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Economic Impact Analysis of the Industrial Boilers and Process Heaters NESHAP

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Economic Impact Analysis of the Industrial Boilers and Process Heaters NESHAP

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SECTION 1

INTRODUCTION

The U.S. Environmental Protection Agency (referred to as EPA or the Agency) is developing regulations under Section 112 of the Clean Air Act (CAA) or the Act for industrial, commercial, and institutional (ICI) boilers and process heaters. These combustion devices are used in the production processes of numerous industries in the U.S. The hazardous air pollutants (HAPs) are generated by the combustion of fossil fuels and biomass in boilers and process heaters. The primary HAPs emitted by ICI boilers and process heaters include arsenic, beryllium, cadmium, lead, hydrochloric acid, mercury, and other HAPs. In addition, ICI boilers and process heaters also emit non-HAP pollutants such as sulfur dioxide and particulate matter. To inform this rulemaking, the Innovative Strategies and Economics Group (ISEG) of EPA's Office of Air Quality Planning and Standards (OAQPS) has developed an economic impact analysis (EIA) to estimate the potential social costs of the regulation. This report presents the results of this analysis in which a market model was used to analyze the impacts of the air pollution rule on society.

1.1 Agency Requirements for an EIA

Congress and the Executive Office have imposed statutory and administrative requirements for conducting economic analyses to accompany regulatory actions. Section 317 of the CAA specifically requires estimation of the cost and economic impacts for specific regulations and standards under the authority of the Act. In addition, Executive Order (EO) 12866 requires a more comprehensive analysis of benefits and costs for significant regulatory actions.[1] Other statutory and administrative requirements include examination of the composition and distribution of benefits and costs. For example, the Regulatory Flexibility Act (RFA), as amended by the Small Business Regulatory Enforcement and Fairness Act of 1996 (SBREFA), requires EPA to consider the economic impacts of regulatory actions on small entities. The Agency's *OAQPS Economic Analysis*

[1]Office of Management and Budget (OMB) guidance under EO 12866 stipulates that a full benefit-cost analysis is required only when the regulatory action has an annual effect on the economy of $100 million or more.

Resource Document provides detailed instructions and expectations for economic analyses that support rulemaking (EPA, 1999).

1.2 Scope and Purpose

The CAA's purpose is to protect and enhance the quality of the nation's air resources (Section 101(b)). Section 112 of the CAA Amendments of 1990 establishes the authority to set national emissions standards for HAPs. This report evaluates the economic impacts of pollution control requirements placed on ICI boilers and process heaters under these amendments. These control requirements are designed to reduce releases of HAPs into the atmosphere.

To reduce emissions of HAPs, the Agency establishes maximum achievable control technology (MACT) standards. The term "MACT floor" refers to the minimum control technology on which MACT standards can be based. For existing major sources,[2] the MACT floor is the average emissions limitation achieved by the best performing 12 percent of sources (if there are 30 or more sources in the category or subcategory). For new sources, the MACT floor must be no less stringent than the emissions control achieved in practice by the best controlled similar source. The MACT can also be chosen to be more stringent than the floor, considering the costs and the health and environmental impacts.

The MACT floor will affect approximately 5,600 existing and new units. EPA developed annual compliance costs for model units in each of 83 different model unit types. EPA then linked the annualized compliance costs from the model units to the estimated existing population of boilers and process heaters to obtain national impact estimates. In addition, the Agency projected entrance of new boilers and process heaters through the year 2005, and linked the annualized compliance costs to these projected new units.

The economic impacts of national compliance costs, including both existing and new units, on affected markets was then estimated using a computerized market model. EPA used changes in prices and quantities in energy markets and final product markets to estimate the firm-, industry-, market-, and societal-level impacts associated with the regulation.

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[2]A major source is defined as a stationary source or group of stationary sources located within a contiguous area and under common control that emits, or has the potential to emit considering control, 10 tons or more of any one HAP or 25 tons or more of any combination of HAPs.

1.3 Organization of the Report

The remainder of this report is divided into six sections that describe the methodology and presents the analysis results:

- Section 2 provides background information on ICI boiler and process heater technologies.
- Section 3 profiles existing ICI boilers and process heaters by capacity, fuel type, and industry and presents projections of the future population of units in 2005. National compliance cost estimates are also presented in this section.
- Section 4 profiles the industries with the largest number of affected facilities. Included are profiles of the lumber and wood products (SIC 24/NAICS 321), paper and allied products (SIC 26/NAICS 322), and electrical services (SIC 49/NAICS 221) industries.
- Section 5 describes the methodology for assessing the economic impacts of the National Emission Standard for Hazardous Air Pollutants (NESHAP).
- Section 6 presents the results of the economic analysis, including market, industry, and social cost impacts.
- Section 7 provides the Agency's analysis of the regulation's impact on small entities.

In addition to these sections, Appendix A details the economic model used to predict the economic impacts of the NESHAP, Appendix B presents the results of sensitivity analyses on key model assumptions, and Appendix C presents results of analyses for regulatory alternative Option 1A.

SECTION 2

BOILER AND PROCESS HEATER TECHNOLOGIES

The three categories of combustion devices affected under the regulations are industrial, commercial, and institutional (ICI) boilers and process heaters. Although their primary function is to transfer heat generated from fuel combustion to materials used in the production process, the applications for boilers and process heaters are somewhat different. As a result, the primary industries using boilers may not be the same as those using process heaters. It is important to note that throughout this report the terms "boilers and process heaters," and "units" are synonymous with "ICI boilers and process heaters." Utility boilers primarily engaged in generating electricity are not covered by the NESHAP under analysis and are therefore excluded from this analysis.

Boilers are combustion devices used to produce steam or heat water. Steam is produced in boilers by heating water until it vaporizes. The steam is then channeled to applications within a facility or group of facilities via pipes. Steam is an important power and heating source for the U.S. economy. It is used in the preparation or manufacturing of many key products, such as paper, petroleum products, furniture, and chemicals. Steam is also used to heat buildings and to generate the majority of the electricity consumed in this country. There are literally thousands of boilers currently being used in the United States throughout a wide variety of industries.

Process heaters are primarily used as heat transfer units in which heat from fuel combustion is transferred to process fluids, although they may also be used to transfer heat to other nonfluid materials or to heat transfer materials for use in a process unit (not including generation of steam). Process heaters are generally used in heat transfer applications where boilers are inadequate. Often these are uses in which heat must be transferred at temperatures in excess of 90° to 204°C (200° to 400°F). Process heaters are used in the petroleum refining and petrochemical industries, with minor applications in the asphalt concrete, gypsum, iron and steel, and wood and forest products industries.

Since one of the main uses of boilers is to generate steam, some of the characteristics of steam are discussed in this section. This section also provides an overview of the various types of boiler and process heater characteristics and designs.

2.1 Characteristics of Steam

Steam, an odorless, invisible gas of vaporized water, may be interspersed with water droplets, which gives it a cloudy appearance. It is produced naturally when underground water is heated by volcanic processes and mechanically using boilers and other heating processes. When water is heated at atmospheric pressure, it remains in liquid form until its temperature exceeds 212°F, the boiling point of water. Additional heat does not raise the water's temperature but rather vaporizes the water, converting it into steam. However, if water is heated under pressure, such as in a boiler, the boiling point is higher than 212°F and more heat is required to generate steam. Once all the water has been vaporized into steam, the addition of heat causes the temperature and volume to increase. Steam's heating and work capabilities increase as it is produced under greater pressure coupled with higher temperatures. As steam escapes from the boiler, it can be directed through pipes to drive mechanical processes or to provide heat.

The steam used in most utility, industrial, and commercial applications is referred to as "clean steam." Clean steam encompasses steam purities ranging from pure, solid-free steam used in critical processes to filtered steam for less demanding applications. The various types of clean steam differ in steam purity and steam quality. Steam purity is a quantitative measure of contamination of steam caused by dissolved particles in the vapor or by tiny droplets of water that may remain in the steam. Steam quality is a measure of how much liquid water is mixed in with the dry steam (Fleming, 1992). Firms select the levels of steam quality and steam purity for their applications based on the sensitivity of their equipment to impurities, water droplet size, and condensation as well as the requirements for their production process. Using clean steam minimizes the risk of product contamination and prolongs equipment life. Although there are infinite possible levels of water purity and quality, the term "clean steam" generally refers to three basic types of steam:

- filtered steam—produced by filtering plant steam using high-efficiency filters. Filtered steam is generally of high steam quality because most large water droplets and other contaminants will be filtered out.
- clean steam—steam that is frequently produced from deionized and distilled water. Deionized and distilled water is free of dissolved solids and ions, which may corrode pipework.
- pure steam—similar to clean steam except that it is always produced from deionized and distilled water.

Steam applications can be categorized by the amount of pressure required: hot water, low pressure, and high pressure. Low pressure is 0 to 15 pounds per square inch (psi) and high pressure steam is above 15 psi (*Plant Engineering*, 1991). Hot water systems, which generate little steam, are primarily used for comfort applications, such as hot water for a building. Low pressure applications include process heat and space heating. High pressure steam applications are more frequently used in industrial and utility applications. Some high pressure applications require that the steam be superheated, a process which ensures that the steam is free of water droplets, to avoid damaging sensitive equipment.

Electric cogenerators, such as large factories and processing facilities, use steam to drive turbines to generate electricity. A conventional steam electric power plant burns fossil fuels (coal, gas, or oil) in a boiler, releasing heat that boils water and converts it into high-pressure steam (see Figure 2-1). The steam enters a turbine where it expands and pushes against blades to turn the generator shaft and create electric current. In this way, the thermal energy of steam becomes mechanical energy, which is converted into electricity. Steam used to drive turbines generates most of the electric power in the United States (TXU, 2000).

Industrial operations use steam to perform work such as powering complex machinery operations, in the same way that electric utilities use steam to rotate turbines. Textile mills, pulp and paper mills, and other manufacturing outfits are examples of facilities that use steam to run machinery. Steam also provides heat and pressure for manufacturing processes. Industrial establishments use steam to provide heat for drying or to heat and separate materials. For example, the paper industry uses steam to heat rollers that dry paper during the final stages of the production process. Petroleum refineries and chemical producers use steam to heat petroleum, raw materials, and other inputs to separate inputs into their constituent components or to facilitate chemical interactions. In addition to these applications, steam is employed in many other industrial processes, including textile production, wood working, furniture making, metal working, food preparation, and the manufacture of chemicals. Substitutes for using steam as process heat include electrical heating equipment, infrared, and other radiant drying techniques. Electricity may be used to power machinery, as well. However, switching from steam-powered to electricity-powered machinery would require significant equipment retrofits or replacement.

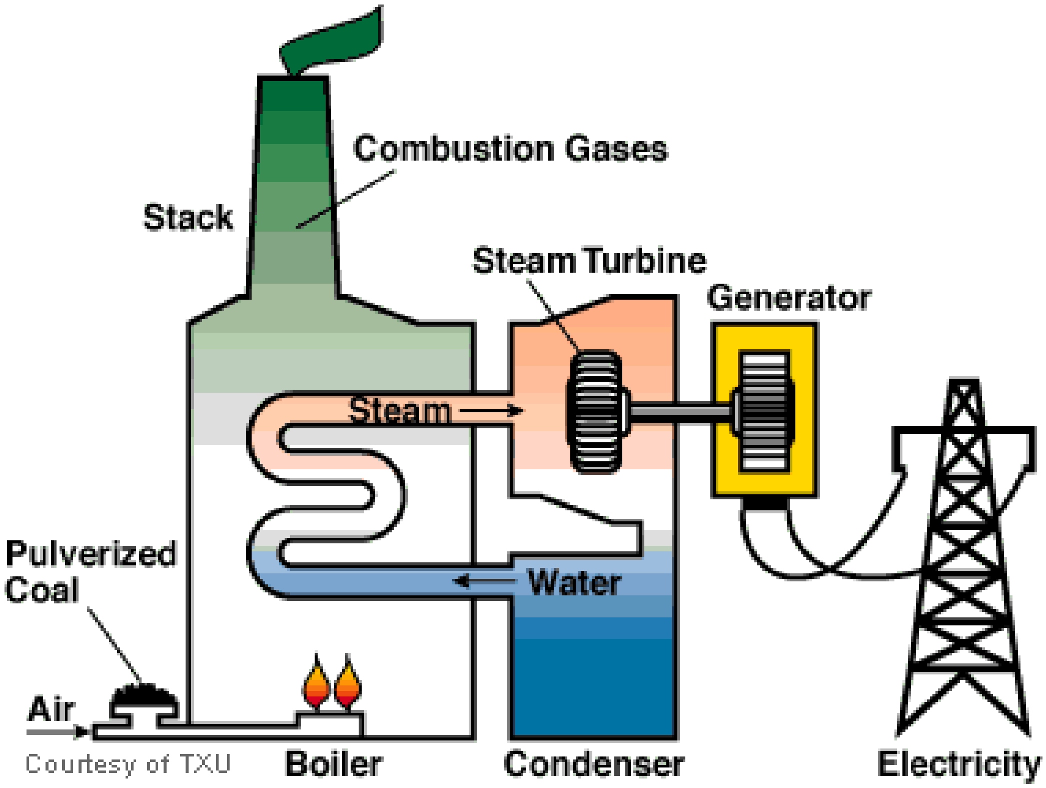

Figure 2-1. Generating Electricity: Steam Turbines

Source: Texas Utilities (TXU). 2000. "Generating Electricity: Steam Turbines." As obtained in September 2000. <http://www.txu.com/knowledge/energy_lib/generating01.html>.

Other steam applications include heating, sanitation, food processing and preparation, and cleaning. In addition to using boilers to heat water, factories, hospitals, government buildings, schools and other large buildings use boiler-generated steam to provide space heating. Substitutes for boilers in heating air and water include electrical water and space heaters; furnaces; and other heating, ventilation, and air conditioning equipment.

2.2 Fossil-Fuel Boiler Characterization

Section 2.2 discusses the different classes of fossil-fuel boilers, the most common heat transfer configurations, and the major design types. The discussion indicates the type(s) of fuel that each design can use to operate.

2.2.1 Industrial, Commercial, and Institutional Boilers

Industrial, commercial, and institutional boilers are primarily used for process heating, electrical or mechanical power generation, and/or space heating. Industrial boilers are used in all major industrial sectors but primarily by the paper products, chemical, food, and petroleum industries. It is estimated that the heat input capacity for these boilers is typically between 10 and 250 MMBtu/hr; however, larger industrial boilers do exist and are similar to utility boilers (EPA, 1997b). Commercial/institutional boilers are generally smaller than the industrial units, with heat input capacities generally below 10 MMBtu/hr. These units normally supply the steam and hot water for space heating in a wide range of locations, including wholesale and retail trade, office buildings, hotels, restaurants, hospitals, schools, museums, government buildings, and airports. Five hundred ninety-three of the 3,615 units potentially affected by the floor alternative for the regulation are commercial/institutional units.

A boiler system includes the boiler itself, associated piping and valves, operation and safety controls, water treatment system, and peripheral equipment such as pollution control devices, economizers, or superheaters (*Plant Engineering*, 1991). Most boilers are made of steel, cast iron, or copper. The primary fuels used by boilers are coal, oil, and natural gas, but some use electricity, waste gases, or biomass.

Boilers may either be erected onsite (field-erected boilers) or assembled at a factory (packaged boilers). Packaged boilers are typically lower in initial cost and more simple to install. However, field-erected boilers may have lower operating costs, less maintenance, and greater flexibility because the furnace or convection pattern chosen to meet required steam pressure, capacity, and fuel specifications is tailored to the boiler's potential use (*Plant Engineering*, 1991). Applications requiring more than 100,000 pounds of steam per hour are usually equipped with a field-erected boiler.

2.2.2 Heat Transfer Configurations

The heat transfer configuration of a boiler refers to the method by which heat is transferred to the water. The four primary boiler configurations are watertube, firetube, cast iron, and tubeless. Most industrial users tend to rely on either watertube or firetube configurations.

In a watertube boiler, combustion heat is transferred to water flowing through tubes lining the furnace walls and boiler passes. The furnace watertubes absorb primarily radiative heat, while the watertubes in the boiler passes gain heat by convective heat transfer. These units have a wide range of heat input capacities (ICI units range from 0.4 to 1,500 MMBtu/hr) and can be either field erected or packaged.[1] Watertube boilers with heat input capacities greater than 200 MMBtu/hr are typically field erected.

Because firetube, cast iron, and tubeless heat transfer configurations typically have heat input capacities below 10 MMBtu/hr, they will not generally be covered by the NESHAP. Therefore, this profile focuses on those boiler types that use watertube heat transfer configurations.

2.2.3 Major Design Types

This section summarizes the five major design types for fossil fuel industrial boilers that will be covered by the NESHAP. It also discusses, where possible, the fuels used, capacity, and assembly method of each of these types of boilers.

2.2.3.1 Stoker-Fired Boilers (Coal)

These units use underfeed air to combust the coal char on a stationary grate, combined with one or more levels of overfire air introduced above the grate. There are three types of stoker units:

- spreader stokers,
- underfeed stokers, and
- overfeed stokers.

Stokers generally burn all types of coal, with the exception of overfeed stokers, which do not burn coking bituminous coals. Stokers can also burn other types of solid fuel, such as wood, wood waste, and bagasse. Spreader stokers are the most common of these boiler types and have heat input capacities that typically range from 5 to 550 MMBtu/hr. However, some of these boilers have capacities as high as 1,500 MMBtu/hr. Smaller stoker units (i.e., those with heat input capacities less than 100 MMBtu/hr) are generally packaged, while larger units are usually field erected.

2.2.3.2 Pulverized Coal Boilers (Coal)

Combustion in pulverized coal-fired units takes place almost entirely while the coal is suspended, unlike in stoker units in which the coal burns on a grate. Finely ground coal is typically mixed with primary combustion air and fed to the burner or burners, where it is ignited and mixed with secondary combustion air. Depending on the location of the burners and the direction of coal injection into the furnace, pulverized coal-fired boilers can be classified into three different firing types:

- single and opposed wall,
- tangential, and
- cyclone.

Of these types, wall and tangential configurations are the most common. These firing methods are described further in Sections 2.2.3.4 and 2.2.3.5.

2.2.3.3 Fluidized Bed Combustion (FBC) Boilers (Coal)

FBC is an integrated technology for reducing sulfur dioxide (SO_2) and NO_x emissions during the combustion of coal. In a typical FBC boiler, crushed coal and inert material (sand, silica, alumina, or ash) and/or a sorbent (limestone) are maintained in a highly turbulent suspended state by the upward flow of primary air from the windbox located directly below the combustion floor. This fluidized state provides a large amount of surface contact between the air and solid particles, which promotes uniform and efficient combustion at lower furnace temperatures than conventional coal-fired boilers. Once the hot gases leave the combustion chamber, they pass through the convective sections of the boiler, which are similar or identical to components used in conventional boilers.

For the FBCs currently in use in all sectors, coal is the primary fuel source, followed in descending order by biomass, coal waste, and municipal waste. The heat input capacities of all ICI FBC units generally range from 1.4 to 1,075 MMBtu/hr.

2.2.3.4 Tangentially Fired Boilers (Coal, Oil, Natural Gas)

The tangentially fired boiler is based on the concept of a single flame zone within the furnace. The fuel-air mixture projects from the four corners of the furnace along a line tangential to an imaginary cylinder located along the furnace centerline. As fuel and air are fed to the burners and the fuel is combusted, a rotating "fireball" is formed. Primarily because of their tangential firing pattern, which leads to larger flame volumes and flame interaction, uncontrolled tangentially fired boilers generally emit relatively lower NO_x than other uncontrolled boiler designs.

Utilities primarily use this type of boiler. Coal is the most common fuel used by these units. Tangentially fired boilers operated by utilities are typically larger than 400 MW, while industrial ones almost always have heat input capacities over 100 MMBtu/hr. In general, most units with heat input capacities over 100 MMBtu/hr are field erected.

2.2.3.5 Wall-fired Boilers (Coal, Oil, Natural Gas)

Wall-fired boilers are characterized by multiple individual burners located on a single wall or on opposing walls of the furnace. In contrast to tangentially fired boilers, each of the burners in a wall-fired boiler has a relatively distinct flame zone, and the burners in wall-fired boilers do not tilt. Superheated steam temperatures are instead controlled by excess air levels, heat input, flue gas recirculation, and/or steam attemperation (water spray). Depending on the design and location of the burners, wall-fired boilers are referred to as single wall or opposed wall.

Wall-fired boilers are used to burn coal, oil, or natural gas, and some designs feature multifuel capability. Almost all industrial wall-fired boilers have heat input capacities greater than 100 MMBtu/hr. Opposed-wall boilers in particular are usually much larger than 250 MMBtu/hr heat input capacity and are much more common in utility rather than in industrial operations. Because of their size, most wall-fired units are field erected. Field-erected watertube boilers strictly designed for oil firing are more compact than coal-fired boilers with the same heat input, because of the more rapid combustion characteristics of fuel oil. Field-erected watertube boilers fired by natural gas are even more compact because of the rapid combustion rate of the gaseous fuel, the low flame luminosity, and the ash-free content of natural gas.

2.3 Process Heater Characterization

Process heaters are heat transfer units in which heat from fuel combustion is transferred to materials used in a production process. The process fluid stream is heated primarily for one of two reasons: to raise the temperature for additional processing or to make chemical reactions occur. This section describes the different classes of process heaters and major design types.

2.3.1 Classes of Process Heaters

The universe of process heaters is divided into two categories:

- indirect-fired process heater—any process heater in which the combustion gases do not mix with or exhaust to the atmosphere from the same stack(s) or vent(s) with any gases emanating from the process or material being processed.

- direct-fired process heater—any process heater in which the combustion gases mix with and exhaust to the atmosphere from the same stack(s) or vent(s) with gases originating from the process or material being processed.

Indirect-fired units are used in situations where direct flame contact with the material being processed is undesirable because of problems with contamination and ignition of the process material. Direct-fired units are used where such problems are not an important factor. Emissions of indirect-fired units consist solely of the products of combustion (including those of incomplete combustion). On the other hand, direct-fired units will generate emissions consisting not only of the products of combustion, but also the process material(s). This means that the emissions from indirect-fired process heaters will be generic to the fuel in use and are common across industries while emissions from direct-fired process heaters are unique to a given process and may vary widely depending on the process material. Only indirect-fired process heaters are considered under this regulation. Many direct-fired process heaters are being considered under separate MACT-development projects.

In addition to the distinction between direct- and indirect-fired heaters, process heaters may also be considered either heated feed or reaction feed. Heated feed process heaters are used to heat a process fluid stream before additional processing. These types of process heaters are used as preheaters for various operations in the petroleum refining industry such as distillation, catalytic cracking, hydroprocessing, and hydroconversion. In addition, heated feed process heaters are used widely in the chemical manufacturing industry as fired reactors (e.g., steam-hydrocarbon reformers and olefins pyrolysis furnaces), feed preheaters for nonfired reactors, reboilers for distillation operations, and heaters for heating transfer oils. Reaction feed process heaters are used to provide enough heat to cause chemical reactions to occur inside the tubes being heated. Many chemical reactions do not occur at room temperature and require the application of heat to the reactants to cause the reaction to take place. Applications include steam-hydrocarbon reformers used in ammonia and methanol manufacturing, pyrolysis furnaces used in ethylene manufacturing, and thermal cracking units used in refining operations.

2.3.2 Major Design Types

Process heaters may be designed and constructed in a number of ways, but most process heaters include burner(s), combustion chamber(s), and tubes that contain process fluids. Sections 2.3.2.1 through 2.3.2.4 describe combustion chambers setups, combustion air supply, tube configurations, and burners, respectively.

2.3.2.1 Combustion Chamber Set-Ups

Process heaters contain a radiant heat transfer area in the combustion chamber. This area heats the process fluid stream in the tubes by flame radiation. Equipment found in this area includes the burner(s) and the combustion chamber(s). Most heat transfer to the process fluid stream occurs here, but these tubes do not necessarily constitute a majority of the tubes in which the process fluid flows.

Most process heaters also use a convective heat transfer section to recover residual heat from the hot combustion gases by convective heat transfer to the process fluid stream. This section is located after the radiant heat transfer section and also contains tubes filled with process fluid. The first few rows of tubes in this section are called shield tubes and are subject to some radiant heat transfer. Typically, the process fluid flows through the convective section prior to entering the radiant section to preheat the process fluid stream. The temperature of the flue gas upon entering the convective section usually ranges from 800°C to 1,000°C (1,500°F to 2,000°F). Preheating in the convective section improves the efficiency of the process heater, particularly if the tube design includes fins or other extended surface areas. An extended tube surface area can improve efficiency by 10 percent. Extended tubes can reduce flue gas temperatures from 800°C to 1,000°C to (1,500°F to 2,000°F) to 120°C to 260°C (250°F to 500°F).

2.3.2.2 Combustion Air Supply

Air for combustion is supplied to the burners via either natural draft (ND) or mechanical draft (MD) systems. Natural draft heaters use ductwork systems to route air, usually at ambient conditions, to the burners. MD heaters use fans in the ductwork system to supply air, usually preheated, to the burners. The combustion air supply must have sufficient pressure to overcome the burner system pressure drops caused by ducting, burner registers, and dampers. The pressure inside the firebox is generally a slightly negative draft of approximately 49.8 to 125 Pascals (Pa) at the radiant-to-convective section transition point. The negative draft is achieved in ND systems via the stack effect and in MD systems via fans or blowers.

ND combustion air supply uses the stack effect to induce the flow of combustion air in the heater. The stack effect, or thermal buoyancy, is caused by the density difference between the hot flue gas in the stack and the significantly cooler ambient air surrounding the stack. Approximately 90 percent of all gas-fired heaters and 76 percent of all oil-fired heaters use ND combustion air supply (EPA, 1993).

There are three types of MD combustion air supply: forced draft, induced draft, and balanced draft. The draft types are named according to the position, relative to the combustion chamber, of the fans used to create the pressure difference in the process heater. All three types of MD heaters rely on the fans to supply combustion air and remove flue gas. In forced draft combustion air supply systems, the fan is located upstream from the combustion chamber, supplying combustion air to the burners. The air pressure supplied to the burners in a forced draft heater is typically in the range of 0.747 to 2.49 kilopascals (kPa). Though combustion air is supplied to the burners under positive pressure, the remainder of the process heater operates under negative pressure caused by the stack effect. In induced draft combustion air systems, the fan is located downstream of the combustion chamber, creating negative pressure inside the combustion chamber.

This negative pressure draws, or induces, combustion air into the burner registers. Balanced draft combustion air systems use fans placed both upstream and downstream (forced and induced draft) of the combustion chamber.

There are advantages and disadvantages for both ND and MD combustion air supply. One advantage to natural draft heaters is that they do not require the fans and equipment associated with MD combustion air supply. However, control over combustion air flow is not as precise in ND heaters as in MD heaters. MD heaters, unlike ND heaters, provide the option of using alternate sources of combustion oxygen, such as gas turbine exhaust. They also allow the use of combustion air preheat. Combustion air preheat has limited application in ND heaters due to the pressure drops associated with combustion air preheaters.

Combustion air preheaters are often used to increase the efficiency of MD process heaters. The maximum thermal efficiency obtainable with current air preheat equipment is 92 percent. Preheaters allow heat to be transferred to the combustion air from flue gas, steam, condensate, hydrocarbon, or other hot streams. The preheater increases the efficiency of the process heater because some of the thermal energy is reclaimed that would have been exhausted from the hot streams via cooling towers. If the thermal energy is from a hot stream other than the flue gas, the entire plant's efficiency is increased. The benefit of higher thermal efficiency is that less fuel is required to operate the heater.

2.3.2.3 Tube Configurations

The orientation of the tubes through which a process fluid stream flows is also taken into consideration when designing a process heater. The tubes in the convective section are oriented horizontally in most process heaters to allow cross-flow convection. However, the tubes in the radiant area may be oriented either horizontally or vertically. The orientation is chosen on a case-by-case basis according to the design specifications of the individual process heater. For example, the arbor, or wicket, type of heater is a specialty design to minimize the pressure drop across the tubes.

2.3.2.4 Burners

Many different types of burners are used in process heaters. Burner selection depends on several factors including process heat flux requirements, fuel type, and draft type. The burner chosen must provide a radiant heat distribution that is consistent with the configuration of the tubes carrying process fluid. Also, the number and location of the burner(s) depend on the process heater application.

Many burner flame shapes are possible, but the most common types are flat and conical. Flat flames are generally used in applications that require high temperatures such as ethylene pyrolysis furnaces, although some ethylene furnaces use conical flames to achieve uniform heat distribution. Long conical flames are used in cases where a uniform heat distribution is needed in the radiant section.

Fuel compatibility is also important in burner selection. Burners may be designed for combustion of oil, gas, or a gas/oil mixture. Gas-fired burners are simpler in operation and design than oil-fired burners and are classified as either premix or raw gas burners. In premix burners, 50 to 60 percent of the air necessary for combustion is mixed with the gas prior to combustion at the burner tip. This air is induced into the gas stream as the gas expands through orifices in the burner. The remainder of the air necessary for combustion is provided at the burner tip. Raw gas burners receive fuel gas without any premixed combustion air. Mixing occurs in the combustion zone at the burner tip.

Oil-fired burners are classified according to the method of fuel atomization used. Atomization is needed to increase the mixing of fuel and combustion air. Three types of fuel atomization commonly used are mechanical, air, and steam. Steam is the most widely used method because it is the most economical, provides the best flame control, and can handle the largest turndown ratios. Typical steam requirements are 0.07 to 0.16 kilogram (kg) steam/kg of oil.

Combination burners can burn 100 percent oil, 100 percent gas, or any combination of oil and gas. A burner with this capability generally has a single oil nozzle in the center of a group of gas nozzles. The air needed for combustion can be controlled separately in this type of burner. Another option is to base load the burners with one fuel and to add the other fuel to meet increases in load demand. Combination burners add flexibility to the process heater, especially when the composition of the fuel is variable.

The location and number of burners needed for a process heater are also determined on an individual basis. Burners can be located on the ceiling, walls, or floor of the combustion chamber. Floor- and wall-fired units are the most common burner types found in process heaters because they are both efficient and flexible. In particular, floor-mounted burners integrate well with the use of combustion air preheat, liquid fuels, and alternate sources of combustion oxygen such as turbine exhaust.

The number of burners in a heater can range from 1 to over 100. In the refinery industry, the average number of burners is estimated at 24 in ND heaters with an average design heat release of 69.4 million Btu per hour (MMBtu/hr). The average number of burners is estimated at 20 in MD heaters with ambient combustion air and an average design heat release of 103.6 MMBtu/hr. The average number of burners is estimated at 14 in MD heaters with combustion air preheat and an average design heat release of 135.4 MMBtu/hr. In general, the smaller the number of burners, the simpler the heater will be. However, multiple burners provide a more uniform temperature distribution.

SECTION 3

PROFILE OF AFFECTED UNITS AND FACILITIES, AND COMPLIANCE COSTS

The floor-level MACT for the regulation will affect existing and new ICI boilers and process heaters that have input capacity greater than 10 million Btus and are fueled by fossil and nonfossil fuel solids and liquids. The economic impact estimates presented in Section 6 and the small entity screening analysis presented in Section 7 are based on the estimated stock of existing units and the projection of new units through the year 2005. They are also based on the compliance costs associated with applying the final rule to these units. This section begins with a review of the industry distribution and technical characteristics of existing boilers and process heaters contained in the Agency's Inventory Database. It also presents projected growth estimates for boilers and process heaters through the year 2005, a description of how costs are estimated, and the national engineering cost estimates and cost-effectiveness (cost/ton) estimates by pollutant controlled.

3.1 Regulatory Alternatives

Section 112 of the CAA requires EPA to promulgate regulations for the control of HAP emissions from each source category listed under section 112(c). The statute requires the regulations to reflect the maximum degree of reductions in emissions of HAP that is achievable taking into consideration the cost of achieving emissions reductions, any nonair quality health and environmental impacts, and energy requirements. This level of control is commonly referred to as MACT. The MACT regulation can be based on the emissions reductions achievable through application of measures, processes, methods, systems, or techniques including, but not limited to: (1) reducing the volume of, or eliminating emissions of, such pollutants through process changes, substitutions of materials, or other modifications; (2) enclosing systems or processes to eliminate emissions; (3) collecting, capturing, or treating such pollutants when released from a process, stack, storage or fugitive emission point; (4) design, equipment, work practices, or operational standards as provided in subsection 112(h); or (5) a combination of the above.

For new sources, MACT standards cannot be less stringent than the emission control achieved in practice by the best-controlled similar source. The MACT standards for existing sources can be less stringent than standards for new sources, but they cannot be less stringent than the average emission limitation achieved by the best-performing 12 percent of existing sources for categories and subcategories with 30 or more sources, or the best-performing 5 sources for categories or subcategories with fewer than 30 sources.

In essence, these MACT standards would ensure that all major sources of air toxic emissions achieve the level of control already being achieved by the better-controlled and lower-emitting sources in each category. This approach provides assurance to citizens that each major source of toxic air pollution will be required to effectively control its emissions. A major source of HAP emissions is any stationary source or group of stationary sources located within a contiguous area and under common control that emits or has the potential to emit any single HAP at a rate of 9.07 Mg (10 tons) or more per year or any combination of HAPs at a rate of 22.68 Mg (25 tons) or more a year. At the same time, this approach provides a level economic playing field, ensuring that facilities that employ cleaner processes and good emission controls are not disadvantaged relative to competitors with poorer controls.

3.1.1 Regulatory Background

In September 1996, EPA chartered the Industrial Combustion Coordinated Rulemaking (ICCR) advisory committee under the Federal Advisory Committee Act (FACA). The committee's objective was to develop recommendations for regulations for several combustion source categories under sections 112 and 129 of the CAA. The ICCR advisory committee, known as the Coordinating Committee, formed Source Work Groups for the various combustion types covered under the ICCR. One of the work groups was formed to research issues related to boilers. Another was formed to research issues related to process heaters. The Boiler and Process Heater Work Groups submitted recommendations, information, and data analysis results to the Coordinating Committee, which in turn considered them and submitted recommendations and information to EPA. The Committee's recommendations were considered by EPA in developing these proposed standards for boilers and process heaters. The Committee’s 2-year charter expired in September 1998.

Following the expiration of the ICCR FACA charter, EPA decided to combine boilers with units in the process heater source category covering indirect fired units, and to regulate both under this NESHAP. This was done because indirect fired process heaters and boilers are similar devices, burn similar fuel, have similar emission characteristics, and emissions from each can be controlled using similar control devices or techniques.

3.1.2 Regulatory Authority

Section 112 of the CAA requires that EPA promulgate regulations requiring the control of HAP emissions from major sources and certain area sources. The control of HAP is achieved through promulgation of emission standards under sections 112(d) and (f) and, in appropriate circumstances, work practice standards under section 112(h) of the CAA.

An initial list of categories of major and area sources of HAP selected for regulation in accordance with section 112(c) of the CAA was published in the Federal Register on July 16, 1992 (57 FR 31576). Industrial boilers, commercial and institutional boilers, and process heaters are three of the listed 174 categories of sources. The listing was based on the Administrator's determination that they may reasonably be anticipated to emit several of the 188 listed HAP in quantities sufficient to designate them as major sources.

This rule affects industrial boilers, institutional and commercial boilers, and process heaters. In this rule process heaters are defined as units in which the combustion gases do not directly come into contact with process gases in the combustion chamber (e.g. indirect fired). Boiler means an enclosed device using controlled flame combustion and having the primary purpose of recovering thermal energy in the form of steam or hot water. A waste heat boiler (or heat recovery steam generator) is a device that recovers normally unused energy and converts it to usable heat. Waste heat boilers are excluded from this rule. A hot water heater is a closed vessel in which water is heated by combustion of gaseous fuel and is withdrawn for use external to the vessel at pressures not exceeding 160 psig. Hot water heaters are excluded from this rule.

Boilers and process heaters emit particulate matter, volatile organic compounds, and hazardous air pollutants, depending on the material burned. Solid and liquid fuel-fired units emit metals, halogenated compounds and organic compounds. Gas fuel-fired units emit mostly organic compounds.

The affected source is each individual industrial, commercial, or institutional boiler or process heater located at a major facility. The affected source does not include units that are municipal waste combustors (40 CFR part 60, subparts AAAA, BBBB or Cb), medical waste incinerators (40 CFR part 60, subpart Ce and Ec), fossil fuel fired electric utility steam generating units, commercial and industrial solid waste incineration units (40 CFR part 60 subparts CCCC or DDDD), recovery boilers or furnaces (40 CFR part 63, subpart MM), or hazardous waste combustion units required to have a permit under section 3005 of the Solid Waste Disposal Act or are subject to 40 CFR part 63, subpart EEE.

The rule applies to an owner or operate a boiler or process heater at a major source meeting the requirements in section II.C. A major source of HAP emissions is any stationary source or group of stationary sources located within a contiguous area and under common control that emits or has the potential to emit any single HAP at a rate of 9.07 Mg (10 tons) or more per year or any combination of HAP at a rate of 22.68 Mg (25 tons) or more a year.

An affected operator must meet the emission limits for the subcategories in Table 3-1 of this preamble for each of the pollutants listed. Emission limits were developed for new and existing sources; and for large, small, and limited use solid, liquid, and gas fuel fired units. Large units are those with heat input capacities greater than 10 MMBtu/hr. Small units are those with heat input capacities less than or equal to 10 MMBtu/hr. Limited use units are those with capacity utilizations less than or equal to 10 percent as required in a federally enforceable permit.

If your new or existing boiler or process heater is permitted to burn a solid fuel, or any combination of solid fuel with liquid or gaseous fuel, the unit is in one of the solid subcategories. If your new or reconstructed boiler or process heater burns a liquid fuel, or a liquid fuel in combination with a gaseous fuel, the unit is in one of the liquid subcategories. If your new or existing boiler or process heater burns a gaseous fuel only, the unit is in the gas subcategory and is not required to meet any emission limit.

For solid fuel-fired boilers or process heaters, we are allowing sources to choose one of two emission limit options: (1) existing and new affected sources may choose to limit PM emissions to the level listed in Table 3-1 or (2) existing and new affected sources may choose to limit total selected metals emissions to the level listed in Table 3-1 of this preamble.

If you do not use an add-on control or use an add-on control other than a wet scrubber, you must maintain opacity level to less than or equal to the level established during the compliance test for mercury and PM or total selected metals, and maintain the fuel chlorine content to less than or equal to the operating level established during the HCl compliance test.

If you use a wet scrubber, you must maintain the minimum pH, pressure drop and liquid flowrate above the operating levels established during the performance tests.

If you use a dry scrubber, you must maintain opacity level and the minimum sorbent injection rate established during the performance test.

Table 3-1. Emission Limits for Boilers and Process Heaters (lb/MMBtu)

Source	Subcategory	PM	or	Total Selected Metals	HC1	Mercury (Hg)	Carbon Monoxide (CO-ppm @ 3% oxygen)
New Boiler or Process Heater	Solid Fuel, Large Unit	0.04	or	0.00007	0.016	0.0000026	200
	Solid Fuel, Small Unit	0.04	or	0.00007	0.032	0.0000026	—
	Solid Fuel, Limited Use	0.04	or	0.00007	0.032	0.0000026	200
	Liquid Fuel, Large Unit	0.068		—	0.00045		200
	Liquid Fuel, Small Unit	0.068		—	0.0009	—	—
	Liquid Fuel, Limited Use	0.068		—	0.0009	—	200
	Gaseous Fuel, Large Unit	—		—	—	—	200
	Gaseous Fuel, Small Unit	—		—	—	—	
	Gaseous Fuel, Limited Use	—		—	—	—	200
Existing Boiler or Process Heater	Solid Fuel, Large Unit	0.062	or	0.001	0.048	0.000004	—
	Solid Fuel, Small Unit	—		—	—	—	—
	Solid Fuel, Limited Use	0.21	or	0.001	—	—	—
	Liquid Fuel, Large Unit	—		—	—	—	—
	Liquid Fuel, Small Unit	—		—	—	—	—
	Liquid Fuel, Limited Use	—		—	—	—	—
	Gaseous Fuel	—		—	—	—	—

If you use an ESP in combination with a wet scrubber and cannot monitor the opacity, you must maintain the average secondary current and voltage or total power input established during the performance test.

There is an alternative compliance procedure and operating limit for meeting the total selected metals emission limit option. If you have no control or do not want to take credit of metals reductions with your existing control device, and can show that total metals in the fuel would be less than the metals emission level, then you can monitor the metals fuel analysis to meet the metals emissions limitations. Similarly, if you have no control or do not want to take credit of mercury reduction with your existing control device, and can show that mercury in the fuel would be less than the mercury emission level, then you can monitor the mercury fuel analysis to meet the mercury emission limitations.

3.1.3 Regulatory Alternatives and Control Technologies

3.1.3.1 MACT Floor Development

We considered several approaches to identifying MACT floor for existing industrial, commercial, and institutional boilers and process heaters. First, we considered using emissions data on boilers and process heaters to set the MACT floor. However, after review of the data available, we determined that emissions information was inadequate to set MACT floors. We then considered using State regulations and permits to set the MACT floors. However, we found no State regulations or State permits which specifically limit HAP emissions from these sources.

Consequently, we concluded that the only reasonable approach for determining MACT floors is to base it on control technology. Information was available on the control technologies employed by the population of boilers identified by the EPA. We considered several possible control technologies (i.e., factors that influence emissions), including fuel substitution, process changes and work practices, and add-on control technologies.

We first considered whether fuel switching would be an appropriate control option for sources in each subcategory. Both fuel switching to other fuels used in the subcategory and fuels from other subcategories were considered. This consideration included determining whether switching fuels would achieve lower HAP emissions. A second consideration was whether fuel switching could be technically done on boilers and process heaters in the subcategory considering the existing design of boilers and process heaters. We also considered the availability of the alternative fuel.

After considering these factors, we determined that fuel switching was not an appropriate control technology to be included in determining the MACT floor level of control for any subcategory. This decision was based on the overall effect of fuel switching on HAP emissions, technical and design considerations discussed in section III.A of this preamble, and concerns about fuel availability.

Based on the data available in the emissions database, we determined that while fuel switching from solid fuels to gaseous or liquid fuels would decrease PM and some metals emissions, emissions of some organic HAP would also increase, resulting in uncertain benefits. We determined that it would be inappropriate in a MACT rulemaking, that is technology based, to consider a technology that potentially will result in an increase in a HAP regardless of its potential to reduce other HAP without determining the overall benefit. Determining the benefits of fuel switching would require an assessment of the risk associated which each HAP emitted and a determination of which fuel results in the overall lower risk taking into account the available control technology for each fuel. This assessment will be performed in a future rulemaking.

A similar determination was made when considering fuel switching to “cleaner” fuels within a subcategory. For example, the term “clean coal” refers to coal that is lower in sulfur content and not necessarily lower in HAP content. Data gathered by EPA also indicates that within specific coal types HAP content can vary significantly. Switching to a “clean coal” may increase emissions of some HAP. Therefore, fuel switching to a “cleaner” coal would not be an appropriate option. Fuel switching from coal to biomass would result in similar impacts on HAP emissions. While metallic HAP emissions would be reduced, emissions of organics would increase based on information in the emissions database.

Another factor considered was the availability of alternative fuels. Natural gas pipelines are not available in all regions of the U.S., and natural gas is simply not available as a fuel for many industrial, commercial, and institutional boilers and process heaters. Moreover, even where pipelines provide access to natural gas, supplies of natural gas may not be adequate. For example, it is common practice in cities during winter months (or periods of peak demand) to prioritize natural gas usage for residential areas before industrial usage. Requiring EPA regulated combustion units to switch to natural gas would place an even greater strain on natural gas resources. Consequently, even where pipelines exist some units would not be able to run at normal of full capacity during these times if shortages were to occur. Therefore, under any circumstances, there would be some units that could not comply with a requirement to switch to natural gas.

Similar problems for fuel switching to biomass could arise. Existing sources burning biomass generally are combusting a recovered material from the manufacturing or agriculture process. Industrial, commercial, and institutional facilities that are not associated with the wood products industry or agriculture may not have access to a sufficient supply of biomass materials to replace their fossil fuel.

There are many concerns with switching fuels on sources designed and operated to burn specific fuels. Changes to the fuel type (solid, liquid, or gas) will require extensive changes to the fuel handling and feeding system (e.g., a stoker using wood as fuel would need to be redesigned to handle fuel oil or gaseous fuel). Additionally, burners and combustion chamber designs are generally not capable of handling different fuel types, and generally cannot accommodate increases or decreases in the fuel volume and shape. Design changes to allow different fuel use, in some cases, may reduce the capacity and efficiency of the boiler or process heater. Reduced efficiency may result in a greater degree of incomplete combustion and, thus, an increase in organic HAP emissions. For the reasons discussed above, we decided that fuel switching to "cleaner" solid fuels or to liquid or gaseous fuels would not be appropriate or available as a MACT floor level.

We also determined that using process changes or work practices were not appropriate in developing MACT floors. HAP emissions from boilers and process heaters are primarily dependent upon the composition of the fuel. Fuel dependent HAP are metals, including mercury, and acid gases. Fuel dependent HAP are typically controlled by removing them from the flue gas after combustion. Therefore, they are not affected by the operation of the boiler or process heater. Consequently, process changes would be ineffective in reducing these fuel-related HAP emissions.

On the other hand, organic HAP can be formed from incomplete combustion of the fuel. Data are not available that definitively show that organic HAP emissions are related to the operation of the boiler or process heater. Some studies indicate that organic HAP are greatly influence by time, turbulence and temperature. Other studies indicate that organic HAP emissions are not affected by the operation of the unit. The measurement of CO is generally an indicator of incomplete combustion since CO will burn to carbon dioxide if adequate oxygen is available. Correcting incomplete combustion may be accomplished through providing more combustion air. Therefore, we consider monitoring and maintaining CO emission levels to be associated with minimizing organic HAP emission levels and, thus, CO monitoring would be a good indicator of combustion efficiency and organic HAP emissions.

In summary, we determined that considering process changes and work practices would not be appropriate in developing MACT floors for existing units. We are requesting comment, and information on emission reductions, on whether there are other GCP practices that would be appropriate for minimizing organic HAP emissions from industrial, commercial, and institutional boilers and process heaters.

Consequently, we concluded that add-on control technology is the only factor that significantly controls HAP emissions.

In order to determine the MACT floor based on add-on control technologies, we first examined the population database of existing sources. Units not meeting the definition of an industrial, commercial, or institutional boiler or process heater, and units located at area sources were removed from the database. The remaining units were divided first into three subcategories based on fuel state: gaseous fuel-fired, liquid fuel-fired, and solid fuel-fired units. Each of these three subcategories was then further divided into subcategories based on capacity: (1) large boilers and process heaters (units with heat inputs greater than 10 MMBtu/hr); (2) small units (with a maximum rated heat input capacity of 10 MMBtu/hr or less); and (3) limited use units with capacity utilization less than 10 percent.

We identified the types of air pollution control techniques currently used by existing boilers and process heaters in each subcategory. We ranked those controls according to their effectiveness in removing the different categories of pollutants; including metallic HAP and PM, inorganic HAP such as acid gases, mercury, and organic HAP. The EPA ranked these existing control technologies by incorporating recommendations made by the ICCR, and by reviewing emissions test data, previous EPA studies, and other literature, as well as by using engineering judgement.

Based upon the emissions reduction potential of existing air pollution control techniques, we listed all the boilers and process heaters in the population database in order of decreasing control device effectiveness for each subcategory. Then the technology basis of the existing source MACT floor was determined for each pollutant category by identifying the best-performing 12 percent of units. We then selected the technology used by the median unit in the best performing 12 percent of units (i.e., the boiler or process heater unit representing the 94th percentile) as the technology associated with the MACT floor level of control for each subcategory. As previously described, emissions data for this category is insufficient to identify the best-performing units. The most appropriate way to identify the average emission limitation achieved by the best-performing 12 percent of existing sources is to identify the technology used by the unit in the middle of the range of the best performing 12 percent of units, i.e., the median unit).

After establishing the technology basis for the existing source MACT floor for each subcategory and each type of pollutant, the EPA examined the emissions data available for boilers and process heaters controlled by these technologies to determine achievable emission levels. The resulting emission levels associated with the existing source MACT floors for each pollutant are based on the average of the lowest three run average test data from units using the technology associated with the MACT floor level of control, and by incorporating operational variability using results from multiple tests on these best performing units. This approach reasonably ensures that the emission limit selected as the MACT floor represents a level of control that can be consistently achieved by a unit in the subcategory using the control technology associated with the MACT floor. This approach is reasonable because the most informative way to predict the worst reasonably foreseeable performance of the best-controlled units, with available data, is to examine the available long-term performance of the best performing units that had multiple test results. In other words, the EPA considers all units with the same control technology that is properly designed and operated to be equally well controlled, even if the emission test results from such units vary considerably.

The level of control "achieved" by the average of the top performing 12 percent of units is best represented by the average emissions observed from all units using the same technology as that employed by the unit representing the median of the top 12 percent.

The EPA's review of emissions data indicates that some boilers and process heaters within each subcategory may be able to meet the floor emission levels without using the air pollution control technology that is associated with the MACT floor. This is to be expected, given the variety of fuel types, fuel input rates, and boiler designs included within each subcategory and the resulting variability in emission rates. Thus, for instance, boilers or process heaters within the large unit solid fuel subcategory that burn lower percentages of solid fuels may be able to achieve the emission levels for the large unit solid fuel subcategory without the need for additional control devices.

Furthermore, solid fuels, especially coal, are very heterogeneous and can vary in composition by location. Coal analysis data obtained from the electric utility industry in another rulemaking contained information on the mercury, chlorine, and ash content of various coals. A preliminary review of this data indicate that the composition can vary greatly from location to location, and also within location. Based on the range of variation of mercury, chlorine, and ash content in coal, it is possible for a unit with a lower performing control system to have emission levels lower than a unit considered to be included in the best performing 12 percent of the units.

This situation is reflected in the emissions information used to set the MACT floor emission limits. In some instances there are boilers with ESP's or other controls that achieve similar, or lower, outlet emission levels of non-mercury metallic HAP, PM, or mercury to fabric filters. In most cases, this is due to concentrations entering these other control devices being lower, even though the percent reduction achieved is lower than fabric filters.

Additionally, the design of some control devices may have a substantial effect on the their emission reduction capability. For example, fabric filters are largely insensitive to the physical characteristics of the inlet gas stream. Thus, their design does not vary widely, and emissions reductions are expected to be similar (e.g. 99 percent reduction of PM). However, ESP design can vary significantly.

Consequently, since fuel substitution has been determined not to be an appropriate MACT floor control technology, EPA still considers the fabric filter to be the best-performing control for non-mercury metallic HAPs, PM, and mercury and only emissions information for fabric filters was used to develop emission limits. A detailed discussion of the MACT floor methodology is presented in the memorandum "MACT Floor Analysis for New and Existing Sources in the Industrial, Commercial, and Institutional Boilers and Process Heaters Source Categories" in the docket.

Existing Solid Fuel Boilers and Process Heaters Large Units-Heat Inputs Greater than 10 MMBtu/hr. The most effective control technologies identified for removing non-mercury metallic HAP and PM are fabric filters. About 14 percent of solid fuel-fired boilers and process heater use fabric filters. Because this is the technology used by the 94th percentile (the median of the best-performing 12 percent), the EPA considers a fabric filter to be the technology basis for the MACT floor for non-mercury metallic HAP control for existing boilers and process heaters in this subcategory.

The most effective control technologies identified for removing inorganic HAP that are acid gases, such as hydrogen chloride, are wet scrubbers and packed bed scrubbers. These technologies are used by about 12 percent of the boilers and process heaters in the solid fuel subcategory. About 10 percent of solid-fired boilers and process heaters use wet scrubbers, and approximately 1 percent use packed bed scrubbers. Because wet scrubbers are the technology used by the 94th percentile (median of the best-performing 12 percent), the EPA considers a wet scrubber to be the technology basis for the MACT floor for acid gas control for existing boilers and process heaters in the solid fuel subcategory. The MACT floor emission level based on wet scrubbers and incorporating operational variability is 0.048 lb HCl/MMBtu.

Based on test information on utility boilers, we have concluded that fabric filters are most effective in controlling mercury, and units having them would constitute the best controlled mercury sources. As discussed previously, more than 6 percent of sources in the subcategory have fabric filters. The MACT floor emission level based on fabric filters and incorporating operational variability is 0.000004 lb mercury/MMBtu.

For organic HAP, we assessed whether maintaining and monitoring CO levels would be part of the MACT floor, and determined that less than 6 percent of the units in this subcategory do so. Therefore, we concluded the MACT floor for existing sources in this subcategory is no emissions reductions for organic HAP.

Therefore, the EPA determined that the combination of fabric filter and wet scrubber control technologies forms the basis for the MACT floor level of control for existing solid fuel boilers or process heaters in this subcategory. We recognize that some boilers and process heaters that use technologies other than those used as the basis of the MACT floor can achieve the MACT floor emission levels. For example, emission test data show that many boilers with well-designed and operated ESP can meet the MACT floor emission levels for non-mercury metallic HAP and PM, even though the floor emission level for these pollutants is based on a fabric filter (however, we would not expect that all units using ESP would be able to meet the proposed rule).

Small Units—Heat Inputs Less than or Equal to 10 MMBtu/hr. Less than 6 percent of the units in this subcategory used control techniques that would reduce non-mercury metallic HAP and PM, mercury, and inorganic HAP, such as HCl. Also, maintaining and monitoring CO levels was used by less than 6 percent of the units in the subcategory.

Therefore, we determined that the MACT floor emission level for existing units for any of the pollutant categories in this subcategory is no emissions reductions.

Limited Use Units—Capacity Utilizations Less than or Equal to 10 Percent. The most effective control technologies identified for removing non-mercury metallic HAP and PM are ESP and fabric filters. Less than 2 percent of solid fuel-fired boilers and process heater in this subcategory use fabric filters, and 14 percent use ESP. Because ESP are the technology used by the 94th percentile (the median of the best-performing 12 percent), the

EPA considers an ESP to be the technology basis for the MACT floor for non-mercury metallic HAP control for existing boilers and process heaters in the solid fuel subcategory. A PM level is set as a surrogate for non-mercury metallic HAP control. The MACT floor emission level based on ESPs, considering operational variability, is 0.021 lb PM/MMBtu. We are also providing an alternative metals limit of 0.001 lb metals/MMBtu which can be used to show compliance in cases where metal HAP emissions are low in proportion to PM emissions.

Similar control technology analyses were done for the boilers and process heaters in this subcategory for the other pollutant groups of interest, including inorganic HAP, organic HAP and mercury. Less than 6 percent of the units in this subcategory have controls that would reduce emissions of organic HAP, mercury, and inorganic HAP, so the existing source MACT floor for those pollutants is no emissions reductions. Therefore, we determined that ESP control technology, which achieves non-mercury metallic HAP and PM control forms the basis for the MACT floor level of control for existing solid fuel boilers and process heaters in this subcategory.

Existing Liquid Fuel Boilers and Process Heaters. Emissions data for liquid subcategories was inadequate to identify the best-performing sources for reasons described in section D of the preamble. We also found no State regulations or permits which specifically limit HAP emissions from these sources. Therefore, we examined control technology data to identify a MACT floor. We found that less than 6 percent of the units in each of the liquid subcategories used control techniques that would reduce non-mercury metallic HAP and PM, mercury, organic HAP, or inorganic HAP (such as HCl). Therefore, we determined that the control technique associated with the 94th percentile (the median of the best-performing 12 percent) could not be identified.

Therefore, we are unable to identify the best performing 12 percent of units in the subcategories. In light of this analysis, we concluded the MACT floor for existing sources in these liquid subcategory is no emissions reductions for non-mercury metallic HAP, mercury, inorganic HAP, and organic HAP.

Existing Gaseous Fuel Boilers and Process Heaters. Emissions data for gas subcategories was inadequate to identify the best-performing sources for reasons described in section D of the preamble. We also found no State regulations or permits which specifically limit HAP emissions from these sources. Therefore, we examined control technology data to identify a MACT floor. We found that no existing units in the gaseous fuel-fired subcategories were using control technologies that achieve consistently lower emission rates than uncontrolled sources for any of the pollutant groups of interest. Therefore, we are unable to identify the best performing 12 percent of units in the subcategories. Consequently, the EPA determined that no existing source MACT floor based on control technologies could be identified for gaseous fuel-fired units. Therefore, we concluded the MACT floor for existing sources in this subcategory is no emissions reductions for non-mercury metallic HAP, mercury, inorganic HAP, and organic HAP.

3.1.3.2 Consideration of Options Beyond the Floor for Existing Units

Once the MACT floor determinations were done for each subcategory, the EPA considered various regulatory options more stringent than the MACT floor level of control (i.e., technologies or other work practices that could result in lower emissions) for the different subcategories.

Maintaining and monitoring CO levels was identified as a possible control for organic HAPs. However, less than 6 percent of the sources in the existing source subcategories used this control method and it was not considered the MACT floor control technology. We then looked at it as an above-the-floor option. However, information was not available to estimate the HAP emissions reductions that would be associated with CO monitoring and emission limits. This option would also require a high cost to install and operate CO monitors. Given the cost and the uncertain emissions reductions that might be achieved, we chose to not require CO monitoring and emission limits as MACT.

The following sections discuss the above-the-floor options analyzed to control emissions of metallic HAP, mercury, and inorganic HAP. Based on the analysis described in these sections, the EPA decided to not go beyond the MACT floor level of control for the proposed rule for any of the subcategories of existing sources.

Existing Solid Fuel Units. Large Units—Heat Inputs Greater than 10 MMBtu/hr. Besides fuel switching (see section III.D of this preamble), we identified a better designed and operated fabric filter (the MACT floor for new units) as a control technology that could achieve greater emissions reductions of metallic HAP and PM emissions than the MACT floor level of control (i.e., a typical existing fabric filter). Consequently, the EPA analyzed the emissions reductions and additional cost of adopting an emission limit representative of the performance of a unit with a better designed and operated fabric filter. The additional annualized cost to comply with this emission limit was estimated to be approximately 500 million dollars with an additional emission reduction of approximately 100 tons of metallic HAP. The results indicated that while additional emissions reductions would be realized, the costs would be too high to consider it a feasible above the floor option. Non-air quality health, environmental impacts, and energy effects were not significant factors, because there would be little difference in the non-air quality health and environmental impacts of replacing existing fabric filters with improved performance fabric filters. Therefore, we did not select these controls as MACT. Fuel switching was not considered a feasible beyond-the-floor option for the same reasons described in section III.E of the proposal preamble.

We identified packed bed scrubbers as a control technology that could achieve greater emissions reductions of inorganic HAP, like HCl, than the MACT floor level of control (i.e., a wet scrubber). Consequently, the EPA analyzed the emissions reductions and additional cost of adopting an emission limit representative of the performance of a unit with a packed bed scrubber. The additional annualized cost to comply with this emission limit (using a packed bed scrubber) was estimated to be approximately 900 million dollars with an additional emission reduction of approximately 20,000 tons of HCl. The results indicated that while additional emissions reductions would be realized, the costs would be too high to consider it a feasible above the floor option. Non-air quality health, environmental impacts, and energy effects were not significant factors, because there would be little difference in the non-air quality health and environmental impacts between packed bed scrubbers and wet scrubbers. Therefore, we did not select these controls as MACT.

In reviewing potential regulatory options for existing sources, the EPA identified one existing industrial boiler that was using a technology, carbon injection, used in other industries to achieve greater control of mercury emissions than the MACT floor level of control. However, emission data indicated that this unit was not achieving mercury emission reductions. The EPA does not have information that would show carbon injection is effective for reducing mercury emissions from industrial, commercial, and institutional boilers and process heaters. Therefore, carbon injection was not evaluated as a regulatory option.

However, the EPA requests comments on whether carbon injection should be considered as a beyond-the-floor option and whether existing industrial, commercial, or institutional boilers and process heaters could use carbon injection technology, or other control techniques to consistently achieve mercury emission levels that are lower than levels from similar sources with the MACT floor level of control. The EPA is aware that research continues on ways to improve mercury capture by PM controls, sorbent injection, and the development of novel techniques. The EPA requests comment and information on the effectiveness of such control technologies in reducing mercury emissions.

Small Units—Heat Inputs Less than or Equal to 10 MMBtu/hr. The EPA could not identify a technology-based level of control for the MACT floor for this subcategory. To control non-mercury metallic HAP and mercury, we analyzed the above the floor option of a fabric filter which was identified as the most effective control device for non-mercury metallic HAP and mercury. To control inorganic HAP such as hydrogen chloride, we analyzed the above the floor option of a wet scrubber since it was identified as the least cost option.

The total annualized cost of complying with the fabric filter option was estimated to be $10 million, with an estimated emission reduction of 1.9 tons per year of non-mercury metallic HAP and 0.003 tons of mercury. The annualized cost of complying with the wet scrubber option was estimated to be $11 million, with an emission reduction of 48 per year of HCl. The results of this analysis indicated that while additional emissions reductions could be realized, the costs would be too high to consider them feasible options. Therefore, we did not select these controls as MACT. Non-air quality health, environmental impacts, and energy effects were not significant factors.

Limited Use Units—Capacity Utilizations Less than or Equal to 10 Percent. The MACT floor level of control for this subcategory for non-mercury metallic HAP control is an ESP. Although fabric filters were identified as being more effective, many ESP can achieve similar levels. Any additional emission reduction from using a fabric filter would be minimal and costly considering retrofit costs for existing units that already have ESP. Therefore, an above-the-floor option for metallic HAP was not analyzed in detail, and we did not select fabric filters as MACT. However, an above the floor option of a fabric filter was analyzed for mercury control. The total annualized costs of the fabric filter option was estimated to be an additional $21 million, with an estimated emission reduction of 0.04 tons of mercury.

The EPA could not identify a technology-based level of control for the MACT floor for inorganic HAP in this subcategory. To control inorganic HAP, we analyzed the above-the-floor option of a wet scrubber since it was identified as the least cost option. The total annualized costs of the wet scrubber option was estimated to be $49 million, with an estimated emission reduction of 463 tons per year of HCl.

The results of the above the floor options analyses indicated that while additional emissions reductions could be realized, the costs would be too high to consider them feasible options. Therefore, we did not select these controls as MACT. Non-air quality health, environmental impacts, and energy effects were not significant factors.

Existing Liquid Fuel Units. For the liquid fuel subcategories, the EPA could not identify a technology-based level of control for the MACT floor. For beyond-the-floor options for the liquid subcategory, the EPA identified several PM controls (e.g., fabric filters, electrostatic precipitators, and venturi scrubbers) that would reduce non-mercury metallic HAP emissions. For the above-the-floor analysis, we analyzed the cost and emission reduction of applying a high efficiency PM control device, such as a fabric filter, since these would be more likely to be installed for units firing liquid fuel. We identified wet scrubbers as a technology option beyond the floor for reduction of inorganic HAP, such as HCl. We identified fabric filters as a technology option beyond the floor for reduction of mercury. Consequently, the EPA analyzed the emissions reductions and additional cost of applying high efficiency PM controls and wet scrubbers on liquid fuel-fired units. The additional total annualized cost of a high efficiency PM control device (such as a fabric filter) was estimated to be $460 million, with an additional estimated emission reduction of 1,500 tons per year for non-mercury metallic HAP and 3 tons per year for mercury. The annualized cost of a wet scrubbers was estimated to be an additional $480 million, with an additional HCl reduction of 30 tons per year. The results indicated that while additional emissions reductions would be realized, the costs would be too high to consider them feasible options. Non-air quality health, environmental impacts, and energy effects were not significant factors. Therefore, the EPA chose to not select these controls as MACT for existing liquid units.

Existing Gas-fired Units. For the gaseous fuel subcategories, the EPA could not identify a technology-based level of control for the MACT floor. The great majority, if not all, of the emissions from gas-fired units are organic HAP. As discussed in section III.E of the preamble, CO monitoring and emission limits were considered as an above the floor option but was not selected as MACT given the costs and uncertain reductions achieved. Therefore, no above the floor control technique was analyzed for organic HAPs, and MACT is no emission reduction of non-mercury metallic HAP and mercury, inorganic HAP, and organic HAP.

Fuel Switching as a Beyond-the-floor Option. For the solid fuel and liquid fuel subcategories, fuel switching to natural gas is a regulatory option more stringent than the MACT floor level of control that would reduce mercury, metallic HAP, and inorganic HAP emissions. We determined that fuel switching was not an appropriate above-the-floor option for the reasons discussed in sections III.A and III.D of this proposal preamble. In some cases, organic HAP would be increased by fuel switching. Additionally, the estimated emissions reductions that would be achieved if solid and liquid fuel units switched to natural gas were compared with the estimated cost of converting existing solid fuel and liquid fuel units to fire natural gas. The annualized cost of fuel switching was estimated to be $12 billion. The additional emission reduction associated with it was estimated to be 1,500 tons per year for metallic HAP, 11 tons per year for mercury, and 13,000 tons per year for inorganic HAP. Additional detail on the calculation procedures is provided in the memorandum "Development of Fuel Switching Costs and Emissions reductions for Industrial, Commercial, and Institutional Boilers and Process Heaters" in the docket.

3.1.3.3 EPA Response to Recent Court Decisions in Developing the Emission Limitations

In developing the emission limitations, we tried to be responsive to the recent court decisions from *National Lime Association v. EPA and Cement Kiln Recycling Coalition v. EPA*, regarding the methodology used for determining the MACT floor. In response, we determined that the most acceptable and appropriate approach for determining the MACT floor appears to be using only emission data. As discussed and explained in section II.E of the proposal preamble, we determined that for these source categories and the subcategories established the use of only the available emission data would be inappropriate for determining the MACT floor for existing and new units. If only the available emission data (from a population of units that is deemed unrepresentative) is used, the resulting MACT floor emission levels would be, in most many cases, unachievable. This is because the concentration of HAP (metals, HCl, mercury) vary greatly within each fuel type. Some even have fuel analysis levels below the detection limit. Therefore, some units without any add-on controls have emission levels below those with add-on controls. Section III.E of the proposal preamble explains in more detail the approach used to develop the MACT floors for each subcategory and why the approach is appropriate for the subcategories regulated by this rule and why the mandating of fuel choice (using low HAP-containing fuel) is also inappropriate.

In terms of subcategorizing, the main difficulty of establishing a separate subcategory for each specific fuel type is that many industrial boilers burn a combination of fuels. Determining which subcategory applies if the mixture varies would be problematic. Would the applicable emission limits change each time the fuel mixture changes? How would compliance be determine and how would continuous compliance be monitored? Because of these concerns, EPA chose not to further subcategorize sources by each specific fuel type.

However, if we were to further subcategorize solid-fuel units into separate fossil and non-fossil subcategories, we would first determine if the MACT floor could be developed, for either subcategory, based on emissions information. If not, then we would look at developing MACT floors based on control technologies. First we would determine if fuel switching or work practices could be used. Based on the MACT floor analysis for solid-fuel fired boilers, it is expected that emissions information and fuel switching would not be appropriate to develop the MACT floors for a solid fossil or solid non-fossil subcategory. Similarly, there would be an insufficient number of boilers or process heaters that would be meeting CO limits to set a level for existing units. However, new units would likely be subject to a CO limit and monitoring.

In order to determine the MACT floor based on add-on control technologies, we would follow similar procedures described in section III.E of the preamble. We would examine the population database of existing sources and subcategorize solid fossil and non-fossil fuel fired boilers into each of the following three subcategories based on capacity: (1) large boilers and process heaters (units with heat inputs greater than 10 MMBtu/hr); (2) small units (with a maximum rated heat input capacity of 10 MMBtu/hr or less); and (3) limited use units with capacity utilization less than 10 percent.

We would identify the types of air pollution control techniques currently used by existing boilers and process heaters in each subcategory. Then we would rank those controls according to their effectiveness in removing the different categories of pollutants; including metallic HAP and PM, inorganic HAP such as acid gases, mercury, and organic HAP.

Based upon the emissions reduction potential of existing air pollution control techniques, we would list all the boilers and process heaters in the population database in order of decreasing control device effectiveness for each subcategory. Then the technology basis of the existing source MACT floor would be determined for each pollutant category by identifying the best-performing 12 percent of units. We would then selected the technology used by the median unit in the best performing 12 percent of units (i.e., the boiler or process heater unit representing the 94th percentile) as the technology associated with the MACT floor level of control for each subcategory.

After establishing the technology basis for the existing source MACT floor for each subcategory and each type of pollutant, we would examine the emissions data available for boilers and process heaters controlled by these technologies to determine achievable emission levels. The resulting emission levels associated with the existing source MACT floors for each pollutant would be based on the average of the lowest three run average test data from units using the technology associated with the MACT floor level of control, and by incorporating operational variability using results from multiple tests on these best performing units.

The preliminary MACT floor control technology for solid fossil-fuel fired units would be a combination of a fabric filter and a scrubber. The preliminary MACT floor control technology for solid non-fossil-fuel fired units would be a combination of an ESP and a scrubber.

3.1.3.4 How did EPA Determine the Emission Limitations for New Units?

All standards established pursuant to section 112 of the CAA must reflect MACT, the maximum degree of reduction in emissions of air pollutants that the Administrator, taking into consideration the cost of achieving such emissions reductions, and any non-air quality health and environmental impacts and energy requirements, determines is achievable for each category. The CAA specifies that the degree of reduction in emissions that is deemed achievable for new boilers and process heaters must be at least as stringent as the emissions control that is achieved in practice by the best-controlled similar unit. However, the EPA may not consider costs or other impacts in determining the MACT floor. The EPA may require a control option that is more stringent than the floor (beyond-the-floor) if the Administrator considers the cost, environmental, and energy impacts to be reasonable.

Determining the MACT floor for New Units. Similar to the MACT floor process used for existing units, we considered several approaches to identifying MACT floors for new industrial, commercial, and institutional boilers and process heaters. First, we considered using emissions data on boilers and process heaters to set the MACT floor. However, after review of the data available, we determined that emissions information was inadequate to set MACT floors. We also reviewed State regulations and permits for these sources, but found no State regulations or State permits which specifically limit HAP emissions from industrial, commercial, and institutional boilers and process heaters.

Consequently, we concluded that the only reasonable approach for determining MACT floors is to base it on control technology. Data were available on the control technologies employed by the population of boilers identified by the EPA. We considered several possible control technologies (i.e., factors that influence emissions), including fuel substitution, process changes and work practices, and add-on control technologies.

We first considered whether fuel switching would be an appropriate control option for sources in each subcategory. Both fuel switching to other fuels used in the subcategory and fuels from other subcategories were considered. This consideration included determining whether switching fuels would achieve lower HAP emissions. A second consideration was whether fuel switching could be technically done on boilers and process heaters in the subcategory considering the existing design of boilers and process heaters. We also considered the availability of the alternative fuel.

As discussed in section III.D of the proposal preamble, based on the data available in the emissions database, we determined that while fuel switching would decrease some HAPs, emissions of some organic HAPs would increase, resulting in uncertain benefits. We determined that it would be inappropriate in a MACT rulemaking, that is technology based, to consider a technology that potentially will result in an increase in a HAP regardless of its potential to reduce other HAP without determining the overall benefit. A detailed discussion of the consideration of fuel switching is discussed in proposal preamble section III.D.

We also determined that using process changes or work practices were not appropriate in most cases for developing MACT floors. HAP emissions from boilers and process heaters are primarily dependent upon the composition of the fuel. Fuel dependent HAP are metals, including mercury, and acid gases. Fuel dependent HAP are typically controlled by removing them from the flue gas after combustion. Therefore, they are not affected by the operation of the boiler or process heater. Consequently, process changes would be ineffective in reducing their emissions. The exception to this conclusion is monitoring and maintaining CO levels. The measurement of CO is generally an indicator of incomplete combustion since CO will burn to carbon dioxide if adequate oxygen is available. Correcting incomplete combustion may be accomplished through providing more combustion air. Therefore, we consider monitoring and maintaining CO emission levels to be associated with minimizing organic HAP emission levels and, thus, CO monitoring would be a good indicator of combustion efficiency and organic HAP emissions. As discussed in the final preamble, CO is considered a surrogate for organic HAP emissions in this rule.

To determine if CO monitoring would be the basis of the new source MACT floor for organic emissions control, we examined available information. The population databases did not contain information on existing units monitoring CO emissions. We reviewed State regulations applicable to boilers and process heaters that required the use of CO monitoring to maintain a specific CO limit.   The analysis of the State regulations indicated that at least one of the boilers and process heaters in the large and limited use subcategories for solid fuel, liquid fuel, and gaseous fuel were required to monitor CO emissions and meet a CO limit of 200 parts per million. Therefore, the new source MACT floor level of control includes a CO emission limit of 200 parts per million for large and limited use units.

We concluded that, except for CO monitoring for organic HAP, add-on control technology is the only factor that significantly controls emissions. To determine the MACT floor for new sources, the EPA reviewed the population database of existing major sources.

Based upon the emission reduction potential of existing air pollution control devices, the EPA listed all the boilers and process heaters in the population database in order of decreasing control device effectiveness for each subcategory and each type of pollutant. Once the ranking of all existing boilers and process heaters was completed for each subcategory and type of pollutant, the EPA determined the technology basis of the new source MACT floor by identifying the best-controlled source using the air pollution control rankings.

After establishing the technology basis for the new source MACT floor for each subcategory and each type of pollutant, the EPA examined the emissions data available for boilers and process heaters controlled by these technologies to determine achievable emission levels for PM (as a surrogate for non-mercury metallic HAP), total selected non-mercury metallic HAP, mercury, HCl (as a surrogate for inorganic HAP), and CO (as a surrogate for organic HAP). This approach is reasonable because the most informative way to predict the worst reasonably foreseeable performance of the best-controlled unit, with available data, is to examine the performance of other units that use the same technology. In other words, the EPA considers all units with the same control technology to be equally well controlled, and each unit with the best control technology is a "best controlled similar unit" even if the emission test results from such units vary considerably.

Accordingly, we selected as the floor for new units the level of control that was being achieved in practice by the best-controlled similar source, that is, the source with emissions representing the performance of the most effective control technology under the worst reasonably foreseeable circumstances. A detailed description of the MACT floor determination is in the memorandum "MACT Floor Analysis for New and Existing Sources in the Industrial, Commercial, and Institutional Boilers and Process Heaters Source Categories" in the docket.

New Solid Fuel-fired Units. Large Units—Heat Inputs Greater than 10 MMBtu/hr. The most effective control technology identified for removing PM from boilers in this subcategory is fabric filters. Therefore, the EPA considers a fabric filter to be the technology basis for the new source MACT floor for non-mercury metallic HAP emissions. The MACT floor emission level based on fabric filters is 0.04 lb PM/MMBtu. This PM emission level was selected from a subset of fabric filters contained in the database. This subset includes fabric filters assumed to be subject or achieving the NSPS for industrial boilers. The NSPS (40 CFR 60.40b), which represent best demonstrated technology for criteria pollutants, is based on the use of a fabric filter for PM and requires the use of a scrubber for sulfur dioxide. Therefore, fabric filters subjected to the NSPS are assumed to be better designed, and operated than those built prior to the NSPS.

We are also providing an alternative metals limit of 0.00007 lb metals/MMBtu which can be used to show compliance in cases where metal HAP emissions are low in proportion to PM emissions. The emissions database indicates that some biomass units have low metals content but high PM emissions. The emission level for metals was selected from metals test data associated with PM emission tests from fabric filters that met the MACT floor PM emission level. The most effective control technologies identified for removing inorganic HAP including acid gases, such as HCl, are wet scrubbers and packed bed scrubbers. Wet scrubbers is a generic term that is most often used to describe venturi scrubbers, but can include packed bed scrubbers, impingement scrubbers, etc. One percent of boilers and process heaters in this subcategory reported using a packed bed scrubber. Emission test data from other industries suggests that packed bed scrubbers achieve consistently lower emission levels than wet scrubbers. Therefore, the EPA considers a packed bed scrubber to be the technology basis for the new source MACT floor for acid gas control for boilers and process heaters in the solid fuel subcategory. The MACT floor emission level based on packed scrubbers is 0.016 lb HCl/MMBtu.

For mercury control, one technology, carbon injection, that has demonstrated mercury reductions in other source categories (i.e., municipal waste combustors), was identified as being used on one existing industrial boiler. However, test data on this carbon injection system indicated that this unit was not achieving mercury emissions reductions. Therefore, we did not consider carbon injection to be a MACT floor control technology for industrial, commercial, and institutional boilers and process heaters. Data from electric utility boilers indicate that fabric filters can achieve mercury emissions reductions.

Therefore, the EPA considers a fabric filter to be the control technology basis for controlling mercury in this subcategory. The MACT floor emission level based on fabric filters is 0.0000026 lb mercury/MMBtu.

Similar control technology analysis was done for the boilers and process heaters in this subcategory for organic HAP. One control technique, controlling inlet temperature to the PM control device, that has demonstrated controlling downstream formation of dioxins in other source categories (e.g., municipal waste combustors) was analyzed for industrial boilers. Inlet and outlet dioxins test data were available on four boilers controlled with PM control devices. In all cases, no increase in dioxins emissions were indicated across the PM control device even at high inlet temperatures. However, we are requesting comment on controls that would achieve reductions of organic HAP, including any additional data that might be available. The EPA did find that CO monitoring can reduce organic HAP emissions, and has included it in the new source MACT floors as described under section III.F. of this preamble.

In light of this analysis, the EPA determined that the combination of a fabric filter, a packed bed scrubber, and CO monitoring forms the control technology basis for the new source MACT floor for boilers and process heaters in this subcategory.

Small Units—Heat Inputs Less than or Equal to 10 MMBtu/hr. The most effective control technologies identified for removing non-mercury metallic HAP used by units in this subcategory are fabric filters. Therefore, the EPA considers fabric filters to be the technology basis for the new source MACT floor for non-mercury metallic HAP control in this subcategory. The most effective control technology identified for units in this subcategory for removing acid gases, such as HCl, are wet scrubbers. The most effective control technologies identified for removing mercury used by units in this subcategory are fabric filters.

The EPA identified no control technology being used in the existing population of boilers and process heaters that consistently achieved lower emission rates than uncontrolled levels, such that a best-controlled similar source for organic HAP could be identified. We concluded the MACT floor for new sources in this subcategory is no emissions reductions for organic HAP. Furthermore, CO monitoring is not required for small boilers and process heaters by any State rules.

Thus, the EPA determined that the combination of a fabric filter and a wet scrubber forms the control technology basis for the new source MACT floor for boilers and process heaters in this subcategory.

The emissions test database did not contain test data for boilers and process heaters less than 10 MMBtu/hr heat input. In order to develop emission levels for this subcategory, we decided to use information from units in the large solid subcategory. We considered this to be an appropriate methodology because although the units in this subcategory are different enough to warrant their own subcategory (i.e., different designs and emissions), emissions of the specific HAP for which limits are being proposed (HCl, PM and metals) are expected to be related more to the type of fuel burned and the type of control used than to the unit design. Consequently, we determined that emissions information from units greater than 10 MMBtu/hr heat input could be used to establish the MACT floor levels for this subcategory for HCl, non-mercury metallic HAP (using PM as a surrogate), and mercury because the fuels and controls are similar.

The MACT floor emission level based on emissions data for fabric filters on solid fuel-fired boilers is 0.04 lb PM/MMBtu or 0.00007 lb selected non-mercury metals/MMBtu, and 0.0000026 mercury/MMBtu. The MACT floor emission level based on wet scrubbers is 0.032 lb HCl/MMBtu. We are requesting comment on using emission data from another subcategory to develop emission levels for this subcategory. We are also requesting any available emissions information for this subcategory.

Limited Use Units—Capacity Utilizations Less than or Equal to 10 Percent. The most effective control technologies identified for removing non-mercury metallic HAP and mercury used by units in this subcategory are fabric filters. Therefore, the EPA considers fabric filters to be the technology basis for the new source MACT floor for non-mercury metallic HAP and mercury control in this subcategory. The most effective control technology identified for units in this subcategory for removing acid gases, such as hydrogen chloride, are wet scrubbers.

The EPA did find that monitoring CO is used by at least one unit and can reduce organic HAP emissions, and has included it in the new source MACT floor for this subcategory as described under section III.F of this preamble.

Therefore, based on this analysis, the EPA determined that the combination of a fabric filter, a wet scrubber, and CO monitoring forms the control technology basis for the new source MACT floor for boilers and process heaters in this subcategory.

Consequently, we determined that emissions information from units greater than 10 MMBtu/hr heat input could be used to establish MACT floor levels for this subcategory because the fuels and controls are similar. The MACT floor emission level based on fabric filters is 0.04 lb PM/MMBtu or 0.00007 lb metals/MMBtu, and 0.0000026 mercury/MMBtu. The MACT floor emission level based on wet scrubbers is 0.032 lb HCl/MMBtu. We are requesting comment on using emission data from another subcategory to develop emission levels for this subcategory. We are also requesting any available emissions information for this subcategory.

New Liquid Fuel-fired Units. Large Units—Heat Inputs Greater than 10 MMBtu/hr. The most effective control technologies identified for removing non-mercury metallic HAP and PM from units in this subcategory are fabric filters. Therefore, the EPA considers a fabric filter to be the technology basis for the new source MACT floor for non-mercury metallic HAP. A PM level is set as a surrogate for non-mercury metallic HAP control. The MACT floor emission level based on emission data for fabric filters on liquid fuel fired boilers is 0.068 lb PM/MMBtu. Unlike for solid fuel subcategories, we are not aware of any liquid fuels that are low in metals but would have high PM emissions. Therefore, we are not proposing an alternative metals standard for the liquid subcategories.

The most effective control technologies identified for removing inorganic HAP that are acid gases, such as HCl, are packed bed scrubbers. Therefore, the EPA considers a packed bed scrubber to be the technology basis for the new source MACT floor for acid gas control for boilers and process heaters in the liquid fuel subcategory. The MACT floor emission level based on packed scrubbers is 0.00045 lb HCl/MMBtu.

Similar control technology analyses were done for the boilers and process heaters in this subcategory for mercury and organic HAP.

Information in the emissions database or from other source categories does not show that control technologies, such as fabric filters or wet scrubbers, achieve reductions in mercury emissions from liquid fuel-fired industrial, commercial, and institutional boilers and process heaters. Therefore, EPA identified no control technology being used in the existing population of boilers and process heaters in these subcategories that consistently achieved lower emission rates than uncontrolled levels, such that a best-controlled similar source for organic HAP could be identified. However, we did find that monitoring CO is a good combustion practice that can reduce organic HAP emissions, and has included it in the new source MACT floor as described under section III.D of this preamble. We concluded the MACT floor for new sources in this subcategory is no emissions reductions for mercury.

In light of this analysis, the EPA determined that the combination of a fabric filter, a packed bed scrubber, and CO monitoring forms the control technology basis for the new source MACT floor for boilers and process heaters in this subcategory.

Small Units—Heat Inputs Less than or Equal to 10 MMBtu/hr. The most effective control technologies identified for removing non-mercury metallic HAP used by units in this subcategory are fabric filters. Therefore, the EPA considers fabric filters to be the technology basis for the new source MACT floor for non-mercury metallic HAP control in this subcategory. The most effective control technology identified for units in this subcategory for removing acid gases, such as hydrogen chloride, are wet scrubbers.

Information in the emissions database or from other source categories does not show that other control technologies, such as fabric filters or wet scrubbers, achieve reductions in mercury emissions from liquid fuel-fired industrial, commercial, and institutional boilers and process heaters. Therefore, EPA could not identify a control technology being used in the existing population of boilers and process heaters that consistently achieved lower emission rates than uncontrolled levels, such that a best-controlled similar source for mercury or organic HAP could be identified. We concluded the MACT floor for new sources in this subcategory is no emissions reductions for mercury or organic HAP.

Thus, the EPA determined that the combination of a fabric filter and a wet scrubber forms the control technology basis for the new source MACT floor for boilers and process heaters in this subcategory.

The emissions test database did not contain test data for boilers and process heaters less than 10 MMBtu/hr heat input. In order to develop emission levels for this subcategory, we decided to use information from units in the large liquid subcategory. We considered this to be an appropriate methodology because although the units in this subcategory are different enough to warrant their own subcategory (i.e., different designs and emissions), emissions of the specific types of HAP for which limits are being proposed (HCl and metals) are expected to be more related to the type of fuel burned and the type of control than to unit design. Consequently, we determined that emissions information from units greater than 10 MMBtu/hr heat input could be used to establish MACT floor levels for this subcategory because the fuels and controls are similar. The MACT floor emission level based on fabric filters is 0.068 lb PM/MMBtu. The MACT floor emission level based on wet scrubbers is 0.0009 lb HCl/MMBtu.

Limited Use Units—Capacity Utilizations Less than or Equal to 10 Percent. The most effective control technologies identified for removing non-mercury metallic HAP used by units in this subcategory are fabric filters. Therefore, the EPA considers fabric filters to be the technology basis for the new source MACT floor for non-mercury metallic HAP control in this subcategory. The most effective control technology identified for units in this subcategory for removing acid gases, such as hydrogen chloride, are wet scrubbers.

Information in the emissions database or from other source categories does not show that other control technologies, such as fabric filters or wet scrubbers, achieve reductions in mercury emissions from liquid fuel-fired industrial, commercial, and institutional boilers and process heaters. The EPA identified no control technology being used in the existing population of boilers and process heaters that consistently achieved lower emission rates than uncontrolled levels, such that a best-controlled similar source for mercury could be identified. We concluded the MACT floor for new sources in this subcategory is no emissions reductions for mercury.

We did find that monitoring CO can reduce organic HAP emissions and is used by at least one unit in this subcategory, and have included it in the new source MACT floor as described under section III.D of this preamble. Therefore, based on this analysis, the EPA determined that the combination of a fabric filter, a wet scrubber, and CO monitoring forms the control technology basis for the new source MACT floor for boilers and process heaters in this subcategory.

The emissions test database did not contain test data for limited use liquid-fired boilers and process heaters. In order to develop emission levels for this subcategory, we decided to use information from units in the large liquid subcategory. Consequently, we determined that emissions information from units greater than 10 MMBtu/hr heat input could be used to establish MACT floor levels for this subcategory because the fuels and controls are similar. The MACT floor emission level based on fabric filters is 0.068 lb PM/MMBtu. The MACT floor emission level based on wet scrubbers is 0.0009 lb HCl/MMBtu. We are requesting comment on using emission data from another subcategory to develop emission levels for this subcategory. We are also requesting any available emissions information for this subcategory.

Gaseous Fuel Subcategories. No existing units were using control technologies that achieve consistently lower emission rates than uncontrolled sources for any of the pollutant groups of interest, except organic HAP. At least one unit in the population database in the large and limited use gaseous fuel subcategories is required to monitor CO. Therefore, the MACT floor for gaseous fuel-fired units includes a CO monitoring requirement and emission limit, as described in section III.D of this preamble, but it does not include any emission limits for PM, metallic HAP, mercury, or inorganic HAP based on the utilization of add-on control technology.

How EPA Considered Beyond the Floor Options for New Units. The MACT floor level of control for new units is based on the emission control that is achieved in practice by the best controlled similar source within each of the subcategories. No technologies were identified that would achieve non-mercury metals reduction greater than the new source floors (i.e., fabric filters) for the liquid and solid subcategories or CO monitoring for the solid, liquid, and gaseous subcategories. For inorganic HAP control, we determined that packed bed scrubbers achieve higher emissions reductions than MACT floors consisting of a wet scrubber. Packed bed scrubbers are the technology basis of the MACT floor for the large unit subcategory, but wet scrubbers were the technology basis of the floors for the small unit and limited unit subcategories. Therefore, we examined the cost and emission reductions of applying a packed bed scrubber as a beyond the floor option for new solid and liquid units within the small and limited use subcategories. We determined that costs were excessive for the limited emission reduction that would be achieved. Non-air quality health, environmental impacts, and energy effects were not significant factors, because there would be little difference in the non-air quality health and environmental impacts between packed bed scrubbers and wet scrubbers. Therefore, the EPA did not select this beyond-the-floor option, and the proposed new source MACT level of control for PM, metallic HAP, and inorganic HAP (HCl) is the same as the MACT floor level of control for all of the subcategories.

In reviewing potential regulatory options beyond the new source MACT floor level of control, the EPA identified one existing solid fuel-fired industrial boiler that was using carbon injection technology for mercury control. However, emission data obtained from this unit indicated that it was not achieving mercury emission reductions from the uncontrolled levels. Moreover, we do not have information to otherwise show that carbon injection is effective for reducing mercury emissions from industrial, commercial, and institutional boilers and process heaters. Information in the emissions database or from other source categories does not show that other control technologies, such as fabric filters or wet scrubbers, achieve reductions in mercury emissions from liquid fuel-fired industrial, commercial, and institutional boilers and process heaters. Therefore, carbon injection, for solid fuel units, and other control techniques, for liquid fuel units, were not evaluated as regulatory options.

For the solid fuel and liquid fuel subcategories, fuel switching to natural gas is a potential regulatory option beyond the new source floor level of control that would reduce mercury and metallic HAP emissions. However, based on current trends within the industry, the EPA projects that the majority of new boilers and process heaters will be built to fire natural gas as opposed to solid and liquid fuels such that the overall emissions reductions associated with this option would be minimal. Furthermore, organic HAP may be increased by fuel switching. Limited emissions reductions in combination with the high cost of fuel switching and considerations about the availability and technical feasibility of fuel switching makes this an unreasonable regulatory option that was not considered further. Non-air quality health, environmental impacts, and energy effects were not significant factors. No beyond-the-floor options for gas-fired boilers were identified.

Based on the analysis discussed above, the EPA decided to not go beyond the MACT floor level of control for new sources for MACT in the rule.

3.1.4 Considerations of Possible Risk-Based Alternatives to Reduce Impacts to Sources

The Agency has made every effort in developing this rule to minimize the cost to the regulated community and allow maximum flexibility in compliance options consistent with our statutory obligations. However, we recognize that the rule may still require some facilities to take costly steps to further control emissions even though their emissions may not result in exposures which could pose an excess individual lifetime cancer risk greater than one in one million or which exceed thresholds determined to provide an ample margin of safety for protecting public health and the environment from the effects of hazardous air pollutants. We therefore solicited comment on whether there are further ways to structure the rule to focus on the facilities which pose significant risks and avoid the imposition of high costs on facilities that pose little risk to public health and the environment.

Representatives of the plywood and composite wood products industry provided EPA with descriptions of three mechanisms that they believed could be used to implement more cost-effective reductions in risk. The docket for today's rule contains "white papers" prepared by industry that outline their proposed approaches (see docket number A-98-44, Item # II-D-525). These approaches could be effective in focusing regulatory controls on facilities that pose significant risks and avoiding the imposition of high costs on facilities that pose little risk to public health or the environment, and we sought public comment on the utility of each of these approaches with respect to this rule.

One of the approaches, an applicability cutoff for threshold pollutants, would be implemented under the authority of CAA section 112(d)(4); the second approach, subcategorization and delisting, would be implemented under the authority of CAA sections 112(c)(1) and 112(c)(9); and, the third approach, would involve the use of a concentration-based applicability threshold. We sought comments on whether these approaches are legally justified and asked for information that could be used to support such approaches.

The approach the Agency has chosen to include in the final rule is the first approach - an applicability cutoff for threshold pollutants. The threshold pollutants for which an applicability cutoff is applied are hydrochloric acid (Hcl) and a series of eight metals known as the total selected metals (TSM).

3.1.4.1 Applicability Cutoffs for Threshold Pollutants Under Section 112(d)(4) of the CAA

This approach is an "applicability cutoff" for threshold pollutants that is based on EPA's authority under CAA section 112(d)(4). A "threshold pollutant" is one for which there is a concentration or dose below which adverse effects are not expected to occur over a lifetime of exposure. For such pollutants, section 112(d)(4) allows EPA to consider the threshold level, with an ample margin of safety, when establishing emissions standards. Specifically, section 112(d)(4) allows EPA to establish emission standards that are not based upon the maximum achievable control technology (MACT) specified under section 112(d)(2) for pollutants for which a health threshold has been established. Such standards may be less stringent than MACT. Historically, EPA has interpreted 112(d)(4) to allow us to avoid further regulation of categories of sources that emit only threshold pollutants, if those emissions result in ambient levels that do not exceed the threshold, with an ample margin of safety.[1]

In the past, EPA routinely treated carcinogens as non-threshold pollutants. The EPA recognizes that advances in risk assessment science and policy may affect the way EPA differentiates between threshold and non-threshold HAP. The EPA's draft Guidelines for Carcinogen Risk Assessment (EPA, 1999) suggest that carcinogens be assigned non-linear

[1]See 63 FR 18754, 18765-66 (April 15, 1998) (Pulp and Paper Combustion Sources Proposed NESHAP).

dose-response relationships where data warrant. Moreover, it is possible that dose-response curves for some pollutants may reach zero risk at a dose greater than zero, creating a threshold for carcinogenic effects. It is possible that future evaluations of the carcinogens emitted by this source category would determine that one or more of the carcinogens in the category is a threshold carcinogen or is a carcinogen that exhibits a non-linear dose-response relationship but does not have a threshold.

The dose-response assessments for formaldehyde and acetaldehyde are currently undergoing revision by the EPA. As part of this revision effort, EPA is evaluating formaldehyde and acetaldehyde as potential non-linear carcinogens. The revised dose-response assessments will be subject to review by the EPA Science Advisory Board, followed by full consensus review, before adoption into the EPA Integrated Risk Information System (IRIS). At this time, EPA estimates that the consensus review will be completed sometime in 2004. The revision of the dose-response assessments could affect the potency factors of these HAP, as well as their status as threshold or non-threshold pollutants. At this time, the outcome is not known. In addition to the current reassessment by EPA, there have been several reassessments of the toxicity of and carcinogenicity of formaldehyde in recent years, including work by the World Health Organization and the Canadian Ministry of Health.

3.1.4.2 Applicability Cutoffs for Hydrogen Chloride Controls Under Section 112(d)(4) of the CAA

HCl Compliance Alternative. As an alternative to the requirement for each large solid fuel-fired boiler to demonstrate compliance with the HCl emission limit in the final rule, you may demonstrate compliance with a health-based facility-wide HCl equivalent allowable emission limit.

The procedures for demonstrating eligibility for the HCl compliance alternative (as outlined in appendix A of the final rule) are:

(1) You must include in your demonstration every emission point within the facility that emits a respiratory toxicant included on EPA's list of hazardous air pollutants.

(2) You must conduct HCl and chlorine emissions tests for every emission point covered under subpart DDDDD.

(3) You must obtain either through emission testing or through the development and documentation of best engineering estimates of maximum emissions of

respiratory toxicants from all emission points at the facility not covered under subpart DDDDD of part 63 from which a respiratory toxicant might reasonably be emitted.

(4) You must determine the total maximum hourly mass HCl-equivalent emission rate for your facility by summing the maximum hourly toxicity-weighted emission rates of all appropriate respiratory toxicants (calculated using the maximum rated capacities of the units) for each of the units at your facility.

(5) Use the look-up table in the appendix A of subpart DDDDD to determine if your facility is in compliance with health-based HCl-equivalent emission limit.

(6) Select the maximum allowable HCl-equivalent emission rate from the look-up table in appendix A of subpart DDDDD of part 63 for your facility using the average stack height of your subpart DDDDD emission units as your stack height and the minimum distance between any respiratory toxicant emission point at the facility and the closest boundary of the nearest residential (or residentially zoned) area as your fenceline distance.

(7) Your facility is in compliance if your maximum HCl-equivalent emission rate does not exceed the value specified in the look-up table in appendix A of subpart DDDDD.

(8) As an alternative to using the look-up table, you may conduct a site-specific compliance demonstration (as outlined in appendix A of subpart DDDDD of part 63) which demonstrate that your facility cannot cause an individual chronic inhalation exposure from respiratory toxicants which can exceed a Hazard Index (HI) value of 1.0.

3.1.4.3 Applicability Cutoffs for Total Selected Metals Controls Under Section 112(d)(4) of the CAA

In lieu of complying with the emission standard for TSM in subpart DDDDD of part 63 based on the sum of emissions for the eight selected metals (arsenic, cadmium, chromium, mercury, manganese, nickel, lead, and), you may demonstrate eligibility for complying with the TSM standard based on excluding manganese emissions from the summation of TSM emissions for the affected source unit.

The procedures for demonstrating eligibility for the TSM compliance alternative (as outlined in appendix A of the subpart DDDDD) are:

(1) You must include in your demonstration every emission point within the facility that emits a CNS toxicant included on EPA's list of hazardous air pollutants.

(2) You must conduct manganese emissions tests for every emission point covered under subpart DDDDD that emits manganese.

(3) You must obtain either through emission testing or through the development and documentation of best engineering estimates of maximum emissions of CNS toxicants from all emission points at the facility not covered under subpart DDDDD from which a CNS toxicant might reasonably be emitted.

(4) You must determine the total maximum hourly manganese equivalent emission rate from your facility by summing the maximum hourly toxicity-weighted emission rates of all appropriate CNS toxicants (calculated using the maximum rated heat input capacities) for each of the units at your facility.

(5) Use the look-up table in appendix A of subpart DDDDD to determine if your facility is eligible for complying with the TSM limit based on the sum of emissions for seven metals (excluding manganese) for the affected source units.

(6) Select the maximum allowable manganese-equivalent emission rate from the look-up table in appendix A of subpart DDDDD for your facility using the average stack height of your subpart DDDDD emission units as your stack height and the minimum distance between any CNS toxicant emission point at the facility and the closest boundary of the nearest residential (or residentially zoned) area as your fenceline distance.

(7) Your facility is eligible if your maximum manganese-equivalent emission rate does not exceed the value specified in the look-up table in appendix A of subpart DDDDD.

(8) As an alternative to using look-up table to determine if your facility is eligible for the TSM compliance alternative, you may conduct a site-specific compliance demonstration (as outlined in appendix A of subpart DDDDD) which demonstrates that your facility cannot cause an individual chronic inhalation exposure from CNS toxicants which can exceed a HI value of 1.0.

If you elect to demonstrate eligibility for either of the health-based compliance alternatives, you must submit certified documentation supporting compliance with the procedures at least 1 year before the compliance date.

You must submit supporting documentation including documentation of all maximum capacities, existing control devices used to reduce emissions, stack parameters, and property boundary distances to each on-site source of HCl-equivalent and/or manganese-equivalent emissions.

You must keep records of the information used in developing the eligibility demonstration for your affected source.

To be eligible for either health-based compliance alternative, the parameters that defined your affected source as eligible for the health-based compliance alternatives (including, but not limited to, fuel type, type of control devices, process parameters documented as worst-case conditions during the emissions testing used for your eligibility demonstration) must be incorporated as Federally enforceable limits into your title V permit. If you do not meet these criteria, then your affected source is subject to the applicable emission limits, operating limits, and work practice standards in Subpart DDDDD.

If you intend to change key parameters (including distance of stack to the property boundary) that may result in lower allowable health-based emission limits, you must recalculate the limits under the provisions of this section, and submit documentation supporting the revised limits prior to initiating the change to the key parameter.

If you intend to install a new solid fuel-fired boiler or process heater or change any existing emissions controls that may result in increasing HCl-equivalent and/or manganese-equivalent emissions, you must recalculate the total maximum hourly HCl-equivalent and/or manganese-equivalent emission rate from your affected source, and submit certified documentation supporting continued eligibility under the revised information prior to initiating the new installation or change to the emissions controls.

Facilities that could not demonstrate that they are eligible to be included in the low-risk subcategory would be subject to MACT and possible future residual risk standards.

3.2 Profile of Existing Boiler and Process Heaters Units

This section profiles existing boilers and process heaters, collectively referred to as "units," with respect to business applications, industry of parent company, and fuel use. The unit population database in combination with the model units that helped in preparing that database were used to determine which types of boilers, fuel, and control devices were in the existing unit population so that corresponding emission factors could be developed for all combinations. The development of the population database and the model units are discussed in the memoranda, "Development of the Population Database for the Industrial, Commercial, and Institutional Boiler and Process Heater National Emission Standard for Hazardous Air Pollutants (NESHAP)" and "Development of the Model Units for the Industrial, Commercial, and Institutional Boiler and Process Heater National Emission Standard for Hazardous Air Pollutants (NESHAP)." The units contained in the Inventory

Database are based on information from the Aerometric Information Retrieval System (AIRS) and Ozone Transport Assessment Group (OTAG) databases, state and local permit records, and the combustion source Information Collection Request (ICR) conducted by the Agency in 1997. The list of units contained in the Inventory Database was reviewed and updated by industry and environmental stakeholders as part of the Industrial Combustion Coordinated Rulemaking (ICCR), chartered under the Federal Advisory Committee Act (FACA).

The entire Inventory Database contains more than 58,000 ICI boilers and process heaters; however, only about 4,000 are estimated to be affected by the final rule. Of these existing units, a little over half had sufficient information on operating parameters to be included in the floor-level EIA. The number of potentially affected units included in the profile for the final rule was 2,186.

3.2.1 Distribution of Existing Boilers and Facilities by Industry

Table 3-2 presents the number of existing boilers and process heaters and the number of facilities owning units by two-digit SIC code and three-digit NAICS code that may be affected by the final rule. For the final rule, the industries with the largest number of potentially affected units are the furniture, paper, lumber, and electrical services industries. These four industries alone account for nearly 60 percent of affected units. Almost all the process heaters are in the lumber industry. (Section 4 presents industry profiles for the lumber and wood products, electrical services, and paper industries, among others.) The remaining units are primarily distributed across the manufacturing sector and service industries.

3.2.2 Technical Characteristics of Existing Boilers

Figure 3-1 characterizes the population of 2,186 units identified in the Inventory Database by capacity range, fuel type, and level of preexisting control.

3.2.2.1 Final Rule

- Capacity Range: Unit input capacities in the population are expressed in four ranges: 0–10, 10–100, 100–250, and >250 MMBtu/hr. Fifty-two percent of the units affected for this alternative have capacities between 10 and 100 MMBtu/hr. The two largest capacity ranges each contain approximately one quarter of the population. Only 1 percent of units have input capacities less than 10 MMBtu/hr.

- Fuel Type: About half of these units consume coal as their primary fuel (1,074 units). After coal, the next most common fuel type is wood (479 units).

Table 3-2. Units and Facilities Affected by the Final Rule by Industry[a]

SIC Code	NAICS Code	Description	Boilers	Heaters	Total Units	Facilities
01	111	Agriculture—Crops	3	0	3	3
02	112	Agriculture—Livestock	0	0	0	0
07	115	Agricultural Services	0	0	0	0
10	212	Metal Mining	9	0	9	4
12	212	Coal Mining	2	0	2	1
13	211	Oil and Gas Extraction	0	0	0	0
14	212	Mining/Quarrying—Nonmetallic Minerals	8	0	8	4
17	235	Construction—Special Trade Contractors	0	0	0	0
20	311	Food and Kindred Products	138	0	138	60
21	312	Tobacco Products	11	0	11	7
22	313	Textile Mill Products	135	0	135	71
23	315	Apparel and Other Products from Fabrics	2	0	2	2
24	321	Lumber and Wood Products	335	25	360	262
25	337	Furniture and Fixtures	234	0	234	154
26	322	Paper and Allied Products	321	0	321	194
27	511	Printing, Publishing, and Related Industries	0	0	0	0
28	325	Chemicals and Allied Products	171	3	174	70
29	324	Petroleum Refining and Related Industries	11	0	11	8
30	326	Rubber and Miscellaneous Plastics Products	17	0	17	13
31	316	Leather and Leather Products	1	0	1	1
32	327	Stone, Clay, Glass, and Concrete Products	9	0	9	7
33	331	Primary Metal Industries	41	0	41	16
34	332	Fabricated Metal Products	16	0	16	10
35	333	Industrial Machinery and Computer Equipment	23	0	23	12
36	335	Electronic and Electrical Equipment	5	0	5	5
37	336	Transportation Equipment	102	0	102	41
38	334	Scientific, Optical, and Photographic Equip.	8	0	8	4
39	339	Miscellaneous Manufacturing Industries	2	0	2	2
40	482	Railroad Transportation	4	0	4	1
42	484	Motor Freight and Warehousing	5	0	5	1
46	486	Pipelines, Except Natural Gas	0	0	0	0

(continued)

Table 3-2. Units and Facilities Affected by the Final Rule by Industry[a] (continued)

SIC Code	NAICS Code	Description	Boilers	Heaters	Total Units	Facilities
49	221	Electric, Gas, and Sanitary Services	318	0	318	160
50	421	Wholesale Trade—Durable Goods	3	0	3	2
51	422	Wholesale Trade—Nondurable Goods	2	0	2	1
55	441	Automotive Dealers and Gasoline Service Stations	0	0	0	0
58	722	Eating and Drinking Places	0	0	0	0
60	522	Depository Institutions	0	0	0	0
59	445–454	Miscellaneous Retail	0	0	0	0
70	721	Hotels and Other Lodging Places	1	0	1	1
72	812	Personal Services	0	0	0	0
76	811	Miscellaneous Repair Services	2	0	2	1
80	621	Health Services	37	0	37	18
81	541	Legal Services	0	0	0	0
82	611	Educational Services	105	0	105	45
83	624	Social Services	2	0	2	1
86	813	Membership Organizations	0	0	0	0
87	541	Engineering, Accounting, Research, Management and Related Services	2	0	2	2
89	711/514	Services, N.E.C.	2	0	2	1
91	921	Executive, Legislative, and General Administration	1	0	1	1
92	922	Justice, Public Order, and Safety	29	0	29	9
94	923	Administration of Human Resources	1	0	1	1
96	926	Administration of Economic Programs	4	0	4	3
97	928	National Security and International Affairs	29	0	29	11
NA		SIC Information Not Available	7	0	7	4
			2,158	28	2,186	1,214

[a] Based on the Inventory Database.

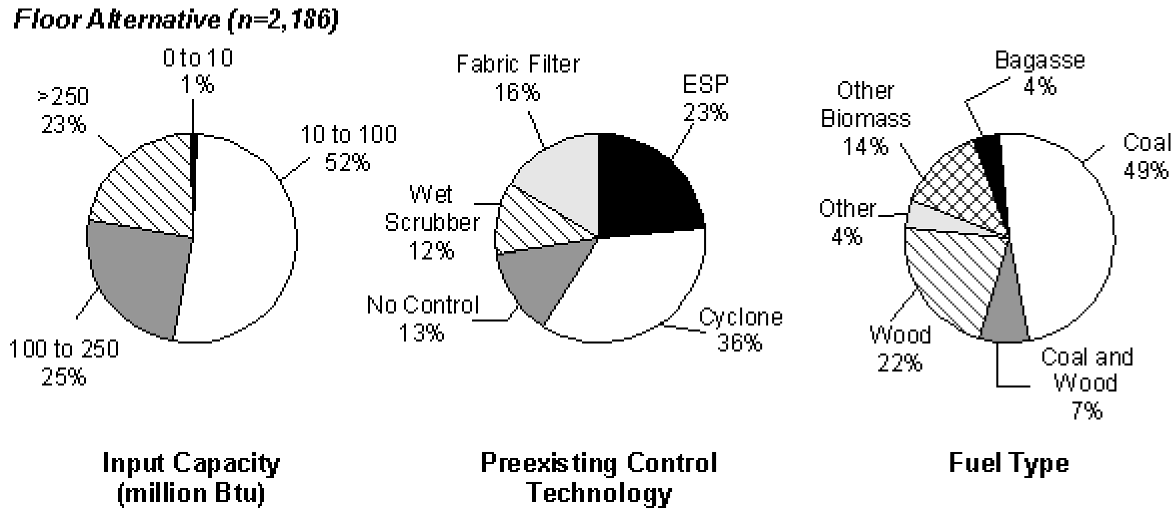

Figure 3-1. Characteristics of Units Affected

- Control Level: Eighty-three percent of units have some type of control device already installed; 289 do not. Typical control devices include fabric filters, wet scrubbers, and electrostatic precipitators.

3.3 Methodology for Estimating Cost Impacts

The predominant type of control measure that is considered in the analysis of emission reductions needed for sources to achieve the MACT floor is add-on control technologies. Add-on control techniques are those technologies that are applied to the vent gas stream of the boiler or process heater to reduce emissions. The boiler and process heaters population database includes information on all control techniques that are applied to industrial, commercial, institutional boilers and process heaters. Generally, they can be grouped into PM control or acid gas control. The most common technologies, and the ones analyzed for the impacts analysis, include fabric filters, ESP's, packed scrubbers, venturi scrubbers, and spray dryers. In addition, when add-on technologies are used, the cost of ductwork and associated equipment also needed to be considered.

Components of capital cost include

- purchased equipment cost of the primary device and auxiliary equipment,
- instrumentation,

- sales tax and freight, and
- installation costs. Installation costs include foundations and support, handling and erection, electrical, piping, insulation, and painting, engineering, construction and field expenses, contractor fees, start-up, performance tests, and contingencies.

Components of annual cost include

- raw materials,
- utilities (electricity, fuel, steam, air, water),
- waste treatment and disposal,
- labor (operating, supervisory, maintenance),
- maintenance materials,
- replacement parts,
- overhead,
- property taxes,
- insurance,
- administration charges, and
- capital recovery costs.

For this analysis, costs were estimated in 1999 dollars. Capital recovery was calculated assuming 7 percent interest rate over the life of the equipment. The use of this interest rate is based on Office of Management and Budget (OMB) guidance (Circular A-94, October 29, 1992).

The algorithms used to estimate these costs were obtained from previous EPA studies. These cost algorithms are included as appendices to the cost methodology memorandum in the public docket. Inputs for the algorithms used in the impacts analysis are also presented in this memorandum.

Fabric Filter

The algorithms used to estimate capital and annual costs of fabric filters were obtained from EPA's EPA Air Pollution Control Cost Manual. Algorithms were provided for 4 types of fabric filters: shaker, reversed air, pulse-jet modular, and pulse-jet common.

The cost algorithms for estimating capital costs reduced to basic equations for each are provided in Appendix A-1 of the cost methodology memorandum (henceforth called the "cost memo"). Capital costs are based on the gross cloth area of the fabric filter, which is a function of the gas inlet flow rate. Algorithms for calculating annual costs are provided in Appendix A-2 of the cost memo. Annual costs include dust disposal, electricity, maintenance, labor, bag replacement, maintenance labor, compressed air, overhead, administrative, property taxes, and insurance. Capital recovery is annualized over 20 years at 7 percent interest. Appendix A-3 of the cost memo presents the values for the inputs used in this analysis and the reasons for their use.

Electrostatic Precipitator

The algorithms used to estimate capital and annual costs of ESPs were obtained from EPA's Air Pollution Control Cost Manual. Capital costs are based on the total collection plate area, which is calculated from the gas inlet flow rate and the required removal efficiency. The cost algorithms for estimating capital costs of ESPs reduced to basic equations are provided in Appendix B-1 of the cost memo. Algorithms for calculating annual costs are provided in Appendix B-2 of the cost memo. Annual costs include dust disposal, electricity, maintenance, labor, maintenance labor, overhead, administrative, property taxes, and insurance. Capital recovery is annualized at 7 percent interest. Appendix B-3 of the cost memo presents the values for the inputs used in this analysis and the reasons for their use.

Venturi Scrubber

The algorithms used to estimate capital and annual costs of venturi scrubbers were obtained from EPA cost algorithms on EPA's website(http://www.epa.gov/ttn/catc/products.html#cccinfo.) Capital costs include not only the cost of the venturi scrubber but also a pump to provide motive force for the solvent. Capital costs are based on the gas flow rate and saturation temperature of the gas-solvent. The cost algorithms for estimating capital costs of each piece of equipment were reduced to basic equations in Appendix C-1 of the cost memo. The cost algorithms for estimating annual costs were reduced to basic equations in Appendix C-2 of the same memorandum. Annual costs include wastewater disposal, solvent, electricity, maintenance, labor, maintenance labor overhead, administrative, property taxes, and insurance. Capital recovery is an annualized cost estimated using a 7 percent interest rate. Appendix C-3 of the cost memo presents the values for the inputs used in this analysis and the reasons for their use.

Packed Bed Scrubber

The algorithms used to estimate capital and annual costs of packed bed scrubbers were obtained from EPA's Air Pollution Control Cost Manual. The capital costs are comprised of the scrubber tower, packing, pumps, and fans. Capital costs are based primarily on gas flow rate and removal efficiency. The cost algorithms for estimating capital costs of packed scrubber equipment reduced to their basic equations for each are provided in Appendix D-1 of the cost memo. The cost algorithms for estimating annual costs of packed scrubbers are provided in Appendix D-2 of the cost memo. Annual costs include caustic, wastewater disposal, water, electricity, maintenance, labor, overhead, administrative, property taxes, and insurance. Capital recovery is an annualized cost estimated using a 7 percent interest rate. Appendix D-3 of the cost memo presents the values for the inputs used in this analysis and the reasons for their use.

Spray Dryer

The algorithms used to estimate capital and annual costs of spray dryers were obtained from previous EPA studies. Capital costs include the cost of the spray dryer and pumps. Capital costs are based on the gas flow rate. The cost algorithms for estimating capital costs of spray dryer equipment reduced to basic equations are provided in Appendix E-1 of the cost memo. The cost algorithms for estimating annual costs for spray dryers are provided in Appendix E-2 of the cost memo. Annual costs include lime, water, electricity, maintenance, labor, maintenance labor, overhead, administrative, property taxes, and insurance. Capital recovery is an annualized cost estimated using a 7 percent interest rate. Appendix E-3 of the cost memo presents the values for the inputs used in this analysis and the reasons for their use.

Ductwork

The algorithms used to estimate capital and annual costs of ductwork were obtained from EPA's Air Pollution Control Cost Manual. Capital costs include 500 feet of ductwork, elbows, and fans. The 500 feet of ductwork was based on engineering judgement and previous experience on the distance between emission points and control devices in chemical facilities and the availability of space for retrofitting controls. Costs are based on ductwork diameter, which is calculated from the gas flow rate. The cost algorithms for estimating capital costs and annual costs reduced to basic equations are provided in Appendix F-1 of the cost memo. Annual costs include electricity, maintenance, maintenance labor, overhead, administrative, property taxes, and insurance. Capital recovery is an annualized cost estimated using a 7 percent interest rate. Required inputs to the ductwork algorithms are provided in the input tables provided in Appendices A-3, B-3, C-3, D-3, and E-3 of the cost memo.

Good Combustion Practices

Few sources in the population database specifically reported using good combustion practices. Boilers and process heaters within each subcategory might use any of a wide variety of different work practices, depending on the characteristics of the individual unit.

Consequently, any uniform requirements or set of work practices that would meaningfully reflect the use of good combustion practices, or that could be meaningfully implemented across any subcategory of boilers and process heaters could not be identified.

Additionally, few of the GCP's have been documented to reduce organic HAP emissions, and they could not be considered in the MACT analysis. One GCP that may effect organic HAP emissions is maintaining CO emission levels. CO is generally an indicator of incomplete combustion because CO will burn to carbon dioxide if adequate oxygen is available. Controlling CO emissions is a mechanism for ensuring combustion efficiency, and therefore may be viewed as a kind of GCP.

Capital and annual costs for CO monitoring is presented in Appendix G of the cost memo. The costing information was obtained from a previous EPA study. Capital costs are comprised of the initial cost of the equipment. Annual costs include operating and maintenance costs, annual and quarterly checks, recordkeeping and reporting, taxes, insurance, and administrative costs. Annualized costs such as capital recovery costs are calculated assuming an equipment life of 20 years and an interest rate of 7 percent.

Testing and Monitoring Costs

The final rule includes emission limits for HCl, PM, metallic HAP, and mercury. Additionally, as mentioned in Section 1 of this EIA and the preamble, the rule allows sources to meet requirements by monitoring fuel content instead of emissions. Consequently, testing and monitoring costs of meeting the standards were incorporated into the cost estimates. Capital costs for testing include initial stack tests for PM, HCl, and metals for fossil fuels, and materials and fuel analysis for biomass. Capital cost components include operation and maintenance costs and capital recovery assuming the initial capital investment is annualized over a 5 year period at 7 percent interest. Monitoring costs are included for opacity monitoring, HCl monitoring, and scrubber parametric monitoring.[2] Monitoring costs include the capital cost of monitoring equipment, and the annual costs of capital recovery assuming the initial capital investment is annualized over a 20 year period at 7 percent interest. Annual monitoring costs also include operation and maintenance as well as other additional costs. The testing and monitoring costs are shown in Table 3-3. Appendix G of the cost memo includes further details on these costs. Information used to estimate testing and monitoring costs were obtained from previous EPA studies.

Costs to Control Non-Air Effects Related to Rule Implementation

The EPA estimated the additional water usage that would result from the MACT floor level of control to be 110 million gallons per year for existing sources and 0.6 million gallons per year for new sources. In addition to the increased water usage, an additional 3.7 million gallons per year of wastewater would be produced for existing sources and 0.6 million gallons per year for new sources. The EPA estimated the additional solid waste that would result from the MACT floor level of control to be 102,000 tons per year for existing sources and 1 ton per year for new sources. The costs ($900,000) of handling the additional solid waste generated from applying MACT floor technology are accounted for in the control cost estimates for ESP and fabric filter applications. The costs ($20,000) of treating wastewater from venturi and packed bed scrubber are also accounted for in the control cost estimates.

Cost Effectiveness

To provide additional information on the magnitude of the cost estimates, Table 3-4 shows the cost-effectiveness (cost/ton reduced estimates) for the HAP and non-HAP pollutants whose emissions are reduced by this rule.

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[2]The monitoring costs reported for existing units are not the cost of continuous emission monitors (CEM), but the costs associated with monitoring the process parameters of the control device. Installation of these process monitors are integral to the control device and would be installed with or without the monitoring requirements of the MACT. Therefore, even though we present these monitoring costs separately, they are included in the overall reported control costs and should not be considered as an additional cost for emission monitoring.

Table 3-3. Testing and Monitoring Costs for Units Covered

Material or Fuel	No. of Industrial Boilers	No. of Process Heaters	Total Capital Investment of Testing and Monitoring ($)	Total Annual Costs of Testing ($)	Total Annual Costs of Monitoring ($)	Annual Capital Recovery - Testing and Monitoring (1999$)	Total Annual Costs of Testing and Monitoring (1999$)
Regular Use Units							123,436,995
Liquid/NFF Solid							3,747,240
Biomass/Liquid FF							5,237,834
							0
Solid/Gas							6,005,266
							0
							11,660,854
Biomass/NFF							5,004,638
Liquid/NFF Solid							
							3,381,728
							158,114,555
Units							0

Gas/Wood/Other

Table 3-3. Testing and Monitoring Costs for Units Covered (continued)

Material or Fuel	No. of Industrial Boilers	No. of Process Heaters	Total Capital Investment of Testing and Monitoring ($)	Total Annual Costs of Testing ($)	Total Annual Costs of Monitoring ($)	Annual Capital Recovery - Testing and Monitoring (1999$)	Total Annual Costs of Testing and Monitoring (1999$)
Limited Use Units							3,330,416
Liquid/NFF Solid							61,772
Biomass/Liquid FF							169,020 0
Solid/Gas							79,696 0
Biomass/NFF							555,200
Liquid/NFF Solid							97,620
Units							4,263,724
Coal/Wood/NFF							0 162,738,279

Gas/Wood/Other

Table 3-4. Cost Effectiveness (C/E) of Industrial Boiler and Process Heater MACT on Existing Units and Subcategories

	Total Annualized Costs	Large Solid Fuel Subcategory	Large Solid Fuel Subcategory—Coal Only	Large Solid Fuel Subcategory—Wood Only	Limited Use Solid Fuel Subcategory
Control Costs ($)	833,273,781[b]	810,422,230	669,353,690	141,068,540	22,851,551
PM Emissions Reduction (Tons/Year)	565,900	563,060	359,920	203,140	2,840
C/E ($/ton PM)	1,472[a]	1,439	1,860	694	8,046
Metals Emissions Reduction (Tons/Year)	1,093	1,087	591	496	6
C/E ($/ton metals)	762,373[a]	745,558[a]	1,132,578[a]	284,412[a]	3,808,592[a]
HCl Emissions Reduction (Tons/Year)	46,515	46,515	45,136	1,379	—
C/E ($/ton HCl)	17,914[a]	17,422[a]	14,830[a]	102,298[a]	—
HAP Emissions Reduction (Tons/Year)	47,608	47,602	45,727	1,875	6
C/E ($/ton HAP)	**17,502**	**17,025**	**14,638**	**75,236**	**3,808,500**

[a] The cost-effectiveness value is based on the total annualized cost of the rule and not on the cost for controlling the specific pollutant, and, thus, overstates the cost/ton for the specific HAP or other pollutant.

[b] Costs are in 1999 dollars. Emission reductions are calculated for 2005.

Cost Uncertainties

The primary limitation to the cost estimates developed for the rule is that costs were calculated for model units rather than each individual boiler or process heater. Consequently, the costs do not characterize any "real" unit. This was done for practical reasons. Because there are over 60,000 units in the U.S., it would not be possible to gather unit-specific information for each unit necessary for estimating costs, such as flue gas temperatures and flow rates. Additionally, emission information was only available for less than 1 percent of the units. In order to estimate costs and emission reductions of the rule, model units were developed to represent the population of boilers and process heaters in the U.S. While sufficient information was not available for characterizing each unit, sufficient emissions and process information were available to develop model units. Each unit in the U.S. was then assigned to a model based on their size and fuel burned. It also should be noted that the costing methodology is the cost algorithms for the control devices provide a cost range of +/- 30 percent. This aspect of the costing methodology reflects the degree of variability typically found in study-level cost estimates. This is also the degree of variability found in the cost methodology employed in the EPA Air Pollution Control Cost Manual, which is an important reference for the cost estimates supplied in the RIA. Cost information available to owners and operators of boilers and process heaters will be more specific and accurate. Consequently, the cost estimates may overestimate or underestimate costs.

3.4 Projection of New Boilers and Process Heaters

Energy Information Administration fuel consumption forecasts were used in conjunction with existing model boiler population data to project the number and type of new boilers to be installed by 2005. EPA used the following steps to calculate new boiler population estimates:

1. *Calculate the percentage change in industrial fuel consumption*. Energy Information Administration data were used to obtain industrial and commercial fuel use projections. The percentage change in consumption (1998 to 2005) in the industrial and commercial sectors was calculated for the following fuel categories using 1998 as the base year (the same year that the model boiler algorithms are based on): steam coal (2.6%), natural gas (6.3%), residual fuel oil (-7.4%), distillate fuel oil (12.0%), and biomass (11.5%). It should be noted that 1998 was a year of below average energy prices, and that current and potential future energy prices are higher than the historical average. If real fuel prices increase faster than the EIA's projections, then conservation measures may lead to fewer projected boilers and process heaters. This trend would lead to an overestimate (upward bias) of the impact estimates presented in this report.

2. *Estimate the number of new boilers by model number-fuel type.* To predict the number of new boilers in operation by 2005, EPA applied the percentage difference for each fuel category to the 1998 fuel consumption of boilers represented by the boiler models to calculate total energy consumed by boilers in 2005 for each model number. The number of new boilers per model was calculated by dividing the model fuel forecasts by the annual fuel consumption of one unit and then subtracting the number of units present in 1998, as follows:

$$\text{Number of New Units} = \left(\frac{\text{Total energy consumed (2005) [MMBtu/yr]}}{\text{Avg capacity [MMBtu/hr]} \times 8{,}760 \text{ [hr/yr]}} \right) - \text{Number of Units} \quad (1998)$$

Following these steps, EPA projects that 1,458 boilers and 374 process heaters to be installed between 1998 and 2005 will be affected by the new source MACT floor. The only new ICI boilers and process heaters that will be unaffected are those natural gas and distillate fuel units that have input capacities less than 10 MMBtu/hr. These projections were developed by model unit type, not by industry. To assess the distribution of the boilers and process heaters estimated to be operating in 2005 across industries, EPA attached unit-level weights by model number to each unit in the Inventory Database. These weights allow each unit in the Inventory Database to represent a number (or fraction) of units that are predicted to be in use by the end of 2005. The weights were then summed by two-digit SIC code to estimate the distribution of units by industry.

Table 3-5 presents the projected number of new boilers and process heaters for the MACT floor. Industries with the estimated greatest concentrations of new units include chemicals and allied products (295), petroleum refining (198), electric services (134), and paper and allied products (96).

3.5 National Engineering Population, Cost Estimates, and Cost-Effectiveness Estimates

The Agency estimates that in 2005, 5,562 units (existing units and new units) may be affected by the final rule. This population was used to estimate national engineering costs. The population estimates were determined by unit configuration, not by industry. Thus, the distribution of units by industry shown in Tables 3-5 and 3-6 was determined by weighting

Table 3-5. New Unit Projections by Industry, MACT Floor

SIC Code	NAICS Code	Description	New Units	Cost
01	111	Agriculture—Crops	—	—
02	112	Agriculture—Livestock	—	—
07	115	Agricultural Services	—	—
10	212	Metal Mining	6	$47,040
12	212	Coal Mining	1	$7,840
13	211	Oil and Gas Extraction	89	$697,760
14	212	Mining/Quarrying—Nonmetallic Minerals	6	$87,740
17	235	Construction—Special Trade Contractors	—	—
20	311	Food and Kindred Products	63	$801,836
21	312	Tobacco Products	7	$54,880
22	313	Textile Mill Products	73	$1,329,391
23	315	Apparel and Other Products from Fabrics	—	—
24	321	Lumber and Wood Products	61	$1,748,655
25	337	Furniture and Fixtures	47	$1,354,701
26	322	Paper and Allied Products	96	$1,526,704
27	511	Printing, Publishing, and Related Industries	19	$148,960
28	325	Chemicals and Allied Products	295	$3,793,738
29	324	Petroleum Refining and Related Industries	198	$1,552,320
30	326	Rubber and Miscellaneous Plastics Products	44	$385,660
31	316	Leather and Leather Products	5	$39,200
32	327	Stone, Clay, Glass, and Concrete Products	37	$549,975
33	331	Primary Metal Industries	80	$2,873,492
34	332	Fabricated Metal Products	53	$496,920
35	333	Industrial Machinery and Computer Equipment	35	$396,500
36	335	Electronic and Electrical Equipment	40	$313,600
37	336	Transportation Equipment	80	$1,133,423
38	334	Scientific, Optical, and Photographic Equipment	11	$86,240
39	339	Miscellaneous Manufacturing Industries	9	$162,323
40	482	Railroad Transportation	—	—
42	484	Motor Freight and Warehousing	1	$48,540

(continued)

Table 3-5. New Unit Projections by Industry, MACT Floor (continued)

SIC Code	NAICS Code	Description	New Units	Cost
46	486	Pipelines, Except Natural Gas	1	$7,840
49	221	Electric, Gas, and Sanitary Services	134	$2,094,546
50	421	Wholesale Trade—Durable Goods	—	—
51	422	Wholesale Trade—Nondurable Goods	—	—
55	441	Automotive Dealers and Gasoline Service Stations	—	—
58	722	Eating and Drinking Places	—	—
59	445–454	Miscellaneous Retail	—	—
60	522	Depository Institutions	—	—
70	721	Hotels and Other Lodging Places	—	—
72	812	Personal Services	1	$7,840
76	811	Miscellaneous Repair Services	—	—
80	621	Health Services	6	$209,840
81	541	Legal Services	—	—
82	611	Educational Services	19	$815,855
83	624	Social Services	—	—
86	813	Membership Organizations	—	—
87	541	Engineering, Accounting, Research, Management and Related Services	2	$388,350
89	711/514	Services, N.E.C.	—	—
91	921	Executive, Legislative, and General Administration	—	—
92	922	Justice, Public Order, and Safety	4	$153,460
94	923	Administration of Human Resources	—	—
96	926	Administration of Economic Programs	—	—
97	928	National Security and International Affairs	2	$97,080
NA		SIC Information Not Available	307	$2,497,327
State		Parent is a State Government	—	—
			1,832	$25,909,574

Table 3-6. Unit Cost and Population Estimates for the Final Rule by Industry, 2005

			Total Units		Total Cost	
SIC Code	NAICS Code	Description	Floor Units	Percent	Floor Costs (by Unit)	Percent
01	111	Agriculture—Crops	5	0.08%	$628,943	0.07%
02	112	Agriculture—Livestock	—	0.00%	—	0.00%
07	115	Agricultural Services	—	0.00%	—	0.00%
10	212	Metal Mining	27	0.48%	$6,651,678	0.77%
12	212	Coal Mining	6	0.10%	$683,026	0.08%
13	211	Oil and Gas Extraction	89	1.60%	$697,760	0.08%
14	212	Mining/Quarrying—Nonmetallic Minerals	25	0.46%	$8,253,479	0.96%
17	235	Construction—Special Trade Contractors	—	0.00%	—	0.00%
20	311	Food and Kindred Products	312	5.60%	$37,774,020	4.38%
21	312	Tobacco Products	28	0.51%	$6,014,216	0.70%
22	313	Textile Mill Products	360	6.47%	$74,152,804	8.59%
23	315	Apparel and Other Products from Fabrics	4	0.08%	$679,510	0.08%
24	321	Lumber and Wood Products	483	8.68%	$48,896,055	5.67%
25	337	Furniture and Fixtures	311	5.59%	$29,632,880	3.43%
26	322	Paper and Allied Products	565	10.15%	$123,008,263	14.25%
27	511	Printing, Publishing, and Related Industries	19	0.34%	$148,960	0.02%
28	325	Chemicals and Allied Products	644	11.58%	$116,236,183	13.47%
29	324	Petroleum Refining and Related Industries	217	3.91%	$4,620,563	0.54%
30	326	Rubber and Miscellaneous Plastics Products	73	1.32%	$6,356,835	0.74%
31	316	Leather and Leather Products	7	0.13%	$607,530	0.07%
32	327	Stone, Clay, Glass, and Concrete Products	57	1.02%	$6,253,678	0.72%
33	331	Primary Metal Industries	159	2.85%	$27,110,619	3.14%
34	332	Fabricated Metal Products	87	1.56%	$10,042,680	1.16%
35	333	Industrial Machinery and Computer Equipment	84	1.51%	$11,208,392	1.30%
36	335	Electronic and Electrical Equipment	52	0.93%	$3,744,828	0.43%
37	336	Transportation Equipment	300	5.39%	$55,440,341	6.42%
38	334	Scientific, Optical, and Photographic Equipment	26	0.46%	$3,511,206	0.41%
39	339	Miscellaneous Manufacturing Industries	12	0.22%	$826,346	0.10%
40	482	Railroad Transportation	9	0.16%	$1,251,062	0.14%
42	484	Motor Freight and Warehousing	12	0.22%	$2,128,148	0.25%

(continued)

Table 3-6. Unit Cost and Population Estimates for the Final Rule by Industry, 2005 (continued)

SIC Code	NAICS Code	Description	Total Units: Floor Units	Total Units: Percent	Total Cost: Floor Costs (by Unit)	Total Cost: Percent
46	486	Pipelines, Except Natural Gas	1	0.02%	$7,840	0.00%
49	221	Electric, Gas, and Sanitary Services	718	12.91%	$150,341,645	17.42%
50	421	Wholesale Trade—Durable Goods	6	0.12%	$2,154,760	0.25%
51	422	Wholesale Trade—Nondurable Goods	4	0.07%	$1,673,511	0.19%
55	441	Automotive Dealers and Gasoline Service Stations	—	0.00%	—	0.00%
58	722	Eating and Drinking Places	—	0.00%	—	0.00%
59	445–454	Miscellaneous Retail	—	0.00%	—	0.00%
60	522	Depository Institutions	—	0.00%	—	0.00%
70	721	Hotels and Other Lodging Places	2	0.04%	$567,811	0.07%
72	812	Personal Services	1	0.02%	$7,840	0.00%
76	811	Miscellaneous Repair Services	4	0.08%	$625,531	0.07%
80	621	Health Services	86	1.55%	$15,172,212	1.76%
81	541	Legal Services	—	0.00%	—	0.00%
82	611	Educational Services	251	4.52%	$60,490,956	7.01%
83	624	Social Services	5	0.08%	$820,191	0.10%
86	813	Membership Organizations	—	0.00%	—	0.00%
87	541	Engineering, Accounting, Research, Management and Related Services	38	0.68%	$2,240,544	0.26%
89	711/514	Services, N.E.C.	2	0.04%	$918,360	0.11%
91	921	Executive, Legislative, and General Administration	2	0.04%	$312,765	0.04%
92	922	Justice, Public Order, and Safety	69	1.23%	$13,707,649	1.59%
94	923	Administration of Human Resources	2	0.04%	$314,316	0.04%
96	926	Administration of Economic Programs	8	0.15%	$2,300,308	0.27%
97	928	National Security and International Affairs	64	1.16%	$18,018,010	2.09%
NA		SIC Information Not Available	326	5.86%	$6,747,652	0.78%
State		Parent is a state government	—	0.00%	—	0.00%
			5,562		$862,981,906	

existing units by the estimates by unit configuration and tallying weighted units by SIC code. The average cost of control by unit configuration was multiplied by the weighted number of units to determine industry-level control cost estimates.

Table 3-6 presents industry-level population and cost estimates for boilers and process heaters. The distribution of weighted units across industries mirrors that of the analysis population even though it was determined by weighting units by configuration, not industry-level growth estimates. The floor cost of control for the estimated 5,562 boilers and process heaters is $863.0 million, with an average per-unit additional control cost of $155,157.

SECTION 4

PROFILES OF AFFECTED INDUSTRIES

This section contains profiles of the major industries affected by the MACT for boilers and process heaters. Included are profiles of the following industries:

- Textile Mill Products (SIC 22/NAICS 313)
- Lumber and Wood Products (SIC 24/NAICS 321)
- Furniture and Related Product Manufacturing (SIC 25/NAICS 337)
- Paper and Allied Products (SIC 26/NAICS 322)
- Medicinal Chemicals and Botanical Products and Pharmaceutical Preparations (SICs 2833, 2834/NAICS 32451)
- Industrial Organic Chemicals (SIC 2869/NAICS 3251)
- Electric Services (SIC 4911/NAICS 22111)

4.1 Textile Mill Products (SIC 22/NAICS 313)

The textile industry is one of the few industries found throughout the world, from the most industrialized countries to the poorest. This industry includes firms producing the following products: broadwoven fabric; weft, lace, and warp knit fabrics; carpets and rugs; spun yarn products; and man-made fibers. The United States has typically run a trade deficit in the textiles sector in recent years, importing about $1.3 billion more than was exported in 1995. Although trade has become an increasingly important part of this industry, trade in this segment is relatively small compared with trade in the downstream apparel segment. In 1996, the total value of shipments for the textile industry was $80,242 million.

4.2 Lumber and Wood Products (SIC 24/NAICS 321)

The lumber and wood products industry comprises a large number of establishments engaged in logging; operating sawmills and planing mills; and manufacturing structural wood panels, wooden containers, and other wood products. Table 4-1 lists the lumber and wood products markets that are likely to be affected by the regulation on boilers. Most

Table 4-1. Lumber and Wood Products Markets Likely to Be Affected by the Regulation

SIC	NAICS	Description
2421	321113	Sawmills and Planing Mills, General
2434	33711	Wood Kitchen Cabinets
2449	32192	Wood Containers, N.E.C.
2491	32114	Wood Preserving
2493	321219	Reconstituted Wood Products
2499	321999	Wood Products, N.E.C.

Source: Industrial Combustion Coordinated Rulemaking (ICCR). 1998. Data/Information Submitted to the Coordinating Committee at the Final Meeting of the Industrial Combustion Coordinated Rulemaking Federal Advisory Committee. EPA Docket Numbers A-94-63, II-K-4b2 through -4b5. Research Triangle Park, North Carolina. September 16-17.

products are produced for the domestic market, but exports increasingly account for a larger proportion of sales (Haltmaier, 1998). The largest consumers of lumber and wood products are the remodeling and construction industries.

In 1996, the lumber and wood products industry's total value of shipments was $85,724.0 million. As seen in Table 4-2, shipment values increased steadily through the late 1980s before declining slightly through the early 1990s as new construction starts and furniture purchases declined (Haltmaier, 1998). Shipment values recovered, however, as the economy expanded in the mid-1990s.

4.2.1 Supply Side of the Industry

This section describes the lumber industry's production processes, output, costs of production, and capacity utilization.

4.2.1.1 Production Processes

Sawn lumber. Sawn lumber is softwood or hardwood trimmed at a sawmill for future uses in construction, flooring, furniture, or other markets. Softwoods, such as Douglas fir and spruce, are used for framing in residential or light-commercial construction. Hardwoods, such as maple and oak, are used in flooring, furniture, crating, and other applications.

Table 4-2. Value of Shipments for the Lumber and Wood Products Industry (SIC 24/NAICS 321), 1987–1996

Year	Value of Shipments (1992 $\$10^6$)
1987	85,383.4
1988	85,381.2
1989	85,656.8
1990	86,203.0
1991	81,666.0
1992	81,564.8
1993	74,379.6
1994	79,602.0
1995	87,574.6
1996	85,724.0

Sources: U.S. Department of Commerce, Bureau of the Census. 1996. *1992 Census of Manufactures, Subject Series: General Summary*. Washington, DC: Government Printing Office.
U.S. Department of Commerce, Bureau of the Census. 1990–1998. *Annual Survey of Manufactures [Multiple Years]*. Washington, DC: Government Printing Office.

Lumber is prepared at mills using a four-step process. First, logs are debarked and trimmed into cants, or partially finished lumber. The cants are then cut to specific lengths. Logs are generally kept wet during storage to prevent cracking and to keep them supple. However, after being cut, the boards undergo a drying process, either in open air or in a kiln, to reduce the moisture content. The drying process may take several months and varies according to the plant's climate and the process used. Finally, the lumber may be treated with a surface protectant to prevent sap stains and prepare it for export (EPA, 1995a).

Reconstituted wood products. Reconstituted wood products, such as particleboard, medium density fiberboard, hardboard, and oriented strandboard, are made from raw wood that is combined with resins and other additives and processed into boards. The size of the wood particles used varies from sawdust to strands of wood. Once combined, the ingredients are formed into a mat and then, at high temperatures, pressed into a board. A final finishing process prepares the boards for delivery.

Wood preserving. Wood is treated with preservative to protect it from mechanical, physical, and chemical influences (EPA, 1995a). Treatment agents are either water-based inorganics, such as copper arsenate (78 percent), or oil-borne organics, such as creosote (21 percent) (EPA, 1995a). Wood preservatives are usually applied using a pressure treatment process or a dipping tank. Producers achieve the best results when the lumber's moisture content is reduced to a point where the preservative can be easily soaked into the wood. Treated wood is then placed in a kiln or stacked in a low-humidity climate to dry.

4.2.1.2 Types of Output

The lumber and wood products industry produces essential inputs into the construction, remodeling, and furniture sectors. Lumber and reconstituted wood products are produced in an array of sizes and can be treated to enhance their value and shelf-life. These products are intermediate goods; they are purchased by other industries and incorporated into higher value-added products. In addition to sawmills, the lumber and wood products industry includes kitchen cabinets, wood containers, and other wooden products used for fabricating finished goods for immediate consumption.

4.2.1.3 Major By-Products and Co-Products

Shavings, sawdust, and wood chips are the principal co-products of sawn lumber. Paper mills and makers of reconstituted wood products frequently purchase this material as an input. By-products are limited to emissions from the drying process and from use of preservatives.

Very little solid waste is generated by reconstituted wood products manufacturing. Because the production process incorporates all parts of the sawn log, little is left over as waste. However, air emissions from dryers are a source of emissions.

Wood preserving results in two types of by-products: air emissions and process debris. As preservatives dry, either in a kiln or outside, they emit various chemicals into the air. At plants with dipping processes, wood chips, stones, and other debris build up in the dipping tank. The debris is routinely collected and disposed of.

4.2.1.4 Costs of Production

The costs of production for the wood products industry fluctuate with the demand for the industry's products. Most notably, the costs of production steadily declined during the early 1990s as recession stifled furniture purchases and new housing starts (see Table 4-3). Overall, employment in the lumber and wood products industry increased approximately 6 percent from 1987 to 1996. During this same period, payroll costs decreased 12 percent, indicating a decrease in average annual income per employee. New capital investment and

Table 4-3. Inputs for the Lumber and Wood Products Industry (SIC 24/NAICS 321), 1987–1996

Year	Labor: Quantity (10^3)	Labor: Payroll (1992 $\$10^6$)	Materials (1992 $\$10^6$)	New Capital Investment (1992 $\$10^6$)
1987	698.4	15,555.5	50,509.2	2,234.3
1988	702.4	15,800.0	51,341.0	2,099.4
1989	684.2	15,381.3	51,742.2	2,329.9
1990	677.7	15,612.9	53,369.0	2,315.3
1991	623.6	14,675.8	50,416.3	2,006.5
1992	655.8	13,881.8	48,570.0	1,760.1
1993	685.4	11,798.9	45,300.3	1,538.1
1994	718.5	12,212.5	48,535.6	1,956.8
1995	740.2	13,915.4	53,732.9	2,553.1
1996	738.7	13,933.7	52,450.1	2,659.9

Sources: U.S. Department of Commerce, Bureau of the Census. 1996. *1992 Census of Manufactures, Subject Series: General Summary*. Washington, DC: Government Printing Office.
U.S. Department of Commerce, Bureau of the Census. 1990–1998. *Annual Survey of Manufactures [Multiple Years]*. Washington, DC: Government Printing Office.

costs of materials generally moved in tandem over the 10-year period, increasing from 1987 to 1990 and 1994 to 1996 and decreasing from 1991 to 1993.

4.2.1.5 Capacity Utilization

Full production capacity is broadly defined as the maximum level of production an establishment can obtain under normal operating conditions. The capacity utilization ratio is the ratio of the actual production level to the full production level. Table 4-4 presents the historical trends in capacity utilization for the lumber and wood products industry. The varying capacity utilization ratios reflect adjusting production levels and new production facilities going on- or off-line. The capacity utilization ratio for the industry in 1996 was 78; the average over the last 6 years was 79 percent.

4.2.2 Demand Side of the Industry

This section describes the demand side of the market, including product characteristics, the uses and consumers of the final products, organization of the industry, and markets and trends.

Table 4-4. Capacity Utilization Ratios for Lumber and Wood Products Industry, 1991–1996

1991	1992	1993	1994	1995	1996
78	80	81	80	77	78

Note: All values are percentages.
Source: U.S. Department of Commerce, Bureau of the Census. 1998. *Survey of Plant Capacity: 1996.* Washington, DC: Government Printing Office.

4.2.3 Product Characteristics

Lumber and wood products are valued both for their physical attributes and their relative low cost. Wood is available in varying degrees of durability, shades, and sizes and can be easily shaped. Lumber and wood products have long been the principal raw materials for the residential and light commercial construction industries, the remodeling industry, and the furniture industry. Wood is readily available because over one-third of the United States is forested. The ready supply of wood reduces its costs.

4.2.4 Uses and Consumers of Outputs

Lumber and wood products are used in a wide range of applications, including residential and noresidential construction; repair/remodeling and home improvement projects; manufactured housing; millwork and wood products; pulp, paper, and paperboard mills; toys and sporting goods; kitchen cabinets; crates and other wooden containers; office and household furniture; and motor homes and recreational vehicles (Haltmaier, 1998).

4.2.5 Organization of the Industry

In 1992, 33,878 companies produced lumber and wood products and operated 35,807 facilities, as shown in Table 4-5. By way of comparison, in 1987, 32,014 companies controlled 33,987 facilities. About two-thirds of all establishments have nine or fewer employees. Between 1987 and 1992, the number of facilities with nine or fewer employees increased more than 10 percent to 23,590. These facilities' share of the value of shipments increased about 18.3 percent. Although the number of establishments employing 100 to 249 people decreased during that time, that category's shipment value jumped nearly 40 percent. The remaining facility categories lost both facilities and value of shipment.

Table 4-5. Size of Establishments and Value of Shipments for the Lumber and Wood Products Industry (SIC 24/NAICS 321)

Average Number of Employees in Establishment	1987 Number of Facilities	1987 Value of Shipments (1992 $\$10^6$)	1992 Number of Facilities	1992 Value of Shipments (1992 $\$10^6$)
1 to 4 employees	14,562	2,769.7	15,921	3,288.9
5 to 9 employees	6,702	4,264.4	7,669	5,030.4
10 to 19 employees	5,353	6,982.3	5,331	6,902.8
20 to 49 employees	4,160	28,551.3	3,924	26,964.9
50 to 99 employees	1,702	(D)	1,615	(D)
100 to 249 employees	1,190	24,583.3	1,082	34,051.4
250 to 499 employees	260	12,093.4	219	(D)
500 to 999 employees	47	3,907.9	39	3,331.4
1,000 to 2,499 employees	4	2,231.3	4	598.6
2,500 or more employees	2	(D)	3	1,396.4
Total	33,987	85,383.4	35,807	81,564.8

(D) = undisclosed

Sources: U.S. Department of Commerce, Bureau of the Census. 1991. *1987 Census of Manufactures, Subject Series: General Summary*. Washington, DC: Government Printing Office.
U.S. Department of Commerce, Bureau of the Census. 1996. *1992 Census of Manufactures, Subject Series: General Summary*. Washington, DC: Government Printing Office.

Market structure can affect the size and distribution of regulatory impacts. Concentration ratios are often used to evaluate the degree of competition in a market, with low concentration indicating the presence of a competitive market, and higher concentration suggesting less-competitive markets. Firms in less-concentrated industries are more likely to be price takers, while firms in more-concentrated industries are more likely to influence market prices. Typical measures include four- and eight-firm concentration ratios (CR4 and CR8) and Herfindahl-Hirschmann indices (HHI). The CR4 for lumber and wood products subsectors represented in the boilers inventory database ranges between 13 and 50, meaning that, in each subsector, the top firms' combined sales ranged from 13 to 50 percent of that respective subsector's total sales. The CR8 ranges from 47 to 66 (U.S. Department of Commerce, 1995d).

Although there is no objective criterion for determining market structure based on the values of concentration ratios, the 1992 Department of Justice's (DOJ's) Horizontal Merger Guidelines provide criteria for doing so based on HHIs. According to these criteria, industries with HHIs below 1,000 are considered unconcentrated (i.e., more competitive), those with HHIs between 1,000 and 1,800 are considered moderately concentrated (i.e., moderately competitive), and those with HHIs above 1,800 are considered highly concentrated (i.e., less competitive) (DOJ, 1992). Firms in less-concentrated industries are more likely to be price takers, while firms in more-concentrated industries are more likely to be able to influence market prices. The unconcentrated nature of the markets is also indicated by HHIs of 1,000 or less (DOJ, 1992). Table 4-6 presents various measures of market concentration for sectors within the lumber and wood products industry. All lumber and wood products industries are considered unconcentrated and competitive.

Table 4-6. Measures of Market Concentration for Lumber and Wood Products Markets

SIC	Description	Comparable NAICS	CR4	CR8	HHI	Number of Companies	Number of Facilities
2421	Saw Mills and Planing Mills	321912, 321113, 321918, 321999	14	20	78	5,302	6004
2434	Wood Kitchen Cabinets	33711	19	25	156	4,303	4323
2449	Wood Containers, N.E.C.	32192	34	47	414	217	225
2491	Wood Preserving	321114	17	28	152	408	486
2493	Reconstituted Wood Products	321219	50	66	765	193	288
2499	Wood Products, N.E.C.	339999, 333414, 32192, 321999	13	19	70	2,656	2754

Sources: U.S. Department of Commerce, Bureau of the Census. 1995d. *1992 Concentration Ratios in Manufacturing*. Washington, DC: Government Printing Office.
U.S. Department of Commerce, Bureau of the Census. 1996. *1992 Census of Manufactures, Subject Series: General Summary*. Washington, DC: Government Printing Office.

4.2.6 Markets and Trends

The U.S. market for lumber and wood products is maturing, and manufacturers are looking to enter other markets. Although 91 percent of the industry's products are consumed by the U.S. domestic market, the share of exports increases each year. Exports more than doubled in value from $3 billion in 1986 to $7.3 billion in 1996 (Haltmaier, 1998). The U.S. market grew only 2 percent between 1986 and 1996. American manufacturers are focusing on growing construction markets in Canada, Mexico, and the Pacific Rim, with products such as durable hardwood veneer products and reconstituted wood boards (EPA, 1995a).

4.3 Furniture and Related Product Manufacturing (SIC 25/NAICS 337)

More than 20,000 establishments in the United States produce furniture and furniture-related products. These establishments are located across the United States but are traditionally most concentrated in southern states, such as North Carolina, Mississippi, Alabama, and Tennessee. According to the "1997 Economic Census," these establishments employed more than 600,000 people and paid annual wages of nearly $15 billion. The overall industry-wide value of shipments was $63.9 billion that year (U.S. Department of Commerce, 2001).

This industry is in a state of change: rapid U.S. economic growth translated into vigorous sales of household and office furniture, but this trend is unlikely to continue as the U.S. economy cools after its record run. Adding to industry fluctuation is the merger of two large firms, Lay-Z-Boy and LADD Furniture. Although the industry includes a multitude of niche market players, it is really dominated by a few large companies that operate several subsidiaries, each with its own brand identity. It is unclear whether the merger between two key players in the market will compel other large manufacturers to pursue mergers and acquisitions.

What is clear, however, is that large U.S. manufacturers will seek to leverage their brand identities into wider profit margins by operating direct sales establishments and co-branding. Manufacturers that are moving into retail and distribution include Bassett Furniture, Thomasville Furniture, Ethan Allen Interiors, and Drexel. Co-branding efforts are aimed at capitalizing on the combined power of two identities, such as the Thomas Kinkade Collection from Lay-Z-Boy and popular artist Thomas Kinkade and the Ernest Hemingway Collection from Thomasville. The overarching goal is to enhance margins and ward off invigorated competition from foreign companies that have used this strategy to capture U.S. market share, such as the Swedish manufacturer Ikea (Lemm, 2000).

U.S. imports of household furniture totaled nearly $7 billion in 1998. Between 1992 and 1998, furniture imports grew at an annualized rate of nearly 15 percent. Jamie Lemm, an analyst with the U.S. Department of Commerce's Office of Consumer Goods attributes this growth to changes in U.S. manufacturing and markets:

> A portion of [the] increase can be attributed to the labor-intensive furniture parts imported by U.S. manufacturers to enhance product lines, but the increase also signifies the growing importance of the U.S. market to foreign firms. While some U.S. manufacturers operate showrooms, galleries, and retail outlets in foreign markets, few sell internationally on a large scale. In 1998, U.S. furniture exports totaled $1.6 billion, accounting for only 6 percent of all U.S. product shipments.

4.4 Paper and Allied Products (SIC 26/NAICS 322)

The paper and allied products industry is one of the largest manufacturing industries in the United States. In 1996, the industry shipped nearly $150 billion in paper commodities. The industry produces a wide range of wood pulp, primary paper products, and paperboard products such as printing and writing papers, industrial papers, tissues, container board, and boxboard. The industry also includes manufacturers that "convert" primary paper and paperboard into finished products like envelopes, packaging, and shipping containers (EPA, 1995b). Paper and allied products industry subsectors that are likely to be affected by the regulation are listed in Table 4-7.

Table 4-7. Paper and Allied Products Industry Markets Likely to Be Affected by Regulation

SIC	NAICS	Industry Description
2611	32211	Pulp Mills
2621	32212	Paper Mills
2676	322291	Sanitary Paper Products

Source: Industrial Combustion Coordinated Rulemaking (ICCR). 1998. Data/Information Submitted to the Coordinating Committee at the Final Meeting of the Industrial Combustion Coordinated Rulemaking Federal Advisory Committee. EPA Docket Numbers A-94-63, II-K-4b2 through -4b5. Research Triangle Park, North Carolina. September 16-17.

Table 4-8 lists the paper and allied products industry's value of shipments from 1987 to 1996. The industry's performance is tied to raw material prices, labor conditions, and worldwide inventories and demand (EPA, 1995b). Performance over the 10-year period was typical of most manufacturing industries. The industry expanded in the late 1980s, then contracted as demand tapered off as the industry suffered recessionary effects. In the two years after 1994, the industry's value of shipments increased 9.3 percent to $149.5 billion.

Table 4-8. Value of Shipments for the Paper and Allied Products Industry (SIC 26/NAICS 322), 1987–1996

Year	Value of Shipments (1992 $$10^6$)
1987	129,927.8
1988	136,829.4
1989	138,978.3
1990	136,175.7
1991	132,225.0
1992	133,200.7
1993	131,362.2
1994	136,879.9
1995	135,470.3
1996	149,517.1

Sources: U.S. Department of Commerce, Bureau of the Census. 1996. *1992 Census of Manufactures, Subject Series: General Summary*. Washington, DC: Government Printing Office.
U.S. Department of Commerce, Bureau of the Census. 1990–1998. *Annual Survey of Manufactures, [Multiple Years]*. Washington, DC: Government Printing Office.

4.4.1 Supply Side of the Industry

4.4.1.1 Production Process

The manufacturing paper and allied products industry is capital- and resource-intensive, consuming large amounts of pulp wood and water in the manufacturing process. Approximately half of all paper and allied products establishments are integrated facilities, meaning that they produce both pulp and paper on-site. The remaining half produce only paper products; few facilities produce only pulp (EPA, 1995b).

The paper and paperboard manufacturing process can be divided into three general steps: pulp making, pulp processing, and paper/paperboard production. Paper and paperboard are manufactured using what is essentially the same process. The principal difference between the two products is that paperboard is thicker than paper's 0.3 mm.

Producers manufacture pulp mixtures by using chemicals, machines, or both to reduce raw material into small fibers. In the case of wood, the most common pulping material, chemical pulping actions release cellulose fibers by selectively destroying the chemical bonds that bind the fibers together (EPA, 1995b). Impurities are removed from the pulp, which then may be bleached to improve brightness. Only about 20 percent of pulp and paper mills practice bleaching (EPA, 1995b). The pulp may also be further processed to aid in the paper-making process.

During the paper-making stage, the pulp is strengthened and then converted into paper. Pulp can be combined with dyes, resins, filler materials, or other additives to better fulfill specifications for the final product. Next, the water is removed from the pulp, leaving the pulp on a wire or wire mesh conveyor. The fibers bond together as they are carried through heated presses and rollers. The paper is stored on large rolls before being shipped for conversion into another product, such as envelopes and boxes, or cut into paper sheets for immediate consumption.

4.4.1.2 Types of Output

The paper and allied products industry's output ranges from writing papers to containers and packaging. Paper products include printing and writing papers; paperboard boxes; corrugated and solid fiber boxes; fiber cans, drums, and similar products; sanitary food containers; building paper; packaging; bags; sanitary paper napkins; envelopes; stationary products; and other converted paper products.

4.4.1.3 Major By-Products and Co-Products

The paper and allied products industry is the largest user of industrial process water in the United States. In 1988, a typical mill used between 16,000 and 17,000 gallons of water per ton of paper produced. The equivalent amount of waste water discharged each day is about 16 million cubic meters (EPA, 1995b). Most facilities operate waste water treatment facilities on site to remove biological oxygen demand (BOD), total suspended solids (TSS), and other pollutants before discharging the water into a nearby waterway.

4.4.1.4 Costs of Production

Historical statistics for the costs of production for the paper and allied products industry are listed in Table 4-9. From 1987 to 1996, industry payroll generally ranged from approximately $19 to 20 billion. Employment peaked at 633,200 people in 1989 and declined slightly to 630,600 people by 1996. Materials costs averaged $74.4 billion a year and new capital investment averaged $8.3 billion a year.

Table 4-9. Inputs for the Paper and Allied Products Industry (SIC 26/NAICS 322), 1987–1996

	Labor			
Year	Quantity (10^3)	Payroll (1992 $$10^6$)	Materials (1992 $$10^6$)	New Capital Investment (1992 $$10^6$)
1987	611.1	20,098.6	70,040.6	6,857.5
1988	619.8	19,659.0	73,447.4	8,083.8
1989	633.2	19,493.1	75,132.5	10,092.9
1990	631.2	19,605.2	74,568.8	11,267.2
1991	624.7	19,856.3	72,602.5	9,353.9
1992	626.3	20,491.9	73,188.0	7,962.4
1993	626.3	20,602.6	73,062.6	7,265.2
1994	621.4	20,429.7	76,461.6	6,961.7
1995	629.2	18,784.3	79,968.6	7,056.8
1996	630.6	19,750.0	75,805.9	8,005.9

Sources: U.S. Department of Commerce, Bureau of the Census. 1996. *1992 Census of Manufactures, Subject Series: General Summery*. Washington, DC: Government Printing Office.
U.S. Department of Commerce, Bureau of the Census. 1990–1998. *Annual Survey of Manufactures [Multiple Years]*. Washington, DC: Government Printing Office.

4.4.1.5 Capacity Utilization

Table 4-10 presents the trend in capacity utilization for the paper and allied products industry. The varying capacities reflect adjusting production levels and new production facilities going on- or off-line. The average capacity utilization ratio for the paper and allied products industry between 1991 and 1996 was approximately 80, with capacity declining slightly in recent years.

Table 4-10. Capacity Utilization Ratios for the Paper and Allied Products Industry, 1991–1996

1991	1992	1993	1994	1995	1996
78	80	81	80	77	78

Note: All values are percentages.
Source: U.S. Department of Commerce, Bureau of the Census. 1998. *Survey of Plant Capacity: 1996.* Washington, DC: Government Printing Office.

4.4.2 Demand Side of the Industry

4.4.2.1 Product Characteristics

Paper is valued for its diversity in product types, applications, and low cost due to ready access to raw materials. Manufacturers produce papers of varying durabilities, textures, and colors. Consumers purchasing large quantities of papers may have papers tailored to their specification. Papers may be simple writing papers or newsprint for personal consumption and for the printing and publishing industry or durable for conversion into shipping cartons, drums, or sanitary boxes. Inputs in the paper production process are readily available in the United States because one-third of the country is forested, and facilities generally have ready access to waterways.

4.4.2.2 Uses and Consumers of Products

The paper and allied products industry is an integral part of the U.S. economy; nearly every industry and service sector relies on paper products for its personal, education, and business needs. Among a myriad of uses, papers are used for correspondence, printing and publishing, packing and storage, and sanitary purposes. Common applications are all manners of reading material, correspondence, sanitary containers, shipping cartons and drums, and miscellaneous packing materials.

4.4.3 Organization of the Industry

In 1992, 4,264 companies produced paper and allied products and operated 6,416 facilities. By way of comparison, 4,215 companies controlled 1,732 facilities in 1987.

Although the number of small firms and facilities increased during those 5 years, the industry is dominated by high-volume, low-cost producers (Haltmaier, 1998). Even though they account for only 45 percent of all facilities, those with 50 or more employees contribute more than 93 percent of the industry's total value of shipments (see Table 4-11). (According to the Small Business Administration, those companies employing fewer than 500 employees are "small.")

Table 4-11. Size of Establishments and Value of Shipments for the Paper and Allied Products Industry (SIC 26/NAICS 322)

Number of Employees in Establishment	1987 Number of Facilities	1987 Value of Shipments ($\$10^6$)	1992 Number of Facilities	1992 Value of Shipments ($\$10^6$)
1 to 4 employees	729	640.6	786	216
4 to 9 employees	531	(D)	565	483
10 to 19 employees	888	1,563.4	816	1,456.5
20 to 49 employees	1,433	18,328.6	1,389	6,366.6
50 to 99 employees	1,018	(D)	1,088	12,811.5
100 to 249 employees	1,176	32,141.7	1,253	35,114.0
250 to 499 employees	308	24,221.1	298	22,281.2
500 to 999 employees	145	28,129.1	159	31,356.5
1,000 to 2,499 employees	63	24,903.1	62	23,115.4
2,500 or more employees	1	(D)		
Total	1,732	129,927.8	6,416	133,200.7

(D) = undisclosed

Sources: U.S. Department of Commerce, Bureau of the Census. 1990c. *1987 Census of Manufactures, Industry Series: Pulp, Paper, and Board Mills*. Washington, DC: Government Printing Office.
U.S. Department of Commerce, Bureau of the Census. 1995c. *1992 Census of Manufactures, Industry Series: Pulp, Paper, and Board Mills*. Washington, DC: Government Printing Office.

For paper and allied products markets likely to be affected by the boilers regulation, the CR4 ranged between 29 and 68 in 1992 (see Table 4-12). This means that, in each subsector, the top firms' combined sales ranged from 29 to 68 percent of their respective industry's total sales. For example, in the sanitary paper products industry, the CR4 ratios indicate that a few firms control 68 percent of the market. This sector's moderately concentrated nature is also indicated by its HHI of 1,451 (DOJ, 1992). The remaining two sectors' HHIs indicate that their respective markets are unconcentrated (i.e., competitive).

Table 4-12. Measurements of Market Concentration for Paper and Allied Products Markets

SIC	Description	CR4	CR8	HHI	Number of Companies	Number of Facilities
2611	Pulp Mills	48	75	858	29	45
2621	Paper Mills	29	49	392	127	280
2676	Sanitary Paper Products	68	82	1,451	80	150

Sources: U.S. Department of Commerce, Bureau of the Census. 1995d. *1992 Concentration Ratios in Manufacturing*. Washington, DC: Government Printing Office.
U.S. Department of Commerce, Bureau of the Census. 1995c. *1992 Census of Manufactures, Industry Series: Pulp, Paper, and Board Mills*. Washington, DC: Government Printing Office.

4.4.4 Markets and Trends

The Department of Commerce projects that shipments of paper and allied products will increase through 2002 by an annual average of 2.5 percent (Haltmaier, 1998). Because nearly all of the industry's products are consumer related, shipments will be most affected by the health of the U.S. and global economy. The United States is a key competitor in the international market for paper products and, after Canada, is the largest exporter of paper products. According to Haltmaier (1998), the largest paper and allied products exporters in the world are Canada (with 23 percent of the market), the United States (10 to 15 percent), Finland (8 percent), and Sweden (7 percent).

4.5 Medicinal Chemicals and Botanical Products and Pharmaceutical Preparations (SICs 2833, 2834/NAICS 32451)

The pharmaceutical preparations industry (SIC 2834/NAICS 32451) and the medicinal chemicals and botanical products industry (SIC 2833/NAICS 32451) are both primarily engaged in the research, development, manufacture, and/or processing of medicinal chemicals and pharmaceutical products. Apart from manufacturing drugs for human and veterinary consumption, the industries grind, grade, and mill botanical products that are inputs for other industries. Typically, most facilities cross over into both industries (EPA, 1997a). Products include drugs, vitamins, herbal remedies, and production inputs, such as alkaloids and other active medicinal principals.

Table 4-13 presents both industries' value of shipments from 1987 to 1996. Medicinals and botanicals' performance during the late 1980s and early 1990s was mixed. However, shipments increased steadily from 1994 to 1996, increasing 37.7 percent as natural

Table 4-13. Value of Shipments for the Medicinals and Botanicals and Pharmaceutical Preparations Industries, 1987–1996

Year	SIC 2833[a] Medicinals & Botanicals ($\$10^6$)	SIC 2834[a] Pharmaceutical Preparations ($\$10^6$)
1987	4,629.1	44,345.7
1988	5,375.4	46,399.1
1989	5,708.9	48,083.6
1990	5,535.8	49,718.0
1991	6,637.7	49,866.3
1992	6,438.5	50,417.9
1993	5,669.2	50,973.5
1994	5,774.7	53,144.7
1995	6,404.1	53,225.9
1996	7,952.8	55,103.6

[a] Comparable NAICS: 325411, 325412.

Sources: U.S. Department of Commerce, Bureau of the Census. 1995a. *1992 Census of Manufactures, Industry Series: Drug Industry*. Washington, DC: Government Printing Office.
U.S. Department of Commerce, Bureau of the Census. 1990–1998. *Annual Survey of Manufactures [Multiple Years]*. Washington, DC: Government Printing Office.

products such as herbs and vitamins became more popular (EPA, 1997a). Pharmaceutical preparations' shipments increased steadily over the 10-year period. From 1987 to 1996, the industry's shipments increased 24.3 percent to $55.1 billion in 1996.

4.5.1 Supply Side of the Industry

4.5.1.1 Production Processes

The medicinals and botanical products industry and the pharmaceutical preparations industry share similar production processes. Many products of the former are inputs in the latter's production process. There are three manufacturing stages: research and development, preparation of bulk ingredients, and formulation of the final product.

The research and development stage is a long process both to ensure the validity and benefit of the end product and to satisfy the requirements of stringent federal regulatory committees. (The pharmaceutical industry operates under strict oversight of the Food and Drug Administration [FDA].) Therefore, every stage in the development of new drugs is thoroughly documented and studied. After a new compound is discovered, it is subjected to numerous laboratory and animal tests. Results are presented to the FDA via applications that present and fully disclose all findings to date. As research and development proceeds, studies are gradually expanded to involve human trials of the new compound. Should FDA approve the compound, the new product is readied for mass production.

To ensure a uniform product, all ingredients are prepared in bulk using batch processes. Companies produce enough of each ingredient to satisfy projected sales demand (EPA, 1997a). Prior to production, all equipment is thoroughly cleaned, prepared, and validated to prevent any contaminants from entering the production cycle. Most ingredients are prepared by chemical synthesis, a method whereby primary ingredients undergo a complex series of processes, including many intermediate stages and chemical reactions in a step-by-step fashion (EPA, 1997a).

After the bulk materials are prepared, they are converted into a final usable form. Common forms include tablets, pills, liquids, creams, and ointments. Equipment used in this final stage is prepared in the same manner as that involved in the bulk preparation process. Clean and validated machinery is used to process and package the pharmaceuticals for shipment and consumption.

4.5.1.2 Types of Output

Both industries produce pharmaceutical and botanical products for end consumption and intermediate products for the industries' own applications. Products include vitamins, herbal remedies, and alkaloids. Prescription and over-the-counter drugs are produced in liquid, tablet, cream, and other forms.

4.5.1.3 Major By-Products and Co-Products

Both industries produce many by-products because of the large number of primary inputs and the extensive chemical processes involved. Wastes and emissions vary by the process employed, raw materials consumed, and equipment used. In general, emissions originate during drying and heating stages and during process water discharge. Emissions controls are in place pursuant to environmental regulations. Other wastes include used filters, spent raw materials, rejected product, and reaction residues (EPA, 1997a).

4.5.1.4 Costs of Production

Table 4-14 presents SIC 2833 industry's costs of production and employment statistics from 1987 to 1996. Employment was stable during the late 1980s before steadily growing in the 1990s. In 1987, medicinals and botanicals employed 11,600 people. By

Table 4-14. Inputs for Medicinal Chemicals and Botanical Products Industry (SIC 2833/NAICS 32451), 1987–1996

Year	Labor: Quantity (10^3)	Labor: Payroll ($\$10^6$)	Materials ($\$10^6$)	New Capital Investment ($\$10^6$)
1987	11.6	520.2	2,229.3	158.2
1988	11.3	494.4	2,658.8	194.9
1989	11.4	504.9	3,118.4	263.4
1990	10.9	476.4	2,902.4	218.9
1991	12.5	568.6	3,368.2	512.9
1992	13.0	587.1	3,245.9	550.5
1993	13.0	584.3	2,638.4	470.0
1994	13.9	572.6	2,755.2	480.3
1995	14.1	625.0	3,006.0	356.2
1996	16.8	752.1	3,793.9	752.1

Sources: U.S. Department of Commerce, Bureau of the Census. 1995a. *1992 Census of Manufactures, Industry Series: Drug Industry*. Washington, DC: Government Printing Office.
U.S. Department of Commerce, Bureau of the Census. 1990–1998. *Annual Survey of Manufactures, [Multiple Years]*. Washington, DC: Government Printing Office.

1996, the industry employed 16,800, an increase of nearly 45 percent. Materials costs matched the increase in shipments over this same period. Industry growth also fed new capital investments, which averaged $191.2 million a year in the late 1980s and $515.6 million a year in the early to mid-1990s.

SIC 2834's costs of production and employment for 1987 to 1996 are presented in Table 4-15. The number of people employed by the industry ranged between 123,000 and 144,000; employment peaked in 1990 before declining by 21,000 jobs by the end of 1992. During this 10-year period, the cost of materials rose 42.1 percent. The increase is associated with increased product shipments and the development of new, more expensive medications (Haltmaier, 1998). New capital investment averaged $2.3 billion a year.

Table 4-15. Inputs for the Pharmaceutical Preparations Industry (SIC 2834/NAICS 32451), 1987–1996

Year	Labor: Quantity (10^3)	Labor: Payroll (\$$10^6$)	Materials (\$$10^6$)	New Capital Investment (\$$10^6$)
1987	131.6	5,759.2	11,693.7	2,032.7
1988	133.4	5,447.2	12,634.8	2,234.0
1989	141.8	6,177.5	12,874.2	2,321.4
1990	143.8	6,223.9	13,237.6	2,035.3
1991	129.1	5,275.8	13,546.6	1,864.7
1992	122.8	4,949.4	13,542.5	2,450.0
1993	128.2	5,184.2	13,508.7	2,385.2
1994	134.2	5,368.4	13,526.1	2,531.9
1995	143.0	5,712.4	15,333.6	2,856.1
1996	136.9	5,547.3	16,611.1	2,317.0

Sources: U.S. Department of Commerce, Bureau of the Census. 1995a. *1992 Census of Manufactures, Industry Series: Drug Industry*. Washington, DC: Government Printing Office.
U.S. Department of Commerce, Bureau of the Census. 1990–1998. *Annual Survey of Manufactures, [Multiple Years]*. Washington, DC: Government Printing Office.

4.5.1.5 Capacity Utilization

Table 4-16 presents the trend in these ratios from 1991 to 1996 for both industries. The varying capacity ratios reflect adjusting production volumes and new production facilities and capacity going both on- and off-line. In 1996, the capacity utilization ratios for SICs 2833 and 2834 were 84 and 67, respectively.

4.5.2 Demand Side of the Industry

New product introductions and improvements on older medications by the drug industry have greatly improved the health and well-being of the U.S. population (Haltmaier, 1998). Products help alleviate or reduce physical, mental, and emotional ailments or reduce the severity of symptoms associated with disease, age, and degenerative conditions. Dietary supplements, such as vitamins and herbal remedies, ensure that consumers receive nutrients

Table 4-16. Capacity Utilization Ratios for the Medicinal Chemicals and Botanical Products (SIC 2833/NAICS 32451) and Pharmaceutical Preparations (SIC 2834/NAICS 32451) Industries, 1991–1996

	1991	1992	1993	1994	1995	1996
SIC 2833/NAICS 32451	84	86	89	80	90	84
SIC 2834/NAICS 32451	76	74	70	67	63	67

Note: Capacity utilization ratio is the ratio of the actual production level to the full production level. All values are percentages.
Source: U.S. Department of Commerce, Bureau of the Census. 1998. *Survey of Plant Capacity: 1996*. Washington, DC: Government Printing Office.

of which they may not ordinarily consume enough. Products are available in a range of dosage types, such as tablets and liquids.

Although prescription medications are increasingly distributed through third parties, such as hospitals and health maintenance organizations, the general population remains the end user of pharmaceutical products. As the average age of the U.S. population adjusts to reflect large numbers of older people, the variety and number of drugs consumed increases. An older population will generally consume more medications to maintain and improve quality of life (Haltmaier, 1998).

4.5.3 Organization of the Industry

In 1992, 208 companies produced medicinal chemicals and botanical products and operated 225 facilities (see Table 4-17). The number of companies and facilities in 1992 was the same as that of 1987, although shipment values increased almost 40 percent. The average facility employed more people in 1992 than in 1987. In fact, the number of facilities employing 50 or more people grew from 37 to 45. These facilities accounted for the lion's share of the industry's shipments. According to the Small Business Administration, companies in this SIC code are considered small if they employ fewer than 750 employees. It is unclear what percentage of the facilities listed in Table 4-17 are small companies.

In 1992, 585 companies manufactured pharmaceutical preparations and operated 691 facilities. By way of comparison, 640 companies operated 732 facilities in 1987. Although the number of facilities declined by 41, no particular category lost or gained an exceptional number of facilities. The biggest movement was in the five to nine employees category,

Table 4-17. Size of Establishments and Value of Shipments for the Medicinal Chemicals and Botanical Products (SIC 2833/NAICS 32451) and Pharmaceutical Preparations (SIC 2834/NAICS 32451) Industries

	1987		1992	
Number of Employees in Establishment	Number of Facilities	Value of Shipments ($\$10^6$)	Number of Facilities	Value of Shipments ($\$10^6$)
SIC 2833/NAICS 32451				
1 to 4 employees	61	20.7	62	23.8
5 to 9 employees	34	38.6	42	58.3
10 to 19 employees	46	237.0	47	357.1
20 to 49 employees	47	287.3	29	182.0
50 to 99 employees	15	273.6	25	653.9
100 to 249 employees	12	520.6	10	5,163.4
250 to 499 employees	5	753.0	4	(D)
500 to 999 employees	4	2478.2	3	(D)
1,000 to 2,499 employees	1	(D)	3	(D)
Total	225	4629.1	225	6,438.5
SIC 2834/NAICS 32451				
1 to 4 employees	158	58.7	152	115.6
5 to 9 employees	108	178.8	73	105.4
10 to 19 employees	102	320.3	101	284.6
20 to 49 employees	117	932.5	110	815.7
50 to 99 employees	66	1231.0	65	1,966.8
100 to 249 employees	76	3596.0	77	2,912.4
250 to 499 employees	50	9239.7	56	11,394.6
500 to 999 employees	23	4946.9	30	10,077.7
1,000 to 2,499 employees	24	15,100.9	21	14,525.7
2,500 employees or more	8	8740.9	6	8,219.4
Total	732	44,345.7	691	50,417.9

(D) = undisclosed

Sources: U.S. Department of Commerce, Bureau of the Census. 1990a. *1987 Census of Manufactures, Industry Series: Drug Industry*. Washington, DC: Government Printing Office.
U.S. Department of Commerce, Bureau of the Census. 1995a. *1992 Census of Manufactures, Industry Series: Drug Industry*. Washington, DC: Government Printing Office.

which lost 35 facilities. In both years, facilities with more than 50 employees accounted for at least 95 percent of the industry's shipments.

Table 4-18 presents the measures of market concentration for both industries. For the medicinals and botanicals industry, the CR4 was 76 in 1992, and the CR8 was 84 (U.S. Department of Commerce, 1995b). The highly concentrated nature of the market is further indicated by an HHI of 2,999 (DOJ, 1992). According to the Department of Justice's Horizontal Merger Guidelines, industries with HHIs above 1,800 are less competitive.

Table 4-18. Measures of Market Concentration for the Medicinal Chemicals and Botanical Products (SIC 2833/NAICS 32451) and Pharmaceutical Preparations (SIC 2834/NAICS 32451) Industries

SIC	NAICS	Industry	CR4	CR8	HHI	Number of Companies	Number of Facilities
2833	32451	Medicinal Chemicals and Botanical Products	76	84	2,999	208	225
2834	32451	Pharmaceutical Preparations	26	42	341	585	691

Sources: U.S. Department of Commerce, Bureau of the Census. 1995d. *1992 Concentration Ratios in Manufacturing*. Washington, DC: Government Printing Office.
U.S. Department of Commerce, Bureau of the Census. 1995a. *1992 Census of Manufactures, Industry Series: Drug Industry*. Washington, DC: Government Printing Office.

The pharmaceuticals preparations industry is less concentrated than the medicinal chemicals and botanical products industry. For SIC 2834, the CR4 and CR8 were 26 and 42, respectively, in 1992. The industry's HHI was 341, indicating a competitive market.

4.5.4 Markets and Trends

According to the Department of Commerce, global growth in the consumption of pharmaceuticals is projected to accelerate over the coming decade as populations in developed countries age and those in developing nations gain wider access to health care. Currently, the United States remains the largest market for drugs, medicinals, and botanicals and produces more new products than any other country (Haltmaier, 1998). But, nearly two-fifths of American producers' sales are generated abroad. Top markets for American exports are China, Canada, Mexico, Australia, and Japan. Most imports originate in Canada, Russia, Mexico, Trinidad and Tobago, and Norway.

4.6 Industrial Organic Chemicals Industry (SIC 2869/NAICS 3251)

The industrial organic chemicals (not elsewhere classified) industry (SIC 2869/NAICS 3251) produces organic chemicals for end-use applications and for inputs into numerous other chemical manufacturing industries. In nominal terms, it was the single largest segment of the $367 billion chemical and allied products industry (SIC 28) in 1996, accounting for approximately 17 percent of the industry's shipments.

All organic chemicals are, by definition, carbon-based and are divided into two general categories: commodity and specialty. Commodity chemical manufacturers compete on price and produce large volumes of staple chemicals using continuous manufacturing processes. Specialty chemicals cater to custom markets, using batch processes to produce a diverse range of chemicals. Specialty chemicals generally require more technical expertise and research and development than the more standardized commodity chemicals industry (EPA, 1995c). Consequently, specialty chemical manufacturers have a greater value added to their products. End products for all industrial organic chemical producers are as varied as synthetic perfumes, flavoring chemicals, glycerin, and plasticizers.

Table 4-19 presents the shipments of industrial organic chemicals from 1987 to 1996. In real terms, the industry's shipments rose in the late 1980s to a high of $54.9 billion before declining in the early 1990s as the U.S. economy went into recession. By the mid-1990s, the industry recovered, as product values reached record highs (Haltmaier, 1998). Between 1993 and 1996, the industry's shipments grew 7.3 percent to $57.7 billion.

4.6.1 Supply Side of the Industry

4.6.1.1 Production Processes

Processes used to manufacture industrial organic chemicals are as varied as the end-products themselves. There are thousands of possible ingredients and hundreds of processes. Therefore, the discussion that follows is a general description of the ingredients and stages involved in a typical manufacturing process.

Essentially a set of ingredients (feedstocks) is combined in a series of reactions to produce end products and intermediates (EPA, 1995c). The typical chemical synthesis processes incorporate multiple feedstocks in a series of chemical reactions. Commodity chemicals are produced in a continuous reactor, and specialty chemicals are produced in batches. Specialty chemicals may undergo a series of reaction steps, as opposed to

Table 4-19. Value of Shipments for the Industrial Organic Chemicals, N.E.C. Industry (SIC 2869/NAICS 3251), 1987-1996

Year	Value of Shipments (1992 $\$10^6$)
1987	48,581.7
1988	53,434.7
1989	54,962.9
1990	53,238.8
1991	51,795.6
1992	54,254.2
1993	53,805.2
1994	57,357.1
1995	59,484.3
1996	57,743.3

Sources: U.S. Department of Commerce, Bureau of the Census. 1995b. *1992 Census of Manufactures, Industry Series: Industrial Organic Chemicals*. Washington, DC: Government Printing Office.
U.S. Department of Commerce, Bureau of the Census. 1990–1998. *Annual Survey of Manufactures, Multiple Years*. Washington, DC: Government Printing Office.

commodity chemicals' one continuous reaction because a finite amount of ingredients are prepared and used in the production process. Reactions usually take place at high temperatures, with one or two additional components being intermittently added. As the production advances, by-products are removed using separation, distillation, or refrigeration techniques. The final product may undergo a drying or pelletizing stage to form a more manageable substance.

4.6.1.2 Types of Output

Miscellaneous industrial organic chemicals comprise nine general categories of products:

- aliphitic and other acyclic organic chemicals (ethylene); acetic, chloroaceptic, adipic, formic, oxalic, and tartaric acids and their metallic salts; chloral, formaldehyde, and methylamine;
- solvents (ethyl alcohol etc.); methanol; amyl, butyl, and ethyl acetates; ethers; acetone, carbon disulfide and chlorinated solvents;
- polyhydric alcohols (synthetic glycerin, etc.);

- synthetic perfume and flavoring materials (citral, methyl, oinone, etc.);
- rubber processing chemicals, both accelerators and antioxidants (cyclic and acyclic);
- cyclic and acyclic plasticizers (phosphoric acid, etc.);
- synthetic tanning agents;
- chemical warfare gases; and
- esters, amines, etc., of polyhydric alcohols and fatty and other acids.

4.6.1.3 Major By-Products and Co-Products

Co-products, by-products, and emissions vary according to the ingredients, processes, maintenance practices, and equipment used (EPA, 1997b). Frequently, residuals from the reaction process that are separated from the end product are resold or possibly reused in the manufacturing process. A by-product from one process may be another's input. The industry is strictly regulated because it emits chemicals through many types of media, including discharges to air, land, and water, and because of the volume and composition of these emissions.

4.6.1.4 Costs of Production

Of all the factors of production, employment in industrial organic chemicals fluctuated most often between 1987 and 1996 (see Table 4-20). During that time, employment fell 8.18 percent to 92,100, after a high of 101,000 in 1991. Most jobs lost were at the production level (Haltmaier, 1998). Facilities became far more computerized, incorporating advanced technologies into the production process. Even with the drop in employment, payroll was $200 million more in 1995 than in 1987. The cost of materials fluctuated between $29 and $36 billion for these years, and new capital investment averaged $3,646 million a year.

4.6.1.5 Capacity Utilization

Table 4-21 presents the trend in capacity utilization ratios from 1991 to 1996 for the industrial organic chemicals industry. The varying capacity utilization ratios reflect changes in production volumes and new production facilities and capacities going on- and off-line. The capacity utilization ratio for the industry averaged 85.3 over the 6-year period presented.

Table 4-20. Inputs for the Industrial Organic Chemicals Industry (SIC 2869/NAICS 3251), 1987–1996

Year	Labor		Materials (1992 $$10^6$)	New Capital Investment (1992 $$10^6$)
	Quantity (10^3)	Payroll (1992 $$10^6$)		
1987	100.3	4,295.8	28,147.7	2,307.4
1988	97.1	4,045.1	29,492.8	2,996.5
1989	97.9	3,977.4	29,676.4	3,513.0
1990	100.3	4,144.6	29,579.2	4,085.5
1991	101.0	4,297.3	29,335.2	4,428.7
1992	100.1	4,504.2	31,860.6	4,216.6
1993	97.8	4,540.2	30,920.1	3,386.1
1994	89.8	4,476.5	33,267.4	2,942.8
1995	92.1	4,510.4	33,163.9	3,791.0
1996	100.3	5,144.8	36,068.9	4,794.7

Sources: U.S. Department of Commerce, Bureau of the Census. 1995b. *1992 Census of Manufactures.* Washington, DC: Government Printing Office.
U.S. Department of Commerce, Bureau of the Census. 1990–1998. *Annual Survey of Manufactures.* Washington, DC: Government Printing Office.

Table 4-21. Capacity Utilization Ratios for the Industrial Organic Chemicals Industry (SIC 2869/NAICS 3251), 1991–1996

	1991	1992	1993	1994	1995	1996
SIC 2869/NAICS 3251	86	81	91	89	84	84

Note: The capacity utilization ratio is the ratio of the actual production level to the full production level. All values are percentages.
Source: U.S. Department of Commerce, Bureau of the Census. 1998. *Survey of Plant Capacity: 1996.* Washington, DC: Government Printing Office.

4.6.2 Demand Side of the Industry

Industrial organic chemicals are components of many chemical products. Most of the chemical sectors (classified under SIC 28) are downstream users of organic chemicals. These sectors either purchase commodity chemicals or enter into contracts with industrial organic chemical producers to obtain specialty chemicals. Consumers include inorganic chemicals (SIC 281), plastics and synthetics (SIC 282), drugs (283), soaps and cleaners (SIC 284), paints and allied products (SIC 286), and miscellaneous chemical products (SIC 289).

4.6.3 Organization of the Industry

Although the industry's value of shipments increased nearly 12 percent between 1987 and 1992, the number of facilities producing industrial organic chemicals only increased by 6 percent. Facilities with 100 or more employees continued to account for the majority of the industry's shipment values. For example, in 1992, 28 percent of all facilities had 100 or more employees (see Table 4-22), and these facilities produced 89 percent of the industry's shipment values. The average number of facilities per firm was 1.4 in both years. According to the Small Business Administration, an industrial organic chemicals company is considered small if the total number of employees does not exceed 500. It is unclear what percentage of facilities are owned by small businesses.

The industrial organic chemicals (not elsewhere classified) industry is unconcentrated and competitive. The CR4 was 29 and the CR8 43; the industry's HHI was 336.

4.6.4 Markets and Trends

The U.S. industrial organic chemical industry is expected to expand through 2002 at an annual rate of 1.4 percent (Haltmaier, 1998). U.S. producers face increasing competition domestically and abroad as chemical industries in developing nations gain market share and increase exports to the United States. American producers will, however, benefit from decreasing costs for raw materials and energy and productivity gains.

4.7 Electric Services (SIC 4911/NAICS 22111)

The ongoing process of deregulation of wholesale and retail electric markets is changing the structure of the electric power industry. Deregulation is leading to the functional unbundling of generation, transmission, and distribution and to competition in the generation segment of the industry. This profile provides background information on the U.S. electric power industry and discusses current industry characteristics and trends that will influence the future generation and consumption of electricity. It is important to note

Table 4-22. Size of Establishments and Value of Shipments for the Industrial Organic Chemicals Industry (SIC 2869/NAICS 3251)

	1987		1992	
Number of Employees in Establishment	Number of Facilities	Value of Shipments (1992 $\$10^6$)	Number of Facilities	Value of Shipments (1992 $\$10^6$)
1 to 4 employees	97	552.8	100	102.6
5 to 9 employees	80	200.9	80	208.7
10 to 19 employees	91	484.7	97	533.9
20 to 49 employees	137	1,749.9	125	1,701.5
50 to 99 employees	99	2556.3	106	3,460.9
100 to 249 employees	110	10,361.2	111	8,855.9
250 to 499 employees	41	17,156.9	41	9,971.1
500 to 999 employees	27	9,615.5	30	13,755.0
1,000 to 2,499 employees	11	9,184.6	10	9,051.0
2,500 or more employees	6	7,156.9	5	6,613.5

Sources: U.S. Department of Commerce, Bureau of the Census. 1995b. *1992 Census of Manufactures, Industry Series: Industrial Organic Chemicals*. Washington, DC: Government Printing Office. U.S. Department of Commerce, Bureau of the Census. 1990b. *1987 Census of Manufactures, Industry Series, Paints and Allied Products*. Washington, DC: Government Printing Office.

that through out this report the terms "boilers," "process heaters," and "units" are synonymous with "ICI boilers" and "process heaters." Boilers primarily engaged in the generation of electricity are not covered by the NESHAP under analysis and are therefore excluded from this analysis. Utility sources are not affected by this NESHAP except for a small number of nonfossil fuel units within this industry. Those units in this industry that are affected may be engaged in activities such as heating and mechanized work.

4.7.1 Electricity Production

Figure 4-1 illustrates the typical structure of the electric utility market. Even with the technological and regulatory changes in the 1970s and 1980s, at the beginning of the 1990s the structure of the electric utility industry could still be characterized in terms of generation, transmission, and distribution. Commercial and retail customers were in essence "captive," and rates and service quality were primarily determined by public utility commissions.

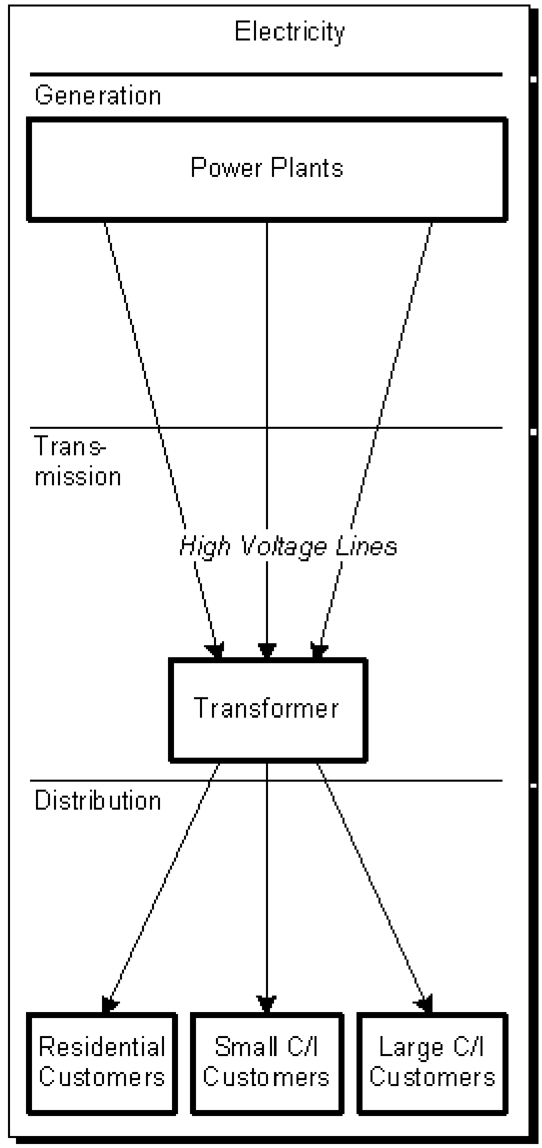


Figure 4-1. Traditional Electric Power Industry Structure

The majority of utilities are interconnected and belong to a regional power pool. Pooling arrangements enable facilities to coordinate the economic dispatch of generation facilities and manage transmission congestion. In addition, pooling diverse loads can increase load factors and decrease costs by sharing reserve capacity.

4.7.1.1 Generation

As shown in Table 4-23, coal-fired plants have historically accounted for the bulk of electricity generation in the United States. With abundant national coal reserves and advances in pollution abatement technology, such as advanced scrubbers for pulverized coal and flue gas-desulfurization systems, coal will likely remain the fuel of choice for most existing generating facilities over the near term.

Table 4-23. Net Generation by Energy Source, 1995

Energy Source	Utility Generators (MWh)	Nonutility Generators (MWh)	Total (MWh)
Fossil fuels	2,021,064	287,696	2,308,760
Coal	1,652,914	63,440	
Natural gas	307,306	213,437	
Petroleum	60,844	3,957	
Nuclear	673,402	—	673,402
Hydroelectric	293,653	14,515	308,168
Renewable/other	6,409	98,295	104,704
Total	2,994,582	400,505	3,395,033

Sources: U.S. Department of Energy, Energy Information Administration. 1996. *Electric Power Annual, 1995*. Vol. 1. DOE/EIA-0348(95/1). Washington, DC: U.S. Department of Energy.
U.S. Department of Energy, Energy Information Administration. 1999b. *The Changing Structure of the Electric Power Industry 1999: Mergers and Other Corporate Combinations*. Washington, DC: U.S. Department of Energy.

Natural gas accounts for approximately 10 percent of current generation capacity but is expected to grow; advances in natural gas exploration and extraction technologies and new coal gasification have contributed to the use of natural gas for power generation.

Nuclear plants and renewable energy sources (e.g., hydroelectric, solar, wind) provide approximately 20 percent and 10 percent of current generating capacity, respectively. However, there are no plans for new nuclear facilities to be constructed, and there is little additional growth forecasted in renewable energy.

4.7.1.2 Transmission

Transmission refers to high voltage lines used to link generators to substations where power is stepped down for local distribution. Transmission systems have been traditionally characterized as a collection of independently operated networks or grids interconnected by bulk transmission interfaces.

Within a well-defined service territory, the regulated utility has historically had responsibility for all aspects of developing, maintaining, and operating transmissions. These responsibilities included

- system planning and expanding,
- maintaining power quality and stability, and
- responding to failures.

Isolated systems were connected primarily to increase (and lower the cost of) power reliability. Most utilities maintained sufficient generating capacity to meet customer needs, and bulk transactions were initially used only to support extreme demands or equipment outages.

4.7.1.3 Distribution

Low-voltage distribution systems that deliver electricity to customers comprise integrated networks of smaller wires and substations that take the higher voltage and step it down to lower levels to match customers' needs.

The distribution system is the classic example of a natural monopoly because it is not practical to have more than one set of lines running through neighborhoods or from the curb to the house.

4.7.2 Cost of Production

Table 4-24 shows total industry expenditures by production activities. Generation accounts for approximately 75.6 percent of the cost of delivered electric power in 1996. Transmission and distribution accounted for 2.5 percent and 5.6 percent, respectively.

Table 4-24. Total Expenditures in 1996 ($\$10^3$)

Utility Ownership	Generation	Transmission	Distribution	Customer Accounts and Sales	Administration and General Expenses
Investor-owned	80,891,644	2,216,113	6,124,443	6,204,229	13,820,059
Publicly owned	12,495,324	840,931	1,017,646	486,195	1,360,111
Federal	3,685,719	327,443	1,435	55,536	443,809
Cooperatives	15,105,404	338,625	1,133,984	564,887	1,257,015
	112,178,091	3,723,112	8,277,508	7,310,847	16,880,994
	75.6%	2.5%	5.6%	4.9%	11.4%
	148,370,552				

Sources: U.S. Department of Energy, Energy Information Administration (EIA). 1998b. *Financial Statistics of Major Publicly Owned Electric Utilities, 1997*. Washington, DC: U.S. Department of Energy.
U.S. Department of Energy, Energy Information Administration (EIA). 1997. *Financial Statistics of Major U.S. Investor-Owned Electric Utilities, 1996*. Washington, DC: U.S. Department of Energy.

Customer accounts and sales and administrative costs accounted for the remaining 16.3 percent of the cost of delivered power.

4.7.3 Organization of the Industry

Because the restructuring plans and time tables are made at the state level, the issues of asset ownership and control throughout the current supply chain in the electric power industry vary from state to state. However, the activities conducted throughout the supply chain are generally the same. This section focuses on the generation segment of the market because all the boilers affected by the regulation are involved in generation.

As part of deregulation, the transmission and distribution of electricity are being separated from the business of generating electricity, and a new competitive market in electricity generation is evolving. As power generators prepare for the competitive market, the share of electricity generation attributed to nonutilities and utilities is shifting.

More than 7,000 electricity suppliers currently operate in the U.S. market. As shown in Table 4-25, approximately 42 percent of suppliers are utilities and 58 percent are nonutilities. Utilities include investor-owned, cooperatives, and municipal systems. Of the approximately 3,100 utilities operating in the United States, only about 700 generate electric power. The majority of utilities distribute electricity that they have purchased from power generators via their own distribution systems.

Table 4-25. Number of Electricity Suppliers in 1999

Electricity Suppliers	Number	Percent
Utilities	3,124	42%
Investor-owned utilities	222	
Cooperatives	875	
Municipal systems	1,885	
Public power districts	73	
State projects	55	
Federal agencies	14	
Nonutilities	4,247	58%
Nonutilities (excluding EWGs)	4,103	
Exempt wholesale generators	144	
Total	7,371	100%

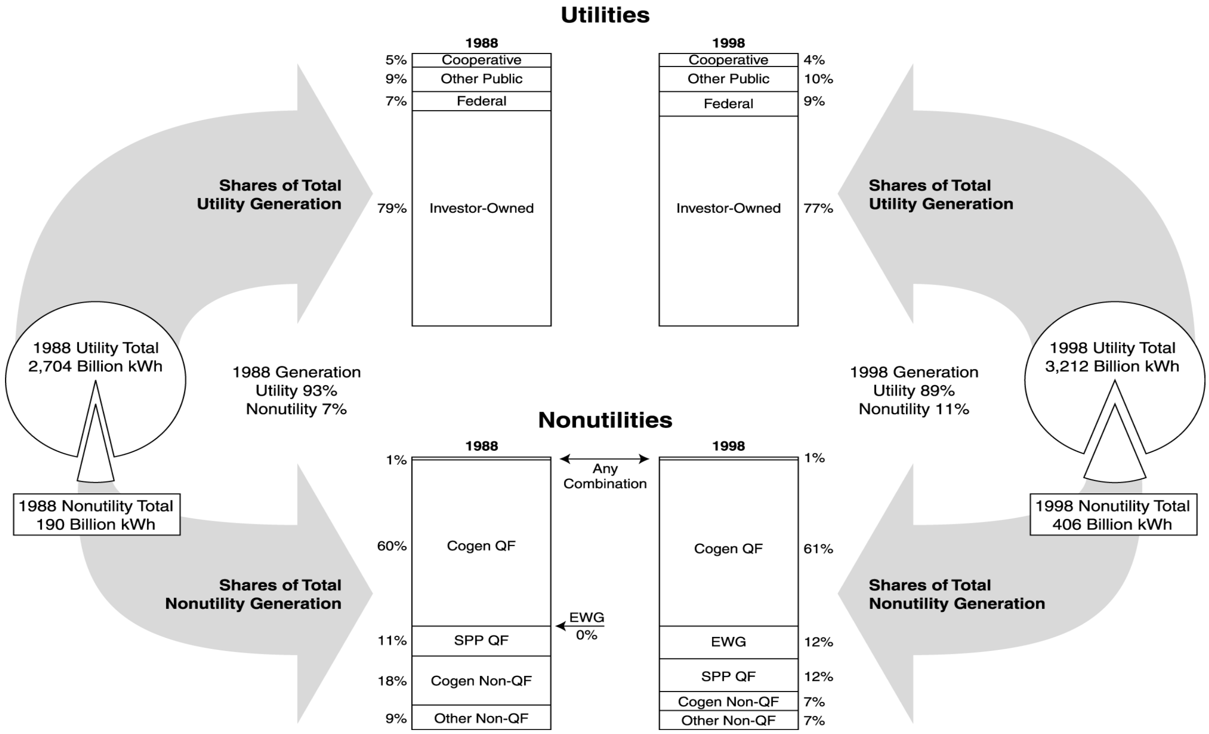
Source: U.S. Department of Energy, Energy Information Administration (EIA). 1999b. *The Changing Structure of the Electric Power Industry 1999: Mergers and Other Corporate Combinations.* Washington, DC: U.S. Department of Energy.

Utility and nonutility generators produced a total of 3,369 billion kWh in 1995. Although utilities generate the vast majority of electricity produced in the United States, nonutility generators are quickly eroding utilities' shares of the market. Nonutility generators include private entities that generate power for their own use or to sell to utilities or other end users. Between 1985 and 1995, nonutility generation increased from 98 billion kWh (3.8 percent of total generation) to 374 billion kWh (11.1 percent). Figure 4-2 illustrates this shift in the share of utility and nonutility generation.

4.7.3.1 Utilities

There are four categories of utilities: investor-owned utilities (IOUs), publicly owned utilities, cooperative utilities, and federal utilities. Of the four, only IOUs always generate electricity.

IOUs are increasingly selling off generation assets to nonutilities or converting those assets into nonutilities (Haltmaier, 1998). To prepare for the competitive market, IOUs have been lowering their operating costs, merging, and diversifying into nonutility businesses.



[a] Includes facilities classified in more than one of the following FERC designated categories: cogenerator QF, small power producer QF, or exempt wholesale generator.
Cogen = Cogenerator.
EWG = Exempt wholesale generator.
Other Non-QF = Nocogenerator Non-QF.
QF = Qualifying facility.
SPP = Small power producer.
Note: Sum of components may not equal total due to independent rounding. Classes for nonutility generation are determined by the class of each generating unit.
Sources: **Utility data:** U.S. Department of Energy, Energy Information Administration (EIA). 1996. *Electric Power Annual 1995*. Volumes I and II. DOE/EIA-0348(95)/1. Washington, DC: U.S. Department of Energy; Table 8 (and previous issues); **1985 nonutility data:** Shares of generation estimated by EIA; total generation from Edison Electric Institute (EEI). 1998. *Statistical Yearbook of the Electric Utility Industry 1998*. November. Washington, DC; **1995 nonutility data:** U.S. Department of Energy, Energy Information Administration (EIA). 1996. *Electric Power Annual 1995*. Volumes I and II. DOE/EIA-0348(95)/1. Washington, DC: U.S. Department of Energy.

Figure 4-2. Utility and Nonutility Generation and Shares by Class, 1988 and 1998

In 1995, utilities generated 89 percent of electricity, a decrease from 96 percent in 1985. IOUs generate the majority of the electricity produced in the United States. IOUs are either individual corporations or a holding company, in which a parent company operates one or more utilities integrated with one another. IOUs account for approximately three-quarters of utility generation, a percentage that held constant between 1985 and 1995.

Many states, municipalities, and other government organizations also own and operate utilities, although the majority do not generate electricity. Those that do generate electricity operate capacity to supply some or all of their customers' needs. They tend to be small, localized outfits and can be found in 47 states. These publicly owned utilities accounted for about one-tenth of utility generation in 1985 and 1995. In a deregulated market, these generators may be in direct competition with other utilities to service their market.

Rural electric cooperatives are formed and owned by groups of residents in rural areas to supply power to those areas. Cooperatives generally purchase from other utilities the energy that they sell to customers, but some generate their own power. Cooperatives only produced 5 percent of utility generation in 1985 and only 6 percent in 1995.

Utilities owned by the federal government accounted for about one-tenth of generation in both 1985 and 1995. The federal government operated a small number of large utilities in 1995 that supplied power to large industrial consumers or federal installations. The Tennessee Valley Authority is an example of a federal utility.

4.7.3.2 Nonutilities

Nonutilities are private entities that generate power for their own use or to sell to utilities or other establishments. Nonutilities are usually operated at mines and manufacturing facilities, such as chemical plants and paper mills, or are operated by electric and gas service companies (DOE, EIA, 1998a). More than 4,200 nonutilities operate in the United States.

4.7.4 Demand Side of the Industry

4.7.4.1 Electricity Consumption

This section analyzes the growth projections for electricity consumption as well as the price elasticity of demand for electricity. Growth in electricity consumption has traditionally paralleled gross domestic product growth. However, improved energy efficiency of electrical equipment, such as high-efficiency motors, has slowed demand growth over the past few decades. The magnitude of the relationship has been decreasing over time, from growth of 7 percent per year in the 1960s down to 1 percent in the 1980s. As a result, determining what the future growth will be is difficult, although it is expected to be positive (DOE, EIA, 1999a). Table 4-26 shows consumption by sector of the economy over the past 10 years. The table shows that since 1989 electricity sales have increased at least 10 percent in all four sectors. The commercial sector has experienced the largest increase, followed by residential consumption.

Table 4-26. U.S. Electric Utility Retail Sales of Electricity by Sector, 1989 Through 1998 (10^6 kWh)

Period	Residential	Commercial	Industrial	Other[a]	All Sectors
1989	905,525	725,861	925,659	89,765	2,646,809
1990	924,019	751,027	945,522	91,988	2,712,555
1991	955,417	765,664	946,583	94,339	2,762,003
1992	935,939	761,271	972,714	93,442	2,763,365
1993	994,781	794,573	977,164	94,944	2,861,462
1994	1,008,482	820,269	1,007,981	97,830	2,934,563
1995	1,042,501	862,685	1,012,693	95,407	3,013,287
1996	1,082,491	887,425	1,030,356	97,539	3,097,810
1997	1,075,767	928,440	1,032,653	102,901	3,139,761
1998	1,124,004	948,904	1,047,346	99,868	3,220,121
Percentage change 1989–1998	19%	24%	12%	10%	18%

[a] Includes public street and highway lighting, other sales to public authorities, sales to railroads and railways, and interdepartmental sales.

Sources: U.S. Department of Energy, Energy Information Administration (EIA). 1999d. *Electric Power Annual 1998*. Volumes I and II. Washington, DC: U.S. Department of Energy.
U.S. Department of Energy, Energy Information Administration (EIA). 1996. *Electric Power Annual 1995*. Volumes I and II. Washington, DC: U.S. Department of Energy.

In the future, residential demand is expected to be at the forefront of increased electricity consumption. Between 1997 and 2020, residential demand is expected to increase at 1.6 percent annually. Commercial growth in demand is expected to be approximately 1.4 percent, while industry is expected to increase demand by 1.1 percent (DOE, EIA, 1999a). Figure 4-3 shows the annual electricity sales by sector from 1970 with projections through 2020.

The literature suggests that electricity consumption is relatively price inelastic. Consumers are generally unable or unwilling to forego a large amount of consumption as the

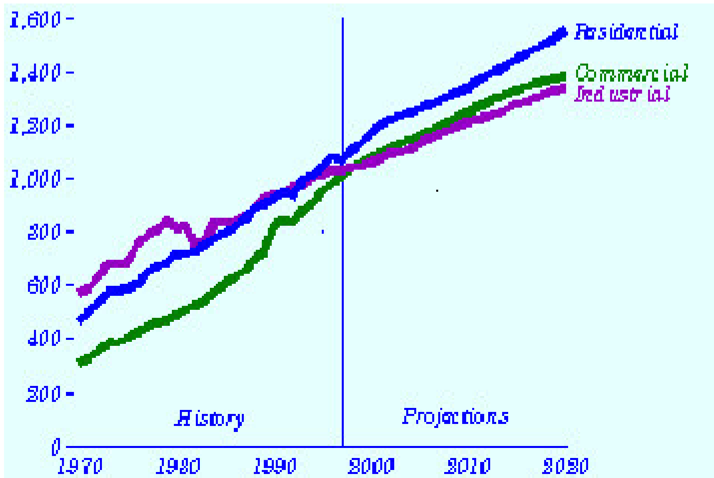


Figure 4-3. Annual Electricity Sales by Sector

price increases. Numerous studies have investigated the short-run elasticity of demand for electricity. Overall, the studies suggest that, for a 1 percent increase in the price of electricity, demand will decrease by 0.15 percent. However, as Table 4-27 shows, elasticities vary greatly, depending on the demand characteristics of end users and the price structure. Demand elasticities are estimated to range from a –0.05 percent elasticity of demand for a "flat rates" case (i.e., no time-of-use assumption) up to a –0.50 percent demand elasticity for a "high consumer response" case (DOE, EIA, 1999c).

4.7.4.2 Trends in the Electricity Market

Beginning in the latter part of the 19th century and continuing for about 100 years, the prevailing view of policymakers and the public was that the government should use its power to require or prescribe the economic behavior of "natural monopolies" such as electric utilities. The traditional argument is that it does not make economic sense for there to be more than one supplier—running two sets of wires from generating facilities to end users is more costly than one set. However, since monopoly supply is not generally regarded as likely

Table 4-27. Key Parameters in the Cases

Case Name	Key Assumptions: Cost Reduction and Efficiency Improvements	Short-Run Elasticity of Demand (Percent)	Natural Gas Prices	Capacity Additions
AEO97 Reference Case	AEO97 Reference Case	—	AEO97 Reference Case	As needed to meet demand
No Competition	No change from 1995	—	AEO97 Reference Case	As needed to meet demand
Flat Rates (no time-of-use rates)	AEO97 Reference Case	–0.05	AEO97 Reference Case	As needed to meet demand
Moderate Consumer Response	AEO97 Reference Case	–0.15	AEO97 Reference Case	As needed to meet demand
High Consumer Response	AEO97 Reference Case	–0.50	AEO97 Reference Case	As needed to meet demand
High Efficiency	Increased cost savings and efficiencies	–0.15	AEO97 Reference Case	As needed to meet demand
No Capacity Additions	AEO97 Reference Case	–0.15	AEO97 Low Oil and Gas Supply Technology Case	Not allowed
High Gas Price	AEO97 Reference Case	–0.15	AEO97 High Oil and Gas Supply Technology Case	As needed to meet demand
Low Gas Price	AEO97 Reference Case	–0.15	AEO97 Reference Case	As needed to meet demand
High Value of Reliability	AEO97 Reference Case	–0.15	AEO97 Reference Case	As needed to meet demand
Half O&M	AEO97 Reference Case	–0.15	AEO97 Reference Case	As needed to meet demand
Intense Competition	AEO97 Reference Case	–0.15	AEO97 Reference Case	As needed to meet demand

— = not applicable.

Source: U.S. Department of Energy, Energy Information Administration (EIA), Office of Integrated Analysis and Forecasting. "Competitive Electricity Price Projections." <http://www.eia.doe.gov/oiaf/elepri97/chap3.html>. As obtained on November 15, 1999c.

to provide a socially optimal allocation of resources, regulation of rates and other economic variables was seen as a necessary feature of the system.

Beginning in the 1970s, the public policy view shifted against traditional regulatory approaches and in favor of deregulation for many important industries including transportation, communications, finance, and energy. The major drivers for deregulation of electric power included the following:

- existence of rate differentials across regions offering the promise of benefits from more efficient use of existing generation resources if the power can be transmitted across larger geographic areas than was typical in the era of industry regulation;
- the erosion of economies of scale in generation with advances in combustion turbine technology;
- complexity of providing a regulated industry with the incentives to make socially efficient investment choices;
- difficulty of providing a responsive regulatory process that can quickly adjust rates and conditions of service in response to changing technological and market conditions; and
- complexity of monitoring utilities' cost of service and establishing cost-based rates for various customer classes that promote economic efficiency while at the same time addressing equity concerns of regulatory commissions.

Viewed from one perspective, not much changes in the electric industry with restructuring. The same functions are being performed, essentially the same resources are being used, and in a broad sense the same reliability criteria are being met. In other ways, the very nature of restructuring, the harnessing of competitive forces to perform a previously regulated function, changes almost everything. Each provider and each function become separate competitive entities that must be judged on their own.

This move to market-based provision of generation services is not matched on the transmission and distribution side. Network interactions on AC transmission systems have made it impossible to have separate transmission paths compete. Hence, transmission and distribution remain regulated. Transmission and generation heavily interact, however, and transmission congestion can prevent specific generation from getting to market. Transmission expansion planning becomes an open process with many interested parties. This open process, coupled with frequent public opposition to transmission expansion, slows transmission enhancement. The net result is greatly increased pressure on the transmission system.

Restructuring of the electric power industry could result in any one of several possible market structures. In fact, different parts of the country will probably use different structures, as the current trend indicates. The eventual structure may be dominated by a power exchange, bilateral contracts, or a combination. A strong Regional Transmission Organization (RTO) may operate in the area, or a vertically integrated utility may continue to operate a control area. In any case, several important characteristics will change:

- Commercial provision of generation-based services (e.g., energy, regulation, load following, voltage control, contingency reserves, backup supply) will replace regulated service provision. This drastically changes how the service provider is assessed.
- Individual transactions will replace aggregated supply meeting aggregated demand. It will be necessary to continuously assess each individual's performance.
- Transaction sizes will shrink. Instead of dealing only in hundreds and thousands of MW, it will be necessary to accommodate transactions of a few MW and less.
- Supply flexibility will greatly increase. Instead of services coming from a fixed fleet of generators, service provision will change dynamically among many potential suppliers as market conditions change.

SECTION 5

ECONOMIC ANALYSIS METHODOLOGY

The final rule to control emissions of HAPs from industrial, commercial, and institutional boilers and process heaters will affect almost all sectors of the U.S. economy. Several markets will bear the direct compliance costs. In addition, sectors that consume energy will also bear indirect costs through higher prices for energy. Finally, consumers of goods and services will experience impacts from higher market prices.

This section presents the methodology for analyzing the economic impacts of the NESHAP. This economic analysis provides the economic data and supporting information needed by EPA to support its regulatory determination. The methodology is based on microeconomic theory and the methods developed for earlier EPA studies. These methods are tailored to and extended for this analysis, as appropriate, to meet EPA's requirements for an EIA of controls placed on boilers and process heaters.

This methodology section includes background information on typical economic modeling approaches, the conceptual approach selected for this EIA, and an overview of the computerized market model used in the analysis with emphasis on the links between energy markets and the markets for goods and services. Appendix A includes a description of the model's baseline data set and specification.

5.1 Background on Economic Modeling Approaches

In general, the EIA methodology needs to allow EPA to consider the effects of the different regulatory alternatives. Several types of economic impact modeling approaches have been developed to support regulatory development. These approaches can be viewed as varying along two modeling dimensions:

- the scope of economic decisionmaking accounted for in the model and
- the scope of interaction between different segments of the economy.

Each of these dimensions was considered in determining the approach for this study. The advantages and disadvantages of different modeling approaches are discussed below.

5.1.1 Modeling Dimension 1: Scope of Economic Decisionmaking

Models incorporating different levels of economic decisionmaking can generally be categorized as *with* behavior responses and *without* behavior responses (accounting approach). Table 5-1 provides a brief comparison of the two approaches. The nonbehavioral approach essentially holds fixed all interactions between facility production and market forces. It assumes that firms absorb all control costs and consumers do not face any of the costs of regulation. Typically, engineering control costs are weighted by the number of affected units to develop "engineering" estimates of the total annualized costs. These costs are then compared to company or industry sales to determine the regulation's impact.

Table 5-1. Comparison of Modeling Approaches

EIA With Behavioral Responses
• Incorporates control costs into production function
• Includes change in quantity produced
• Includes change in market price
• Estimates impacts for
✓ affected producers
✓ unaffected producers
✓ consumers
✓ foreign trade
EIA Without Behavioral Responses
• Assumes firm absorbs all control costs
• Typically uses discounted cash flow analysis to evaluate burden of control costs
• Includes depreciation schedules and corporate tax implications
• Does *not* adjust for changes in market price
• Does *not* adjust for changes in plant production

In contrast, the behavioral approach is grounded in economic theory related to producer and consumer behavior in response to changes in market conditions. Owners of affected facilities are economic agents that can, and presumably will, make adjustments such as changing production rates or altering input mixes that will generally affect the market environment in which they perate. As producers change their behavior in response to regulation, consumers are typically faced with changes in prices that cause them to alter the quantity that they are willing to purchase. In essence, this approach models the expected reallocation of society's resources in response to a regulation. The changes in price and production from the market-level impacts are used to estimate the distribution of social costs between consumers and producers.

5.1.2 Modeling Dimension 2: Interaction Between Economic Sectors

Because of the large number of markets potentially affected by the regulation on boilers and process heaters, an issue arises concerning the level of sectoral interaction to model. In the broadest sense, all markets are directly or indirectly linked in the economy; thus, the regulation affects all commodities and markets to some extent. For example, controls on boilers and process heaters may indirectly affect almost all markets for goods and services to some extent because the cost of fuel (an input in the provision of most goods and services) is likely to increase with the regulation in effect. However, the impact of rising fuel prices will differ greatly between different markets depending on how important fuel is as an input in that market.

The appropriate level of market interactions to be included in the EIA is determined by the scope of the regulation across industries and the ability of affected firms to pass along the regulatory costs in the form of higher prices. Alternative approaches for modeling interactions between economic sectors can generally be divided into three groups:

- Partial equilibrium model: Individual markets are modeled in isolation. The only factor affecting the market is the cost of the regulation on facilities in the industry being modeled.

- General equilibrium model: All sectors of the economy are modeled together. General equilibrium models operationalize neoclassical microeconomic theory by modeling not only the direct effects of control costs, but also potential input substitution effects, changes in production levels associated with changes in market prices across all sectors, and the associated changes in welfare economywide. A disadvantage of general equilibrium modeling is that substantial time and resources are required to develop a new model or tailor an existing model for analyzing regulatory alternatives.

- Multiple-market partial equilibrium model: A subset of related markets are modeled together, with intersectoral linkages explicitly specified. To account for the relationships and links between different markets without employing a full general equilibrium model, analysts can use an integrated partial equilibrium model. The multiple-market partial equilibrium approach represents an intermediate step between a simple, single-market partial equilibrium approach and a full general equilibrium approach. This approach involves identifying and modeling the most significant subset of market interactions using an integrated partial equilibrium framework. In effect, the modeling technique is to link a series of standard partial equilibrium models by specifying the interactions between supply functions and then solving for prices and quantities across all markets simultaneously. In instances where separate markets are closely related and there are strong interconnections, there are significant advantages to estimating market adjustments in different markets simultaneously using an integrated market modeling approach.

5.2 Selected Modeling Approach for Boilers and Process Heaters Analysis

To conduct the analysis for the boilers and process heaters MACT, the Agency used a market modeling approach that incorporates behavioral responses in a multiple-market partial equilibrium model as described above. This approach allows for a more realistic assessment of the distribution of impacts across different groups than the nonbehavioral approach, which may be especially important in accurately assessing the impacts of a significant rule affecting numerous industries. Because of the size and complexity of this regulation, it is important to use a behavioral model to examine the distribution of costs across society. Because the regulations on boilers and process heaters primarily affect energy costs, an input into many production processes, complex market interactions need to be captured to provide an accurate picture of the distribution of regulatory costs. Because of the large number of affected industries under this MACT, an appropriate model should include multiple markets and the interactions between them. Multiple-market partial equilibrium analysis provides a manageable approach to incorporate interactions between energy markets and final product markets into the EIA to accurately estimate the regulation's impact.

The model used for this analysis includes energy, agriculture, manufacturing, mining, commercial, and transportation markets affected by the controls placed on boilers and process heaters.[1] The energy markets are divided into natural gas, petroleum products, coal, and electricity. The residential sector is treated as a single representative demander in the energy markets.

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[1]These markets are defined at the two- and three-digit NAICS code level. This allows for a fairly disaggregated examination of the regulation's impact on producers. However, if the costs of the regulation are concentrated on a particular subset of one of these markets, then treating the cost as if it fell on the entire NAICS code may still underestimate the impacts on the subset of producers affected by the regulation.

Figure 5-1 presents an overview of the key market linkages included in the economic impact model used for analyzing the boilers and process heaters MACT. The analysis' emphasis is on the energy supply chain and the consumption of energy by producers of goods and services. The industries most directly affected by the boilers and process heaters MACT are the electric power industry, chemical industry and pulp and paper industry. However, changes in the equilibrium prices and quantities of energy and goods and services affect all sectors of the economy. (See Figure 5-1.) This analysis explicitly models the linkages between these market segments to capture both the direct costs of compliance and the indirect costs due to changes in prices. For example, production costs will increase for chemical companies using boilers and process heaters as a result of the capital investments and monitoring costs, as well as the resulting increase in the price of electricity used as an energy input in the production process.

The economic model also captures behavioral changes of producers of goods and services that feedback into the energy markets. Changes in production levels and fuel switching in the manufacturing process affect the demand for Btus in fuel markets. The change in output is determined by the size of the cost increase per Btu (typically variable cost per output), the facility's production function (slope of supply curve), and the demand characteristics of the facility's downstream market (other market suppliers and market demanders). For example, if consumers' demand for a product is not very sensitive to price, then producers can pass the majority of the cost of the regulation through to consumers and output may not change appreciably. However, if only a small proportion of market output is produced by producers affected by the regulation, then competition will prevent the affected producers from raising their prices significantly.

One possible feedback pathway that this analysis does *not* model is technical changes in the manufacturing process. For example, if the cost of Btus increases, a facility may use measures to increase manufacturing efficiency or capture waste heat. Facilities could also possibly change the input mix that they use, substituting other inputs for fuel. These facility-level responses will also act to reduce pollution, but including these responses is beyond the scope of this analysis.

5.2.1 Directly Affected Markets

Markets where boilers and process heaters are used as an input to production are considered to be directly affected. As outlined in Section 2, facilities using several types of boilers or process heaters will be required to add controls. In addition, a larger population of

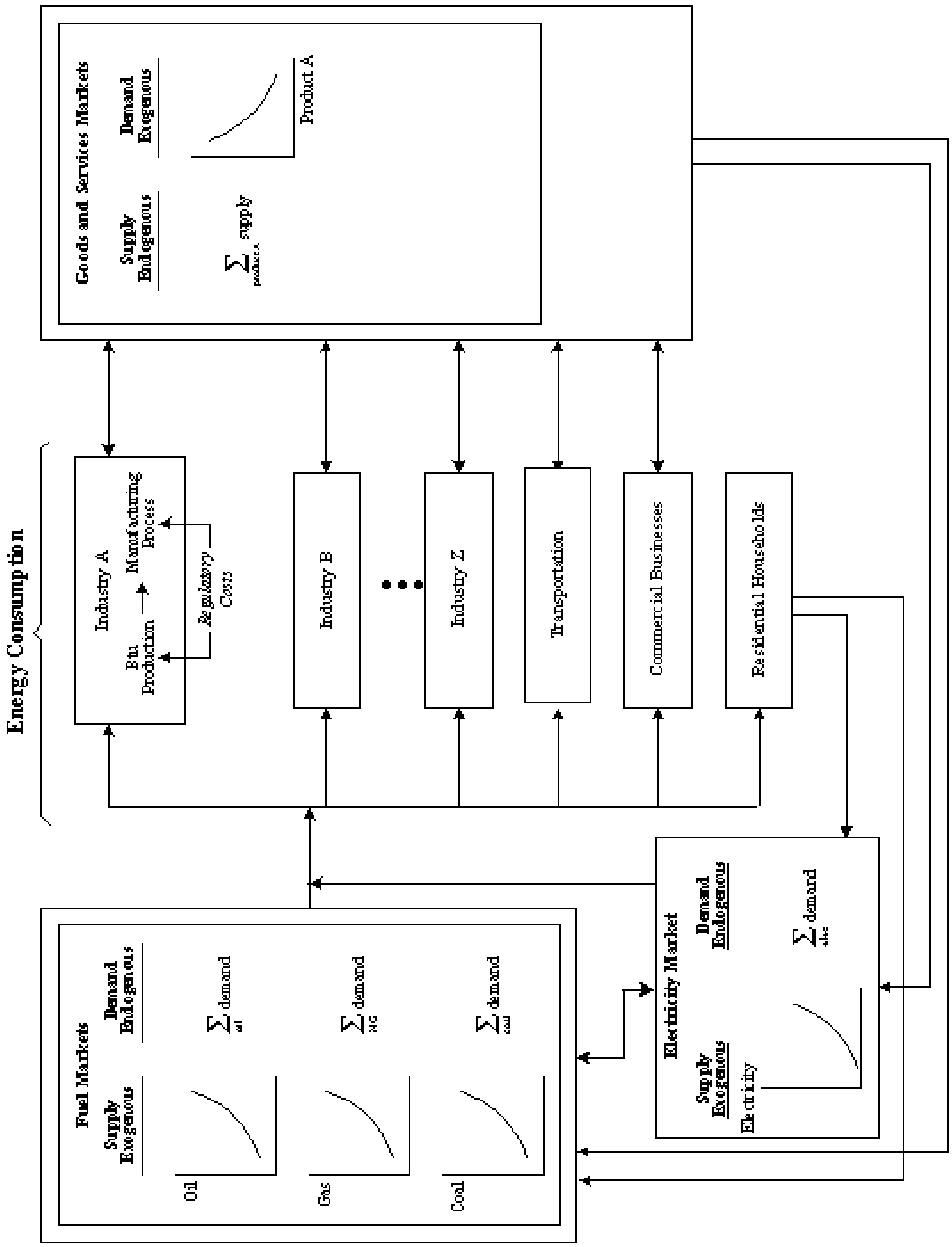


Figure 5-1. Links Between Energy and Goods and Services Markets

boilers and process heaters will incur monitoring costs to comply with the regulation. Therefore, the regulation will increase their production costs and cause these directly affected firms to reduce the quantity that they are willing to supply at any given price.

5.2.1.1 Electricity Market

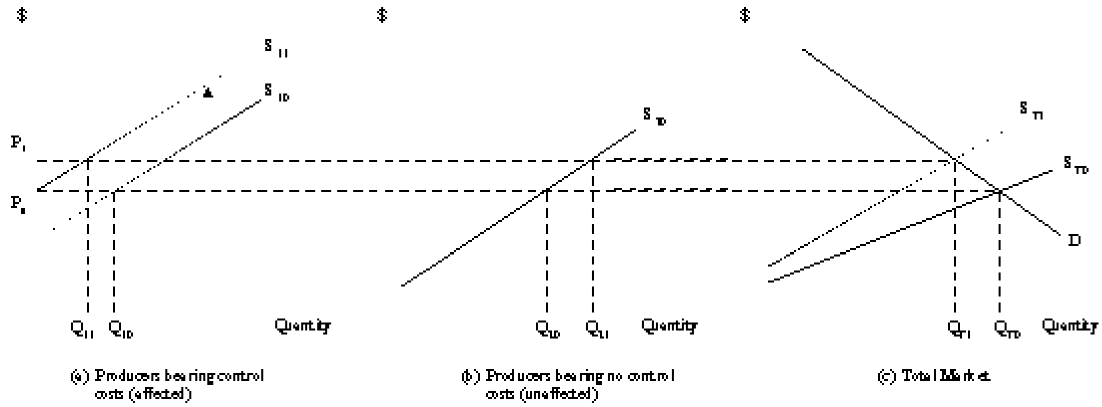
Boilers are used to generate power throughout the electric power industry. Even though utility boilers are not covered under this regulation, the Agency estimates over 300 industrial, commercial, and institutional boilers involved in providing electric services (SIC 4911/NAICS22111) will be affected. Most of these are owned by municipal electric service providers.

For this study, the electricity market was modeled as a nationally competitive market. The direct costs of compliance on affected boilers lead to an upward shift in the total market supply for electricity. Figure 5-2 illustrates the shifts in the supply curve for a representative energy market. In addition to the direct costs, the market for electricity will also be indirectly affected through changes in fuel prices. Electricity generators are extremely large consumers of coal, natural gas, and petroleum products. For example, some of the impact of control costs on the petroleum industry will be on the electricity industry in the form of higher prices. Indirect costs will also lead to an upward shift in the supply curve.

The demand for electricity is derived by aggregating across the goods and services markets and the residential sector. Because of direct compliance costs on the goods and services markets, the demand curve for electricity will shift downward. Therefore, it is ambiguous whether equilibrium quantity will rise or fall. The changes in the price and quantity are determined by the relative magnitude of the shifts in the price elasticities of the supply and demand curves.

5.2.1.2 Petroleum Market

Control costs associated with boilers and process heaters will increase the cost of refining petroleum products. The supply curve for petroleum products will shift upward by the proportional increase in total production costs caused by the control costs on boilers and process heaters. For petroleum products, a single composite product was used to model market adjustment because boilers and process heaters are used throughout the refinement process, from distillation to reformulation. As a result, assigning costs to specific end products, such as fuel oil #2 or reformulated gasoline, is difficult. The use of a composite



P_0	=	market price without regulation
P_1	=	market price with regulation
S_{10}	=	supply function for affected firms without regulation
S_{11}	=	supply function for affected firms with regulation
Q_{10}	=	quantity sold for affected firms without regulation
Q_{11}	=	quantity sold for affected firms with regulation
S_{20}	=	supply function for unaffected firms both with and without regulation
Q_{20}	=	quantity sold for unaffected firms without regulation
Q_{21}	=	quantity sold for unaffected firms with regulation
S_{T0}	=	total market supply function without regulation
S_{T1}	=	total market supply function with regulation
Q_{T0}	=	total market quantity sold without regulation
Q_{T1}	=	total market quantity sold with regulation

Figure 5-2. Market Effects of Regulation-Induced Costs

product tends to understate the impacts for petroleum products where compliance costs as a percentage of production costs are greater than average and overstate impacts for products where compliance costs as a percentage of production costs are less than average.

5.2.1.3 Goods and Services Markets: Agriculture, Manufacturing, Mining, Commercial, and Transportation

Many manufacturing facilities use boilers and process heaters in their production processes to generate steam and process heat. Commercial entities use boilers for space heating and to generate supplementary electricity. In addition to the direct costs of the regulation, goods and services markets are indirectly affected through price increases in the energy markets.

Directly affected producers are segmented into sectors defined at the two- or three-digit NAICS code level. A partial equilibrium analysis was conducted for each sector to model the supply and demand. Changes in production levels and fuel switching due to the regulation's impact on the price of Btus were then linked back into the energy markets.

The impact of the regulation on producers in these sectors was modeled as an increase in the cost of Btus used in the production process. In this context, Btus refer to the generic energy requirements used to generate process heat, process steam, or shaft power. Compliance costs associated with the regulation will increase the cost of Btu production in the manufacturing sectors. The cost of Btu production for industry increases because of both direct control costs on boilers and process heaters owned by manufacturers, and increases in the price of fuels. Because Btus are an input into the production process, these price increases lead to an upward shift in the facility (and industry) supply curves as shown in Figure 5-2, leading to a change in the equilibrium market price and quantity.

The changes in equilibrium supply and demand in each market are modeled to estimate the regulation's impact on each sector. In a perfectly competitive market, the point where supply equals demand determines the market price and quantity, so market price and quantity are determined by solving the model for the price where the quantity supplied and the quantity demanded are equal. The size of the regulation-induced shifts in the supply curve is a function of the total direct control costs associated with boilers and process heaters and the indirect fuel costs (determined by the change in fuel price and intensity of use) in each goods and services market. The proportional shift in the supply curve is determined by the ratio of total control costs (both direct and indirect) to total revenue.

This impact on the price of Btus facing industrial users feeds back to the fuel market in two ways (see Figure 5-3). The first is through the company's input decision concerning the fuel(s) that will be used for its manufacturing process. As the cost of Btus increases, firms may switch fuels and/or change production processes to increase energy efficiency and reduce the number of Btus required per unit of output. Fuel switching impacts were modeled using cross-price elasticities of demand between energy sources. For example, a cross-price elasticity of demand between natural gas and electricity of 0.5 implies that a 1 percent increase in the price of electricity will lead to a 0.5 percent increase in the demand for natural gas. Own-price elasticities of demand are used to estimate the change in the use of fuel by demanders. For example, a demand elasticity of –0.175 for electricity implies that a 1 percent increase in the price of electricity will lead to a 0.175 percent decrease in the quantity of electricity demanded.

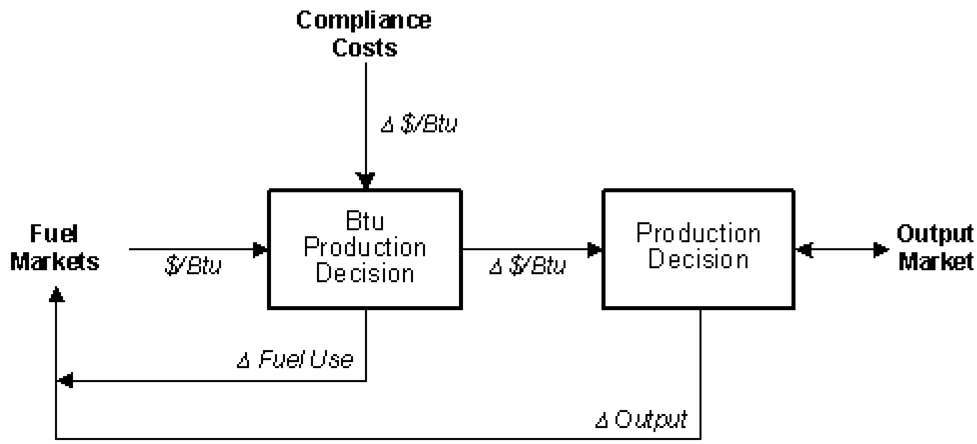


Figure 5-3. Fuel Market Interactions with Facility-Level Production Decisions

The second feedback pathway to the energy markets is through the facility's change in output. Because Btus are an input into the production process, energy price increases lead to an upward shift in the facility supply curves (not modeled individually). This leads to an upward shift in the industry supply curve when the shifts at the facility level are aggregated across facilities. A shift in the industry supply curve leads to a change in the equilibrium market price and quantity. In a perfectly competitive market, the point where supply equals demand determines the new market price and quantity. The Agency modeled the feedback into the energy market by assuming that the percentage change in output in the manufacturing sectors translates into a equivalent percentage change in the demand for energy (Btus). This implies that there are constant returns to scale from energy inputs in the manufacturing process over the relevant range of output and time period of analysis. This is an appropriate assumption for this analysis because the output changes in these sectors being modeled are relatively small (always less than 1 percent) and reflect short-run production decisions.[2]

The Agency assumed that the demand curves for goods and services in all sectors are unchanged by the regulation. However, because the demand function quantifies the change in quantity demanded in response to a change in price, the baseline demand conditions are

[2]Long-run production decisions of fuel switching and increased energy efficiency are captured by the cross- and own-price elasticities in the energy markets.

important in determining the regulation's impact. The key demand parameters are the elasticities of demand with respect to changes in the price of goods and services. For these markets, a "reasonable" range of elasticity values is assigned based on estimates from similar commodities. Because price changes are anticipated to be small, the point elasticities at the original price and quantity should be applicable throughout the relevant range of prices and quantities examined in this model.

5.2.2 Indirectly Affected Markets

In addition to the many markets that are directly affected by the regulation on boilers and process heaters, some markets feel the regulation's impacts despite having no direct costs resulting from the regulation. Firms in these markets generally face changes in the price of energy that affect their production decisions.

5.2.2.1 Market for Coal

The coal market is not directly affected by the regulation, but it has the potential to be significantly affected through indirect costs. Although boilers and process heaters are not commonly used in the production or transportation of coal, the supply of coal will be affected by the price of energy used in coal production. However, the indirect impacts on coal production costs are relatively small compared to the direct impacts on the production costs in the electricity and petroleum markets; thus, the "relative" price of coal (per Btu) will decrease compared with other energy sources.

The demand for coal from the industrial sectors will be affected by differences in compliance costs by fuel type applied to boilers and process heaters in the industrial sectors. Because compliance costs are high for coal-fired units, manufacturers will switch away from coal units toward natural gas units with lower compliance costs. However, the overall impact on the demand for coal is ambiguous because the relative increase in the cost of producing Btus by burning coal will be offset by the relative decrease in the price of coal. Similarly, the demand for coal by utility generators will be affected through changes in the relative price of alternative (noncoal) energy sources and direct costs on coal boilers.

5.2.2.2 Natural Gas Market

The natural gas market is included in the economic model to complete coverage of the energy markets. EPA projects that there are no direct and minimal indirect impacts on the production costs of natural gas. However, the demand for natural gas will increase because of the relative decrease in the price of natural gas and the lower relative compliance costs for gas-fired boilers and process heaters.

5.2.2.3 Goods and Services Markets

Some goods and services markets do not include any boilers or process heaters and are therefore not directly affected by the regulation. However, these markets will still be affected indirectly because of the changes in energy prices that they will face following the regulation. There will be a tendency for these users to shift away from electricity and petroleum products and towards natural gas and coal.

5.2.2.4 Impact on Residential Sector

The residential sector does not bear any direct costs associated with the regulation because this sector does not own boilers or process heaters. However, they bear indirect costs due to price increases. The residential sector is a significant consumer of electricity, natural gas, and petroleum products used for heating, cooling, and lighting, as well as many other end uses. The change in the quantity of energy demanded by these consumers in response to changes in energy prices is modeled as a single demand curve parameterized by demand elasticities for residential consumers obtained from the literature.

5.3 Operationalizing the Economic Impact Model

Figure 5-4 illustrates the linkages used to operationalize the estimation of economic impacts associated with the compliance costs. Compliance costs placed on boilers and process heaters shift the supply curve for electricity and petroleum products. Adjustments in the electricity and petroleum energy markets determine the share of the cost increases that producers (electric service providers and petroleum companies) and consumers (product manufacturers, commercial business, and residential households) bear.

The supply and demand relationships between the energy markets are fully modeled. For example, changes in electricity production feed back and affect the demand for coal, natural gas and petroleum products. Similar changes in refinery production affect the petroleum industry's demand for electricity.

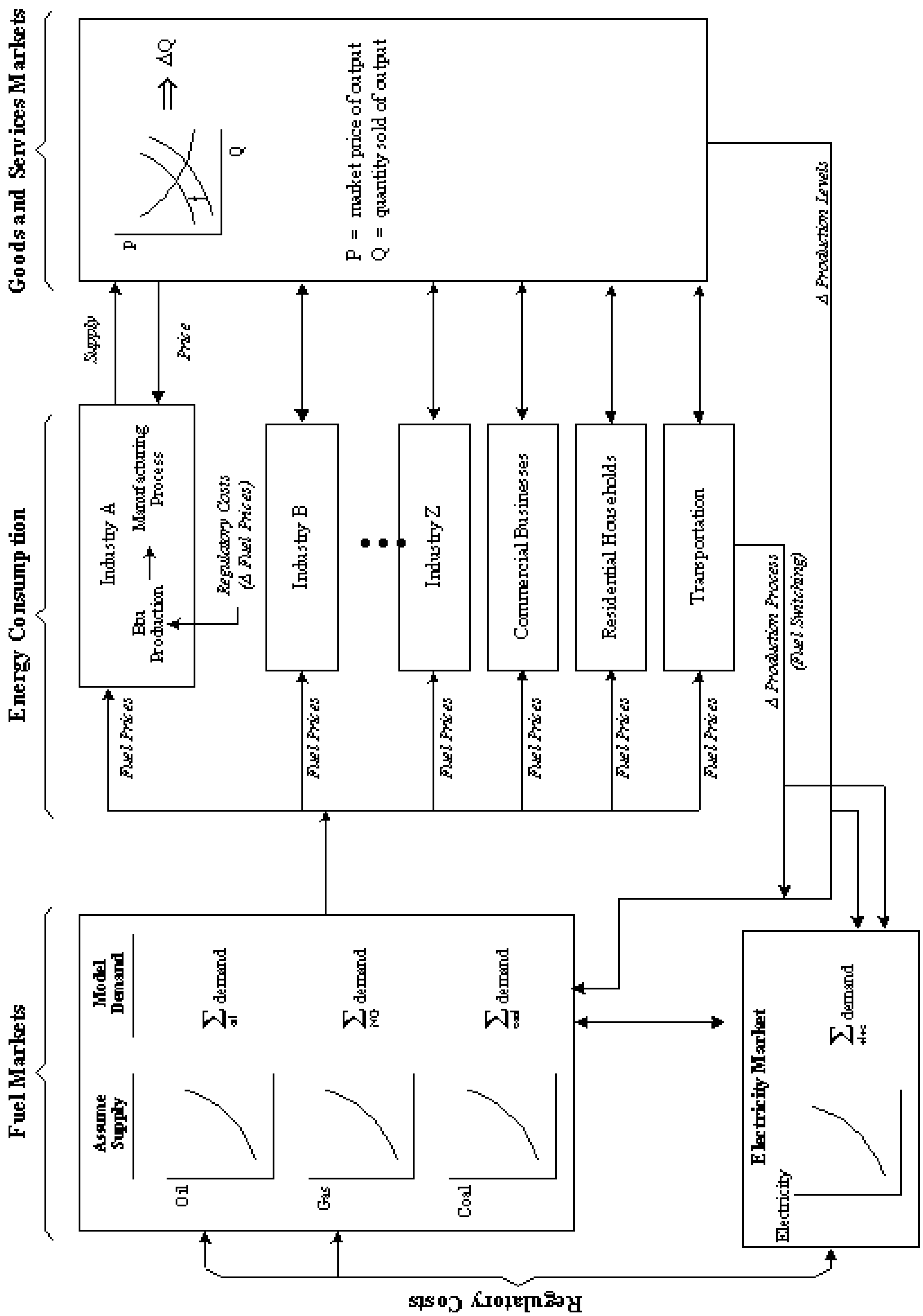


Figure 5-4. Operationalizing the Estimation of Economic Impact

Manufacturers experience supply curve shifts due to control costs on affected boilers and process heaters they operate and changes in prices for natural gas, petroleum, electricity, and coal. The share of these costs borne by producers and consumers is determined by the new equilibrium price and quantity in the goods and services markets. Changes in manufacturers' Btu demands due to fuel switching and changes in production levels feed back into the energy markets.

Adjustments in price and quantity in all markets occur simultaneously. A computer model was used to numerically simulate market adjustments by iterating over commodity prices until equilibrium is reached (i.e., until the quantity supplied equals the quantity demanded in all markets being modeled). Using the results provided by the model, economic impacts of the regulation (changes in consumer and producer surplus) were estimated for all sectors of the economy being modeled.

5.3.1 Computer Model

The computer model comprises a series of computer spreadsheet modules. The modules integrate the engineering cost inputs and the market-level adjustment parameters to estimate the regulation's impact on the price and quantity in each market being analyzed. At the heart of the model is a market-clearing algorithm that compares the total quantity supplied to the total quantity demanded for each market commodity.

Current prices and production levels are used to calibrate the baseline scenario (without regulation) for the model. Then, the compliance costs associated with the regulation are introduced as a "shock" to the system, and the supply and demand for market commodities are allowed to adjust to account for the increased production costs resulting from the regulation. Using an iterative process, if the supply does not equal demand in all markets, a new set of prices is "called out" and sent back to producers and consumers to "ask" what quantities they would supply and demand based on these new prices. This technique is referred to as an auctioneer approach because new prices are continually called out until an equilibrium set of prices is determined (i.e., where supply equals demand for all markets).

Supply and demand quantities are computed at each price iteration. The market supply for each market is obtained by using a mathematical specification of the supply function, and the key parameter is the point elasticity of supply at the baseline condition. Table 5-2 lists the supply elasticities for the markets used in the model.

Table 5-2. Supply and Demand Elasticities

	Supply Elasticities	Demand Elasticities			
		Industrial	Residential[a]	Transportation	Commercial
Petroleum	0.58[b]	Derived	–0.28	Derived	Derived
Natural Gas	0.41[b]	Derived	–0.26	Derived	Derived
Electricity	0.75[c]	Derived	–0.23	Derived	Derived
Coal	1.00[b]	Derived	–0.26	Derived	Derived

NAICS	Description	Supply[d]	Demand[d]
311	Food	0.75[c]	–0.30
312	Beverage and Tobacco Products	0.75[c]	–1.30
313	Textile Mills	0.37[e]	–0.85[e]
314	Textile Product Mills	0.37[e]	–0.85[e]
315	Apparel	0.75[c]	–1.80
316	Leather and Allied Products	0.75[c]	–1.20
321	Wood Products	0.75[d]	–0.20
322	Paper	1.20[c]	–1.09
323	Printing and Related Support	0.75[c]	–1.80
325	Chemicals	0.75[c]	–1.50
326	Plastics and Rubber Products	0.75[c]	–1.80
327	Nonmetallic Mineral Products	0.75[c]	–0.90
331	Primary Metals	3.50[f]	–0.80
332	Fabricated Metal Products	0.75[c]	–0.20
333	Machinery	0.75[c]	–0.50
334	Computer and Electronic Products	0.75[c]	–0.30
335	Electrical Equipment, Appliances, and Components	0.75[c]	–0.50
336	Transportation Equipment	0.75[c]	–1.00[c]
337	Furniture and Related Products	0.75[c]	–3.40
339	Miscellaneous	0.75[c]	–0.60
11	Agricultural Sector	0.75[c]	–1.80

(continued)

Table 5-2. Supply and Demand Elasticities (continued)

NAICS	Description	Supply[d]	Demand[d]
23	Construction Sector	0.75[c]	–1.00[c]
21	Other Mining Sector	0.43	–0.30
48	Transportation	0.75[c]	–0.70
Commercial	Commercial	0.75[c]	–1.00[c]

[a] U.S. Department of Energy, Energy Information Administration (EIA). "Issues in Midterm Analysis and Forecasting 1999—Table 1." <http://www.eia.doe.gov/oaif/issues/pricetbl1.html>. As obtained on May 8, 2000a.

[b] Dahl, Carol A., and Thomas E. Duggan. 1996. "U.S. Energy Product Supply Elasticities: A Survey and Application to the U.S. Oil Market." *Resource and Energy Economics* 18:243-263.

[c] Assumed value.

[d] E.H. Pechan & Associates, Inc. 1997. Qualitative Market Impact Analysis for Implementation of the Selected Ozone and PM NAAQS. Appendix B. Prepared for the U.S. Environmental Protection Agency.

[e] Warfield, et al. 2001. "Multifiber Arrangement Phaseout: Implications for the U.S. Fibers/Textiles/Fabricated Products Complex." www.fibronet.com.tw/mirron/ncs/9312/mar.html> As obtained September 19, 2001.

[f] U.S. International Trade Commission (USITC). November 21, 2001. Memorandum to the Commission from Craig Thomsen, John Giamalua, John Benedetto, Joshua Levy, International Economists. Investigation No. TA-201-73: STEEL-Remedy Memorandum.

The demand curves for the energy markets are the sum of demand responses across all markets. The demand for energy in the manufacturing sectors is a derived demand calculated using baseline energy usage and changes associated with fuel switching and changes in output levels. Similarly, the energy demand in residential sectors is obtained through mathematical specification of a demand function (see Appendix A).

The demand for goods and service in the two- and three-digit NAICS code manufacturing sectors is obtained by using a mathematical specification of the demand function. Table 5-2 lists the demand elasticities for the markets used in the model.

EPA modeled fuel switching using secondary data developed by the U.S. Department of Energy for the National Energy Modeling System (NEMS). Table 5-3 contains fuel price elasticities of demand for electricity, natural gas, petroleum products, and coal. The diagonal elements in the table represent own-price elasticities. For example, the table indicates that for steam coal, a 1 percent change in the price of coal will lead to a 0.499 percent decrease in the use of coal. The off diagonal elements are cross-price elasticities and indicate fuel switching propensities. For example, for steam coal, the second column indicates that a

Table 5-3. Fuel Price Elasticities

	Own and Cross Elasticities				
Inputs	**Electricity**	**Natural Gas**	**Coal**	**Residual**	**Distillate**
Electricity	–0.074	0.092	0.605	0.080	0.017
Natural Gas	0.496	–0.229	1.087	0.346	0.014
Steam Coal	0.021	0.061	–0.499	0.151	0.023
Residual	0.236	0.036	0.650	–0.587	0.012
Distillate	0.247	0.002	0.578	0.044	–0.055

Source: U.S. Department of Energy, Energy Information Administration (EIA). January 2000b. *Model Documentation Report: Industrial Sector Demand Module of the National Energy Modeling System*. DOE/EIA-M064(2000). Washington, DC: U.S. Department of Energy.

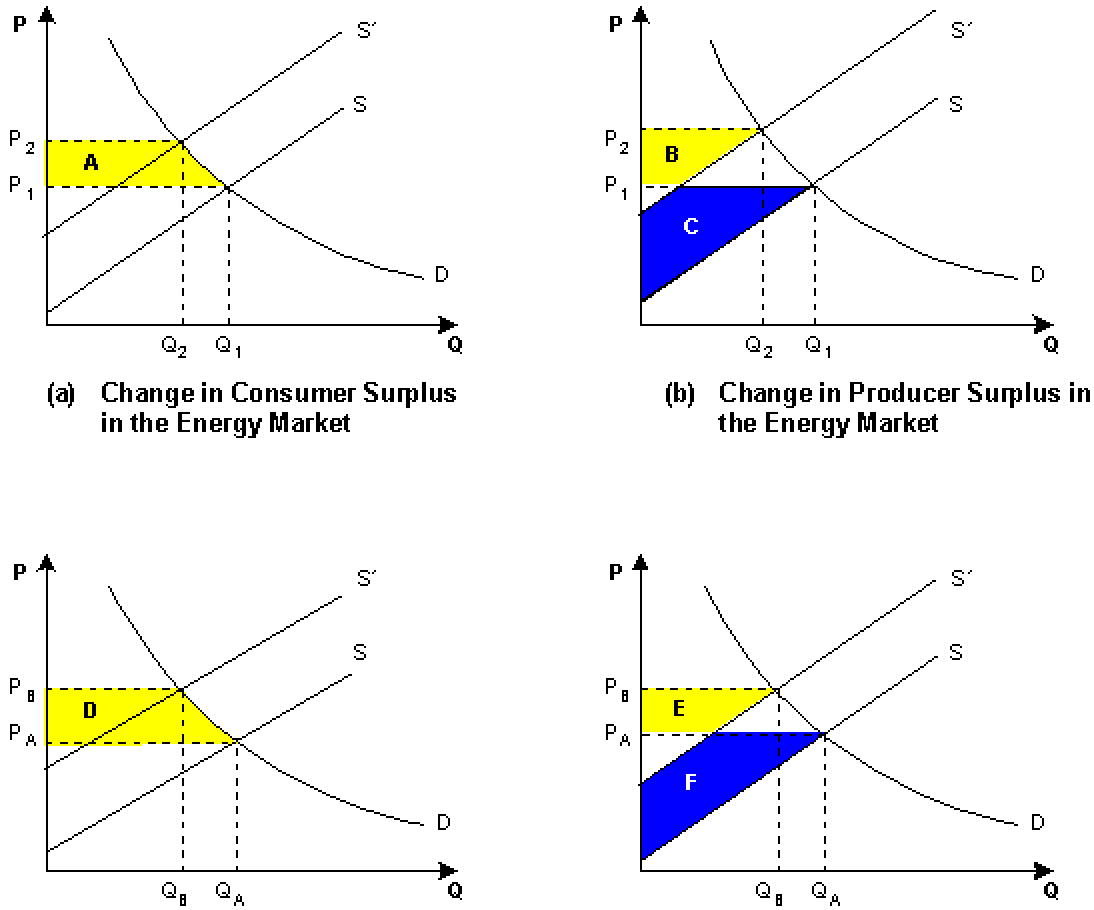
1 percent increase in the price of coal will lead to a 0.061 percent increase in the use of natural gas.

5.3.2 Calculating Changes in Social Welfare

The boilers and process heaters MACT will impact almost every sector of the economy, either directly through control costs or indirectly through changes in the price of energy and final products. For example, a share of control costs that originate in the energy markets is passed through the goods and services markets and borne by both the producers and consumers of their products. To estimate the total change in social welfare without double-counting impacts across the linked partial equilibrium markets being modeled, EPA quantified social welfare changes for the following categories:

- change in producer surplus in the energy markets;
- change in producer surplus in the goods and services markets;
- change in consumer surplus in the goods and services markets; and
- change in consumer surplus in the residential sector.

Figure 5-5 illustrates the change in producer and consumer surplus in the intermediate energy market and the goods and services markets. For example, assume a simple world with only



(a) Change in Consumer Surplus in the Energy Market

(b) Change in Producer Surplus in the Energy Market

(c) Change in Consumer Surplus in Goods and Services Markets

(d) Change in Producer Surplus in Goods and Services Markets

Figure 5-5. Changes in Economic Welfare with Regulation

one energy market, wholesale electricity, and one product market, pulp and paper. If the regulation increases the cost of generating wholesale electricity, then part of the cost of the regulation will be borne by the electricity producers as decreased producer surplus, and part of the costs will be passed on to the pulp and paper manufacturers. In Figure 5-5(a), the pulp and paper manufacturers are the consumers of electricity, so the change in consumer surplus is displayed. This change in consumer surplus in the energy market is captured by the product market (because the consumer is the pulp and paper industry in this case), where it is split between consumer surplus and producer surplus in those markets. Figure 5-5(b) shows the change in producer surplus in the energy market, where B represents an increase in producer surplus and C represents a decrease.

As shown in Figures 5-5(c) and 5-5(d), the cost affects the pulp and paper industry by shifting up the supply curve in the pulp and paper market. These higher electricity prices therefore lead to costs in the pulp and paper industry that are distributed between producers and consumers of paper products in the form of lower producer surplus and lower consumer surplus. Note that the change in consumer surplus in the intermediate energy market must equal the total change in consumer and producer surplus in the product market. Thus, to avoid double-counting, the change in consumer surplus in the intermediate energy market was not quantified; instead the total change in social welfare was calculated as

$$\text{Change in Social Welfare} = \sum \Delta PSE + \sum \Delta PSF + \sum \Delta CSF + \sum \Delta CSR \qquad (5.1)$$

where

ΔPSE = change in producer surplus in the energy markets;

ΔPSF = change in producer surplus in the goods and services markets;

ΔCSF = change in consumer surplus in the goods and services markets; and

ΔCSR = change in consumer surplus in the commercial, residential, and transportation energy markets.

Appendix A contains the mathematical algorithms used to calculate the change in producer and consumer surplus in the appropriate markets. The market analysis is conducted for the year 2005 and incorporates both growth in supply and demand. As a result, both new and existing sources are evaluated using the same analysis approach.

The engineering control costs presented in Section 3.3 are inputs (regulatory "shocks") in the market model approach. The magnitude and distribution of the regulatory costs' impact on the economy depend on the relative size of the impact on individual markets (relative shift of the market supply curves) and the behavioral responses of producers and consumers in each market (measured by the price elasticities of supply and demand).

SECTION 6

ECONOMIC IMPACT ANALYSIS RESULTS

The underlying objective of the EIA is to evaluate the effect of the regulation on the welfare of affected stakeholders and society in general. Although the engineering cost analysis presented in Section 3 does represent an estimate of the resources required to comply with the rule under baseline economic conditions, the analysis does not account for the fact that the regulations may cause the economic conditions to change. For instance, producers may reduce production in the face of higher production costs, thereby reducing market supply. Moreover, the control costs may be passed along to other parties through various economic exchanges. Therefore, EPA developed an analytical structure and economic model to measure and track these effects (described in detail in Section 5 and Appendix A). In this section, we report quantitative estimates of these welfare impacts and their distribution across stakeholders.

6.1 Social Cost Estimates

Under the final rule, EPA estimates the total change in social welfare is $862.9 million (see Table 6-1). This estimate is slightly smaller (less than $0.3 million) than the estimated baseline engineering costs as a result of behavior changes by producers and consumers. Possible behavior responses include changes in consumption and production patterns and fuel switching.

Table 6-1. Social Cost Estimates ($1998 10^6): Final Rule

	Change in Social Welfare
Baseline engineering costs	$863.0
Social costs with market adjustments	$862.9
Difference between engineering and social costs	$0.1

EPA also estimated the distribution of social costs between producers and consumers and report the distribution of impacts across sectors/markets in Table 6-2. The market analysis estimates that consumers will bear $414.3 million, or 48 percent of the total social cost as a result of higher prices and lower consumption levels. Producer surplus is projected to decrease by $448.7 million, or 52 percent of the total social cost as result of direct control costs, higher energy costs, and reductions in output.

With exception of the natural gas market, energy producers are expected to experience producer surplus losses. Under the final rule, electricity, petroleum, and coal producer surplus is projected to decline by approximately $35 million. In contrast, natural gas producer surplus is projected to increase by $4 million as they benefit from increased demand from industries switching from petroleum and electricity.

The majority welfare impacts fall on the agriculture, manufacturing, and mining industries. EPA estimates total welfare losses of $609.8 million for these sectors. Manufacturing industries with large number of boilers and process heaters and industries that consume electricity experience the majority these losses (e.g., chemicals and allied products, paper, textile mill products, and food). Consumers in these industries experience losses of $295.2 million and producers bear $314.6 million. The cost of this rule to producers as a percentage of baseline 2005 shipments is less than 0.5 percent.

EPA also examined the impact on the commercial, transportation and residential sectors. The total welfare loss for the commercial sector is estimated to be $167.1 million. Therefore, the regulatory burden associated with the MACT is estimated as 0.001 percent of total 2005 commercial sector revenues. Consumers in this sector bear approximately $71.6 million and producers bear $95.5 million of these impacts. In contrast, the total welfare loss for the transportation sector is estimated to be $9.0 million. The regulatory burden associated with the rule is estimated as 0.003 percent of total 2005 transportation sector revenues. Transportation consumers bear approximately $4.7 million and producers bear $4.3 million of these impacts. Finally, the social cost burden to residential consumers of energy, $42.7 million, is 0.037 percent of annual residential energy expenditures in 2005.

6.2 National Market-Level Impacts

Increases in the costs of production in the energy and final product markets due to the regulation are expected to result in changes in prices, production, and consumption from

Table 6-2. Distribution of Social Costs by Sector/Market: Final Rule ($1998 10^6)

Sectors/Markets			Change in: Producer Surplus	Consumer Surplus	Social Welfare
Energy Markets					
Petroleum			–$1.9		
Natural gas			$4.1		
Electricity			–$33.7		
Coal			–$2.7		
Subtotal			–$34.2		
NAICS Code	**SIC Code**	**Description**			
311	20 (pt)	Food	–$28.2	–$11.3	–$39.4
312	20 (pt); 21	Beverage and Tobacco Products	–$2.4	–$4.1	–$6.5
313	22 (pt)	Textile Mills	–$22.7	–$52.0	–$74.7
314	22 (pt)	Textile Product Mills	–$0.1	–$0.1	–$0.2
315	23	Apparel	–$0.4	–$1.1	–$1.5
316	31	Leather and Allied Products	–$0.3	–$0.4	–$0.7
321	24	Wood Products	–$39.1	–$10.4	–$49.5
322	26	Paper	–$66.1	–$60.0	–$126.1
323	27	Printing and Related Support	–$0.2	–$0.4	–$0.6
325	28	Chemicals	–$40.9	–$81.8	–$122.8
326	30	Plastics and Rubber Products	–$2.2	–$5.4	–$7.6
327	32	Nonmetallic Mineral Products	–$3.4	–$4.0	–$7.4
331	33	Primary Metals	–$25.2	–$5.7	–$30.9
332	34	Fabricated Metal Products	–$8.5	–$2.3	–$10.8
333	35	Machinery	–$7.3	–$4.9	–$12.2
334	36 (pt)	Computer and Electronic Products	–$3.6	–$1.4	–$5.0
335	36 (pt)	Electrical Equipment, Appliances, and Components	–$2.5	–$1.6	–$4.1
336	37	Transportation Equipment	–$24.6	–$32.8	–$57.3
337	25	Furniture and Related Products	–$5.4	–$24.6	–$30.1
339	39	Miscellaneous	–$0.8	–$0.7	–$1.5
11	01-08	Agricultural Sector	–$0.6	–$1.3	–$1.9
23	15-17	Construction Sector	–$0.8	–$1.1	–$1.9
21	10; 14	Other Mining Sector	–$10.1	–$7.0	–$17.2
48	40-47 (pt)	Transportation	–$4.7	–$4.3	–$9.0
42; 44-45; 49; 51-56; 61-62; 71-72; 81	40-48 (pt); 50-99	Commercial	–$71.6	–$95.5	–$167.1
		Residential	NA	–$42.7	–$42.7
Grand Total			–$414.3	–$448.7	–$862.9

NA = Not applicable.
pt = Part.

Table 6-3. Market-Level Impacts: Final Rule

Sectors/Markets			Percent Change: Price	Percent Change: Quantity
Energy Markets				
Petroleum			0.002%	0.000%
Natural gas			0.005%	0.002%
Electricity			0.050%	–0.011%
Coal			–0.007%	–0.010%
NAICS Code	**SIC Code**	**Description**		
311	20 (pt)	Food	0.006%	–0.002%
312	20 (pt); 21	Beverage and Tobacco Products	0.003%	–0.004%
313	22 (pt)	Textile Mills	0.025%	–0.021%
314	22 (pt)	Textile Product Mills	0.000%	0.000%
315	23	Apparel	0.000%	–0.001%
316	31	Leather and Allied Products	0.002%	–0.003%
321	24	Wood Products	0.041%	–0.008%
322	26	Paper	0.026%	–0.028%
323	27	Printing and Related Support	0.000%	0.000%
325	28	Chemicals	0.009%	–0.013%
326	30	Plastics and Rubber Products	0.001%	–0.002%
327	32	Nonmetallic Mineral Products	0.003%	–0.003%
331	33	Primary Metals	0.011%	–0.009%
332	34	Fabricated Metal Products	0.003%	–0.001%
333	35	Machinery	0.002%	–0.001%
334	36 (pt)	Computer and Electronic Products	0.001%	0.000%
335	36 (pt)	Electrical Equipment, Appliances, and Components	0.002%	–0.001%
336	37	Transportation Equipment	0.004%	–0.004%
337	25	Furniture and Related Products	0.008%	–0.026%
339	39	Miscellaneous	0.001%	0.000%
11	01-08	Agricultural Sector	0.000%	0.000%
23	15-17	Construction Sector	0.000%	0.000%
21	10; 14	Other Mining Sector	0.012%	–0.004%
48	40-47 (pt)	Transportation	0.001%	–0.001%
42; 44-45; 49; 51-56; 61-62; 71-72; 81	40-48 (pt); 50-99	Commercial	0.000%	0.000%

pt = Part.

baseline levels. As shown in Table 6-3, the electricity market price increases by 0.050 percent, while production/consumption decreases by 0.011 percent as a result of additional control costs. A significant share of electricity is produced in the United States using coal as a primary input. Therefore, projected reductions in electricity production also lead to a decrease in demand for coal. As a result, the price and quantities of coal are projected to fall by 0.007 percent and 0.010 percent, respectively. In the petroleum market, the model projects small price and quantity effects (i.e., less than 0.01 percent). In the natural gas market, the model projects the market price will rise in response to increased demand (0.005 percent). The price increase is the result of additional control costs and increased demand. Production and consumption quantities also increase in this market (0.002) as a result of increased demand.

Additional control costs and higher energy costs associated with the regulation lead to higher goods and services prices in all markets and a decline in output. However, the changes are generally very small. Under the MACT Floor, three markets have price increases greater than or equal to 0.02 percent—Wood Products (NAICS 321), Paper (NAICS 322), and Textile Mills (NAICS 313). The producers in these sectors are expected to face higher per-unit control costs relative to other industries. In addition, these industries are also electricity-intensive; therefore, costs of production also increase as a result of higher electricity prices.

Although the impacts on price and quantity in the goods and services markets are estimated to be small, one possible effect of modeling market impacts at the two and three digit NAICS code level is that fuel-intensive industries within the larger NAICS code definition may be affected more significantly than the average industry for that NAICS code. Thus, the changes in price and quantity should be interpreted as an average for the whole NAICS code, not necessarily for each disaggregated industry within that NAICS code.

6.3 Executive Order 13211 (Energy Effects)

Executive Order 13211, "Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use" (66 Fed. Reg. 28355 [May 22, 2001]), requires EPA to prepare and submit a Statement of Energy Effects to the Administrator of the Office of Information and Regulatory Affairs, Office of Management and Budget, for certain actions identified as "significant energy actions." Section 4(b) of Executive Order 13211 defines "significant energy actions" as "any action by an agency (normally published in the *Federal Register*) that promulgates or is expected to lead to the promulgation of a final rule or regulation, including notices of inquiry, advance notices of rulemaking, and notices of rulemaking:

- that is a significant regulatory action under Executive Order 12866 or any successor order, and is likely to have a significant adverse effect on the supply, distribution, or use of energy; or
- that is designated by the Administrator of the Office of Information and Regulatory Affairs as a significant energy action."

EPA has provided additional information on the impacts of the final rule on affected energy markets below.[1]

Energy Price Effects. As described in the market-level results section, electricity prices are projected to increase by less than 1 percent. Petroleum and natural gas prices are all projected to increase by less than 0.1 percent. The price of coal is projected to decrease slightly.

Impacts on Electricity Supply, Distribution, and Use. We project the increased compliance costs for the electricity market will result in an annual production decline of approximately 415 million kWh under the MACT floor.

Impacts on Petroleum, Natural Gas, and Coal Supply, Distribution, and Use. The model projects decreases in petroleum production/consumption of approximately 68 barrels per day under the MACT floor. In contrast, natural gas production/consumption is projected to increase by 1.1 million cubic feet per day under the MACT floor. This is the result of fuel switching in response to relative price changes. Finally, the model also projects less than a 1,000 tons per day decrease in coal production/consumption in response to reduced output from the electricity sector (a significant consumer of coal).

6.4 Conclusions

The decrease in social surplus estimated using the market analysis is $862.9 million. This estimate is slightly smaller than the estimated baseline engineering costs because the market model accounts for behavioral changes of producers and consumers. Although the rule affects boilers and process heaters used in energy industries, energy producers only incur less than 6 percent of the total social cost of the regulation. This burden is spread across

[1]Conversion factors for heat rates were obtained from AEO 2002, Appendix H. These factors vary by year to year; 2010 values are reported in this Appendix.

numerous markets because the price of energy increases slightly as a result of the regulation, which increases the cost of production for all markets that use energy as part of their production process.

The remaining share of the social cost is mostly borne by the manufacturing sectors which operate the majority of the boilers and process heaters affected by the regulation. Manufacturing industries bearing the largest social costs include percent—Wood Products (NAICS 321), Paper (NAICS 322), and Textile Mills (NAICS 313). However, the market model predicts that changes in these industries' price and quantity do not exceed 0.02 percent.

Because of the minimal changes in price and quantity estimated for most of the affected markets, EPA expects that there would be no discernable impact on international trade. Although an increase in the price of U.S. products relative to those of foreign producers is expected to decrease exports and increase imports, the changes in price due to the industrial boilers and process heaters MACT are generally too small to significantly influence trade patterns. There may also be a small decrease in employment, but because the impact of the regulation is spread across so many industries and the decreases in market quantities are so small, it is unlikely that any particular industry will face a significant decrease in employment.

SECTION 7

SMALL ENTITY IMPACTS

This section investigates the potential impact the regulation will have on small entities. The Agency has identified 185 small entities that will be affected by the final rule for the ICI boilers and process heaters NESHAP. For these entities, the average cost-to-sales ratio (CSR) is 0.78 percent and the average annual control cost is $199,000. Ten entities will incur annual costs that are greater than or equal to 3 percent of their annual sales (see Table 7-1).

Table 7-1. Summary of Small Entity Impacts

	Final Rule
Number of small entities	185
Total number of entities	576
Average annual control cost per small entity (10^3)	$199
Average control cost/sales ratio	0.78%
Number of small entities with cost-to-sales ratios ≥1 percent	34
Number of small entities with cost-to-sales ratios ≥3 percent	10

7.1 Background on Small Entity Screenings

The regulatory costs imposed on domestic producers and government entities to reduce air emissions from boilers and process heaters will have a direct impact on owners of the affected facilities. Firms, individuals, or governmental jurisdictions that own the facilities with boilers and process heaters are typically business entities that have the capacity to conduct business transactions and make business decisions that affect the facility. The legal and financial responsibility for compliance with a regulatory action ultimately rests with these owners, who must bear the financial consequences of their decisions. Environmental regulations potentially affect all sizes of businesses, but small businesses may have special problems relative to large businesses in complying with such regulations.

The Regulatory Flexibility Act (RFA) generally requires an agency to prepare a regulatory flexibility analysis of any rule subject to notice and comment rulemaking requirements under the Administrative Procedure Act or any other statute unless the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. Small entities include small businesses, small organizations, and small governmental jurisdictions.

For purposes of assessing the impacts of today's rule on small entities, small entity is defined as: (1) a small business according to Small Business Administration (SBA) size standards by the North American Industry Classification System (NAICS) category of the owning entity. The range of small business size standards for the 40 affected industries ranges from 500 to 1,000 employees, except for petroleum refining and electric utilities. In these latter two industries, the size standard is 1,500 employees and a mass throughput of 75,000 barrels/day or less, and 4 million kilowatt-hours of production or less, respectively. (2) a small governmental jurisdiction that is a government of a city, county, town, school district or special district with a population of less than 50,000; and (3) a small organization that is any not-for-profit enterprise which is independently owned and operated and is not dominant in its field.

This section investigates characteristics of businesses and government entities that own existing boilers and process heaters affected by this rule and provides a preliminary screening-level analysis to assist in determining whether this rule is likely to impose a significant impact on a substantial number of the small businesses within this industry. The screening-level analysis employed here is a "sales test," which computes the annualized compliance costs as a share of sales/revenue for existing companies/government entities.

7.2 Identifying Small Entities

To support the economic impact analysis of the regulation, EPA identified 2,186 boilers and process heaters located at commercial, industrial, and government facilities that would be affected by the regulation. The population of boilers and process heaters was developed from the EPA ICCR Inventory Database version 4.1.[1] The list of boilers and process heaters contained in these databases was developed from information in the AIRS and OTAG databases, state and local permit records, and the combustion source ICR conducted by the Agency. Industry and environmental stakeholders reviewed the units

[1] The ICCR Inventory Database contains data for boilers, process heaters, incinerators, landfill gas flares, turbines, and internal combustion engines.

contained in these databases as part of the ICCR FACA process. In addition, stakeholders contributed to the databases by identifying and including omitted units. Information was extracted from the ICCR databases to support the ICI boilers and process heaters NESHAP. This modified database containing information on only boilers and process heaters is referred to as the Inventory Database.

The small entities screening analysis for the regulation is based on the evaluation of existing owners of boilers and process heaters for which information was available. It is assumed that the size and ownership distribution of units in the Inventory Database is representative of the entire estimated population of existing boilers and process heaters. In addition, it is assumed that new sources included in the 2005 population will also be representative of the Inventory Database. However, because our analysis is based on a subset of the total population of boilers and process heaters, the number of entities identified as highly affected in this analysis may not be identical to the actual impact of the regulation on small entities. The remainder of this section presents cost and sales information on small companies and government organizations that own existing boilers and process heaters.

7.3 Analysis of Facility-Level and Parent-Level Data

The 2,186 units in the Inventory Database with full information were linked to 1,214 existing facilities. As shown in Table 7-2, these 1,186 facilities are owned by 576 parent entities. The average number of facilities per entity is approximately 2.0; however, as is also illustrated in Table 7-2, several large entities in the health services industry and government sectors own many facilities with boilers and process heaters.

Employment and sales are typically used as measures of business size. Employment, sales, population, and tax revenue data (when applicable) were collected for the 576 parent companies and government entities.[2] Figure 7-1 shows the distribution of employees by parent company for the final rule. Employment for parent companies ranges from 5 to 608,000 employees. One hundred seventy-eight or more of the firms have fewer than 500 employees, and 55 companies have more than 25,000 employees.

Sales provide another measure of business size. Figure 7-2 presents the sales or revenue distribution for affected parent entities. The median sales figure for affected companies is $300 million ($200 million), and the average sales figure is $4.1 billion

[2]Total annualized cost is compared to tax revenue to assess the relative impact on local governments.

Table 7-2. Facility-Level and Parent-Level Data by Industry

SIC Code	NAICS Code	Description	Number of Units	Number of Facilities	Number of Parent Entities	Avg. Number of Facilities Per Parent Entity
01	111	Agriculture—Crops	3	3	3	1.0
02	112	Agriculture—Livestock	—	—	—	—
07	115	Agricultural Services	—	—	—	—
10	212	Metal Mining	9	4	2	2.0
12	212	Coal Mining	2	1	—	—
13	211	Oil and Gas Extraction	—	—	—	—
14	212	Mining/Quarrying—Nonmetallic Minerals	8	4	3	1.3
17	235	Construction—Special Trade	—	—	—	—
20	311	Food and Kindred Products	138	60	32	1.9
21	312	Tobacco Products	11	7	4	1.8
22	313	Textile Mill Products	135	71	33	2.2
23	315	Apparel & Other Products from Fabrics	2	2	1	2.0
24	321	Lumber and Wood Products	360	262	122	2.1
25	337	Furniture and Fixtures	234	154	67	2.3
26	322	Paper and Allied Products	321	194	68	2.9
27	511	Printing, Publishing, and Related Industries	—	—	—	—
28	325	Chemicals and Allied Products	174	70	41	1.7
29	324	Petroleum Refining and Related Industries	11	8	9	0.9
30	326	Rubber and Misc. Plastics Products	17	13	9	1.4
31	316	Leather and Leather Products	1	1	1	1.0
32	327	Stone, Clay, Glass, and Concrete Products	9	7	4	1.8
33	331	Primary Metal Industries	41	16	10	1.6
34	332	Fabricated Metal Products	16	10	7	1.4
35	333	Industrial Machinery and Computer Equip.	23	12	9	1.3
36	335	Electronic and Electrical Equipment	5	5	3	1.7
37	336	Transportation Equipment	102	41	12	3.4
38	334	Scientific, Optical, and Photographic Equipment	8	4	3	1.3
39	339	Misc. Manufacturing Industries	2	2	2	1.0
40	482	Railroad Transportation	4	1	1	1.0

(continued)

Table 7-2. Facility-Level and Parent-Level Data by Industry (continued)

SIC Code	NAICS Code	Description	Number of Units	Number of Facilities	Number of Parent Entities	Avg. Number of Facilities Per Parent Entity
42	484	Motor Freight and Warehousing	5	1	1	1.0
46	486	Pipelines, Except Natural Gas	—	—	—	—
49	221	Electric, Gas, and Sanitary Services	318	160	80	2.0
50	421	Wholesale Trade—Durable Goods	3	2	1	2.0
51	422	Wholesale Trade—Nondurable Goods	2	1	1	1.0
55	441	Automotive Dealers and Gasoline Service Stations	—	—	—	—
58	722	Eating and Drinking Places	—	—	—	—
59	445–454	Miscellaneous Retail	—	—	—	—
60	522	Depository Institutions	—	—	—	—
70	721	Hotels and Other Lodging Places	1	1	1	1.0
72	812	Personal Services	—	—	—	—
76	811	Misc. Repair Services	2	1	—	—
80	621	Health Services	37	18	2	9.0
81	541	Legal Services	—	—	—	—
82	611	Educational Services	105	45	30	1.5
83	624	Social Services	2	1	—	—
86	813	Membership Organizations	—	—	—	—
87	541	Engineering, Accounting, Research, Management and Related Services	2	2	1	2.0
89	711/514	Services, N.E.C.	2	1	—	—
91	921	Executive, Legislative, and General Administration	1	1	—	—
92	922	Justice, Public Order, and Safety	29	9	—	—
94	923	Administration of Human Resources	1	1	—	—
96	926	Administration of Economic Programs	4	3	1	3.0
97	928	National Security and International Affairs	29	11	2	5.5
NA		SIC Information Not Available	7	4	—	—
State		Parent is a state government	—	—	10	—
		Total	2,186	1,214	576	2.0

Source: Industrial Combustion Coordinated Rulemaking (ICCR). 1998. Data/Information Submitted to the Coordinating Committee at the Final Meeting of the Industrial Combustion Coordinated Rulemaking Federal Advisory Committee. EPA Docket Numbers A-94-63, II-K-4b2 through -4b5. Research Triangle Park, North Carolina. September 16-17.

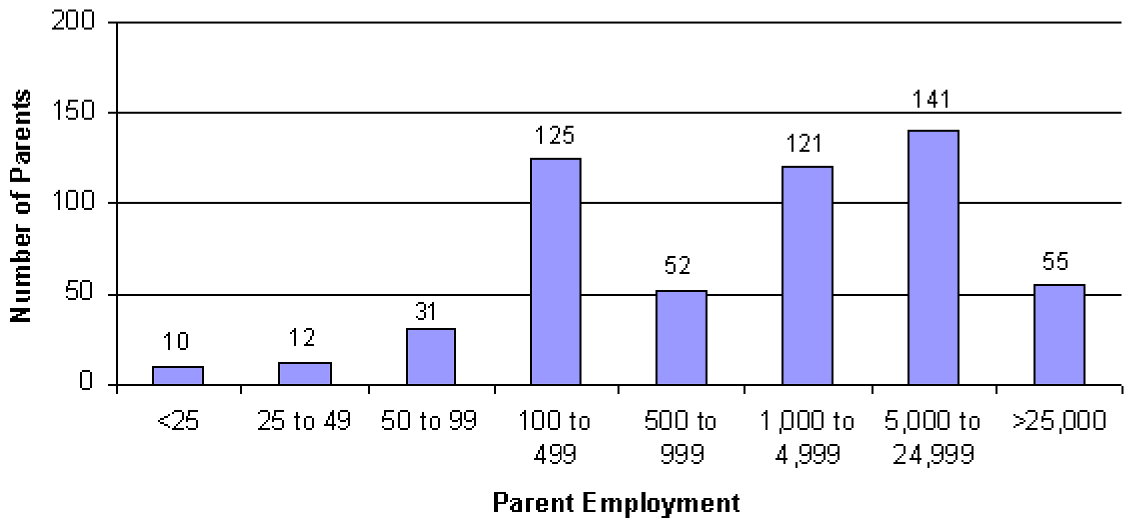


Figure 7-1. Parent Size by Employment Range

*Excludes 29 parent government entities.

($3.5 billion) (excluding the federal government). As shown in Figure 7-2, revenue and sales figures vary greatly across the population: 209 firms and governments affected by the final rule have annual revenues less than $100 million per year. These figures include all sales associated with the parent company, not just facilities affected by the regulation (i.e., facilities with boilers or process heaters).

Based on SBA guidelines, 185 of the entities were identified as small businesses.[3] Small businesses by business type are presented in Table 7-3. The lumber and wood products industry contains the largest number of the small businesses with 84, followed by furniture and fixtures with 28, electric services with 26, and paper and allied products with 13. The remaining small businesses are distributed across 40 different two-digit SIC code groupings.

[3]Small business guidelines typically define small businesses based on employment, and the threshold varies from industry to industry. For example, in the paints and allied products industry, a business with fewer than 500 employees is considered a small business; whereas in the industrial gases industry, a business with fewer than 1,000 employees is considered small. However, for a few industries, usually services, sales are used as the criterion. For example, in the veterinary hospital industry, companies with less than $5 million in annual sales are defined as small businesses.

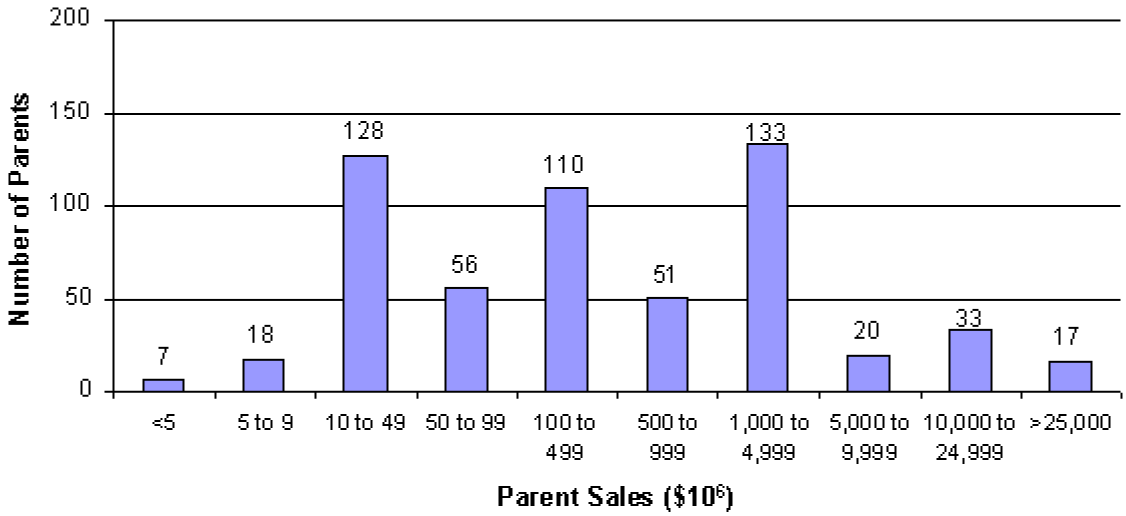


Figure 7-2. Number of Parents by Sales Range

*Excludes 3 parent entities for which sales or revenue information was unavailable.

7.4 Small Entity Impacts

Table 7-4 presents a summary of the ratio of control costs to sales for affected large and small entities. The average CSR is 0.14 percent for large entities (excluding the federal government) and 0.78 percent for small entities. Forty-four small parents had CSRs greater than 1 percent, assuming add-on control is employed to meet the standard. For these 44 parent companies, the CSRs ranged from 1.00 percent to 7.83 percent. Ten entities out of these 44 had CSRs ratios greater than 3 percent.

7.5 Affected Government Entities: Supplemental Analysis

Of the 185 small entities identified, 13 were small governmental jurisdictions that own and operate “public power” producers with affected boilers. The Regulatory Flexibility Act as amended by the Small Business Regulatory Enforcement Fairness Act provides the following standard definition of “small governmental jurisdiction”: a city, county, town, township, village, school district, or special district with a population of less than 50,000. For this analysis, public power producers are defined as nonprofit publicly owned electrical utilities operated by municipalities, counties, and states or other publicly owned bodies such as public utility districts. This excludes rural electric cooperatives.

Table 7-3. Small Parent Entities by Industry

SIC Code	NAICS Code	Description	Number of Parent Entities	Number of Small Parent Entities
01	111	Agriculture—Crops	3	—
02	112	Agriculture—Livestock	—	—
07	115	Agricultural Services	—	—
10	212	Metal Mining	2	2
12	212	Coal Mining	—	—
13	211	Oil and Gas Extraction	—	—
14	212	Mining/Quarrying—Nonmetallic Minerals	3	—
17	235	Construction—Special Trade Contractors	—	—
20	311	Food and Kindred Products	32	12
21	312	Tobacco Products	4	—
22	313	Textile Mill Products	33	5
23	315	Apparel and Other Products from Fabrics	1	—
24	321	Lumber and Wood Products	122	84
25	337	Furniture and Fixtures	67	28
26	322	Paper and Allied Products	68	13
27	511	Printing, Publishing, and Related Industries	—	—
28	325	Chemicals and Allied Products	41	4
29	324	Petroleum Refining and Related Industries	9	2
30	326	Rubber and Misc. Plastics Products	9	1
31	316	Leather and Leather Products	1	1
32	327	Stone, Clay, Glass, and Concrete Products	4	—
33	331	Primary Metal Industries	10	1
34	332	Fabricated Metal Products	7	3
35	333	Industrial Machinery and Computer Equip.	9	1
36	335	Electronic and Electrical Equipment	3	—
37	336	Transportation Equipment	12	1
38	334	Scientific, Optical, and Photographic Equip.	3	—
39	339	Miscellaneous Manufacturing Industries	2	—
40	482	Railroad Transportation	1	—
42	484	Motor Freight and Warehousing	1	—
46	486	Pipelines, Except Natural Gas	—	—
49	221	Electric, Gas, and Sanitary Services	80	26
50	421	Wholesale Trade—Durable Goods	1	—

(continued)

Table 7-3. Small Parent Entities by Industry (continued)

SIC Code	NAICS Code	Description	Number of Parent Entities	Number of Small Parent Entities
51	422	Wholesale Trade—Nondurable Goods	1	—
55	441	Automotive Dealers and Gasoline Service Stations	—	—
58	722	Eating and Drinking Places	—	—
59	445–454	Miscellaneous Retail	—	—
60	522	Depository Institutions	—	—
70	721	Hotels and Other Lodging Places	1	—
72	812	Personal Services	—	—
76	811	Misc. Repair Services	—	—
80	621	Health Services	2	1
81	541	Legal Services	—	—
82	611	Educational Services	30	—
83	624	Social Services	—	—
86	813	Membership Organizations	—	—
87	541	Engineering, Accounting, Research, Management and Related Services	1	—
89	711/514	Services, N.E.C.	—	—
91	921	Executive, Legislative, and General Administration	—	—
92	922	Justice, Public Order, and Safety	—	—
94	923	Administration of Human Resources	—	—
96	926	Administration of Economic Programs	1	—
97	928	National Security and International Affairs	2	—
NA		SIC Information Not Available	—	—
State		Parent is a State Government	10	—
		Total	576	185

Source: Industrial Combustion Coordinated Rulemaking (ICCR). 1998. Data/Information Submitted to the Coordinating Committee at the Final Meeting of the Industrial Combustion Coordinated Rulemaking Federal Advisory Committee. EPA Docket Numbers A-94-63, II-K-4b2 through -4b5. Research Triangle Park, North Carolina. September 16-17.

Table 7-4. Summary Statistics for SBREFA Screening Analysis

	Value
Total Number of Small Entities	185
Average Annual Compliance Cost per Small Entity ($$10^3$)	$199
Entities with Sales/Revenue Data	
Compliance costs are <1% of sales	141
Compliance costs are ≥1 to 3% of sales	34
Compliance costs are ≥3% of sales	10
Compliance Cost-to-Sales/Revenue Ratios	
Average	0.78
Median	0.50
Maximum	7.83
Minimum	0.01

As illustrated in Table 7-5, the vast majority of small municipal systems with affected boilers are located in the Midwest (11 systems or 85 percent). Four of the 11 municipal systems are located in Minnesota, with two in Indiana and two in Michigan.

Historically municipal utilities were created to provide residents of a community with reliable energy. For example, the residential sector accounts for more than two-thirds of total consumers in all cases (see Table 7-6). However, the residential sector generally represents the smallest group in terms of total energy consumption. The industrial and commercial sectors consume approximately 70 percent of total energy supplied. Power not consumed by the residential, commercial, or industrial sector is sold into the wholesale energy market.

Public power producers do not pay state or local taxes. However, they typically are under agreement to make annual contributions to state and local government operating funds. In addition, they are not guaranteed a rate of return (as regulated public utilities are); however, their rates are set by agreement with local councils, and these rates are typically adjusted to reflect changes in operating costs.

Table 7-5. Regional Distribution of Municipal Systems

Regional Distribution	Number of Facilities
East	
Vermont	1
Midwest	
Indiana	2
Iowa	1
Michigan	2
Minnesota	4
Ohio	1
Wisconsin	1
West	
California	1
Total	13

Municipal utilities can generate capital by issuing tax-exempt municipal bonds. These municipal bonds are exempt from federal income taxes, which allows the publicly owned utilities to finance capital projects at a more affordable rate. Additionally, the local governments investing in municipal utilities generally issue revenue bonds rather than general obligation bonds. This ensures that the debt can be paid back through revenues from generating electricity and does not obligate the local government or community tax base.

As shown in Table 7-7, the average total annual compliance costs per entity are $223,000 under the final rule. The median cost-to-revenue ratio is 0.94 percent, and ratios range from less than 0.5 percent to 8 percent. Three of the affected small governments have cost-to-revenue ratios at or above 3 percent.

7.6 Assessment of SBREFA Screening

This analysis indicates that over two-thirds of the entities affected by the industrial boilers and process heaters standard are large.[4] The relatively small proportion of small entities affected by the regulation at the MACT floor is due in part to the exclusion of ICI

[4]Based on SBA guidelines for determining small entities.

Table 7-6. Selected Municipal Utilities' Capacity, Usage, and Consumer Types

Row ID	Capacity (MW)	Energy Usage (kWh/y)	Distribution of Energy Usage by Customer Type			Total Consumers	Distribution of Customers		
			Residential	Commercial	Industrial		Residential	Commercial	Industrial
1	50.5	332,524,000	27%	NA	NA	19,313	82%	15%	3.7%
2	115	371,823,000	36%	28%	16%	15,615	87%	11%	0.3%
3	24.3	388,066,000	19%	10%	70%	9,082	84%	14%	1.0%
4	22.2	185,191,000	26%	14%	58%	6,235	86%	13%	1.6%
5	34.5	147,335,000	26%	27%	44%	5,955	86%	14%	0.3%
6	23	573,003,000	8%	NA	NA	7,207	90%	7%	1.0%
7	35	338,903,000	38%	8%	51%	13,247	87%	11%	1.3%
8	46	194,753,000	22%	NA	NA	6,890	85%	13%	0.1%
9	103.1	837,175,000	NA	NA	NA	NA	NA	NA	NA
10	32	218,208,000	40%	3%	55%	10,829	88%	3%	8.4%
11	26	267,201,000	16%	NA	NA	9,471	75%	24%	0.3%
12	34	95,642,000	33%	67%	NA	5,747	83%	17%	0.3%

Source: Giles, Ellen F. 2000. *Platt's Directory of Electric Power Producers and Distributors, 109th Edition of the Electrical World Directory*. New York: McGraw Hill.

Table 7-7. Supplemental Screening Analysis for Small Governmental Jurisdictions

	Value
Total Number of Small Entities	13
Average Total Annual Compliance Cost (TACC) per Small Entity ($$10^3$)	$223
Entities with Sales/Revenue Data	
Compliance costs are <1% of revenue	7
Compliance costs are ≥1 to 3% of revenue	3
Compliance costs are ≥3% of revenue	3
Compliance Cost-to-Sales/Revenue Ratios	
Average	1.67
Median	0.94
Maximum	7.83
Minimum	0.02

Source: American Public Power Association (APPA). 2002. *Straight Answers to False Charges about Public Power*. Washington, DC: APPA. <http://www.appanet.org/about/publicpower/index.cfm>. As obtained on November 13, 2003.

boilers and process heaters with less than 10 MMBtu input capacity that also use a fossil fuel liquid or gas as primary fuel. As a result, a large share of small boilers and process heaters, which are presumably owned disproportionately by smaller entities, will not incur compliance costs. The Agency estimates that approximately 57 percent of the U.S. population are less than 10 MMBtus or are emergency units and, hence, are excluded from the regulation.

Of the small entities affected by the final rule, the majority are in the lumber and wood products, furniture and fixtures, paper and allied products, and electric, gas and sanitary services sectors. As shown in Table 7-8, the median profit margin for these four sectors is approximately 3 percent. Table 7-8 also shows the profit margins for the other industry sectors with affected small businesses. All profit margins of industry sectors with affected small businesses are above 2 percent.

Table 7-8. Profit Margins for Industry Sectors with Affected Small Businesses

SIC Code	NAICS Code	Description	Median Profit Margin
20	311	Food and Kindred Products	3.6%
22	313	Textile Mill Products	2.1%
24	321	Lumber and Wood Products	3.0%
25	337	Furniture and Fixtures	3.0%
26	322	Paper and Allied Products	3.3%
28	325	Chemicals and Allied Products	2.7%
49	221	Electric, Gas, and Sanitary Services	7.5%

Source: Dun & Bradstreet. 1997. *Industry Norms & Key Business Ratios*. Desktop Edition 1996-97. Murray Hill, NJ: Dun & Bradstreet, Inc.

After considering the economic impact of the final rule on small entities, EPA certifies that this action will not have a significant impact on a substantial number of small entities. In accordance with the RFA, as amended by the SBREFA, 5 U.S.C. 601, et. seq., EPA conducted an assessment of the standard on small businesses within the industries affected by the rule. Based on SBA size definitions and reported sales and employment data, the Agency identified 185 entities, or 32 percent. Although small entities represent 32 percent of the SBREFA screening population, they are expected to incur only 8 percent of the total compliance costs of $445.6 million (1998$). Only ten small entities have compliance costs equal to or greater than 3 percent of their sales. In addition, only 34 small entities have CSRs between 1 and 3 percent. Additional analysis of small governmental jurisdictions shows 3 of 13 have CSRs greater than 3 percent, and 3 have CSRs between 1 and 3 percent.

An EIA was performed to estimate the changes in product price and production quantities for this rule. As mentioned in the summary of economic impacts earlier in this report, the estimated changes in prices and output for affected firms (including small firms) are no more than 0.04 percent.

This rule will not have a significant economic impact on a substantial number of small entities as a result of several decisions EPA made regarding the development of this rulemaking which resulted in limiting the impact of this rule on small entities. First, as mentioned earlier, EPA identified small units (heat input of 10 MMBtu/hr or less) and limited-use boilers (operate less than 10 percent of the time) as separate subcategories from large units. Many small and limited-use units are located at small entities. As also discussed earlier, the result of the MACT floor analysis for these subcategories of existing sources was that no MACT floor could be identified except for the limited-use solid fuel subcategory, which is less stringent than the MACT floor for large units. Furthermore, the results of the above-the-floor analysis for these subcategories indicated that the costs would be too high to be considered feasible. Consequently, this rule contains no emission limitations for any of the existing small and limited-use subcategories except the existing limited-use solid fuel subcategory. In addition, the alternative metals emission limit resulted in minimizing the impacts on small entities because some of the potential entities burning a fuel containing very little metals are small entities.

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APPENDIX A:

ECONOMIC MODEL OF MARKETS AFFECTED BY THE BOILERS AND PROCESS HEATERS MACT

The primary purpose of the EIA for the rule is to describe and quantify the economic impacts associated with the rule. The Agency used a basic framework that is consistent with economic theory and the analyses performed for other rules to develop estimates of these impacts. This approach employs standard microeconomic concepts to model behavioral responses expected to occur with regulation. This appendix describes the spreadsheet model in more detail and discusses how the Agency

- collected the baseline data set from the Annual Energy Outlook 2002 (DOE, EIA, 2002), U.S. Census Bureau (U.S. Department of Commerce, 2001), and U.S. Department of Agriculture (USDA, 2002).
- characterized market supply and demand for each market and specified links between the energy and agricultural, manufacturing, mining, and commercial markets.
- introduced a policy "shock" into the model by using control cost-induced shifts in the supply functions, and
- used a solution algorithm to determine a new with-regulation equilibrium for each market.

A.1 Baseline Data Set

EPA collected the following data to characterize the baseline year, 2005:

- *Energy Market Data*—The Department of Energy's Supplemental Tables to the Annual Energy Outlook 2002 report forecasts of price, quantity, and fuel intensities used to calibrate the model.
- *Agriculture, Mining, Manufacturing, Commercial Sectors*—EPA obtained shipment data from the 1997 Economic Census and 1997 Agriculture Census. We then used annual growth rates reported by the Bureau of Economic Analysis (BEA, 1997) to estimate baseline shipment data for 2005. The Agency selected units for output such that the price in each market equals one. We computed energy demand using fuel intensity data reported in the AEO 2002.

- *Supply and Demand Elasticities*—The supply and demand elasticity values used in the market model are reported in Table 5-2 of this report. Given the uncertainties regarding these parameters, EPA also conducted several sensitivity analyses and report these results in Appendix B.

A.2 Multi-Market Model

The model includes four energy markets (coal, electricity, natural gas, and petroleum) and 24 goods and service markets. The following sections describe model equations the Agency developed to characterize these markets and estimate welfare changes resulting from the rule.

A.1.1 Supply Side Modeling

EPA estimated the change in quantity supplied as follows:

$$\Delta q^S = q_0^S \cdot \varepsilon^S \cdot \frac{\Delta p - c - \sum_{j=1}^{n} \alpha_j \Delta p_j}{p_0} \qquad \text{(A.1)}$$

where q_0^S is the baseline quantity, ε^S is the domestic supply elasticity, the term $\Delta p - c - \sum_{j=1}^{n} \alpha_j \Delta p_j$ is the change in the producer's net price, and p_0 is the baseline price. The change in net price is composed of the change in baseline price resulting from the regulation, the direct shift in the supply function resulting from compliance costs, and the indirect shift in the supply function resulting from changes in input prices in energy market (j). The fuel share is allowed to vary using a fuel switching rule relying on cross-price elasticities of demand between energy sources.

A.1.1.2 Producer Welfare Measurement

EPA approximated the change in producer surplus with the following equation:

$$\Delta PS = q_1 \cdot (\Delta p - c - \sum_{j=1}^{n} \alpha_j \Delta p_j) - 0.5 \cdot \Delta q \cdot (\Delta p - c - \sum_{j=1}^{n} \alpha_j \Delta p_j) \qquad \text{(A.2)}$$

Increased control costs, higher energy input costs, and output declines have a negative effect on domestic producer surplus. However, these losses are mitigated to some degree as a result of higher market prices.

A.1.2 Energy Demand Side Modeling

Market demand in the energy markets is expressed as the sum of the energy, residential, agriculture, manufacturing, mining, commercial, and transportation sectors:

$$Q_{Dj} = \sum_{i=1}^{n} q_{Dji} \,, \qquad \text{(A.3)}$$

where j indexes the energy market and i indexes the consuming sector. The change in residential quantity demanded of energy market j can be approximated as follows:

$$\Delta q^{D_j} = q_0^{D_j} \cdot \eta^{D_j} \cdot \frac{\Delta p_j}{p_{j0}} \qquad \text{(A.4)}$$

where $q_0^{D_j}$ is baseline consumption, η^{D_j} is the residential demand elasticity and (Δp) is the change in the market price.

In contrast, energy demand from energy, agricultural, manufacturing, mining, commercial, and transportation sectors is modeled as a derived demand resulting from the production and consumption choices in these industries. Energy demand responds to changes in sector output and fuel switching that occurs in response to changes in relative energy prices. For each of these sectors, energy demand is expressed as follows:

$$BTU_{ji1} = \frac{BTU_{ji}}{q_{i0}} \cdot FSW \cdot q_{i1} \qquad \text{(A.5)}$$

where BTU is demand for energy market j from sector i, q is sector i's output, and FSW is a factor generated by the fuel switching algorithm. The subscripts 0 and 1 represent baseline and with regulation conditions, respectively.

A.1.3 Agriculture, Manufacturing, Mining, Commercial, and Transportation Demand Side Modeling

The change in quantity demanded in these markets can be approximated as follows:

$$\Delta q^{D_i} = q_0^{D_i} \cdot \eta^{D_i} \cdot \frac{\Delta p_i}{p_{i0}} \qquad \text{(A.6)}$$

where $q_0^{D_i}$ is baseline output, η^D is the demand elasticity of the respective market (i) and (Δp_i) is the change in the market price.

The change in consumer surplus in markets is approximated as follows:

$$\Delta CS = - q_1 \cdot \Delta p + 0.5 \cdot \Delta q \cdot \Delta p \qquad (A.7)$$

As shown, higher market prices and reduced consumption lead to welfare losses for consumers.

A.2 With-Regulation Market Equilibrium Determination

Market adjustments can be conceptualized as an interactive feedback process. Supply segments face increased production costs as a result of the rule and are willing to supply smaller quantities at the baseline price. This reduction in market supply leads to an increase in the market price that all producers and consumers face, which leads to further responses by producers and consumers and thus new market prices. The new with-regulation equilibrium is the result of a series of iterations in which price is adjusted and producers and consumers respond, until a set of stable market prices arises where total market supply equals market demand (i.e., $Qs = Q_D$) in each market. Market price adjustment takes place based on a price revision rule that adjusts price upward (downward) by a given percentage in response to excess demand (excess supply).

The algorithm for determining with-regulation equilibria can be summarized by seven recursive steps:

1. Impose the control costs on affected supply segments, thereby affecting their supply decisions.
2. Recalculate the market supply in each market. Excess demand currently exists.
3. Determine the new prices via a price revision rule.
4. Recalculate market supply with new prices, accounting for fuel switching choices associated with new energy prices.
5. Compute market demand in each market.

6. Compare supply and demand in each markets. If equilibrium conditions are not satisfied, go to Step 3, resulting in a new set of market prices. Repeat until equilibrium conditions are satisfied (i.e., the ratio of supply to demand is arbitrarily close to one).

APPENDIX B

ASSUMPTIONS AND SENSITIVITY ANALYSIS

In developing the economic model to estimate the impacts of the industrial/ commercial/institutional boilers and process heaters NESHAP, several assumptions were necessary to make the model operational. This appendix lists and explains the major model assumptions and describes their potential impact on the analysis results. Sensitivity analyses are presented for numeric assumptions.

Assumption: The domestic markets for goods and services are all perfectly competitive.

Explanation*:* Assuming that these markets are perfectly competitive implies that the producers of these products are unable to unilaterally affect the prices they receive for their products. Because the industries used in this analysis are aggregated across a large number of individual producers, it is a reasonable assumption that the individual producers have a very small share of industry sales and cannot individually influence the price of output from that industry.

Possible Impact: If these product markets were in fact imperfectly competitive, implying that individual producers can exercise market power and thus affect the prices they receive for their products, then the economic model would understate possible increases in the price of final products due to the regulation as well as the social costs of the regulation. Under imperfect competition, producers would be able to pass along more of the costs of the regulation to consumers; thus, consumer surplus losses would be greater, and producer surplus losses would be smaller in the final product markets.

Assumption: Market Supply and Demand Elasticity Uncertainty

Explanation: The goods and service markets are modeled at the two or three-digit NAICS code level to operationalize the economic model. Because of the high level of aggregation, only limited data on elasticities of supply and demand estimates are available. However, these elasticities strongly influence the distribution of economic impacts between producers and consumers.

Sensitivity Analysis: Tables B-1a and Table B-1b show how the economic impact estimates vary as the supply and demand elasticities for goods and services change by 25 percent.

Table B-1a. Sensitivity Analysis: Supply and Demand Elasticities in the Goods and Services Markets

Change Supply Demand Constant	25% Decrease	Elasticities Reported in Section 6	25% Increase
Change in consumer surplus	–367.8	–414.3	–450.5
Change in producer surplus	–495.2	–448.7	–412.4
Change in social welfare	–862.9	–862.9	–862.9

Table B-1b. Sensitivity Analysis: Supply and Demand Elasticities in the Goods and Services Markets

Supply Constant Demand Change	25% Decrease	Elasticities Reported in Section 6	25% Increase
Change in consumer surplus	–462.7	–414.3	–364.4
Change in producer surplus	–400.2	–448.7	–498.5
Change in social welfare	–862.9	–862.9	–862.9

Assumption: Cross-price elasticities of demand for fuels are based on 2015 NEMS projections.

Explanation: Cross- and own-price elasticities of demand from NEMS were used to capture fuel switching in the manufacturing sectors in the economic model. As shown in Table 5-2, allowing manufacturers to switch fuels in response to changes in relative energy prices decreases the change in social welfare by approximately 10 percent. However, the NEMS projection reflects aggregate behavioral responses in the year 2015. Because this is a longer window of analysis compared to the baseline year 2005, this analysis may overestimate firms' ability to switch fuels in the short run.

Sensitivity Analysis: Table B-2 shows how the economic impact estimates vary as the own- and cross-price elasticities used in the EIA are reduced by 50 percent and 75 percent.

Table B-2. Sensitivity Analysis: Own- and Cross-Price Elasticities Used to Model Fuel Switching

	Fuel Price Elasticities Presented in Table 5-2	Reduced by 50 Percent	Reduced by 75 Percent
Change in consumer surplus	–414.3	–414.6	–414.9
Change in producer surplus	–448.7	–448.4	–448.0
Change in social welfare	–862.9	–862.9	–862.9

Assumption: The domestic markets for energy are perfectly competitive.

Explanation: Assuming that the markets for energy are perfectly competitive implies that individual producers are not capable of unilaterally affecting the prices they receive for their products. Under perfect competition, firms that raise their price above the competitive price are unable to sell at that higher price because they are a small share of the market and consumers can easily buy from one of a multitude of other firms that are selling at the competitive price level. Given the relatively homogeneous nature of individual energy products (petroleum, coal, natural gas, electricity), the assumption of perfect competition at the national level seems to be appropriate.

Possible Impact: If energy markets were in fact imperfectly competitive, implying that individual producers can exercise market power and thus affect the prices they receive for their products, then the economic model would understate possible increases in the price of energy due to the regulation as well as the social costs of the regulation. Under imperfect competition, energy producers would be able to pass along more of the costs of the regulation to consumers; thus, consumer surplus losses would be greater, and producer surplus losses would be smaller in the energy markets.

Assumption: The elasticity of supply in the electricity market for existing sources is approximately 0.75.

Explanation: The price elasticity of supply in the electricity markets represents the behavioral responses from existing sources to changes in the price of electricity. However, there is no consensus on estimates of the price elasticity of supply for electricity. This is in part because, under traditional regulation, the electric utility industry had a mandate to serve all its customers and utilities were compensated on a rate-based rate of return. As a result, the market concept of supply elasticity was not the driving force in utilities' capital investment decisions. This has changed under deregulation. The market price for electricity has become the determining factor in decisions to retire older units or to make higher cost units available to the market.

***Sensitivity Analysis*:** Table B-3 shows how the economic impact estimates vary as the elasticity of supply in the electricity markets varies.

Table B-3. Sensitivity Analysis: Elasticity of Supply in the Electricity Markets

	ES = 0.5	**ES = 0.75**	**ES = 1.0**
Change in consumer surplus	–405.0	–414.3	–419.6
Change in producer surplus	–457.9	–448.7	–443.4
Change in social welfare	–862.9	–862.9	–862.9

APPENDIX C

ECONOMIC ANALYSIS OF REGULATORY ALTERNATIVE: OPTION 1A

EPA examined one above-the-floor alternative referred to in this appendix as Option 1A. Option 1A broadens the scope of affected units to include those fueled by residual fuel oil and units of covered fuel types with input capacities less than 10 million Btus. In this appendix, we describe the engineering compliance costs associated with this option, estimate the size and distribution of social cost, and report the results of the small entity screening analysis

C.1 Engineering Cost Analysis: Affected Population and Cost Estimates

The entire Inventory Database contains more than 58,000 ICI boilers and process heaters. The number of units included in the profile was 3,580 for Option 1A. As shown in Table C-1, the industries with the largest number of potentially affected units are the furniture, paper, lumber, and electrical services industries. These four industries alone account for nearly 60 percent of affected units. Almost all the process heaters are in the lumber industry. The remaining units are primarily distributed across the manufacturing sector and service industries. The distribution of units affected by the Option 1A alternative is similar to the final rule, although both the number of units and the number of facilities is greater for Option 1A.

We describe the technical characteristics of existing boilers affected under Option 1A below (see Figure C-1). These characteristics include capacity range, fuel type, and level of preexisting controls.

- Capacity Range: About half of the 3,580 units affected by this alternative have input capacities between 10 and 100 MMBtu/hr. Twenty percent have capacities between 100 and 250, 16 percent have capacities greater than 250, and 13 percent have capacities less than 10 MMBtu/hr.

- Fuel Type: Coal and residual fuel oil are the primary fuel types each accounting for slightly less than one-third of the units. The remaining third primarily consists of units that consume wood or some other type of biomass fuel.

Table C-1. Units and Facilities Affected by the Option 1A Alternative by Industry[a]

SIC Code	NAICS Code	Description	Boilers	Heaters	Total Units	Facilities
01	111	Agriculture—Crops	6	0	6	6
02	112	Agriculture—Livestock	0	0	0	0
07	115	Agricultural Services	0	0	0	0
10	212	Metal Mining	10	1	11	5
12	212	Coal Mining	2	0	2	1
13	211	Oil and Gas Extraction	8	10	18	4
14	212	Mining/Quarrying—Nonmetallic Minerals	10	0	10	5
17	235	Construction—Special Trade Contractors	2	0	2	1
20	311	Food and Kindred Products	163	0	163	72
21	312	Tobacco Products	22	0	22	11
22	313	Textile Mill Products	247	3	250	134
23	315	Apparel and Other Products from Fabrics	4	0	4	4
24	321	Lumber and Wood Products	434	28	462	337
25	337	Furniture and Fixtures	310	0	310	209
26	322	Paper and Allied Products	503	0	503	272
27	511	Printing, Publishing, and Related Industries	8	0	8	6
28	325	Chemicals and Allied Products	332	101	433	163
29	324	Petroleum Refining and Related Industries	54	108	162	50
30	326	Rubber and Miscellaneous Plastics Products	56	0	56	37
31	316	Leather and Leather Products	22	0	22	12
32	327	Stone, Clay, Glass, and Concrete Products	40	2	42	25
33	331	Primary Metal Industries	83	2	85	33
34	332	Fabricated Metal Products	44	0	44	28
35	333	Industrial Machinery and Computer Equipment	46	0	46	25
36	335	Electronic and Electrical Equipment	45	0	45	29
37	336	Transportation Equipment	158	0	158	61
38	334	Scientific, Optical, and Photographic Equip.	33	0	33	16
39	339	Miscellaneous Manufacturing Industries	14	0	14	10
40	482	Railroad Transportation	4	0	4	1
42	484	Motor Freight and Warehousing	5	2	7	3
46	486	Pipelines, Except Natural Gas	3	3	6	5

(continued)

Table C-1. Units and Facilities Affected by the Option 1A Alternative by Industry[a] (continued)

SIC Code	NAICS Code	Description	Boilers	Heaters	Total Units	Facilities
49	221	Electric, Gas, and Sanitary Services	371	1	372	185
50	421	Wholesale Trade—Durable Goods	3	0	3	2
51	422	Wholesale Trade—Nondurable Goods	2	0	2	1
55	441	Automotive Dealers and Gasoline Service Stations	0	1	1	1
58	722	Eating and Drinking Places	0	0	0	0
60	522	Depository Institutions	0	0	0	0
59	445–454	Miscellaneous Retail	1	0	1	1
70	721	Hotels and Other Lodging Places	1	0	1	1
72	812	Personal Services	0	0	0	0
76	811	Miscellaneous Repair Services	2	0	2	1
80	621	Health Services	40	0	40	19
81	541	Legal Services	0	0	0	0
82	611	Educational Services	114	0	114	50
83	624	Social Services	3	0	3	2
86	813	Membership Organizations	0	0	0	0
87	541	Engineering, Accounting, Research, Management and Related Services	6	0	6	5
89	711/514	Services, N.E.C.	2	0	2	1
91	921	Executive, Legislative, and General Administration	2	0	2	2
92	922	Justice, Public Order, and Safety	33	0	33	10
94	923	Administration of Human Resources	1	0	1	1
96	926	Administration of Economic Programs	4	0	4	3
97	928	National Security and International Affairs	41	0	41	13
NA		SIC Information Not Available	24	0	24	18
			3,318	262	3,580	1,881

[a] Based on the Inventory Database.

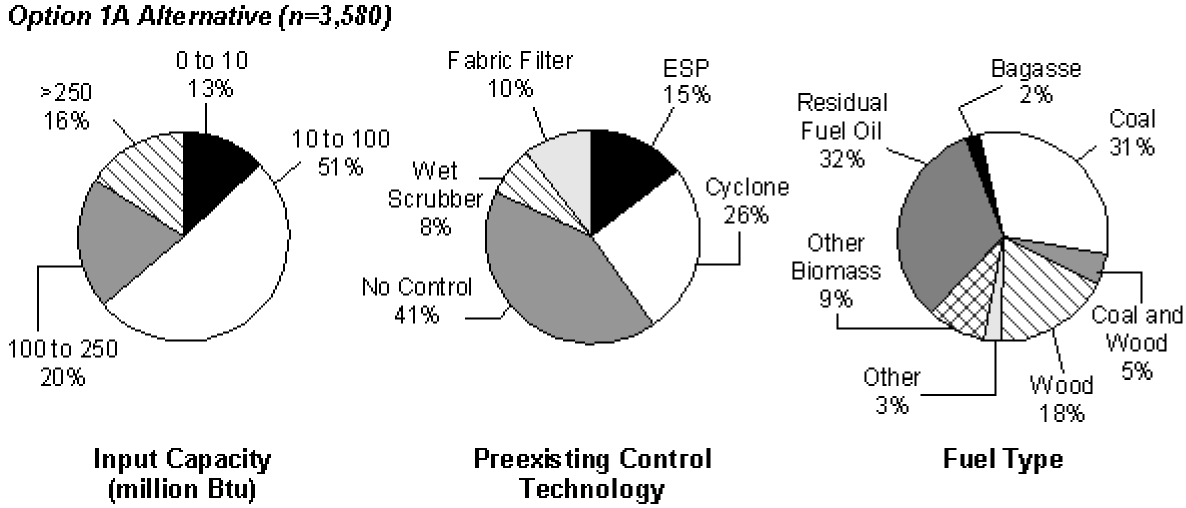

Figure C-1. Characteristics of Units Affected

Control Level: Forty-one percent have no existing pollution control equipment installed. Typical control devices include fabric filters, wet scrubbers, and electrostatic precipitators.

- Fuel Type: This alternative includes those units affected under Option 1A, as well as a large number of natural gas units that were not affected under Option 1A. The vast majority of the 78 percent of the total number of potentially affected units are fueled by natural gas.
- Control Level: Eighty-eight percent of the affected units have no preexisting control equipment.

The Agency estimates that in 2005, 9,163 units (existing units and new units) may be affected by the Option 1A. These populations were used to estimate national engineering costs. As shown in Table C-2, the cost of controls for Option 1A is $1,995.8 million, with an average per-unit cost of $218,000.

Table C-2. Unit Cost and Population Estimates for the Option 1A by Industry, 2005

SIC Code	NAICS Code	Description	Total Units: Option 1A Units	Total Units: Percent	Total Cost: Option 1A Costs (by Unit)	Total Cost: Percent
01	111	Agriculture—Crops	11	0.12%	$1,633,841	0.08%
02	112	Agriculture—Livestock	—	0.00%	—	0.00%
07	115	Agricultural Services	—	0.00%	—	0.00%
10	212	Metal Mining	34	0.37%	$8,952,098	0.45%
12	212	Coal Mining	6	0.06%	$683,026	0.03%
13	211	Oil and Gas Extraction	137	1.50%	$6,070,001	0.30%
14	212	Mining/Quarrying—Nonmetallic Minerals	31	0.34%	$17,958,177	0.90%
17	235	Construction—Special Trade Contractors	2	0.03%	$230,525	0.01%
20	311	Food and Kindred Products	376	4.10%	$122,487,346	6.14%
21	312	Tobacco Products	56	0.61%	$13,685,614	0.69%
22	313	Textile Mill Products	673	7.34%	$147,094,726	7.37%
23	315	Apparel and Other Products from Fabrics	10	0.11%	$1,213,586	0.06%
24	321	Lumber and Wood Products	620	6.77%	$89,961,854	4.51%
25	337	Furniture and Fixtures	421	4.60%	$50,045,573	2.51%
26	322	Paper and Allied Products	1,050	11.46%	$323,736,302	16.22%
27	511	Printing, Publishing, and Related Industries	37	0.40%	$1,824,933	0.09%
28	325	Chemicals and Allied Products	1,359	14.83%	$293,027,205	14.68%
29	324	Petroleum Refining and Related Industries	677	7.38%	$73,172,001	3.67%
30	326	Rubber and Miscellaneous Plastics Products	178	1.94%	$18,100,195	0.91%
31	316	Leather and Leather Products	66	0.72%	$6,924,480	0.35%
32	327	Stone, Clay, Glass, and Concrete Products	154	1.68%	$17,509,996	0.88%
33	331	Primary Metal Industries	271	2.95%	$65,174,064	3.27%
34	332	Fabricated Metal Products	165	1.80%	$22,066,661	1.11%
35	333	Industrial Machinery and Computer Equipment	151	1.65%	$26,418,385	1.32%
36	335	Electronic and Electrical Equipment	167	1.82%	$18,770,867	0.94%
37	336	Transportation Equipment	453	4.95%	$107,402,909	5.38%
38	334	Scientific, Optical, and Photographic Equipment	104	1.13%	$13,638,983	0.68%
39	339	Miscellaneous Manufacturing Industries	37	0.41%	$4,222,427	0.21%
40	482	Railroad Transportation	9	0.10%	$2,240,871	0.11%
42	484	Motor Freight and Warehousing	19	0.21%	$3,475,610	0.17%

(continued)

Table C-2. Unit Cost and Population Estimates for the Option 1A by Industry, 2005 (continued)

			Total Units		Total Cost	
SIC Code	NAICS Code	Description	Option 1A Units	Percent	Option 1A Costs (by Unit)	Percent
46	486	Pipelines, Except Natural Gas	19	0.21%	$1,959,589	0.10%
49	221	Electric, Gas, and Sanitary Services	865	9.44%	$331,479,389	16.61%
50	421	Wholesale Trade—Durable Goods	6	0.07%	$2,675,296	0.13%
51	422	Wholesale Trade—Nondurable Goods	4	0.04%	$2,693,380	0.13%
55	441	Automotive Dealers and Gasoline Service Stations	2	0.02%	$195,421	0.01%
58	722	Eating and Drinking Places	—	0.00%	—	0.00%
59	445–454	Miscellaneous Retail	3	0.03%	$259,585	0.01%
60	522	Depository Institutions	—	0.00%	—	0.00%
70	721	Hotels and Other Lodging Places	2	0.02%	$849,114	0.04%
72	812	Personal Services	1	0.01%	$7,840	0.00%
76	811	Miscellaneous Repair Services	4	0.05%	$1,120,435	0.06%
80	621	Health Services	93	1.01%	$22,545,605	1.13%
81	541	Legal Services	—	0.00%	—	0.00%
82	611	Educational Services	273	2.98%	$91,770,778	4.60%
83	624	Social Services	8	0.08%	$1,448,405	0.07%
86	813	Membership Organizations	—	0.00%	—	0.00%
87	541	Engineering, Accounting, Research, Management and Related Services	49	0.54%	$5,016,627	0.25%
89	711/514	Services, N.E.C.	2	0.02%	$1,211,582	0.06%
91	921	Executive, Legislative, and General Administration	5	0.06%	$845,423	0.04%
92	922	Justice, Public Order, and Safety	77	0.85%	$21,308,885	1.07%
94	923	Administration of Human Resources	2	0.02%	$314,316	0.02%
96	926	Administration of Economic Programs	8	0.09%	$4,200,975	0.21%
97	928	National Security and International Affairs	96	1.05%	$36,080,306	1.81%
NA		SIC Information Not Available	368	4.01%	$12,099,975	0.61%
State		Parent is a state government	—	0.00%	—	0.00%
			9,163		$1,995,805,181	

C.2 Economic Impact Analysis Results

As shown in Table C-3, EPA estimates the welfare impacts are over twice as high as the MACT floor ($1,995.5 million). The market analysis shows that consumers will bear $955.3 million, or 48 percent of the total social cost as a result of higher prices and lower consumption levels. Producer surplus is projected to decrease by $1,040.2 million, or 52 of the total social cost as result of direct control costs, higher energy costs, and reductions in output.

Table C-3. Social Cost Estimates ($1998 10^6)

	Change in Social Welfare, MACT Floor	Change in Social Welfare, Option 1A
Baseline engineering costs	$863.0	$1,995.8
Social costs with market adjustments	$862.9	$1,995.5
Difference between engineering and social costs	$0.1	$0.3

With exception of the natural gas market, energy producers are expected to experience producer surplus losses. Electricity, petroleum, and coal producer surplus is projected to decline by approximately $113 million under Option 1A. In contrast, natural gas producer surplus is projected to increase by $2 million as they benefit from increased demand from industries switching from petroleum and electricity (Table C-4).

The majority welfare impacts fall on the agriculture, manufacturing, and mining industries and EPA estimates losses of $1,444.3 million for these sectors. Manufacturing industries with large number of boilers and process heaters and industries that consume electricity experience the majority these losses (e.g., chemicals and allied products, paper, textile mill products, and food). Consumers in these industries experience losses of $709.9 million and producers bear $734.4 million.

EPA also examined the impact on the commercial, transportation and residential sectors. We project the commercial sector has the highest welfare losses among the three ($302 million) with commercial customers bearing approximately 42 percent of these losses, or $129 million. EPA estimates similar consumer surplus loss ($92 million) for residential

Table C-4. Distribution of Social Costs by Sector/Market: Option 1A ($1998 10^6)

Sectors/Markets			Change in: Producer Surplus	Consumer Surplus	Social Welfare
Energy Markets					
Petroleum			–$27.3		
Natural gas			$2.4		
Electricity			–$79.5		
Coal			–$6.4		
Subtotal			–$110.8		
NAICS Code	**SIC Code**	**Description**			
311	20 (pt)	Food	–$90.0	–$36.0	–$126.0
312	20 (pt); 21	Beverage and Tobacco Products	–$5.4	–$9.3	–$14.7
313	22 (pt)	Textile Mills	–$45.0	–$103.2	–$148.2
314	22 (pt)	Textile Product Mills	–$0.1	–$0.3	–$0.4
315	23	Apparel	–$0.9	–$2.1	–$3.0
316	31	Leather and Allied Products	–$2.7	–$4.3	–$7.1
321	24	Wood Products	–$72.0	–$19.2	–$91.2
322	26	Paper	–$173.1	–$157.2	–$330.3
323	27	Printing and Related Support	–$0.4	–$1.0	–$1.4
325	28	Chemicals	–$102.4	–$204.7	–$307.1
326	30	Plastics and Rubber Products	–$6.1	–$14.6	–$20.7
327	32	Nonmetallic Mineral Products	–$9.1	–$10.9	–$20.0
331	33	Primary Metals	–$59.5	–$13.6	–$73.1
332	34	Fabricated Metal Products	–$18.6	–$5.0	–$23.6
333	35	Machinery	–$17.1	–$11.4	–$28.5
334	36 (pt)	Computer and Electronic Products	–$12.0	–$4.8	–$16.8
335	36 (pt)	Electrical Equipment, Appliances, and Components	–$11.7	–$7.8	–$19.6
336	37	Transportation Equipment	–$47.8	–$63.7	–$111.4
337	25	Furniture and Related Products	–$9.2	–$41.8	–$51.0
339	39	Miscellaneous	–$3.2	–$2.5	–$5.7
11	01-08	Agricultural Sector	–$1.5	–$3.6	–$5.1
23	15-17	Construction Sector	–$3.2	–$4.3	–$7.5
21	10; 14	Other Mining Sector	–$18.9	–$13.1	–$32.0
48	40-47 (pt)	Transportation	–$24.1	–$22.5	–$46.5
42; 44-45; 49; 51-56; 61-62; 71-72; 81	40-48 (pt); 50-99	Commercial	–$129.3	–$172.5	–$301.8
		Residential	NA	–$92.0	–$92.0
Grand Total			–$955.3	–$1,040.2	–$1,995.5

NA = Not applicable.

energy consumers. Finally, the total welfare loss for the transportation sector is estimated to be $46.5 million, with transportation customers bearing slightly more than half of these losses (51 percent). However, all of these losses (consumer or producer) for these sectors represent less than 0.05 percent of baseline value of consumption or shipments.

C.2.1 Market-Level Impacts

Increases in the costs of production in the energy and final product markets due to the regulation are expected to result in changes in prices, production, and consumption from baseline levels. As shown in Table C-5, the electricity market price increases by 0.11 percent, while production/consumption decreases by 0.03 percent as a result of additional control costs. A significant share of electricity is produced in the United States using coal as a primary input. Therefore, projected reductions in electricity production also lead to a decrease in demand for coal. As a result, the price and quantities of coal are projected to fall by 0.02 percent and 0.02 percent, respectively. In the petroleum market, the model projects small price and quantity effects (i.e., less than 0.02 percent). In the natural gas market, the model projects the market price will rise in response to increased demand (0.01 percent). The price increase is the result of additional control costs and increased demand. Production and consumption quantities also slightly increase in this market as a result of increased demand.

Additional control costs and higher energy costs associated with the regulation lead to higher goods and services prices in all markets and a decline in output. However, the changes are generally very small. Under Option 1A, three markets have price increases greater than or equal to 0.05 percent—Wood Products (NAICS 321), Paper (NAICS 322), and Textile Mills (NAICS 313). The producers in these sectors are expected to face higher per-unit control costs relative to other industries. In addition, these industries are also electricity-intensive; therefore, costs of production also increase as a result of higher electricity prices.

C.2.2 Executive Order 13211 (Energy Effects)

EPA has provided additional information on the impacts of the rule on affected energy markets below.[1]

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[1]Conversion factors for heat rates were obtained from AEO 2002, Appendix H. These factors vary by year to year; 2010 values are reported in this appendix.

Table C-5. Market-Level Impacts: Option 1A

Sectors/Markets			Option 1A Percent Change Price	Option 1A Percent Change Quantity
Energy Markets				
Petroleum			0.019%	–0.005%
Natural gas			0.005%	0.001%
Electricity			0.108%	–0.026%
Coal			–0.020%	–0.024%
NAICS Code	**SIC Code**	**Description**		
311	20 (pt)	Food	0.019%	–0.006%
312	20 (pt); 21	Beverage and Tobacco Products	0.007%	–0.009%
313	22 (pt)	Textile Mills	0.050%	–0.043%
314	22 (pt)	Textile Product Mills	0.000%	0.000%
315	23	Apparel	0.001%	–0.001%
316	31	Leather and Allied Products	0.025%	–0.030%
321	24	Wood Products	0.075%	–0.015%
322	26	Paper	0.068%	–0.074%
323	27	Printing and Related Support	0.000%	–0.001%
325	28	Chemicals	0.021%	–0.032%
326	30	Plastics and Rubber Products	0.003%	–0.005%
327	32	Nonmetallic Mineral Products	0.009%	–0.008%
331	33	Primary Metals	0.026%	–0.021%
332	34	Fabricated Metal Products	0.007%	–0.001%
333	35	Machinery	0.005%	–0.002%
334	36 (pt)	Computer and Electronic Products	0.002%	–0.001%
335	36 (pt)	Electrical Equipment, Appliances, and Components	0.009%	–0.004%
336	37	Transportation Equipment	0.007%	–0.007%
337	25	Furniture and Related Products	0.013%	–0.044%
339	39	Miscellaneous	0.003%	–0.002%
11	01-08	Agricultural Sector	0.001%	–0.001%
23	15-17	Construction Sector	0.000%	0.000%
21	10; 14	Other Mining Sector	0.023%	–0.007%
48	40-47 (pt)	Transportation	0.007%	–0.005%
42; 44-45; 49; 51-56; 61-62; 71-72; 81	40-48 (pt); 50-99	Commercial	0.001%	–0.001%

pt = Part.

Energy Price Effects. As described in the market-level results section, electricity prices are projected to increase by less than 1 percent. Petroleum and natural gas prices are all projected to increase by less than 0.1 percent. The price of coal is projected to decrease slightly.

Impacts on Electricity Supply, Distribution, and Use. We project the increased compliance costs for the electricity market will result in an annual production decline of approximately 980 million kWh under Option 1A.

Impacts on Petroleum, Natural Gas, and Coal Supply, Distribution, and Use. The model projects decreases in petroleum production/consumption of approximately 975 barrels per day under Option 1A. In contrast, natural gas production/consumption is projected to increase by 600,000 cubic feet per day under Option 1A. This is the result of fuel switching in response to relative price changes. Finally, the model also projects less than a 1,000 tons per day decrease in coal production/consumption in response to reduced output from the electricity sector (a significant consumer of coal).

C.3 Small Entity Screening

The 3,580 units in the Inventory Database with full information were linked to 1,881 existing facilities. As shown in Table C-6, these are facilities owned by 970 parent companies. The average number of facilities per company is approximately 2.2; however, several large entities in the health services industry and government sectors own many facilities with boilers and process heaters.

Based on SBA guidelines, 369 of the companies were identified as small businesses.[2] The lumber and wood products industry contains the largest number of the small businesses with 134, followed by furniture and fixtures with 55, electric services with 30, and paper and allied products with 30. The remaining small businesses are distributed across 40 different two-digit SIC code groupings (Table C-7).

[2]Small business guidelines typically define small businesses based on employment, and the threshold varies from industry to industry. For example, in the paints and allied products industry, a business with fewer than 500 employees is considered a small business; whereas in the industrial gases industry, a business with fewer than 1,000 employees is considered small. However, for a few industries, usually services, sales are used as the criterion. For example, in the veterinary hospital industry, companies with less than $5 million in annual sales are defined as small businesses.

Table C-6. Facility-Level and Parent-Level Data by Industry

SIC Code	NAICS Code	Description	Number of Units	Number of Facilities	Number of Parent Companies	Avg. Number of Facilities Per Parent Entity
01	111	Agriculture—Crops	6	6	6	1.0
02	112	Agriculture—Livestock	—	—	—	—
07	115	Agricultural Services	—	—	—	—
10	212	Metal Mining	11	5	2	2.5
12	212	Coal Mining	2	1	—	—
13	211	Oil and Gas Extraction	18	4	1	4.0
14	212	Mining/Quarrying—Nonmetallic Minerals	10	5	4	1.3
17	235	Construction—Special Trade	2	1	1	1.0
20	311	Food and Kindred Products	163	72	38	1.9
21	312	Tobacco Products	22	11	6	1.8
22	313	Textile Mill Products	250	134	73	1.8
23	315	Apparel & Other Products from Fabrics	4	4	3	1.3
24	321	Lumber and Wood Products	462	337	175	1.9
25	337	Furniture and Fixtures	310	209	100	2.1
26	322	Paper and Allied Products	503	272	100	2.7
27	511	Printing, Publishing, and Related Industries	8	6	3	2.0
28	325	Chemicals and Allied Products	433	163	91	1.8
29	324	Petroleum Refining and Related Industries	162	50	31	1.6
30	326	Rubber and Misc. Plastics Products	56	37	24	1.5
31	316	Leather and Leather Products	22	12	8	1.5
32	327	Stone, Clay, Glass, and Concrete Products	42	25	15	1.7
33	331	Primary Metal Industries	85	33	22	1.5
34	332	Fabricated Metal Products	44	28	18	1.6
35	333	Industrial Machinery and Computer Equip.	46	25	20	1.3
36	335	Electronic and Electrical Equipment	45	29	19	1.5
37	336	Transportation Equipment	158	61	26	2.3
38	334	Scientific, Optical, and Photographic Equipment	33	16	9	1.8
39	339	Misc. Manufacturing Industries	14	10	9	1.1
40	482	Railroad Transportation	4	1	1	1.0

(continued)

Table C-6. Facility-Level and Parent-Level Data by Industry (continued)

SIC Code	NAICS Code	Description	Number of Units	Number of Facilities	Number of Parent Companies	Avg. Number of Facilities Per Parent Entity
42	484	Motor Freight and Warehousing	7	3	3	1.0
46	486	Pipelines, Except Natural Gas	6	5	1	5.0
49	221	Electric, Gas, and Sanitary Services	372	185	98	1.9
50	421	Wholesale Trade—Durable Goods	3	2	1	2.0
51	422	Wholesale Trade—Nondurable Goods	2	1	1	1.0
55	441	Automotive Dealers and Gasoline Service Stations	1	1	1	1.0
58	722	Eating and Drinking Places	—	—	—	—
59	445–454	Miscellaneous Retail	1	1	1	1.0
60	522	Depository Institutions	—	—	—	—
70	721	Hotels and Other Lodging Places	1	1	1	1.0
72	812	Personal Services	—	—	—	—
76	811	Misc. Repair Services	2	1	—	—
80	621	Health Services	40	19	2	9.5
81	541	Legal Services	—	—	—	—
82	611	Educational Services	114	50	35	1.4
83	624	Social Services	3	2	2	1.0
86	813	Membership Organizations	—	—	—	—
87	541	Engineering, Accounting, Research, Management and Related Services	6	5	2	2.5
89	711/514	Services, N.E.C.	2	1	—	—
91	921	Executive, Legislative, and General Administration	2	2	1	2.0
92	922	Justice, Public Order, and Safety	33	10	—	—
94	923	Administration of Human Resources	1	1	—	—
96	926	Administration of Economic Programs	4	3	1	3.0
97	928	National Security and International Affairs	41	13	2	6.5
NA		SIC Information Not Available	24	18	2	9.0
State		Parent is a state government	—	—	11	—
		Total	3,580	1,881	970	2.2

Source: Industrial Combustion Coordinated Rulemaking (ICCR). 1998. Data/Information Submitted to the Coordinating Committee at the Final Meeting of the Industrial Combustion Coordinated Rulemaking Federal Advisory Committee. EPA Docket Numbers A-94-63, II-K-4b2 through -4b5. Research Triangle Park, North Carolina. September 16-17.

Table C-7. Small Parent Companies by Industry

SIC Code	NAICS Code	Description	Number of Parent Companies	Number of Small Parent Companies
01	111	Agriculture—Crops	6	1
02	112	Agriculture—Livestock	—	—
07	115	Agricultural Services	—	—
10	212	Metal Mining	2	2
12	212	Coal Mining	—	—
13	211	Oil and Gas Extraction	1	1
14	212	Mining/Quarrying—Nonmetallic Minerals	4	—
17	235	Construction—Special Trade Contractors	1	1
20	311	Food and Kindred Products	38	15
21	312	Tobacco Products	6	—
22	313	Textile Mill Products	73	27
23	315	Apparel and Other Products from Fabrics	3	2
24	321	Lumber and Wood Products	175	134
25	337	Furniture and Fixtures	100	55
26	322	Paper and Allied Products	100	30
27	511	Printing, Publishing, and Related Industries	3	2
28	325	Chemicals and Allied Products	91	19
29	324	Petroleum Refining and Related Industries	31	9
30	326	Rubber and Misc. Plastics Products	24	4
31	316	Leather and Leather Products	8	4
32	327	Stone, Clay, Glass, and Concrete Products	15	3
33	331	Primary Metal Industries	22	3
34	332	Fabricated Metal Products	18	5
35	333	Industrial Machinery and Computer Equip.	20	5
36	335	Electronic and Electrical Equipment	19	—
37	336	Transportation Equipment	26	5
38	334	Scientific, Optical, and Photographic Equip.	9	1
39	339	Miscellaneous Manufacturing Industries	9	1
40	482	Railroad Transportation	1	—
42	484	Motor Freight and Warehousing	3	1
46	486	Pipelines, Except Natural Gas	1	—
49	221	Electric, Gas, and Sanitary Services	98	30

(continued)

Table C-7. Small Parent Companies by Industry (continued)

SIC Code	NAICS Code	Description	Number of Parent Companies	Number of Small Parent Companies
50	421	Wholesale Trade—Durable Goods	1	—
51	422	Wholesale Trade—Nondurable Goods	1	—
55	441	Automotive Dealers and Gasoline Service Stations	1	1
58	722	Eating and Drinking Places	—	—
59	445–454	Miscellaneous Retail	1	1
60	522	Depository Institutions	—	—
70	721	Hotels and Other Lodging Places	1	—
72	812	Personal Services	—	—
76	811	Misc. Repair Services	—	—
80	621	Health Services	2	1
81	541	Legal Services	—	—
82	611	Educational Services	35	3
83	624	Social Services	2	1
86	813	Membership Organizations	—	—
87	541	Engineering, Accounting, Research, Management and Related Services	2	—
89	711/514	Services, N.E.C.	—	—
91	921	Executive, Legislative, and General Administration	1	—
92	922	Justice, Public Order, and Safety	—	—
94	923	Administration of Human Resources	—	—
96	926	Administration of Economic Programs	1	—
97	928	National Security and International Affairs	2	—
NA		SIC Information Not Available	2	2
State		Parent is a State Government	11	—
		Total	970	369

Source: Industrial Combustion Coordinated Rulemaking (ICCR). 1998. Data/Information Submitted to the Coordinating Committee at the Final Meeting of the Industrial Combustion Coordinated Rulemaking Federal Advisory Committee. EPA Docket Numbers A-94-63, II-K-4b2 through -4b5. Research Triangle Park, North Carolina. September 16-17.

C.3.1 Small Entity Screening Results

As shown in Table C-8, the average cost per entity is $270,000. The median cost-to-sales ratio is 0.8 percent, and ratios range from 0.01 to 39 percent. Forty-five of the 369 affected small businesses have CSRs at or above 3 percent.

Table C-8. Summary Statistics for SBREFA Screening Analysis

	Option 1A
Total Number of Small Entities	369
Average Annual Compliance Cost per Small Entity ($$10^3$)	$270
Entities with Sales/Revenue Data	
Compliance costs are <1% of sales	176
Compliance costs are ≥1 to 3% of sales	148
Compliance costs are ≥3% of sales	45
Compliance Cost-to-Sales/Revenue Ratios	
Average	1.65
Median	0.77
Maximum	38.83
Minimum	0.009

C.3.2 Affected Government Entities: Supplemental Analysis

As shown in Table C-9, the average total annual compliance costs per entity are $548,000 for Option 1A. The median cost-to-revenue ratio is 2.2 percent, and ratios range from less than 0.5 percent to 16 percent. Five of the 13 affected small governments have cost-to-revenue ratios at or above 3 percent.

Table C-9. Supplemental Screening Analysis for Small Governmental Jurisdictions

	Option 1A
Total Number of Small Entities	13
Average Total Annual Compliance Cost (TACC) per Small Entity ($)	$548
Entities with Sales/Revenue Data	
Compliance costs are <1% of revenue	2
Compliance costs are ≥1 to 3% of revenue	6
Compliance costs are ≥3% of revenue	5
Compliance Cost-to-Sales/Revenue Ratios	
Average	4.18
Median	2.21
Maximum	16.30
Minimum	0.02

Source: American Public Power Association (APPA). 2002. *Straight Answers to False Charges about Public Power*. Washington, DC: APPA. <http://www.appanet.org/about/publicpower/index.cfm>. As obtained on November 13, 2003.

APPENDIX D:

IMPACTS FROM APPLICATION OF RISK-BASED ALTERNATIVES

As an alternative to the requirement for each large solid fuel-fired boiler to demonstrate compliance with the HC1 emission limit in the final rule, the source may demonstrate compliance with a health-based facility-wide HC1 equivalent allowable emission limit. The procedures for complying with this compliance alternative are in Appendix A of the final rule. Also, in lieu of complying with the emission standard for what are called total selected metals (TSM) in subpart DDDDD of part 63 based on the sum of emissions for metals (such as arsenic, cadmium, chromium, mercury, manganese, nickel, and lead facilities may demonstrate eligibility for complying with the TSM standard based on excluding manganese emissions from the summation of TSM emissions for the affected source unit.

The impacts discussed below reflect the effects of compliance with both risk-based alternatives to the final rule.

Per technical direction received February 5, 2004, RTI performed an economic and small entity analysis of a modified emission control scenario under the Industrial Boilers and Process Heaters MACT. The key elements of the sensitivity scenario are as follows:

- Exempt controls for HCL emissions for coal-fired units—(model plants 2d, 3e, 6d, and 7e).
- Exempt controls for manganese emissions for wood-fired units (model plants 30a, 30b, 34a, 34b, and 34d).
- Monitoring, record-keeping, and reporting costs for units linked to these model plants remain unchanged.

This appendix highlights the key results of these analyses.

- *Social Cost Estimates*—The social cost estimates fall from $863 billion to $746 billion, or approximately 14 percent (see Table D-1). The sensitivity analysis does not show significant changes in the distribution of these costs across sectors and stakeholders (see Table D-2).

Table D-1. Social Cost Estimates ($1998 10^6)

	Change in Social Welfare
Baseline engineering costs	$746.49
Social costs with market adjustments	$746.44
Difference between engineering and social cost estimates	$.04

- *Market-Level Impacts*—A comparison of the relative price and quantity changes shows the sensitivity scenario moderates price and quantity effects, but the differences are very small (see Table D-3).
- *Energy Effects*—Energy impacts are small in both analyses. However, electricity and natural gas production/consumption impacts in the sensitivity scenario are approximately half the values projected under the MACT floor. Annual electricity production declines by 246 million kWh compared to 415 kWh. Natural gas production/consumption declines by 230,000 cubic feet per day compared to 1.1 million cubic feet per day. Petroleum and coal sector effects do not significantly change.
- *Small Entity Impacts*—The average annual control costs fall from $199K to $142K under the sensitivity scenario (see Table D-4). Similarly, the average (median) cost-to-sales ratio (CSR) falls from 0.78 percent (0.50 percent) to 0.52 percent (0.16 percent) (see Table D-5). Twenty-two entities have CSRs greater than 1 percent under the sensitivity scenario compared with 34 entities under the MACT floor. Eight entities have CSRs that are 3 percent or higher compared to 10 entities under the MACT floor.
- *Affected Government Entities: Supplemental Analysis*—The average annual control costs fall from $223K to $217K under the sensitivity scenario(see Table D-6). CSRs remain essentially unchanged (e.g., the average [median] CSR falls from 1.67 percent [0.94 percent] to 1.66 percent [0.94 percent]). As a result, there is no change in projections of the number of government entities affected at the 1 or 3 percent level.

Table D-2. Distribution of Social Costs by Sector/Market: ($1998 10^6)

Sectors/Markets			Change in: Producer Surplus	Change in: Consumer Surplus	Change in: Social Welfare
Energy Markets					
Petroleum			–$2.4		
Natural gas			$0.9		
Electricity			–$32.3		
Coal			–$2.6		
Subtotal			–$36.3		
NAICS Code	**SIC Code**	**Description**			
311	20 (pt)	Food	–$21.4	–$8.6	–$30.0
312	20 (pt); 21	Beverage and Tobacco Products	–$2.1	–$3.7	–$5.8
313	22 (pt)	Textile Mills	–$20.8	–$47.6	–$68.4
314	22 (pt)	Textile Product Mills	–$0.1	–$0.1	–$0.2
315	23	Apparel	–$0.3	–$0.8	–$1.2
316	31	Leather and Allied Products	–$0.3	–$0.4	–$0.7
321	24	Wood Products	–$25.2	–$6.7	–$31.9
322	26	Paper	–$63.3	–$57.5	–$120.8
323	27	Printing and Related Support	–$0.2	–$0.4	–$0.5
325	28	Chemicals	–$35.5	–$71.0	–$106.5
326	30	Plastics and Rubber Products	–$2.1	–$5.0	–$7.0
327	32	Nonmetallic Mineral Products	–$2.6	–$3.1	–$5.7
331	33	Primary Metals	–$21.6	–$4.9	–$26.6
332	34	Fabricated Metal Products	–$6.3	–$1.7	–$8.0
333	35	Machinery	–$6.3	–$4.2	–$10.5
334	36 (pt)	Computer and Electronic Products	–$3.2	–$1.3	–$4.5
335	36 (pt)	Electrical Equipment, Appliances, and Components	–$2.4	–$1.6	–$4.1
336	37	Transportation Equipment	–$19.9	–$26.6	–$46.5
337	25	Furniture and Related Products	–$3.3	–$14.8	–$18.1
339	39	Miscellaneous	–$0.8	–$0.6	–$1.4
11	01-08	Agricultural Sector	–$0.5	–$1.2	–$1.7
23	15-17	Construction Sector	–$0.7	–$0.9	–$1.6
21	10; 14	Other Mining Sector	–$9.9	–$6.9	–$16.8
48	40-47 (pt)	Transportation	–$3.5	–$3.2	–$6.7
42; 44-45; 49; 51-56; 61-62; 71-72; 81	40-48 (pt); 50-99	Commercial	–$63.7	–$84.9	–$148.6
		Residential	NA	–$36.3	–$36.3
Grand Total			–$352.3	–$394.2	–$746.4

NA = Not applicable.
pt = Part.

Table D-3. Market-Level Impacts: Final Rule

Sectors/Markets			Percent Change Price	Percent Change Quantity
Energy Markets				
Petroleum			0.001%	0.000%
Natural gas			0.002%	0.000%
Electricity			0.044%	–0.010%
Coal			–0.008%	–0.010%
NAICS Code	**SIC Code**	**Description**		
311	20 (pt)	Food	0.004%	–0.001%
312	20 (pt); 21	Beverage and Tobacco Products	0.003%	–0.004%
313	22 (pt)	Textile Mills	0.023%	–0.020%
314	22 (pt)	Textile Product Mills	0.000%	0.000%
315	23	Apparel	0.000%	–0.001%
316	31	Leather and Allied Products	0.002%	–0.003%
321	24	Wood Products	0.026%	–0.005%
322	26	Paper	0.025%	–0.027%
323	27	Printing and Related Support	0.000%	0.000%
325	28	Chemicals	0.007%	–0.011%
326	30	Plastics and Rubber Products	0.001%	–0.002%
327	32	Nonmetallic Mineral Products	0.003%	–0.002%
331	33	Primary Metals	0.009%	–0.007%
332	34	Fabricated Metal Products	0.002%	–0.000%
333	35	Machinery	0.002%	–0.001%
334	36 (pt)	Computer and Electronic Products	0.001%	0.000%
335	36 (pt)	Electrical Equipment, Appliances, and Components	0.002%	–0.001%
336	37	Transportation Equipment	0.003%	–0.003%
337	25	Furniture and Related Products	0.005%	–0.015%
339	39	Miscellaneous	0.001%	0.000%
11	01-08	Agricultural Sector	0.000%	0.000%
23	15-17	Construction Sector	0.000%	0.000%
21	10; 14	Other Mining Sector	0.012%	–0.004%
48	40-47 (pt)	Transportation	0.001%	–0.001%
42; 44-45; 49; 51-56; 61-62; 71-72; 81	40-48 (pt); 50-99	Commercial	0.000%	0.000%

pt = Part.

Table D-4. Summary of Small Entity Impacts

	Final Rule
Number of small entities	185
Total number of entities	576
Average annual control cost per small entity (10^3)	$142
Average control cost/sales ratio	0.52%
Number of small entities with cost-to-sales ratios ≥1 percent	22
Number of small entities with cost-to-sales ratios ≥3 percent	8

Table D-5. Summary Statistics for SBREFA Screening Analysis

	Value
Total Number of Small Entities	185
Average Annual Compliance Cost per Small Entity ($\$10^3$)	$142
Entities with Sales/Revenue Data	
Compliance costs are <1% of sales	155
Compliance costs are ≥1 to 3% of sales	22
Compliance costs are ≥3% of sales	8
Compliance Cost-to-Sales/Revenue Ratios	
Average	0.52
Median	0.16
Maximum	7.83
Minimum	0.01

Table D-6. Supplemental Screening Analysis for Small Governmental Jurisdictions

	Value
Total Number of Small Entities	13
Average Total Annual Compliance Cost (TACC) per Small Entity ($\$10^3$)	$217
Entities with Sales/Revenue Data	
Compliance costs are <1% of revenue	7
Compliance costs are ≥1 to 3% of revenue	3
Compliance costs are ≥3% of revenue	3
Compliance Cost-to-Sales/Revenue Ratios	
Average	1.66
Median	0.94
Maximum	7.83
Minimum	0.01

Source: American Public Power Association (APPA). 2002. *Straight Answers to False Charges about Public Power*. Washington, DC: APPA. <http://www.appanet.org/about/publicpower/index.cfm>. As obtained on November 13, 2003.

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16. ABSTRACT

This report evaluates the economic impacts of the Industrial Boilers and Process Heaters NESHAP. The social costs of the rule are estimated by incorporating the expected costs of compliance in a partial equilibrium model and projecting the market impacts. The report also provides the screening analysis for small business impacts.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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