Taconite Mining and Processing Industry Profile

Draft Report

Prepared for

Bryan J. Hubbell
U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Innovative Strategies and Economics Group (MD-15)
Research Triangle Park, NC 27711

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Prepared by

Katherine B. Heller
Jui-Chen Yang
Research Triangle Institute
Center for Regulatory Economics and Policy Research
Research Triangle Park, NC 27709

CONTENTS

LIST OF FIGURES

LIST OF TABLES

SECTION 1

INTRODUCTION

This industry profile provides information to support the economic impact analysis (EIA) of a proposed National Emission Standard for Hazardous Air Pollutants (NESHAP) regarding taconite iron ore processing. Taconite mining and processing fall under the North American Industry Classification System (NAICS) 21221 Iron Ore Mining. According to the 1997 Economic Census of Manufacturing, in 1997, 32 establishments owned by 26 companies produced products that are categorized in NAICS 21221 (U.S. Department of Commerce, Bureau of the Census, 2001). In 1997, these firms employed 7,920 workers and shipped products valued at $1.9 billion (U.S. Department of Commerce, Bureau of the Census, 2001).

Taconite, the principal iron ore mined in the United States, has a low (20 percent to 30 percent) iron (Fe) content and is found in hard, fine-grained, banded iron formations. The main taconite iron ore deposits are located near Lake Superior in Minnesota (Mesabi Iron Range) and Michigan (Marquette Iron Range). The taconite mining operations in Michigan and Minnesota accounted for virtually all domestic iron ore production (Kirk, 1999a). The following taconite ore production processes will be covered by the proposed rule (EPA, 2001):

- liberation of the iron ore by wet or dry crushing and grinding in gyratory crushers, cone crushers, rod mills, and ball mills;
- concentrating of the iron ore by magnetic separation or flotation;
- pelletization by wet tumbling with a balling drum or balling disc; and
- indurating using a vertical shaft furnace, straight grate, or grate/kiln, and material handling (transfer, pellet cooling) of the indurated pellets.

The economic effects of the rule are conditional on the technology for producing taconite iron ore and their costs of production; the value of the taconite products to end users; and the organization of the industries engaged in iron ore production and use. This profile

provides background information on these topics organized within a conventional economic framework.

- Section 2 includes a detailed description of the production process for the taconite mining industry, with a brief discussion of the inputs to the production process and costs of production.
- Section 3 describes the characteristics, uses, and consumers of iron ore pellets as well as substitution possibilities.
- Section 4 discusses the organization of the industry and provides facility- and company-level data. In addition, small businesses are reported separately for use in evaluating the impact on small businesses to meet the requirements of the Regulatory Flexibility Act (RFA) as amended in 1996 by the Small Business Regulatory Enforcement and Fairness Act (SBREFA).
- Section 5 contains market-level data on prices and quantities and discusses trends and projections for the industry.

SECTION 2

THE SUPPLY SIDE

Domestic iron ore supply (production minus exports) satisfied 70 percent of domestic demand in 2000 (McGraw-Hill, 2000). Low-grade taconite ores mined in Michigan and Minnesota virtually accounted for all the useable ore production. Minnesota produced 76 percent of the national output of useable ore while Michigan accounted for 23 percent. The production process typically involves four stages, and taconite iron ore is the primary input. The production process, product characteristics and the associated costs of production are the focus of this section.

2.1 Taconite Pellet Production Processes, Inputs and Outputs

Low-grade taconite ore in Michigan and Minnesota is the source of primary iron for the iron and steel industry in the United States. Taconite iron ore processes are illustrated in Figure 2-1. Figure 2-1 also demonstrates the emission points from taconite ore production. Three types of hazardous air pollutants (HAPs) are released from the processes: acidic gases (hydrochloric and hydrofluoric acid), metallic particulate matters, and products of incomplete combustion (PICs) (EPA, 2001).

2.1.1 Mining of Crude Ore

Iron ore is a mineral substance that, when heated in the presence of a reductant, yields metallic iron (Fe). It almost always consists of iron oxides, the primary forms of which are magnetite (Fe_3O_4—iron content 72.4 percent), hematite (Fe_2O_3—iron content 69.9 percent), and goethite ($Fe_2O_3H_2O$—iron content 62.9 percent) (McKetta, 1988). In the United States, iron ore is mined and processed primarily on the Mesabi Iron Range of northern Minnesota and the Marquette Iron Range of the Upper Peninsula of Michigan (see Table 2-1). Domestic taconite is mined from open pits because most commercial ore bodies lie close to the surface and their lateral dimensions are large. Mining activities involve overburden removal, drilling, blasting, and removal of waste rock and crude taconite from the open-pit (EPA, 2001).

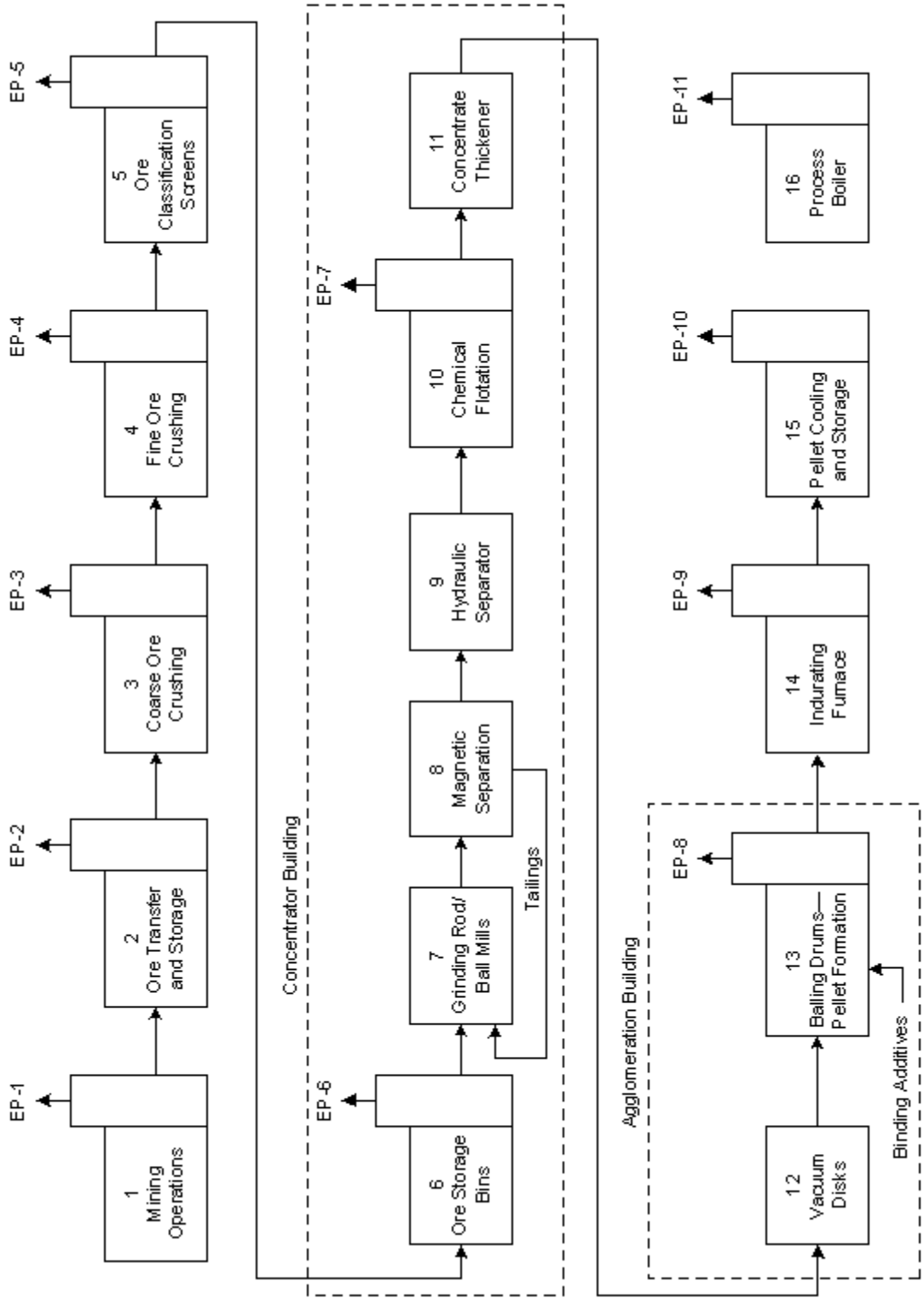

Figure 2-1. Process Flow Diagram for Taconite Iron Ore Processing

Table 2-1. Crude Iron Ore Mined in the United States, 1999

District and State	Number of Mines	Open Pit (10^3 metric tons)	Underground (10^3 metric tons)
Lake Superior			
Michigan	2	39,800	NA
Minnesota	8	152,000	NA
Other States			
Missouri	1	NA	448
Others	1	33	NA
Total	12	191,833	448

NA = Not available.
Source: Kirk, W.S. 1999b. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1999. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340499.pdf>.

Mining in open pits is mostly done with large powerful shovels and trucks. Shovels at taconite mines are used to dig surface overburden as well as iron ore and waste rock. Rotary drills with 12- to 17 ½-inch bits are used to create holes about 16 inches in diameter to a depth of 45 to 55 feet into the taconite ore for explosives to be placed for blasting activities. The commonly used blasting agent is a mixture of ammonium nitrate fertilizer and fuel oil (called ANFO), which is pumped into the holes. The quantity of taconite broken by individual blasts usually ranges from about 0.4 to 1.5 million tons. Trucks then transport the crude iron ore to the primary or coarse crushers. In some mining operations, trains are used to haul ore to the crushers (EPA, 2001; EPA, 1994; McKetta, 1988).

2.1.2 Beneficiation

The mined taconite is beneficiated to increase its iron content, reduce the content of impurities, and improve its physical structure, according to the needs of consumers. Beneficiation processes include milling (crushing and grinding), screening, washing, and processes that separate ore minerals from gangue (sand, rock, and other impurities surrounding the iron) by differences in physical or chemical properties. Figure 2-2 illustrates the general beneficiation processes.

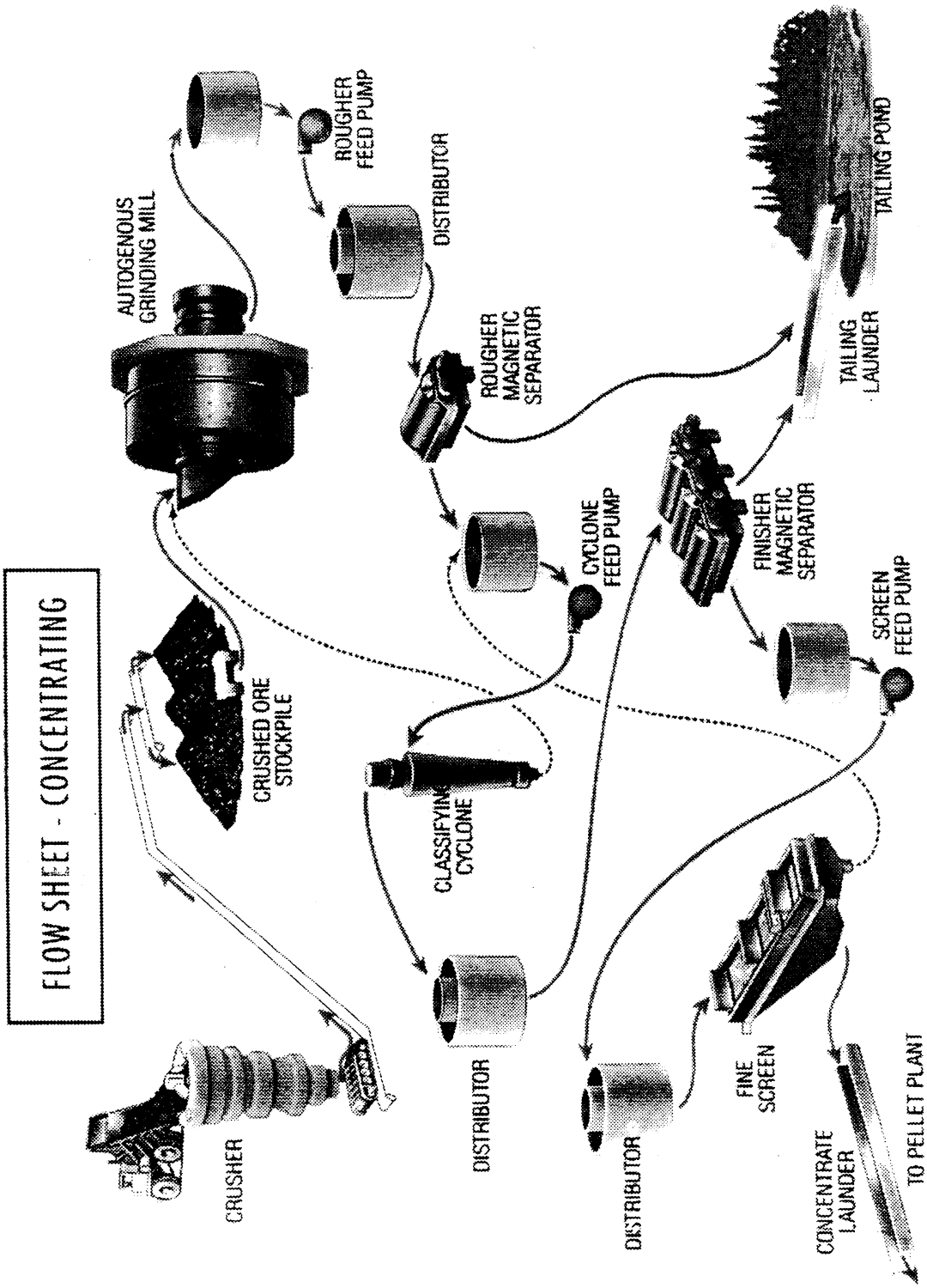

Figure 2-2. Flow Sheet: Concentrating

2.1.2.1 Crushing and Grinding

Crushing and grinding are necessary to produce acceptable concentrates from crude taconite ores. A gyratory crusher is generally used for primary crushing down to approximately 6 inches. Secondary and tertiary fine crushing stages can be done in a cone crusher to further reduce the material to 3/4 inch. Intermediate vibratory screens remove undersized material from the feed before the next crusher. Table 2-2 presents the crushing stages operating at the taconite facilities located in Minnesota and Michigan (EPA, 2001).

Table 2-2. Crushing Stages Operated at Taconite Facilities, 2000

State	Company	Mine	Pelletizing Plant	Stages of Crushing	Number of Indurating Furnaces
Minnesota	EVTAC Mining, LLC	Eveleth[a]	Forbes[a]	Four	2
	Hibbing Taconite Co.	Hibbing[a]	Hibbing	Single	2
	Ispat-Inland Steel Mining Co.	Virginia[a]	Virginia	Three	2
	LTV Steel Mining Co.[b]	Hoyt Lakes[a]	Hoyt Lakes	Three	2
	National Steel Pellet Co.	Keewatin[c]	Keewatin	Single	2
	Northshore Mining Co.	Babbitt[a]	Silver Bay[d]	Three	2
	U.S. Steel Group of USX Corp. (Minntac)	Mountain Iron[a]	Mountain Iron	Three	3
Michigan	Empire Iron Mining Partnership	Palmer[e]	Palmer	Single	2
	Tilden Mining Co., LC	Ishpeming[e]	Ishpeming	Single	1

[a] Located in Saint Louis County
[b] Closed its Hoyt Lakes, MN, operation in early 2001
[c] Located in Itasca County
[d] Located in Lake County
[e] Located in Marguette County

Source: U.S. Environmental Protection Agency (EPA). 2001. *National Emissions Standard for Hazardous Air Pollutants (NESHAPs) for Taconite Iron Ore Processing Plants—Background Information for Proposed Standards.* Washington, DC: U.S. Environmental Protection Agency.

After crushing, the crushed ore is sent to rod mills for fine grinding, then followed by either ball or pebble mills (McKetta, 1988). A rod/ball mill is a large horizontal cylinder that rotates on its horizontal axis and is charged with heavy steel rods or balls and taconite ore with water slurry. The taconite ore slurry discharged from the rod/ball mills is passed through multiple stages of magnetic separation (EPA, 2001). In some cases, autogenous grinding can be used to replace the cone crushers and rod mills. Autogenous mills use coarse pieces of the ore itself as grinding media instead of steel balls and rods (Kirk-Othmer, 1995).

2.1.2.2 Magnetic Separation

Magnetic separation involves three stages of separation: cobbing, cleaning/roughing, and finishing. Each stage works on finer particles as a result of removing oversized particles in earlier separations. Ore material not picked up by magnetic separators is rejected as nonmagnetic gangue or tailings. Cobbers and rotating cylinders are partially submerged in the taconite ore slurry, which allows iron-bearing particles to adhere to the magnetized cylinder surface. As the cylinder surface rotates past the magnetic field, the iron-bearing ore drops from the cylinder surface and into a weir located just below the point where the magnetic field ends. About 40 percent of the feed is rejected as tailings, which are re-ground to extract as much iron as possible. Cleaners and finishers then work on ore particles in the range of 48 mesh and less than 100 mesh, respectively. Tailings from these two stages are sometimes re-ground or discharged to the tailing basin (EPA, 2001; EPA 1994).

2.1.2.3 Flotation

The iron-bearing slurry flows into a hydraulic concentrator where excess water is removed through gravity separation. Sediment collected at the bottom of the concentrator is passed on to the chemical flotation unit (see Figure 2-3). In the flotation process, three types of additives are used to upgrade the iron ore concentrates by removing residual gangue (silica) from the iron-bearing slurry: frothers, collectors/amines, and anifoams. Frothers enable the formation of stable air bubbles in the aerated tank. Collectors and amines enhance silica-bearing particles to adhere to the rising air bubbles. Anifoams destabilize air bubbles as the iron-rich concentrates fall to the bottom of the tank. Then the iron-rich concentrates become the raw materials for producing taconite pellets in the agglomerating process.

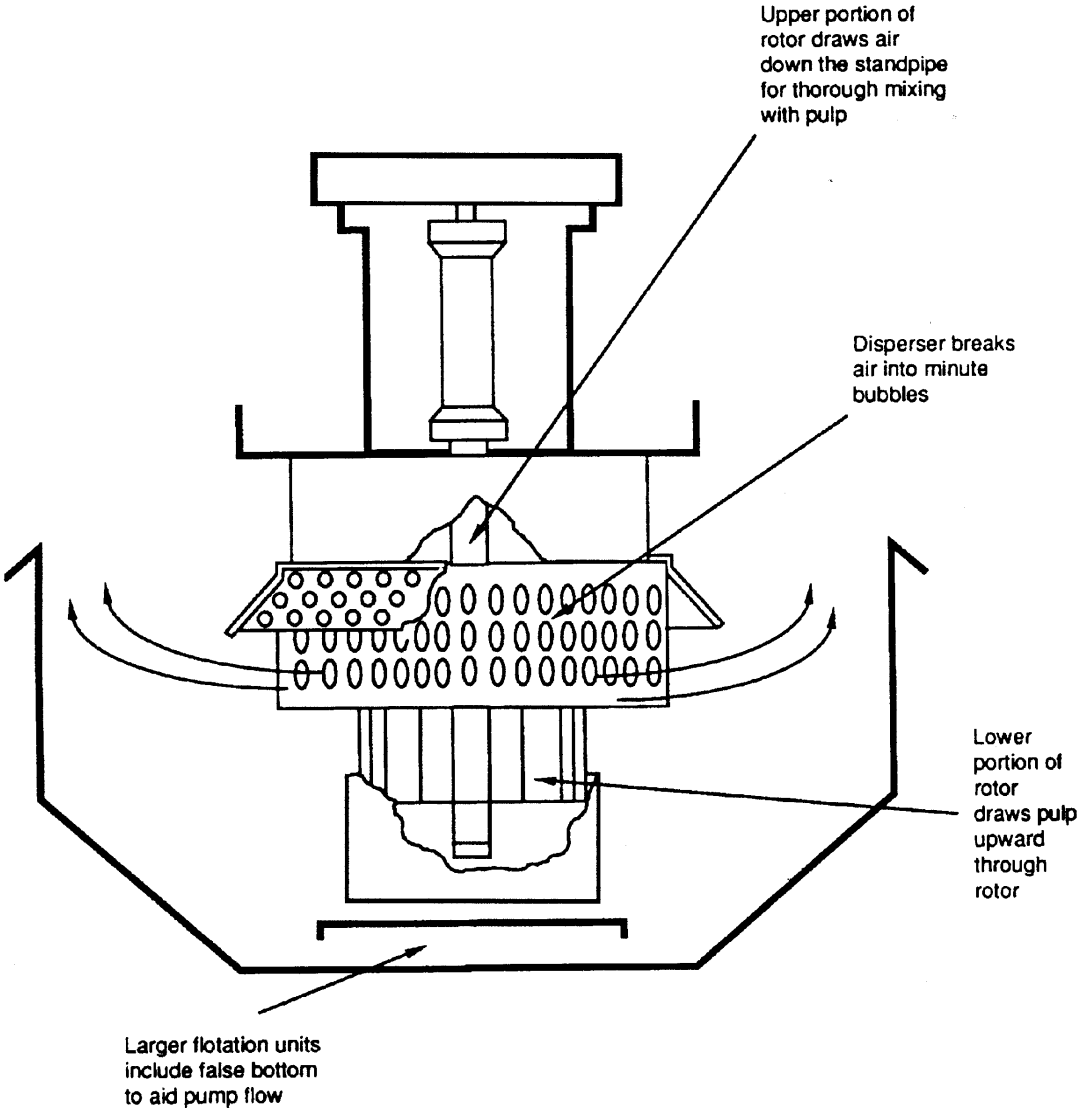

Figure 2-3. Cross-Section of a Typical Flotation Cell

2.1.3 Agglomeration

After concentration activities, agglomeration is used to combine the iron-rich concentrates into pellets, sinter, briquettes, or nodules. This section focuses only on the pelletizing (indurating) processes because pellets account for more than 95 percent of domestic iron ore production. Figure 2-4 presents the typical pelletizing procedures. In the pelletizing processes, the iron-rich concentrates are mixed with water and a binder, normally bentonite (clay), hydrated lime, or organic material (peridor). Then the concentrate is rolled into marble-sized balls (3/8 to 5/8 inch [9-15 mm] in diameter) inside large rotating cylinders. These green (moist and unfired) balls are then dried and heated to 2,354 to 2,552°F. The induration or heating of the green balls can be done in a vertical shaft furnace on a travel grate (straight grate) or by a combination of a travel grate and a rotary kiln (grate-kiln). The finished product is taconite pellets. As Table 2-3 shows, the travel grate and grate-kiln are the most commonly used in the pelletizing processes in the United States (EPA, 2001; EPA, 1994).

Vertical Shaft Furnace. In the vertical shaft furnace (see Figure 2-5), the green pellets are distributed across the top of a conveyor belt that descends at a rate of 1 to 1.5 inches per minute. The pellets are dried and heated to 2,400°F and move downwards through firing and cooling zones. The bottom two-thirds of the furnace is used to cool the pellets. The pellets are discharged from hoppers at the bottom. In 2000, LTV Steel Mining Company was the only taconite plant in the United States that used vertical shaft furnaces.

Travel Grate (Straight Grate). As shown in Figure 2-6, the green pellets are fed to a travel grate to be dried and preheated. The pellets then are carried to the ignition section of the grate, where all the magnetite is oxidized to hematite. Finally, the pellets are cooled by intake air at cooling stages before they are discharged by conveyor belt to storage. In 2000, Hibbing Taconite Company, Ispat-Inland Steel Mining Company, and Northshore Mining Company used travel grate indurating furnaces.

Grate-Kiln. The grate-kiln system combines a travel grate, a rotary kiln, and an annular cooler (see Figure 2-7). Drying of the green pellets and partial induration occur at the grate while final induration is finished in the rotary kiln. The pellets are heated to a temperature of 2,000°F on the travel grate before being hardened in the rotary kiln furnace.

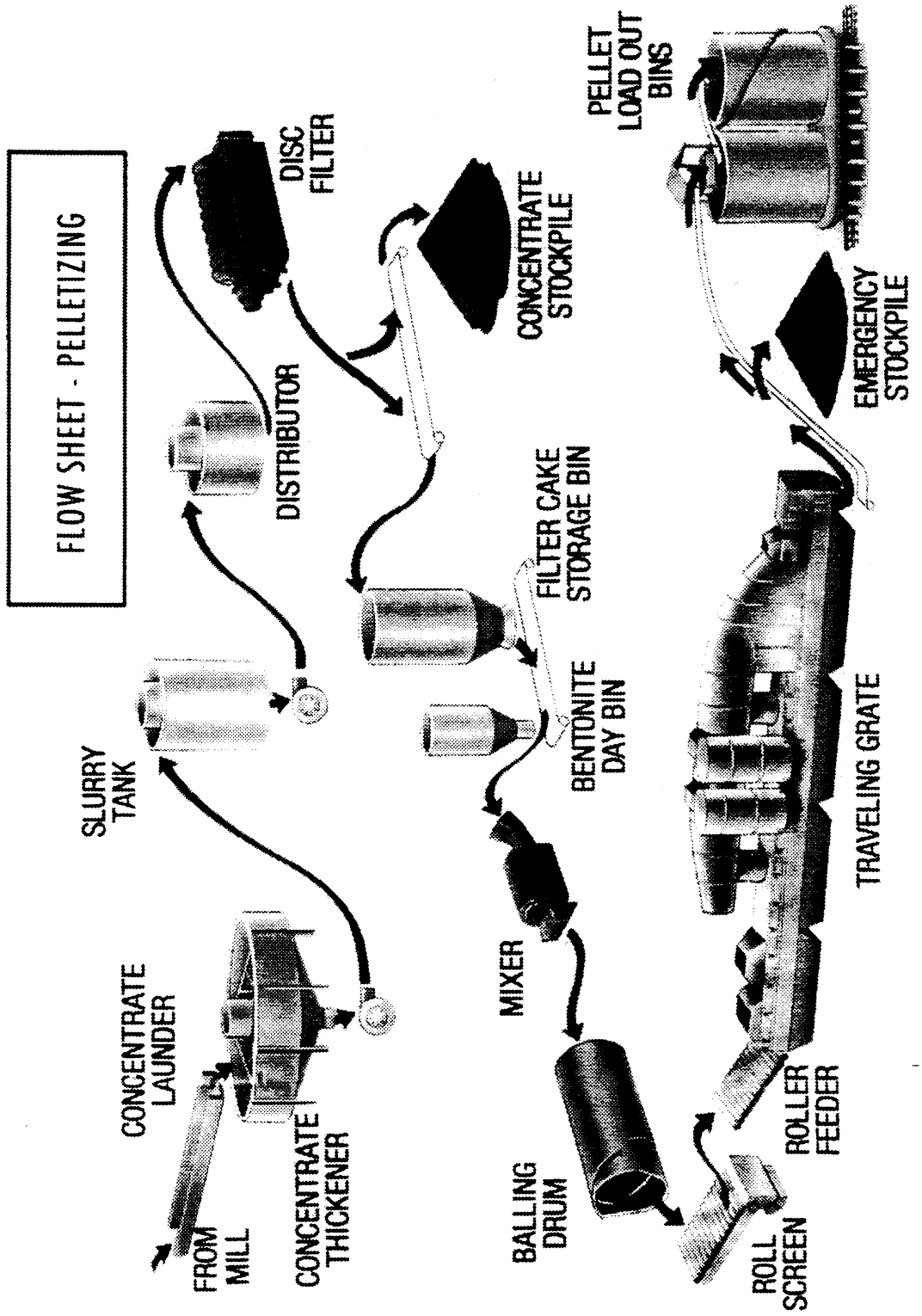

Figure 2-4. Flow Sheet: Pelletizing

Table 2-3. Types of Indurating Furnaces Used at Taconite Facilities, 2000

State	Company	Mine	Pelletizing Plant	Type of Indurating Furnaces	Number of Indurating Furnaces
Minnesota	EVTAC Mining, LLC	Eveleth[a]	Forbes[a]	Grate-kiln	2
	Hibbing Taconite Co.	Hibbing[a]	Hibbing	Travel grate	3
	Ispat-Inland Steel Mining Co.	Virginia[a]	Virginia	Travel grate	1
	LTV Steel Mining Co.[b]	Hoyt Lakes[a]	Hoyt Lakes	Vertical shaft	23
	National Steel Pellet Co.	Keewatin[c]	Keewatin	Grate-kiln	1
	Northshore Mining Co.	Babbitt[a]	Silver Bay[d]	Travel grate	4
	U.S. Steel Group of USX Corp. (Minntac)	Mountain Iron[a]	Mountain Iron	Grate-kiln	5
Michigan	Empire Iron Mining Partnership	Palmer[e]	Palmer	Grate-kiln	4
	Tilden Mining Co., LC	Ishpeming[e]	Ishpeming	Grate-kiln	2

[a] Located in Saint Louis County
[b] Closed its Hoyt Lakes, MN operation in early 2001
[c] Located in Itasca County
[d] Located in Lake County
[e] Located in Marguette County

Source: U.S. Environmental Protection Agency (EPA). 2000. *Economic Impact Analysis of Proposed Integrated Iron and Steel.* Washington, DC: U.S. Environmental Protection Agency.

Then the hardened pellets enter the cooling zone of the annular cooler. In 2000, grate-kiln indurating furnaces were used at five facilities (EVTAC Mining, LLC; National Steel Pellet Company; Minntac; Empire Iron Mining Partnership; and Tilden Mining Company, LC).

2.2 Types of Products

Ninety-nine percent of domestic iron ore production was pelletized before shipment (Kirk 1999b). Standard (acid) pellets and fluxed pellets (pellets with a basicity ratio of 0.6 or greater [American Iron Ore Association, 2000]) are the two major types of pellet products.

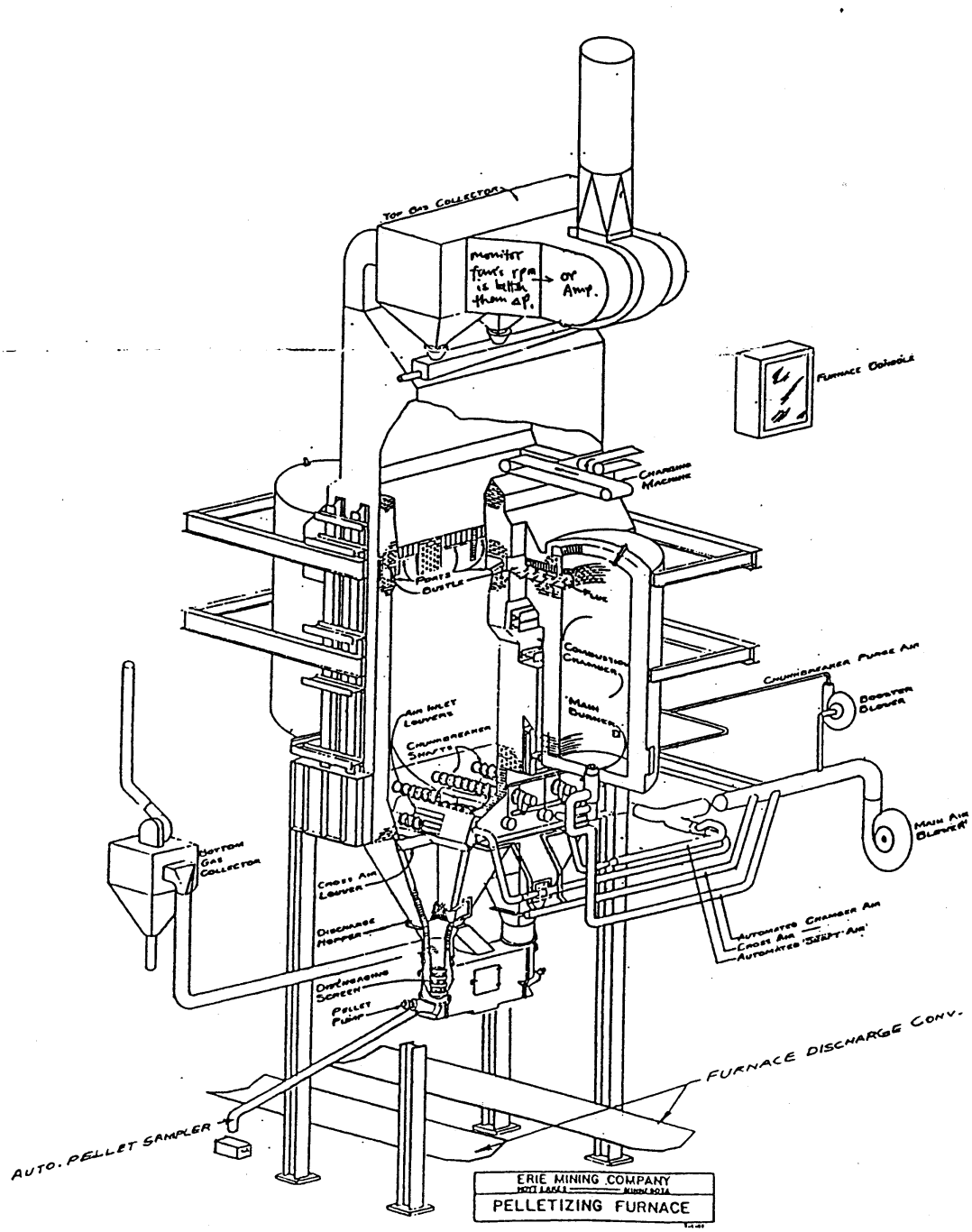

Figure 2-5. A Vertical Shaft Furnace for Taconite Pellet Induration

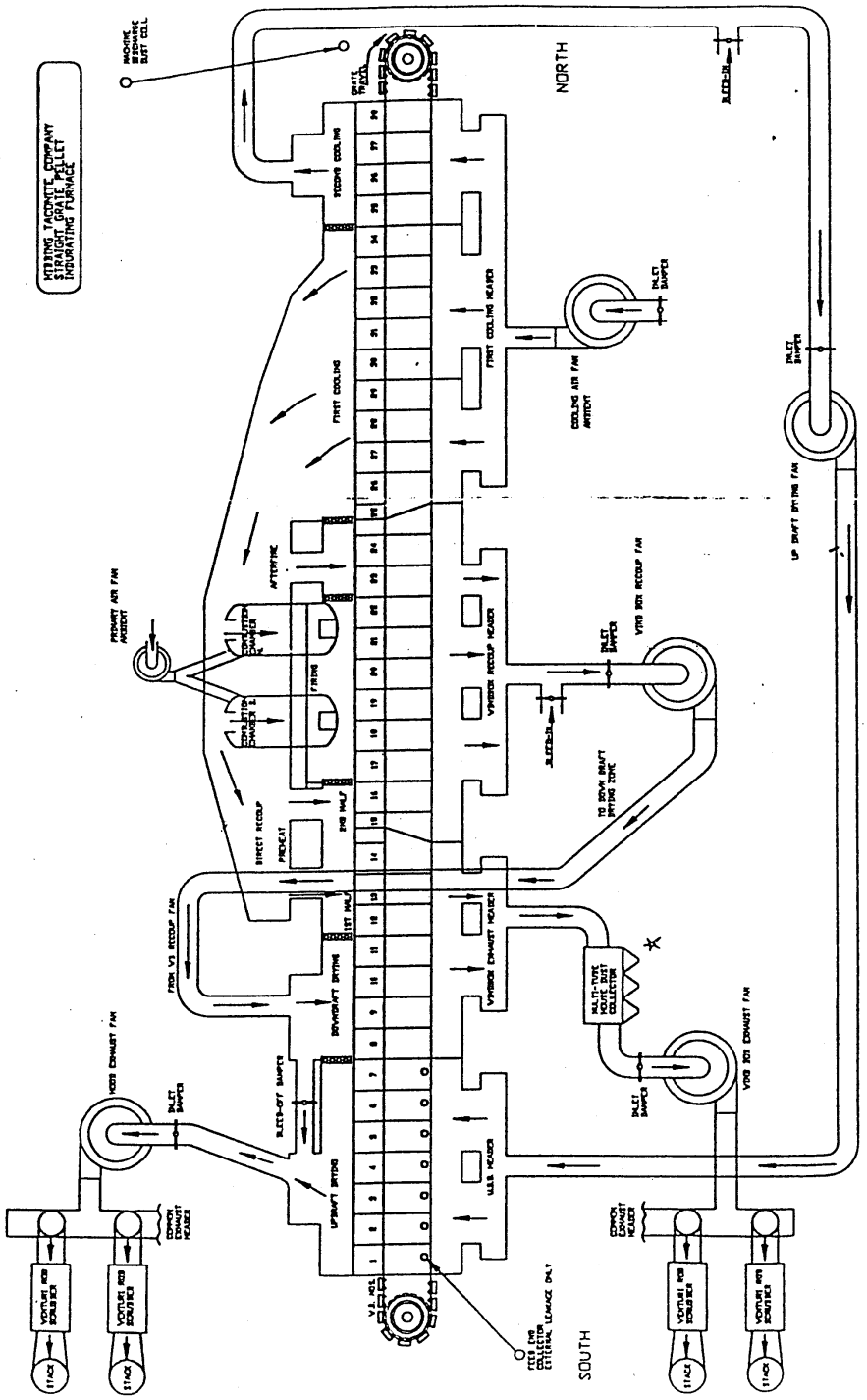

Figure 2-6. A Schematic of a Straight Grate Indurating Furnace

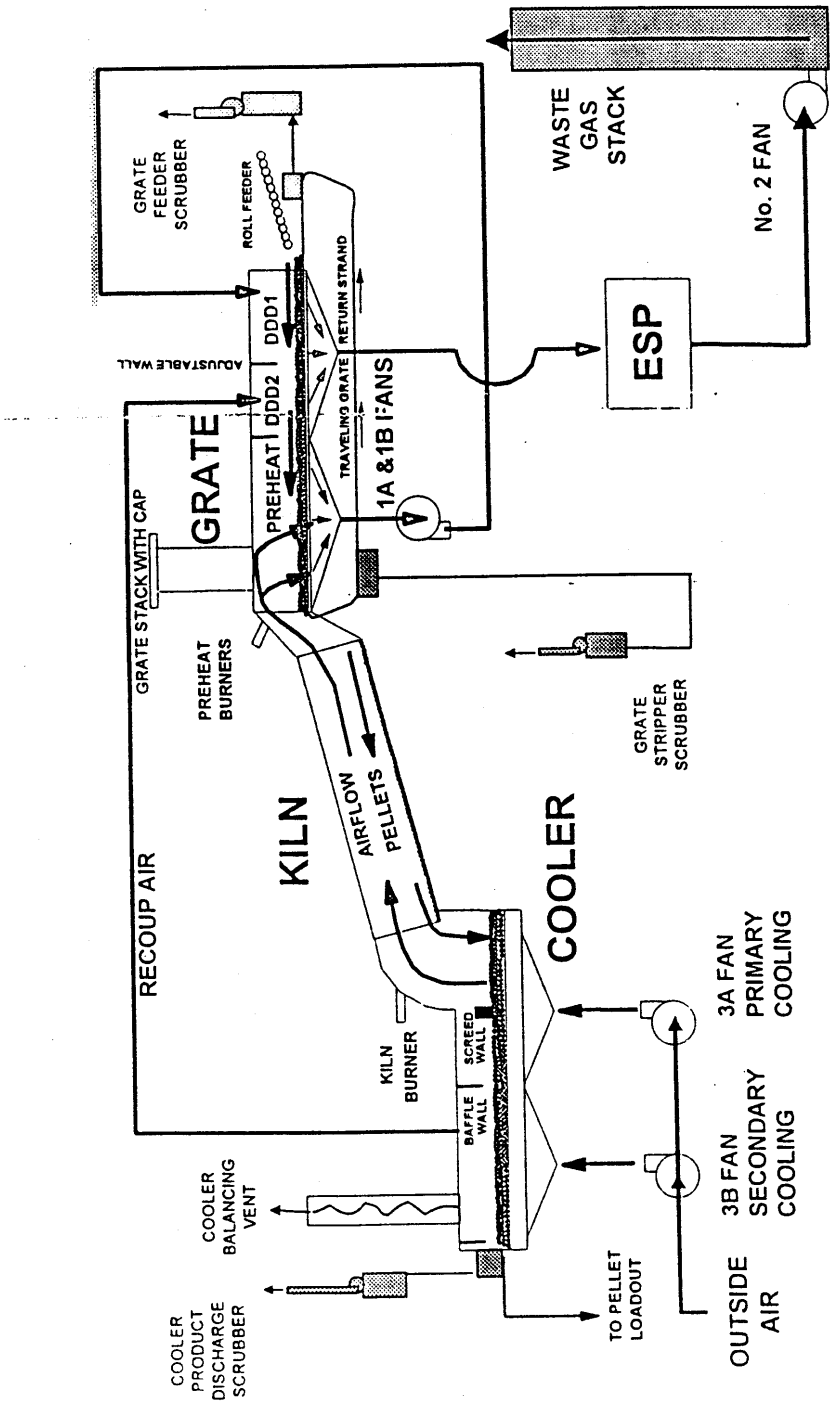

Figure 2-7. Grate-Kiln-Cooler General Arrangement

In addition to iron, standard pellets can include silica, alumina, magnesia, manganese, phosphorus, and sulfur. Fluxed pellets contain a certain amount of limestone (calcium carbonate, $CaCO_3$) and/or dolomite in addition to all the constituents of standard pellets. Sometimes fluxed pellets are characterized by basicity ratio, which is a mass ratio of the sum of calcium oxide and magnesium oxide divided by the sum of silicon oxide and aluminum oxide:

$$\text{Basicity ratio} = [(CaO + MgO)/(SiO_2 + Al_2O_3)]$$

Fluxed pellets of at least 1.0 basicity ratio are called fully fluxed pellets. Fluxed pellets' share of total pellet production was 61.5 percent in 1999 while the total pellet production was 57.1 million tons.

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

Manganese, phosphorus (apatite), cobalt, copper, vanadium, and small quantities of silver and gold are the by-products or co-products of U.S. iron ores. Manganese has a close association with iron so that the oxides of both metals are usually smelted together. Cobalt was an important by-product of iron ore mined in Pennsylvania until 1972. Both vanadium and cobalt are not economically recoverable (McKetta, 1988).

Iron ore is the only source of primary iron. Hematite (jaspilite), magnetite (taconite), goethite (limonite), siderite, ilmenite, and pyrite are the major types of iron ores mined. Hematite, magnetite, and goethite are the most common ore types in the United States. The main iron ore deposits in the United States are located in Michigan and Minnesota, which are primarily magnetite and hematite with a small amount of goethite. Other minor iron ore deposits located in Missouri and Utah are the possible substitutes for taconite. Besides domestic iron ores, imported iron ore products, such as iron-rich concentrates, fine ores, and pellets, are used as substitutes for taconite ore.

2.4 Costs of Production and Plant Size Efficiency

This section examines the costs of production as reported in the 1997 Economic Census of Mining for the iron ore industry, historical costs for the industry, and plant size efficiency. These figures are reported for NAICS 21221, Iron Ore Mining.

2.4.1 Costs of Production

The three primary types of production costs for the iron ore industry are capital expenditures, labor expenses, and cost of inputs used. Each of these cost categories is discussed below for the iron ore industry (U.S. Department of Commerce, Bureau of the Census, 1999).

- As shown in Table 2-4, capital costs in 1997 for the iron ore industry totaled approximately $91 million, or 5 percent of total production costs. Buildings and other structures accounted for $81 million (about 90 percent of capital costs) while $9 million (10 percent of these costs) can be attributed to mineral exploration and development. The expenditures for mineral land and rights amounted $0.1 million.

- The iron ore industry spent approximately $542 million in 1997 on labor for a total of 32 percent of total production costs. Twenty-seven percent of labor costs were spent on fringe benefits, and the remaining expenditures (about $394 million) went toward the annual payroll.

- Cost of inputs used for the iron ore industry totaled $1 billion in 1997. Supplies used, minerals received, and purchased machinery installation costs accounted for the most significant portion of this cost (approximately 58 percent). Other material costs included $117 million for fuel expenditures and about $259 million for purchased electricity.

2.4.2 Economies of Size

Table 2-5 provides information on the efficiency of plant size for facilities in NAICS 21221. Using the value added per production worker as a measure of efficiency, there are no apparent economies of size for the iron ore industry. As Table 2-5 shows, the overall value added per production worker hour was $64.20. For those facilities with five to nine employees, the value added per production worker hour peaked at $87.73. However, companies with 20 or more employees chose not to disclose data on their employment and annual payroll.

Table 2-4. Production Costs for NAICS 21221—Iron Ore Mining, 1997

	1997 (10^3)	Percentage of Total Cost of Production
Total Cost of Production	$1,677,400	100.0%
Total Capital Expenditures	$90,963	5.4%
Buildings and other structures	$81,437	4.9%
Mineral exploration and development	$9,420	0.6%
Mineral land and rights	$106	0.0%
Total Labor Expenditures	$541,771	32.3%
Annual payroll	$393,921	23.5%
Fringe benefits	$147,850	8.8%
Total Cost of Supplies	$1,044,666	62.3%
Supplies used, minerals received, and purchased machinery installed	$603,797	36.0%
Resales	NA	NA
Fuels	$117,001	7.0%
Purchased electricity	$258,971	15.4%
Contract work	NA	NA

NA = Not available.

Source: U.S. Department of Commerce, Census Bureau. 1999. *1997 Economic Census of Mining, Industry Series—Mining*. Washington, DC: Government Printing Office.

Table 2-5. Efficiency of Plant Size for Facilities in NAICS 21221—Iron Ore Mining, 1997

Employees	Establishments	Value Added by Manufacturer (10^3)	Number of Production Worker Hours (10^3)	Value Added/ Production Worker Hour
0 to 4 employees	9	1,382	17	$81.29
5 to 9 employees	3	1,930	22	$87.73
10 to 19 employees	8	8,313	124	$67.04
20 to 49 employees	1	NA	NA	NA
50 to 99 employees	1	NA	NA	NA
100 to 249 employees	2	NA	NA	NA
250 to 499 employees	2	NA	NA	NA
500 to 999 employees	3	NA	NA	NA
1,000 to 2,499 employees	3	NA	NA	NA
Total	32	983,940	15,326	$64.20

NA = Not available.

Source: U.S. Department of Commerce, Census Bureau. 1999. *1997 Economic Census of Mining, Industry Series—Mining.* Washington, DC: Government Printing Office.

SECTION 3

THE DEMAND SIDE

In addition to the supply side, estimating the economic impacts of the regulation on the taconite iron ore manufacturing industry requires characterizing various aspects of the demand for taconite pellets. This section describes the product characteristics desired by end users and possible substitutes for taconite pellets.

3.1 Uses and Consumers

3.1.1 Uses

Taconite pellets are primarily consumed by iron and steel producers. As Table 3-1 illustrates, almost all (98 percent) of the iron ore produced in the United States was used for manufacturing iron and steel in 1999. During the same year, integrated iron and steel plants consumed about 95 percent of domestic iron ore production. The use of iron ore in integrated iron and steel mills has been steadily decreasing since 1995. In addition to the taconite pellets consumed in the iron and steel industry, the remaining 2 percent of taconite ore production is used in manufacturing other commodities such as cement, heavy-medium materials, ballast, iron oxide pigments, high-density concrete, ferrites, specialty chemicals, and additives to animal feed (McKetta, 1988).

3.1.2 Consumer Characteristics

As of 1999, 60 percent of taconite pellet production was produced for captive use (Kirk, 1999b). That is, taconite ore is mined, processed into pellets, and used in company-owned blast furnaces to make iron and steel; the plants performing different steps in the process are owned by a single company or by related companies. For example, Ispat-Inland International N.V., USX Corporation, and Rouge Industries Incorporated have ownership interests in mines to ensure secure sources of iron ore for their integrated steel mills. Other

Table 3-1. U.S. Consumption of Iron Ore by End Use, 1993-1999 (10^3 metric tons)

End Use/Year	1999	1998	1997	1996	1995	1994	1993
Integrated Iron and Steel Plants	67,800	70,000	71,800	71,700	74,200	71,500	69,900
Blast furnaces	62,100	63,500	64,900	64,900	67,600	65,500	63,900
Steel furnaces	57	101	86	87	60	80	76
Sintering plants	5,840	6,330	6,660	6,670	6,490	5,770	5,790
Miscellaneous	2	48	146	58	29	103	86
Direct-reduced iron for steelmaking	2,420	2,400	752	684	675	716	441
Nonsteel End Uses	1,290	1,280	1,280	1,260	931	958	1,130
Total	71,500	73,600	73,800	73,300	75,800	73,200	71,500

Note: Because of rounding, numbers may not add up to the total.

Source: Kirk, W.S. 1994. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1994. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340494.pdf>.
Kirk, W.S. 1995. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1995. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340495.pdf>.
Kirk, W.S. 1996b. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1996. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340496.pdf>.
Kirk, W.S. 1997b. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1997. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340497.pdf>.
Kirk, W.S. 1998b. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1998. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340498.pdf>.
Kirk, W.S. 1999b. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1999. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340499.pdf>.

steel mills acquire iron ore pellets based on long-term contractual agreements with pellet producers. For instance, Geneva Steel Company purchases iron ore pellets from USX Corporation under a long-term pellet supply contract.

In 1997, 14 companies owned 20 operating integrated iron and steel facilities. All facilities have iron making, steel making, and casting operations. Table 3-2 lists the companies and their iron making operations. Five facilities are located in Ohio; four are in Indiana; two each are in Illinois, Alabama, and Michigan; and one each is in Kentucky, Maryland, Utah, Pennsylvania, and West Virginia. USX Corporation has the most

Table 3-2. Iron Making Capacity and Facility Location of U.S. Integrated Iron and Steel Companies (10^3 metric tons per year)

Company Name	Iron-Making Capacity (10^3 Mt/yr)	Facility Locations
Acme Metals Incorporated	907	Riverdale, IL
AK Steel Holdings Corporation	3,901	Ashland, KY; Middletown, OH
Bethlehem Steel Corporation	7,312	Burns Harbor, IN; Sparrows Pt., MD
Geneva Steel Company	2,384	Orem, UT
Gulf States Steel Incorporated[a]	998	Gadsden, AL
Ispat-Inland International N.V.	NA	East Chicago, IN
LTV Corporation	6,886	Cleveland, OH; East Chicago, IN
National Steel Corporation	5,384	Granite City, IL; Ecorse, MI
Renco Group Incorporated	1,325	Warren, OH
Rouge Industries Incorporated	2,662	Dearborn, MI
Republic International LLC	2,029	Lorain, OH
USX Corporation	10,641	Braddock, PA; Fairfield, AL; Gary, IN
Weirton Steel Corporation	2,449	Weirton, WV
WHX Corporation	1,953	Mingo Junction, OH
Total	48,831	

[a] Closed on August 2000 because of bankruptcy.

NA = Not available.

Source: U.S. Environmental Protection Agency (EPA). 2000. *Economic Impact Analysis of Proposed Integrated Iron and Steel.* Washington, DC: U.S. Environmental Protection Agency.
Association of Iron and Steel Engineers (AISE). 1998. 1998 Directory Iron and Steel Plants. Pittsburgh, PA: AISE.
U.S. Environmental Protection Agency (EPA). 1998. Update of Integrated Iron and Steel Industry Responses to Information Collection Request (ICR) Survey. Database prepared for EPA's Office of Air Quality Planning and Standards. Research Triangle Park, NC: U.S. Environmental Protection Agency.

production capacity for iron making, while Acme Metals Incorporated has the least capacity of all companies owning integrated facilities.

3.2 Product Characteristics

Pellets are usually the most desirable form of iron ore because they contribute the most to the productivity of the blast furnace. Pellets usually measure from 3/8 to 5/8 inch (9.55 to 16.0 millimeters) in diameter and contain 60 to 66 percent iron. In addition to iron, standard pellets can include silica, alumina, magnesia, manganese, phosphorus, sulfur, and moisture. Fluxed pellets contain a certain amount of limestone (calcium carbonate, $CaCO_3$), dolomite and/or lime (CaO) besides all the constituents of standard pellets. Table 3-3 lists the product characteristics for specific mines.

3.3 Substitution Possibilities in Consumption

Domestic iron ore production has been steady since 1990 although the steel demand has risen from 96 million metric tons in 1990 to 133 million metric tons in 1999 (a 39 percent increase). The need for domestic iron ore production in iron and steel making may decrease because of the growth of minimills and imports of iron ore substitutes. Iron ore substitutes for both integrated mills and minimills are steel mill products, scrap, pig iron, and direct reduced iron (DRI). Steel mill products are semi-finished steel, such as blooms, billets, and slabs, which must be finished before being shipped to consumers, and finished steel, which consumers may use as is. Besides the domestic steel mill products, imports of cheap semi-finished foreign steel are projected to rise to 10.1 million tons per year by 2003. This increase would decrease the need for iron ore pellets from Minnesota and Michigan (*Skillings Mining Review*, 2001). Pig iron is the product of blast furnaces and is used by integrated mills and to some extent by minimills. DRI is a product obtained by reducing iron ore to iron metal at temperatures below the melting point of iron. DRI is used as a scrap substitute in electric arc furnace steel making at minimills (Kirk, 1999b).

Table 3-3. Taconite Iron Ores and Pellets Characteristics by Mine, 2000

State	Company	Mine	Pelletizing Plant	Ore Grade (iron content per ton taconite)	Pellet Characteristics
Minnesota	EVTAC Mining, LLC	Eveleth[a]	Forbes[a]	23%	65.2% iron, 5.3% silica, 0.9% CaO
	Hibbing Taconite Co.	Hibbing[a]	Hibbing	31%	66.2% iron, 4.5% silica
	Ispat-Inland Steel Mining Co.	Virginia[a]	Virginia	25%	61.7% iron, 4.13% silica[f]
	LTV Steel Mining Co.[b]	Hoyt Lakes[a]	Hoyt Lakes	20%	65.3% iron, 5.1% silica
	National Steel Pellet Co.	Keewatin[c]	Keewatin	19%	65.2% iron, 4.4% silica, 0.7% CaO[d]
	Northshore Mining Co.	Babbitt[a]	Silver Bay[e]	25%	Standard: 65.1% iron, 4.8% silica, 2% limestone
					Fluxed: 63.2% iron, 4.0% silica, 4.0% CaO
	U.S. Steel Group of USX Corp. (Minntac)	Mountain Iron[a]	Mountain Iron	20%	63.6% iron, 4.3% silica, 1.0% basicity
Michigan	Empire Iron Mining Partnership	Palmer[f]	Palmer	21%	Standard: 63.8% iron, 5.5% silica, 0.33% CaO[f]
					Royal Fluxed: 59.7% iron, 5.4% silica, 4.8% CaO[f]
					Viceroy Fluxed: 58.5% iron, 5.4% silica, 6.4% CaO[f]
	Tilden Mining Co., LC	Ishpeming[f]	Ishpeming	Hematite: 36%	Hematite ore: 61.5% iron, 4.9% silica, 0.9% basicity
				Magnetite: 26% – 27%	Magnetite ore: 61.3% iron, 5.3% silica, 0.9% basicity

(continued)

[a] Located in Saint Louis County
[b] Closed its Hoyt Lakes, MN, operation in early 2001
[c] Located in Itasca County
[d] Information from American Iron Ore Association (2000)
[e] Located in Lake County
[f] Located in Marguette County

Table 3-3. Taconite Iron Ores and Pellets Characteristics by Mine, 2000 (continued)

Source: American Iron Ore Association. 2000. *Iron Ore: 1999 Statistical Report*. Cleveland: American Iron Ore Association.
U.S. Environmental Protection Agency (EPA). 2001. *National Emissions Standard for Hazardous Air Pollutants (NESHAPs) for Taconite Iron Ore Processing Plants—Background Information for Proposed Standards*. Washington, DC: U.S. Environmental Protection Agency.
U.S. Environmental Protection Agency (EPA). August 1994. *Technical Resource Document: Extraction and Beneficiation of Ores and Minerals*. Volume 3—Iron. Washington, DC: U.S. Environmental Protection Agency.
"US/Canadian Iron Ore Production 2001." *Skillings Mining Review* July 28, 2001. pp. 19-32.
"US/Canadian Iron Ore Production 2000." *Skillings Mining Review* July 29, 2000. pp. 21-36.
Kirk, W.S. 1999b. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1999. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340499.pdf>.

SECTION 4

INDUSTRY ORGANIZATION

This section identifies the characteristics of the taconite industry in the United States. The issues affecting this industry's organization are addressed at both the company and facility levels.

4.1 Taconite Manufacturing Facility Characteristics

Table 4-1 lists the nine taconite mining and pelletizing plants in the United States as of 2000. Seven of these operations were on the Mesabi Iron Range in northeastern Minnesota: EVTAC Mining LLC, Hibbing Taconite Company, Inland Steel Mining Company, LTV Steel Mining Company (closed its operation in Hoyt Lakes in early 2001) (Skillings Mining Review, 2001), National Steel Pellet Company, Northshore Mining Company, and the U.S. Steel Group of USX Corporation (Minntac). The other two operations, located on the Marquette Iron Range in the Upper Peninsula of Michigan, were the Empire and Tilden Mines (Kirk, 1999a). Figure 4-1 illustrates the locations of taconite facilities.

Besides the plant locations, Table 4-1 also provides information on plant annual capacity, year 2000 production, and employment. The total U.S. pellet production in 2000 was about 63 million metric tons and the workforce totaled 7,460 employees. These nine taconite mining operations in Michigan and Minnesota accounted for virtually all domestic iron ore production. The facilities operated by Cleveland-Cliffs produced 35 million metric tons in total, which was 56 percent of the total U.S. pellet production. Except for EVTAC Mining LLC and Inland Steel Mining Company, all the plants employed more than 500 people. Employment at these facilities ranged from 368 employees at Ispat-Inland Steel Mining Company to 1,586 employees at USX's Minntac operations. Data on plant locations and employment were obtained from the EPA (2001), Skillings Mining Review (2001), and Kirk (1999b).

Table 4-1. Taconite Iron Ore Facility Capacity and Production, 2000

	Mine	Pelletizing Plant	Annual Capacity (metric tons)	2000 Production	Employment
					477
					790
					368
					1,400
					529
U.S. Steel Group of USX Corp. (Minntac)	Mountain [a]	Mountain Iron			517
					1,586
					1,003
					799
					7,469

. Washington, DC: U.S. Environmental Protection Agency.

<http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340499.pdf>.

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Figure 4-1. Locations of Taconite Iron Ore Processing Facilities

4.2 Firm Characteristics

Facilities comprise a site of land with a plant and equipment that combine inputs (taconite iron ore) to produce output (taconite pellets). Companies owning these facilities are legal business entities that have the capacity to conduct transactions and make business decisions that affect that facility. The terms establishment, facility, and plant are synonymous in this study and refer to the physical location where products are manufactured. Likewise, the terms company and firm are synonymous and refer to the legal business entity that owns one or more facilities. This section presents information on the parent companies that own the taconite mining and pelletizing plants identified in the previous section.

4.2.1 Ownership

As discussed in Section 4.1, ten companies operated nine mining and pelletizing facilities in 2000. Table 4-2 lists companies that own and/or operate these facilities. With five facilities, Cleveland-Cliffs operates more plants that produce taconite pellets than any other domestic manufacturer.

As Table 4-2 shows, most iron ore mines are captive wholly owned subsidiaries of one or more steel-producing companies. Some of the pellets are also produced for commercial purposes. In 1999, about 60 percent of domestic ore was produced for captive mines and did not reach the open market (Kirk, 1999a). For example, Ispat-Inland Steel Mining Company obtains iron ore pellets directly from the Empire Mine in Michigan and Minorca Mine in Minnesota, in which it has ownership interests. Stelco Incorporated has ownership interests in EVTAC Mining Company, Hibbing Taconite Company, and Tilden Mine to ensure secure sources of iron ore for its integrated steel companies. Other steel mills acquire iron ore pellets based on long-term contractual agreements with pellet producers. For instance, Geneva Steel Company purchases iron ore pellets from USX Corporation under a long-term pellet supply contract.

4.2.2 Size Distribution

Company sales and employment ranges are reported in Table 4-3. Most companies are large, publicly owned integrated steel companies, such as AK Steel Corporation, Bethlehem Steel Corporation, Ispat International N.V., LTV Corporation, and USX Corporation. Two companies have sales volumes less than $1 billion, six between $1 to $5 billion, and two with more than $5 billion. Five companies have fewer than 10,000 employees and the other five companies employ 10,000 or more people. Sales and employment data were collected from Hoover's Online and complemented with information from InfoUSA.

4.2.3 Horizontal and Vertical Integration

Whether a firm in this industry is vertically or horizontally integrated depends on the nature of the primary business activity that the parent company does. Vertically integrated firms may produce the inputs used in their production process or use the product as an input into other production processes. These firms may own several plants and/or operate many

Table 4-2. Taconite Iron Ore Facility Operator and Ownership, 2000

State	Company	Operator	Ownership	Share (%)
Minnesota	EVTAC Mining, LLC	Independent	Eveleth Taconite Co.[a]	45
			Virginia Horn Taconite Co.[b]	40
			Ontario Eveleth Taconite Co.[c]	15
	Hibbing Taconite Co.	Cleveland-Cliffs	Cleveland-Cliffs	15
			Bethlehem Steel Corp.	70
			Stelco Inc.	15
	Ispat-Inland Steel Mining Co.	Ispat Inland, Inc.	Ispat International N.V.	100
	LTV Steel Mining Co.[d]	Cleveland, Cliffs	The LTV Corp.	NA
			Cleveland-Cliffs	NA
	National Steel Pellet Co.	National Steel Corp.	National Steel Corp.	100
	Northshore Mining Co.	Cleveland Cliffs	Cleveland-Cliffs	100
	U.S. Steel Group of USX Corp. (Minntac)	U.S. Steel	USX Corporation	100
Michigan	Empire Iron Mining Partnership	Cleveland Cliffs	Cleveland-Cliffs	35
			Ispat International N.V.	40
			The LTV Corp.	25
	Tilden Mining Co., LC	Cleveland Cliffs	Cleveland-Cliffs	40
			Algoma Steel Inc.	45
			Stelco Inc.	15

[a] Owned by Rouge Steel Company
[b] Owned by AK Steel Holding Corporation
[c] Owned by Stelco Incorporated
[d] Closed its Hoyt Lakes, MN, operation in early 2001
NA = Not available.

Source: U.S. Environmental Protection Agency (EPA). 2001. *National Emissions Standard for Hazardous Air Pollutants (NESHAPs) for Taconite Iron Ore Processing Plants—Background Information for Proposed Standards.* Washington, DC: U.S. Environmental Protection Agency.
"Hibbing Taconite Resumes Operations." *Skillings Minings Review* August 4, 2001. pp. 7.
"US/Canadian Iron Ore Production 2001." *Skillings Mining Review* July 28, 2001. pp. 19-32.
"US/Canadian Iron Ore Production 2000." *Skillings Mining Review* July 29, 2000. pp. 21-36.
Kirk, W.S. 1999b. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1999. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340499.pdf>.
U.S. Securities and Exchange Commission. Electronic Data Gathering, Analysis, and Retrieval (EDGAR) System.
Hoover's Online. Electronic database. <http://www.hoovers.com/>. Obtained on August 28, 2001.

Table 4-3. Taconite Iron Ore Facility Owner Company Sales and Employment, 2000

Owner Company	Legal Form of Organization	Sales (10^6)	Employment
Algoma Steel Inc.	Public	749	3,700
Bethlehem Steel Corp.	Public	4,197	14,700
Cleveland-Cliffs	Public	430	4,636
Eveleth Taconite Co.[a]	Public	1,100	2,881
Ispat International N.V.	Public	5,097	17,800
National Steel Corp.	Public subsidiary	2,979	9,283
Stelco Inc.	NA	1,893	9,922
The LTV Corp.	Public	4,934	16,500
USX Corp.	Public	6,132	30,892
Virginia Horn Taconite Co.[b]	Public	4,612	11,500

[a] Owned by Rouge Steel Company
[b] Owned by AK Steel Holding Corporation

NA = Not available.
Source: U.S. Environmental Protection Agency (EPA). 2001. *National Emissions Standard for Hazardous Air Pollutants (NESHAPs) for Taconite Iron Ore Processing Plants—Background Information for Proposed Standards*. Washington, DC: U.S. Environmental Protection Agency.
"US/Canadian Iron Ore Production 2001." *Skillings Mining Review* July 28, 2001. pp. 19-32.
Stelco Inc. website. <http://www.stelco.com/>. Obtained on August 28, 2001.
Hoover's Online. Electronic database. <http://www.hoovers.com/>. Obtained on August 28, 2001.

subsidiaries, each of which handles a different stage of production or directly or indirectly produces an input or product. In the taconite industry, captive iron ore producers are parts of vertically integrated iron and steel operations. For example, Ispat-Inland Steel Mining Company, National Steel Corporation, and USX Corporation use taconite pellets produced by taconite operations they own in their integrated steel operations to produce iron and steel. Most of the companies in Table 4-2 are vertically integrated.

However, vertical and horizontal integration are not mutually exclusive. A corporation may be both vertically integrated and horizontally integrated. Perceiving a firm as horizontally or vertically integrated depends on vantage point. The above companies can be seen as vertically integrated because one subsidiary feeds an input into another. In its pure form, horizontal integration is the situation in which one company produces various, unrelated products rather than specializing in one particular product. Companies that are not

integrated either horizontally or vertically produce only one type of product or set of closely related products. The smaller companies involved in manufacturing taconite ore products are, for the most part, not integrated; they produce a sole product without having forward or backward corporate linkages. These companies purchase inputs from outside suppliers, not of their corporate tree. Then they manufacture the product and sell it either directly to consumers or through wholesalers.

4.3 Small Businesses in the Taconite Industry

To determine the possible impacts of the proposed NESHAP on small businesses, businesses producing taconite are categorized as small or large using the Small Business Administration's (SBA's) general size standards definitions. For NAICS 21221, these guidelines indicate a small business employs 500 or fewer workers (U.S. Small Business Administration, 2000). Based on the SBA definition and the company employment shown in Table 4-3, this industry has no small businesses.

4.4 Market Structure

Market structure is of interest because it determines the behavior of producers and consumers in the industry. If an industry is perfectly competitive, then individual producers are not able to influence the price of the outputs they sell or the inputs they purchase. This condition is most likely to hold if the industry has a large number of firms, the products sold are undifferentiated, and entry and exit of firms are unrestricted. Product differentiation can occur both from differences in product attributes and quality and from brand name recognition of products. Entry and exit of firms are unrestricted for most industries except, for example, in cases when government regulates who is able to produce, when one firm holds a patent on a product, when one firm owns the entire stock of a critical input, or when a single firm is able to supply the entire market.

When compared across industries, firms in industries with fewer firms, more product differentiation, and restricted entry are more likely to be able to influence the price they receive for a product by reducing output below perfectly competitive levels. This ability to influence price is referred to as exerting market power. At the extreme, a single monopolistic firm may supply the entire market and hence set the price of the output.

4.4.1 Measures of Industry Concentration

To assess the competitiveness of a market, economists often estimate four-firm concentration ratios (CR4), eight-firm concentration ratios (CR8), and Herfindahl-Hirschmann Indexes (HHI) for the subject market or industry. The CR4 and CR8 ratios measure the percentage of sales accounted for by the top four and eight firms in the industry, respectively. The HHI is the sum of the squared market shares of firms in the industry. Unfortunately, there is no objective criterion for determining market structure based on the values of concentration ratios alone. However, economists do have criteria for determining market structure based on the HHIs as provided in the 1997 Department of Justice's revised Horizontal Merger Guidelines (U.S. Department of Justice and the Federal Trade Commission, 1997). 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). 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. Tables 4-1 and 4-2 provide data on the market share that each company holds in terms of pellet production and company ownership share. With fewer than a dozen owner companies, many of them vertically integrated, and with significant barriers to entry, the taconite industry is likely fairly concentrated. However, there is no publicly available market concentration statistics available for the taconite iron ore industry.

4.4.2 Geographic Concentration

As Table 4-1 and Figure 4-1 illustrate, the taconite mining and processing facilities are located in either Minnesota or Michigan. In Minnesota, all of the iron ore production comes from the Mesabi Range, located in Itasca (1990 population: 43,392), Lake (10,707), and Saint Louis (196,414) Counties. In Michigan, the production is from the Empire and the Tilden Mines in Marquette County (1990 population: 62,017). The geographic location of the nine taconite facilities indicates that the potential impact of the proposed rule on regional employment and economy will be concentrated in the four counties mentioned above. Based on the information from Cleveland-Cliffs, the Empire and Tilden Mines have a local economic impact of $390 million per year. The Hibbing Taconite and Northshore Mining Companies have an economic impact of more than $400 million per year on the local economy (Cleveland-Cliffs, 2001).

4.5 Current Trends in the Taconite Industry

U.S. iron ore production in 2000 totaled 61.6 million metric tons. Steel making accounted for about 98 percent of domestic iron ore consumption (Kirk, 2001a). From 1992 to 1997, the production of usable iron ore trended upward from 55.6 million metric tons to about 63.0 million metric tons, an average growth rate of 2.6 percent. The production of iron ore decreased 8 percent in 1999, compared with 1998 production (Kirk, 1999b). The LTV Steel Mining Company closed its taconite mining operation in Hoyt Lakes in early 2001, which may lead to an 8 million metric ton deduction in annual total iron ore production. Besides production, consumption of domestic iron ore has declined since 1995 by an average of 2.5 percent per year.

The U.S. steel industry is experiencing structural changes that have the potential to affect the domestic iron ore industry. Some of the integrated steel makers use iron ore as feedstock to produce direct reduced iron. The feedstock for direct reduced iron produced domestically is imported. The minimills use iron and steel scrap and direct reduced iron, and their shares of the steel market has increased steadily, rising from 15 percent in 1970 to about 50 percent in 2000. This trend is expected to continue and will affect the domestic iron ore industry negatively (McGraw-Hill, 2000).

SECTION 5

MARKETS

This section examines the historical market statistics and future trends and projections for the taconite pellet industry. Historical data for this industry are provided for domestic production and consumption, domestic prices, and foreign trade in iron ore pellets. The future trends section focuses on projected demand and employment for the taconite pellet industry.

5.1 Historical Market Data

This section provides data on historical quantities of iron ore produced and consumed in the United States, the quantities imported and exported, and prices.

5.1.1 Domestic Production

Table 5-1 presents the data on the quantities of iron ore production from 1990 to 1999, including crude ore, usable ore, and pellet productions. However, data on crude ore and usable ore production for 1999 were not available. The domestic production of crude ore ranged from a low of 180 million metric tons in 1993 to a high of 213 million metric tons in 1998. Of the crude ore mined, 30 percent could be processed into usable ore. The domestic pellet production in 1999, at 57 million metric tons, fell by 8 percent because the United Steel Workers of America labor contract expired on July 31, 1999 and a number of producers closed their operations temporarily (Kirk, 1999b). The domestic production of pellets ranged from a low of 54 million metric tons in 1992 to a high of 62 million metric tons in 1998.

5.1.2 Domestic Consumption

Table 5-1 also shows the domestic consumption of iron ore products. In 1999, consumption was 75.1 million metric tons, including both iron ore and agglomerates (pellets and sinter). During the same year, the integrated iron and steel producers consumed 71.1 million metric tons of iron ore products. Of the ore consumed, 84 percent was of domestic

Table 5-1. Domestic Production and Consumption of Iron Ore, 1990-1999 (10^3 metric tons)

Year	Crude Ore	Usable Ore	Pellet Production	Consumption[a]
1990	181,431	56,405	54,817	76,900
1991	183,774	56,758	54,777	66,400
1992	184,600	55,589	54,196	75,100
1993	180,896	55,657	54,497	76,800
1994	191,989	58,378	57,579	80,200
1995	209,988	62,485	61,397	83,100
1996	207,988	62,069	61,096	79,600
1997	208,743	62,968	62,075	79,500
1998	213,357	62,927	62,128	78,200
1999	NA	NA	57,512	75,100

[a] Includes iron ore and agglomerates (pellets and sinter)

NA = Not available.

Source: American Iron Ore Association. 2000. *Iron Ore: 1999 Statistical Report*. Cleveland: American Iron Ore Association.
"US/Canadian Iron Ore Production 2000." Skillings Mining Review. July 29, 2000. pp. 21-36.
Kirk, W.S. 1994. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1994. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340494.pdf>.
Kirk, W.S. 1995. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1995. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340495.pdf>.
Kirk, W.S. 1996b. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1996. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340496.pdf>.
Kirk, W.S. 1997b. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1997. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340497.pdf>.
Kirk, W.S. 1998b. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1998. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340498.pdf>.
Kirk, W.S. 1999b. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1999. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340499.pdf>.

origin, 8 percent was imported from Canada, and 8 percent came from other countries (Kirk, 1999b). The domestic consumption of iron ore ranged from a low of 66.4 million metric tons in 1991 to a high of 83.1 million metric tons in 1995. Iron ore consumption has declined since 1995 by an average of 2.5 percent per year.

5.1.3 Domestic Prices

One of the major structural changes in the domestic iron ore industry occurred in 1982 with the development of a U.S. spot market for pellets, which led to the beginning of price competition. As a result of the spot market for pellets, domestic iron ore producers lowered prices to make domestic ore competitive with imported material and also reduced production costs by improving labor productivity, reducing wages, negotiating lower-cost power contracts and royalty agreements, pressing suppliers to reduce prices for materials, lobbying legislators for tax breaks, and paying off debt (Kirk, 1998b).

Most spot sales are individually negotiated one-time contacts made directly between buyer and seller. The domestic prices of iron ore products from 1990 through 1999 are presented in both current and 2000 dollars in Table 5-2. Adjusted prices in 2000 dollars for iron ore products range from a low of $25.51 per metric ton in 1999 to a high of $31.61 per metric ton in 1992. Between 1993 and 1998, the adjusted price never went above $30 per metric ton. In addition to vertically integrated production and the spot market, long-term contracts (mentioned above) affect prices. The prices at which iron ore products change hands under long-term contracts are frequently tied to movement in the spot market price or the world price. The low spot market price in 1999 coincided with increased imports of pig iron, DRI, and semifinished steel, reducing the demand for domestic iron ore. Steel producers increased their use of imports because it allowed them to increase steel production in response to cyclical increases in steel demand without having to increase their blast furnace production, reopen idled blast furnaces, and hire new personnel.

5.1.4 Foreign Trade

Table 5-3 provides data on the quantities and dollar values of imported iron ore products from 1990 through 2000. The average volume of imported iron ore products during that period was slightly more than 16 million metric tons per year. The average dollar value of iron ore imports between 1990 and 2000 was slightly more than $500 million per year in constant 2000 dollars. Because of declining quantity and price, 1999 imports were valued at less than $400 million. While the import price continued to fall in 2000, the quantity increased slightly so that the value of imported iron ore products in 2000 was approximately $420 million. In 1999, the value of imported iron ore products per metric ton was $27.95 in 2000 dollars. During the same year,

Table 5-2. Historical Prices of Iron Ore Products, 1990-1999

Year	Shipments (10^3 metric tons)	Value of Shipments ($10^3)	Average Value per Metric Ton[a]	
			Current $	$2000
1990	57,000	1,570,000	27.54	31.46
1991	56,800	1,530,000	26.94	30.58
1992	55,600	1,550,000	27.88	31.61
1993	56,300	1,380,000	24.51	28.03
1994	57,600	1,410,000	24.48	28.00
1995	61,100	1,700,000	27.82	28.71
1996	62,200	1,750,000	28.14	27.61
1997	62,800	1,860,000	29.62	29.18
1998	63,200	1,970,000	31.17	30.97
1999	60,700	1,550,000	25.54	25.51

[a] Average value per metric ton = value of shipments/shipments.

Source: Kirk, W.S. 1994. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1994. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340494.pdf>.
Kirk, W.S. 1995. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1995. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340495.pdf>.
Kirk, W.S. 1996b. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1996. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340496.pdf>.
Kirk, W.S. 1997b. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1997. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340497.pdf>.
Kirk, W.S. 1998b. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1998. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340498.pdf>.
Kirk, W.S. 1999b. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1999. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340499.pdf>.
Bureau of Labor Statistics. "Producer Price Index Revision—Current Series: PCU1011#, Iron Ores: 1990-2000." <http://www.146.142.4.24/servlet/surveyoutputservlet?output?>.

about 52 percent of the imports were from Canada, followed by 34 percent from Brazil (see Table 5-5). As shown in Table 5-6, pellets and fine ores were the two major types of imported products.

Table 5-3. U.S. Imports for Consumption and Value of Imports of Iron Ore Products, 1990-2000 (10^3)

Year	Imports (10^3 metric tons)	Value of Imports		Value of Imports per Metric Ton[a]	
		Current $	$2000	Current $	$2000
1990	18,082	559,534	639,176	30.94	35.35
1991	13,331	436,607	495,736	32.75	37.19
1992	12,501	395,618	448,654	31.65	35.89
1993	13,981	415,063	474,719	29.69	33.95
1994	17,552	509,887	583,171	29.05	33.23
1995	17,509	485,846	501,329	27.75	28.63
1996	18,382	555,953	545,496	30.24	29.68
1997	18,599	551,035	542,940	29.63	29.19
1998	17,009	527,059	523,713	30.99	30.79
1999	14,244	398,527	398,103	27.98	27.95
2000	15,677	420,046	420,046	26.79	26.79

Source: U.S. International Trade Commission. "SIC-1011: FAS Value by FAS Value for All Countries." <http://dataweb.usitc.gov>.
U.S. International Trade Commission. "SIC-1011: Customs Value by Customs Value for All Countries." <http://dataweb.usitc.gov>.
Bureau of Labor Statistics. "Producer Price Index Revision—Current Series: PCU1011#, Iron Ores: 1990-2000." <http://www.146.142.4.24/servlet/surveyoutputservlet?output?>.

Overall, the volume of exported iron ore products is much lower than the volume of imported iron ore products, and the price per metric ton is higher. As Table 5-4 presents, the average volume of exported iron ore products during that period was slightly more than 5 million metric tons per year. The average dollar value of iron ore exports between 1990 and 2000 was slightly more than $200 million dollars per year in constant 2000 dollar terms. During that period, the quantities of exports increased by 7 percent. In 1999, most exported iron ore products went to Canada (99 percent), and small amounts were exported to Mexico and other countries (see Table 5-5). The major exported product was pellets, as shown in Table 5-6.

Table 5-4. U.S. Domestic Exports and Value of Exports of Iron Ore Products, 1990-2000 (10^3)

Year	Exports (10^3 metric tons)	Value of Exports		Value of Exports per Metric Ton[a]	
		Current $	$2000	Current $	$2000
1990	3,181	123,236	140,777	38.75	44.26
1991	4,045	156,197	177,351	38.62	43.85
1992	5,055	186,814	211,858	36.95	41.91
1993	5,060	166,805	190,779	32.97	37.71
1994	4,972	162,468	185,819	32.67	37.37
1995	5,267	184,459	190,338	35.02	36.14
1996	6,256	231,701	227,343	37.04	36.34
1997	6,336	234,894	231,443	37.07	36.53
1998	5,994	244,473	242,921	40.79	40.53
1999	6,120	242,962	242,704	39.70	39.66
2000	6,146	245,953	245,953	40.02	40.02

Source: U.S. International Trade Commission. "SIC-1011: FAS Value by FAS Value for All Countries." <http://dataweb.usitc.gov>.
U.S. International Trade Commission. "SIC-1011: Customs Value by Customs Value for All Countries." <http://dataweb.usitc.gov>.
Bureau of Labor Statistics. "Producer Price Index Revision—Current Series: PCU1011#, Iron Ores: 1990-2000." <http://www.146.142.4.24/servlet/surveyoutputservlet?output?>.

5.2 Trends and Projections

In 2000, iron ore was produced in about 50 countries. The seven largest of these producing countries accounted for 77 percent of the world total (1 billion metric tons), and no other country had as much as a 5 percent share (Kirk, 1999b). The U.S. iron ore production in 2000 totaled 61.6 long tons or 6 percent of the world total.

The majority of U.S. iron ore trade involves Canada. Since 1990, about 52 percent of U.S. imports were from Canada, and 99 percent of U.S. exports were shipped there (Kirk, 1999b). The iron ore mines and most of the integrated steel industry are close to the Great

Table 5-5. Value of Imports for Consumption and Exports of Iron Ore by Country, 1999 (10^3)

	Value	Share
Imports from:		
Australia	$8,430	2.1%
Brazil	$138,000	34.6%
Canada	$207,000	51.8%
Chile	$1,300	0.3%
Peru	$918	0.2%
Sweden	$13,300	3.3%
Venezuela	$21,100	5.3%
Others	$9,320	2.3%
Total	$399,368	100.0%
Exports to:		
Canada	$242,000	99.4%
Mexico	$190	0.1%
Others	$1,270	0.5%
Total	$243,460	100.0%

Source: Kirk, W.S. 1999b. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1999. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340499.pdf>.

Lakes, which offers low-cost transportation and helps U.S. ore producers have a competitive advantage. However, each iron ore producer is aware that it must reduce costs substantially to compete with foreign producers.

The domestic pellet industry is experiencing a serious decline in demand for its products and is projecting a tonnage decrease of at least 10 to 15 percent from the 2000 levels as a result of the massive imports of foreign steel (Skillings Mining Review, 2001). The massive imports of foreign steel, mainly cheap semi-finished steel slabs and pig iron, reduces demand for domestic metallic iron. This in turn reduces the need for iron pellets from the mines in Minnesota and Michigan.

Table 5-6. Value of Imports and Exports of Iron Ore by Type of Product, 1999 (10^3)

Type of Product	Imports	Exports
Concentrates	1,440	30
Coarse ores	318	0
Fine ores	3,390	17
Pellets	8,230	6,050
Briquettes	195	<0.5
Other agglomerates	676	21
Roasted pyrites	11	4
Total	14,260	6,122

Source: Kirk, W.S. 1999b. "Iron Ore." U.S. Geological Survey Minerals Yearbook-1999. <http://minerals.usgs.gov/minerals/pubs/commodity/iron_ore/340499.pdf>.

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