United States
Environmental Protection
Agency

Office Of Air Quality
Planning And Standards
Research Triangle Park, NC 27711

EPA-452/R-01-009
August 2001

Air

Economic Impact Analysis for the Final Primary Copper Smelting NESHAP

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Acronyms

CAA	Clean Air Act
EIA	Economic Impact Analysis
EPA	United States Environmental Protection Agency
HAPs	Hazardous Air Pollutants
ISEG	Innovative Strategies and Economics Group
MACT	Maximum Achievable Control Technology
MRR	Monitoring, Recordkeeping, and Recording
NAICS	North American Industry Classification System
NESHAP	National Emission Standards for Hazardous Air Pollutants
OAQPS	Office of Air Quality Planning and Standards
O&M	Operating and Maintenance
RFA	Regulatory Flexibility Act
SBREFA	Small Business Regulatory Enforcement Fairness Act
SIC	Standard Industrial Classification
SX-EW	Solvent Extraction Electrowinning
TAC	Total Annual Costs

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EXECUTIVE SUMMARY

Pursuant to Section 112 of the Clean Air Act, the U.S. Environmental Protection Agency (EPA) is developing National Emissions Standards for Hazardous Air Pollutants (NESHAP) to control emissions released from the primary copper smelting operations. The Innovative Strategies and Economics Group (ISEG) of the Office of Air Quality Planning and Standards (OAQPS) has developed this economic impact analysis (EIA) to support the evaluation of impacts associated with the regulatory options considered for this NESHAP. By controlling emissions of HAPs from primary copper smelting, EPA is protecting and enhancing the quality of the nation's air resources, as stated in Section 101(b) of the Clean Air Act.

The general purpose of this rule is to reduce the flow of the HAPs from potential emission points within primary copper smelting facilities. Eighty percent of the HAPs released are lead and arsenic. The other HAPs include cadmium, cobalt, manganese, nickel selenium, antimony, beryllium, and mercury. The potential production stages during which emissions are released include the concentrating, smelting, and drying stages. The facilities in the primary copper smelting source category are controlling HAP emissions from their smelting operations, as required, to meet maximum achievable control technology (MACT) standards.

There are seven facilities in the primary copper manufacturing source category, six of which are major sources. Since the proposal of this NESHAP, three of the six facilities have shut down and have not resumed operation. Reasons cited for the facility shutdowns include buildups of inventories in 1999 and a shortage of copper concentrates used in primary copper production. The seven facilities included in this source category were owned by five companies when this NESHAP was originally proposed. Since then, the industry has consolidated so that only four companies own the seven facilities that produce primary copper. According to the Small Business Administration size standards, none of these companies are considered small businesses. This rule is therefore not expected to have any significant impacts on small businesses. The total annualized cost of meeting the MACT standards for these facilities is approximately $1.7 million. The impacts of this NESHAP are determined by comparing the annualized costs faced by each facility to their estimated annual copper production revenues. The share of costs to estimated revenues for the affected facilities range from a low of less than 0.01 percent to a high of about 0.2 percent. Thus, compared to the estimated production revenues for each affected facility, the total annualized costs are minimal. Based on the facility-level TAC/sales ratios, impacts of the NESHAP on the companies owning smelting facilities are anticipated to be negligible.

ECONOMIC IMPACT ANALYSIS: PRIMARY COPPER SMELTING

1 INTRODUCTION

Pursuant to Section 112 of the Clean Air Act, the U.S. Environmental Protection Agency (EPA or the Agency) is developing a national emissions standard to control emissions of hazardous air pollutants (HAPs) released from domestic primary copper smelting operations. Production of commercial grade copper entails smelting, a process that results in emissions of several HAPs. Primary copper is produced using mined ore material. The National Emissions Standard for Hazardous Air Pollutants (NESHAP) which this economic impact analysis (EIA) supports was proposed in April of 1998 and is scheduled to be promulgated in late 2001. The Innovative Strategies and Economics Group (ISEG) of the Office of Air Quality Planning and Standards (OAQPS) has developed this analysis to assist in the evaluation of impacts associated with the regulatory options considered for this NESHAP.

1.1 Scope and Purpose

The purpose of this report is to evaluate the economic impacts of pollution control requirements on primary copper smelting operations. The Clean Air Act (CAA) was designed to protect and enhance the quality of the nations's air resources and Section 112 of the Act establishes the authority to control HAP emissions. Eighty percent of the HAP compounds released from primary copper smelters consists primarily of lead and arsenic. Other HAPs released include lead, cadmium, cobalt, manganese, nickel, selenium, antimony, beryllium, and mercury.

To reduce HAP emissions, 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. Normally, the MACT floor is set by the average emissions limitation achieved by the best performing 12 percent of existing sources in a category when the category contains at least 30 sources. When fewer than 30 sources exist in the source category being regulated, the floor is based on the emission limitations achieved by the best performing 5 sources. The primary copper smelting source category contains only six affected facilities at the time of proposal, therefore the MACT floor was based on the limitations achieved by the top 5 sources in the source category. The estimated costs for individual primary copper smelters to comply with these standards are inputs to the economic impact analysis presented in this report. Though this industry currently does not exhibit signs of future growth, a new source MACT is also being established in case new facilities are built. Any new source is expected to have a vastly different production technology than the existing sources. For this reason, the MACT standard for existing sources would not be applicable to new sources.

1.2 Organization of the Report

This report is organized as follows. Section 2 describes primary copper, how it is produced, and how much is produced domestically, while Section 3 describes the characteristics, uses, and consumers of copper. This section also provides data on the price of copper as well. Copper is initially sold to intermediate consumers who then use it to manufacture copper products. These copper products are used as inputs to the production of final goods that then are consumed by final purchasers. Section 4 provides a summary profile of the copper smelting industry. Since the proposal of this rule, there has been a reorganization and consolidation of the industry. This section provides facility-level data on the quantities produced at each smelter, sales and employment data of the owning entities of the facilities, and international trade data. Small business considerations are also made in this section as required by the Regulatory Flexibility Act (RFA) as modified by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA). Section 5 describes the facility-level costs of complying with this NESHAP, and Section 6 provides facility- level impacts of compliance with this rule.

2 PRODUCTION OVERVIEW

Primary copper production begins with the mining of copper ore that only has a copper content of 1 percent and ends with commercial grade copper that is 99.99 percent pure. There are several stages involved in the production of commercial grade copper, but only the smelting stage is covered by this NESHAP since this is the stage in which the most HAPs are released. A description of copper and its production are provided in this section of the report. Section 2.1 explains what copper is and Section 2.2 provides an overview of how it is produced. Emphasis is placed on the smelting stage of production. The major by-products, co-products, and substitution possibilities in the production process are provided in Section 2.3, and Section 2.4 describes the costs of production. Last, Section 2.5 presents the quantity of primary copper produced in the U.S. during the 1990s.

2.1 Product Description

Copper is a metallic element first used over 10,000 years ago. It was the only metal available for close to five millennia, therefore it was used in all metal applications until gold, silver, and iron were discovered (Copper Development Association[2], 1997). Due to its low chemical reactivity, copper is corrosion-resistant. It is an excellent conductor of heat and electricity and is also known for its combination of strength and flexibility. All of these characteristics make copper, and its principle alloys, brass and bronze, useful for several applications such as electrical wiring, plumbing, cookware, metalwork, and refrigerator and air conditioning coils. In addition, copper compounds are found in fertilizers, insecticides, fungicides, and as pigments in chemical and manufacturing industries. Copper is found in mines in the form of copper ore, a relatively impure product. The ore is purified through a process which involves smelting and refining. Smelting of primary copper falls under the Standard Industrial Classification (SIC) code 3331, Primary Copper Smelting and Refining and under the North American Industry Classification System (NAICS) code 331411, Primary Smelting and Refining of Copper (U.S. Department of Commerce, 2000).

2.2 Stages of Production

The following discussion of the production processes for primary copper is derived from EPA's Sector Notebook on Nonferrous Metals (1995). Primary copper production starts with the mining of copper ore which has a copper content of only 1 percent and ends with commercial grade copper that is 99.99 percent pure. The production process involves a number of steps to remove virtually all impurities present. Once the ore is mined, it is concentrated, smelted into matte copper, converted into blister copper, and then further refined into commercial grade copper. As shown in Figure 2-1, each successive stage in the production process results in a purer form of copper.

All copper is produced from mined copper ore. This ore, containing approximately 1 percent copper, is crushed and ground into a powder. The ore proceeds to the concentrating stage, where it is slurried in floatation cells by adding water and chemical reagents. Air is blown through the slurry to form bubbles that attach to the copper minerals. As the air bubbles float up, they create a froth that contains copper on top of the floatation cells. This froth, or concentrate, is skimmed off of the top of the cells. The concentrate is 20 to 30 percent copper, while the remaining 70 to 80 percent is made up of a number of impurities such as sulfur, iron, and several metal HAPs. The copper concentrate then proceeds to the smelting stage of production.

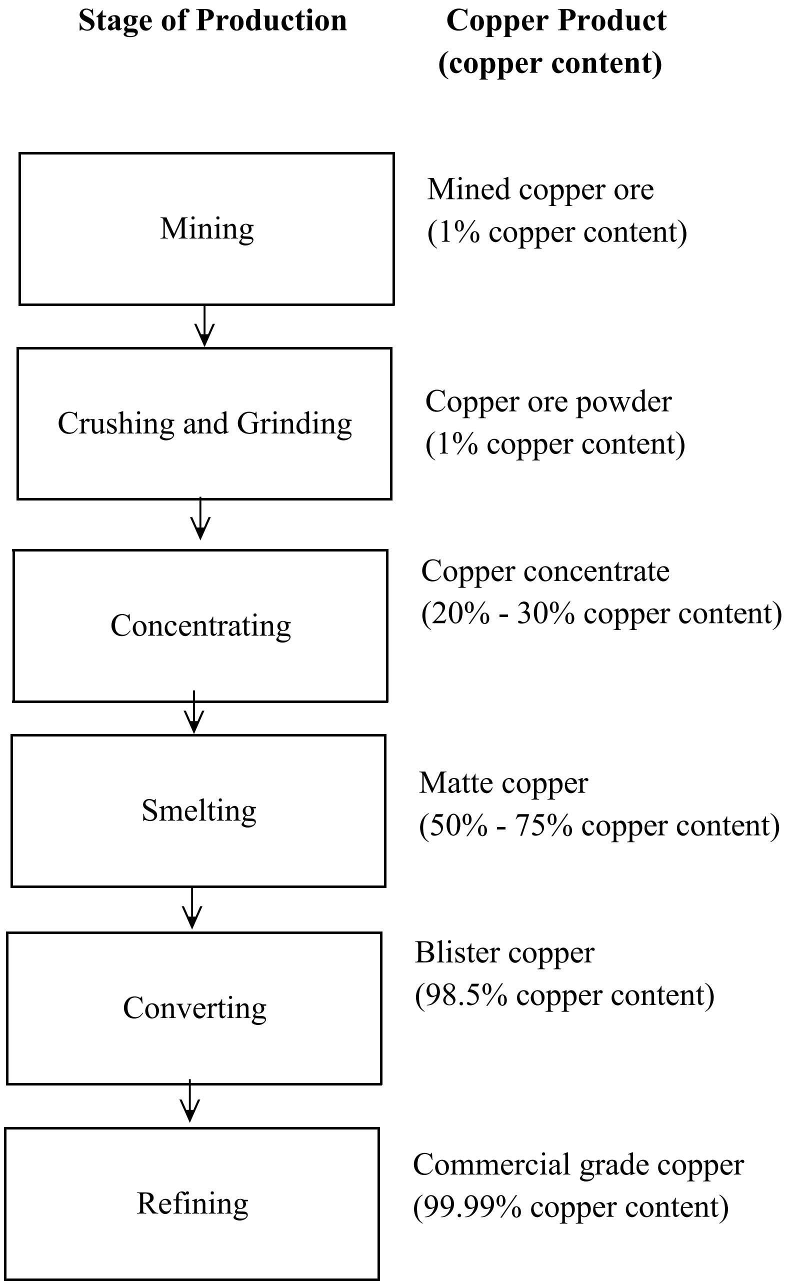

Figure 2-1. Flow Diagram of Primary Copper Production

The traditional smelting process is shown in Figure 2-2. Its purpose is to further eliminate impurities present in the copper concentrate. Before the concentrate can be fed into the smelting furnace, it must be processed further. The concentrate is crushed and milled to obtain the proper sized material to smelt and fluxes are added to facilitate the smelting process. This material is then dried to reduce its moisture content and fed into the smelter furnace. As the material is heated, it becomes molten and collects in a bath at the bottom of the furnace. This molten material separates into lighter density slag, which contains impurities such as iron silicates, and heavier density matte copper, which has a copper content of approximately 50 to 75 percent. Both the slag and matte copper are tapped from the bottom of the furnace every few hours. The slag is disposed of and the matte copper is charged to the converters. The converting operations further removes sulfur, iron, and other impurities in the form of slag. It is an oxidation process in which matte copper is poured into large cylindrical steel vessels that are fitted with a row of pipes. The pipes are used to inject air into the converters. As air is blown in to the molten matte copper, the furnace is rotated so that any remaining iron sulfide can react with oxygen to form iron oxide and sulfur dioxide. Lime and silica are added to react with the iron oxide that formed. The result is a slag that is removed. This process is repeated until all of the iron is eliminated and a relatively pure product of copper sulfide remains. A final blow of air oxidizes the remaining sulfur to form blister copper. This product has a copper content of at least 98.5 percent.

The blister copper is further refined into commercial grade copper in two steps. First, the blister copper is fire refined. This requires pouring the blister copper into a furnace in which air and natural gas are blown through to eliminate any remaining sulfur and oxygen. The resulting molten copper is cast into anodes for electrolytic refining. Electrolytic refining separates out any remaining impurities from copper through electrolysis in a solution that contains copper sulfate. Copper anodes are loaded into electrolytic cells that contain cathodes. A DC current is passed through the cells causing the copper to dissolve from the anodes, transport through the solution, and re-deposit on the cathodes. Any impurities contained in the anodes fall to the bottom of the cell in the form of sludge. These cathodes are the product and they contain 99.99 percent copper. This copper can then be refined and used as an input to produce final products. The primary copper smelting NESHAP only affects smelting operations and is not applicable to the mining, concentrating, or electrolytic refining of copper (EPA, June 1997).

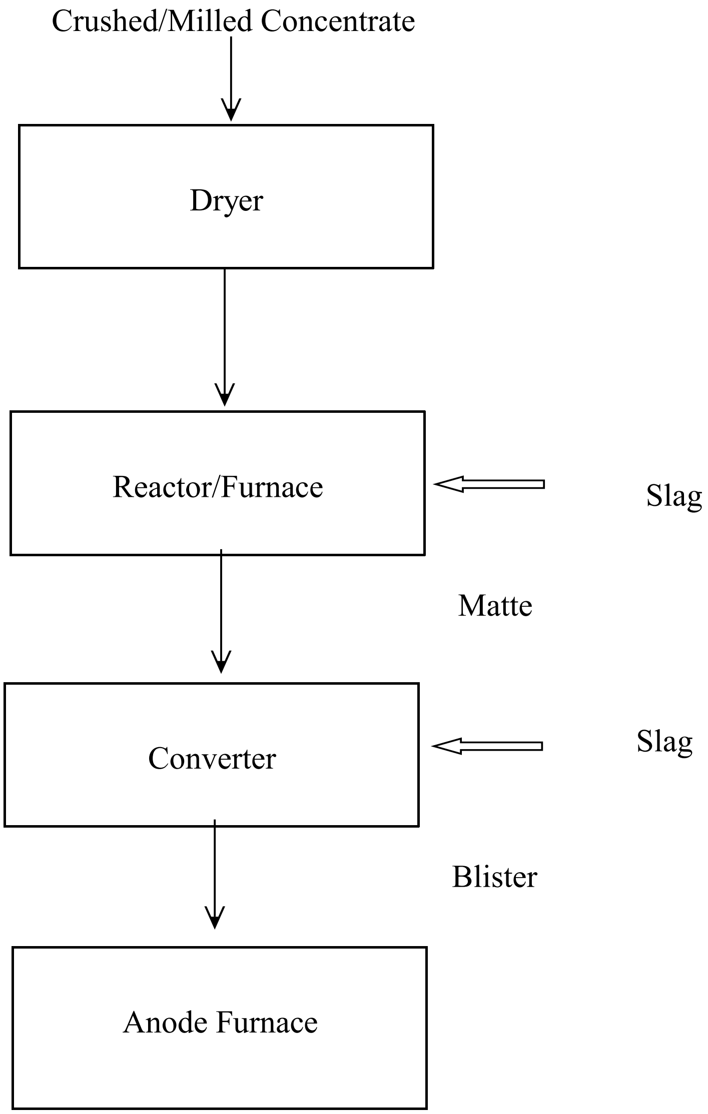

Figure 2-2. Flow Diagram of Primary Copper Smelting

SX-EW is an alternative method of producing purified copper from oxidized ores. In this process, a solution of sulfuric acid is poured over the copper concentrate, leaching the copper out in the form of a solution. This copper-rich solution is then passed into an electrowinning cell. An electrowinning cell differs from an electrorefining cell because it uses a permanent insoluable anode. In the cell, the copper is attracted out of the solution to a charged cathode. The cathodes produced using the SX-EW method are as pure as those produced using the smelting method discussed above. Approximately 30 percent of copper is produced using SX-EW, while the rest is produced using the traditional smelting process.

2.3 By-Products, Co-Products, and Substitution Possibilities

The copper smelting and converting processes generate slag, which is waste material that remains after the copper is concentrated and converted. Most of the slag is stored or discarded on site, but a small amount is sold for use as sand blasting grit and for railroad ballast. Smelters also generate air emissions, a large amount of which are HAPs. The HAPs emitted from primary copper smelters consist of close to 80 percent lead and arsenic compounds. The other 20 percent of HAP emissions are antimony, beryllium, cadmium, chromium, cobalt, manganese, mercury, nickel, and selenium. Sulfur dioxide is another by-product of the production process. The sulfur dioxide is captured and converted to sulfuric acid at all the smelters in co-located acid plants.

Input substitution possibilities are limited. Scrap copper can be substituted for the matte copper in charging the converter, however the final copper product is no longer primary copper, but rather secondary copper. In addition, the SX-EW process can be substituted for the traditional smelting process for oxide ores and secondary sulfide ores. It is not suitable for primary sulfide ores however, which predominate in many U.S. mines (Hillstrom, 1994).

2.4 Costs of Production

This section discusses the costs of primary copper production, which include labor costs, cost of materials, and capital expenditures. Labor costs are those associated with workers involved in primary copper production. Cost of materials includes the cost of parts, containers, fuels, electricity, and contracted work used in the smelting and refining of primary copper. Capital expenditures refer to the costs of equipment and its installation. The production costs incurred by the Primary Copper Smelting and Refining industry (SIC 3331) are available from the U.S. Census Bureau and are categorized in Table 2-1 for the years 1990 through 1997. It is evident from this table that material costs account for the largest share of the value of shipments over this time period, followed far behind by both capital expenditures and labor costs. On average, material costs represent 80 percent of the value of shipments while capital expenditures and labor costs are both approximately 4 percent of value of shipments.

Upon further examination of the production cost data for primary copper production, there is evidence of an increase in costs through the early 1990s. Capital expenditures and cost of materials reached their peaks in the years 1994 and 1995, respectively. Both categories of costs started to fluctuate after 1995 through 1997. Labor costs have increased over the 1990s and continued to do so up through 1997.

Table 2-1. Production Costs for the Primary Copper Smelting and Refining Industry ($\$10^6$)

Year	Labor Costs	Material Costs	Capital Expenditures	Value of Shipments
1990	$145.5	$3,216.2	$95.5	$4,201.2
1991	$152.5	$2,987.0	$110.3	$3,898.1
1992	$188.6	$4,598.7	$195.5	$5,578.2
1993	$199.6	$4,527.3	$312.8	$5,596.0
1994	$238.9	$4,719.4	$702.7	$6,185.1
1995	$254.1	$6,858.4	$179.7	$8,660.9
1996	$268.0	$4,964.7	$235.9	$6,089.6
1997	$287.4	$5,459.3	$184.6	$6,540.4
Average	$216.8	$4,666.4	$252.1	$5,843.7

Source: U.S. Department of Commerce, Bureau of the Census. 1992 *Census of Manufactures: Industry Series, Smelting and Refining of Nonferrous Metals and Alloys, Industries 3331, 3334, 3339, and 3341*. 1995.
U.S. Department of Commerce, Bureau of the Census. 1997 *Economic Census: Primary Smelting and Refining of Copper*. 2000.

2.5 Production of Primary Copper

Table 2-2 shows that the quantity of domestic primary copper produced using smelters steadily increased over the 1990s but fell to its lowest level in 1999. In 1991, 1.12 billion metric tons of primary copper were produced through smelting and by 1998, total production increased by 37 million metric tons to 1.49 billion. The average annual growth rate from 1991 to 1998 is approximately 4.3 percent. Following 1998, the year in which the largest quantity of copper was produced, production fell to its lowest level in the 1990s. In 1999, only 1.08 billion metric tons of primary copper were produced through smelting operations. This represents a 27.5 percent decrease from the quantity produced in 1998.

Growth in smelted primary copper production over most of the 1990s can be attributed to a number of factors including the increased use of copper in the building construction and automotive industries. Both homes and automobiles have grown in size, therefore the amount of copper used in these products has increased. While demand for copper has remained strong over the 1990s, a dramatic reduction in the quantity produced did occur in 1999. This was partially due to the shut down of three copper smelters that took place in 1998 and 1999, which is further discussed in Section 4 of this report.

Table 2-2. Domestic Production of Primary Copper Using Smelters: 1991 - 1998

Year	Quantity (10^3 metric tons)
1991	1,120
1992	1,180
1993	1,270
1994	1,310
1995	1,240
1996	1,300
1997	1,440
1998	1,490
1999	1,080

Note: Production data rounded to three significant digits.

Source: Edelstein, Daniel. “ Copper,” *Minerals Yearbook 1998*. U.S. Geological Survey.
Edelstein, Daniel. “Copper,” *Minerals Yearbook 1995*. U.S. Geological Survey.
Edelstein, Daniel. “Copper in December 1999,” *Mineral Industry Surveys, 2000.* U. S. Geological Survey.

3 USES, CONSUMPTION, AND DEMAND

Copper is widely used in industrial and consumer applications. Initially, copper products are used by manufacturing industries to produce final goods. These final products are then sold to consumers. For example, copper plumbing pipes and electrical wiring are used by the building construction industry. Construction companies use copper pipes and electrical wiring to build homes that are then sold to consumers. This section further elaborates on the uses and consumers of copper, as well as the demand for copper. Section 3.1 begins with a description of the various uses of copper. In Section 3.2, the domestic consumption of copper is discussed and the immediate and final consumers of copper are identified. Also provided in this section is a description of the available substitutes for copper. Section 3.3 provides the trends in copper consumption by the various end markets and last, market price data for copper are presented in Section 3.4.

3.1 Uses of Copper

Copper products are generally used as inputs to produce several types of end products for the building construction market, the automotive market, the transportation products market, the electrical and electronic products market, the general consumer products market, and the major appliances market. A sample of these markets are described here.

In 1997, approximately 8.5 billion pounds of copper products were consumed in the U.S. During this year, the largest share of copper products was consumed by building construction market, as shown in Figure 3-1 (Copper Development Association[4], 2000). The construction market consumed 3.5 billion pounds of copper products, which represents 42 percent of all copper products consumed in 1997. Following the construction market, the electrical and electronic products market consumed about 2.1 billion pounds, or 25 percent, of all copper products consumed in 1997. The transportation products market consumed 1 billion pounds and the consumer and general products market consumed almost 800 million pounds. The transportation market did not consume the largest share of copper, but it is the fastest growing market of those using copper products as inputs. Growth of any of these markets positively impacts demand for copper products as inputs to production.

The largest market for copper is the residential and non-residential construction market. Home construction involves the use of electrical wiring, plumbing, architectural detailing, heating units, and cooling units, all of which rely on copper as an input. Construction companies and contractors purchase these copper-containing products to use in the building of homes, structures, and buildings. The amount of copper used in construction has increased since 1970 because the size of the average home has grown. Larger buildings and homes require more wiring, plumbing, and larger air conditioning units, therefore the amount of copper found in the average house increased from approximately 280 pounds in the 1970s to approximately 450 pounds in the 1990s (Copper Development Association[4], 2000).

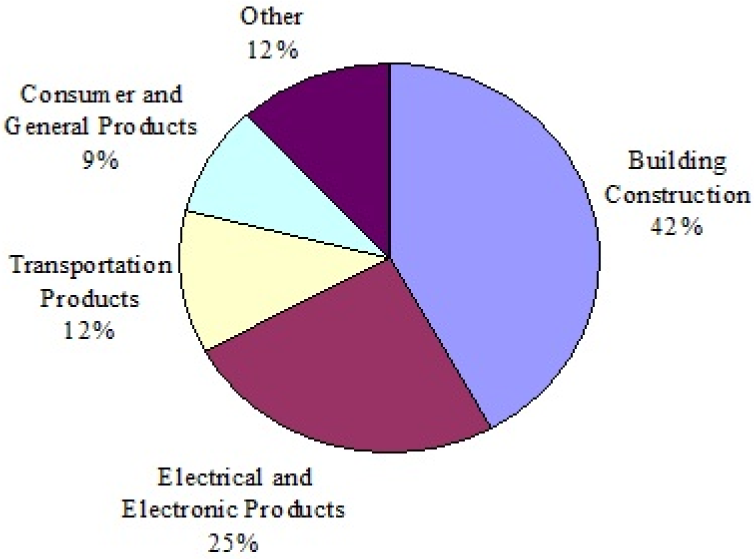

Figure 3-1. Consumption of Copper Products by Major Market: 1997
8.5 billion pounds

The electrical and electronic products market is made up of four market segments, which include power utilities, telecommunications, business electronics, and lighting and wiring devices. Two key segments that drive the consumption of copper for this market are electrical distribution and telecommunications. Electrical distribution and control products include switchgear and industrial circuit breakers, fuse equipment, and transformers. Building codes have become more rigorous over time by requiring residences to include more circuits. This increases the demand for electrical distribution products, most of which contain copper. The telecommunications market segment relies on copper for telephone equipment. The popularity of the Internet has led to an increase in demand for phone lines. In fact, many households now install second lines so that phone access can be maintained even when the Internet is being used.

Copper is not only used in the construction of homes and buildings, but also in the manufacture of transportation products such as automobiles, trucks, buses, aircraft, aerospace, and railroads. In 1997, the transportation products market used approximately 12 percent of the annual quantity of copper consumed. Most of this is consumed in automobile production. The average amount of copper used in automobiles has increased to approximately 55 pounds in 1991 from about 36 pounds in 1980 (Copper Development Association[4], 2000). The quantity of copper used has risen for a number of reasons, including the increase of the use of electronics and wiring in automobiles and an increase in popularity of larger sized automobiles in the form of sports utility vehicles (SUVs). As SUVs have become more popular, their production has included upgraded features such as power locks, power steering, power windows, and intermittent windshield wipers. All of these upgrades rely on copper-based electrical wiring.

3.2 Consumption of Copper

Several intermediate consumers use copper and copper products to produce final goods. The output of primary copper producers, mostly refined cathode copper and wire rod, is initially consumed by copper fabricators. Copper fabricators, in turn, use copper in wire mills, brass mills, foundries, and powder plants. The fabricators produce copper and copper alloy mill and foundry products, such as electrical wire, strip, sheet, plate, rod, bar, mechanical wire, tube, forgings, extrusions, castings, and powder. These products are then sold to a variety of users: chiefly the construction industry and manufacturing industries. Final products are then sold to consumers in households (Copper Development Association[2], 1997).

Table 3-1 shows the U.S. consumption of refined copper by copper fabricators from 1992 to 1998. The largest share of refined copper was purchased by wire mills followed by brass mills. On average, wire mills consume close to 77 percent of the total quantity of refined copper consumed. They consume the largest quantity of copper due to the nature of the products they produce, which includes building wire, insulated wire and cable, and telecommunication wire. Wire and cable allow for the transference of electricity, communication, and information. Brass mills consume about 22 percent of the total quantity of copper consumed by copper fabricators. These fabricators produce plumbing tube and pipe, strip, sheet, plate, foil, and mechanical wire.

Table 3-1. U.S. Consumption of Refined Copper by Copper Fabricators (10^3 short tons): 1992 - 1998

Year	Wire Mills	Brass Mills	Ingot Makers	Foundries	Powder Plants	Other	Total
1992	1,846.3	505.4	5.6	15.3	8.0	16.7	2,397.3
1993	2,006.2	554.5	5.3	13.6	7.1	14.8	2,601.5
1994	2,270.8	626.1	7.5	19.0	10.0	20.8	2,954.2
1995	2,145.1	587.2	5.1	13.1	6.8	14.3	2,771.6
1996	2,188.1	647.9	5.0	12.8	6.7	13.9	2,874.4
1997	2,336.5	656.6	4.8	12.3	6.4	13.4	3,030.0
1998	2,390.9	746.0	5.2	11.1	5.7	12.5	3,171.4
Average	2,169.1	617.7	5.5	13.9	7.2	15.2	2,828.6

Source: Copper Development Association[1]. "Consumption of Refined Copper in the U.S.," 2000. http://marketdata.copper.org/annual_98/01Item16.htm

Once copper fabricators produce copper-containing products, these products are then sold to different end markets for use in production of final goods that individual households, businesses, and governments will purchase. Households are major purchasers of homes, while both businesses and government purchase buildings where they can conduct business. Included in homes and buildings is copper in the form of wiring for electricity and telephones, plumbing for running water, commercial equipment and appliances for the purpose of manufacturing end products by governments and businesses, and consumer appliances for the simplification of household chores.

Copper is not the only input available for use in the production of wiring, plumbing, and automobile parts. A common substitute is aluminum for electrical equipment, refrigerator tubing, and automobile radiators. Aluminum long ago replaced copper as the primary input used to manufacture radiators. Though this is the case, copper still is the main component for electrical systems in automobiles. This explains why the amount of copper used in automotive production has increased over the years even though it is no longer used for radiators. Other materials used instead of copper are titanium and steel for the production of heat exchanger systems. For applications involving telecommunications, optical fiber replaces copper and in plumbing applications, plastic is a common substitute. Copper is a common input to the production of a variety of goods, but other materials can easily substitute for many of these applications.

3.3 Trends in Copper Consumption

Overall, there has been an increase in the quantity of copper used in the domestic end markets. Table 3-2 shows the amount of copper consumed by various end markets over the years 1992 to 1998. Each of the markets represented generally used increasing amounts of copper over time, as shown by the positive average annual growth rates of copper use. The market that increased the amount of copper used at the fastest rate over this time period is the transportation equipment market followed closely by the electrical and electronic products market, both with average annual growth rates over 5 percent.

Table 3-2. Consumption of Copper Mill Products by End Market (10^6 million pounds): 1992 - 1998

Year	Building Construction	Electrical and Electronic	Industrial Machinery	Transportation Equipment	Consumer Products
1992	2,705	1,650	858	774	638
1993	2,828	1,757	825	878	611
1994	3,217	1,980	965	960	732
1995	3,104	1,955	934	943	746
1996	3,237	2,079	967	979	759
1997	3,478	2,160	984	1,049	794
1998	3,572	2,247	967	1,068	782
Average Annual Growth Rates					
1992-1998	4.87%	5.36%	2.25%	5.63%	3.72%

Source: Copper Development Association[5]. "Supply of Wire Mill, Brass Mill, Foundry, and Powder Products and their Consumption in the End-Use Markets," 2000 http://marketdata.copper.org/annual_98/Table4.htm

As mentioned earlier in Section 3.1, both the electronic and transportation equipment markets have consumed increasing amounts of copper over the 1990s. This is mostly due to the increased size of homes and automobiles. Not only have the end products of these markets increased in size, but both types of products rely more heavily on electrical systems than before. Now homes must include more circuits and cars include more elaborate electrical systems.

3.4 Market Prices for Copper

Table 3-3 provides the historical price data of refined copper from 1990 to 1999. While the average price of copper over this time period was $1.05, the price of copper has fluctuated from a high of $1.38 in 1995 to a recent low of $.76 in 1999. The high price in 1995 can be attributed to a global supply deficit that occurred in 1994. World production of copper at this time was on the rise, however world consumption was increasing at a faster rate. The resulting deficit caused copper prices to rise in 1994 and continue to increase through 1995. The recent low price of copper is a response to a growing oversupply and an increase in inventories.

Table 3-3. Historical Price Data for Refined Copper ($ per pound): 1990 - 1998

Year	Price
1990	$1.23
1991	$1.09
1992	$1.07
1993	$0.92
1994	$1.11
1995	$1.38
1996	$1.09
1997	$1.07
1998	$0.79
1999	$0.76
Average Price	$1.05

Source: Edelstein, Daniel. " Copper," *Minerals Yearbook 1998*. U.S. Geological Survey.
Edelstein, Daniel. "Copper," *Minerals Yearbook 1995*. U.S. Geological Survey.
Edelstein, Daniel. "Copper in December 1999," *Mineral Industry Surveys*. U.S. Geological Survey.

Certain large companies ended up with large stocks of copper in their U.S. warehouses, mostly on the West Coast. A major reason for this inventory buildup was the weakness of the Asian economy. The Asian economic crisis resulted in fewer copper exports from the West Coast to Asia because of the weakness of Asian currencies.

4 INDUSTRY ORGANIZATION

Since the proposal of the Primary Copper Smelting NESHAP, the nature of the copper industry has changed. In 1996, seven smelters owned by five companies were producing 1.3 million tons of copper per year, however, since the end of 1998 three smelters have shut down. Copper production fell to its lowest level in 1999 as a result. In addition to the smelter shutdowns, there was a consolidation of the copper industry resulting from the takeover of two copper companies. This reorganization of the copper industry can be attributed to a number of factors including the fall in the price of copper due to overstocked inventory during the mid-1990s and a decrease in Asian demand for copper due to its economic crisis.

This section describes the domestic copper industry and how it has transformed. In Section 4.1, the market structure of the copper industry is described. Section 4.2 characterizes the manufacturing facilities in this industry, while the companies that own these facilities are described in Section 4.3. Last, Section 4.4 provides U.S. data for its foreign trade.

4.1 Market Structure

Market structure is of interest because it determines the behavior of producers and consumers in the industry. In perfectly competitive industries, no producer or consumer is able to influence the price of the product sold. In addition, producers are unable to affect the price of inputs purchased for use in production. This condition most likely holds if the industry has a large number of buyers and sellers, the products sold and inputs used are homogeneous, and entry and exit of firms are unrestricted. Entry and exit of firms are unrestricted for most industries, except in the cases where government regulates who is able to produce output, where one firm holds a patent on a product, where one firm owns the entire stock of a critical input, or where a single firm is able to supply the entire market. In industries that are not perfectly competitive, producer and/or consumer behavior can have an effect on price.

The Herfindahl-Hirschman index (HHI) can provide some insight into the competitiveness of an industry. The U.S. Department of Commerce reports these indices for industries at the fourdigit SIC code level for 1992, the most recent year these measures are available. The criteria for evaluating the HHI is based on the 1992 Department of Justice's Horizontal Merger Guidelines. 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). In general, firms in less concentrated industries are more likely to be price takers, while those in more concentrated industries have more ability to influence market prices. The HHI for the Primary Copper Smelting and Refining industry (SIC 3331) is equal to 2827. By the Horizontal Merger Guidelines, this industry is considered highly concentrated. Recently, this industry has become even more concentrated due to two separate mergers that occurred in the late 1990s.

4.2 Manufacturing Facilities

In 1996, seven smelters were in operation in the U.S. Two smelters are located in New Mexico, three are in Arizona, one is in Texas, and the final smelter is in Utah. All of these smelters are major sources of HAPs except for the facility located in Utah. The Utah facility is considered an area source because it emits less than 10 tons per year of any single HAP or less than 25 tons per year of any combination of HAPs. Table 4-1 provides 1996 facility employment data and estimated production quantities for the six major sources. The smelter in Utah is omitted from this table due to a lack of facility-level data. As the table shows, each of the smelters potentially affected by this regulation was operating near design capacity in 1996. The smelter operated by ASARCO, Inc. in Hayden, Arizona has the largest number of employees, but BHP Company, Ltd. operates the smelter estimated to produce the largest quantity of copper due to its production capacity.

Table 4-2 shows the 1996 estimated sales of primary copper that was produced at each of the six major source smelters. Facility sales data were estimated by first converting the estimated copper production quantities from metric tons to pounds. The annual number of pounds produced at each smelter was then multiplied by the 1996 average price of refined copper, $1.09 per pound. The total estimated sales figure for the 1.27 million pounds of copper produced by these six smelters is approximately 2.78 billion dollars. This total sales figure is based on the quantities produced by the smelters, not on the final quantity sold. In many cases, companies that own copper smelting operations also operate facilities that manufacture copper products. The facilities retain some share of the primary copper produced in-house for use in the production of copper products.

Table 4-1. Estimated Production, Design Capacity, and Employment of U.S. Copper Smelting Facilities: 1996

Smelter	Location	Estimated Production (tons/year)	Design Capacity	Estimated Capacity Used (%)	Employment
ASARCO, Inc.	El Paso, TX	126,000	126,500	99.6%	450
ASARCO, Inc.	Hayden, AZ	193,500	220,000	90%	1,658
BHP Co., Ltd.	San Manuel, AZ	368,000	374,000	98%	1,000
Cyprus Amax	Globe, AZ	188,258	198,000	95%	993
Phelps Dodge	Hidalgo, NM	224,000	242,000	72%	500
Phelps Dodge	Hurley, NM	177,800	187,000	73%	550
Total	6 locations	1,277,558	1,347,500	avg = 95%	5,151

Note: Total 1996 estimated production of primary copper smelters does not equal the 1996 total production of 1.300 billion metric tons shown in Table 2-2 because the smelter in Utah is not included in this table and production data for 1996 is rounded to three significant digits.

Source: Dun & Bradstreet. 1997. "Dun's Market Identifiers," On-line database, accessed through EPA's National Computation Center computer, FINDS system.

Edelstein, Daniel. U.S. Geological Survey Tele-conference with Jean Domanico, Research Triangle Institute. October 9, 1997.

Since the end of 1999, the smelters located in El Paso, TX, San Manuel, AZ, and Hidalgo, NM have ceased operation. ASARCO, Inc. shut down its smelter in El Paso in November 1998. Next, BHP Company, Ltd. closed its facility in May of 1999 for regular maintenance and has not resumed operation since. Last, the Phelps Dodge facility in Hidalgo, New Mexico shut down during the third quarter of 1999. Since two facilities closed during 1999 and one facility did not even operate for that entire year, the domestic quantity of primary copper produced in 1999 dropped to its lowest level of the 1990s. Reasons cited for the facility shutdowns include buildups of inventories in the first half of 1999 and a shortage of copper concentrates used in the production of commercial grade copper (Virta, 1998). Since the regulation has only been proposed, none of the facilities have faced increased costs of production due to compliance with this rule. Also, it is unlikely that the smelters ceased operation in expectation of the compliance costs they would face after the promulgation of this NESHAP, as the economic impacts in Section 6 will show.

Table 4-2. Estimated Sales of Primary Copper from Smelters ($\$10^6$ per year): 1996

Smelter	Location	Estimated Copper Sales
ASARCO, Inc.	El Paso, TX	$274.79
ASARCO, Inc.	Hayden, AZ	$422.00
BHP Company, Ltd.	San Manuel, AZ	$802.56
Cyprus Amax Minerals Co.	Globe, AZ	$410.57
Phelps Dodge Corp.	Hidalgo, NM	$488.52
Phelps Dodge Corp.	Hurley, NM	$387.76
Total	6 locations	$2,786.2

Note: Sales estimates are based on production estimates, which vary based on capacity utilization rates and 1996 production capacity. Estimated 1996 production was multiplied by the 1996 average price of refined copper, $1.09 per pound.

Source: Edelstein, Daniel. " Copper," *Minerals Yearbook 1998*. U.S. Geological Survey.

4.3 Firm Characteristics

In 1996, the seven copper smelters that were in operation were owned by five companies. Table 4-3 shows the sales and employment data for the parent companies of the smelters at this time. All of the copper smelting operations in the U.S. are owned by large mining companies. According to the Small Business Administration, small primary copper smelting and refining companies are defined as those having 1,000 or fewer employees. This rule is therefore not expected to have significant impacts on small businesses.

Since the proposal of the Primary Copper Smelting NESHAP, there has been a consolidation of the industry. On September 30, 1999 Phelps Dodge, Inc. acquired Cyprus Amax Minerals Co. and its smelting operation in Globe, Arizona. Around the same time, Phelps Dodge and a Mexican copper mining company, Grupo Mexico, S.A. de C.V., were both attempting to acquire ASARCO, Inc. Phelps Dodge had gone so far as to sign a merger agreement with ASARCO, but Grupo Mexico increased its original offer and successfully acquired ASARCO and its smelter operations in El Paso, Texas and Hayden, Arizona. The smelter in El Paso, was not in operation when it was acquired by Grupo Mexico and still has not restarted.

Table 4-3. Characteristics of Companies Owning Primary Copper Smelters: 1996

Parent Company	Smelter Locations	Sales ($\$10^3$)	Employment
ASARCO, Inc.	El Paso TX, Hayden, AZ	$2,696.69	12,000
BHP Company, Ltd.[a]	San Manuel, AZ	>$926.40	>5,000
Cyprus Amax Minerals Co.	Globe, AZ	$2,843.00	9,700
Phelps Dodge, Inc.	Hidalgo, NM, Hurley, NM	$3,786.60	15,343
Rio Tinto plc	Salt Lake City, UT	$7,076.00	34,809[b]
Total	7 locations	>$17,328.69	>76,852

Notes: [a] Sales and employment data for BHP Co., Inc. for 1996 is unavailable, however this information is available for BHP (USA) Holdings, a subsidiary of BHP Company. This data for BHP (USA) Holdings is provided in the above table to show that BHP Co., Inc. is not a small business.

[b] The employment data for Rio Tinto plc is from 1998 since 1996 employment data was not available.

Source: Dun & Bradstreet. 1997. "Dun's Market Identifiers," On-line database, accessed through EPA's National Computation Center computer, FINDS system.
Hoovers Online. 2000. http://www.hoovers.com

Now, four parent companies own the seven primary copper smelters, three of which are still shut down. The 1998/9 sales and employment data for the current parent companies are provided in Table 4-4 and they show that the smelters are still owned by companies that are not considered small by the SBA size standard definitions.

Table 4-4. Characteristics of Companies Owning Primary Copper Smelters: 1998/1999

Parent Company	Smelter Locations	Sales ($\$10^3$)	Employment
BHP Company, Ltd.*	San Manuel, AZ	$12,553.0	50,000
Grupo Mexico S.A. de C.V.+	El Paso, TX, Hayden, AZ	$1,061.5	22,555
Phelps Dodge, Inc.*	Hidalgo, NM, Hurley, NM, Globe, AZ	$3,114.4	16,400
Rio Tinto plc+	Salt Lake City, UT	$7,112.0	34,809
Total	7 locations	$23,840.9	123,764

Note: * indicates company data are from 1999 and + indicates company data are from 1998.

Source: Hoovers Online. 2000. http://www.hoovers.com

4.3 Foreign Trade

The market for copper spans not only the U.S., but also the world. Copper is exported and imported worldwide both in the form of commercial grade copper and copper-containing products. The U.S. is the second largest producer of mine copper, after Chile. Over the years 1994 through 1998, Chile and the U.S. together accounted for approximately 45 percent of world mine copper production. Over this same time period, the U.S. was the leading producer of smelted copper followed behind by Chile and Japan.

This section presents historical data on foreign trade including the quantities of refined copper exported to and imported from other countries. As shown in Table 4-5, the U.S. has annually imported larger quantities of refined copper than it has exported. The table also shows that U.S. copper exports have steadily declined while imports they receive have steadily increased. In fact, imports of copper to the U.S. have increased at a faster rate than exports have decreased. The average annual growth rate for exports over this time period is -10.6 percent and for imports the average annual growth rate is 14 percent. The amount of copper consumed domestically has continued to increase over time with an increasingly larger portion supplied by imports.

In addition to the export and import data, the annual foreign trade concentration ratios have also been calculated and are provided in Table 4-4. Average foreign trade concentration ratios determine the share of U.S. refined copper sold abroad and the share of U.S. consumption supplied from abroad. The average share of refined copper produced in the U.S. and exported abroad is 6.2 percent and the average share of copper consumed in the U.S. that is supplied from abroad is 14.4 percent. The table shows that over the time period examined, the share of U.S. produced copper that is exported has decreased. In 1991, over 13 percent of copper produced in the U.S. was exported, but by 1999, this fell to 3.5 percent. The opposite trend exists for imports. In 1991, the share of U.S. copper consumption supplied from abroad was just over 14 percent, and by 1999, just under 24 percent of copper consumed in the U.S. came from foreign sources.

Table 4-5. Foreign Trade and Foreign Trade Concentration Ratios of Refined Copper (10^3 metric tons): 1991 - 1998

Year	Exports	Exports/Production	Imports	Imports/Consumption
1991	263	13.2%	289	14.1%
1992	177	8.3%	289	13.3%
1993	217	9.6%	343	14.5%
1994	157	7.0%	470	17.5%
1995	217	9.5%	429	17.0%
1996	169	7.2%	543	20.8%
1997	92.9	3.8%	632	22.7%
1998	86.2	3.5%	683	23.6%
Average	137.91	6.2%	367.8	14.4%

Source: Edelstein, Daniel. “Copper,” *Minerals Yearbook 1998*. U.S. Geological Survey.
Edelstein, Daniel. “Copper,” *Minerals Yearbook 1995*. U.S. Geological Survey.

5 REGULATORY COST

A facility may have to purchase and install two types of equipment to comply with this NESHAP. First, they may have to purchase equipment to control the emissions they release (if the equipment they currently operate does not meet the MACT floor), and then additional equipment may have to be purchased for the monitoring, recordkeeping, and recording (MRR) of emissions. For the primary copper smelters, emissions are generally controlled through the operation of baghouses and emissions are monitored using leak detector systems installed on the baghouses. Not all facilities are required to install new emissions control equipment for this rule, however all facilities are expected to incur costs from the purchase and operation of monitoring, recordkeeping, and recording equipment. The costs of complying with this NESHAP were estimated by identifying the capital equipment smelters would be expected to use to control and monitor the release of HAP emissions. The operating and maintenance costs associated with both types of equipment were also estimated.

Two types of costs are incurred when equipment is installed and operated in a facility, regardless of whether the equipment is used for emissions control or monitoring of emissions:

capital costs and operating and maintenance (O&M) costs. Capital costs are the lump-sum costs that are incurred when capital equipment is purchased and installed. O&M costs are those costs associated with the upkeep and operation of the capital equipment.

To estimate the annual burden of these costs on the smelters, the lump-sum capital costs associated with both emissions control and MRR are converted to a stream of annualized costs using a 7 percent discount rate over the expected life of the capital equipment. For primary copper smelters, the expected life of a baghouse used to control emissions is 15 years and the expected life of the leak detector systems used for monitoring, recordkeeping, and recording is estimated at 10 years. Added to the annualized capital costs are the annual costs of operating and maintaining the capital equipment. Table 5-1 shows the facility-specific total annual control costs and Table 5-2 shows the total annual MRR costs. The sum of the annual control costs and annual MRR costs is the total annual costs of complying with this NESHAP, as shown in Table 5-3.

Table 5-1. Emissions Control Costs for Primary Smelting Facilities: (1997$)

Facility	Total Capital Costs	Annualized Capital Costs	O&M Costs	Total Annual Control Costs
BHP-San Manuel, AZ*	$0	$0	$0	$0
Grupo Mexico-Hayden, AZ	$4,100,000	$386,630	$417,000	$803,630
Grupo Mexico-El Paso, TX*	$0	$0	$0	$0
Phelps Dodge-Globe, AZ	$0	$0	$0	$0
Phelps Dodge-Hidalgo, NM*	$4,100,000	$386,630	$417,000	$803,630
Phelps Dodge-Hurley, NM	$0	$0	$0	$0
Total[a]	$8,200,000	$773,000	$834,000	$1,607,000

Note: *Currently not in operation

[a] Rounded to nearest thousands.

Source: U.S. Environmental Protection Agency. July 2001. Memorandum from Gene Crumpler, Emissions Standards Division to Aaiysha Khursheed, Air Quality Strategies and Standards Division. “Information for Development of Costs for the Primary Copper Smelter Standard.”

Only two of the six affected facilities incur positive costs associated with emissions control due to this rule. The other four facilities already have the necessary control equipment installed.

Of the two affected facilities, one is currently shut down. This facility would therefore face emission control costs if it were to resume operation. If these two smelters are in operation, they would be required to meet the MACT standard. The costs indicated for this facility are an estimate of the control costs the facility may incur in meeting the standard. This cost estimate was based on the purchase and installation of a baghouse, which is $4.1 million. This is the emission control technology used by the operating facilities affected by this MACT standard. The annual costs of operating and maintenance of a baghouse equal to $417,000. If the smelter in Hidalgo, NM resumes operation, the total annual control costs are estimated at $1.6 million.

Table 5-2 shows the MRR costs for each of the potentially affected smelters. Costs are again divided into the initial capital investment, which is annualized over the expected life of the equipment and the annual costs of operating and maintaining the MRR equipment. For this NESHAP, the MRR equipment is a leak detector system. Unlike emissions control costs, each facility potentially affected by this NESHAP has positive MRR costs. However, three facilities are currently closed. If the three closed smelters begin operations again, the total annual MRR costs of this NESHAP are about $98 thousand.

Table 5-2. Monitoring, Recordkeeping, and Recording Costs for Primary Smelting Facilities: (1997$)

Facility	Total Capital Costs	Annualized Capital Costs	O&M Costs	Total Annual MRR Costs
BHP- San Manuel, AZ*	$72,000	$6,789	$18,783	$25,572
Grupo Mexico-El Paso, TX*	$36,000	$3,395	$9,390	$12,785
Grupo Mexico-Hayden, AZ	$36,000	$3,395	$9,390	$12,785
Phelps Dodge- Globe, AZ	$36,000	$3,395	$9,390	$12,785
Phelps Dodge-Hidalgo, NM*	$48,000	$4,526	$12,520	$17,046
Phelps Dodge-Hurley, NM	$48,000	$4,526	$12,520	$17,046
Total[a]	$276,000	$26,000	$72,000	$98,000

Note: *Currently not in operation

[a] Rounded to nearest thousands.

Source: U.S. Environmental Protection Agency. July 2001. Memorandum from Gene Crumpler, Emissions Standards Division to Aaiysha Khursheed, Air Quality Strategies and Standards Division. "Information for Development of Costs for the Primary Copper Smelter Standard."

The last table in this section, Table 5-3, provides the total annual compliance costs for the smelters in the primary copper smelting source category. The nationwide annual compliance costs are equal to just about $1.7 million if all the smelters are in operation. Otherwise, if the smelters are permanently shutdown, the total annual cost of the rule are $846 thousand. The total annual costs per facility vary from a low of about $13 thousand to a high of $821 thousand. The total annual compliance costs of the facilities are significantly affected by whether a smelter has to purchase emissions control equipment.

Table 5-3. Total Annual Capital Costs for Primary Smelting Facilities (1997$)

Facility	Total Annual Control Costs	Total Annual MRR Costs	Total Annual Costs
BHP-San Manuel, AZ*	$0	$25,572	$25,572
Grupo Mexico-El Paso, TX*	$0	$12,785	$12,785
Grupo Mexico-Hayden, AZ	$803,630	$12,785	$816,415
Phelps Dodge-Globe, AZ	$0	$12,785	$12,785
Phelps Dodge-Hidalgo, NM*	$803,630	$17,046	$820,676
Phelps Dodge-Hurley, NM	$0	$17,046	$17,046
Total[a]	$1,607,000	$98,000	$1,705,000

Note: *Currently not in operation

[a] Rounded to nearest thousands.

Source: U.S. Environmental Protection Agency. May 3, 2000. Memorandum from Gene Crumpler, Emissions Standards Division to Aaiysha Khursheed, Air Quality Strategies and Standards Division. "Information for Development of Costs for the Primary Copper Smelter Standard."

6 ECONOMIC IMPACTS

The Agency has estimated the economic impacts of the primary copper smelting NESHAP by comparing the estimated costs of compliance with the smelters' estimated baseline sales of refined primary copper. It was assumed that the operating facilities produced the same quantity of primary copper as they had in 1996 prior to changes in firm ownership. The annual sales for these firms were calculated by multiplying these estimated production quantities for the facilities by the 1996 average price of copper, $1.09. These sales figures are provided in Table 4-2. Table

6-1 shows the ratio of total annualized compliance costs (TAC) to the estimated facility sales. As is evident from these compliance cost-to-sales ratios, the estimated economic impacts of the primary copper smelting NESHAP on smelting facilities appears quite low. In addition, the Rio Tinto plc smelter in Utah is expected to incur no compliance costs because it is an area source. This NESHAP is therefore expected to have no direct economic impact on this facility.

Table 6-1. Estimated Economic Impacts of the Primary Copper Smelting NESHAP: 1997

Smelter	Location	TAC/Sales (percent)
BHP, Inc.*	San Manuel, AZ	< 0.01%
Grupo Mexico, Inc.*	El Paso, TX	< 0.01%
Grupo Mexico, Inc.	Hayden, AZ	0.20%
Phelps Dodge Corp.	Globe, AZ	< 0.01%
Phelps Dodge Corp.*	Hidalgo, NM	0.2%
Phelps Dodge Corp.	Hurley, NM	< 0.01%
Average		< 0.10%

Note: *Currently not in operation

The maximum total annual compliance cost-to-sales ratio incurred by any smelter is about 0.2 percent. The maximum ratio of TAC to refined copper sales is incurred by facilities that are expected to need to install a baghouse, in addition to leak detector systems. For four of the other facilities, total annual compliance costs are estimated to be less than 0.01 percent of copper sales. Based on the facility-level TAC/sales ratios above, impacts of the NESHAP on the companies owning smelting facilities are anticipated to be negligible.

On average, the TAC/sales ratios of 0.10 percent are expected for the facilities affected by the NESHAP assuming all smelters are in operation. With facilities expected to incur such small impacts, no appreciable impact on international trade in copper, or on other secondary markets, is anticipated.

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TECHNICAL REPORT DATA *(Please read Instructions on reverse before completing)*

1. REPORT NO. EPA-452/R-01-009	2.	3. RECIPIENT'S ACCESSION NO.

4. TITLE AND SUBTITLE Economic Impact Analysis for the Final Primary Copper Smelting NESHAP	5. REPORT DATE August 2001
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Environmental Protection Agency Office of Air Quality Planning and Standards Research Triangle Park, NC 27711	10. PROGRAM ELEMENT NO.
	11. CONTRACT/GRANT NO. None
12. SPONSORING AGENCY NAME AND ADDRESS - Director Office of Air Quality Planning and Standards, Office of Air and Radiation U.S. Environmental Protection Agency, Research Triangle Park, NC 27711	13. TYPE OF REPORT AND PERIOD COVERED Promulgated regulation
	14. SPONSORING AGENCY CODE EPA/200/04

15. SUPPLEMENTARY NOTES

16. ABSTRACT Pursuant to Section 112 of the Clean Air Act, the U.S. Environmental Protection Agency (EPA) is developing National Emissions Standards for Hazardous Air Pollutants (NESHAP) to control emissions released from the primary copper smelting operations. The purpose of this rule is to reduce the flow of HAPs from potential emission points within primary copper smelting facilities. Eighty percent of the HAPs released are lead and arsenic. The other HAPs include cadmium, cobalt, manganese, nickel, selenium, antimony, beryllium, and mercury. The facilities in the primary copper smelting source category are controlling HAP emissions from their smelting operations, as required, to meet maximum achievable control technology (MACT) standards.

There are seven facilities in the primary copper manufacturing source category, six of which are major sources. Since the proposal of this NESHAP, three of the six facilities have shut down. The seven facilities were owned by five companies when this NESHAP was proposed. Since then, the industry has consolidated so that only four companies own the seven primary copper smelters. According to the Small Business Administration size standards, none of these businesses are considered small.

The total annual costs for this rule are $1.7 million. The share of costs to estimated revenues for the affected facilities range from a low of <0.01 percent to a high of 0.20 percent. Based on the facility-level cost-to-sales ratios, impacts of the NESHAP on companies owning smelting facilities are anticipated to be negligible.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
	air pollution control, environmental regulation, economic impact analysis, maximum achievable control technology, primary copper smelting	

18. DISTRIBUTION STATEMENT Release Unlimited	19. SECURITY CLASS *(Report)* Unclassified	21. NO. OF PAGES 35
	20. SECURITY CLASS *(Page)* Unclassified	22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE