,732	2,212	1,737
		50	765	619	486
		83	450	364	286
2%-sulfur coal	85	14	2,205	1,786	1,402
		50	617	500	392
		83	363	294	231
3.43%-sulfur coal	85	14	1,286	1,040	818
		50	360	291	229
		83	212	171	134

Calculations based on information available from EPA Publications, EPA-452/F-03-034, *Air Pollution Control Technology Fact Sheet*, and EPA-600/R-05-034, *Multipollutant Emission Control Technology Options for Coal-fired Power Plants*

(Converted from 2005 to 2006 dollars using a conversion factor of 1.0322 www.inflationdata.com)

Cost of FGD

Installation of post-combustion SO₂ control in the form of FGD has several impacts on facility operation, maintenance, and waste handling. FGD systems typically require significant area for construction of the absorber towers, sorbent tanks, and waste handling. The facility costs are, therefore, variable and dependent on the availability of space for construction of the FGD system. Solid waste handling is another factor that influences the cost of FGD control systems. Significant waste material may be generated that requires disposal. This cost may be mitigated, however, by utilization of a forced oxidation FGD process that produces commercial quality gypsum, which may be sold as a raw material for other commercial processes.

Table 4.4 presents the total estimated cost effectiveness of adding FGD based SO₂ controls to ICI boilers based on boiler size, fuel type, and capacity factor. There is no indication that these cost data include revenue from gypsum sales. Revenue from gypsum sales would reduce the cost of these controls.

Table 4.4 Estimated Flue Gas Desulfurization (FGD) Costs For ICI Boilers (2006 dollars)

Fuel	Technology	SO ₂ Reduction (%)	Capacity Factor (%)	Cost Effectiveness (\$/Ton of SO ₂)		
				100 MMBTU/hr	250 MMBTU/hr	1,000 MMBTU/hr
High-sulfur coal ^a	FGD (Dry)	40	14	3,781	2,637	1,817
			50	1,379	1,059	828
			83	1,006	814	676
Lower-sulfur coal ^b	FGD (Dry)	40	14	4,571	3,150	2,119
			50	1,605	1,207	928
			83	1,147	906	744
Coal	FGD (Spray dry)	90	14	4,183	2,786	1,601
			50	1,290	899	567
			83	843	607	407
High-sulfur coal ^a	FGD (Wet)	90	14	3,642	2,890	1,909
			50	1,116	875	601
			83	709	563	398
Lower-sulfur coal ^b	FGD (Wet)	90	14	4,797	3,693	2,426
			50	1,415	1,106	751
			83	892	705	492
Oil ^c	FGD (Wet)	90	14	10,843	8,325	5,424
			50	2,269	1,765	1,184
			83	1,371	1,079	740

a. Assumes sulfur content = 3.43% and ash content = 12.71%.

b. Assumes sulfur content = 2.0% and ash content = 13.2%.

c. Sulfur content of oil is not specified.

Table references:

Source: *Controlling Fine Particulate Matter Under the Clean Air Act: A Menu of Options*, STAPPA-ALAPCO, 2006.

Primary Reference: Khan, S. *Methodology, Assumptions, and References—Preliminary SO₂ Controls Cost Estimates for Industrial Boilers* (EPA-HQ-OAR-2003-0053-166), October-November 2003.

(Converted from 2004 to 2006 dollars using a conversion factor of 1.0672 www.inflationdata.com)

Time Necessary for Compliance

Generally, sources are given a 2-4 year phase-in period to comply with new rules. Under the previous Phase I of the NO_x SIP Call, EPA provided a compliance date of about 3½ years from the SIP submittal date. Most MACT standards allow a 3-year compliance period. Under Phase II

of the NO_x SIP Call, EPA provided a 2-year period after the SIP submittal date for compliance. States generally provided a 2-year period for compliance with RACT rules. For the purposes of this review, we have assumed that a 2-year period after SIP submittal is adequate for pre-combustion controls (fuel switching or cleaning) and a three year period for the installation of post combustion controls.

For BART control measures, the proposed BART guidelines require States to establish enforceable limits and require compliance with the BART emission limitations no later than 5 years after EPA approves the regional haze SIP.

Refiners in the United States are already producing low sulfur diesel fuel which may be marketed as distillate oil. There is a potential that offshore refiners may not be able to produce enough 15 ppm sulfur for export to the Northeast United States to meet peak demand, but so far this has not occurred.

ICI boilers would not have to retrofit or install expensive control technology to burn ULSD distillate fuel oil, therefore, compliance with the standard is driven by supply and demand of the lower sulfur distillate oils.

For combustion based and post-combustion based engineering and construction leads times will vary between 2 and 5 years depending on the size of the facility and specific control technology selected.

Energy and Non-Air Impacts

Fuel switching and cleaning do not significantly affect the efficiency of the boiler but may add to transportation issues and secondary environmental impacts from waste disposal and material handling operations (e.g. fugitive dust). FGD systems typically operate with high pressure drops across the control equipment, resulting in a significant amount of electricity required to operate blowers and circulation pumps. In addition, some combinations of FGD technology and plant configuration may require flue gas reheating to prevent physical damage to equipment, resulting in higher fuel usage.

The primary environmental impact of FGD systems is the generation of wastewater and sludge from the SO₂ removal process. When the exhaust gas from the boiler enters the FGD the SO₂, metals, and other solids are removed from the exhaust and collected in the FGD liquid. The liquid slurry collects in the bottom of the FGD in a reaction tank. The slurry is then dewatered and a portion of the contaminant-laden water is removed from the system as wastewater. Waste from the FGD systems will increase sulfate, metals, and solids loading in a facility's wastewater, potentially impacting community wastewater treatment facilities for smaller units that do not have self contained water treatment systems. In some cases FGD operation necessitates installation of a clarifier on site to remove excessive pollutants from wastewater. This places additional burdens on a facility or community wastewater treatment and solid waste management capabilities. These impacts will need to be analyzed on a site-specific basis. If lime or limestone scrubbing is used to produce calcium sulfite sludge, the sludge must be stabilized prior to land filling. If a calcium sulfate sludge is produced, dewatering alone is necessary before land filling,

however, SO₂ removal costs are higher due to increased equipment costs for this type of control system. In some cases calcium sulfate sludge can be sold for use in cement manufacturing.

With wet FGD technologies a significant visible plume is present from the source due to condensation of water vapor as it exits the smoke stack. Although the water eventually evaporates and the plume disappears, community impact may be significant.

Reducing the sulfur contents of distillate fuel oil has a variety of beneficial consequences for ICI boilers. Low sulfur distillate fuel is cleaner burning and emits less particulate matter which reduces the rate of fouling of heating units substantially and permits longer time intervals between cleanings. According to a study conducted by the New York State Energy Research and Development Authority, (NYSERDA), boiler deposits are reduced by a factor of two by lowering the fuel sulfur content from 1,400 ppm to 500 ppm. These reductions in buildup of deposits result in longer service intervals between cleanings. (Batey and McDonald 2005)

Remaining Useful Life of the Source

Available information for remaining useful life estimates of ICI boilers indicates a wide range of operating time, depending on size of the unit, capacity factor, and level of maintenance performed. Typical life expectancies range from about 10 years up to over 30 years.

REFERENCES

Batey, J.E. and R. McDonald, 2005. *Low Sulfur Home Heating Oil Demonstration Project Summary Report*. Project funded by The New York State Energy Research and Development Authority. Contract No. 6204-IABR-BR-00.

U.S. EPA, 2005, *Multipoint Emission Control Technology Options for Coal-fired Power Plants*, Washington, DC, EPA-600/R-05/034.

U.S. EPA, 2003, *Air Pollution Control Technology Fact Sheet*, Washington, DC, EPA-425/F-03-034.

STAPPA ALAPCO, 2006, *Controlling Fine Particulate Matter Under the Clean Air Act: A Menu of Options*.

The Lake Michigan Air Directors Consortium, *Midwest Regional Planning Organization Boiler Best Available Retrofit Technology Engineering Analysis*, March 30, 2005

U.S. EPA, 1993, *PM-10 Innovative Strategies: A Sourcebook for PM-10 Control Programs*, Research Triangle Park, NC, EPA-452/R-93-016.

U.S. Energy Information Administration, October 2000, *Energy Policy Act Transportation Rate Study: Final Report on Coal Transportation*, Publication downloaded from World Wide Web in February, 2007 at http://www.eia.doe.gov/cneaf/coal/coal_trans/epact2000.html

GE Water & Process Technologies. Information accessed on web March 27, 2007:
http://www.zenon.com/applications/FGD_wastewater_treatment.shtml

U.S. Energy Information Administration, 2007. :”No. 2 Distillate Prices By Sales Type”, Information downloaded from the World Wide Web on March 7, 2007, at
http://tonto.eia.doe.gov/dnav/pet/pet_pri_dist_dcu_R1X_m.htm

U.S. Energy Information Administration, 2007. :”weekly Inputs, Utilization and Production”, Information downloaded from the World Wide Web on March 7, 2007, at
http://tonto.eia.doe.gov/dnav/pet/pet_pnp_wiup_dcu_r10_w.htm

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CHAPTER 5

ANALYSIS OF SELECTED INDUSTRIAL, COMMERCIAL, AND INSTITUTIONAL BOILERS

SOURCE CATEGORY DESCRIPTION

Modeling of visibility impacts on Class I regions was conducted by the Vermont Department of Environmental Conservation (VTDEC) and MANE-VU to identify the major ICI sources contributing to visibility impairment in the northeast. Table 5.1 lists the ICI sources identified to contribute significant levels of SO₂ to the MANE-VU region. MACTEC was directed by MARAMA and the Reasonable Progress Workgroup to focus on the 17 major sources listed in Table 5.1.

As explained in the previous chapter, there are a wide variety of proven control technologies for reducing SO₂ emissions from ICI boilers and specifically the control method for SO₂ applied to any individual ICI boiler is dependent upon the type of boiler, type of fuel, capacity utilization, and the types and staging of other air pollution control devices. However, cost effective emissions reduction technologies for SO₂ are available and are effective in reducing emissions from the exhaust gas stream of ICI boilers.

INFORMATION OBTAINED FROM STATE AGENCIES

For the selected ICI boilers, MACTEC contacted State and or regional regulatory agencies to evaluate the status of each unit and determine if additional pollution controls had been mandated as a part of regulatory actions taken since the data used for the visibility impairment modeling were collected. Table 5.1 presents the information obtained from the States.

Table 5.1 Point Source Information Collected from the Top 17 Industrial Facilities Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	2002 SO ₂ Total (tons)	Primary Emissions Point Description	Point ID (Permit ID No.)	Design Capacity	Existing Control(s)	Proposed/Planned Control(s)	Additional Information
Motiva Enterprises LLC – Delaware City ¹	DE	29,747	Fluid Coking Unit (FCU) and FCU Carbon Monoxide Boiler	002	57,199 barrels per day of total feed	None	Cansolv Regenerative Wet Gas Scrubber and SNCR	Data from Permit APC-82/0829 Amendment 5 SO ₂ permit limit is 174 tpy
			Fluid Catalytic Cracking Unit (FCCU) and FCCU Carbon Monoxide Boiler	012	FCCU coke burn rate limit is 56,000 lbs/hr	None	Cansolv Regenerative Wet Gas Scrubber	Data from Permit APC-82/0981 Amendment 6 SO ₂ permit limit is 361 tpy

Table 5.1 Point Source Information Collected from the Top 17 Industrial Facilities Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	2002 SO ₂ Total (tons)	Primary Emissions Point Description	Point ID (Permit ID No.)	Design Capacity	Existing Control(s)	Proposed/Planned Control(s)	Additional Information
Kodak Park Division ^{2,3}	NY	23,508	Building 31 and 321 stationary combustion installations, including package ABD built up boilers used for the generation of process steam and electricity Boilers: 1 – Package boiler, No. 6 2 – Package boiler, No. 6 3 – Package boiler, No. 6 4 – Package boiler, No. 6 13 – Underfed stoker, coal 14 – Underfed stoker, coal 11 – Underfed stoker, coal 12 – Underfed stoker, coal 15 – Wet bottom cyclone, coal/No. 6 16 – Wall-fired, coal/No. 6 41 – Wet bottom cyclone, coal/No. 6 42 – Wet bottom cyclone, coal/No. 6 43 – Wet bottom cyclone, coal/No. 6 44 – Tangential-fired pulverized coal, coal/No. 2	U0015 Boilers (EP-031B-1): 1 2 3 4 13 14 Boilers (EP-031B-2): 11 12 15 16 Boilers (EP-321B-3): 41 42 Boilers (EP-321B-4): 43 44	98 MMBTU/hr 98 MMBTU/hr 98 MMBTU/hr 98 MMBTU/hr 265 MMBTU/hr 265 MMBTU/hr 197 MMBTU/hr 222 MMBTU/hr 478 MMBTU/hr 544 MMBTU/hr 500 MMBTU/hr 500 MMBTU/hr 640 MMBTU/hr 670 MMBTU/hr	None	BART analysis - NO _x & SO ₂ controls affordable on Boilers 41, 42, & 43 Wet scrubber (90% reduction) would be ~\$2,150/ton Dry scrubber (40% reduction) would be ~\$1,850/ton	Process K07 (Bldg 31) is No. 6 fuel oil combustion in package boilers Process K09 (Bldg 31) is bituminous coal combustion in built up Boilers 13 and 14 Process K10 (Bldg 31) is No. 6 fuel oil combustion in built up Boilers 15 and 16 Process K11 (Bldg 31) is bituminous coal combustion for built up Boiler 15 Process K12 (Bldg 321) is No. 6 fuel oil combustion for built up Boilers 41, 42 and 43 Process K13 (Bldg 321) is bituminous coal combustion for built up Boilers 41, 42 and 43 Process K14 (Bldg 321) is No. 2 fuel oil combustion with NSPS applicability in Boiler 44 Process K15 (Bldg 321) is bituminous low sulfur coal combustion

Table 5.1 Point Source Information Collected from the Top 17 Industrial Facilities Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	2002 SO ₂ Total (tons)	Primary Emissions Point Description	Point ID (Permit ID No.)	Design Capacity	Existing Control(s)	Proposed/Planned Control(s)	Additional Information
MW Custom Papers LLC – Chillicothe Mill ⁴	OH	23,216	No.5 Coal Boiler - wet bottom, pulverized coal-fired boiler (C. E. model VU-40), capable of running on #2 fuel oil as backup fuel	B001	380 MMBTU/hr maximum heat input	Cyclone/ multi-clone ESP	None	9.9 lbs of sulfur dioxide per MMBTU actual heat input
			No.7 Coal Boiler - wet bottom, pulverized coal-fired boiler (C. E. model VU-405), capable of running on #2 fuel oil as backup fuel	B002	422 MMBTU/hr maximum heat input	Cyclone/ multi-clone ESP	None	9.9 lbs of sulfur dioxide per MMBTU actual heat input
			No.8 Coal Boiler - wet bottom, pulverized coal-fired boiler (C. E. model VU-40), capable of running on #2 fuel oil as backup fuel.	B003	505 MMBTU/hr maximum heat input	Cyclone/ multi-clone ESP	None	9.9 lbs of sulfur dioxide per MMBTU actual heat input

Table 5.1 Point Source Information Collected from the Top 17 Industrial Facilities Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	2002 SO ₂ Total (tons)	Primary Emissions Point Description	Point ID (Permit ID No.)	Design Capacity	Existing Control(s)	Proposed/Planned Control(s)	Additional Information
Eastman Chemical Company ^{5, 6}	TN	22,882	Two fuel burning installations (B-83-1 & B-253-1) w/a total of 19 coal fired boilers of which 14 units (#18-#24) are located at Powerhouse B-83-1 & 5 units (#25-#29) are located at Powerhouse B-253-1. The primary fuel is coal. In addition, wood, waste solids, waste liquids, & biosludge may be burned in these Powerhouses, while NG & process gas may also be burned in the Powerhouse B-253-1 boilers.	82-0003-01-19 (020101, 021520)	6,625 Million BTU/hr nominal heat input	ESP	Scubbers potentially	The five boilers in Powerhouse B-253-1 are subject to BART. The State does not have confirmation yet, but they believe that the boilers will be controlled by scrubbers of some sort. Units #11-#17, that were located at Powerhouse B-83-1, have been removed
			Coal-Fired Boilers 30 and 31	PES B-325-1 or 82-1010-15 (261501)	Heat input is limited to 780 and 880 MMBTU/hr, respectively, on a 30 calendar day rolling average basis	None	None	
Westvaco Fine Papers ^{7, 8}	MD	19,083	Boiler 24 is a coal fired-cyclone boiler	1	590 MMBTU/hr maximum heat input	SNCR (NO _x) ESP (PM)	Baghouse (PM)	Not BART eligible due to age

Table 5.1 Point Source Information Collected from the Top 17 Industrial Facilities Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	2002 SO ₂ Total (tons)	Primary Emissions Point Description	Point ID (Permit ID No.)	Design Capacity	Existing Control(s)	Proposed/Planned Control(s)	Additional Information
			Boiler 25 is a coal fired-tangential boiler	2	785 MMBTU/hr maximum heat input	Low NO _x burners/overfired air (NO _x) ESP (PM)	Scrubber (FGD in design) SNCR (NO _x) Baghouse to replace ESP (PM)	BART eligible
PPG Industries Inc. ⁹	WV	12,678	Boiler 3 is a coal-fired boiler installed in 1942 and modified in 1981	R011 (002) or S076	243 MMBTU/hr	Fabric filter Low NO _x burners	None	Not BART eligible
			Boiler 4 is a coal-fired and natural gas-fired boiler installed in 1952	R015 (001) or S076	496 MMBTU/hr	ESP Low NO _x burners	None	Not BART eligible
			Boiler 5 is a coal-fired boiler installed in 1966	R072 (003) or S482	878 MMBTU/hr	ESP Low NO _x burners	None	BART eligible, facility to decrease emissions by using low-sulfur coal and taking an emission limit of 1,478.8 lb SO ₂ /hr

Table 5.1 Point Source Information Collected from the Top 17 Industrial Facilities Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	2002 SO ₂ Total (tons)	Primary Emissions Point Description	Point ID (Permit ID No.)	Design Capacity	Existing Control(s)	Proposed/Planned Control(s)	Additional Information
Williams Ethanol Services Inc. ^{10, 11}	IL	12,244	4 boilers Boiler A & B are coal-fired boilers constructed in 1944 Boiler C is a coal/oil supplemental-fired boiler constructed in 1958 Boiler D is a NG/No. 2 oil-fired boiler constructed in 1976	10	Boilers A & B: 242 MMBTU/hr Boiler C: 330 MMBTU/hr Boiler D: 195 MMBTU/hr	Boilers A & B: Multi-cyclone Boiler C: ESP Boiler D: None	None	Not BART eligible. There is also a steep acid preparation system (Unit 2) that converts sulfur into sulfurous acid that will be used for the steeping process. Total sulfur usage for this unit is limited to 961,750 lbs/yr (at least 48% of the sulfur added to steepwater shall be retained in the products shipped from the plant).

Table 5.1 Point Source Information Collected from the Top 17 Industrial Facilities Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	2002 SO ₂ Total (tons)	Primary Emissions Point Description	Point ID (Permit ID No.)	Design Capacity	Existing Control(s)	Proposed/Planned Control(s)	Additional Information
Corn Products International Inc. ^{10, 11}	IL	9,281	Utilities: Coal fired Boilers #1, #2, & #3 (pre 1972) Natural gas-fired Boilers #4 & #5 (pre 1972) Natural gas-fired Boiler #6 constructed in 1992 2 natural gas-fired turbines constructed in 1995	Group 9	Boilers #1, #2, & #3: 250 MMBTU/hr Boilers #4 & #5: 312.5 MMBTU/hr Boiler #6: 600 MMBTU/hr Turbines: 65 MMBTU/hr	Boilers #1, #2, & #3: ESP Boilers #4 & #5: None Boiler #6: low-NO _x burner & flue gas recirculation Turbines: None	None	Not BART eligible
Mead Westvaco Packaging Resource Group ¹²	VA	8,552	Four (4) boilers #6 – primarily coal-fired #7 – coal/bark/wood-fired #8 - coal/bark/wood-fired #9 – primarily coal-fired	25	550 MMBTU/hr 440 MMBTU/hr 580 MMBTU/hr 807 MMBTU/hr	ESP Scrubbers FGR LNB	None	
PH Glatfelter Co./Spring Grove ^{13, 14}	PA	7,855	#4 Power Boiler that burns bituminous coal (13 tons/hr), #6 oil (751 gal/hr), & #2 oil (108 gal/hr)	034	363.7 MMBTU/hr	Cyclone dust collector ESP	None	Not BART eligible

Table 5.1 Point Source Information Collected from the Top 17 Industrial Facilities Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	2002 SO ₂ Total (tons)	Primary Emissions Point Description	Point ID (Permit ID No.)	Design Capacity	Existing Control(s)	Proposed/Planned Control(s)	Additional Information
			#5 Power Boiler that burns bituminous coal (10.3 tons/hr), #6 oil (300 gal/hr), "as fired" wood (12.2 tons/hr), & #2 oil (451.2 gal/hr)	035	262.3 MMBTU/hr	Cyclone dust collector ESP	None	BART eligible
Goodyear Tire & Rubber Co. ⁴	OH	5,903	"A" Boiler, which is a coal-fired boiler	B101	301 MMBTU/hr	ESP	None	4.64 lbs of sulfur dioxide per MMBTU actual heat input for B101, B102, and B103 exiting through Stack 4
			"B" Boiler, which is a coal-fired boiler	B102	301 MMBTU/hr	ESP	None	4.64 lbs of sulfur dioxide per MMBTU actual heat input for B101, B102, and B103 exiting through Stack 4
			"C" Boiler, which is a coal-fired boiler	B103	174 MMBTU/hr	ESP	None	4.64 lbs of sulfur dioxide per MMBTU actual heat input for B101, B102, and B103 exiting through Stack 4

Table 5.1 Point Source Information Collected from the Top 17 Industrial Facilities Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	2002 SO ₂ Total (tons)	Primary Emissions Point Description	Point ID (Permit ID No.)	Design Capacity	Existing Control(s)	Proposed/Planned Control(s)	Additional Information
Sunoco Inc. (R&M) ^{15, 16}	PA	3,645	Plt. 10-4 FCC Unit	101	4,792.000 bbl/hr fresh feed	None	SCR and a wet gas scrubber installed in 2010. At the latest, compliance is required by 2013.	SO ₂ limit of 9.8 lbs/1000 lbs of coke burn-off in the catalyst regenerator determined daily on a 7-day rolling average basis
Valero Refining Co. – NJ ^{17, 18}	NJ	3,597	FCCU Regenerator with In-Line Heater	E21 or U1	102 MMBTU/hr	WGS	None	Per Consent Decree, SO ₂ concentration emission limits at the point of emission to the atmosphere of no greater than 25 ppmvd, measured as a 365-day rolling average, and 50 ppmvd, measured as a 7-day rolling average, both at 0% O ₂ .
Stone Container Corp. (dba Smurfit-Stone Contain) ¹⁹	VA	3,379	#8 Power Boiler that burns bituminous coal	2	1,056 MMBTU/hr	None	Wet gas scrubber (2007)	Consent Decree dated 11/2004 which states that SO ₂ emission rate will not exceed 0.26 lb/MMBTU on a 30-day rolling average basis.

Table 5.1 Point Source Information Collected from the Top 17 Industrial Facilities Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	2002 SO ₂ Total (tons)	Primary Emissions Point Description	Point ID (Permit ID No.)	Design Capacity	Existing Control(s)	Proposed/Planned Control(s)	Additional Information
Great Northern Paper Inc. Mill West ^{20, 21}	ME	1,842	Power Boilers #4 (Riley-Stoker))	004 (WB4)	740 MMBTU/hr	None	None	Unit to be shut down so BART not an issue (only BART eligible source at this facility)
NRG Energy Center Dover LLC ^{1, 22, 23}	DE	1,836	Riley Stoker Boiler fired on pulverized bituminous coal (primary fuel) and natural gas (for startup/ignition).	C-1 (001)	243 MMBTU/hr	Four (4) DB Riley Low NO _x burners Cyclonic Combustion Venturi burner assemblies Low excess air ESP w/23,000 ft ² collecting electrode area	None	Not BART eligible
Sappi-Somerset ^{20, 21}	ME	1,734	Power Boiler #1 (Babcock & Wilcox)	001 (PB#1)	848 MMBTU/hr (all fuels) & 250 MMBTU/hr (fossil fuels)	None	None	CEMS for SO ₂ Facility to reduce SO ₂ emissions by 50% by 2013 (BART deadline)

¹ MACTEC Federal Programs, Inc., "Revised Draft Final, Assessing Reasonable Progress for Regional Haze in the Mid-Atlantic North Eastern Class I Areas", March 8, 2007. Comments regarding Motiva Enterprises LLC – Delaware City and NRG Energy Center Dover LLC facilities received from Mr. John Sipple (302-739-9435, John.Sipple@state.de.us) via E-mail on March 13, 2007.

- ² New York State Department of Environmental Conservation, Division of Air Resources. Personal communications regarding Kodak Park Division facility between Mr. Mike Cronin, P.E. (518-402-8403, mpcronin@gw.dec.state.ny.us) and Ms. Lori Cress, MACTEC Federal Programs, Inc., on February 1 and 9, 2007.
- ³ New York State Department of Environmental Conservation, Division of Air Resources. Personal communications regarding Kodak Park Division facility from Mr. Mike Cronin, P.E. (518-402-8403, mpcronin@gw.dec.state.ny.us) via E-mail on February 12, 2007.
- ⁴ Ohio Environmental Protection Agency, Division of Air Pollution Control. Personal communication regarding MW Custom Papers LLC – Chillicothe Mill and Goodyear Tire and Rubber Company facilities from Mr. William Spires (614-644-3618, bill.spires@epa.state.oh.us) via E-mails on February 20, 2007.
- ⁵ Tennessee Department of Environment and Conservation, Division of Air Pollution Control. Personal communication regarding Eastman Chemical Company facility from Ms. Julie Aslinger (615-532-0587, Julie.Aslinger@state.tn.us) via E-mail on March 1, 2007.
- ⁶ MACTEC Federal Programs, Inc., “Revised Draft Final, Assessing Reasonable Progress for Regional Haze in the Mid-Atlantic North Eastern Class I Areas”, March 8, 2007. Comments regarding Eastman Chemical Company facility received from Ms. Julie Aslinger (615-532-0587, Julie.Aslinger@state.tn.us) via E-mail on March 30, 2007.
- ⁷ Maryland Department of the Environment. Personal communication regarding Westvaco Fine Papers facility between Mr. Andy Heltibridle (410-537-4218, aheltibridle@mde.state.md.us) and Ms. Lori Cress, MACTEC Federal Programs, Inc. on January 31, 2007.
- ⁸ Maryland Department of the Environment. Personal communication regarding Westvaco Fine Papers facility from Mr. Andy Heltibridle (410-537-4218, aheltibridle@mde.state.md.us) via E-mail on January 31, 2007.
- ⁹ West Virginia Division of Air Quality. Personal communications regarding PPG, Industries, Inc. facility between Ms. Laura Crowder (304-926-0499 Ext. 1247, LCROWDER@wvdep.org) and Mr. Steve Pursley (304-926-0499 Ext. 1218) and Ms. Lori Cress, MACTEC Federal Programs, Inc., on March 14, 2007.
- ¹⁰ Virginia Department of Environmental Quality, Division of Air Quality. Personal communication regarding Mead Westvaco Packaging Resource Group facility between Ms. Doris McLeod (504-698-4197, damcleod@deq.virginia.gov) and Ms. Lori Cress, MACTEC Federal Programs, Inc., on February 20, 2007.
- ¹¹ Pennsylvania Department of Environmental Protection, Bureau of Air Quality. Personal communication regarding PH Glatfelter Company/Spring Grove facility between Ms. Nancy Herb (717-783-9269, nherb@state.pa.us) and Ms. Lori Cress, MACTEC Federal Programs, Inc. on January 31, 2007.
- ¹² Pennsylvania Department of Environmental Protection, Bureau of Air Quality. Personal communications regarding PH Glatfelter Company/Spring Grove facility from Ms. Nancy Herb (717-783-9269, nherb@state.pa.us) via E-mail on January 31 and February 7, 2007.
- ¹³ Illinois Environmental Protection Agency, Bureau of Air. Personal communication regarding Williams Ethanol Services Incorporated and Corn Products International Incorporated facilities between Mr. Rob Kaleel (217-524-4387, Rob.Kaleel@illinois.gov) and Ms. Lori Cress, MACTEC Federal Programs, Inc. on February 2, 2007.
- ¹⁴ Illinois Environmental Protection Agency, Bureau of Air. Personal communication regarding Williams Ethanol Services Incorporated and Corn Products International Incorporated facilities from Mr. Rob Kaleel (217-524-4387, Rob.Kaleel@illinois.gov) via E-mail on February 2, 2007.
- ¹⁵ Pennsylvania Department of Environmental Protection, Bureau of Air Quality. Personal communications regarding Sunoco Inc. (R&M) facility between Ms. Nancy Herb (717-783-9269, nherb@state.pa.us) and Ms. Lori Cress, MACTEC Federal Programs, Inc. on January 31, 2007.
- ¹⁶ Pennsylvania Department of Environmental Protection, Bureau of Air Quality. Personal communications regarding Sunoco Inc. (R&M) facility from Ms. Nancy Herb (717-783-9269, nherb@state.pa.us) via E-mail on February 22, 2007.
- ¹⁷ New Jersey Department of Environmental Protection, Division of Air Quality. Personal communications regarding Valero Refining Company facility between Mr. Ray Papalski (609-633-7225, Ray.Papalski@dep.state.nj.us) and Ms. Lori Cress, MACTEC Federal Programs, Inc. on January 31 and February 2, 2007.
- ¹⁸ New Jersey Department of Environmental Protection, Division of Air Quality. Personal communication regarding Valero Refining Company facility from Mr. Ray Papalski (609-633-7225, Ray.Papalski@dep.state.nj.us) via E-mail on February 21, 2007.
- ¹⁹ Virginia Department of Environmental Quality, Division of Air Quality. Personal communication regarding Stone Container Corporation facility from Ms. Doris McLeod (504-698-4197, damcleod@deq.virginia.gov) via E-mail on February 9, 2007.
- ²⁰ Maine Department of Environmental Protection Agency, Bureau of Air Quality. Personal communications regarding Great Northern Paper Incorporated Mill West and Sappi - Somerset facilities between Ms. Lynn Ross (207-287-8106, Lynn.Ross@maine.gov) and Mr. Marc Cone (207-287-2437) and Ms. Lori Cress, MACTEC Federal Programs, Inc. on February 2, 2007.
- ²¹ Maine Department of Environmental Protection Agency, Bureau of Air Quality. Personal communication regarding Great Northern Paper Incorporated Mill West and Sappi - Somerset facilities between Ms. Lynn Ross (207-287-8106, Lynn.Ross@maine.gov) via E-mail on February 2, 2007.

- ²² Delaware Department of Natural Resources and Environmental Control, Division of Air and Waste Management. Personal communications regarding NRG Energy Center Dover LLC facility between Ms. Tammy Henry (302-323-4542, Tammy.Henry@state.de.us) and Ms. Lori Cress, MACTEC Federal Programs, Inc. on March 5, 2007.
- ²³ Delaware Department of Natural Resources and Environmental Control, Division of Air and Waste Management. Personal communications regarding NRG Energy Center Dover LLC facility from Ms. Tammy Henry (302-323-4542, Tammy.Henry@state.de.us) via E-mail on March 5, 2007.

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CHAPTER 6

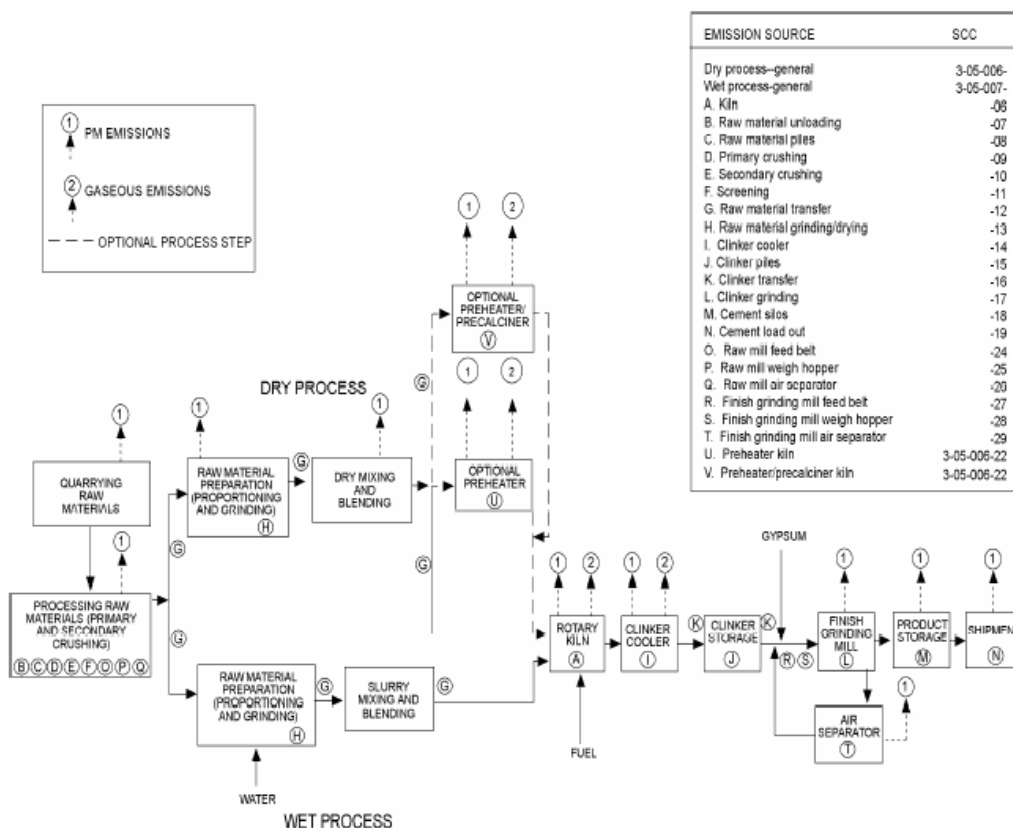
SOURCE CATEGORY ANALYSIS: KILNS

SOURCE CATEGORY DESCRIPTION

Portland cement is a main ingredient for concrete and other common building materials. Portland cement is mainly composed of clinker, a material formed by heating limestone and other ingredients to temperatures over 1,400°C (2,650°F). High combustion temperatures require large amounts of fuel and can result in significant emissions of SO₂ and NO_x. Crushing of ingredients and finished clinker can release dust and particles. Ammonia is sometimes produced during the heating of limestone.

Figure 6.1 shows a process flow diagram of a Portland cement facility. The process flow diagram (taken from AP-42) shows both wet and dry Portland cement processes.

Figure 6.1 Portland Cement Process Flow Diagram



EPA. January, 1995. AP42 Section 11.6 – “Portland Cement Manufacturing”.

Figure 6.1 shows that the Portland cement process can generally be broken down into the following steps: raw materials handling, raw material preparation, dry mixing, optional

preheating and/or precalcining, kiln treatment (pyroprocessing step), clinker handling and storage, and finishing operations (finishing, storage and shipment). The pyroprocessing step transforms the raw mix into clinkers, which are gray, glass-hard, spherically shaped nodules that range from 0.125 to 2.0 inches in diameter.

The pyroprocessing step is the predominant source of gaseous pollutant emissions. In general, there are five different processes used in the Portland cement industry to accomplish the pyroprocessing step: the wet process, the dry process (long dry process), the semidry process, the dry process with a preheater, and the dry process with a preheater/precalciner.

Each of the pyroprocessing types vary with respect to equipment design, method of operation, and fuel consumption. Generally, fuel consumption decreases in the order of the processes listed due to the heat required to evaporate water present in the raw material slurry (e.g., wet processes use the most fuel).

In the long dry process, all of the pyroprocessing activity occurs in the rotary kiln. Dry process pyroprocessing systems have been improved in thermal efficiency and productive capacity through the addition of one or more cyclone-type preheater vessels in the gas stream exiting the rotary kiln. This system is called the preheater process. The vessels are arranged vertically, in series, and are supported by a structure known as the preheater tower. Hot exhaust gases from the rotary kiln pass countercurrently through the downward-moving raw materials in the preheater vessels. Compared to the simple rotary kiln (long dry process), the heat transfer rate is significantly increased, the degree of heat utilization is greater, and the process time is markedly reduced by the intimate contact of the solid particles with the hot gases. The improved heat transfer allows the length of the rotary kiln to be reduced. An added benefit of the preheater operation is that hot gases from the preheater tower are used to help dry raw materials in the raw mill. Because the catch from the mechanical collectors, fabric filters, and/or electrostatic precipitators (ESP) that follow the raw mill is returned to the process, these devices can also be considered to be production machines as well as pollution control devices.

Additional thermal efficiencies and productivity gains have been achieved by diverting some of the fuel to a calciner vessel at the base of the preheater tower. This system is called the preheater/precalciner process.

Regardless of the type of pyroprocess used, the last component of the pyroprocessing system is the clinker cooler. The clinker cooler serves two main purposes. First, this portion of the process:

- recoups up to 30% of the heat input to the kiln system;
- locks in desirable product qualities by freezing mineralogy; and
- makes it possible to handle the cooled clinker with conventional conveying equipment.

The more common types of clinker coolers are reciprocating grate, planetary, and rotary. In these coolers, the clinker is cooled from about 1,100°C to 90°C (2000°F to 200°F) by ambient air that passes through the clinker and into the rotary kiln for use as combustion air. However, in the reciprocating grate cooler, lower clinker discharge temperatures are achieved by passing an

additional quantity of air through the clinker. Because this additional air cannot be used in the kiln for efficient combustion, it is vented to the atmosphere, used for drying coal or raw materials, or used as a combustion air source for the precalciner.

The second portion of the clinker process, a series of blending and grinding operations, completes the transformation of clinker into finished cement. Up to 5% gypsum or natural anhydrite is added to the clinker during grinding to control the cement setting time, and other specialty chemicals are added as needed to impart specific product properties. This finish milling is accomplished almost exclusively in ball or tube mills. Typically, finishing is conducted in a closed-circuit system, with product sizing by air separation.

Coal is the fuel of choice in cement kilns, primarily because of its low cost, but also because the coal ash contributes to the product. The current fuel usage in cement kilns is about 82% coal; 4% natural gas; and 14% other fuels, mainly combustible waste (industrial waste, tires, sewage sludge, etc.). In addition to conventional fuels, many Portland cement facilities are employing the use of petroleum derived coke (petcoke) blended with coal to fire kilns.

Lime kilns are similar to cement kilns. The kiln is the heart of the lime manufacturing plant, where various fossil fuels (such as coal, petroleum coke, natural gas, and fuel oil) are combusted to produce the heat needed for calcination. There are five different types of kilns used in lime manufacturing: rotary, vertical, double-shaft vertical, rotary hearth, and fluidized bed. The most popular is the rotary kiln, however the double-shaft vertical kiln is an emerging new kiln technology gaining in acceptance primarily due to its energy efficiency. Similar to cement plants, rotary kilns at lime manufacturing plants may also have preheaters to improve energy efficiency. Additionally, energy efficiency is improved by routing exhaust from the lime cooler to the kiln. SO₂ emissions from lime predominately originate from compounds in the limestone feed material and fuels and are formed from the combustion of fuels and the heating of feed material in the kiln.

All types of kilns at lime manufacturing plants use external equipment to cool the lime product, except vertical (including double-shaft) kilns, where the cooling zone is part of the kiln. Ambient air is most often used to cool the lime (although a few use water as the heat transfer medium), and typically all of the heated air stream exiting the cooler goes to the kiln to be used as combustion air for the kiln. The exception to this is the grate cooler, where more airflow is generated than is needed for kiln combustion, and consequently a portion (about 40%) of the grate cooler exhaust is vented to the atmosphere. EPA has estimated that there are about five to ten kilns in the United States that use grate coolers. The emissions from grate coolers include lime dust (PM) and trace metallic HAPs found in the lime dust, but not typically SO₂.

For cement and lime kilns, add-on control technology options identified for SO₂ include advanced flue gas desulfurization (AFGD), dry FGD, and wet FGD.

EVALUATION OF SO₂ EMISSION CONTROL OPTIONS

Sulfur dioxide may be generated both from the sulfur compounds in the raw materials and from sulfur in the fuel. The sulfur content of both raw materials and fuels varies from plant to plant and with geographic location. However, the alkaline nature of the cement provides for direct

absorption of SO₂ into the product, thereby reducing the quantity of SO₂ emissions in the exhaust stream. Depending on the process and the source of the sulfur, SO₂ absorption ranges from about 70% to more than 95%.

In contrast to electric utility and industrial boilers, SO₂ emissions from rotary cement kilns are not strongly dependent on fuel sulfur content. Instead, SO₂ emissions are more closely related to the amount of sulfide (e.g. pyrite) in kiln feedstocks and to the molar ratio of total sulfur to total alkali input to the system. In cement kilns SO₂ emissions generally depend on:

- Inherent SO₂ removal efficiency of kiln system during processing,
- Form of sulfur (e.g. pyritic) and sulfur concentrations in raw material,
- Molecular ratio between sulfur and alkalis,
- Prevailing conditions (oxidizing or reducing) and their location within the kiln, and
- Temperature profile in the kiln system.

SO₂ emission reductions may also result from attempts to reduce other pollutants (primarily NO_x), typically due to changes in the flame characteristics of combustion. For example, staged combustion with mid-kiln injection of a low-sulfur fuel may be considered for reducing SO₂. Similarly, including high pressure air injection at a mid-kiln firing site can limit oxygen in the kiln and suppress SO₂ formation (Hansen, 2002). Since these techniques are primarily used to reduce NO_x and because their efficiencies are typically more limited than other techniques they are not considered in additional detail here.

Other more specific SO₂ control technologies applicable to cement kilns are listed below. A summary of controls evaluated for this work is provided in Table 6.1. Details of each of the control technologies follow Table 6.1. Additional information on this source category and associated controls can be found in the 2005 NESCAUM document titled: *Assessment of Control Technology Options for BART-Eligible Sources*.

Table 6.1 SO₂ Control Technologies for Cement Kilns

Technology	Description	Applicability	Performance
Fuel Switching	Limiting the sulfur content of both raw materials and fuels can reduce releases of SO ₂ . Availability of these materials is highly site-specific.	All Kilns	Depends on availability of low-sulfur raw materials
Dry Flue Gas Desulfurization - Spray Dryer Absorption (FGD)	Addition of absorbents such as slaked lime (Ca(OH) ₂), quicklime (CaO) or activated fly ash with high CaO content to the exhaust gas of the kiln can absorb some of the SO ₂ .	All Kilns	60-80% reduction
Wet Flue Gas Desulfurization (FGD)	SO ₂ is absorbed by a liquid/slurry sprayed in a spray tower or is bubbled through the liquid/slurry. Wet scrubbers also significantly reduce the HCl, residual dust, metal and NH ₃ emissions.	All Kilns	90-99.9% reduction
Advanced Flue Gas Desulfurization (FGD)	DOE demonstrated a retrofit Passamaquoddy Technology Recovery Scrubber™ using cement kiln dust (CKD), an alkaline-rich (potassium) waste, to react with the acidic flue gas.	All Kilns	95-99.5% reduction

Table References:

1. *Assessment of Control Technology Options for BART-Eligible Sources*, NESCAUM, March 2005.
2. Miller, F.M. et. al. *Formation and Techniques of Control of Sulfur Dioxide and Other Sulfur Compounds in Portland Cement Kiln Systems*. Portland Cement Association R&D Serial No. 2460, 2001.

Fuel Switching

As with any fuel-fired SO₂ emission source, reduction of sulfur levels in the fuel itself typically results in lowered emissions. However, this technique is less effective in cement-making systems, where SO₂ emissions are not strongly dependent on fuel sulfur content. Depending upon the level of sulfur in a plant's limestone, and more specifically the pyrite content, compared to the sulfur content of its heating fuel, fuel switching may not be sufficient to reduce SO₂ emissions (Tanna and Schipholt, 2004). However, when fuel sulfur levels are high, fuel switching may have a significant benefit in SO₂ levels.

Flue Gas Desulfurization (FGD)

Both wet and dry flue gas desulfurization (FGD) systems have been used effectively to control SO₂ emissions from cement kilns. FGD systems at cement facilities typically are, 1) dry flue gas desulfurization (spray dryer absorption) 2) wet flue gas desulfurization, and 3) advanced flue gas desulfurization (AFGD). A brief description of each of these technologies is provided below.

Dry Flue Gas Desulfurization (Spray Dryer Absorption)

Spray dryer absorption (SDA) systems spray lime slurry into an absorption tower where SO₂ is absorbed by the slurry, forming a mixture of calcium sulfite and calcium sulfate. The liquid-to-gas ratio is such that the water evaporates before the droplets reach the bottom of the tower. The dry solids are carried out with the gas and collected with a fabric filter or ESP. When used to specifically control SO₂, the term dry flue-gas desulfurization (dry FGD) may also be used. As with other types of dry scrubbing systems (such as lime/limestone injection) exhaust gases that exit at or near the adiabatic saturation temperatures can create problems with this control technology by causing the baghouse filter cake to become saturated with moisture and plug both the filters and the dust removal system. In addition, the lime slurry would not dry properly and would plug up the dust collection system. However there is some argument in the control community that indicates that some of the SO₂ removal actually occurs on the filter cake. Therefore, dry FGD (spray dryer absorption) may not be technically feasible if exit gas temperatures are not substantially above the adiabatic saturation temperatures. For Portland cement facilities, these temperatures are likely to be above the adiabatic saturation temperatures.

Most of the spray dryer type SO₂ control technologies in the cement industry are applied to preheater or preheater/precalciner kilns. Exhaust gases from long dry kilns are cooled by either spray water introduced into the feed end of the kiln or by dilution air-cooling after the gases leave the kiln. Adding a conditioning tower to replace wet suppression or dilution air enables the alkaline slurry system to be used to reduce SO₂ emissions (the equivalent of a spray dryer). The use of an alkaline slurry spray dryer type scrubber should be applied to long wet kilns with care because the addition of the lime slurry may drop the exhaust gases temperature below the acid adiabatic saturation temperatures, creating significant plugging and corrosion problems in the downstream particulate control device, duct work, and induced draft fan.

Wet Flue Gas Desulfurization (FGD)

Wet scrubbing processes used to control SO₂ and particulate emissions are generally termed flue-gas desulfurization (FGD). FGD utilizes gas absorption technology, the selective transfer of materials from a gas to a contacting liquid, to remove SO₂ in the waste gas. Caustic, crushed limestone, or lime are used as scrubbing agents. Our screening evaluation assumes that lime is the scrubbing agent.

Caustic scrubbing produces a liquid waste, and minimal equipment is needed. When lime or limestone is used as the reagent for SO₂ removal, additional equipment is needed for preparing the lime/limestone slurry and collecting and concentrating the resultant sludge. Calcium sulfite sludge is watery and is typically stabilized with fly ash for land filling. Calcium sulfate sludge is stable and easy to dewater. To produce calcium sulfate, an air injection blower is needed to supply the oxygen for the second reaction to occur. The normal SO₂ control efficiency range for SO₂ scrubbers is 80-90% for low efficiency scrubbers and 90-99.9% for high efficiency scrubbers.

While wet scrubbers have been used successfully in the utility industry, they require more care when used for a Portland cement facility. Calcium sulfate scaling and cementitious buildup when a wet scrubber is used for acid gas control (applied to the exhaust gas from a cement kiln)

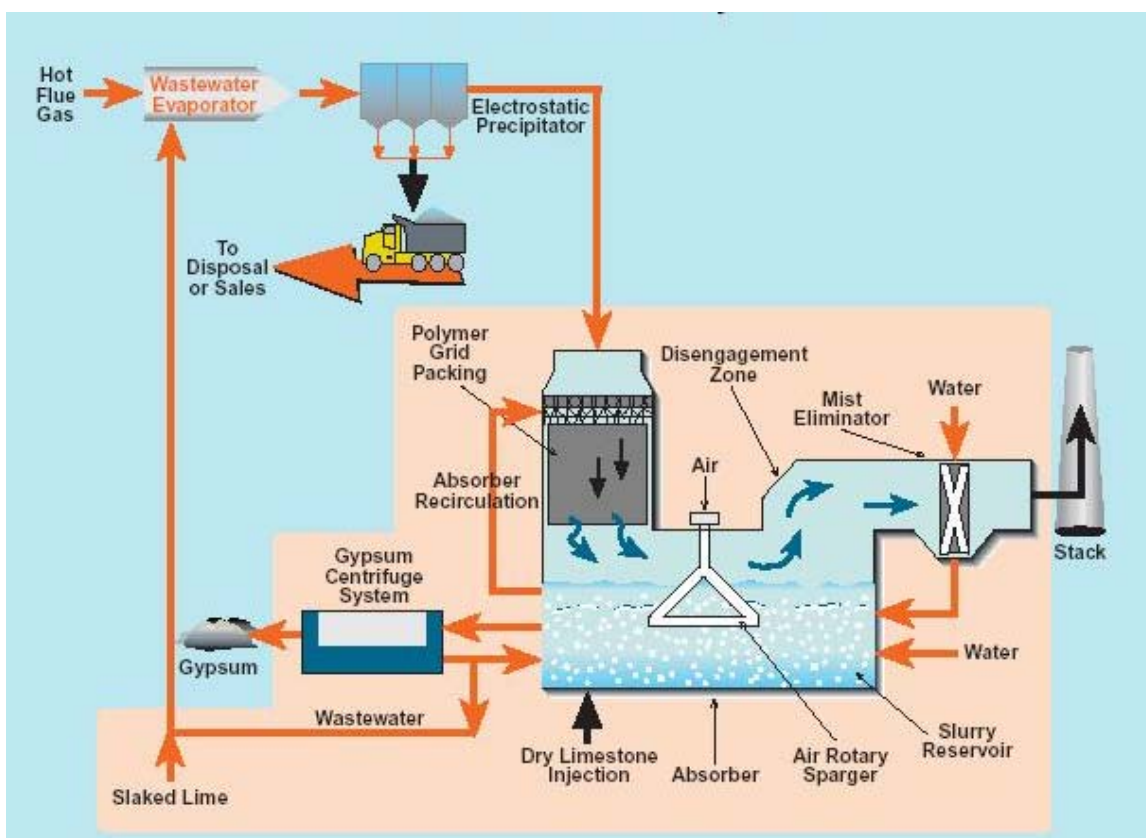
can be avoided if these systems are installed downstream of a high efficiency particulate control device (e.g., fabric filter). Failure of the particulate control device can pose difficult problems for a downstream wet scrubber.

Advanced Flue Gas Desulfurization (FGD)

The AFGD process accomplishes SO₂ removal in a single absorber which performs three functions: prequenching the flue gas, absorbing SO₂, and oxidizing the resulting calcium sulfite to wallboard-grade gypsum. Figure 6.2 shows the process flow for an AFGD system.

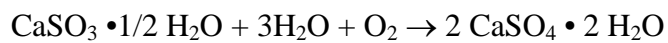
Incoming flue gas is cooled and humidified with process wet suppression before passing to the absorber. In the absorber, two tiers of fountain-like sprays distribute reagent slurry over polymer grid packing that provides a large surface area for gas/liquid contact. The gas then enters a large gas/liquid disengagement zone above the slurry reservoir in the bottom of the absorber and exits through a horizontal mist eliminator.

Figure 6.2 Advanced Flue Gas Desulfurization Process Flow



As the flue gas contacts the slurry, the sulfur dioxide is absorbed, neutralized, and partially oxidized to calcium sulfite and calcium sulfate. The overall reactions are shown in the following equations:





After contacting the flue gas, slurry falls into the slurry reservoir where any unreacted acids are neutralized by limestone injected in dry powder form into the reservoir. The primary reaction product, calcium sulfite, is oxidized to gypsum by the air rotary spargers, which both mix the slurry in the reservoir and inject air into it. Fixed air spargers assist in completing the oxidation. Slurry from the reservoir is circulated to the absorber grid.

A slurry stream is drawn from the tank, dewatered, and washed to remove chlorides and produce wallboard quality gypsum. The resultant gypsum cake contains less than 10% water and 20 ppm chlorides. The clarified liquid is returned to the reservoir, with a slipstream being withdrawn and sent to the wastewater evaporation system for injection into the hot flue gas ahead of the electrostatic precipitator. Water evaporates and dissolved solids are collected along with the flyash for disposal or sale.

The production of gypsum may actually be beneficial for Portland cement as gypsum is added to Portland cement in the final grinding process to regulate the setting time of the concrete. However, to date there are no known installations of AFGD at Portland cement facilities.

Inherent Removal

Removal of SO₂ in the cement manufacturing process is inherent to that process. The raw materials used in the process, primarily limestone, are preheated in the cement-making process either in the preheater tower or in the rotary kiln. In either case, the limestone comes in contact with hot combustion exhaust gases generating a free lime, which then reacts with SO₂ in the gas stream, providing in-process removal of sulfur in the kiln system. Removal efficiencies in rotary kiln systems range between 38% and 99% of sulfur input, and 50% to 70% of the remaining SO₂ is removed from exhaust gases when passing through an in-line raw mill system (Miller et al., 2001). The overall effectiveness and costs associated with this method are highly variable and are related primarily to the type of kiln operation and the ability of the facility to change raw material feeds. These costs can be difficult to quantify.

Process Alterations

The following methods to remove and prevent formation of SO₂ by modifying or controlling conditions in the system are available due to the nature of the Portland cement manufacturing process:

- Change in the oxygen concentration in the flame/exhaust gas area. The concentrations of oxygen and (more importantly) carbon monoxide strongly influence the stability of alkali and calcium sulfates in the burning zone. By ensuring that sufficient oxygen is present to stabilize these compounds, SO₂ emissions can be controlled. Control of burning-zone O₂ and CO concentrations is a widely used industrial practice, and a control technique applicable to all rotary cement kilns. The downside of this technique is the more favorable conditions created for generation of NO_x in the rotary kiln.

- Burning-zone flame shape can be modified to ensure that reducing conditions in the flame are minimized. Flame impingement in the hot zone has a major effect on SO₂ emissions from the kiln, even if total oxygen is sufficient to fully combust all fuel. Avoiding flame impingement in the burning zone minimizes SO₂ formation. Avoiding flame impingement on the clinker, a technique applicable to all rotary kilns producing cement clinker, requires proper solid fuel preparation and proper flame shaping and control.
- Changes in raw materials to alter the alkali/sulfur molar ratio can also be used to control SO₂ emissions. SO₂ concentrations in kiln exit gases vary with the molar ratio of alkali to sulfur. When there are sufficient alkalis in excess of sulfur, SO₂ emissions are typically low, due to more sulfur being retained as alkali sulfates in the clinker. Cement plants may also change their raw materials to reduce SO₂ emissions. Typically this is accomplished by substituting a raw material containing pyritic sulfur or organic sulfur with one containing lesser amounts of these compounds, leading to reduced SO₂ emissions. Replacement of raw materials, however, is often constrained by economic considerations, while alkali input increase may also be limited by cement product quality specifications on total alkali in cement.
- Alterations to system can influence SO₂ emissions. It has been found that an improved distribution of kiln feed may equalize temperatures in bottom stage cyclones and reduce SO₂ emission by as much as 20% (Miller, 2001).

As with inherent removal, the overall effectiveness and costs associated with this method are highly variable and are related primarily to the type of kiln operation and the ability of the facility to change raw material feeds. These costs can be difficult to quantify.

FOUR FACTOR ANALYSIS OF POTENTIAL CONTROL SCENARIOS FOR KILNS

Cost of Compliance

To compare the various control options, information has been compiled on the cost-effectiveness of retrofitting controls. In general, cost-effectiveness increases with the amount of cement produced by the facility.

In a study performed for LADCO for a BART analysis, MACTEC developed control costs for SO₂ for a “model” cement plant for SO₂. For the wet scrubber, the control cost estimates were prepared using lime as the base in the scrubbing liquor. Caustic (NaOH) and limestone are potential alternatives for a scrubber and could change the costs slightly. While lime and limestone require additional equipment for slurry preparation and for solids separation from the sludge generated in the scrubber, lime scrubbers are the most commonly used since lime is plentiful and relatively cheap. Materials of construction must also be made suitable for caustic, lime, or limestone if existing equipment is modified for wet scrubbing of SO₂.

AFGD systems require additional capital costs for the spargers and blowers necessary to oxidize the waste product to gypsum and for equipment to dewater the product (e.g., centrifuge). However if the commercial grade gypsum can be sold or used by the cement facility, some of these costs can be offset.

Dry FGD costs were calculated based on the low and high control efficiencies typical for these systems. For dry scrubbers, the flue gas must be cooled to a temperature 10 to 20 degrees above adiabatic saturation. This is typically accomplished using a heat recovery boiler, an evaporative cooler or a heat exchanger. In addition, if the facility does not have one, a particulate removal device is required for removal of the dry materials used to absorb SO₂.

For all scrubbers, costs for an additional or upgraded induced air draft fan to make up for pressure drops within the system may be required. In addition, for wet systems, flue gas reheating may be required, thus a reheater may be necessary.

Tables 6.2 – 6.4 present estimated SO₂ control costs for AFGD, Wet FGD, and Dry FGD applied to dry kilns and preheater kilns. The range of costs for these systems vary depending on the size of the kiln and control efficiency, so costs are presented for three size ranges of kilns. Although the capital and annual operating costs of these three types of control vary widely depending on kiln size and control efficiency, the ultimate cost in terms of \$/ton of SO₂ reduction are estimated to be from \$2,000 - \$7,000 for dry kilns and \$9,000 to \$73,000 for preheater kilns.

**Table 6.2 SO₂ Control Costs for AFGD Applied to Dry Kilns and Preheater Kilns
(2006 dollars)**

	Dry Kiln			Preheater Kiln		
Unit Relative Size	Capital Costs (10 ⁶ \$)	Annual Operating Costs (10 ⁶ \$)	SO ₂ Cost Effectiveness (\$/ton SO ₂ reduction)	Capital Costs (10 ⁶ \$)	Annual Operating Costs (10 ⁶ \$)	SO ₂ Cost Effectiveness (\$/ton SO ₂ reduction)
Small	\$7.03 – \$22.9	\$3 - \$6	\$2,000 - \$4,000	\$4.5 - \$14.5	\$1.2 – \$11.8	\$13,600- \$38,000
Medium	\$14.1 - \$45.9	\$6.1 - \$11.9		\$8.9 - \$29.0		
Large	\$28.1 - \$91.6	\$12.1 – \$23.7		\$17.8 - \$58.0		

**Table 6.3 SO₂ Control Costs for Wet FGD Applied to Dry Kilns and Preheater Kilns
(2006 dollars)**

	Dry Kiln			Preheater Kiln		
Unit Relative Size	Capital Costs (10 ⁶ \$)	Annual Operating Costs (10 ⁶ \$)	SO ₂ Cost Effectiveness (\$/ton SO ₂ reduction)	Capital Costs (10 ⁶ \$)	Annual Operating Costs (10 ⁶ \$)	SO ₂ Cost Effectiveness (\$/ton SO ₂ reduction)
Small	\$2.43 – \$36.5	\$3 - \$9	\$2,000 - \$6,200	\$1.5 - \$23.1	\$0.9 – \$18.9	\$9,700- \$64,600
Medium	\$4.9 - \$73.0	\$6.0 - \$18.4		\$3.1 - \$46.3		
Large	\$9.5 - \$142.5	\$11.9 – \$36.8		\$6.2 - \$92.5		

**Table 6.4 SO₂ Control Costs for Dry FGD Applied to Dry Kilns and Preheater Kilns
 (2006 dollars)**

Unit Relative Size	Dry Kiln			Preheater Kiln		
	Capital Costs (10 ⁶ \$)	Annual Operating Costs (10 ⁶ \$)	SO ₂ Cost Effectiveness (\$/ton SO ₂ reduction)	Capital Costs (10 ⁶ \$)	Annual Operating Costs (10 ⁶ \$)	SO ₂ Cost Effectiveness (\$/ton SO ₂ reduction)
Small	\$1.45 – \$37.0	\$3 - \$9	\$1,900 - \$7,000	\$0.9 - \$26.3	\$0.9 – \$21.0	\$10,000-\$72,800
Medium	\$2.9 - \$84.9	\$5.5 - \$20.0		\$1.8 - \$52.6		
Large	\$5.6 - \$165.5	\$10.7 – \$38.9		\$3.6 - \$105.2		

The LADCO region had no wet kilns so cost estimates were not available for those type kilns. For the purposes of this study, wet kiln cost effectiveness is assumed to be similar to that for long dry kilns.

Additional details concerning the calculation of cost effectiveness of controls for kilns is located in a document developed by MACTEC for LADCO titled: *Cement Best Available Retrofit Technology (BART) Engineering Analysis*. This document can be downloaded from the web at the following location:

http://www.ladco.org/reports/rpo/Regional%20Air%20Quality/BART/Cement_BART_Engineering%20Analysis%20%2B%20Appendix%20A1.pdf.

Time Necessary for Compliance

Generally, sources are given a 2-4 year phase-in period to comply with new rules. Under the NO_x SIP Call for Phase I sources, EPA provided a compliance date of about 3½ years from the SIP submittal date. Most MACT standards allow a 3-year compliance period. Under Phase II of the NO_x SIP Call, EPA provided a 2-year period after the SIP submittal date for compliance. States generally provided a 2-year period for compliance with RACT rules. For BART control measures, the proposed BART guidelines require States to establish enforceable limits and require compliance with the BART emission limitations no later than 5 years after EPA approves the regional haze SIP.

For the purposes of this review, we have assumed that a 2-year period after SIP submittal is adequate for pre-combustion controls (fuel switching or cleaning) and a three year period for the installation of post combustion controls.

Energy and Non-Air Impacts

Fuel switching and cleaning and process changes do not significantly impact efficiency of the cement operation, but may add to transportation issues and secondary environmental impacts from waste disposal and material handling operations (e.g. fugitive dust). FGD systems typically operate with high pressure drops across the control equipment, resulting in a significant amount of electricity required to operate blowers and circulation pumps. In addition, some combinations

of FGD technology and plant configuration may require flue gas reheating to prevent physical damage to equipment, resulting in higher fuel usage.

Environmental Impacts

The primary environmental impact of AFGD is the generation of byproduct gypsum. While gypsum is generated as a byproduct, the intent of the AFGD system is to produce gypsum that is commercial grade that can be sold. In the case of cement kilns, production of gypsum would result in some cost offsets since gypsum is a component of Portland cement. Thus the gypsum produced could be used to offset gypsum purchases.

The primary environmental impact of wet scrubbers is the generation of wastewater and sludge. Waste from wet scrubbers will increase the sulfate and solids loading in the facility's wastewater. This places additional burdens on a facility's wastewater treatment and solid waste management capabilities. These impacts will need to be analyzed on a site-specific basis. If lime or limestone scrubbing is used to produce calcium sulfite sludge, the sludge is water-laden, and it must be stabilized for land filling. If lime or limestone scrubbing is used to produce calcium sulfate sludge, it is stable and easy to dewater. However, control costs will be higher because additional equipment is required. Scrubber exhaust gases are saturated with water, thus creating a visible plume. Plume visibility may be a local/community concern. Once the exhaust mixes with sufficient air, the moisture droplets evaporate, and the plume is no longer visible.

Disposal of removed material from dry FGD systems is also required and will result in landfill impacts.

Energy Impacts

A scrubber operates with a high pressure drop, resulting in a significant amount of electricity required to operate the blower and pump. In addition for some technologies, a flue gas reheater may be required resulting in slightly increased fuel usage.

Remaining Useful Life of the Source

MACTEC could find little information on the typical lifetime of a cement plant. In a Security and Exchange filing (<http://www.secdb.org/prosmcldopr.html>) for a facility in India, typical lifetimes of various components of the plant range between 20-50 years. In an evaluation of waste management of cement kiln dust (CKD), remaining useful lifetimes of waste management units were around 20 years (<http://www.epa.gov/epaoswer/other/ckd/rtc/chap-4.pdf>). Thus we found nothing to suggest that the amortization of capital costs or calculation of annual operating costs would be affected by the remaining useful life.

For the purposes of this analysis, we assumed that the remaining useful life of each emission unit was a minimum of at least 10 years and that it was likely that some units would continue to operate for at least 20-30 more years with proper maintenance and upkeep.

REFERENCES

Assessment of Control Technology Options for BART-Eligible Sources, NESCAUM, March 2005.

EPA. January, 1995. AP42 Section 11.6 – “Portland Cement Manufacturing”.

Hansen, Eric R. *Staged Combustion for NO_x Reduction Using High Pressure Air Injection*, IEEE-IAS/PCA 43rd Cement Industry Technical Conference; Jacksonville, FL: May 2002.

Miller, F.M. et. al. *Formation and Techniques of Control of Sulfur Dioxide and Other Sulfur Compounds in Portland Cement Kiln Systems*. Portland Cement Association R&D Serial No. 2460, 2001.

Tanna, B. and B. Schipholt. *Waste-Derived Fuel Use in Cement Kilns* ERAtech Group, LLC <http://www.eratech.com/papers/wdf.htm>, accessed September, 2004.

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CHAPTER 7

ANALYSIS OF SELECTED KILNS

SOURCE CATEGORY DESCRIPTION

Emission control regulations for cement kilns have historically focused on particulate emissions. Over the past several years, regulations for the control of NO_x and hazardous air pollutant (HAP) emissions have also been adopted. SO₂ emission controls are largely non-existent. Some States have mandated emission limits as part of the Title V requirements but no national regulatory program for SO₂ controls for cement kilns exists. The only exceptions to this is for sources subject to New Source Review under Title I of the Clean Air Act and for sources subject to the Best Available Retrofit Technology (BART) requirements of the regional haze regulations.

Title I subjects new and modified large stationary sources that increase their emissions to permitting requirements that impose control technologies of varying levels of stringency (known as New Source Review, or NSR). NSR prescribes control technologies for new plants and for plant modifications that result in a significant increase in emissions, subjecting them to Best Available Control Technology (BACT) in attainment areas and to the Lowest Achievable Emission Rate (LAER) in nonattainment areas. The control strategies that constitute BACT and LAER evolve over time and are reviewed on a case-by-case basis in State permitting proceedings.

INFORMATION OBTAINED FROM STATE AGENCIES

MACTEC contacted State agencies to obtain information on kilns from those facilities in the list of the top 20 individual non-EGU sources. We requested permit information, information about SO₂ controls recently implemented or planned at the facility and any available information on BART, consent decrees, or other regulations that will impact control devices at the facilities. The information we obtained is included in Table 7.1.

Table 7.1 Point Source Information Collected from the Top 3 Kilns Responsible for Visibility Impairment in MANE-VU Class I Areas

Facility Name	State	2002 SO ₂ Total (tons)	Primary Emissions Point Description	Point ID (Permit ID No.)	Design Capacity	Existing Control(s)	Proposed/Planned Control(s)	Additional Information
LaFarge Building Materials Inc. ¹	NY	14,800	Two rotary, wet process kilns (Kiln 1 & 2) and two clinker coolers (Clinker Cooler 1 & 2). There are buildings at either end of the kilns; the discharge end building where the clinker coolers are located, and the feed end building.	041000	Unknown	Fabric filter dust collector on clinker coolers (PM) ESP (PM)	None	
St. Lawrence Cement Corp. – Catskill Quarry ^{2,3}	NY	3,562	Cement kiln permitted to burn coal, oil, tires, waste oil, natural gas, non-hazardous fuels, and coke. This is a wet kiln built in 1964.	U00K18	Unknown	ESP	Low-sulfur fuel	Consent Decree dated 1/9/91 limits burning solid fuel with a max sulfur content of 3.8 lbs/MMBTU/hr. BART analysis has not been completed.
Lafarge Midwest, Inc., Alpena Plant ⁴	MI	16,576	Five rotary dry kilns, clinker coolers and associated materials handling operations. Kilns fire with coal, coke or waste derived fuel	EU-Kiln19 EU-Kiln20 EU-Kiln21 EU-Kiln22 EU-Kiln23	Unknown	Baghouses on kiln dust return systems	Unknown as of date of report - these units are subject to BART	SO ₂ Emission limits on all five kilns: EUKiln19 = 2,088 tons EUKiln20 = 2,065 tons EUKiln21 = 2,056 tons EUKiln22 = 9,685 tons EUKiln23 = 9,728 tons

¹ New York State Department of Environmental Conservation, Division of Air Resources. Personal communication regarding LaFarge Building Materials Incorporated facility between Mr. Rick Leone (518-402-8403) and Ms. Lori Cress, MACTEC Federal Programs, Inc., on February 2, 2007.

² New York State Department of Environmental Conservation, Division of Air Resources. Personal communication regarding St. Lawrence Cement Corporation – Catskill Quarry facility between Mr. Rick Leone (518-402-8403) and Ms. Lori Cress, MACTEC Federal Programs, Inc., on February 9, 2007.

- ³ New York State Department of Environmental Conservation, Division of Air Resources. Personal communication regarding St. Lawrence Cement Corporation – Catskill Quarry facility from Mr. Rick Leone (518-402-8403) via E-mail on February 9, 2007.
- ⁴ Michigan Department of Environmental Quality, Air Quality Division. Personal communication regarding LaFarge Midwest, Incorporated Alpena Plant from Ms. Teresa Walker (517-335-2247, walkertr@michigan.gov) via E-mail on February 7, 2007.

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CHAPTER 8

HEATING OIL

BACKGROUND

Number 2 distillate fuel oil, heating oil, and diesel fuel oil are essentially the same refinery-produced liquid. In the Northeast United States, home heating accounts for 54% of distillate fuel oil demand. In comparison, highway diesel accounts for 38% (NESCAUM, 2005). Annually, home heating oil use generates an estimated 100,000 tons of sulfur dioxide (SO₂) emissions in the Northeast (NESCAUM, 2005). Climate and seasonality play important roles in the use of heating oil, and therefore the emissions from combustion of heating oil. While it is important to consider the emissions from heating oil in the Northeast United States, emissions from heating oil combustion in other areas of the United States such as the VISTAS States are not significant in comparison to other emission sources.

SO₂ emissions are proportional to fuel oil sulfur content. It is not feasible to control SO₂ emissions from homes using control devices; therefore, the most efficient method for controlling SO₂ emissions from home heating is by lowering the amount of sulfur in the fuel. Currently, the sulfur limits in heating oil vary between 2,000 to 20,000 ppm. Table 8.1 provides information on the range of sulfur in heating oils throughout the Northeast.

Table 8.1 State Sulfur Limits for Heating Oil

State	Sulfur Limit in Percent	Sulfur Limit in parts per million (ppm)
Connecticut	0.3	3,000
Maine	0.3 to 0.5	3,000 to 5,000
Massachusetts	0.3	3,000
New Hampshire	0.4	4,000
New Jersey	0.2 to 0.3	2,000 to 3,000
New York Upstate	1.0 to 1.5	10,000 to 15,000
New York Downstate	0.2 to 0.37	2,000 to 3,700
Rhode Island	0.5	5,000
Vermont	2.0	20,000

Source: NESCAUM, 2005

Beginning in 2006, the permissible level of sulfur in highway diesel fuel (ultra low sulfur diesel, or ULSD) was 15 ppm. Prior to that, highway low sulfur diesel fuel was refined to contain 500 ppm sulfur (Low Sulfur Diesel, or LSD). Consequently, refineries have already performed the capital investments required for the production of LSD and ULSD fuel oil. The Northeast States are considering adopting consistent low sulfur heating oil requirements, and a memorandum titled *DRAFT Memorandum of Understanding for Regional Fuel Sulfur Content Standards for*

Distillate Number 2 Heating Oil, the Northeast States proposed to reduce the sulfur content to 500 ppm. A reduction of sulfur in heating oils from the current levels to 500 ppm would reduce SO₂ emissions by approximately 75% per year on a nationwide basis (Batey and McDonald, 2005). There has also been some discussion regarding the reduction of heating oil sulfur content to 15 ppm.

This memorandum presents the four factor analysis that was applied to the heating oil sulfur reduction proposal. The four factors are: cost of compliance, time necessary for compliance, energy and non-air impacts, and remaining useful life of the sources. This document primarily focuses on reducing the sulfur content of heating oil to 500 ppm. Information on reducing the sulfur content of heating oil to 15 ppm is presented wherever data were available.

FOUR FACTOR ANALYSIS OF POTENTIAL CONTROL SCENARIOS FOR EMISSIONS FROM HEATING OIL COMBUSTION

Cost of Compliance

Refinery Retrofit Costs

Refineries were required to make significant capital investments to meet the LSD and ULSD highway fuel sulfur requirement. To achieve the LSD and ULSD sulfur goals, refineries were required to implement diesel desulfurization technologies. Estimates for the capital costs were developed in 2001 by the Energy Information Administration (EIA) and are based on calendar year 1999. Table 8.2 presents the capital costs for desulfurization technologies developed by the EIA, which were converted from a calendar year 1999 dollar basis to 2006 dollars. The EIA developed estimates for new and revamped desulfurization technologies at existing refineries.

Table 8.2 Ultra Low Sulfur Diesel (ULSD) Desulfurization Technology Costs for Individual Refineries^{a,b}

Desulfurization Unit Type	Throughput (Barrels per Day)	Capital Costs (2006 Dollars per Daily Barrel Produced)	Total Capital Cost per Unit (Million 2006 Dollars)
New	50,000	1,204	60.3
New	10,000	2,187	21.9
Revamp	50,000	716	35.8
Revamp	10,000	1,464	14.6

^aBased on cost estimates for hydrotreaters to produce ULSD.

^bSource for this information is the Energy Information Administration

Note – A conversion factor of 1.2101 was used to convert the dollar values from 1999 to 2006

www.inflationdata.com

In its highway diesel fuel rulemaking, EPA also developed cost estimates for the deployment and implementation of desulfurization technologies at refineries. EPA estimated that it would cost existing refineries an estimated \$56 million (2006 dollars) per refinery to install desulfurization

technologies, and that this effort would be spread out over a 2-year time period. EPA based its conclusions on the assumption that refineries would revamp their hydrotreating technologies. It further estimated that 80% of the hydrotreaters at the refineries would be revamped. The EPA also estimated that the cost of a new hydrotreater would be \$91 million (2006 dollars), and that roughly 25 refineries nationwide would have to make this investment. No estimates were made for the costs associated with new refineries as none are currently being constructed in the United States. The EPA analysis spread the investment cost over a 2-year period. Consequently, it was estimated that the US refinery-wide investment for calendar year 2004 was \$2.45 billion and \$2.83 billion for calendar year 2005 (EIA 2001) (Converted from 2001 to 2006 dollars using a conversion factor of 1.1383. www.inflationdata.com).

In the August 9, 2006 edition of *This Week in Petroleum*, EIA reported that total ULSD production progress has been good and that ULSD is currently being produced in all Petroleum Administration for Defense Districts (PADDs). Stocks of ULSD in the United States in January 2007 were approximately equal to distillate oil containing greater than 500 ppm sulfur. However on the East Coast, stocks of ULSD were approximately one-third the size of distillate oil stocks containing more than 500 ppm sulfur (EIA). Another independent source, The Marathon Petroleum Company, LLC, found that 90% of refineries in the continental United States that were included in a survey had designed units capable of producing ULSD. Also, Marathon determined that the planned US capacity for ULSD would be in excess of 2.5 million barrels per day in 2006 (Marathon Petroleum Corporation 2007).

Heating Oil Cost Increases

It is assumed that the costs for retrofitting refineries will be passed on to consumers. In its December 2005 study, NESCAUM estimated that the average price increment for the lower sulfur product (500 ppm) would be \$0.16 per gallon. In December 2005, this represented a 1% increase of the average oil price.

To update these costs we compared the costs of low-sulfur diesel fuel (15 – 500 ppm) with regular diesel fuel (2,000 ppm) for 2006. These data were gathered from DOE EIA Web site on March 8, 2007. We used the difference in diesel fuel prices because the cost for low sulfur heating oil is currently not reported and because diesel fuel and number 2 distillate are essentially the same product. It is therefore reasonable to assume that the cost differential between low sulfur and regular diesel fuel should reflect the potential cost differential between low sulfur and regular heating oil. All cost comparisons are before taxes. EIA only reports a low-sulfur diesel fuel category which includes both low sulfur (500 ppm) and ultra low sulfur diesel (15 ppm). For the first two months on 2007, EIA reports that stocks of 15 ppm sulfur oil were roughly twice that of 500 ppm sulfur oil. We averaged monthly costs to compute annual average costs for PADD 1A (CT, ME, MA, NH, RI, VT) and PADD 1B (DE, DC, MD, NJ, NY, PA) for low sulfur and regular diesel fuel from January to December 2006. For PADD 1A, the cost of low sulfur diesel fuel ranged from \$1.954 to \$2.433 per gallon and the cost of regular diesel fuel ranged from \$1.963 to \$2.429 per gallon. The monthly difference between low sulfur and regular diesel fuel ranged from -1.1 cents per gallon to 0.5 cents per gallon with an annual average of -0.8 cents per gallon. That is, low-sulfur diesel fuel was on average less expensive than regular diesel fuel in PADD 1A in 2006. Similarly in PADD 1B, the cost of low sulfur diesel fuel ranged from \$1.894 to \$2.358 per gallon and the cost of regular diesel fuel ranged

from \$1.894 to \$2.321 per gallon. The monthly difference between low sulfur and regular diesel fuel ranged from -1.3 cents per gallon to 4.7 cents per gallon with an annual average of 1.6 cents per gallon. In both regions fuel costs were highest in the summer and the difference in cost between low sulfur and regular diesel fuel was also highest in summer. To calculate an average cost differential, we weighed the PADD 1A and PADD 1B cost differentials by residential fuel use in each PADD for 2005 (the latest date data are available from EIA). In 2005, PADD 1A States used 1.9 million gallons and PADD 1B States used 2.5 million gallons. Therefore, on average low sulfur distillate oil would be expected cost 0.8 cents per gallon more than regular heating oil in MANE-VU States. This average price differential translates in to \$734/ton of sulfur removed if it assumed that the low sulfur diesel has a concentration of 500 ppm sulfur or \$554/ton of sulfur removed for ultra low 15 ppm sulfur diesel.

STAPPA-ALAPCO (2006) estimates that the annual fuel oil consumption per household is 865 gallons per year. Using the price differential data presented above, the average household would spend about \$7 per year additional on home heating costs by using low or ultra low sulfur fuel.

The use of LSD/ULSD will also result in cost savings to owners/operators of residential furnaces and boilers due to reduced maintenance costs. When the existing heating oil sulfur content is 2,000 ppm and 500 ppm sulfur is substituted, the service interval can be extended by a factor of three or more (e.g., cleaning at three year intervals rather than annually). Vacuums are used to remove deposition caused by SO₂ from furnaces and boilers.

The potential vacuum cleaning costs savings for the United States, for a starting fuel sulfur content of 2,000 ppm ranges from approximately \$200 million a year to \$390 million a year for service costs of \$50 to \$100 per hour. Therefore, if all oil heated homes switched to 500 ppm sulfur heating oil, more than \$200 million a year could be saved, which would significantly lower the overall operating costs of fuel oil marketers. Given the dominant share of the U.S. heating oil market represented by the Northeast States, a large percentage of the projected national benefits would accrue in the region (NESCAUM 2005). In a brochure distributed by EIA titled *Residential Heating Oil Prices: What Consumers Should Know*, EIA reports that 6.3 million of the 8.1 million households using heating oil in the United States (78%) are in the Northeast Region. This region includes the New England and Central Atlantic States.

Heating Oil Supply

EPA addressed the issue of using ULSD for heating oil purposes in its regulatory impact analysis for Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements (2000). EPA found that refiners in the Mid-Atlantic and Northeast (PADD 1) could produce more of this fuel and reduce the need for imports.

EIA reports that in 2004, 5,975,966,000 gallons of heating oil were sold in the United States. This decreased to 5,548,827,000 gallons in 2005. The EIA publishes weekly updates on the availability of heating oil. Information was retrieved for January 2007 and is summarized in Table 8.3 below.

**Table 8.3 Average January 2007 Distillate Stocks
 (Million Barrels)^a**

Location	15 ppm and Under Stocks	15 ppm -- 500 ppm Stocks	>500 ppm Stocks	Total Distillate Stocks
US (Total)	57.2	25.0	59.7	141.8
East Coast	14.7	21.9	44.5	66.5
Average Days of Supply of Distillate Fuel Oil ^b	34.4	34.4	34.4	34.4

^aSource for this information is the Energy Information Administration.

^bThe sulfur content of distillate stocks is not distinguished by the EIA for this data point.

The EIA also makes available information regarding the production and imports of heating oil. This information is summarized in Table 8.4, and includes specific data for the East Coast.

The information presented in Table 8.4 indicates that on a nationwide basis, more ULSD is produced than both LSD and high sulfur fuel. This is due to the predominant use of ULSD in highway diesel vehicles. This information also supports the conclusion that the United States has the infrastructure to produce adequate stocks of LSD and ULSD.

**Table 8.4 Distillate Production and Imports
 (Million Barrels per Day)^{a,b}**

Location	15 ppm and Under Production	15 ppm - 500 ppm Production	>500 ppm Production	Total Distillate Production
US	2.659	0.624	0.970	4.253
East Coast	0.248	0.024	0.277	0.549
Imports	0.204	0.018	0.115	0.392

^aSource for this information is the Energy Information Administration.

^bBased on the four week average ending January 12, 2007.

Currently, the 15 ppm fuel is sold for highway use diesel, whereas the >500 ppm stocks are sold for heating oil. The 15-500 ppm fuel can still be used until 2010 under the hardship provisions of the heavy duty highway diesel program (EPA 2004). Under these provisions of the heavy duty highway diesel program, if there is a shortage of 15 ppm fuel, the 15 -500 ppm fuel could be used to relieve the shortage. With this flexibility, the likelihood of a fuel shortage in the short term, due to usage of ULSD for heating oil is reduced.

Time Necessary for Compliance

Refiners in the United States are already producing low sulfur highway diesel fuel. This same fuel can be marketed as heating oil since it is the same refinery product as highway diesel except with dye added to the fuel to differentiate it for tax purposes. Some time may be required to

allow petroleum marketers to adjust to distributing ULSD to heating oil customers, however, the distribution network for motor fuels and heating oil are already in place.

NESCAUM (2005) estimated that during peak periods of demand, up to 20% of the required heating oil is imported. This analysis does not address whether offshore refineries should be able to produce 15 ppm sulfur for export to the Northeast United States. In case of a shortage of 15 ppm fuel during the transition period from LSD to ULSD, the heavy duty highway diesel program allows the use of 15-500 ppm sulfur fuel.

Existing residential furnaces and boilers do not need to be retrofitted or modified to combust 15 ppm sulfur. The capacity for producing LSD and ULSD already exists among US refiners. Consequently, the time necessary for compliance does not hinge on the heating oil furnace/boiler.

Energy and Non-Air Impacts

Reducing the sulfur contents of heating oil has a variety of beneficial consequences for residential furnaces and boilers. Low sulfur distillate fuel is cleaner burning and emits less particulate matter which reduces the rate of fouling of heating units substantially and permits longer time intervals between cleanings. According to a study conducted by the New York State Energy Research and Development Authority, (NYSERDA), boiler deposits are reduced by a factor of two by lowering the fuel sulfur content from 1,400 ppm to 500 ppm. These reductions in buildup of deposits result in longer service intervals between cleanings. (Batey and McDonald 2005). Batey and McDonald (2005) estimated that the potential cost savings from decreased vacuum cleanings ranges from \$200 million per year to \$390 million per year. The decreased deposits would also enable a more efficient transfer of heat, thereby reducing the fuel usage. Further reducing the heating oil sulfur from 500 to 15 ppm would increase the cost savings from decreased maintenance needs due to heat exchanger fouling.

The decreased sulfur levels would enable manufacturers to develop more efficient furnaces and boilers by using more advanced condensing furnaces and boilers. These boilers recoup energy that is normally lost to the heating of water vapor in the exhaust gases. Historically, the use of high sulfur fuels prevented this due to the corrosion of the furnace/boiler due to the creation of sulfuric acid in the exhaust gases. The increased efficiency results in a decrease in the amount of heating oil a heating unit uses, therefore, this would make a switch to lower sulfur heating oils more attractive and cost effective.

Remaining Useful Life of the Source

Residential furnaces and boilers have finite life times, but they do not need to be replaced to burn low or ultra low sulfur fuel. The Energy Research Center estimates that the average life expectancy of a residential heating oil furnace is approximately 18 years, and that the average life expectancy of a residential heating oil boiler is 20-25 years (Personal communication with Mr. John Batey, Energy Research Center on February 6, 2007).

Finally, the number of homes that are being heated with heating oil is declining by approximately 100,000/year (RedOrbit 2007). No geographical distribution was available for

this estimate, but since heating oil is predominantly used in the Northeast, most of the changes will be occurring there. Consequently, emissions from heating oil combustion will become less significant of a source of SO₂ emissions in the future.

REFERENCES

Batey, J.E. and R. McDonald, 2005. *Low Sulfur Home Heating Oil Demonstration Project Summary Report*. Project funded by The New York State Energy Research and Development Authority. Contract No. 6204-IABR-BR-00.

Energy Research Center. Personal communication on February 6, 2007 with Mr. John Batey and Mr. Bernd Haneke of MACTEC Federal Programs, Inc.

EPA, 2004. *Overview of EPA's Low Sulfur Diesel Fuel Programs*. Presented at the Ultra-Low Sulfur Diesel Fuel Implementation Workshop by the EPA's Office of Transportation and Air Quality, New Orleans, Louisiana, November 15, 2004.

Marathon Petroleum Company, LLC. Ultra Low Sulfur Diesel. PowerPoint Presentation downloaded from the World Wide Web on January 31, 2007 from:
<http://www.marathonpetroleum.com/>

NESCAUM, 2005. *Low Sulfur Heating Oil in the Northeast States: An Overview of Benefits, Costs and Implementation Issues*.

RedOrbit, 2007. *Refiners Have Many Options to Convert High-Aromatic Streams into ULSD*. Article downloaded from the World Wide Web on January 31, 2007 at: <http://www.redorbit.com>

STAPPA ALAPCO, 2006. *Controlling Fine Particulate Matter Under the Clean Air Act: A Menu of Options*.

US Energy Information Administration, August 9, 2006. *This Week in Petroleum*.

US Energy Information Administration, 2001. Brochure titled *Residential Heating Oil Prices: What Consumers Should Know*.

US Energy Information Administration, 2001. The Transition to Ultra-Low –Sulfur Diesel Fuel: Effects on Prices and Supply. Publication downloaded from the World Wide Web on January 31, 2007 at: www.eia.doe.gov/oiaf/servicerpt/ulsd

US Energy Information Administration, 2007. Information downloaded from the World Wide Web on March 8, 2007 at: http://tonto.eia.doe.gov/dnav/pet/pet_pri_dist_dcu_R1X_m.htm

US EPA, 2000. Regulatory Impact Analysis: *Heavy Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements*. EPA Publication Number EPA420-R-00-026.

CHAPTER 9

RESIDENTIAL WOOD COMBUSTION

BACKGROUND

The MANE-VU Contribution Assessment and other MANE-VU reports have documented that visibility impairment in this region is primarily due to regional secondary sulfate. However, in the MANE-VU Class I areas, biomass combustion also has been identified as a contributor to visibility impairment. Biomass combustion emissions due to human activity primarily derive from residential wood combustion. While some biomass burning occurs throughout the year, residential wood combustion occurs predominantly in the winter months, potentially contributing to wintertime peaks in PM concentrations.

In the document, *Control Analysis and Documentation for Residential Wood Combustion in the MANE-VU Region*, OMNI Environmental Services, Inc. (OMNI) conducted a control analysis and documentation of residential wood combustion (RWC) in the 11 States and the District of Columbia that make up the MANE-VU region. Information for the OMNI analysis was obtained from: (1) The MANE-VU Residential Wood Combustion Emission Inventory published by MARAMA (July 2004 report), (2) Residential Energy Consumption Surveys published by the EIA, (3) the National Emission Inventory published by the EPA, (4) Simmons Marketing Research reports, and (5) American Housing Surveys for the United States published by the U.S. Department of Commerce and the U.S. Department of Housing and Urban Development. In addition, the results of three RWC surveys at the State-level have been published in the last decade for the Mid-Atlantic and New England area, which allow for comparison of data extrapolated from the national- and regional-scale surveys to the State level for three States. These were the: (1) 1995 Delaware Fuelwood Survey, (2) Residential Fuelwood Use in Maine, Results of 1998/1999 Fuelwood Survey, and (3) Vermont Residential Fuel Wood Assessment for 1997-1998.

To facilitate understanding of the cost effectiveness analyses done by OMNI, descriptions of the various appliances used, as well as a brief discussion of efficiency, are provided from the OMNI report.

Cordwood-Fired Stoves and Fireplace Inserts

Uncertified, certified catalytic, and certified non-catalytic cordwood stoves and fireplace inserts together are considered cordwood heaters. They are designed to burn bulk cordwood and are room space heaters, i.e., they primarily rely on radiant and convection heat transfer, in contrast to centralized heating systems such as warm-air furnaces or boilers which utilize heat distribution systems to heat multiple rooms. Fireplace inserts are essentially wood stoves that are designed to be inserted into an existing fireplace cavity. Because of the heat transfer shielding effect of the fireplace cavity and the fact the majority of existing fireplace chimneys are against an outside wall, their heating efficiency is less than a similar freestanding woodstove. Many fireplace inserts have fans to facilitate transfer of heat from the portion that is inside the fireplace cavity. Both freestanding cordwood stoves and fireplace inserts rely on a natural draft using room air for combustion and the venting of exhaust through the chimney to the atmosphere. Though the

majority of cordwood heaters use room air for combustion, some insert installations, such as in mobile homes, require the use of outside air for combustion.

Uncertified Conventional Cordwood-Fired Stoves and Fireplace Inserts

Uncertified cordwood fired stoves and fireplace inserts include units manufactured before the 40 CFR Part 60, Subpart AAA New Source Performance Standard (NSPS) July 1, 1990 certification requirement, and currently or recently manufactured exempt units which operate similarly to some old pre-EPA certification units.

NSPS Certified Catalytic Cordwood-Fired Stoves and Fireplace Inserts

Certified catalytic units pass the exhaust through a catalyst to achieve emission reductions. Generally, a coated ceramic honeycomb catalyst is located inside the stove where the incompletely combusted gases and particles ignite and are combusted further, thus reducing air emissions and increasing combustion overall efficiency.

NSPS Certified Non-Catalytic Cordwood-Fired Stoves and Fireplace Inserts

Certified non-catalytic stoves and fireplace inserts rely on design features to reduce air emission and increase efficiency. They generally rely on the introduction of heated secondary air to improve combustion, as well as firebox insulation, and baffles to produce a longer, hotter gas flow path, as well as other design features to achieve low emissions and higher efficiency.

Pellet Stoves and Fireplace Inserts

Analogous to cordwood stoves and fireplace inserts, pellet stoves and fireplace inserts are considered room heaters. They burn pellets generally made from sawdust, although there has been, and continues to be, research into utilizing other biomass fuels to make pellets. Combustion air is drawn from the room for most models, and exhaust is vented outdoors. Some pellet appliances use outside air for combustion. Pellet stoves and inserts require the use of electric motors to power the combustion air and heat transfer fans and the pellet-feeding auger. Modern pellet units use electronic sensors and controls. Pellets are introduced into the hopper, and the auger continuously feeds a consistent amount of pellets into the firebox. The feed rate is controlled electronically by a feed rate setting selected by the user. There are two basic designs: bottom-feed and top-feed models. Pellet units have a high efficiency and low emissions due to the use of the electric auger and fan that produce uniform and controlled combustion conditions. Some units are certified by the NSPS process and some are not. The performance of the certified and uncertified models are similar. What is considered by most as a “loop-hole” in the NSPS regulations essentially allows certification to be bypassed.

Wood-burning Fireplaces without Inserts

Fireplaces without inserts include manufactured units (often referred to as “zero-clearance” fireplaces) and site-built masonry units operated both with and without glass doors. Combustion air is drawn from the natural draft created by fire, and that same draft vents the exhaust gases through the chimney. Fireplaces without inserts have low efficiencies due to the large amount of heated room air that is exhausted out of the chimney from the draft. Many fireplaces without inserts are not used in a given year, some are used for aesthetic purposes and some are used for

heating. Those that are used for heating are almost always used for secondary heating purposes and not primary heating due to their low efficiency and lack of heat transfer capabilities. Manufactured wax/fiber firelogs are often used as a fuel in them with about 30% of fireplace users nationwide claiming that they use wax/fiber firelogs some of the time. Most fireplaces are wall-mounted, however, this category also includes some free-standing models.

Direct Vent Gas Stoves and Fireplace Inserts (LPG and Natural Gas)

Direct vent gas stoves and inserts are sealed units that draw their combustion air from, and vent their exhaust to, the outside air. Venting can be extended vertically or horizontally out of the home. A common type of venting is coaxial, which has the exhaust pipe contained within the air inlet pipe, so the temperature of the combustion air is raised, and the temperature of the exhaust is lowered, creating more efficient combustion. It should be noted that natural gas is not readily available in all locations, however LPG may be available for use.

Vent-Free Gas Stoves and Fireplace Inserts (LPG and Natural Gas)

Vent-free gas stoves and inserts receive their combustion air from the room in which the unit is placed, and all of the products of combustion are exhausted into the room as well. The high efficiency of vent free units is due to the fact that the heat produced is kept in the room. Vent free gas stoves and inserts have a maximum heat input in order to avoid emitting excess CO, CO₂, or NO_x into the room, and the units also have an O₂ depletion sensor or other device to shut the unit down if oxygen levels become too low. It is important to note that vent-free natural gas and LPG stoves, inserts and log sets should not be considered options for primary or even significant secondary heating use. There is considerable concern regarding indoor air quality and damage to homes by moisture created from their use, as combustion gases are not vented to the atmosphere. If the devices are used prudently, these problems are reduced. Their appropriate role is for aesthetics and minor secondary heating. Just as with direct vent gas stoves and fireplace inserts, LPG can be used as an alternative where natural gas is not readily available.

B-Vent Gas Stoves and Fireplace Inserts (LPG and Natural Gas)

B-vent gas stoves and inserts draw their combustion air from the room, and exhaust is vented outdoors. These units use a draft hood for the proper venting of exhaust. B-vent gas stoves and inserts have lower efficiency than direct vent due to the fact that already heated room air is used as combustion air, which is then exhausted to the outdoors, taking heat away from the room.

OMNI Study Summary

In the OMNI study, the amount of fuel consumed by RWC devices was considered the measure of activity. Activity data were provided by individual appliance type by State and for the total MANE-VU region. The activity study conducted by OMNI showed that there were approximately 6.4 million tons of fuel burned in 2002 by RWC devices in the MANE-VU region. The majority of RWC combustion was located in New York (1.9 million tons of fuel burned) and Pennsylvania (1.4 million tons of fuel burned).

OMNI then compiled an emissions inventory by county, by State, and for the entire MANE-VU region for the 2002 base year. The dry mass of fuel (activity) for cordwood, pellets, and manufactured wax/fiber firelogs compiled in the activity task was multiplied by the applicable emission factor in the units of mass air pollutant per mass of dry fuel. The emission factors were obtained by reviewing and averaging (if multiple sources were available) data obtained from available reports and publications. PM and VOC (an ozone precursor) are the main criteria pollutants of concern for RWC and non attainment areas. The OMNI emissions inventory reported that there were 92,470 tons of total PM emissions and 87,741 tons of VOC generated from RWC devices in the MANE-VU region during the base year (2002). It should be noted that this analysis assumed that PM_{10} was equivalent to PM. The only emissions control efficiency, and control device information available is for PM_{10} . We have therefore assumed that data for PM_{10} are applicable to $PM_{2.5}$.

Table 9.1 from the OMNI report summarizes measures for RWC RACM developed by EPA in EPA-450/2-89-015. OMNI reported the RACM fall in three primary categories: (1) improvement of performance, (2) reducing the use of RWC devices, and (3) episodic curtailment. The effectiveness in reducing RWC emissions and a related discussion of each of the various activities are also provided in Table 9.1. In addition to the three primary categories for RWC RACM, the RACM document emphasizes the importance of public awareness in many RWC emission control programs and provides considerable information on the subject.

Table 9.1 Summary of Measures Available for RWC RACM – PM₁₀

Program Elements	Estimated Effectiveness (%)	Discussion
IMPROVEMENT OF PERFORMANCE		
State implementation of NSPS	0	States are not expected to adopt this program element at levels that would affect program effectiveness significantly.
Ban on resale of uncertified devices	0	No credit recognized because requirement is largely unenforceable: other elements will be required to include disabling of retired used devices.
Installer Training Certification or Inspection Program	~ 5	Reduction in emissions from each new certified RWC device where either the installer is trained/certified or the installation is inspected.
Pellet stoves	90	Reduction in emissions from each new or existing conventional, uncertified RWC device replaced with a pellet stove.
	75	Reduction in emissions from each new or existing Phase II EPA certified RWC device replaced with a pellet stove.
EPA Phase II certified RWC devices	~50	Reduction in emissions from each new or existing conventional, uncertified RWC device replaced with an EPA Phase II certified RWC device.
Retrofit requirement	<5	Reduction in emissions from each existing conventional, uncertified RWC device equipped with a retrofit catalyst or pellet hopper (to maximum when all existing uncertified RWC devices have retrofit devices installed).
Accelerated changeover requirement	~50	Reduction in emissions from each existing conventional, uncertified RWC device replaced with Phase II certified device.
	100	Reduction in emissions from each existing conventional, uncertified RWC device removed and not replaced: requires existing device to be disabled and not resold.
Accelerated changeover inducement	~50	Reduction in emissions from each existing conventional, uncertified RWC device replaced with Phase II certified device.
	100	Reduction in emissions from each existing conventional, uncertified RWC device removed and not replaced: requires existing device to be disabled and not resold.

Table 9.1 Summary of Measures Available for RWC RACM – PM₁₀

Program Elements	Estimated Effectiveness (%)	Discussion
Require fireplace inserts	0	No credit recognized for fireplace inserts, since inserts change use of fireplace from aesthetic to primary heat source, resulting in an increase in amount of wood combusted and higher overall emissions.
Wood moisture	<5	Reduction in total emissions from all RWC devices in the community/airshed.
Trash burning prohibition	0	No credit recognized for eliminating trash burning in RWC devices.
Weatherization of residences	<5	Reduction in total emissions from all RWC devices in the community/airshed.
Opacity limits	<5	Reduction in total emissions from all RWC devices in the community/airshed.
REDUCING USE OF RWC DEVICES		
Availability of alternative fuels	100	Reduction in emissions from each RWC device removed from service and replaced with device using natural gas: recognize no more than 10% of RWC devices replaced under program with no additional incentives.
Emission trading	Computation required	For a 2:1 trading ratio, the reduction in emissions from each new stove would be calculated as the difference between emissions of a new RWC device and 2 times the average emissions per stove in the community: multiplier would change for other trading ratios.
Taxes on RWC devices	Variable	Emission reduction credit would vary with utility or tax rate structure adopted and extent to which this structure resulted in reduction in number of RWC devices in the community versus reduction in use of RWC devices.
Regulatory ban on RWC devices in new dwellings	100	Reduction in emissions from new RWC devices purchased for installation in new dwellings.
Regulatory ban on existing RWC devices	100	Reduction in emissions from each RWC device removed.

Table 9.1 Summary of Measures Available for RWC RACM – PM₁₀

Program Elements	Estimated Effectiveness (%)	Discussion
EPISODIC CURTAILMENT		
Voluntary	10	Reduction in emissions for all RWC devices not exempted.
Mandatory	60% fireplace 50% woodstoves	Reduction in emissions for all RWC devices not exempted.

Table Reference: U.S. EPA, 1992, *Technical Information Document for Residential Wood Combustion Best Available Control Measures*, Research Triangle Park, NC, EPA-450/2-92-002.

Table 9.2 from the OMNI report summarizes measures for RWC BACM developed by EPA in EPA-450/2-92-002. As shown in Table 9.2, the BACM fall into two primary categories: (1) integral measures which are necessary for the success of a long-term RWC pollutant reduction programs but, by themselves, are not adequate to provide long-term reductions and (2) flexible (long-term) measures to reduce, eliminate, or prevent increases in pollutant emissions for existing and/or new installations. With the exceptions of the device and upgrade offsets, the specific elements of the BACM are essentially those described in the RACM document with the various efficiencies listed in Table 9.1 being applicable.

Table 9.2 Summary of Measures Available for RWC BACM – PM₁₀

Integral Measures¹	Flexible Measures that Reduce or Eliminate Emissions from Existing Installations²	Flexible Measures that Reduce Emissions or Prevent Emission Increases from New Installations²	Flexible Measures that Reduce Emissions from New and Existing Installations²
1. Public awareness and education.	1. Conversion of existing wood-burning fireplaces to gas logs.	1. Gas fireplaces or gas logs in new wood burning fireplace installations.	1. Device offset. ⁴
2. Mandatory curtailment during predicted periods of high PM ₁₀ concentrations.	2. Changeover to EPA certified, Phase II stoves or equivalent.	2. Upgrade offset. ⁴	2. Upgrade offset. ⁴
3. All new stove installations EPA-certified, Phase II stoves or equivalent.	3. Changeover to low emitting device. ³	3. Restriction on number and density of new wood-burning stove and/or fireplace installations.	

Table 9.2 Summary of Measures Available for RWC BACM – PM₁₀

Integral Measures¹	Flexible Measures that Reduce or Eliminate Emissions from Existing Installations²	Flexible Measures that Reduce Emissions or Prevent Emission Increases from New Installations²	Flexible Measures that Reduce Emissions from New and Existing Installations²
4. Measures to improve wood burning performance: -control of wood moisture content -weatherization of homes with wood stoves -educational opacity program		4. Requirement that new stove installations be low emitting.	

¹ Integral measures are regarded as critical for the success of a RWC control program, but by themselves are not intended to result in long-term attainment of the PM₁₀ NAAQS for serious PM₁₀ nonattainment areas.

² Flexible measures are designed for permanent control of RWC emissions and thus long-term attainment of the PM₁₀ NAAQS.

³ This measure is virtually identical to item 2, except that the changeover is recommended to a “low-emitting” device that can document “in-home” field test emissions less than the emission factor averages of “in-home” field test emissions data for EPA-certified stoves. This can include classes of devices that are demonstrated to be capable as a class of producing lower field emissions, as well as, specific model units that perform better in the field than the class collectively (an example might include masonry heaters, uncertified pellet-fueled devices, and wood fired gasification centralized heating systems).

⁴ Offsets are intended to achieve emission reductions, when retiring (device offset) or changing-out (upgrade offset) conventional stoves, greater than the emissions increase resulting from new stove installations.

Table Reference: U.S. EPA, 1992, *Technical Information Document for Residential Wood Combustion Best Available Control Measures*, Research Triangle Park, NC, EPA-450/2-92-002.

OMNI reported that the RWC RACM and BACM have been the basis for PM₁₀ innovative strategies implemented in various western States and in local jurisdictions and have also been, in large part, the basis for a number of western State and their local RWC regulations. As part of these strategies, strict particulate emission standards have been developed which will take effect in 2008.

The OMNI report states that the Washington State standard is notable among State and local regulations for residential wood burning devices. Washington State has implemented more stringent standards for residential wood burning devices, so devices installed in Washington State must be certified to the more stringent standard. This has affected the stove market because many U.S. certified stove manufacturers choose to have their appliances certified to the more stringent Washington State standard, unless the manufacturer can not or does not choose to test to the tighter standard. Discussions with EPA indicate that most manufacturers are choosing to design and sell units that meet the Washington State standards of 4.5 g/hr for non catalytic wood stoves and 2.5 g/hr for catalytic wood stoves (personal communication with Mr. John Dupree of the U.S. EPA).

FOUR FACTOR ANALYSIS OF POTENTIAL CONTROL SCENARIOS FOR RESIDENTIAL WOOD COMBUSTION

Cost of Compliance

OMNI analyzed the cost effectiveness of five categories of widely existing, older technology wood-burning devices. These are: (1) freestanding cordwood stoves, (2) cordwood-fueled fireplace inserts, (3) cordwood fireplaces (without inserts) used for heating purposes, (4) centralized cordwood heating systems and (5) cordwood fireplaces used for aesthetic purposes. Table 9.3 lists these five categories with the available, improved technology replacement, installation scenarios, and fuel switching alternatives that would reduce particulate and VOC emissions.

OMNI noted that wood resources are abundant and widely utilized as fuel, and heating is essential due to the climate of the region. The cost to households of any regulatory program mandating acceptable heating practices is an important consideration. Likewise, the cost to households of any voluntary program is paramount for its success. The cost effectiveness of all reasonable scenarios for the replacement, modification or alternative fuel use for older existing, high emission wood-burning appliances was provided in the OMNI report for regulators and policy makers charged with the task of specifically lowering particulate and VOC emissions from residential wood combustion.

The tables provided in this chapter based on the OMNI report allow for a direct comparison of the cost burden for each realistic mitigation option that would be shouldered by residential users. As an example, for an average resident in the MANE-VU region with an existing older technology centralized cordwood heating system, the best current option in terms of cost among the pellet, natural gas, and LPG options, is natural gas (assuming natural gas is available). Similarly, for wood-burning fireplaces used for aesthetics, manufactured wax/fiber firelogs offer the lowest cost per unit mass of air pollutant reduction. The cost effectiveness of each option is dependent on the costs of the new equipment and the cost of required fuels. The costs presented in the tables in this chapter were the most current information available as of the date of the OMNI report.

Estimates of costs per ton of reductions in the tables in this chapter are specific to the MANE-VU region because they reflect the estimated usage of various devices in this region.

Table 9.3 Improved Technologies and Fuel Alternatives

Existing Cordwood Device	High Technology Replacement, Installation or Alternative Fuel
Uncertified Freestanding Cordwood Stove	Replacement with Certified NSPS Non-Catalytic Cordwood Stove
	Replacement with Certified NSPS Catalytic Cordwood Stove
	Replacement with Pellet Stove
	Replacement with Gas Stove – natural gas (B vent, direct vent)
	Replacement with Gas Stove – LPG (B vent, direct vent)
Uncertified Cordwood Fireplace Insert	Replacement with Certified NSPS Non-Catalytic Cordwood Insert
	Replacement with Certified NSPS Catalytic Cordwood
	Replacement with Pellet Insert
	Replacement with Gas Insert – natural gas (B vent, direct vent)
	Replacement with Gas Insert – LPG (B vent, direct vent)
Cordwood Fireplace without Insert Used for Heating	Installation of Certified NSPS Non-Catalytic Cordwood Insert
	Installation of Certified NSPS Catalytic Cordwood Insert
	Installation of Pellet Insert
	Installation of Gas Insert – natural gas (B-vent, direct vent)
	Installation of Gas Insert – LPG (B-vent, direct vent)
Cordwood Fireplace Used for Aesthetic Purposes	Installation of Gas Log Set – natural gas (vented and vent free)
	Installation of Gas Lo g Set – LPG (vented and vent free)
	Wax/Fiber Firelog Fuel
Centralized Cordwood Heating System	Pellet Furnace or Boiler
	Gas Furnace or Boiler – natural gas
	Gas Furnace or Boiler – LPG

Table 9.4 from the OMNI report demonstrates the cost effectiveness of replacing three types of cordwood stoves and fireplaces with devices that emit less PM. Table 9.5 from the OMNI report demonstrates the impact on cost effectiveness of the same replacements on VOC reductions. The cost effectiveness tables are in reference to the replacement of an existing RWC device, and do not include new construction.

In Tables 9.4 and 9.5, if the total annual cost of the improved technology and alternative fuel replacement or installation is less than the total annual cost of the existing device, and there is corresponding pollutant reduction after installation or replacement, then there is no cost for the pollution reduction, and the cell is marked as “**”. The replacement options for which there is no cost may actually represent cost savings, and thus are the most cost effective options for replacement.

Table 9.4 PM Reduction Cost Effectiveness for Replacement of Existing Uncertified Freestanding Cordwood Stove/Insert and Cordwood Fireplace w/o Insert for Heating

Existing Cordwood Device	Certified NSPS Non-Catalytic Cordwood Stove	Certified NSPS Catalytic Cordwood Stove	Pellet Stove	Gas Stove-NG, B Vent	Gas Stove-NG, Direct Vent	Gas Stove-LPG, B Vent	Gas Stove-LPG, Direct Vent
PM Reduction Cost Effectiveness (\$/ton)							
Uncertified Freestanding Cordwood Stove	1,170	3,300	8,960	5,350	3,530	12,600	9,760
Uncertified Cordwood Fireplace Insert	**	**	5,180	1,910	**	8,980	6,040
Cordwood Fireplace w/o Insert for Heating	3,880	5,670	8,330	**	**	1,880	695

OMNI Environmental Services, Inc. *Task 6, Technical Memorandum 4 (Final Report), Control Analysis and Documentation for Residential Wood Combustion in the MANE-VU Region*. Project funded by Mid-Atlantic Regional Air Management Association, Inc., December 19, 2006.

**No cost for the pollution reduction.

Tables 9.4 and 9.5 indicate that OMNI estimated that in the MANE-VU region there are several options for reducing emissions from two of the above types of fireplaces that would reduce emissions at essentially no cost, due to fuel cost savings.

Table 9.5 VOC Reduction Cost Effectiveness for Replacement of Existing Uncertified Freestanding Cordwood Stove/Insert and Cordwood Fireplace w/o Insert for Heating

Existing Cordwood Device	Certified NSPS Non-Catalytic Cordwood Stove	Certified NSPS Catalytic Cordwood Stove	Pellet Stove	Gas Stove-NG, B Vent	Gas Stove-NG, Direct Vent	Gas Stove-LPG, B Vent	Gas Stove-LPG, Direct Vent
VOC Reduction Cost Effectiveness (\$/ton)							
Uncertified Freestanding Cordwood Stove	1,260	2,960	7,740	4,940	3,260	11,800	9,130
Uncertified Cordwood Fireplace Insert	**	**	4,480	1,760	**	8,410	5,640
Cordwood Fireplace w/o Insert for Heating	7,900	10,400	13,200	**	**	3,090	1,140

OMNI Environmental Services, Inc. *Task 6, Technical Memorandum 4 (Final Report), Control Analysis and Documentation for Residential Wood Combustion in the MANE-VU Region.* Project funded by Mid-Atlantic Regional Air Management Association, Inc., December 19, 2006.

**No cost for the pollution reduction.

Table 9.6 presents the cost effectiveness in terms of dollars per ton of PM reduction and VOC reduction for replacement of an existing centralized cordwood heating system with three available technologies. The cost effectiveness tables are in reference to the replacement of an existing RWC device, and do not include new construction. The most cost effective option is replacing the existing system with a natural gas furnace or boiler. This option is not feasible in areas that do not have access to natural gas, and the increase in costs associated with using LPG is significant.

Table 9.6 Reduction Cost Effectiveness for the Replacement of an Existing Centralized Cordwood Heating System

High Technology Replacement, Installation or Alternative Fuel	PM Reduction Cost Effectiveness (\$/ton)	VOC Reduction Cost Effectiveness (\$/ton)
Pellet Furnaces and Boilers	7,810	17,200
Gas Furnaces and Boilers–Natural Gas	3,030	7,150
Gas Furnaces and Boilers-LPG	9,370	23,100

OMNI Environmental Services, Inc. *Task 6, Technical Memorandum 4 (Final Report), Control Analysis and Documentation for Residential Wood Combustion in the MANE-VU Region.* Project funded by Mid-Atlantic Regional Air Management Association, Inc., December 19, 2006.

Table 9.7 presents the cost effectiveness in terms of dollars per ton of PM reduction and VOC reduction for the addition of a gas log set or use of wax/fiber firelogs in an existing fireplace with

no insert. Burning wax/fiber firelogs in the existing fireplace is, by far, the most cost effective option for reducing emissions of PM and VOC.

Table 9.7 Pollutant Reduction Cost Effectiveness for the Addition of a Gas Log Set or Use of Wax/Fiber Firelogs in an Existing Fireplace w/o Insert Used for Aesthetics

Pollutant	Pollutant Reduction Cost Effectiveness (\$/ton)				
	Vent-Free Gas Log Set-NG	Vented Gas Log Set-NG	Vent-Free Gas Log Set-LPG	Vented Gas Log-LPG	Wax/Fiber Firelog Fuel
PM	27,100	29,900	29,400	34,100	2,530
VOC	43,900	48,500	48,300	56,600	5,110

OMNI Environmental Services, Inc. *Task 6, Technical Memorandum 4 (Final Report), Control Analysis and Documentation for Residential Wood Combustion in the MANE-VU Region*. Project funded by Mid-Atlantic Regional Air Management Association, Inc., December 19, 2006.

OMNI presented no cost-effectiveness summary for other RWC control measures such as described in EPA's PM₁₀ RACM/BACM guideline documents. Costs associated with these measures are predominantly organizational and administrative associated with the implementation of regulations.

Time Necessary For Compliance

Because the control methods discussed in the previous section for RWC are existing technology, the time necessary for compliance would depend on the amount of time it would take to regulate the sources and establish compliance deadlines. The *Feasibility Assessment of a Change-out/Education Program for Residential Wood Combustion* from the Canadian Council of Ministers of the Environment suggests a phased approach for national implementation. A phased approach will enable the program to evolve over time and benefit from lessons learned in the early stages of the program. Phasing also reflects the reality that building awareness and changing behavior is a long-term investment. The approach that this report proposed had two phases. The first phase (2005-2006) focused on building a base for support and understanding around RWC in a single province. The second phase (2007 and beyond) and full roll-out involved the realization of independent, arms length management of public education and outreach by all stakeholders throughout Canada. The main steps for this phase included:

- Implementation of national regulation as soon as possible (i.e. 2008-2009);
- Full operational capacity across Canada;
- Funding to come from multiple sources (i.e. nationwide partnerships with the insurance, financial, and utilities industries);
- Movement of various groups from being target audiences to becoming key players in designing and delivering woodstove change-out/public education campaigns; and
- Multi-stakeholder involvement and shared leadership (governments together with business and industry, communities, and non-governmental organizations).

Energy and Non-Air Impacts

Other factors beyond PM_{2.5} and regional haze (i.e., VOC and fine particles) should also influence RWC regulatory policy. The greenhouse gas benefits of biomass combustion and the minimal acid gas emissions (acid precipitation impacts) from wood combustion are strong environmental advantages. Further, the fact that wood is a domestic renewable energy source and the fact that the cost of natural gas, propane, and fuel oil have a history of rising together have been responsible for the increase in the use of RWC. For example, several States are encouraging the use of renewable energy sources such as wood for heating purposes.

The Canadian Council of Ministers of the Environment study estimated that the increase in combustion efficiency associated with a switch out to a more efficient stove would save on average more than one cord of wood per stove per heating season.

Any mandatory change out program should be mindful that even with assistance, woodstove change out programs will impact families that are least able to bear the burden of additional costs. Voluntary programs do not impose this economic burden on families less able to bear associated costs.

Remaining Useful Life Of The Source

From information obtained from a scoping study that was prepared for Environment Canada in 1997, (Gulland Associates Inc., 1997) the durability of low emission stoves has improved considerably. Premature stove degradation is not viewed as a problem. In most new stoves today, vulnerable parts can be replaced, and manufacturers now use more heat-resistant materials such as ceramics and stainless steel. The performance and durability of catalytic stoves has also improved through better design and use of materials. The useful life of a wood stove catalytic element is estimated to be 9,000 to 12,000 hours, or three to five years of use, depending on heating demand, user skill, and degree of maintenance provided.

The best mechanism by which to lower smoke emissions from residential wood burning appliances is to replace conventional equipment with certified low emission stoves. Given the minimum useful life span of a wood stove of 10-15 years (per industry references), over which time the incremental cost of advanced technologies is spread, the cost impacts did not seem unreasonable to Environment Canada. It is also possible that the price of the least expensive advanced technology stove would come down after a regulation were established as manufacturers seek to fill the low cost market niche formerly filled by conventional stoves; that is, plain, unadorned styling and lacking additional features such as ash pan and large glass door panel. (Gulland Associates Inc., 1997) Many woodstove manufacturers have chosen to manufacture products at a reasonable cost that meet more stringent emissions standards such as those in Washington State (personal communication with Mr. John Dupree of EPA). Implementation of stricter emissions standards in additional states or regions will likely increase the competition to produce these woodstoves at even more reasonable prices.

REFERENCES

OMNI Environmental Services, Inc. *Task 6, Technical Memorandum 4 (Final Report), Control Analysis and Documentation for Residential Wood Combustion in the MANE-VU Region*. Project funded by Mid-Atlantic Regional Air Management Association, Inc., December 19, 2006.

Headquarters, U.S. EPA. Personal communication regarding the number of new residential wood burning devices meeting the Washington State standards from Mr. John Dupree (202) 564-5950, (Dupree.john@epa.gov) via telephone on April 12, 2007.

U.S. EPA, 1989, *Guideline Series, Guidance Document for Residential Wood Combustion Emission Control Measures*, Research Triangle Park, NC, EPA-450/2-89-015.

U.S. EPA, 1992, *Technical Information Document for Residential Wood Combustion Best Available Control Measures*, Research Triangle Park, NC, EPA-450/2-92-002.

U.S. EPA, 1993, *PM-10 Innovative Strategies: A Sourcebook for PM-10 Control Programs*, Research Triangle Park, NC, EPA-452/R-93-016.

The Canadian Centre for Pollution Prevention, CULLBRIDG Marketing and Communications and Action-Environment, *Feasibility Assessment of a Change-out/Education Program for Residential Wood Combustion, A Step-by-Step Approach to a National Program Aimed at Reducing Emissions from Residential Wood Combustion*. September 20, 2004.

Gulland Associates Inc., *Scoping Study: Reducing Smoke Emissions From Home Heating With Wood*. Prepared for Environment Canada, March 31, 1997.

Environment Australia (2002). *Technical Report No. 4: Review of Literature on Residential Firewood Use, Wood-Smoke and Air Toxics*. 49p. Report available on the Environment Australia website
[http://ea.gov.au/atmosphere/airtoxics/report 4/exec-summary.html](http://ea.gov.au/atmosphere/airtoxics/report%204/exec-summary.html).

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CHAPTER 10

RESIDENTIAL WOOD COMBUSTION - OUTDOOR WOOD-FIRED BOILERS

BACKGROUND

Outdoor wood-fired boilers are used in the Northeast United States, and their use is increasing as more traditional heating fuels (heating oil, natural gas) are becoming more expensive. NESCAUM (2007) estimates that the sale of outdoor wood-fired boilers is increasing by 25-50% annually. Nationwide there are between 155,000 and 200,000 boilers in service (Personal communication with Lisa Rector, NESCAUM). If the sales trends continue, NESCAUM estimates that there may be up to 500,000 boilers nationally by 2010.

Outdoor wood-fired boilers are used for heating and providing hot water for both individual homes and for “mini-district heating” (Woodheat.org 2007). Additional uses of outdoor wood-fired boilers include heating swimming pools and greenhouses. Outdoor wood-fired boilers are typically located in sheds that are located near buildings. Heated water is conveyed through underground or insulated pipes.

Even though outdoor wood-fired boilers may be economical solutions to home heating and hot water production, they contribute significantly to air pollution. Outdoor boilers emit so much smoke they have been banned by some local jurisdictions (Woodheat.org 2007). NESCAUM (2007) estimates that the average fine particulate emissions from one outdoor wood-fired boiler are equivalent to the emissions from 22 US Environmental Protection Agency (EPA) certified wood stoves, 205 oil-fired furnaces, or 8,000 natural gas-fired furnaces.

On the basis of heat input, NESCAUM (2007) estimated that outdoor wood-fired boilers emit from 1.5 to 3.1 pounds of PM per MMBTU heat input. This information was calculated by NESCAUM using data from tests conducted on outdoor wood-fired boilers for EPA (EPA 1998a). (Guldberg 2007) used data from 56 outdoor wood-fired boilers tests conducted by EPA in 1995 and 1999, and estimated that outdoor wood-fired boilers emit 1.44 pounds of PM per MMBTU heat input. In comparison, the EPA estimate (EPA 1998b) for PM from residential fuel oil combustion is 0.4 pounds of PM per thousand gallons of fuel combusted. Assuming a heating value of 140 MMBTU per thousand gallons of fuel oil, the PM emission factor is 0.003 pounds of PM per MMBTU heat input for residential fuel oil combustion. Similarly, for residential natural gas combustion, (EPA 1998c) assuming a natural gas heating value of 1,020 BTU per standard cubic foot, the PM emission factor is 0.002 pounds per MMBTU heat input. Based on these emission factor estimates, and strictly on the basis of heat input, outdoor wood-fired boilers emit roughly 500 times as much PM as oil-fired residential furnaces and 750 times as much PM as natural gas-fired residential furnaces based on the low-range estimate of PM emissions from outdoor wood-fired boilers. Based on the upper range of the PM emissions estimate from outdoor wood-fired boilers, they emit roughly 1,000 times as much PM as oil-fired residential furnaces and 1,500 times as much PM as natural gas-fired furnaces.

Heavy emissions from outdoor wood-fired boilers can be attributed to their designs. For example, most outdoor wood-fired boilers have fireboxes that are surrounded by a water jacket. The water jacket makes complete combustion of the wood nearly impossible due to the cooling

effect that the jacket has on the firebox. The flaming combustion of wood cannot occur below about 540 C (1,000 F), so the steel surfaces of the water jacket backed up by water at approximately 65 C (150 F) chill and quench the flames well before complete combustion can occur.

In addition outdoor wood-fired boilers smoke heavily due to their cyclical operating pattern. When the temperature of the water within the boiler falls below a set point, its combustion air damper opens and/or a small fan forces combustion air into the firebox. Once the water is heated back to the upper set point, the fan is turned off and/or the combustion air damper closes. During the off cycles the fire smolders and much of the smoke condenses as creosote on the cold steel internal surfaces. When the thermostat again calls for heat and incoming combustion air rekindles the fire, the heat ignites the creosote clinging to the boiler walls. This leads to an increase in emissions that accompanies the poor combustion in the firebox.

Outdoor wood-fired boilers are also sometimes not sized appropriately for the house that they are intended to heat. For example, an oversized boiler will tend to run in the smoldering phase longer than in the full out burn phase, thereby producing more smoke.

It has been suggested that excessive production of emissions by outdoor wood-fired boilers is associated improper installation of the boiler or the use of fuels not designed to be combusted in the boiler (personal communication with Peter Guldberg, Tech Environmental). Additionally, Guldberg, 2007 suggests that emissions from outdoor wood-fired boilers are comparable to other wood-fired combustion devices in terms of lbs/MMBTU heat generated. In any case, Guldberg, 2007 indicates that outdoor wood-fired boiler manufacturers have worked with EPA to develop a voluntary Outdoor Wood-fired Heater Program with a Phase I emission target of 0.6 lb/MMBTU. According to Guldberg, 2007 manufacturers will offer the outdoor wood-fired heaters qualified to achieve the Phase I standard later in 2007.

NESCAUM's Model Rule

On January 29, 2007, NESCAUM made available its "Outdoor Hydronic Heater Model Regulation." The model rule is designed to serve as a template to assist State and local agencies in adopting requirements that will reduce air pollution from outdoor wood-fired boilers. The model rule was developed in cooperation with a number of States and EPA. The model rule has provisions for:

- Critical definitions,
- Emission standards,
- Test method procedures,
- Certification process, and
- Labeling requirements.

The model rule contains a single method for regulating new units with respect to the critical elements and contemplates that States may propose alternative approaches for other provisions. It also provides alternatives for states to consider for regulating previously installed units (NESCAUM 2007).

NESCAUM's model rule sets standards for particulate matter (PM) emissions by phases for residential and commercial boilers. The PM standards for both boiler types are identical. Phase I calls for a PM emission limit of 0.44 pounds per million BTU heat input. This standard would have to be met by March 31, 2008. Phase II calls for a PM emission standard of 0.32 lb/MMBTU which is to be met by March 31, 2010.

Vermont's Rule on Outdoor Wood-fired Boilers

On April 12, 2007 Vermont filed a regulation on outdoor wood-fired boilers with the Secretary of State and the Legislative Committee on Administrative Rules. The rule legally went into effect on April 27, 2007, and adopts NESCAUM's model rule Phase 1 PM emission standard of 0.44 lb/MMBTU. As of March 31, 2008, outdoor wood-fired boilers not meeting the standard of 0.44 lb/MMBTU cannot be sold in Vermont. Additional information on Vermont's final rule on outdoor wood-fired boilers can be found on the following web site:
<http://www.vtwoodsmoke.org>. (Etter, personal communication)

This section of this document addresses the four factor analysis which includes the following elements: cost of compliance, time necessary for compliance, energy and non-air impacts, and remaining useful life of the source.

FOUR FACTOR ANALYSIS OF POTENTIAL CONTROL SCENARIOS FOR OUTDOOR WOOD-FIRED BOILERS

Cost of Compliance

Outdoor wood-fired boilers are priced according to their size (heat output). For example, Northwest Manufacturing sells a line of outdoor wood-fired boilers that ranges in price from \$4,295 for a boiler that will heat a 2,000 square foot house to \$12,995 for a boiler that can heat up to 20,000 square feet. Similarly, Hud-Son Forest Equipment has a line of outdoor wood-fired boilers that range in price from \$6,095 for boiler that can heat a 2,000 square foot house to \$7,795 for a boiler that can heat up to 10,000 square feet.

There are currently only a few outdoor wood-fired boiler manufacturers whose products would meet the 2008 NESCAUM phase I standard of 0.44 lb/MMBTU. NESCAUM estimates that there are "several units currently on the market that can meet this standard." In addition, NESCAUM estimates that more stringent air standards that it proposed should come into compliance in 2010 would currently only be met by one unit. Consequently, manufacturers of outdoor wood-fired boilers would have to invest money into research and development in order to manufacture boilers that would meet NESCAUM's model standards. MACTEC contacted an outdoor wood-fired boiler manufacturer to determine cost increases due to the NESCAUM rule. The boiler manufacturer was not able to provide estimated cost increases necessary to manufacture boilers meeting the NESCAUM model rule standards (personal communication with Central Boiler, Inc.).

MACTEC also investigated the costs of replacing the outdoor wood-fired boilers with heating oil-fired furnaces and boilers. We determined that the capital cost of oil-fired water boilers ranged from \$2,800 - \$3,825. Similarly, the capital cost of oil-fired furnaces range from \$1,560 -

\$1,800 (Alpine Home Air 2007). Therefore, oil-fired boilers and furnaces can be substantially less expensive than outdoor wood-fired boilers.

In a previous section, information was presented on the average amount of distillate fuel oil used on an annual basis by households in the Northeast. It was estimated that households use approximately 865 gal/yr of fuel oil (STAPPA-ALAPCO 2006). Therefore, the annual average heating cost using fuel would currently be approximately \$2,100 (assuming a fuel oil price of \$2.40/gal). The University of Wisconsin Solid and Hazardous Waste Education Center (2007) estimates that it would take only 4 full cords of oak firewood to heat a house per year. At approximately \$200/cord (Boston.com 2004), this equates to an annual fuel cost of \$800/year. Consequently, the annual cost for firewood is \$1,300 less than the cost of distillate fuel oil. Additionally, many operators of outdoor wood boilers have access to a free supply of firewood for the boiler, thus the only fuel cost to these operators is the time, effort, and expense associated with gathering the wood and cutting it for use in the outdoor wood-fired boiler.

Assuming the average household use of 865 gal/yr of fuel oil, and a fuel oil heating value of 140 MMBTU per thousand gallons, the annual heat input required is 121.1 MMBTU. The emission factors for residential fuel oil combustion, natural gas combustion, and wood combustion in outdoor wood-fired boilers are 0.003, 0.002, and 1.5 to 3.1 pounds of PM per MMBTU heat input respectively. Using the annual heat input requirement of 121.1 MMBTU, the annual emissions from an oil-fired furnace would be 0.4 pounds, the emissions from a natural gas-fired furnace would be 0.2 pounds, and the emissions from the outdoor wood-fired boiler would be from 180 to 380 pounds. The cost of replacing an outdoor wood-fired boiler with an oil-fired furnace or boiler is estimated to be from \$1,560 to \$3,825 (Alpine Home Air 2007). If the capital cost of the oil-fired furnace or boiler is spread over ten years, the annualized capital cost is between \$156 and \$383. Additionally, the cost of fuel oil is estimated to be from \$0 to \$2,100 more than the outdoor wood-fired boiler fuel costs depending on whether the operator has access to a free wood supply, or must purchase the wood by the cord. Based on these estimates, the PM cost effectiveness of replacing an outdoor wood-fired boiler with an oil-fired furnace or boiler would be from \$1,700 to \$13,000 per ton of PM reduced. The costs for replacement of outdoor wood-fired boilers with natural gas-fired furnaces or boilers have not been quantified.

Time Necessary for Compliance

Outdoor wood-fired boilers have been in operation for approximately the last 15 years (personal communication with P. Etter from Vermont Air Pollution Control). Consequently, the average age of outdoor wood-fired boilers is not known. On at least one occasion, a boiler vendor opted to go out of business rather than honor 5-year warranties (personal communication with J. Gulland from OutdoorHeat.org). If States pass a rule similar to NESCAUM's and existing boilers are grandfathered, only new boilers would be required to meet the more stringent standards. In the section on residential heating, it was estimated that the average useful life of a residential boiler is between 18-25 years. Well manufactured outdoor wood-fired boilers may have similar useful lives. Therefore, new boilers meeting more stringent PM emissions standards would be phased in slowly as older boilers are replaced.

Replacement of wood-fired boilers with oil-fired furnaces or boilers could occur on a very quick schedule. The number of residential boiler/furnace manufacturers in the United States is

indicative of the fact that there is an ample supply of manufacturers. Although it is possible for outdoor wood-fired boilers to be replaced quickly, realistically, most of these units have been installed within the past 15 years. Since they are designed to last for approximately 20 years, operators of the outdoor wood-fired boilers would likely be reluctant to replace them immediately.

Energy and Non-Air Impacts

Wood is a renewable resource that is plentiful in the United States Northeast. The increased use of outdoor wood-fired boilers would lead to an increase in the amount of firewood that is combusted in the US Northeast on an annual basis. Alternatively, tighter rules regarding the PM emissions from outdoor wood-fired boilers may lead to a decrease in their use, which would make more firewood available for use in wood stoves and fire places. A move away from wood-fired boilers would increase the demand on heating fuels such as heating oil, propane, and potentially coal or natural gas.

The increased use of outdoor wood-fired boilers may have a variety of non-air impacts on the environment, especially on forest and water resources. The potential impacts are outlined below.

Nuisance Smoke: Outdoor wood-fired boilers typically have very short stacks, and are prone to smoke. The short stacks oftentimes prevent proper mixing of the smoke and soot with the surrounding air, thereby creating nuisance smoke problems for surrounding houses or communities (Michigan DEQ 2007).

Water: Increased logging to satisfy the demand for firewood may increase runoff of silts and sediments into adjacent creeks and rivers. This increased sediment load in rivers can affect aquatic ecosystems that are integral to rivers and streams.

Soils: Increased logging may impact soils in many ways. For example, heavy machinery used to fell and process trees may lead to rutting and compaction of the soil, which in turn leads to higher erosion and/or altered vegetative regrowth.

Wildlife: Increased logging may put pressure on existing wildlife populations in the US Northeast by altering their critical habitat.

Threatened and Endangered Species: Increased logging in Northeast may impact threatened and endangered species through habitat destruction or alteration.

Remaining Useful Life of the Source

The useful life of outdoor wood-fired boilers is approximately 20 years, which is also very close to the useful life of other residential boilers (Etter, personal communication). In addition, Mr. Etter indicated that outdoor wood-fired boilers have only been around for approximately 15 years, therefore, most of the boilers that have been put into service are likely to remain there for at least the next five years.

REFERENCES

EPA, 1998a. *Emissions from Outdoor Wood-Burning Residential Hot Water Furnaces*. EPA Publication Number EPA-600/R-98-017.

EPA, 1998b. AP-42 section 1.3. *Fuel Oil Combustion*.

EPA, 1998c. AP-42 section 1.4. *Natural Gas Combustion*.

Etter, P., Vermont Department of Environmental Conservation, Air Pollution Control Division. Personal communication with Mr. Bernd Haneke, MACTEC Federal Programs, Inc., on March 9, 2007.

Etter, P., Vermont Department of Environmental Conservation, Air Pollution Control Division. Personal communication with Mr. William Hodan, MACTEC Federal Programs, Inc., on July 3, 2007.

Gulland, J., OutdoorHeat.org. Personal communication with Mr. Bernd Haneke, MACTEC Federal Programs, Inc., via E-mail on March 9, 2007.

Guldberg, P., Tech Environmental, Inc. Personal communication with Mr. William Hodan, MACTEC Federal Programs, Inc. via E-mail on May 17, 2007.

Guldberg, P. 2007. *Outdoor Wood Boilers – New Emissions Test Data and Future Trends*. Presented at the 16th Annual International Emission Inventory Conference - Emission Inventories: “Integration, Analysis, and Communications”

Killeen, W. 2004. *Firewood Shortage Reflected in Prices*. Document obtained from the World Wide Web at: www.boston.com

Michigan Department of Environmental Quality 2007. *Outdoor Wood Boiler and Air Quality Factsheet*. Document obtained from the World Wide Web at: www.michigan.gov/deqair

NESCAUM, 2006. *Assessment of Outdoor Wood-fired Boilers*. Document obtained from the World Wide Web at: <http://burningissues.org/outdoor-wood-boilers.htm>

NESCAUM, 2007. *Outdoor Hydronic Heater Model Regulation*. Document obtained from the World Wide Web at: <http://burningissues.org/outdoor-wood-boilers.htm>

NESCAUM. Personal communication between Ms. Lisa Rector and Dr. Art Werner, MACTEC Federal Programs, Inc., on June 6, 2007.

STAPPA ALAPCO, 2006. *Controlling Fine Particulate Matter Under the Clean Air Act: A Menu of Options*.

Central Boiler, Inc. Personal communication between Mr. Rodney Tollefson and Mr. Bernd Haneke, MACTEC Federal Programs, Inc., on March 8, 2007.

University of Wisconsin 2005. *Using Wood as a Residential Heating Fuel: Issues and Options*. Published by the University of Wisconsin Solid and Hazardous Waste Education Center, and downloaded from the World Wide Web at:
uwm.edu/Dept/shwec/publications/cabinet/p2/outdoorwoodfiredboilers.pdf

Information on prices of furnaces and boilers were obtained from the World Wide Web using the following URLs: www.alpinehomeair.com; www.hud-son.com/woodfurnaces.htm; www.woodmaster.com/web.htm