Volume 5-Chapter 11

REGIONAL ENERGY SYSTEMS AND POTENTIAL COPPER-NICKEL DEVELOPMENT IMPACTS

Minnesota Environmental Quality Board
Regional Copper-Nickel Study
Author: Mark Donaldson*

*Please contact Royden E. Tull regarding questions or comments on this chapter of the report.

REGIONAL COPPER-NICKEL STUDY REPORT OUTLINE

A NOTE ABOUT UNITS

This report, which in total covers some 36 chapters in 5 volumes, is both international and interdisciplinary in scope. As a result, the problem of an appropriate and consistent choice of units of measure for use throughout the entire report proved insurmountable. Instead, most sections use the system of units judged most common in the science or profession under discussion. However, interdisciplinary tie-ins complicated this simple objective, and resulted in the use of a mix of units in many sections. A few specific comments will hopefully aid the reader in coping with the resulting melange (which is a reflection of the international multiplicity of measurement systems):

1) Where reasonable, an effort has been made to use the metric system (meters, kilograms, kilowatt-hours, etc.) of units which is widely used in the physical and biological sciences, and is slowly becoming accepted in the United States.

2) In several areas, notably engineering discussions, the use of many English units (feet, pounds, BTU's, etc.) is retained in the belief that this will better serve most readers.

3) Notable among the units used to promote the metric system is the metric ton, which consists of 2205 pounds and is abbreviated as mt. The metric ton (1000 kilograms) is roughly 10% larger (10.25%) than the common or short ton (st) of 2000 pounds. The metric ton is quite comparable to the long ton (2240 pounds) commonly used in the iron ore industry. (Strictly speaking, pounds and kilograms are totally different animals, but since this report is not concerned with mining in outer space away from the earth's surface, the distinction is purely academic and of no practical importance here).

4) The hectare is a unit of area in the metric system which will be encountered throughout this report. It represents the area of a square, 100 meters on a side (10000 m^2), and is roughly equivalent to 2½ acres (actually 2.4710 acres). Thus, one square mile, which consists of 640 acres, contains some 259 hectares.

The attached table includes conversion factors for some common units used in this report. Hopefully, with these aids and a bit of patience, the reader will succeed in mastering the transitions between measurement systems that a full reading of this report requires. Be comforted by the fact that measurements of time are the same in all systems, and that all economic units are expressed in terms of United States dollars, eliminating the need to convert from British Pounds, Rands, Yen, Kawachas, Rubles, and so forth!

Conversions for Common Metric Units Used in the Copper-Nickel Reports

1 meter	=	3.28 feet = 1.094 yards
1 centimeter	=	0.3937 inches
1 kilometer	=	0.621 miles
1 hectare	=	10,000 sq. meters = 2.471 acres
1 sq. meter	=	10.764 sq. feet = 1.196 sq. yards
1 sq. kilometer	=	100 hectares = 0.386 sq. miles
1 gram	=	0.037 oz. (avoir.) = 0.0322 Troy oz.
1 kilogram	=	2.205 pounds
1 metric ton	=	1000 kilograms = 0.984 long tons = 1.1025 short tons
1 m^3	=	1.308 yd^3 = 35.315 ft^3
1 liter	=	0.264 U.S. gallons
1 liter/minute	=	0.264 U.S. gallons/minute = 0.00117 acre-feet/day
1 kilometer/hour	=	0.621 miles/hour
degrees Celsius	=	(5/9)(degrees Fahrenheit -32)

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Volume 5-Chapter 11 REGIONAL ENERGY SYSTEMS AND POTENTIAL COPPER-NICKEL DEVELOPMENT IMPACTS

11.1 INTRODUCTION AND SUMMARY OF FINDINGS

Faced with inherent energy problems due to ore grade location and climate, the potential impact of copper-nickel development in northeastern Minnesota on the state's energy situation will be significant. The pending curtailments of Canadian supplies of natural gas and crude oil and the problems associated with shipment of coal and electrical energy will be further affected by copper-nickel development and its related population growth in the Study Area.

The energy demand of a copper-nickel mine/mill operation will be large; it will be on the same order as a similarly-sized taconite operation. The smelting and refining phases of copper-nickel production, particularly nickel refining, are very energy intensive, but ever increasing energy costs are a tremendous incentive for the development of energy conserving metallurgical processes. The population growth resulting from development will add to energy demand in an area which will be especially vulnerable to Canadian energy curtailments.

The current regional energy situation is in a state of flux. Consumption is dominated by large users, particularly the taconite and pulp and paper industries. These sectors are in the process of converting their present operations from use of natural gas to coal use. Adding to the unsettled nature of the situation is the question of Canadian imports and the potential sources of replacement crude oil and natural gas sources. Erie Mining Company is developing an experimental coal gasification plant while the city of Virginia is converting a part of its municipal power generation facility to peat burning capability.

Energy consumption in 1976 was dominated by the Industrial sectors, with 60 percent of all non-gasoline energy use (see Table 2). The taconite industry had the largest 1976 consumption with about 31 percent of total Region III (northeastern Minnesota plus Douglas County, Wisconsin) energy use. The largest source of energy was coal, 33 percent of all energy consumed, followed by natural gas and fuel oil, 24 percent and 19 percent, respectively.

Projections of regional energy demand (without copper-nickel) through the year 2000, based on Minnesota Energy Agency model results (MEA 1978), indicate rapid growth in expected energy consumption of all sources with the exception of natural gas, which is expected to diminish from 49,000 billion Btu in 1976 to 29,300 billion Btu by 2000 (less than 60 percent the 1976 level). Coal use is expected to experience the greatest growth (about 3-fold) as the taconite and pulp and paper industries and the electrical utilities shift to coal from other energy sources. In 1976, coal made the largest contribution to meeting regional energy demand and by 2000, it is expected to expand its position as the largest source of energy in the region.

A single, fully integrated copper-nickel operation (mine, mill, smelter, and copper and nickel refineries) producing 100,000 metric tonnes per year of copper and nickel metal would require about 4,350 billion Btu of fossil fuels and about 1.04 billion kwhr of electricity annually. This represents 1.8 percent of projected 1985 baseline fuel demand and 10.4 percent of 1985 baseline demand for electricity. If, by the year 2000, there is the equivalent of 4 fully integrated operations in the region, copper-nickel demand would represent 4.9 percent and 30.4 percent of year 2000 fuel and electrical demand, respectively. As estimated by Minnesota Power and Light Company, the major supplier of electricity in the region, the electrical demands of copper-nickel under a large-scale development scenario would require construction of transmission lines, substation and generation capacity with a present value ($ 1979) of about $468 million.

The impacts of providing energy to potential copper-nickel development will be significant. The construction of fuel and electricity delivery systems will represent sizable disturbances to the economic and land use patterns of the regions. Indeed, the impacts of energy development will more than likely warrant separate environmental impact studies, particularly as regards electric transmission line routing and other major delivery systems. A complete energy study is beyond the scope of this report.

This report does, however, characterize in broad terms the present energy situation in the region (Minnesota Development Region 3 plus Douglas County, Wisconsin) and projects the trends in energy utilization through 2000. Against this background, the energy demands of potential copper-nickel development are placed in perspective.

11.2 REGIONAL ENERGY NETWORKS

The energy delivery system of northeastern Minnesota (Economic Development Region 3 plus Douglas County, Wisconsin) consists of natural gas, petroleum, and coal supply networks and electric utility plants and transmission lines. The regional energy networks are described below.

11.2.1 Natural Gas

Region III is served by three natural gas pipelines (Figure 1). Northern Natural Gas Company receives its gas supplies from wells in Texas, New Mexico, Oklahoma, Kansas, and Montana. The Northern Pipeline extends to the Twin Cities and northward to Duluth. From Duluth there is a branch that extends northeast to Two Harbors and one extending northwest to Hibbing and Virginia.

Figure 1

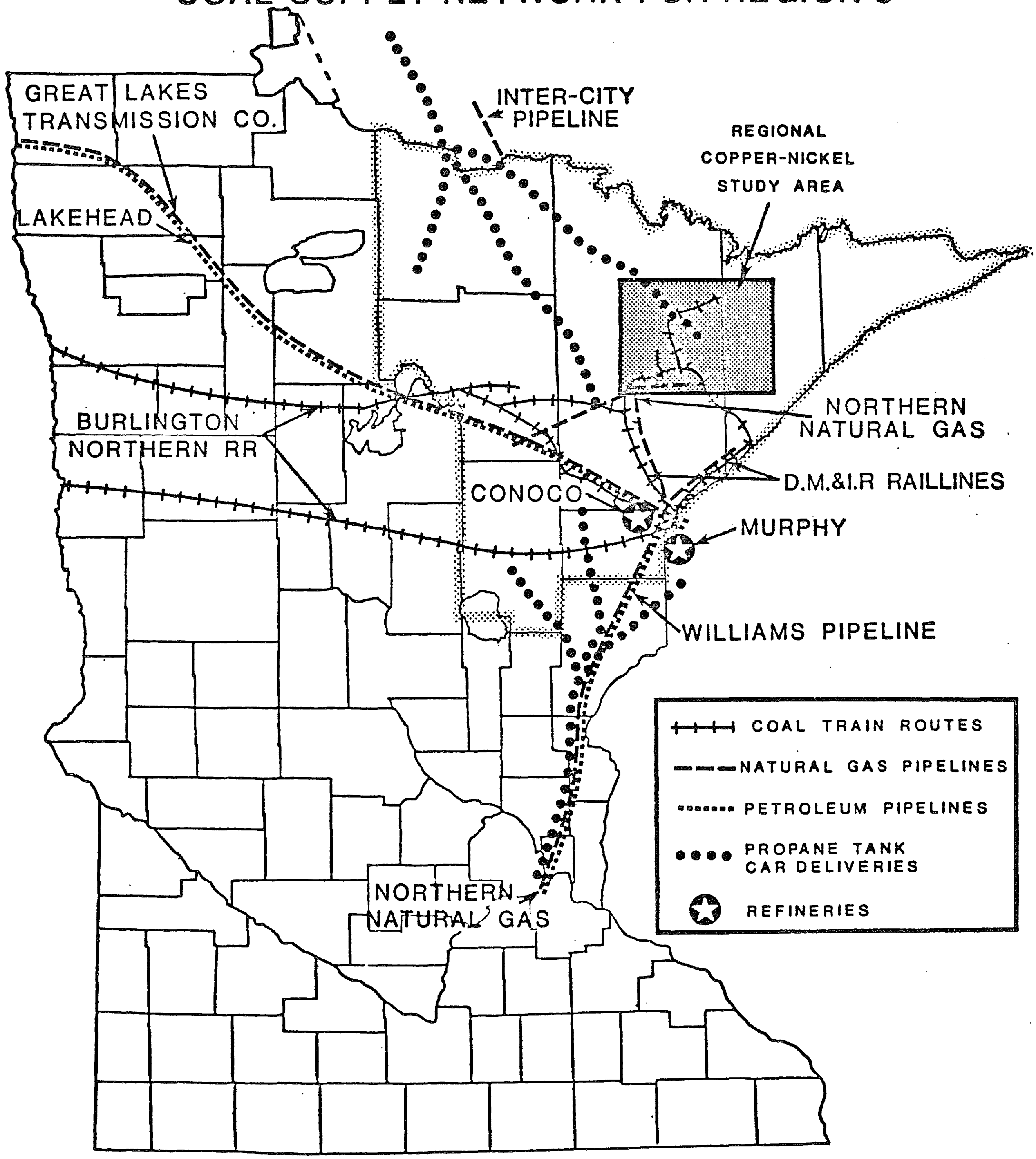
Inter-City Minnesota Pipelines, Ltd. and Great Lakes Gas Transmission Company both recieve their gas from Canada. The Inter-City pipeline barely extends into Minnesota and only serves the communities of International Falls and Ranier. The Great Lakes pipeline enters the state in the extreme northwest corner of the state and sweeps southeast to Duluth and Superior, Wisconsin. This pipeline serves Grand Rapids and Cloquet.

Natural Gas is distributed to all counties in Region III except Aitkin and Cook (breakdown of sales shown in Figure 2). Peoples Natural Gas is the largest distributor, accounting for 28,838 billion Btu (53.5 percent). Peoples receives all of its gas from Northern. The second largest distributor is International Gas Ltd., Inc., accounting for 18,603 Btu (34.4 percent). Inter-City receives approximately 62 percent of its gas from Canadian sources. The remaining 12 percent of the total gas consumed in 1976 was distributed by the following four municipalities: Duluth (9.8 percent), Hibbing (0.8 percent), Two Harbors (0.8 percent), and Virginia (0.7 percent).

Region III consumed 53,906 billion Btu of natural gas in 1976, nearly 19 percent of the state total. The two most energy intensive resource related industries, taconite mining and the pulp and paper industry, accounted for 44,306.7 billion Btu (82 percent). The mining industry alone accounted for 30,894 billion Btu (57 percent).

FIGURE 1

NATURAL GAS, PETROLEUM, AND COAL SUPPLY NETWORK FOR REGION 3



The third largest consumer was the residential sector with 4,068 billion Btu (8 percent). The remaining gas was consumed by all other industrial and commercial sectors, the largest of which included electric utilities, lumber and furniture, educational facilities and petroleum refining.

Figure 2

Minnesota expects its gas supplies to decline slightly from 1976 to 1981 (8 percent) but then rise again by 1983 to the 1976 level. From 1984 to 1995, supplies should decline approximately 5 percent each year. This decline will be a result of declining domestic supplies from Northern Natural (offset slightly with projected Alaskan supplies beginning in 1982) and Canada.

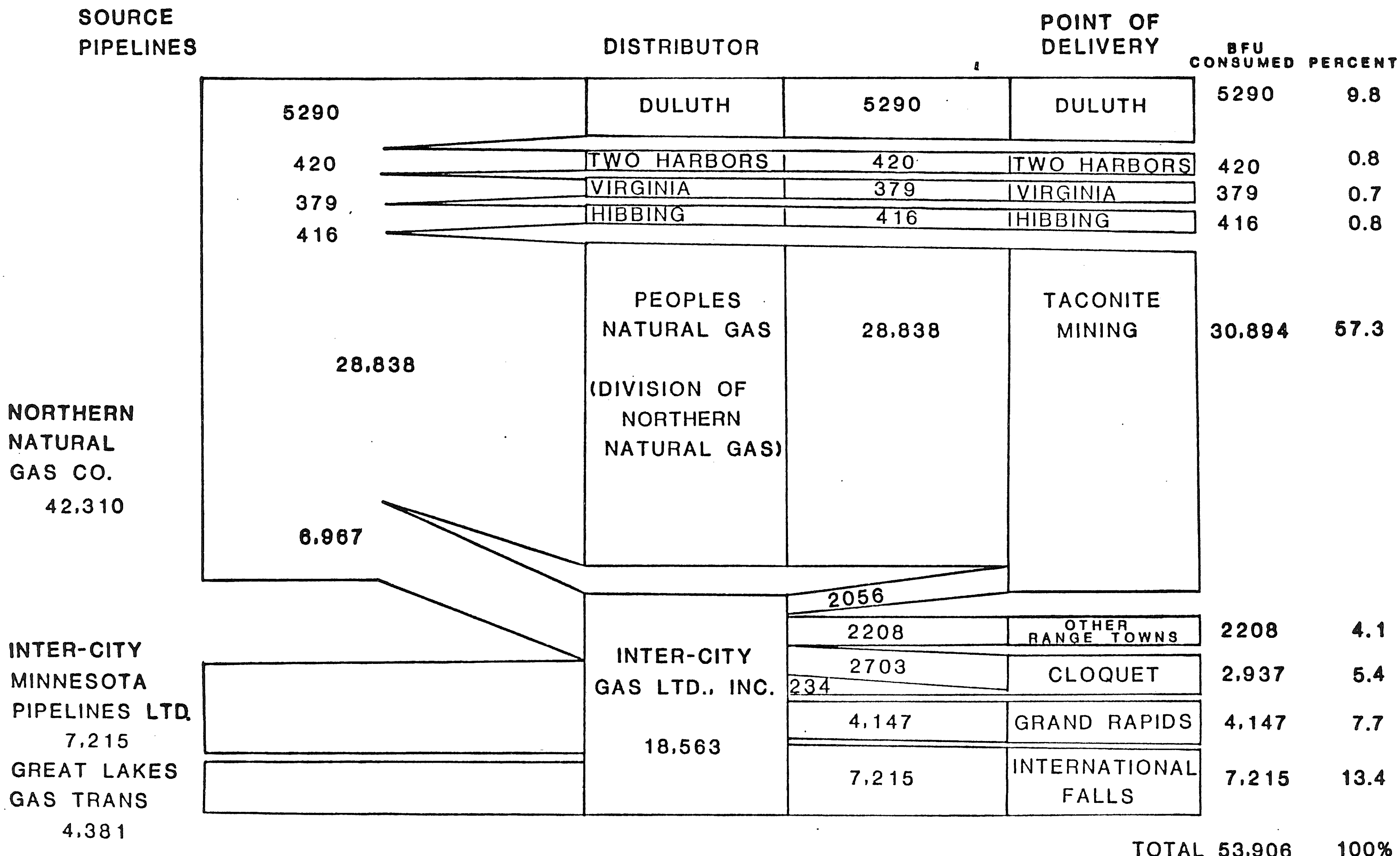
Region III is in a slightly different situation due to increased dependence on Canadian Gas--21.5 percent compared to 7 percent for the state. Natural gas curtailments to the Region will occur in two stages. The first began in 1973 when Northern served notice to large industrial users that they would soon be curtailed of gas. Gas consumption in Region III dropped 7.5 percent from 1974 to 1976, approximately the same as the state decline.

From 1976 to 1977, however, regional gas consumption dropped almost 7 percent and is projected to continue declining at about 6 percent per year through 1982. The heaviest curtailments will occur in the industrial sector, as consumption is projected to decline almost 33 percent by 1982. Within the industrial sector, taconite and iron mining will feel the biggest curtailment of 50 percent by 1982. In the short run this gas shortage will be made up by fuel oil while in the long run, the taconite firms may switch to coal or coal gasification. The electric utilities are almost completely curtailed and have successfully

FIGURE 2

REGION 3 - NATURAL GAS SALES, 1976

(10^9 BTU)



SOURCE : MEA 1978

switched to coal. Other sectors that can anticipate problems include the lumber sector, petroleum refining, stone, clay and glass products, and the Duluth Steam plant. Here again, petroleum products will be the first alternative for many smaller firms while the large users will go to coal or electricity.

The second stage of curtailments should begin in 1984 when Canadian supplies are projected to drop. Canada is expected to have difficulty meeting its demand after 1984 and will probably reduce exports to Minnesota by 10-15 percent per year starting in 1984. Canadian supplies could drop to zero by 1992.

For the two towns in Region III served solely by Canadian gas--Grand Rapids and International Falls--these curtailments present serious problems. Over 90 percent of this gas (10.7 million MCF) is consumed by the two large paper industries. Approximately 40 percent of this total is for electrical generation and may be replaceable by coal. The power plants could also be closed and the two firms could purchase their electricity. The remaining 60 percent may be more difficult to replace.

Another serious effect of this gas curtailment could be that the residential and commercial sectors may be cut off around 1990. These customers may be forced to switch to an alternate fuel if domestic gas does not replace Canadian supplies. Coal gasification plants and peat gas from the proposed peat gasification plant to be located in the Region may be potential sources, however.

11.2.2 Potential Gas Sources

Although Minnesota's traditional sources of natural gas are declining, three new gas sources may be available in the near future. The first and most likely is Alaskan gas. In the 1980s--possibly as early as 1982--Minnesota may receive new gas supplies from the Prudhoe Bay area in Northern Alaska. A moderate amount of Alaskan gas was included in the supply picture for the Region. The amount Minnesota actually receives may be lower if a new pipeline is not built and higher if Minnesota receives a larger share of the gas then it expects.

The second potential new soure is coal gas. This involves a process whereby gaseous fuels are produced from coal. The technology has been available and used successfully in Europe and South Africa. Either high Btu gas (1000 Btu/cu ft) that can be shipped via a pipeline or low Btu gas (200 Btu/cu ft) that must be used at the location where it is generated can be produced from coal.

Low Btu gas holds particular promise for the taconite companies which are searching for a replacement for curtailed natural gas. Erie Mining has proposed building a small low Btu coal gasification plant with the aid of a grant from the federal government. This demonstration plant, scheduled for completion in 1981 or 1982, could supply up to one-third of Erie's fuel requirements for pelletizing (almost 2 trillion Btu). If the project proves successful, Erie would probably triple the size of the plant in order that it could supply all fuel needs for pelletizing. In addition, the other taconite companies may choose to build their own on-site coal gasifiers.

A smaller coal gasification plant (238 billion Btu/year) is being built on the campus of the University of Minnesota, Duluth. This gas will be used primarily for space heating.

The third potential source of new gas is from the peatlands in northern Minnesota. Minnesota has an estmated 7.2 million acres of peat land containing some 16.1 billion tons of peat (at 35 percent moisture) with an estimated heating value of 6,000 Btu/lb. If 10 percent of peat lands were developed for energy, the amount of energy available would be 19.1 quadrillion Btu, or enough energy to satisfy all the energy demand in Minnesota for 16 years (MEA 1978). However, the technology remains unproven in the United States and some very serious environmental questions need to be answered.

Minnegasco has proposed the construction of a demonstration peat gasification plant by 1985 that would produce 28 billion cu ft/yr. If this is successful, a full scale plant producing up to 84 billion cu ft of gas per year could be built by 1992.

11.2.3 Petroleum Products

There are two crude oil refineries in Region III (northeast Minnesota plus Douglas County, Wisconsin)--Continental Oil Company in Wrenshall (23,500 barrels/day), and Murphy Oil Company in Superior, Wisconsin (45,400 barrels/day). These two refineries were completely supplied by Canadian crude oil in 1976 via the Inter-provincial-Lakehead Pipeline System extending from Edmonton, Alberta to Superior, Wisconsin. A new Williams Line from Mason City, Iowa was completed in December, 1977, and began supplying 53,000 barrels/day of crude oil to the Twin Cities area refineries and the Conoco refinery at Wrenshall.

Petroleum products not refined locally enter Minnesota through product pipelines connecting out-of-state refineries to Minnesota distributors. Minnesota is served by two pipeline systems: the Williams Pipeline Company and an Amoco Oil Company pipeline. However, only the Williams system supplies northeastern Minnesota via a pipeline extending from St. Paul to Duluth/Superior.

Most of he propane consumed in Region III is shipped from Canada in 30,000 gallon tank cars. In addition, a small portion is produced in the two local refineries.

11.2.4 Coal

Region III was the second largest coal-using region in Minnesota in 1976, consuming 4 million tons (30 percent of the state's total).

Approximately 65 percent of this coal comes primarily from Montana. The remaining 35 percent is eastern coal that is shipped from Kentucky, Tennessee, West Virginia, and Illinois.

The principal mode of transporting coal into the region is via Burlington Northern Railroad. The Burlington system enters the state from the west at East Grand Forks and continues to Cohasset. The remaining 25 percent is shipped by either barge or railroad while less than 1 percent is shipped by truck.

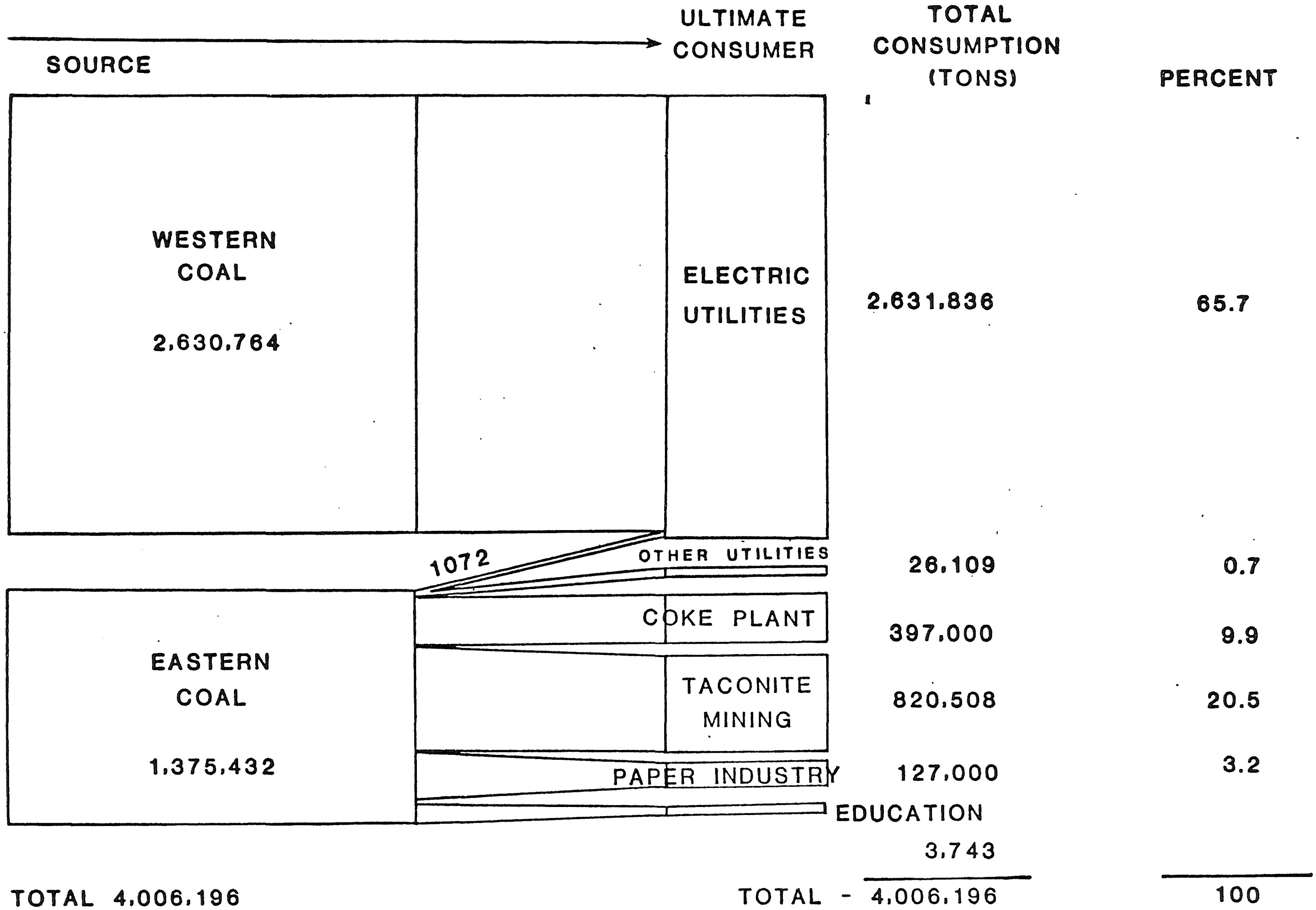
Coal consumption (1976) in Region III, as in the entire state, is dominated by large users (Figure 4). The 5 largest users--2 electric generating plants, 2 taconite firms, and a coke plant--account for 90 percent of regional coal consumption. The remaining 10 percent is divided between smaller electric generating plants, the lumber and paper industry, a steam plant and educational facilities. Overall, more than 85 percent of coal consumed in 1976 was for the generation of electricity.

Figure 3

Coal consumption by present users in the Region is projected to double by 1985 and triple by 1995. Tons burned will increase from 4 million in 1976 to 10 million in 1985 and 14 million in 1995. The major increases will be from mining expansion and new power plants to be built by MP&L.

REGION 3 - COAL USE, 1976

FIGURE 3



SOURCE: MEA 1978

This increased coal use will require additional railroad facilities and barge traffic. In order for this increase to occur, many environmental (see Volume 3-Chapter 3, Air Resources) and economic questions need to be resolved.

11.2.5 Electric Energy

In 1976, there were 29 electric power plants in Region III with a total capacity of 1,296 megawatts. These plants generated 4.42 billion kwh of electricity. Eight hydroelectric plants in the region produced 6.5 percent (290 million kwh) of 1976 electricity output. Steam electric and internal combustion plants contributed the remainder, with internal combustion electric production less than 1 percent in 1976. Steam electric plants in 1976 generated about 4.1 billion kwh. In 1976, 97 percent of the electricity generated by steam electric plants was produced from coal. With the exception of the steam electric generating plants of paper companies, natural gas is used primarily for flame stabilization. Oil is used primarily for peaking purposes with the exception of the MP&L Hibbard plant.

While there are 29 electric power plants within Region III, the 4 largest account for over 85 percent of the total electricity generation. They include 2 MP&L plants (Clay Boswell and Syl Laskin), and 2 private industrial generators (Erie and Reserve Mining).

Minnesota Power and Light, in a 1976 certificate of need hearing, projected an electrical demand requiring about 2,300 megawatts of capacity for the Region III system by 1993. Rising demand for electricity in the Region will be met with the addition of 2 large power plants to be built by MP&L. The first, a 500 MW addition to the Clay Boswell plant, is scheduled for completion in 1980. The second is a 800 MW plant originally scheduled to be built at Floodwood by 1984.

With the completion of these plants, Regional capacity will almost double. Recently, MP&L notified the Minnesota Energy Agency of its interest in reducing the size of its proposed 800 MW plant to 500 MW, due largely to reduced and postponed demand from the taconite industry.

Figure 4

11.3 REGIONAL FUEL CONSUMPTION--1976

Total fuel consumption for the region is summarized in Table 1. Coal is shown to be the largest single source of energy, accounting for one-third of total consumption in 1976. Natural gas (24 percent) and fuel oil (19 percent) are the other significant energy sources.

Table 1

Major end users of fuel are shown for 1976 in Table 2. As shown above, coal is the largest single source of energy, primarily used in electrical generation and by major industries. Natural gas use is dominated by the mining industry, which also contributes to the predominance of industrial use of fuel oil. The residential sector makes up a significant portion of fuel oil use and dominates the use of LPG and gasoline. Electric usage is primarily by the industrial sectors.

Table 2

11.3.1 Energy Intensities by Major End Users

Energy intensities (the amount of energy consumed annually per employee or household) are derived from past and present consumption data to be used to make

FIRURE 4

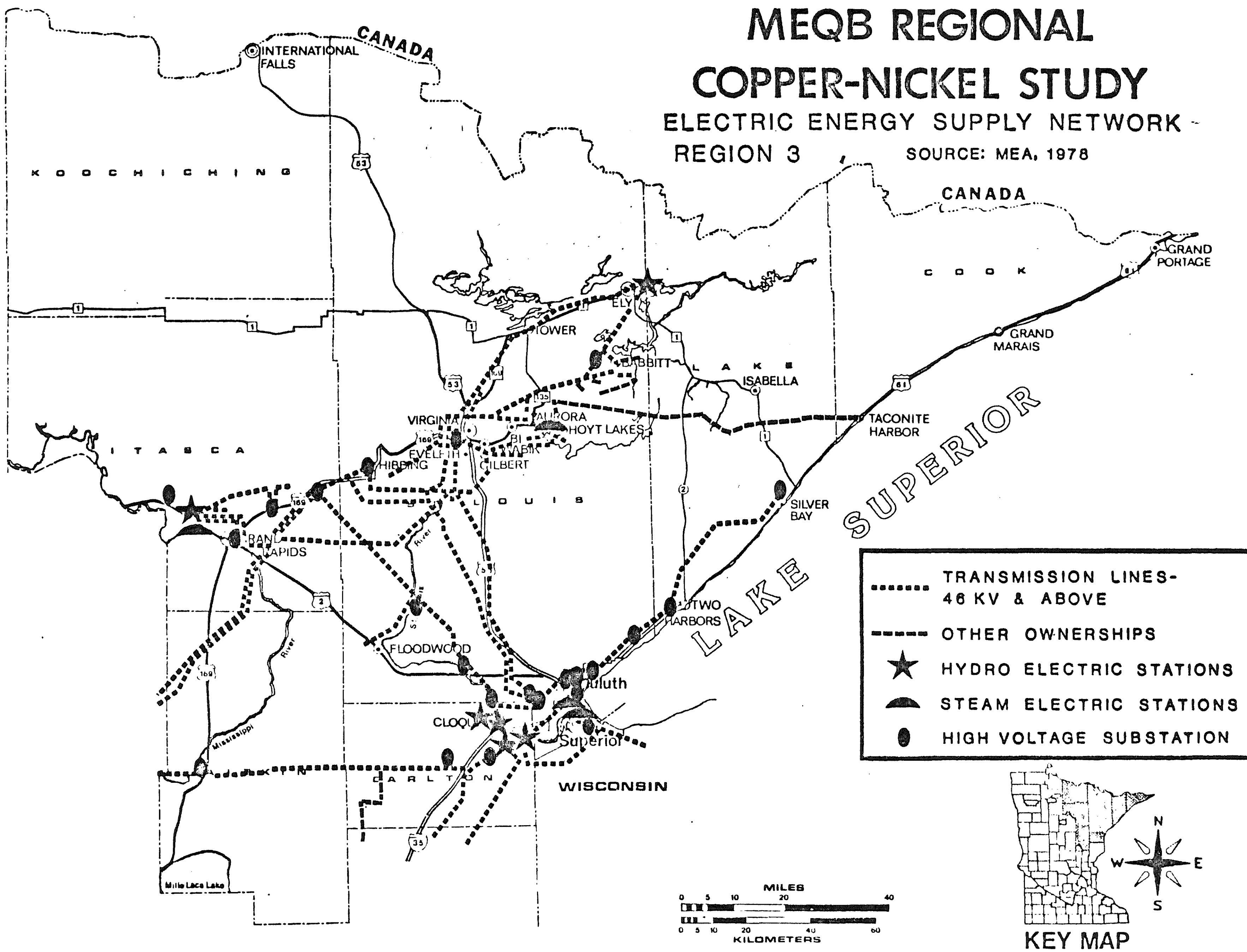

MEQB REGIONAL
COPPER-NICKEL STUDY
ELECTRIC ENERGY SUPPLY NETWORK
REGION 3
SOURCE: MEA, 1978
CANADA
INTERNATIONAL FALLS
KOOCHICHING
CANADA
COOK
GRAND PORTAGE
ELY
TOWER
BABBITT
LAKE
ISABELLA
GRAND MARAIS
VIRGINIA
AURORA
HOYT LAKES
TACONITE HARBOR
EVELETH
BIWABIK
GILBERT
HIBBING
ITASCA
ST. LOUIS
GRAND RAPIDS
SILVER BAY
LAKE SUPERIOR
TWO HARBORS
FLOODWOOD
Duluth
CLOQUET
Superior
CARLTON
WISCONSIN
Mississippi
River
Mille Lacs Lake
TRANSMISSION LINES-
46 KV & ABOVE
OTHER OWNERSHIPS
HYDRO ELECTRIC STATIONS
STEAM ELECTRIC STATIONS
HIGH VOLTAGE SUBSTATION
MILES
KILOMETERS
KEY MAP
N
S
E
W

Table 1. 1976 fuel consumption, Region III.

	10^9 BTU	PERCENT
Coal	79,311	33
Natural gas	57,299	24
Fuel oil	46,215	19
Electric	26,895	11
Gasoline	25,754	11
LPG	3,207	1
TOTAL	238,681	100

Source: Minnesota Energy Agency, 1978.

Table 2. 1976 fuel use estimates by major end-use categories, Region III (10^9 Btu).

	NATURAL GAS	FUEL OIL	LPG	GASOLINE	COAL	ELECTRIC
Northeast Minnesota						
Residential	4,048	12,745	2,002	20,693	--	2,804
Commercial	2,127	4,615	570		80	1,597
Industrial	46,300	16,512	245		30,107	20,410
Electric Generation***	896	2,434	12		48,301	551
Transportation	102	2,039	57	2,019	--	148
Others*	433	44	18		583	80
Total						
Douglas Co., Wisconsin						
Residential	707(1414)**	847	195		33	318
Commercial	312				198	236
Industrial	1,390	6,979	108		9	730
Electric Generation***	267					10
Transportation	--			3,042		
Other	717(10)**					11
Total	3,393	7,826	303	3,042	240	1,305
Copper-Nickel Study Area						
Residential	4,755	13,592	2,197		33	3,122
Commercial	2,439				278	1,833
Industrial	47,690	28,106	923		30,116	21,140
Electric Generation***	1,163	2,434	12		48,301	561
Transportation	102	2,039	57			148
Other	1,150	44	18		583	91
Total	57,299	46,215	3,207	25,754	79,311	26,895

*Communications sector, gas utilities and other utilities.

**Reported by Wisconsin State Planning and Energy. Residential consumption appears overstated because residential units on natural gas for Douglas County sum to only 12% of northeastern Minnesota. The other category was increased by the amount of the overestimate.

***The fuels consumed for electrical generation are used to produce the electrical energy shown in the column on the right.

forecasts of future energy use. Residential and industrial intensities for each of the 13 sectors are presented in Table 3. The 13 sector tables used in the report are condensations of 53 and 62 sector tables used by the MEA in their report completed for the Regional Copper-Nickel Study.

Table 3

11.3.1.1 Residential--Residential consumption of various fuels depends on heating degree days, purpose, and type of equipment.

Space heating dominates all end uses and can vary according to climate, housing structure, building insulation and indoor temperature setting. Average requirements for heating and other residential uses of energy were estimated by MEA for Region III (Table 4).

Table 4

11.3.1.2 Industry Sectors--The forecasting of fuel demands by various industries requires energy intensities for a base year. Applied to changes in employment or gross industrial output, these intensities can be used to project industry energy requirements. Adjustments of energy intensities to account for price-induced conservation and varying process efficiencies for different fuels must also be made.

Due to substitutability between natural gas and fuel oil and long-term shift to coal for large industries, energy intensities are derived by dividing the sum of primary fuels (coal, natural gas, fuel oil) by gross sectional economic changes.

Minnesota Energy Agency estimates energy per employee ratios for Region III using the 62 industry sector definition, but these have been condensed to 13

Table 3. Estimated 1976 industrial fuel use, Region III (10^9 Btu).

SECTOR	NATURAL GAS	COAL	FUEL OIL	PROPANE	GASOLINE	ELECTRICITY
Agriculture	64		257	115		386
Iron Mining	30,894	17,477	10,079	50		16,300
Copper Mining						
Construction	2		100	30		10
Manufacturing	15,341	12,630	5,846	50		3,714
Transportation	102		2,039	57	22,712	148
Communication			43	18		43
Utilities	1,329	48,884	2,434	12		587
Trade	390		1,769	388		619
F, I, RE	33		99			65
Services	1,578	80	2,393	182		634
Other Industries			230			
Government	125		354			308

SOURCE: Minnesota Energy Agency, 1976.

Table 4. Estimated energy requirements per household for various end uses in the residential sector, Region III.

END USES	NATURAL GAS, FUEL OIL, AND LPG	ELECTRIC	
Single Family	million Btu	kilowatt hrs	million Btu
Spaceheating	183	24,898	85
Water heating	32	5,700	19
Cooking	9	1,476	5
Others (clothes drying)	8	996	3
TOTAL	232	33,070	112
Multi Units			
Spaceheating	81	12,449	43
Water heating	14	2,523	9
Cooking	9	1,476	5
Others	8	996	3
TOTAL	112	17,444	60
Mobile homes			
Spaceheating	124	16,939	58
Water heating	22	3,878	13
Cooking	9	1,476	5
Others	8	996	3
TOTAL	168	23,289	79

SOURCE: Janet Peterson, "Residential Energy Prices in Minnesota", Minnesota Energy Agency, St. Paul (Draft September 1977).

sectors for presentation here (Table 5).

Employment data for Region III was estimated using Dun and Bradstreet and Minnesota Department of Employment Services data. Sector definitions and methods of estimating employment could cause differences in energy intensities. However, large differences for the manufacturing sectors could be due to different ages of plants, production processes and extent of self generation of electricity. For commercial sectors, space conditioning requirements vary dramatically according to climate. It appears inadvisable, therefore, to rely solely on energy intensities at the national or state levels in estimating energy and fuel use for small areas. Forecasts using adopted energy intensities would be misleading. The energy intensities presented in Table 5 reflect energy and employment data for Region III and therefore should be more accurate than any figures derived from state or national data.

Table 5

11.4 REGIONAL BASELINE ENERGY PROJECTIONS

In order to discern the impact which copper-nickel development may have on the energy delivery system of the Regional Study Area, the estimated energy consumption of a copper-nickel development scenario must be compared to a regional baseline energy projection and the estimated capacity of the energy delivery system.

The first section of this report described the delivery system of each type of energy source and their respective capacities and outlooks. Natural gas supplies were shown to expect significant and severe curtailments beginning in the mid-1980s. Petroleum and coal delivery systems exist in the region and

Table 5. Estimated 1976 industrial energy use per employee, Region III.

SECTOR	EMPLOYMENT	10^9 Btu Primary Uses	10^9 Btu Purchased Electricity	ENERGY PER EMPLOYEE 10^9 Btu Primary Fuels	ENERGY PER EMPLOYEE 10^9 Btu Purchased Electricity
Agriculture	1,037	435	386	419.5	372.5
Iron Mining	13,383	58,500	16,300	4371.2	1217.9
Copper Mining					
Construction	8,425	132	10	15.7	1.2
Manufacturing	14,824	33,867	3,714	2284.6	250.5
Transportation	3,161	24,910	148	7880.5	46.8
Communication	1,407	61	43	45.3	8.2
Utilities	1,453	52,659	587	36241.7	404.1
Trade	26,014	2,546	619	97.9	23.8
F, I, RE	3,366	132	65	39.1	19.4
Services	17,889	3,143	634	175.7	35.4
Other Industries	133	231	---	1735.3	--
Government	21,954	479	308	21.8	14.0

SOURCE: Minnesota Energy Agency, 1978.

appear to be adequate to handle increased supplies of these fuels providing they are available. Electrical generation capacity is expected to be twice the present capacity with the completion of 2 MP&L projects in the mid-1980s.

Baseline energy projections were prepared by the Minnesota Energy Agency. These include residential and industrial end use projections for each of the major fuel types through the year 2000. The projections are made through use of fuel demand and substitution models developed by MEA for the Copper-Nickel Study and in conjunction with the regional economic analysis model, SIMLAB (see Volume 5-Chapter 15, Regional Economics). Flow charts for the industrial and residential models appear as Figures 5 and 6. In addition, an electric energy demand model (Figure 7) was used to forecast industrial, commericial and residential electrical energy demand for the Study Area.

Figures 5, 6, & 7

11.4.1 Industrial Fuel Demand Projections

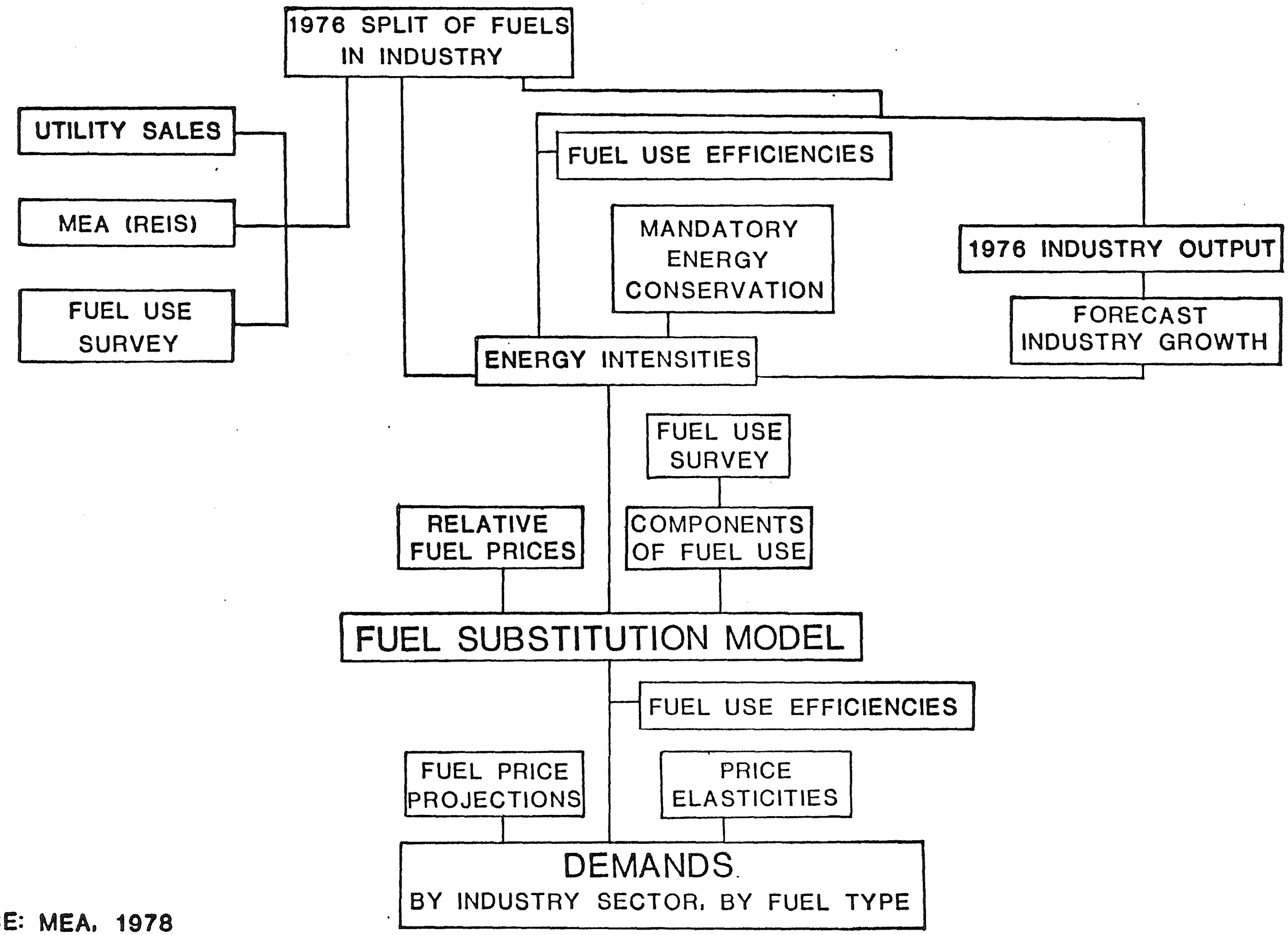
The Minnesota Energy Agency prepared industrial fuel demands for natural gas, fuel oil, and coal for the years 1976, 1985, and 2000. Table 6 is a summary of these estimates (Tables 7, 8, and 9) showing the total industrial fuel demand (without copper-nickel development) by type of fuel for each of the years.

Table 6

The projections show by the year 2000, a significant decline in industrial natural gas demand, 40 percent, while fuel oil demand is expected to increase about 56 percent and coal demand to grow 3-fold. The tremendous growth in coal demand will come as a result of major shifts away from other fuels by the taco-

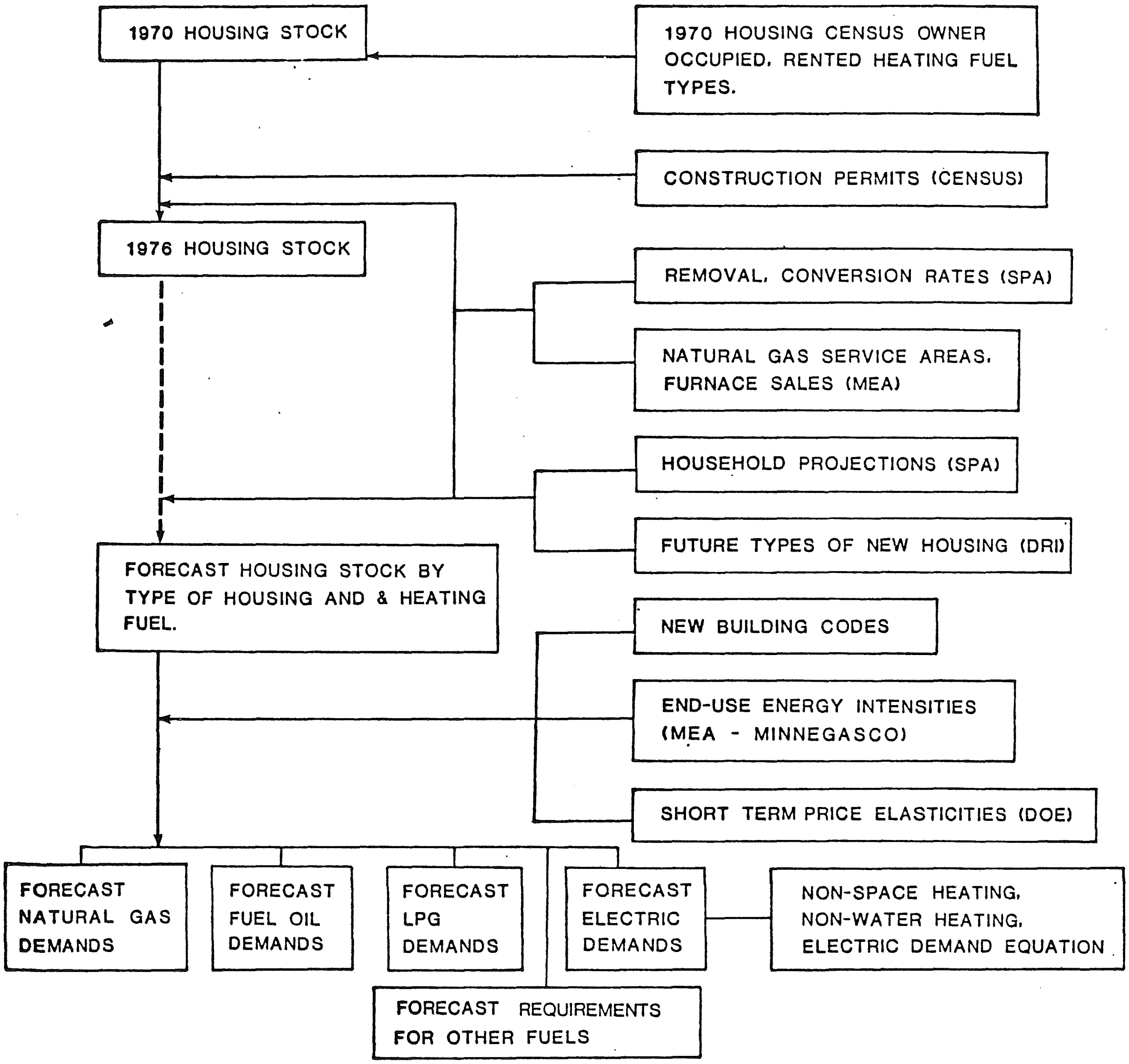
FIGURE 5

PRIMARY FUEL DEMANDS AND SUBSTITUTION MODEL FOR REGION 3



SOURCE: MEA, 1978

FIGURE 6 RESIDENTIAL MODEL - REGION 3

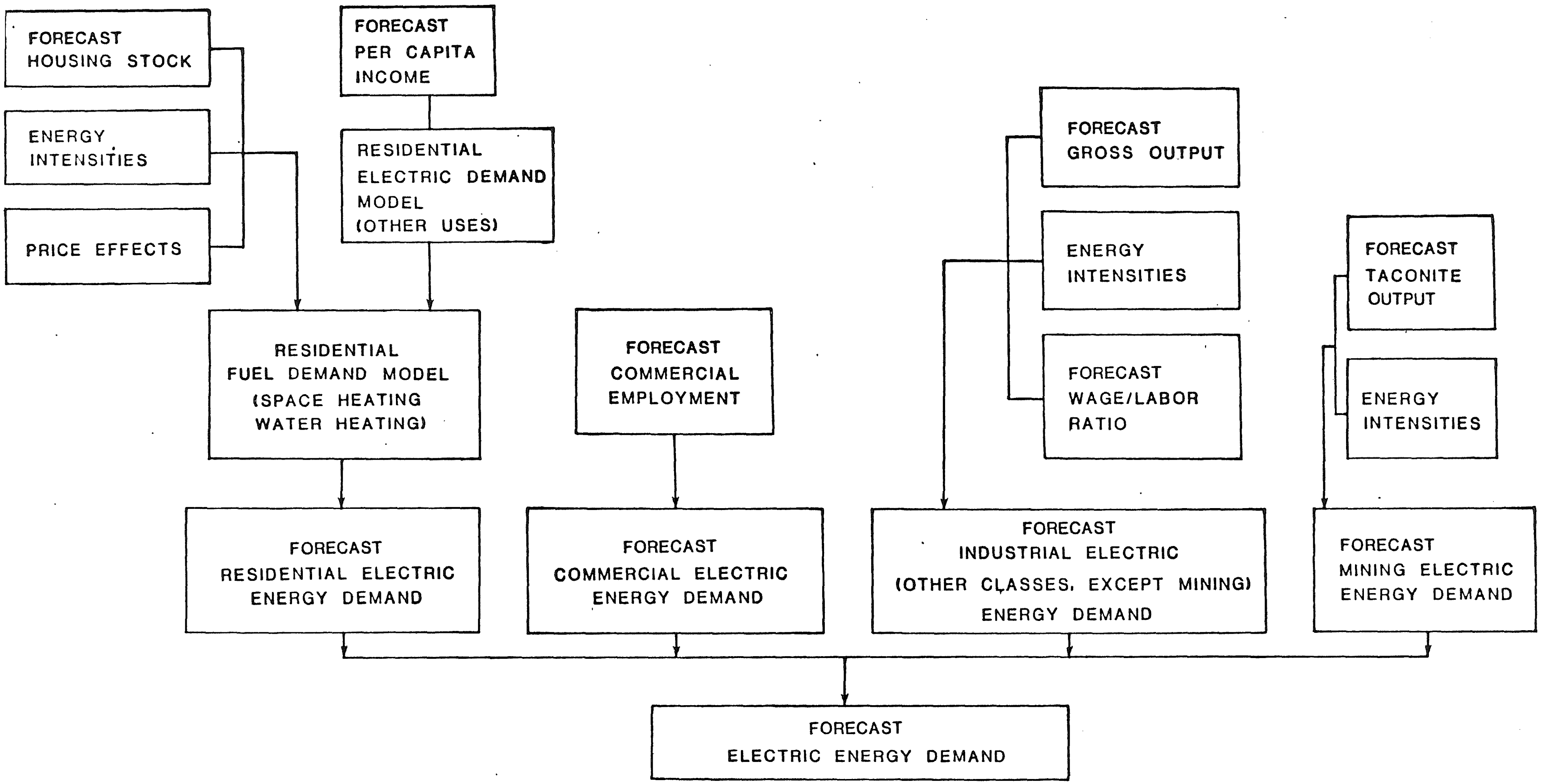


SOURCE: MEA 1978

(CENSUS)	U. S. BUREAU OF THE CENSUS
(SPA)	MINNESOTA STATE PLANNING AGENCY
(MEA)	MINNESOTA ENERGY AGENCY
(MEA-MINN-EGASCO)	MINNESOTA ENERGY AGENCEY ESTIMATES FOR THE REGION BASED ON MINNEGASCO STUDY AND DEGREE DAY DIFFERENCES
(DRI)	DATA RESOURCES, INCORPORATED
(DOE)	U. S. DEPARTMENT OF ENERGY

FIGURE 7

ELECTRIC ENERGY DEMAND MODEL FOR REGION 3



SOURCE: MEA 1978

Table 6. Summary of baseline industrial fuel demand projections (10^{12} Btu).

	1976	1985	2000
Natural Gas	49.0	26.8	29.3
Coal	85.6	150.7	255.8
Fuel Oil	25.4	33.3	39.5
Total Fuels	160.0	210.8	324.6
Gross Output ($\$10^6$)	3,478	4,512	5,819

nite and utility industries. Total demand for all fuels will double from 1976 to 2000.

Tables 7, 8, and 9 show in greater detail the sector by sector demand for each of the fuel sources for the years of analysis.

Tables 7, 8, & 9

11.4.2 Residential Fuel Demand Forecasts

The residential forecasts of fuel and space heating electric energy demand are based on housing structure types, energy intensities and consumer responses to rising prices. Table 10 shows regional fuel demand forecasts for the residential sector based on demographic-economic inputs. The effects of new building codes and consumer responses to rising fuel prices constrain total Btu demands under the baseline scenario. Shifts among fuels are evident, as new units are built in urbanized natural gas service areas. Fuel oil, LPG, and electric units also conserve energy. Such forecasts will change, however, given alternate predictions on number and location of new housing units. Fuel oil and electricity demands will rise faster than natural gas should new units be required in non-urbanized, non-natural gas service areas. According to the estimates of residential settlement (Volume 5-Chapter 7), approximately 40 percent of the copper-nickel induced population growth is expected to locate in rural areas which would not be served by natural gas connections. In addition, Ely and Babbitt, two of the principal development cities nearest the copper-nickel resource zone, do not at present have natural gas service. These factors indicate that fuel oil and electricity demands in this area may increase more rapidly than in the region as a whole.

Table 7. 1976 industry fuel demands and gross output projections, Region III.

SECTOR	FUEL DEMANDS[a] (10^9 Btu) Natural Gas	Coal	Fuel Oil	GROSS OUTPUT (10^6 \$ 1970)
Agriculture	44	---	20	92.4
Iron Mining	30,740	17,390	10,029	582.0
Copper Mining				
Construction	3	---	138	259.6
Manufacturing	14,587	12,170	5,602	976.4
Transportation	102	---	2,030	188.4
Communication	---	---	43	37.1
Utilities[b]	1,322	55,916	2,595	128.0
Trade	408	---	1,801	468.4
F, I, RE	33	---	100	219.3
Services	1,594	81	2,417	287.9
Other Industries	---	---	249	25.8
Government	129	---	364	213.4

[a]Derived by applying MEA fuel demand: gross output ratios to SIMLAB gross output projections.

[b]From MEA.

Table 8. 1985 industry fuel demands and gross output projections, Region III.

SECTOR	FUEL DEMANDS[a] (10^9 Btu) Natural Gas	Coal	Fuel Oil	GROSS OUTPUT (10^6 \$ 1970)
Agriculture	20	---	65	106.8
Iron Mining	7,604	39,667	15,643	676.0
Copper Mining				
Construction	2	---	186	355.7
Manufacturing	13,888	13,706	4,347	1274.7
Transportation	105	---	2,535	234.7
Communication	15	---	47	53.1
Utilities[b]	2,909	97,208	3,249	185.1
Trade	438	---	2,466	637.2
F, I, RE	104	---	69	290.4
Services	1,525	88	3,938	394.6
Other Industries	---	---	323	27.1
Government	145		382	276.9

[a]Derived by applying MEA fuel demand: gross output ratios to SIMLAB gross output projections.

[b]From MEA.

Table 9. 2000 industry fuel demands and gross output projections, Region III.

SECTOR	FUEL DEMANDS[a] (10^9 Btu) Natural Gas	Coal	Fuel Oil	GROSS OUTPUT (10^6 \$ 1970)
Agriculture	6		89	120.7
Iron Mining	2,181	67,784	17,493	1017.7
Copper Mining				
Construction	3	---	193	388.6
Manufacturing	19,803	13,760	7,531	1654.1
Transportation	121	---	3,447	356.6
Communication	47	---	45	81.4
Utilities[b]	5,773	179,150	109	309.7
Trade	283	---	3,365	827.9
F, I, RE	18	---	94	342.5
Services	977	69	6,477	453.5
Other Industries	---	---	492	30.2
Government	71	---	189	288.8

[a]Derived by applying MEA fuel demand: gross output ratios to SIMLAB gross output projections.

[b]From MEA, 1995 forecasts.

Table 10

In addition, forecasts without the effects of new building codes or responses to increasing energy prices show that net conservation savings are not enough to reduce consumption in the area, given State Demographer household forecasts. Larger population changes due to rapid resource development will increase fuel demands dramatically, offsetting conservation savings from new building codes and rising fuel prices.

11.4.3 Electric Energy Demand

The Minnesota Power and Light Company supplies 84 percent of all electric energy sold in the Study Area. Other suppliers for the area are municipal electric utilities and Superior Light, Water, and Power Company for Douglas County, Wisconsin. In estimating forecasting equations for residential, commercial, industrial and other sectors, MP&L data are used entirely because this utility is able to break down electric energy sales according to MEA definitions of commercial and industrial sectors. Other utilities report sales for these categories but their classification system is based on rate structures. Thus, large commercial customers appear as industrial while small industrial users are classified as commercial. MP&L made a separate tabulation to provide the Minnesota Energy Agency with 1960-1976 sales according to user class rather than rate structures.

In its 1976 certificate of need application for a large electric power generating facility, MP&L presented user class demand models. Using MP&L consumption data for the reasons outlined above, MEA constructed more detailed demand models for the same sector.

Table 10. Fuel demand forecasts for the residential sector, Region III, 1976-2000.

YEAR	NO. HOUSEHOLDS	NATURAL GAS (mil. cu ft)	FUEL OIL (million gallons)	LPG (million gallons)	ELECTRIC SPACE HEATING (M-kwhrs)
Baseline (new building codes, price responses)					
1976	130,983	4,755	98	26	212
1980	137,384	5,421	96	25	242
1985	144,965	6,111	93	24	272
1990	147,667	6,277	93	24	272
1995	146,695	6,216	86	21	273
2000	145,306	6,218	84	20	271
Business as Usual					
1976	130,983	4,755	98	26	212
1980	137,384	5,465	96	25	244
1985	144,965	6,166	93	24	275
1990	147,667	6,339	91	23	280
1995	146,695	6,280	87	21	275
2000	145,306	6,285	85	20	274

SOURCE: MEA 1978

The iron mining industry is an obvious key to forecasting electric energy demand for the Regional Study Area. MEA made projections based on three scenarios reflecting possible conditions in the mining industry.

1) Scenario 1 is a high growth condition where MP&L forecasts were adopted for expanding iron mining companies. Erie and Reserve are assumed to retire all generating facilities.

2) Scenario 2 revises the electric energy intensities based on the (1970-1975) observation that energy intensities decline with higher levels of production. Electric energy intensity data of mining companies for 1970-1975 show significant returns to scale above 6 million tons production. The future electric intensities were averaged over 3 size plants and applied to additional production from expansion plans:

	Electric Intensity (Kwhr/ton)	Taconite Production (million tons/year)
(a)	117.132	below 6
(b)	91.068	6-9
(c)	87.711	10 and above

Production rose rapidly in 1973 resulting in reduced electric consumption per ton of production. In forecasting, the lowest electric intensities of each mining company during the 1970-1975 period were assumed for existing plants. Production expansions plus rising electric prices could result in reduced electric intensities. Erie and Reserve electric power purchases were adapted from MP&L forecasts.

Between 1986 and 2000, electric energy intensities are maintained as 1985 levels. Thus, additional electric purchases will increase only as fast as output growth. The growth of steel demand (and taconite production) is forecast at 1.6 percent per year after 1985.

3) Scenario 3 was derived from MP&L revised forecasts.

Table 11 summarizes the electric demand as forecast under each of the 3 scenarios. Scenario 1 presents the highest level of demand by the taconite operations and could be thought of as a worst case scenario. Scenario 2 (with economies of scale reflected) shows the lowest demand among the 3 scenarios shown. The third scenario shows a sizable increase in demand after 1985 by most of the companies but a reduction in demand on the part of Reserve and Erie mining companies.

Table 11

Scenario 1 projects a more than 3-fold increase in demand by 1985 and more than 4-fold demand in 2000 as compared to 1976 levels.

In 1976, the iron mining sector accounted for about 72 percent of all electrical energy consumption in the Study Area. As taconite expansion continues, its percentage of total electrical energy consumption will grow. By 2000, it is expected to be about 80 percent. Total regional electrical energy demand may be estimated if the residential, commercial, and remainder of industrial demand is allowed to grow by 4.5 percent per year, the statewide average. Demand projections are shown in Table 12.

Table 12

Table 11. Forecasts of iron mining electric energy demand, Region III (10^6 kwhrs).

	1976	1980	1985	1990	1995	2000
			Scenario 1[a]			
Taconite Companies		5663.0	7077.0	7661.6	8294.4	8979.6
Reserve-Silver Bay		595.7	1228.1	1330.1	1440.0	1558.9
Reserve-Babbitt		74.5	74.5	80.6	87.3	94.5
Erie		0	134.0	298.2	322.9	349.6
Total	2500.8	6333.2	8513.6	9370.5	10144.6	10982.6
			Scenario 2[b]			
Taconite Companies		4958.8	5737.5	6211.4	6724.5	7280.0
Reserve-Silver Bay		595.7	595.7	675.7	762.2	855.9
Reserve-Babbitt		74.5	74.5	80.6	87.3	94.5
Erie		0	0	0	0	0
Total	2500.8	5629.0	6407.7	6967.7	7574.0	8230.4

Scenario 3[c]

	1976	1980	1985*	1986*	1987*
Taconite Companies	2500.8	5663.0	7077.0	8235.0	8235.0
Reserve-Silver Bay		595.7	595.7	595.7	595.7
Reserve-Babbitt		74.5	74.5	74.5	74.5
Erie		0	0	0	0
Total	2500.8	6333.2	7747.2	8905.2	8905.2

SOURCE: Minnesota Energy Agency, 1978.

*Converted to electric energy from MW winter demand (MP&L revised) using sales to demand ratio in the MP&L and UPA Application for Certificate of Need for a Large Electric Power Generating Facility, October 1976.

[a]High growth condition with retirement of Erie and Reserve generating capacity.

[b]Revised to reflect lower energy intensities at higher levels of production.

[c]MP&L forecast.

Table 12. Projected electrical energy demand, Region III.

	1976	1980	1985	1990	1995	2000
			(10^9 kwhrs)			
Iron Mining[a]	2.5	6.3	8.5	9.4	10.1	11.0
Rest of Region[b]	1.0	1.2	1.5	1.8	2.2	2.7
Total Regional Demand	3.5	7.5	10.0	11.2	12.3	13.7

[a]From scenario 1 of Table 11.

[b]Projected at 4.5% annual growth rate.

Summary--The total energy demand projections of the Study Area are summarized in Table 13.

Table 13

11.5 COPPER-NICKEL DEVELOPMENT IMPACT

Future copper-nickel development will impact upon the energy capacity and delivery systems of the Region in two ways. Primarily, the development itself (mine, mill, smelter and refineries) will make energy demands for both fossil fuels and electricity (Table 14, Figure 8). Secondarily, the regional population growth induced by copper-nickel development will make energy demands through the residental, commercial, and industrial sectors.

To produce a ton of concentrate, a copper-nickel operation requires about 9 times the energy necessary to produce a ton of taconite pellets, a comparable product in the manufacturing process. Studies (see Volume 2-Chapter 5) show that 40.8 million Btu per ton of copper-nickel content of crude ore is required through the concentration phase of the total integrated process. This compares with 4.7 million Btu per ton of iron contained in ore required to produce taconite pellets (Kakela 1978). The large energy difference between taconite and copper-nickel concentrate production is due in part to the ore grades of the respective minerals. It takes only 3 tons of taconite ore to produce a ton of taconite pellets, while 20 to 30 tons of copper-nickel ore are required to produce a ton of copper-nickel concentrate. The lower grade of copper-nickel ore requires that more ore be handled and thus more energy is consumed to produce a comparable product to taconite pellets.

Table 13. Summary of annual energy demand projections, Region III.

	1976	1985	2000
Industrial Fuels (10^{12} Btu)			
Natural gas	49.0	26.8	29.3
Coal	85.6	150.7	255.8
Fuel Oil	25.4	33.3	39.5
Total	160.0	210.8	324.6
Residential Fuels (10^{12} Btu)			
Natural gas	4.8	6.1	6.2
Fuel Oil	13.6	12.9	11.6
LPG	2.4	2.2	1.8
Total	20.8	21.2	19.6
Total Fuels (10^{12} Btu)			
Natural gas	53.8	32.9	35.5
Coal	85.6	150.7	255.8
Fuel Oil	39.0	46.2	51.1
LPG	2.4	2.2	1.8
Total	180.8	232.0	344.2
All Electricity			
(10^9 kwh)	3.5	10.0	13.7
(10^{12} Btu)	11.9	34.1	46.8

Table 14 shows the energy requirements for a single, combination open pit and underground (mine/mill, smelter and refinery) copper-nickel development (see Volume 2-Chapter 5 for additional detail). Comparing a single operation's energy requirements against projected 1985 Regional energy demand indicates that the primary copper-nickel demand would represent an increase of about 1.8 percent over total regional baseline demand for fossil fuels and about 10 percent of regional baseline electrical demand.

Table 14, Figure 8

If 4 similar copper-nickel operations are assumed for the year 2000, their cumulative energy demands would represent 4.9 percent of baseline fossil fuel demand and 30.4 percent of baseline electrical energy demand in that year.

The generation capacity required to satisfy the electrical demands of a single integrated copper-nickel complex would be about 150 megawatts. Minnesota Power and Light Company have included 115 megawatts of capacity for copper-nickel development in their projections through 1993. They have used these projections in recent certificate of need applications. However, a scenario of multiple developments--four operations--would require nearly 600 megawatts of capacity. This is greater than the size of the smaller planned generation facility soon to come on line for MP&L or the NSP Monticello Nuclear generator. These capacity requirements have not been considered in MP&L's projections.

Table 15 presents the average residential household energy demands for the Region in 1976 and estimated 1985 copper-nickel induced demands. As discussed in Volume 5-Chapter 7, a single integrated operation would directly increase the number of residential units in the Region by about 1,440, resulting in an

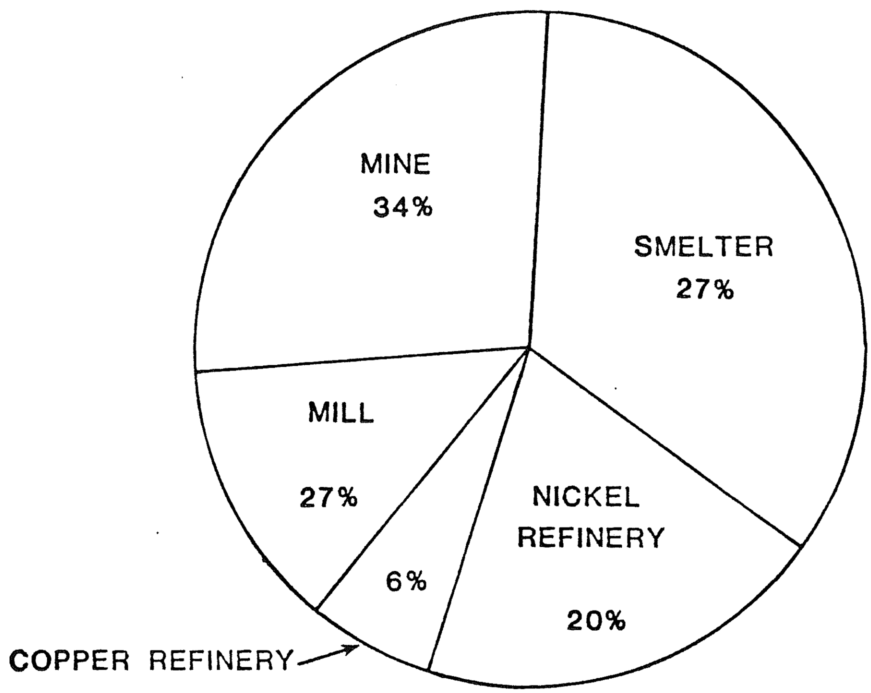
Table 14. Estimated annual energy requirements for a fully integrated copper-nickel operation.

	FUELS 10^9 Btu/yr	ELECTRICITY 10^6 kwhr/yr	PERCENT OF TOTAL ENERGY REQUIREMENT
Mine	1,120	76	27
Mill	100	383	13
Smelter	1,060	381	34
Refinery	1,945	199	26
Copper	362	52	6
Nickel	1,583	147	20
TOTAL	4,225	1,039	100

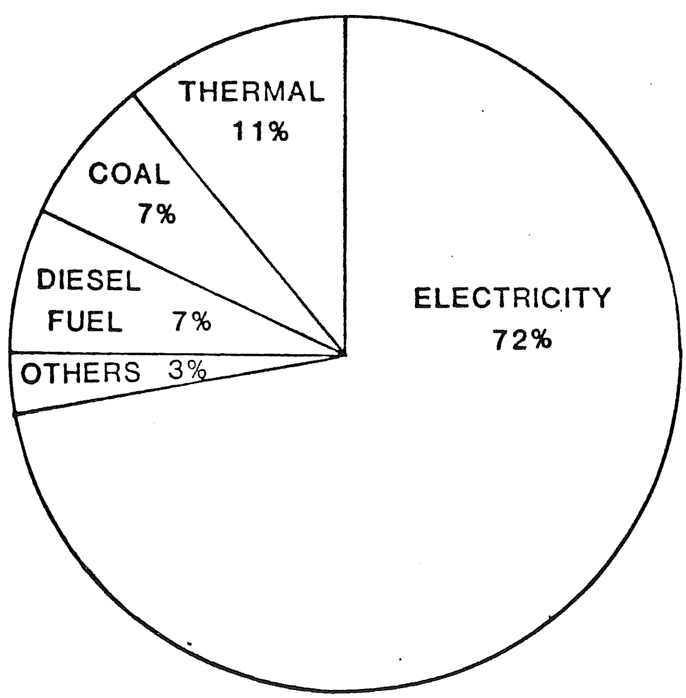
FIGURE 8

DIRECT ENERGY USE. INTEGRATED COPPER NICKEL OPERATION

ENERGY DISTRIBUTION



FUEL TYPE



induced residential energy requirement of 236 X 10^4 Btu of fossil fuels and 10.2 X 10^6 Kwhrs of electricity.

Table 15

Individually, the induced energy requirements of the residential sector represent a 0.1 percent increase over the 1985 residential fuel and electric baseline demands. If population growth induced by the multiple mine development grows proportionately to mine growth, the changes from the baseline would be less than 0.3 percent of the baseline projections for the year 2000.

The secondary energy requirements induced by copper-nickel development in the commercial and industrial sectors of the region will be greater than the operation itself for fuels and about one-eighth the operation's electricity demand. These secondary requirements (Tables 16 and 17) are calculated by applying Minnesota Energy Agency determined energy use intensities to projected changes in the regional economy. For a single integrated complex, the induced commercial and industrial fuel demand could reach 6,600 billion Btu in 1985, or 59 percent of the total copper-nickel related fuel demand. If 4 operations are hypothesized for the year 2000, the secondary fuel demand could reach 26,400 billion Btu; calculated by simply scaling the estimated single operation impact by a factor of four.

Tables 16 & 17

The commercial and industrial electrical demand will be much less significant, about 11 percent of the total copper-nickel related impact. Energy use is estimated to be 139 million kwh in 1985 for a single operation scenario and 556

Table 15. Estimated 1985 residential energy requirements resulting from a single integrated complex, Region III.

	SINGLE FAMILY	MULTI-FAMILY	MOBIL HOME	TOTAL
Number of New Households	1,253	115	72	1,440
Fuel Use Per Household (10^6 Btu)	232	112	163	
Estimated Fuel Use (10^9 Btu)	290.7	12.9	11.7	315.3
Electricity Use Per Household (kwh)	30,070	17,444	23,289	
Estimated Electricity use (10^6 kwh)	41.43	2.0	1.68	45.11

Table 16. Summary of estimated copper-nickel related energy impacts (1985), single integrated complex, Region III.

	FUELS (10^{12} Btu)	PERCENT	ELECTRICITY (10^{6} kwh)	PERCENT
Copper-nickel operation	4.23	38	1,039	85
Residential	.32	3	45	4
Commercial, industrial	6.60	59	139	11
Total	11.15	100	1,223	100
1985 Baseline	232.0		10,000	
Total copper-nickel impact as a percent of baseline	4.8%		12.2%	

Table 17. Summary of estimated copper-nickel related energy impacts (2000), four integrated complex, Region III.

	FUELS (10^{12} Btu)	PERCENT	ELECTRICITY (10^{6} kwh)	PERCENT
Copper-nickel operation	16.92	38	4,156	85
Residential	1.28	3	180	4
Commercial, industrial	26.4	59	556	11
Total Cu-Ni impact	44.6	100	4,892	100
2000 Baseline	344.2		13,700	
Total copper-nickel impact as a percent of baseline	13.0%		35.7%	

million kwh in 2000 for a scenario of four operations. Assuming an average usage of 50 percent of peak requirements (the statewide average) for the commercial sector, the single operation scenario would require a generation capacity of about 32 megawatts to satisfy the projected 1985 copper-nickel induced commercial electricity demand. The four operation scenario would require about 128 megawatts to satisfy the projected commercial demand for electricity in the year 2000; about the equivalent of a single integrated copper-nickel operation.

Summing the direct requirements of the copper-nickel operation, the estimated residential requirements and the estimated induced commercial and industrial demands, the total direct and indirect copper-nickel development related energy impact can be determined. For a single operation scenario, the copper-nickel related fuel demand would represent an addition of 4.8 percent to the projected 1985 fuel demand baseline and 12.2 percent to the 1985 electrical demand baseline (Table 16). For a multiple mine scenario (four mines by 2000), the total development-related impact would represent an addition of 13 percent to the baseline fuel projection for 2000 and nearly 36 percent to the projected 2000 baseline electrical demand (Table 17).

The large electrical requirements of a multiple mine scenario warrant closer examination. The Minnesota Power and Light Company has included the energy requirement for a single copper-nickel operation in their latest certificate of need application, but the possibility of four integrated complexes would require the construction of addition generation capacity to meet the copper-nickel related requirements. In addition, new transmission lines would be required to serve the electrical requirements of copper-nickel development.

11.6 COPPER-NICKEL DEVELOPMENT ELECTRICAL FACILITY REQUIREMENTS

Of critical concern with regard to the energy issue is the impact of delivering electricity to potential copper-nickel developments. Electrical production capacity and construction and location of high voltage transmission lines will impact on the economic, sociologic, and land use environments of the region. It is assumed that the Minnesota Power and Light Company will be responsible for satisfying the electric facilities needed to support copper-nickel operations.

In response to inquiries by the Regional Copper-Nickel Study, MP&L produced preliminary plans of transmission line requirements which would result from three hypothesized development scenarios. The scenarios, in brief, are described below.

Scenario 1--This scenario is designed to show the impacts of large-scale copper-nickel development with two smelter/refinery complexes located in the Study Area and two smelter/refinery complexes ultimately located in the Duluth harbor area. In 1985, a fully integrated complex is projected for the middle portion of the resource zone of the Study Area. By 2000, four mines and two smelter/refinery complexes are located throughout the Study Area in addition to the two smelter/refinery complexes in Duluth. The cumulative electrical energy requirements in 2000 would be 4.15 billion kwhr/yr, with 592 MW of capacity (assuming a 20 percent reserve capacity). In Duluth, the electrical demand would be 1.16 billion kwhr/yr and 166 MW. The remainder of demand would be located in the Study Area.

Scenario 2--This scenario is identical to the first in terms of timing and number of copper-nickel facilities. The difference is that the smelter/refinery complexes located in Duluth in the first scenario are located in the Study Area in Scenario 2. The cumulative energy requirements are identical, 4.15 billion kwhr/yr and 592 MW, and are located entirely within the Study Area.

Scenario 3--This scenario represents the electrical energy requirements of the mine/mill complexes only. There are no smelter/refinery energy demands considered here. It, therefore, represents the minimum electrical requirements of large-scale, multiple operation copper-nickel development. A single mine/mill development is operational in 1985. Every five years, another mine/mill complex is added so that in 2000 there are four operations located along the Resource Zone. Total electrical requirements in 2000 would be 1.8 billion kwhr/yr and 261 MW, all of which is located in the Study Area.

Large-scale development, as suggested in scenarios 1 and 2, would require the addition of about 600 MW of electrical generation capacity, in the region. The present value of capital costs associated with this magnitude of generation capacity, estimated by MP&L in $1979, is about $427 million. The reduced electrical demands presented in scenario 3 would require construction of an additional 261 MW electrical capacity, the present value of which is estimated at about $190 million.

Scenario 1 would require the construction of approximately 30 miles of 230 kv high voltage transmission lines (as indicated in Figures 9 and 10) in the Study Area and Duluth plus the construction of a 230 kv substation in the Study Area. The estimated present value of this construction is about $41 million. Figure 9 indicates the modifications and additions to the present MP&L electrical delivery system in the Study Area. The routes shown on the map should not be considered as definite power line routes but are presented to show the conceptual system design.

Future taconite expansion and environmental considerations in the area will be important factors in the ultimate routing of all potential copper-nickel related lines.

Two 230 kv lines, originating at Minntac (near Virginia) and Forbes (south of Eveleth), would be needed to serve the development at site D by 1985. A substation would be located at site D from which service to other copper-nickel sites would be furnished. These lines could be routed adjacent to existing transmission rights-of-way. Copper-nickel sites to the south and north would be served by looping from or tapping in and out of these original lines and substation. These would largely require new rights-of-way.

Figure 9

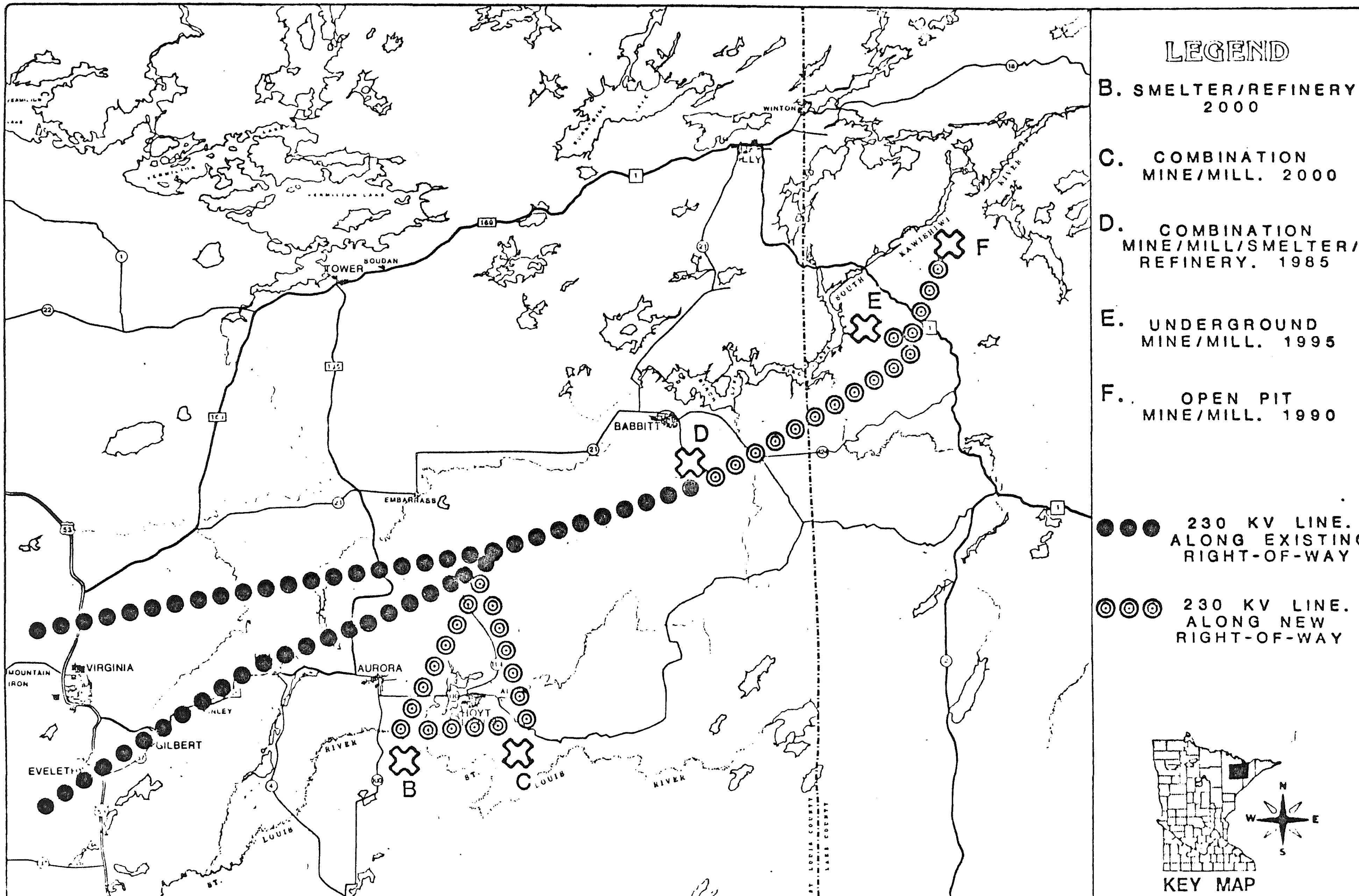
In the Duluth area, a 230 kv line would be constructed by 1990 from the Arrowhead substation to site G and a tap of the 115 kv Fond Du Lac to Hibbard line would be necessary. Both of these lines could be routed adjacent to existing transmission rights-of-way. By 1995, an additional 115 kv, along a new right-of-way, would be required (Figure 10).

Figure 10

The transmission line requirements for scenario 2 would be entirely within the Study Area and would be similar to those of Figure 5 with one exception. Instead of a tap in and out from the substation at site D to site F, a 230 kv loop would be established along newly acquired right-of-way between sites D, F, and A (see Figure 11).

Figure 11

Scenario 3 would result in transmission line requirements similar to that of the first scenario with one exception. Instead of a loop to include sites B and C,



MEQB REGIONAL COPPER-NICKEL STUDY

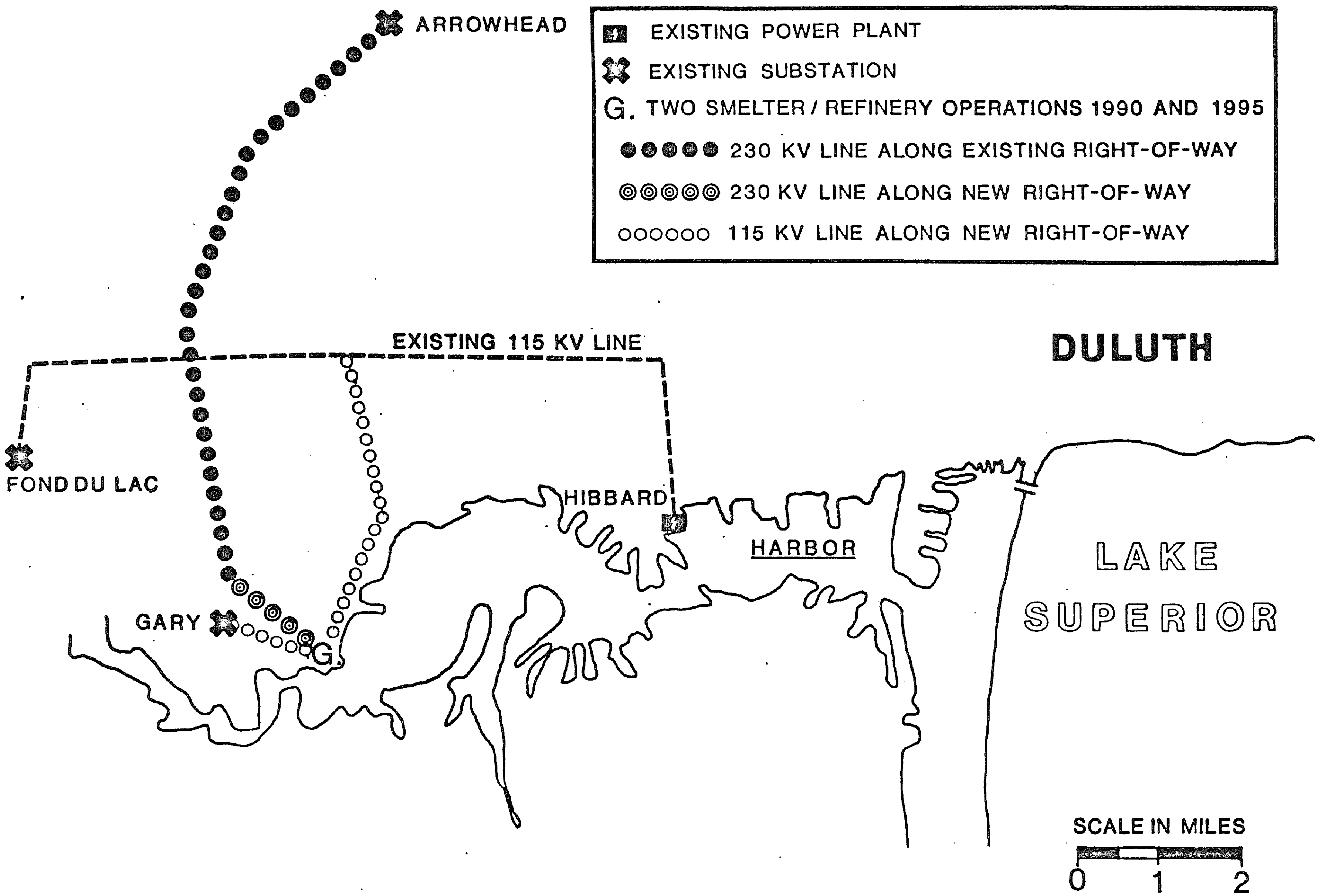
COPPER - NICKEL TRANSMISSION LINE. REQUIREMENTS

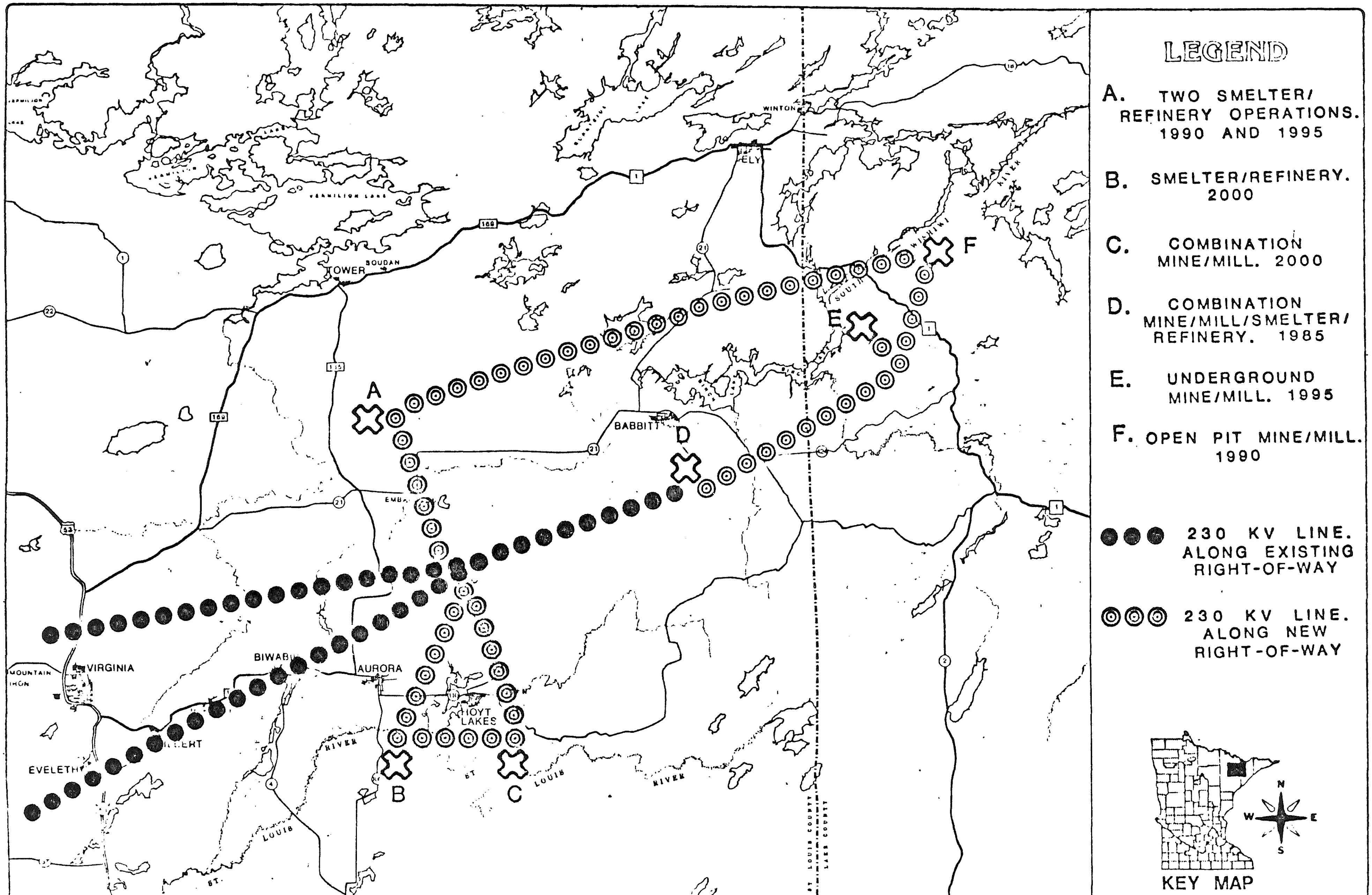
SCENARO 1

FIGURE 9

FIGURE 10

COPPER-NICKEL TRANSMISSION LINE REQUIREMENTS SCENARIO 1





MEQB REGIONAL COPPER-NICKEL STUDY

COPPER - NICKEL TRANSMISSION LINE REQUIREMENTS

SCENARO 2

FIGURE 11

only a tap to site C would be required. Again, all lines would be of 230 kv capacity (Figure 12).

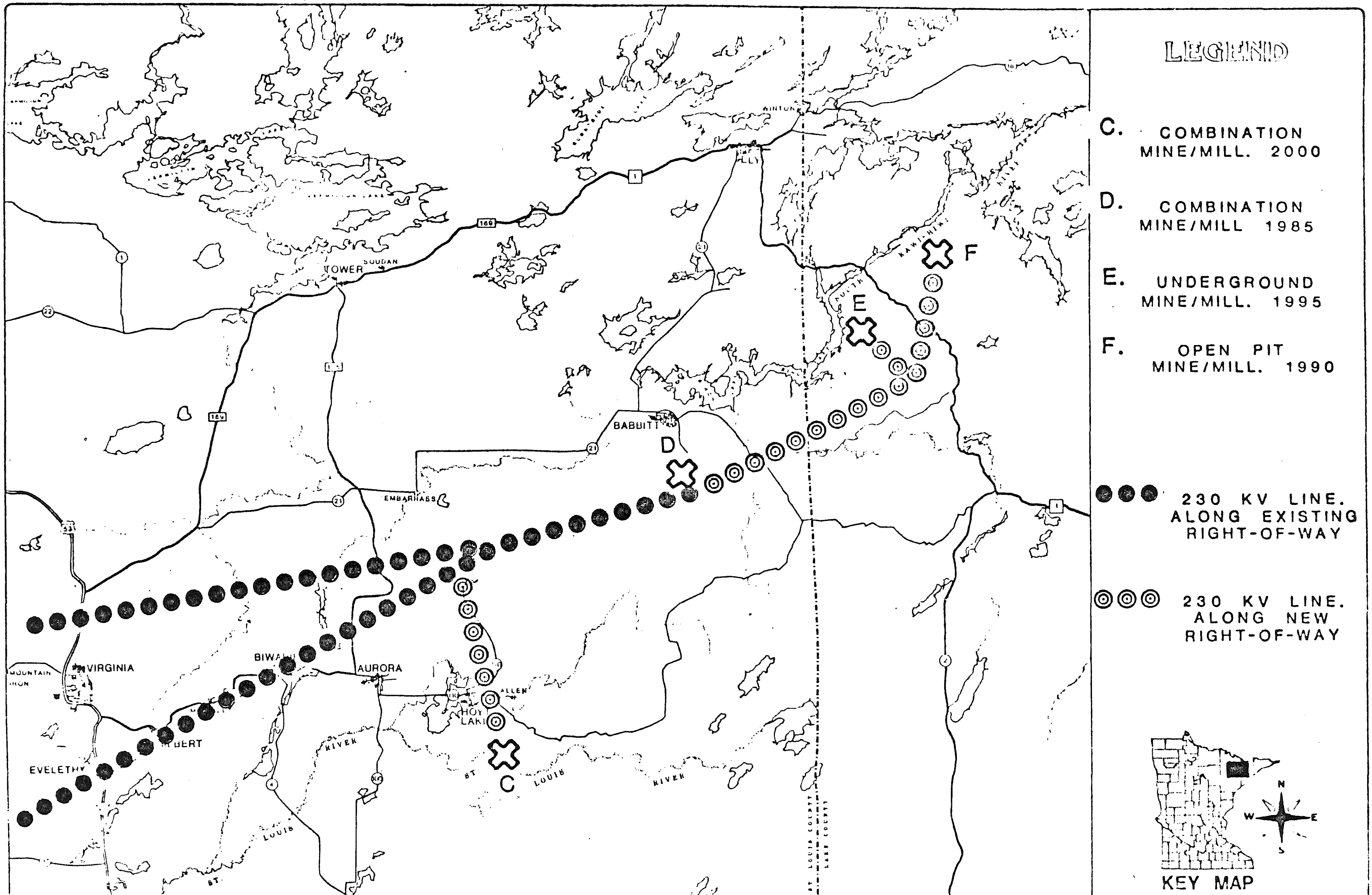
Figure 12

As can be seen from this analysis, copper-nickel development will create a need for extensive expansion of electrical generation and transmission facilities in northeastern Minnesota. The extensive transmission facility requirements are due to three factors: 1) the energy intensive nature of copper-nickel development; 2) the lack of generating capacity near the Copper-Nickel Resource Zone; and 3) the lack of excess transmission capacity near the Resource Zone.

The lack of water supplies near the Resource Zone sufficient for electrical generation and air pollutant emissions from coal-fired power plants will likely preclude generating capacity additions in the Copper-Nickel Study Area. This will create a need for additional transmission lines between the new capacity additions and the present MP&L transmission system serving the Iron Range and the extension of this system to the east into the copper-nickel development area. Because of the power requirements of copper-nickel development and the fact that most operating capacity is in the west and southern portion of the Iron Range, 230 kv high voltage transmission lines are called for in the MP&L preliminary analysis.

The power plant and 230 kv transmission line additions will require individual certificates of need from the Minnesota Energy Agency, siting and routing certificates from the Minnesota Environmental Quality Board, state environmental impact statements, and possible federal environmental impact statements if federal land in the Superior National Forest is crossed and permits from numerous state and federal agencies.

Table 18



MEQB REGIONAL COPPER-NICKEL STUDY

COPPER - NICKEL TRANSMISSION LINE REQUIREMENTS

SCENARO 3

FIGURE 12

Table 18. Summary of MP&L transmission line preliminary plans.

	230 KV TRANSMISSION					115 KV TRANSMISSION		
		Length						
	Cost ($\$10^6$)	New Right-of-Way (miles)	Old Right-of-Way[a] (miles)	Right-of-Way New (acres)	Right-of-Way Old[a] (acres)	Cost ($\$10^6$)	Length (miles)	Right-of-Way (acres)
Scenario 1	40.7	45	68	675	680	NA	5	7.5
Scenario 2	41.1	113	60	1695	600	--	--	--
Scenario 3	33.7	40	60	60	600	--	--	--

[a]Assumes expansion of existing right-of-way for new transmission lines.

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