Center for
Clean Air Policy

Identification of Potential Areas for Further Federal Actions: Industrial, Commercial and Institutional Boilers

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Introduction

Industrial, commercial and institutional (ICI) boilers combust coal, oil or gas to produce heat and process steam in numerous sectors, including chemical manufacturing, petroleum refining, commercial buildings, hospitals, and universities. This paper evaluates emissions from ICI boilers as a potential area for Federal action to reduce emissions over the next few years, based on the criteria discussed within the work group on Regional and National Strategies. Preliminary data and analysis indicate that this sector holds substantial promise for future regulation due to the significant contribution to projected 2010 emissions, the availability of cost-effective control measures, and the likely contributions to nonattainment of the ozone and fine particle standards as well as other environmental impacts associated with boiler emissions. However, this information should be confirmed by EPA peer-reviewed analysis and, if warranted, the public review elements of rulemaking processes. Specifically, further air quality modeling or other analyses are needed to understand the potential contribution of this sector to attainment. In addition, a better characterization of ICI boiler characteristics and their emissions is needed to enable evaluation of costs and emissions reductions of specific control strategies. This could be done through various data collection mechanisms and by hiring a consultant to compile a comprehensive database. Finally, a peer-reviewed evaluation of the costs and control effectiveness of the various control options for a range of boiler sizes is needed to confirm the cost-effectiveness of controlling emissions from this sector.

The recommendation is as follows:

EPA should evaluate the industrial, commercial, and institutional boiler (ICI) sector in detail for possible national or regional regulation. EPA should close data gaps pertaining to characterization of the ICI boiler population and emissions and the effect of reductions from ICI boilers on attainment. EPA should develop improved estimates of the costs and control effectiveness of various emissions control options. EPA should take action consistent with the findings of this analysis and should incorporate cap and trade options into the strategy.

I. Quantity and Geographical Distribution of Emissions

ICI boilers are expected to account for a significant percent of national emissions of key criteria pollutants. In 2010, ICI boilers are projected to account for 2.7 million tons of NO_x, 2.4 million tons of SO_2, and 0.3 million tons of $PM_{2.5}$ nationwide. These emissions represent over 16 percent (one-sixth) of total NO_x emissions, 16 percent of total SO_2 emissions, and 5 percent of total $PM_{2.5}$ emissions projected for that year.[1] The projected 2010 SO_2 and NO_x emissions from ICI boilers are second only to emissions from the power sector (without CAIR, or the Clean Air Interstate Rule). Emissions of NO_x, SO_2 and $PM_{2.5}$ contribute to an array of human health and environmental problems, including ground level ozone, acid rain, fine particle pollution,

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[1] Note that these percentages assume only existing regulations—they do not assume implementation of the proposed Clean Air Interstate Rule (CAIR) that would control emissions from the power sector. If implementation of CAIR were assumed, industrial, commercial and institutional boilers would constitute an even greater share of 2010 emissions. For example, with implementation of CAIR, the ICI boiler share of 2010 SO_2 emissions would be expected to increase to 22% and the ICI boiler share of 2010 NO_x emissions would be expected to increase to 18%.

eutrophication and regional haze.

While all new ICI boilers have had to meet New Source Performance Standards for SO_2 and NO_x that were promulgated by EPA in the mid-1980s based on scrubbing, SCR (coal) and SNCR (oil) technology, boilers that came on-line before the new source performance standards have not been subject to national emissions control requirements. Regulation of such older boilers has been ad hoc. ICI boilers located in ozone nonattainment areas are subject to NOx RACT and some states have opted to regulate NO_x emissions from industrial boilers to help meet requirements of the NO_x SIP Call. For SO2, ICI boilers emitting over 100 tons per year in a 5-state western region (Arizona, New Mexico, Oregon, Utah, Wyoming) are subject to control requirements starting in 2018, the BART rule, which takes effect in 2008, will control many uncontrolled ICI boilers built between 1962 and 1977, and a very small number of industrial boilers have voluntarily opted in to the national Acid Rain Trading Program. A large part of the ICI boiler population remains uncontrolled for NO_x and/or SO_2. And in many cases, boilers subject to NO_x control requirements have only installed combustion technology. Therefore, there may be room for additional cost-effective actions.[2] As a result, ICI boilers are expected to contribute significantly to the projected national emissions inventories for these pollutants in 2010.

ICI boilers—and their emissions--are broadly distributed across the United States.[3] For example, in the case of NO_x, only two states (Texas and Louisiana) are projected to account for more than 5 percent of total national emissions from this sector in 2010. 80 percent of emissions from ICI boilers are projected to be distributed across 48 states and the District of Columbia, each of which comprise 5 percent or less of the sector's NO_x emissions. The projected SO_2 and $PM_{2.5}$ ICI emissions display a similar pattern, with 70 percent and 60 percent of emissions, respectively, distributed across 45 states and the District of Columbia. Since these emissions will not be confined to a limited number of specific areas, there may be economies of scale to having national regulation of ICI boilers in lieu of separate regulations in numerous states. This would also ensure that these sources are regulated and monitored in a consistent manner across states, reducing concerns related to economic competitiveness from having different standards.

ICI boilers may contribute to nonattainment of ozone and fine particle standards both locally and in down-wind states, as well as to a variety of other health and environmental concerns. A comparison of projected emissions from ICI boilers and nonattainment areas suggests a potential relationship between ICI boilers and local air quality impacts. In fact, ICI boilers are expected to represent a sizeable share of emissions in many states that are projected to have one or more counties in nonattainment for the 8-hour ozone and fine particle standards in 2010. Table 1, below, displays eastern[4] states with counties projected to be in nonattainment for ozone and fine particles in 2010, along with the percentage of in-state NO_x and SO_2 emissions that comes from ICI boilers. For example, in five jurisdictions with nonattainment areas for ozone (Arkansas, Texas, Delaware, District of Columbia and Virginia), ICI boilers will account for more than one-fifth of NO_x emissions. Similarly, in five jurisdictions with nonattainment areas for fine particles

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[2] For example, under the NO_x SIP Call, over three-quarters of ICI boilers have installed combustion controls only, primarily overfire air, low-NO_x burner, and low-NO_x burner with overfire air (see Section III, below).

[3] See Appendix A for the shares of total national ICI boiler emissions projected for each state in 2010.

[4] Table 1 is limited to states that are part of the proposed CAIR.

(District of Columbia, Delaware, New York, Maryland and Tennessee), 20 percent or more of SO_2 emissions in 2010 are projected to come from ICI boilers. While these results are for business-as-usual (BAU) conditions, it should be noted that the same jurisdictions are expected to have one or more ozone nonattainment areas even with the implementation of CAIR.

These results suggest that regulation of ICI boilers could make an important contribution to emissions reductions in states that are projected to have one or more areas in nonattainment for ozone or fine particles. Of course, the fact that a boiler is located in the same state as a nonattainment area does not necessarily mean that emissions from that source contribute to nonattainment. Similarly, boilers located in upwind states could contribute to a given area's nonattainment. More detailed analysis is needed to understand the degree to which emissions reductions from industrial boilers would yield improvements in the targeted nonattainment areas.

The Science and Technology workgroup evaluated source apportionment and other studies to identify which sectors are responsible for ozone and fine particle nonattainment and regional haze. Coal-fired industrial boilers and "sources of nitrate" were both implicated. It should be noted that emissions reductions from ICI boilers could also reduce other environmental impacts, including acid deposition and eutrophication, either locally or as a result of regional transport. ICI boilers also produce CO_2 emissions and air toxics. It may be desirable to consider multiple pollutant control approaches for this sector. EPA should consider whether there are avenues to integrate or build consistency across criteria pollutant requirements and proposed measures to reduce emissions of air toxics. EPA should also consider the CO_2 implications of any new requirements and consider ways to encourage multiple pollutant control.

Table 1: Projected ICI Share of Total In-state Emissions in States with Ozone and Fine Particle Nonattainment Counties in 2010

State	Ozone NA counties	ICI Boiler % of State NO_x	$PM_{2.5}$ NA counties	ICI Boiler % of State SO_2
AR	1	27%	0	18%
TX	3	23%	0	8%
DE	1	22%	1	55%
DC	1	21%	1	93%
VA	2	21%	0	19%
RI	1	17%	0	59%
GA	1	14%	11	9%
WI	3	14%	0	32%
NJ	11	13%	0	38%
OH	2	11%	11	10%
IN	1	11%	2	6%
PA	5	11%	4	12%
NC	1	9%	3	19%
CT	3	9%	1	15%
NY	5	8%	1	36%
MD	6	8%	1	21%
KY	0	19%	2	13%
TN	0	16%	5	23%
AL	0	14%	5	7%
WV	0	14%	6	6%
SC	0	14%	1	16%
MI	0	11%	1	11%
IL	0	11%	4	16%
MO	0	9%	1	10%

Source: Information on NO_x and $PM_{2.5}$ nonattainment taken from *Rule to Reduce Interstate Transport of Fine Particulate Matter and Ozone (Interstate Air Quality Rule)*, Federal Register Vol. 69, No. 20, January 30, 2004, http://www.epa.gov/air/interstateairquality/rule.html. State emission shares developed from data provided by US EPA to the Clean Air Act Advisory Committee, and electric generating unit projections from the EPA Base Case 2003 results.
The above data is based on BAU conditions, without CAIR. If CAIR were assumed to be implemented, fewer counties would be in nonattainment in 2010, and ICI boilers would be responsible for a greater share of the remaining emissions.

Table 2, below, displays Western counties currently in nonattainment for ozone under the 8-hour standard[5] and the projected share of 2010 in-state NO_x emissions that come from ICI boilers for these states. Four Western states (Arizona, California, Colorado and Nevada) had counties in nonattainment for ozone in 2004. In Arizona, ICI boilers will account for more than one-fifth of NO_x emissions in 2010. In California and Colorado the ICI share of NO_x will be nearly 15 percent; it should also be noted that in California a significant number of the nonattainment counties are classified as severe or serious. This suggests that regulation of ICI boilers could contribute to helping these Western states achieve attainment for ozone in future years.

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[5] Note that the projected ozone attainment status for 2010 was not available for western states.

Table 2: Counties in Nonattainment in 2004 for 8-hour Ozone Standard in Western States and Projected 2010 ICI Share of Total In-state Emissions[6]

State	2004 Ozone NA Counties	2010 ICI Boiler % of State NO_x
AZ	2	21%
CA	42	13%
CO	9	14%
NV	1	5%

Source: http://www.epa.gov/ozonedesignations/statedesig.htm
Includes counties listed as partial nonattainment. The nine Colorado counties are in the Denver-Boulder-Greeley-Ft. Collins nonattainment area, which has an early action compact. This area had a 3-year average below the standard this year, so is likely to be in attainment before 2010.

Analyses conducted as part of the OTAG process that ultimately supported the NOx SIP Call, as well as more recent studies in support of the CAIR, showed that emissions from upwind states contribute to nonattainment in downwind states. The relative contributions of different sectors were not broken out in these studies, but given the large contribution of ICI boiler emissions to the total inventory, these emissions would be expected to contribute to downwind nonattainment. The relative contribution of ICI boilers to downwind nonattainment would depend on various factors such as stack height and diameter, gas flow rate, gas temperature, configuration of surrounding structures, and the location of the ICI boilers. It is likely, however that in many cases the contribution of large ICI boilers would be significant and similar to an electric power plant of similar size.

Some ICI boilers have already been regulated in the context of reducing transport emissions. As part of the NO_x SIP Call trading program, large steam boilers over 250 MMBtu/hr were included in the development of state NO_x budget allocations, although the selection of specific sources to be regulated was left up to the individual states. An estimated 19 states have elected to regulate about 450 ICI boilers in the SIP Call. A significant number of these boilers are located in Midwest states (see Table 3, below). Of the approximately 330 boilers for which firing rates are available, about one-half are less than 250 MMBtu/hr. [7]

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[6] See comments in Table 1.

[7] This assessment of ICI boiler participation in the NO_X SIP Call was developed by CCAP based on data taken from the US EPA Clean Air Markets website (http://cfpub.epa.gov/gdm). The number of ICI boilers in the NO_x SIP Call was estimated by removing all Acid Rain Program units from the list of SIP Call units, and then screening out records identified as electric generating units. It should be noted that this represents an approximation only. Due to the data and the level of detail currently available, it is possible that some ICI boilers currently in the SIP Call were not included, and that some actual electric generating units have been identified here as steam boilers.

Table 3: ICI Boilers Regulated in the SIP Call[8]

State	AL	CT	DC	DE	IL	IN	KY	MA	MD	MI	NC	NJ	NY	OH	PA	SC	TN	VA	WV	Total
Boilers	20	10	6	12	35	37	6	12	4	16	33	19	35	38	71	13	24	36	26	453

II. Emission Inventories and Future Estimates

The development and maintenance of accurate and reliable emission inventories is an important component of any regulatory effort. Historical inventories ensure credibility of emission estimates and provide benchmarks by which future program performance can be measured. Good quality inventories will also be essential to enable emissions trading as a regulatory option for the ICI boiler sector. Currently, at least one emissions inventory has been developed that includes data for ICI boilers, EPA's National Emissions Inventory (NEI) database. This inventory relies on reporting by the states to EPA. Another source of data is the EPA's ICI database, which is not an emissions inventory but does contain emissions-relevant information on individual boilers. In general, the quality of the data in ICI inventories may be expected to vary by the location, size and age of the boiler. Newer boilers subject to the New Source Performance Standards, for example, have had to install continuous emissions monitors (CEMS) and may be expected to produce accurate emissions estimates. Similarly, most of the steam boilers that are currently part of the NO_x SIP Call use CEMS and have recently started to report ozone season NO_x data (and in some cases annual NO_x data). The quality of the inventories will improve as more CEMS data are integrated. However, new inventories/better data would be required for boilers not currently regulated (e.g., older boilers not in the SIP Call or located in the western states) and for other pollutants. ICI boiler regulation would also require the development of baselines with projections of emissions for future years. This will require a model or methodology that can estimate both operating hours of existing boilers and the construction of new boilers in future years, based on projected growth in steam demand.

Some key considerations in developing an emissions inventory and baseline for use in future regulation include the following:

- In historical inventories, data for prior years may be unavailable for some sources. It will therefore be necessary to develop standards for estimating historical emissions.
- It will be necessary to ensure that monitoring systems are accurate and properly maintained to enable the full range of policy choices.
- Need to develop a methodology to estimate future new builds of ICI boilers, taking into account the share of steam demand that will be met by combined heat and power (CHP).
- Need to ensure that projections and new builds incorporate assumptions for the expected improvement of boiler technology over time, as well as future boiler costs.
- Need to ensure that controls installed on ICI boilers to meet requirements under other federal programs such as the SIP Call are included and accounted for in any inventory, particularly in cases where (compared to CEMS) less accurate estimation methods are used. Projections of future ICI emission baselines must also be adjusted accordingly, and data used in models updated periodically as new controls are added.
- Need to account for the impact of firing or co-firing ICI boilers with waste fuels (e.g., biomass, tires). Must ensure that inventories and future baselines account for them

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[8] See the above footnote.

accordingly, using appropriate percents of waste used (in the case of co-firing) and correct emission factors.

- Ideally, methods to project future emission baselines will estimate, in the aggregate, the extent to which existing ICI boilers will convert to CHP, and account for the impact.

CCAP recommends that US EPA hire a technical consultant to improve the quality and completeness of the ICI boiler inventory and to develop a realistic emissions baseline. The goal would be to create a comprehensive and systematic database listing key unit-level data for all states. The consultant would work closely with representatives from industry and/or states to obtain accurate and consistent data and to ensure that ICI databases and inventories are properly maintained and updated over time. The consultant would seek to integrate data from available data sources, including data in the NEI, data reported as a result of the Consolidated Emissions Reporting Rule, and data pulled together to support MACT regulation and the OTAG effort. To ensure continued improvement and updating of ICI boiler data, it will be necessary to support a mechanism for reporting of emissions from ICI boilers. One way to do this would be to maintain and fully implement the Consolidated Emissions Reporting Rule. Alternatively, the EPA could launch a new information collection request. However, this latter option could be unnecessarily costly and time-consuming, especially as other avenues are already underway for collecting these data.

III. Options for Emissions Control and Reduction

Nearly all of the primary control technologies for NO_x and SO_2 currently used for electric utility boilers can be applied to large ICI boilers. For NO_x, these controls include selective non-catalytic reduction (SNCR), selective catalytic reduction (SCR), and a variety of several combinations of combustion controls including low NO_x burner, low NO_x burner with overfire air, low NO_x burner with overfire air and gas reburning, and gas recirculation. SCR and SNCR can also be used on boilers with combustion controls already installed. Other emission reduction options include combustion optimization and fuel switching, including use of lower sulfur oils. Many of the above technologies have been used extensively in the electric power sector to meet emissions caps under the Title IV Acid Rain Program and the Ozone Transport Commission NO_x control program, and their reliability is widely accepted.

Recently, a number of ICI boilers have adopted NO_x control technologies to comply with the NO_x SIP Call. Table 4, below, displays the primary $NO_\mathbf{x}$ controls used by ICI boilers in the SIP Call, the number of boilers using them, and the relative shares of $NO_\mathbf{x}$ emissions associated with each type of control. Over 75% of boilers have installed combustion controls only. 30% have overfire air only, 25% have low-NOx burners only, and 9% have used combustion optimization only. This indicates that two out of three SIP Call boilers could potentially install additional low-cost combustion controls or undertake optimization measures to achieve additional emission reductions. (These control methods can be combined in many cases: for example, overfire air can be augmented with a low-NO_x burner, and boilers with only combustion optimization can typically be augmented with one or more combustion controls.) Of the records for which emissions data are available, boilers using combustion controls account for 70% of total NO_x emissions in the SIP Call region, demonstrating the potential for achieving significant additional emission reductions. It should also be noted that the units using either combustion controls or combustion optimization could potentially achieve further reductions by installing post-combustion SNCR or SCR controls.

Table 4 displays an assessment of the compliance choices made by industrial boilers subject to the NO_x SIP Call and the share of 2003 NO_x emissions from industrial boilers with the various controls installed. While most boilers opted to use combustion controls, SIP Call ICI boilers also appear to be gaining experience with the higher-cost SCR and SNCR technologies. An estimated 8 boilers installed SCR technology, and 17 boilers installed SNCR. These experiences might be used to inform the design of future regulation.

Table 4: Primary NO_x Controls and Shares of 2003 NO_x Emissions for SIP Call ICI Boilers[9]

Primary NO_x control	Boilers	NO_x Share
Combustion Controls	157	70%
Overfire air only	60	21%
Low-NO_x burner only	51	10%
Low-NO_x burner with overfire air	38	34%
*Other**	8	5%
Combustion Optimization Only	17	11%
SNCR	17	13%
SCR	8	6%
Total	199	100%

*Includes combustion optimization combined with low-NO_x burner, overfire air, and/or steam injection; ammonia injection. Some boilers with SNCR and SCR also have combustion controls installed.

As with electric utility boilers, however, such technologies will not be appropriate in all cases. In some instances, the configuration or operational characteristics of a boiler can make the installation of emission controls difficult. For example, SNCR is often ideal for use with smaller boilers, and can be used in many cases. But the use of SNCR is also site-dependent; with shop-fabricated boilers (mostly fired by oil or gas), for example, the use of SNCR can be more difficult due to issues such as the overall boiler configuration and closely spaced heating surfaces, which may not support specific SNCR design requirements associated with gas residence times and reagent injector location. The ability to use SCR is more a function of gas temperatures than size. In a few cases, the temperatures may fall outside of the range required for proper catalyst operation, but with fossil-fired boilers SCR can be used in the majority of cases. Combustion controls such as low NO_x burners are the most common and least-expensive option, and can be used with nearly all types of boilers. In general, it can be assumed that under a regulatory program ICI boilers would have a range of reliable technology options for emissions control, and that technical feasibility would not pose a challenge to achieving significant emission reductions overall.

While the control technologies are well understood and are often technically feasible, the cost-effectiveness varies depending on the technology and fuel type in question, the boiler size, and the capacity factor. Due to economies of scale, larger boilers will typically have more cost-effective control options than smaller boilers, as will boilers operating at high capacity factors compared to those operating at lower capacity factors.

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[9] See notes on methodology in footnote 7. Emission controls are presented for records for which such data were available. NO_x shares developed from 162 boilers for which control and emissions data were available.

Table 5: Preliminary NO_x Control Costs for Uncontrolled Industrial Boilers[10]

Control Technology	Fuel	% Red	Cost (1999$ per ton) by CF			
			100 MMBtu/hr		250 MMBtu/hr	
			Mid-Range CF	High CF	Mid-Range CF	High CF
SNCR	C	40	2,073	1,625	1,814	1,473
	G	40	3,735	2,521	3,116	2,193
	O	40	2,853	2,123	2,444	1,889
SCR	C	80	2,141	1,349	1,766	1,123
	G	80	2,933	1,689	2,330	1,354
	O	80	2,767	1,694	2,178	1,343
Low NOx burner	C	50	849	512	645	389
LNB/OFA	C	50	1,239	757	947	581
	G	60	1,052	559	797	424
	O	30	1,052	612	797	464
LNB/OFA/GR	G	80	1,278	700	981	543
	O	30	2,337	1,399	1,798	1,085

Source: *Methodology, Assumptions, and References Preliminary NO_x Controls Cost Estimates for Industrial Boilers*, US EPA, October-November 2003.

The preliminary data presented in Tables 5 and 6 indicate that control technologies for industrial boilers can achieve emissions reductions cost-effectively—often well below current allowance prices for NO_x and SO_2, and in many cases, below the levels deemed to be "highly cost-effective" for the electric power sector under the proposed CAIR ($1,300 per ton of NO_x and $700 per ton of SO_2 in 2010)[11]. Low cost NO_x compliance options for most large industrial boilers include low NO_x burners and low NO_x burners in concert with overfire air. These technologies are estimated to achieve control levels of 30 to 60 percent. Similarly, the low NO_x burner/overfire air/gas reburning option is a cost-effective alternative for gas-fired boilers over 100 MMBtu/hr running at medium to high capacity factors and for large (>250 MMBtu/hr) oil-fired boilers running at high capacity factors. SCR technology, capable of reducing NO_x emissions by 80 percent, would be cost-effective for boilers above 250 MMBtu/hr (fired by coal, gas or oil) at high capacity factors, and for 100 MMBtu/hr and up coal-fired boilers at high capacity factors.

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[10] Note: the data presented in this table, found in the EPA docket, are preliminary and have not been peer-reviewed. The data are based on EPA discussions with a limited number of experts in the industry.

[11] It should be noted that EPA did not assume reductions from ICI boilers in the CAIR because they did not believe there was sufficient information to determine that controls met the highly cost effective criteria.

Table 6: Preliminary SO_2 Control Costs for Uncontrolled Industrial Boilers[12]

Control Technology	Fuel	% Red	Cost (1999$ per ton) by Capacity Factor			
			100 MMBtu/hr		250 MMBtu/hr	
			Mid-Range CF	High CF	Mid-Range CF	High CF
Wet FGD	C	90	1,046	664	820	528
Spray dry absorber	C	90	1,209	790	842	569
Dry sorbent injection	C	40	1,292	943	992	763
Wet FGD (oil)	O	90	2,126	1,285	1,654	1,011

Source: *Methodology, Assumptions, and References Preliminary SO_2 Controls Cost Estimates for Industrial Boilers*, US EPA, October-November 2003. Assumes the use of high-sulfur coal.

For SO_2 control, based on the preliminary data shown in Table 6, wet flue gas desulphurization (FGD) appears to be cost-effective for many coal-fired boilers, particularly for boilers over 100 MMBtu/hr firing at high capacity factors. Spray dry absorber technology appears to be cost-effective when used with large, 250 MMBtu/hr boilers firing at high capacity factors. Both of these technologies can achieve very high (90 percent) emissions reductions, at a cost that would be competitive with proposed electric power emissions regulation.

Data on the cost of controlling emissions of $PM_{2.5}$ from utility and steam boilers were not available for this study. However, the regulation of ICI boilers could be an important step in reducing $PM_{2.5}$ emissions, particularly in urban and industrial areas where emissions from many of the ICI boilers may be concentrated. Since both NO_x and SO_2 are precursors to the formation of atmospheric $PM_{2.5}$, the application of the NO_x and SO_2 control technologies discussed above to address boiler emissions would also achieve reductions in $PM_{2.5}$. In addition, several technologies currently available for reducing direct emissions of $PM_{2.5}$ can be used with ICI boilers, including fabric filters and wet scrubbers.

In addition to the control technologies discussed above, other available options for ICI boilers include fuel switching and combustion optimization. Boilers may switch to a lower sulfur fuel, or repower to natural gas. Fuel switching for emissions control would be particularly appropriate for reducing SO_2 emissions from coal-fired boilers due to the large difference in sulfur content with natural gas. Switching from high- to low-sulfur oil can also be useful in the Northeast and in other regions with significant numbers of oil-fired boilers. Fuel switching can be done with most boilers, but the cost-effectiveness will vary considerably (and may be high) from one boiler to another due to the significant modifications that are often required. Switching from coal to gas also typically lowers the efficiency by a few percentage points. For NO_x control, combustion optimization is another option that can be used with most fossil-fired industrial boilers, and with any kind of fossil fuel. This involves alterations to the combustion process (e.g., minimizing the air that enters) that can reduce the formation of NO_x. In some cases combustion optimization may also improve the efficiency of the boiler.

Sufficient, highly cost-effective technologies are available to enable control of industrial boilers, and this information should form the basis for an overall level of control for this sector. There appear to be several control options that would be appropriate for commercial and institutional

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[12] See comments in Table 5.

boilers as well, but more work is needed to understand the potential cost-effectiveness. EPA should develop improved, peer-reviewed estimates of the cost-effectiveness of the various emission reduction measures that might be used with ICI boilers. This should include estimates for a range of boiler sizes and types, and should reflect recent experiences with NO_x and SO_2 control technologies in the ICI boiler sector as well as experiences in similar sectors (e.g., electric power sector). However, given the difficulties that may be experienced by individual units in installing certain technologies, one approach would entail the adoption of a flexible regulatory approach that allows sources discretion in meeting emission standards and does not specify the control method or technology to be used. Under a cap and trade program, for example, regulated ICI boilers would have the option of purchasing emission permits in lieu of meeting these emission control requirements. This would ensure that emissions reductions in the ICI boiler sector are obtained at the lowest cost.

IV. Monitoring Systems

Several approaches for monitoring and verifying emissions are available that could be applied to ICI boilers, including continuous emissions monitors (CEMs), fuel intake measurement, periodic measurement of stack gas emissions, and parametric measurement and application of fuel factors. CEMs employ a pollutant concentration monitor and a volumetric flow monitor to measure SO_2, and pollutant concentration and diluent gas monitors to measure NO_x. CEMs are considered a very reliable and proven technology; however, since they are relatively expensive they are typically used only with large units. Other monitoring methods include the use of oil and gas flow meters that measure the total fuel input (for measuring SO_2), periodic measurements of stack gas emissions by a third party (for NO_x), and parametric measurement (in which emissions are estimated from an algorithm that relates emission levels to varying levels of fuel consumption). These methods have also been used on a large number of sources, and while sometimes less accurate than CEMS, are generally considered to be reliable.

The choice of measurement method will depend upon the accuracy required and the economic viability. Industrial boilers in particular typically operate at very high capacity factors, a factor which has several implications for emissions monitoring. Direct measurement of fuel consumption may be cumbersome and expensive in some cases, since tracking would be required for much of the year. There is no technical limitation on the use of CEMS with ICI boilers. For many large boilers (e.g., in the 100 to 1,000 MMBtu/hr range) CEMS would likely be the most appropriate option due to cost considerations. The use of CEMS would thus ensure the accurate measurement of large emission sources. An additional benefit would be that many states and facilities have already installed and are familiar with CEM technology, which may lower the cost and administrative burden. The usefulness of CEMS in this context can be seen in the EPA SIP Call program, which has approximately 450 (many of them coal-fired) steam boilers, more than three-quarters of which monitor emissions with CEMS.

Periodic measurement of stack gas emissions may be less accurate with ICI boilers, since the typical high capacity factors would make it difficult to guard against the use of outlier emissions data. For smaller boilers or boilers firing at low capacity factors, measurement of fuel intake could be employed to monitor SO_2 with reasonable accuracy; NO_x can be monitored though parametric measurement. These methods would be less accurate than CEMs, but this should not be a major concern since they would most likely monitor a much lower share of emissions. Under the NO_x SIP Call, for example, some ICI boilers used approaches other than CEMS (primarily parametric measurement).

V. Engineering and financing factors

The relative ease/difficulty of acquiring the needed capital and financing will depend on a variety of factors, including the degree of international competition, a given company's bond rating, etc. One measure of industry's ability as a whole to finance new projects is changes in its contribution to GDP. On average over the last several years, the manufacturing industry has maintained a fairly constant contribution to the gross domestic product, showing a 0.6 percent increase in the 1998 to 2002 period, with some sectors seeing considerable increases in their contributions to GDP (e.g., food, chemicals) and others seeing decreases (e.g., computer and electronic products). In any case, emissions trading would provide some flexibility from a financing standpoint as those most able to afford new technology investments could do so, allowing those least able to finance new technology investments to purchase allowances.

As far as engineering constraints, the main issue would be that implementation of the proposed CAIR is already expected to stretch the limited boilermaker resource. The degree to which this is an issue is not yet known, as the demand (and increasing rates) for boilermakers would be expected to result in an increase in supply. The impact of any boilermaker limitations could be reduced by providing extra time for compliance beyond the onset of the proposed Clean Air Interstate Rule. For example, industry boiler requirements could begin in 2011 or 2012 instead of 2010, to avoid coinciding with the first phase of the CAIR. However, this may be a non-issue depending on the chosen level of control as some of the technology measures identified may not require the same degree of boilermaker expertise.

VI. "Controllability"

The large size of many industrial boilers, the significant emissions from the sector, the availability of cost-effective control options, and the ability to measure or estimate emissions from the sector together suggest that industrial boilers are a strong candidate for new regulation. Recent experience in the OTC NO_x Budget program suggests that large industrial boilers can be regulated using emissions trading. In fact, a recent progress report by the Ozone Transport Commission concludes that, "industrial combustion units can be effectively integrated into a cap and trade program." More than 100 industrial units (equivalent to 25 MW power plants and larger) participated in this trading program, and have been active in the allowance trading markets, with transfers both to and from electric generating units, brokers and other market participants.[13]

While smaller than many industrial boilers, commercial and institutional boilers (and the smaller industrial boilers) represent a sizeable share of emissions and should not be overlooked for further reductions. However, the smaller size of these entities does not as easily lend themselves to use of CEMS, and more work is needed to identify cost-effective control measures. Further research is also needed on the relative accuracy of alternative measurement/monitoring

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[13] Source: Ozone Transport Commission NOx Budget Program 1999-2002 Progress Report.

techniques and a determination would need to be made as to whether this level of accuracy would be sufficient to enable participation in a cap-and-trade program. If not, another type of regulatory program could be used, such as an emissions rate limit. Given the low level of participation of industrial boilers in the Acid Rain Trading Program, a voluntary opt-in program is unlikely to be effective for this sector.

VII. Statutory Authority

Several sections of the Act provide federal authority to influence emission levels for new and existing industrial, commercial and institutional boilers. For example:

- EPA is authorized to issue and revise control techniques guidelines (sections 183 and 190) to aid states in defining technology standards to meet ozone and fine particle attainment goals.
- EPA can define NSPS for new sources (section 111), which also sets a floor for BACT control levels. EPA has previously defined NSPS for industrial, commercial and institutional boilers, but could choose to update these standards. EPA is under a court ordered deadline to revisit these standards.
- Under section 111, after notice and public hearing, EPA may establish limits for existing sources in a source category if a Governor shows that the category of stationary sources "contributes significantly to air pollution which may reasonably be anticipated to endanger public health or welfare." The Administrator appears to have some discretion as to the type of regulation that is applied if it is determined that a performance standard is not feasible because it conflicts with the approach to regulating industrial boilers under the SIP Call or Title IV. For example, the Administrator can use a performance standard, a design, equipment, work practice or operational standard, or combination thereof, which reflects the best technological system of continuous emission reduction which the Administrator determines has been adequately demonstrated. The choice of measures can consider the cost of achieving emissions reductions.
- Under section 110(a)(2)(d), states may not contribute significantly to nonattainment in any other state with respect to any national primary or secondary ambient air quality standard. To the extent that industrial, commercial and institutional boilers contribute to interstate transport of NO_x and fine particle emissions, EPA could compel control of these sources by states shown to be the source of down-wind emissions, as was done in the NOx SIP Call. One option would be to establish a model rule that would enable affected sources to achieve cost-effective emissions reductions through emissions trading.

Federal action will also assist states in meeting regional haze goals and will help to reduce air toxic emissions and residual risks. There may be additional language in these sections of the Act that would allow EPA to control emissions from industrial boilers. Moreover, there may be advantages in controlling multiple pollutants simultaneously from the sector to prevent stranded investments and facilitate optimization of controls to address multiple emissions. However, this may not be easy given the different timing of the various requirements and the sometimes inflexible existing statuary authorities.

VIII. Resource requirements

EPA staff time would be required to develop peer-reviewed cost-effectiveness estimates, study the effects of ICI boiler control on attainment, and oversee the database development consultant. Funds would also need to be set aside to compensate the consultant. If national or regional regulation is deemed to be appropriate, EPA staff time would be needed to develop proposed and final rules and design the trading program infrastructure (or other regulatory approach). The state role would be limited to monitoring and source permitting.

The cost of implementation will depend on the type of regulation used and the number of sources covered. For example, the cost of administering an emissions trading program is generally lower than a command-and-control approach. In addition, costs would be expected to increase somewhat if all ICI boilers are included versus those accounting for the majority of pollutants or those exceeding a boiler size or throughput threshold.

Please contact Stacey Davis (sdavis@ccap.org) or Matt Ogonowski (mogonowski@ccap.org) at the Center for Clean Air Policy, (202) 408-9260, with any questions or comments.

APPENDIX A

State % of Total National ICI Emissions

State	NO_x	State	SO_2	State	$PM_{2.5}$
TX	11.1%	NY	6.9%	LA	13.4%
LA	9.0%	IL	6.0%	IN	8.1%
CA	4.9%	LA	5.8%	GA	7.2%
NM	3.7%	OH	5.8%	CA	5.9%
OK	3.6%	PA	5.6%	FL	5.4%
WY	3.5%	ND	4.9%	TX	4.7%
KY	3.2%	WI	4.5%	ID	4.7%
MS	3.0%	TN	4.5%	PA	4.2%
OH	2.9%	MA	3.6%	ME	2.7%
KS	2.8%	IA	3.5%	MS	2.6%
VA	2.7%	FL	3.5%	TN	2.5%
GA	2.7%	MD	2.9%	VA	2.4%
AZ	2.6%	TX	2.6%	MD	2.4%
PA	2.6%	GA	2.6%	IL	2.3%
AR	2.5%	DE	2.6%	OH	2.1%
IL	2.5%	NC	2.6%	NY	2.1%
IN	2.3%	KY	2.5%	AL	1.9%
TN	2.2%	MI	2.4%	AR	1.8%
MI	2.2%	VA	2.3%	WI	1.6%
FL	2.1%	ME	2.0%	NJ	1.6%
AL	2.0%	IN	2.0%	KS	1.6%
ID	1.8%	AL	1.9%	MI	1.5%
WI	1.8%	MO	1.8%	MA	1.5%
NY	1.6%	SC	1.8%	NC	1.4%
WV	1.5%	NJ	1.7%	CO	1.2%
IA	1.5%	AR	1.7%	OR	1.2%
MO	1.4%	WV	1.6%	HI	1.2%
CO	1.4%	WY	1.0%	OK	0.9%
MN	1.3%	OR	1.0%	KY	0.9%
SC	1.2%	SD	0.9%	WA	0.9%
NC	1.2%	MS	0.8%	WV	0.7%
NJ	1.1%	HI	0.7%	MN	0.7%
UT	1.0%	MN	0.6%	SC	0.6%
MA	1.0%	NE	0.6%	DE	0.6%
WA	0.9%	NH	0.5%	MO	0.6%
ND	0.9%	WA	0.5%	UT	0.5%
HI	0.8%	CA	0.5%	IA	0.5%
MT	0.8%	OK	0.5%	NM	0.5%
OR	0.8%	UT	0.4%	ND	0.5%
ME	0.7%	VT	0.3%	WY	0.4%
MD	0.6%	DC	0.3%	AZ	0.4%
NE	0.6%	KS	0.3%	VT	0.3%
DE	0.4%	AZ	0.2%	NE	0.3%
CT	0.3%	RI	0.2%	MT	0.3%
AK	0.3%	NM	0.2%	CT	0.2%
SD	0.2%	CO	0.2%	NV	0.2%
NV	0.2%	CT	0.1%	NH	0.2%
RI	0.2%	NV	0.1%	AK	0.2%
NH	0.1%	ID	0.1%	DC	0.2%
VT	0.1%	MT	0.1%	RI	0.2%
DC	0.1%	AK	0.1%	SD	0.2%

Note: some emission shares may include emissions from internal combustion units