North Dakota Lignite Industry's Contribution to the State Economy

Randal C. Coon and F. Larry Leistritz

Preface

The work upon which this report is based was partially supported by funds from the North Dakota Lignite Council. The purpose of this research was to estimate the economic contribution the lignite industry has on the economy of North Dakota. This report is the current installment of the ongoing effort to assess the impact the lignite industry has had on the state's economy since 1982. Results from the previous studies, the first of which was published in 1983, also are presented in this report to show the relative changes that have taken place in this industry since 1982. This is particularly important because much of the industry's construction has been completed and the new additions have entered into an operational phase.

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Highlights

The North Dakota lignite industry is an important component of the state's economy. The impact this industry has had on the economy of North Dakota has been measured in terms of economic variables for the 1982 to 1985 period and projections were made for 1986. Expenditures data obtained through survey techniques were applied to the North Dakota input-output model to estimate personal income, retail trade activity, and total business activity attributable to the lignite industry.

North Dakota's lignite industry consisted of 11 operation mines in 1985 which produced a total of almost 26 million tons of lignite and 15 coal conversion facilities (primarily producing electricity or synthetic natural gas). Lignite production has increased ten-fold since the early 1960s with a large share of this growth occurring since the mid 1970s. Total coal-fired thermal-electric generation was over 18 billion kilowatt hours in 1984, a significant increase from the slightly over 5 billion kilowatt hours produced in 1975.

Local expenditures by the lignite industry totaled over $400 million for 1985, down from the 1982 to 1985 peak of $550 million that occurred in 1983. Construction expenditures were very large in the early 1980s but with the completion of many projects almost all of the 1985 expenditures were for operational purposes. The 1985 outlays generated personal incomes of over $424 million, retail trade activity around $268 million, and a total level of business activity of over $1,202 million attributable to the lignite industry. Projected expenditures for 1986 were estimated to result in personal income, retail sales activity, and total business activity of $389, $246, and $1,104 million, respectively, for the state.

Tax revenue collections resulting from the industry's operations in North Dakota totaled $67.9 million in 1985 and were projected to amount to $64.1 million in 1986. The largest source of tax revenue from the industry was the coal severance tax, which amounted to $27.0 million in 1985 and was predicted to be $27.7 million in 1986. In addition, the lignite industry directly employed 3,942 workers in 1985 and was estimating direct employment for 1986 to be 3,957 workers. Estimated secondary employment resulting from the industry's expenditures accounted for another 19,745 workers in 1985 and was predicted to provide 17,346 indirect and induced jobs in 1986. When considering the multiplier process, where a dollar injected into a local economy creates "new dollars," the lignite industry creates an additional $1.99 of business activity for each original dollar spent locally. Thus, each original dollar the lignite industry injects into the local economy plus the created $1.99 gives a total of $2.99 in total business activity. The economic impacts of the lignite industry have been very important to North Dakota and provided a source of growth and stability for the state's economy.

NORTH DAKOTA LIGNITE INDUSTRY'S CONTRIBUTION
TO THE STATE ECONOMY

Randal C. Coon and F. Larry Leistritz*

Introduction

North Dakota's lignite industry has grown from about 2.5 million tons mined per year in the early 1960s to over 25 million tons in 1985. This expansion has resulted in the lignite industry becoming a significant force in the state's economy during that period. Measuring, in terms of economic variables, the industry's contribution to the economy of North Dakota provides an indication of how important the industry is to the state.

North Dakota's economy is highly dependent upon natural resource based activities (i.e., either energy or agricultural production). Although agriculture has remained a major force in the state's economy, its relative share of the economic base has declined from 62.7 percent to 41.8 percent from the early 1960s to 1984 (Coon, Leistritz, and Hertsgaard 1986). During the same period, energy sectors of the economy increased their portion of the state's economic base from 2.8 percent to 11.5 percent for the petroleum industries and from one-tenth of one percent to 4.4 percent for lignite industries (i.e., coal mining and coal conversion) (Figure 1). The importance of the energy industries became even more pronounced in western North Dakota where all of the known petroleum and lignite reserves are located.

The economic contribution the lignite industry makes to the state's economy has been estimated annually since 1982. These estimates were provided to the North Dakota Lignite Council for 1982 and 1983 (Coon, Mittleider, and Leistritz 1983) and for 1984 (Coon and Leistritz 1985); the actual 1985 and estimated 1986 results will be presented in this report. The results from the previous studies will be combined with those just completed to show economic contributions the lignite industry has made to the North Dakota economy during a period of transition from rapid growth to stability.

The Lignite Industry

The North Dakota lignite industry was defined for purposes of this study as all firms involved in lignite mining and conversion activities. Eleven coal mines and 12 coal conversion facilities are located in North Dakota (Figure 2). Mines and conversion facilities are located in State Regions 1, 2, 7, and 8, although the majority of these operations are in State Region 7 and more specifically in Mercer County.

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1958-1962 Average = $2,540.3 Million   1984 = $5,736.0 Million

Ag, Livestock
(21.0%)

Ag, Crops
(41.7%)

Petroleum
Refining
(1.3%)

Petroleum
Exploration/Extraction
(1.5%)

Coal Mining
(0.1%)

Households
(23.2%)

Construction
(2.4%)

Retail Trade and
Business and
Personal Service
(2.3%)

Agricultural Processing
and Misc. Manufacturing
(6.5%)

Ag, Crops
(32.7%)

Construction
(1.6%)

Ag, Livestock
(9.1%)

Agricultural
Processing and
Misc. Manufacturing
(7.9%)

Petroleum
Refining
(1.5%)

Petroleum
Exploration/
Extraction
(10.0%)

Households
(29.5%)

Retail Trade
and Business
and Personal
Service
(3.3%)

Thermal-
Electric
Generation
(3.1%)

Coal
Mining
(1.3%)

Figure 1.   Composition of North Dakota Economic Base, 1958-1962 Average and 1984 (1980 = Base Dollars)

SOURCE: Coon, Leistritz, and Hertsgaard 1986.

▲ Coal Mining Facilities
▣ Coal Conversion Facilities
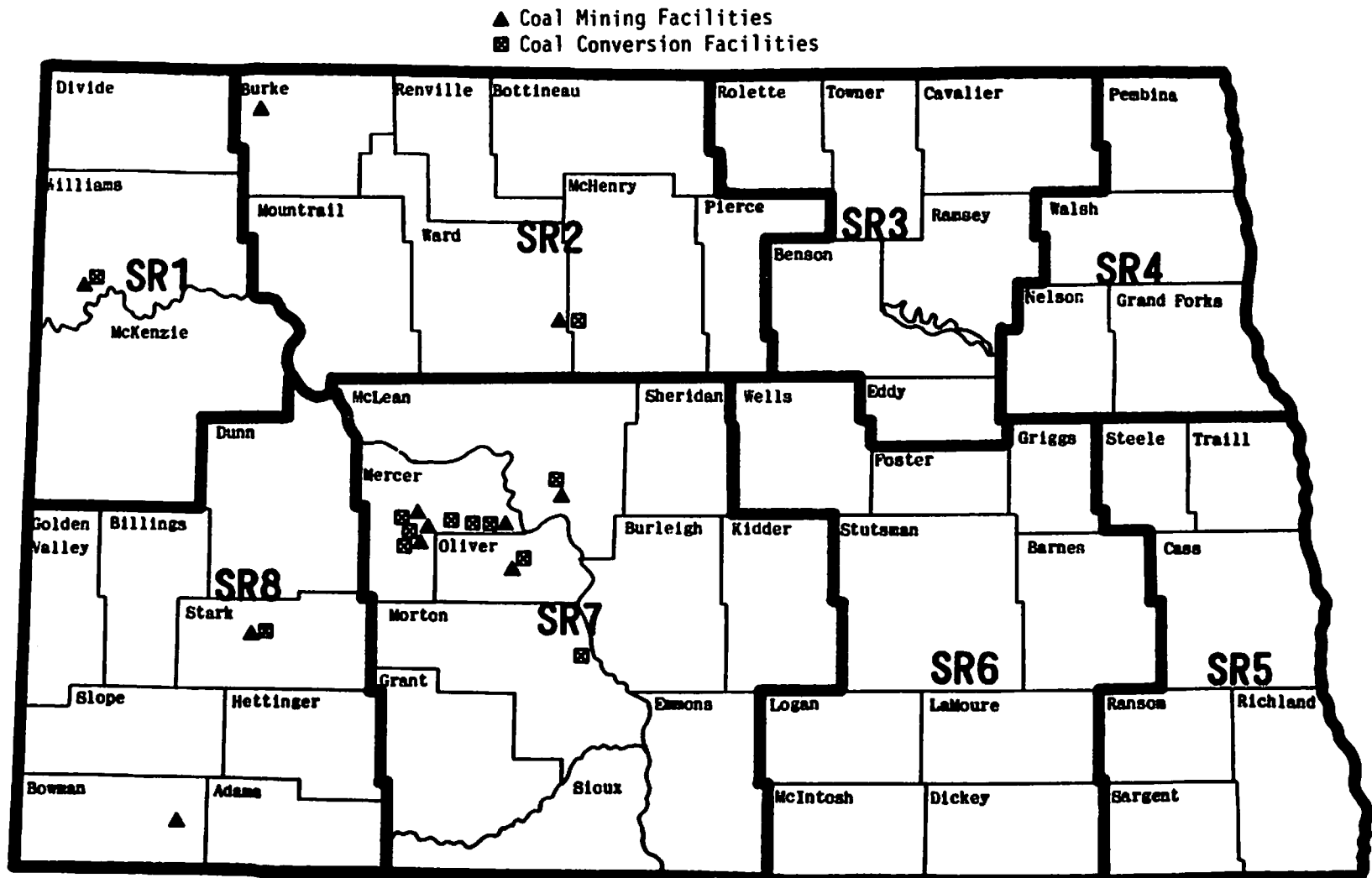
Figure 2. Location of Coal Mining and Coal Conversion Operations in North Dakota, 1986

Lignite Mines

North Dakota lignite reserves are estimated at 351 billion tons, of which recoverable reserves have been projected to be between 16 to 35 billion tons (Nielson 1982). Almost 26 million tons of lignite were mined in 1985 by 11 active mines (Table 1). Lignite production for each of the

TABLE 1. PRODUCTION OF LIGNITE COAL IN NORTH DAKOTA, 1958-1985

Year	Production
	---tons---
1958	2,325,545
1959	2,430,162
1960	2,522,691
1961	2,557,498
1962	2,850,607
1963	2,520,619
1964	2,520,743
1965	2,758,111
1966	3,069,153
1967	3,961,117
1968	4,413,448
1969	4,590,276
1970	5,001,828
1971	5,821,076
1972	6,343,466
1973	6,798,607
1974	7,183,364
1975	7,111,427
1976	10,710,234
1977	12,071,139
1978	12,928,033
1979	14,279,722
1980	16,828,902
1981	17,449,232
1982	17,480,548
1983	18,019,244
1984	20,097,493
1985	25,741,929

SOURCE: State Mine Inspector 1959-1974; Workmen's Compensation Bureau 1975; Office of the State Tax Commissioner 1976; North Dakota Public Service Commission 1977-1978; Office of the State Tax Commissioner 1979-1985.

state regions for the period 1958 to 1985 is presented in Table 1, Appendix A. Growth in lignite mining has been ten-fold during the 1958 to 1985 period. The production of lignite coal presented in Table 1 is also presented graphically in Figure 1, Appendix B, to show the rapid growth of the industry during the post-1975 period. Production remained at a relatively stable level during the early part of that time span; however, expansion of the industry since the mid 1970s has been dramatic. A primary reason for the rapid growth was the changing world energy situation--a shift from petroleum to electric energy sources resulted from oil embargoes and the subsequent desire to decrease the United States' dependence on foreign oil. As would be expected, these conditions gave rise to an increased demand for North Dakota lignite as an energy source for both electric power production and for conversion to synthetic fuels (e.g., synthetic natural gas).

Eleven mines were in operation in North Dakota in 1985 (Table 2). The Falkirk Mine and the Freedom Mine are the two most significant

TABLE 2. COAL MINE, PRINCIPAL OPERATOR, LOCATION, YEAR OPERATIONAL, AND PRODUCTION, NORTH DAKOTA, 1985

Coal Mine	Principal Operator	Location	Year Operational	1985 Production
				---tons---
Beulah	Knife River Coal Mining Co.	Beulah	1945	2,900,000
Freedom Mine	Coteau Properties Co.	Beulah	1983	7,716,860
Indian Head	North American Coal Co.	Zap	1951	1,200,000
Center	Baukol-Noonan, Inc.	Center	1970	3,458,548
Glenharold	Basin Cooperative Svc.	Stanton	1966	2,537,000
Falkirk	Falkirk Mining Co.	Underwood	1978	5,874,649
Velva	Consolidation Coal Co.	Velva	1959	252,000
Larson	Baukol-Noonan, Inc.	Larson	1928	76,625
Geo-Resources	Geo-Resources	Williston	1982	40,000
Husky	Husky Industries	Dickinson	1927	231,000
Gascoyne	Knife River Coal Mining Co.	Scranton	1948	2,216,000

SOURCE: Miller 1986.

additions to mining industry in the state since the mid 1970s. With its production of 7.7 million tons of lignite in 1985, the Freedom Mine was the largest in the state and also one of the largest mines in the United States. Production from the Falkirk Mine was 5.9 million tons of lignite in 1985, making it the second largest mine in North Dakota.

Although several of the lignite mines in the state are older mines, they still contribute significantly to the state's production. For example, the Beulah Mine (opened in 1945) produced 2.9 million tons in 1985, The Gascoyne Mine (opened in 1948) mined 2.2 million tons during the same year, and the Indian Head Mine (opened in 1951) extracted 1.2 million tons of lignite in 1985. Two mines that once produced lignite but are no longer operational are the Smith-Ullman Mine and the Sprecher Mine; the Velva Mine is in the reclamation stage in 1986 after completing its production in 1985. Also, the Larson Mine will probably be operational through 1986, at which time it will begin reclamation. The mines being closed down are relatively small when compared with those remaining operational; their closure will not affect total lignite production significantly (i.e., the total production of lignite is more a function of the demand for the coal and the electricity and synthetic natural gas produced from coal).

It should be noted that the Geo-Resources and Husky Mines are shown in Figure 2 as mines and conversion facilities but will only be listed as mines (Table 2) and not included again when coal conversion facilities are discussed. Geo-Resources is a mine/conversion facility located near Williston where coal is mined and used to manufacture "drilling mud" for use by the petroleum extraction industry. Charcoal briquettes are produced by the Husky Industries mine/conversion facility located in the Dickinson area.

Coal Conversion Facilities

North Dakota coal is classified as lignite on the basis of its physical and chemical properties. Moisture content of the state's lignite averages 35 percent and the average heat content is about 6,700 BTUs per pound (Energy Resources Company 1980). The characteristics of lignite coal make it advantageous to convert it to an energy source more easily transported and distributed. Conversion of North Dakota's lignite coal into electricity is a common means of making it more price competitive with the higher grade coals available in Montana and Wyoming. Thus, a large number of facilities to convert lignite have been built in western North Dakota.

Until recently, almost all of the lignite that was converted was used to produce electricity; however, the addition of a synthetic natural gas plant has altered that trend. In 1985, 80 percent of the North Dakota lignite mined was used for electrical generation, 18 percent was used to produce synthetic natural gas, and 2 percent for other needs (i.e., drilling mud, charcoal briquettes, domestic heating, etc.) (Figure 3). The large share of the state's lignite used to produce synthetic natural gas is especially noteworthy because the plant just became operational in 1985.
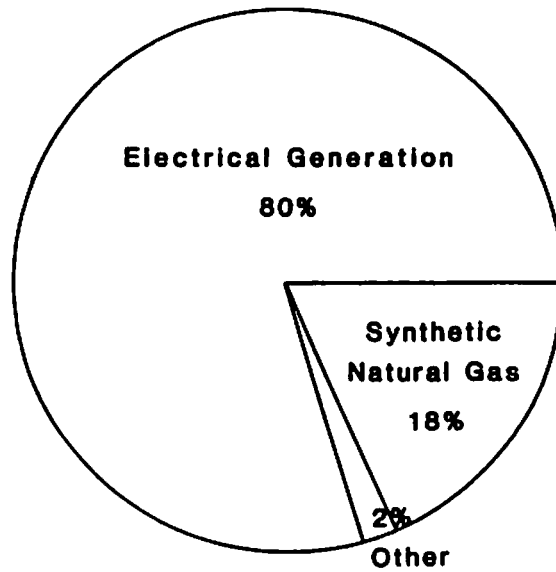
Figure 3. Usage of North Dakota Lignite, 1985

SOURCE: North Dakota Lignite Council 1986.

Many of the coal conversion facilities in North Dakota have been constructed since the mid 1970s to meet the demand for domestically produced energy (as previously discussed) in the form of electricity and synthetic natural gas (Table 3). Antelope Valley Station (Units I and II), Coal Creek Station (Units I and II), Coyote Station, Leland Olds Station (Unit II), and Milton R. Young Station (Unit II) are all electric generation facilities that have been built since the mid 1970s. These are very large-scale plants with capacities greater than 421 MW and up to 550 MW for each unit of the Coal Creek Station. The William J. Neal Station at Velva is currently on standby status, and the Antelope Valley Station Unit II will be coming on-line in June 1986. All of the major electrical generation facilities are located in State Region 7 and are supplied with coal from mines in that region located near the respective plants.

Coal-fired thermal-electric generating capability in North Dakota has followed a stair-step pattern since the early 1970s. Generating capacity showed large increases in 1975, 1977, 1979, 1980, 1981, and 1984 (Table 4). Naturally, these increases correspond to the addition of new facilities becoming operational. Figure 2, Appendix B, depicts the stairstep growth in generating capacity associated with new power plants coming on-line during the last decade. Associated with the increased generation capabilities was the growth in total kilowatt hours of electricity generated (Table 4). Generation has grown from 1.6 to 18.5 billion kilowatt hours during the 1966 to 1985 period, an eleven-fold

TABLE 3. COAL CONVERSION FACILITIES AND PRINCIPAL OPERATOR, CAPACITY, AND SOURCE OF COAL, NORTH DAKOTA, 1986

Conversion Facility	Year Operational	Principal Operator	Capacity	Coal Source	Coal Mine Owner
Antelope Valley Station - I	1984	Basin Electric	460 MW	Freedom Mine	Coteau Properties Co.
- II	1986	Basin Electric	460 MW	Freedom Mine	Coteau Properties Co.
Beulah Station	1927	MDU	14.5 MW	Beulah Mine	Knife River Coal Mining Co.
Coal Creek Station - I	1979	UPA/CPA	550 MW	Falkirk Mine	Falkirk Mining Co.
- II	1981	UPA/CPA	550 MW	Falkirk Mine	Falkirk Mining Co.
Coyote Station	1981	MDU	421 MW	Beulah Mine	Knife River Coal Mining Co.
R.M. Heskett Station - I	1954	MDU	28 MW	Beulah Mine	Knife River Coal Mining Co.
- II	1963	MDU	73 MW	Beulah Mine	Knife River Coal Mining Co.
William J. Neal Station	1952	Basin Electric	47 MW	Velva Mine	Consolidation Coal Co.
Leland Olds Station - I	1966	Basin Electric	216 MW	Glenharold Mine	Basin Cooperative Services
- II	1975	Basin Electric	440 MW	Glenharold Mine	Basin Cooperative Services
UPA Stanton Station	1967	UPA	192 MW	Indian Head Mine	North American Coal Co.
Milton R. Young Station - I	1971	Minnkota Power	235 MW	Center Mine	Baukol-Noonan, Inc.
- II	1977	Minnkota Power	439 MW	Center Mine	Baukol-Noonan, Inc.
Great Plains Coal Gasification Project	1985	ANG Coal Gas. Co.	125 mcf/day	Freedom Mine	Coteau Properties Co.

SOURCE: Miller 1986.

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TABLE 4. COAL-FIRED THERMAL-ELECTRIC GENERATING CAPABILITY AND TOTAL
GENERATION, NORTH DAKOTA, 1969-1984

Year	Generating Capacity	Total Generation
	------------------kwh------------------	
1966	NA	1,640,544,400
1967	NA	2,697,626,400
1968	NA	3,296,815,500
1969	NA	3,311,955,300
1970	854,475	4,070,409,500
1971	856,530	4,865,725,300
1972	892,519	5,628,764,400
1973	868,970	5,365,414,500
1974	864,380	5,737,459,100
1975	1,269,070	5,167,206,400
1976	1,291,790	7,160,642,100
1977	1,700,550	8,381,238,700
1978	1,762,940	9,823,874,200
1979	2,311,230	11,574,317,400
1980	2,821,662	13,054,936,200
1981	3,180,304	14,161,313,600
1982	3,205,034	15,416,217,400
1983	3,242,250	16,884,650,200
1984	3,595,450	18,526,047,400

SOURCE: North Dakota Public Service Commission 1966-1975;
Public Service Commission 1975-1984.

increase. (The total generation data presented in Table 4 also were
presented graphically in Figure 3, Appendix B, to show the dramatic
increase in coal-fired thermal-electric generation in the state during the
past two decades.)

In addition to the electricity produced from the state's lignite, a
synthetic natural gas plant consumed about 18 percent of the North Dakota
coal mined in 1985. The Great Plains Coal Gasification Project, which
began construction in Mercer County in 1981, is one of the world's largest
plants to convert coal to synthetic natural gas. This plant was
constructed at a cost of $2.1 billion and became fully operational in 1985.
This plant has the capacity to produce 125 million cubic feet of synthetic
natural gas per day and will consume 4.7 million tons of coal per year.
Associated with the operation of the gasification plant are the Freedom
Coal Mine and Antelope Valley Station electric generating facility. This
plant also came into existence out of the desire for the United States to
lessen its dependence upon foreign energy sources.

At the time the facility was being constructed, natural gas prices were high, and expectations were for these prices to continue to rise and supplies to remain short. However, since that time natural gas prices have moderated and declined to a level lower than the cost of producing the synthetic natural gas. This situation has caused some concern about the future of the plant--shutdown of the facility would be a major blow to the North Dakota economy because the Great Plains Gasification Plant is one of the largest single economic entities in the state in terms of employment and money injected into the local economy.

Methodology

Defining an economic contribution analysis is beneficial before describing the methodology employed in a study of this type. The effect that expenditures of an individual firm or industry in an area will have on the economic unit in terms of economic variables (i.e., personal income, retail trade activity, and total business activity) is termed an economic contribution analysis. Gathering local expenditures from each of the firms involved in lignite-related activities (i.e., coal mining or conversion) was the first step necessary to perform the contribution assessment.

A survey was developed in conjunction with and administered by the North Dakota Lignite Council to obtain the local expenditures (actual for 1985 and projected for 1986) and employment for all firms involved in lignite-related activities. Similar surveys were previously administered (and results analyzed) for each year during the 1982 to 1984 period. (The results of these prior assessments will be added to those from the 1985 survey to show some of the recent changes in the lignite industry). Estimated lignite industry local expenditures were determined for an annual basis from the surveys. These expenditures were applied to the North Dakota input-output model to determine the contribution the lignite industry makes to the state's economy. The contribution analysis will measure the additions to the state's economy in terms of total business activity, personal income, and retail trade activity. In addition, secondary effects including employment and tax revenue collections will result because of lignite industry expenditures. The analysis will be in terms of current year dollars for each year included in the study (1982 to 1986) because expenditures for each of these years were in terms of that year's dollar value.

Input-Output Model

Economic contribution analysis requires choosing a technique for estimating the indirect and induced effects of an industry on economic activity, employment, and income. Input-output (I-0) analysis was selected as the economic assessment framework for the North Dakota lignite industry because it provides considerably more detailed assessment estimates (i.e., business volume and employment by sector), and I-0 allows the analyst to take explicit account of differences in wage rates and local input purchasing patterns in evaluating the impacts of various development proposals (Lewis 1968; Richardson 1972).

Input-output analysis is a technique for tabulating and describing the linkages or interdependencies between various industrial groups within an economy. The economy considered may be the national economy or an economy as small as that of a multicounty area served by one of the state's major retail trade centers. An input-output model previously developed for North Dakota (Leistritz et al. 1982) has been used extensively to estimate the economic contributions of a wide range of industrial sectors including, for example, the potato industry (Coon, Leistritz, and Scott 1986), the recreation industry (Mittleider and Leitch 1984), and agriculture (Coon, Vocke, and Leistritz 1984) in addition to the previous analyses of the lignite industry. (For a complete discussion of input-output theory and methodology, as well as a review of the North Dakota input-output model, see Coon et al. [1985].)

Interdependence Coefficients

Input-output interdependence coefficients have previously been developed for North Dakota. These coefficients are commonly called multipliers because they measure the number of times a dollar of income "turns over" in the state. The multiplier effect results when each producing sector buys some fraction of its inputs from other sectors of the state's economy and these sectors, in turn, use some fraction of that income to buy some of their inputs from still other sectors, and so on. The multiplier effect is due to the spending and respending within the state's economy of part of each dollar that enters the state. Input-output interdependence coefficients for North Dakota are presented in Appendix A, Table 2. Application of the local expenditures to the respective multipliers will yield levels of business activity necessary to measure the economic impact and contribution of the lignite industry. Because all local expenditures were in terms of current year prices, applying these values to the multipliers also yields economic assessments in similar terms.

Productivity Ratios

The ratio of gross business volume to employment, sometimes called the productivity ratio, indicates the amount of business activity in a sector per worker in that sector. Productivity ratios are particularly useful when conducting economic contribution studies. When in-state expenditures for the lignite industry are applied to the multipliers, the resultant business activity can be divided by the productivity ratios to estimate secondary (or indirect and induced) employment. Secondary employment is that which will arise as a result of the expenditures from the industry as they are spent and respent throughout the economy by the multiplier process. This employment is in addition to the workers directly employed by the industry, and essentially comes into existence to serve and supply the industry. Productivity ratios used to estimate indirect and induced workers resulting from lignite industry expenditures are presented in Table 3, Appendix A.

Tax Revenue Estimation

Several tax revenues can be estimated using the input-output model. These include state personal income tax, corporate income tax, and sales and use tax collections. Tax revenue estimates are based on historic relationships between tax collections and input-output model estimates of gross business volume for selected sectors. Tax rates calculated were based on rates in existence in 1983 for North Dakota (Coon et al. 1984). Data were not available at this time to update the tax estimating equations to reflect the 1985 tax structures.

Estimates of state personal income tax collections were based on the following relationships:

North Dakota personal income tax collections = 2.1 percent x personal income

Personal income from the input-output model is the total business activity of the household sector. The equation to estimate state corporate income tax is as follows:

North Dakota corporate income tax collections = .31 percent x total business activity of all business sectors

All business sectors consist of all sectors of the economy except for the agriculture, household, and government sectors. State sales and use tax collections were estimated based on the following formula:

North Dakota sales and use tax collections = 4.06 percent x retail trade activity

Retail trade activity is the total business activity of the retail trade sector of the input-output model. Applying these tax estimating equations to the business activity generated from the local expenditures provides tax revenue estimations for the three major North Dakota taxes.

Model Validation

Comparing personal income for the household sector of the model with estimates of personal income published by the Bureau of Economic Analysis, U.S. Department of Commerce, provides a good indication of how accurately the input-output model simulates the North Dakota economy. North Dakota personal income estimates from the input-output model have had an average deviation from Department of Commerce estimates of 5.47 percent during the 1958-1984 period. (A year-by-year comparison of the personal income estimates is presented in Table 4, Appendix A.) The Theil coefficient for

the state is close to 0.0, indicating the model is quite accurate for predictive purposes.[1]

Economic Contribution

The economic contribution expenditures the North Dakota lignite industry makes in the local economy were applied to the North Dakota interdependence coefficients to estimate the associated impacts. This relationship resulted in estimates of business activity, personal income, retail trade activity, secondary employment, and selected tax revenue collections. Results will be reported as accruing in North Dakota, although the majority of the effects will be in the western part of the state and more particularly in State Region 7.

Expenditures and Total Business Activity

Total local contribution expenditures attributable to the lignite industry amounted to over $400 million for 1985 (Table 5). Projected expenditures for 1986 were expected to decline to under $370 million. This decline represents the expected decline in demand for electric energy (and, therefore, coal) because of the dramatic decline in world oil prices. It is interesting to note that lignite industry local expenditures have declined during the five-year period; however, this was to be expected with the completion of construction of the Great Plains Gasification Project in 1985. The completion of the construction is mirrored by the large decrease in local expenditures to the construction sector; these expenditures fell from $341.2 million in 1982 to $54.2 million in 1985. Lignite industry expenditures reflect a transition from intensive development to a relatively stable situation or possibly slight declines in demand for lignite and conversion products. Expenditures by the industry were to nine sectors of the local economy with the household sector (i.e., essentially wages and salaries, lease and royalty payments, etc.) receiving the greatest amount in 1985, contrasting with the construction sector's domination during 1982 and 1983. To further illustrate the recent trend in lignite industry expenditures, the totals for each year were graphed and are presented in Figure 4, Appendix B.

The economic contribution attributable to the lignite industry's expenditures included personal income of $424.1 million, retail sales activity totaling $268.3 million, and a total level of business activity of $1,202.5 million for 1985 (Table 6). The same items were down for 1986 ($389.0, $246.3, and $1,103.5 million, respectively) as a result of lower industry expenditures. Personal income, retail sales activity, and total business activity all peaked during the five-year period in 1983,

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[1]The Theil U_1 coefficient is a summary measure, whose value is bounded by 0 and 1. A value of 0 for U_1 indicates perfect prediction, while a value of 1 corresponds to perfect inequality (i.e., between the actual and predicted values). (For a further discussion of the Theil coefficient, see Leuthold [1975] and Pindyck and Rubinfeld [1981].)

TABLE 5. ESTIMATED NORTH DAKOTA EXPENDITURES BY ECONOMIC SECTOR FOR COMPANIES INVOLVED IN LIGNITE-RELATED ACTIVITIES, 1982-1986

Sector	1982	1983	1984	1985	1986
	----------million dollars-----------				
Construction	341.2	323.9	87.2	54.2	44.2
Transportation	7.1	7.8	3.5	8.5	8.0
Communications & public utilities	2.6	3.4	17.9	58.7	54.2
Wholesale trade & ag processing	21.2	26.1	37.7	25.7	25.5
Retail trade	54.6	58.0	53.7	36.9	34.4
Finance, insurance, real estate	2.1	2.4	3.7	31.2	29.2
Business & personal services	1.2	1.4	8.0	16.5	20.3
Professional & social services	1.2	1.4	19.6	20.0	13.2
Households	92.5-	125.7	183.4	149.7	138.7
Total	523.7	550.1	414.7	401.4	367.7

TABLE 6. ESTIMATED PERSONAL INCOME, RETAIL SALES ACTIVITY, TOTAL BUSINESS ACTIVITY OF ALL BUSINESS (NONAGRICULTURAL) SECTORS, AND TOTAL BUSINESS ACTIVITY FOR COMPANIES INVOLVED IN LIGNITE-RELATED ACTIVITIES, 1982-1986

Item	1982	1983	1984	1985	1986
	--------------million dollars--------------				
Personal income	402.3	450.6	436.7	424.1	389.0
Retail sales	299.0	325.2	292.6	268.3	246.3
Total business activity of all business sectors[a]	883.9	921.0	685.7	689.5	631.4
Total business activity	1,370.6	1,466.5	1,220.4	1,202.5	1,103.5

[a]Includes all sectors except agriculture (crop and livestock), households, and government.

corresponding with the year local expenditures were the largest. These economic measures indicate the additions to the state's economy that have resulted from lignite industry expenditures. Figures 5, 6, and 7, Appendix B, present the graphic representation of personal income, retail sales activity, and total business activity, respectively, resulting from the lignite industry's contribution to the North Dakota economy.

Tax Collections

Data in Table 6 provided the necessary measures of business activity to estimate tax revenues generated by the lignite industry. In addition, coal severance and energy conversion tax payments were obtained from the expenditures survey. Estimated tax revenues for the 1982 to 1985 period are presented in Table 7. Total tax revenues attributable to the lignite

TABLE 7. ESTIMATED STATE TAX REVENUES ASSOCIATED WITH COMPANIES INVOLVED IN LIGNITE-RELATED ACTIVITIES, 1982-1986

Tax Revenue	1982	1983	1984	1985	1986
	----------------million dollars----------------				
Coal severance	17.5	18.7	22.0	27.0	27.7
Energy conversion	3.7	4.1	10.9	12.7	10.0
Sales and use	9.3	10.1	11.9	10.9	10.0
Personal and corporate income	6.5	7.2	11.3	11.1	10.1
Other	1.2	1.3	2.5	6.2	6.3
Total	38.2	41.4	58.6	67.9	64.1

industry have steadily increased during the five-year period and reached $67.9 million dollars by 1985. Preliminary tax revenues for 1986 are lower than those for 1985 as a result of lower industry expenditures and less coal conversion. Coal severance tax is the largest tax source from the industry and has increased with higher levels of coal production in recent years. Coal conversion tax payments were at their highest level in the fiveyear period during 1985, the first year the Great Plains Gasification Plant was fully operational. The revenues from this tax were forecast to decline in 1986 due to lower projections of electric generation and reduced production by the synthetic natural gas plant. Overall, the lignite industry was responsible for directly and indirectly adding $67.9 million in tax revenues to the state in 1985, a significantly larger amount than in 1982. The individual tax amounts paid by the lignite industry were plotted collectively in Figure 8, Appendix B, to show the increases in the

individual taxes and the increases in total tax revenues attributable to the industry.

Employment

Direct employment in the lignite industry was 3,942 workers in 1985 and was predicted to grow slightly to 3,957 in 1986 (Table 8). The direct employment in the industry appears to have stabilized, but this condition is dependent upon the Great Plains Gasification plant operating at its current level and no electric generation plants closing due to a lack of demand for electric energy. Construction of the Great Plains plant resulted in significantly higher levels of employment with a peak of 7,996 direct workers in 1983 (also the year of the largest amount of local expenditures). Lignite industry expenditures also were responsible for creating secondary (indirect and induced) employment in North Dakota. Secondary employment generated as a result of the industry's expenditures totaled 19,745 workers for 1985. Secondary employment is down from its highest level of 32,211 for the five-year period, but this is to be expected because local expenditures declined during the same span. As previously mentioned, productivity ratios were used to determine secondary employment, which means they were calculated based on the dollar injections into the local economy by the lignite industry. The capital intensive nature of the industry has resulted in ratios of secondary to direct employment higher than those for most other types of industries in the state. In other words, firms in the lignite industry have higher levels of expenditures per employee than do most of the other economic sectors, so secondary employment resulting from these outlays also tends to be higher than for most other sectors in the North Dakota economy. The levels of direct and secondary employment are presented graphically in Figure 9, Appendix B, for the 1982 to 1985 span. As stated earlier, secondary employment is in addition to direct employment, and essentially arises to serve and supply the industry and its direct employment.

TABLE 8. ESTIMATED DIRECT AND SECONDARY EMPLOYMENT TOTALS FOR COMPANIES INVOLVED IN LIGNITE-RELATED ACTIVITIES, 1982-1986

Employment	1982	1983	1984	1985	1986
Direct	6,458	7,996	5,562	3,942	3,957
Secondary	31,981	32,211	22,644	19,745	17,364

Conclusions

The North Dakota lignite industry makes a significant contribution to the state's economy when measured in terms of key economic variables. Industry expenditures were $401.4 million in 1985, and although this is

down from the 1983 level that resulted from the construction of the Great Plains Gasification plant (costing in excess of $2 billion), these outlays were a significant injection of dollars into the state's economy. After the industry's expenditures had been applied to the multiplier process, they resulted in 1985 levels of personal income, retail trade activity, and total business activity of $424.1, $268.3, and $1,202.5 million, respectively. The economic contribution the industry will make to the state's economy was projected to decrease slightly for 1986; however, these estimates were based on preliminary indicators and the final level will depend upon the conditions and events that occur during the year.

Benefits of the lignite industry also accrue to the state in the form of tax revenues (estimated at $67.9 million for 1985 and $64.1 million for 1986), employment opportunities within the industry itself (3,942 workers in 1985 and 3,957 workers in 1986), and secondary employment generated as a result of the industry's outlays. When considering the multiplier process, where a dollar injected into the economy "turns over" and creates additional "new" dollars, the lignite industry creates an additional $1.99 of business activity for each original dollar. Thus, each original dollar injected into the economy by the lignite industry plus the created $1.99 gives a total of $2.99 in total business activity. The increased levels of business activity resulting from the industry expenditures will, in essence, create additions in personal income, retail sales, and employment in the state. Additional tax revenues that result from lignite industry activities also are a benefit to the state.

The contribution the lignite industry makes to the North Dakota economy has been monitored since 1982. During the period since 1982, the industry has gone through some changes--what a few years ago looked to be an unlimited demand for North Dakota lignite and its products has leveled out and may even decline slightly in 1986. Lower world energy prices have had a profound effect on the state's energy industries including both lignite- and petroleum-related activities. Economic contributions made by the lignite industry have been very important to the state and especially the western part of the state. The contributions the lignite industry is making to the North Dakota economy are especially critical during the 1985 to 1986 period, a time of depressed petroleum and agricultural prices. Economic contributions associated with the lignite industry have provided the impetus for growth and stability in the North Dakota economy.

APPENDIX A

TABLE A1. PRODUCTION OF LIGNITE COAL IN NORTH DAKOTA, BY STATE REGION, 1958-1985

Year	State Region				Total
	1	2	7	8	
			tons		
1958	218,086	826,943	1,014,756	265,760	2,325,545
1959	227,174	860,364	1,046,377	296,247	2,430,162
1960	238,471	905,577	1,163,055	215,588	2,522,691
1961	235,537	899,265	1,172,283	250,413	2,557,498
1962	233,741	1,055,910	1,216,157	344,799	2,850,607
1963	NA	NA	NA	NA	2,520,619
1964	NA	NA	NA	NA	2,520,743
1965	4,151	1,047,396	1,491,313	215,251	2,758,111
1966	4,256	830,278	2,048,253	186,366	3,069,153
1967	5,515	912,997	2,825,663	216,942	3,961,117
1968	3,800	745,151	3,353,584	310,913	4,413,448
1969	4,512	824,350	3,491,501	269,913	4,590,276
1970	7,782	995,695	3,710,887	287,464	5,001,828
1971	3,690	933,629	4,561,339	322,418	5,821,076
1972	5,200	879,498	5,171,025	287,743	6,343,466
1973	9,630	900,031	5,530,945	358,001	6,798,607
1974	9,040	969,218	5,856,041	349,065	7,183,364
1975	9,340	779,156	5,338,435	984,496	7,111,427
1976	--	772,238	7,172,381	2,765,615	10,710,234
1977	16,456	807,629	8,366,506	2,880,548	12,071,139
1978	15,521	842,664	9,472,242	2,597,606	12,928,033
1979	NA	731,614	10,594,462	2,953,646	14,279,722
1980	87,803	788,987	12,748,110	3,204,003	16,828,902
1981	16,725	670,072	13,905,417	2,857,018	17,449,232
1982	16,252	602,518	14,366,794	2,494,984	17,480,548
1983	27,351	582,083	15,152,890	2,256,920	18,019,244
1984	35,544	478,842	17,041,118	2,541,989	20,097,493
1985	52,602	398,784	22,695,346	2,595,197	25,741,929

SOURCE: State Mine Inspector 1959-1974; Workman's Compensation Bureau 1975; Office of the State Tax Commissioner 1976; North Dakota Public Service Commission 1977-1978; Office of the State Tax Commissioner 1979-1985.

TABLE A2.   INPUT-OUTPUT INTERDEPENDENCE COEFFICIENTS, BASED ON TECHNICAL COEFFICIENTS FOR 17-SECTOR MODEL FOR NORTH DAKOTA

	Sector	(1) Ag, Lvstk	(2) Ag, Crops	(3) Nonmetallic Mining	(4) Const	(5) Trans	(6) Comm & Pub Util	(7) Ag Proc & Misc Mfg	(8) Retail Trade	(9) FIRE
(1)	Ag, Livestock	1.2072	0.0774	0.0445	0.0343	0.0455	0.0379	0.1911	0.0889	0.0617
(2)	Ag, Crops	0.3938	1.0921	0.0174	0.0134	0.0178	0.0151	0.6488	0.0317	0.0368
(3)	Nonmetallic Mining	0.0083	0.0068	1.0395	0.0302	0.0092	0.0043	0.0063	0.0024	0.0049
(4)	Construction	0.0722	0.0794	0.0521	1.0501	0.0496	0.0653	0.0618	0.0347	0.0740
(5)	Transportation	0.0151	0.0113	0.0284	0.0105	1.0079	0.0135	0.0128	0.0104	0.0120
(6)	Comm & Public Util	0.0921	0.0836	0.1556	0.0604	0.0839	1.1006	0.0766	0.0529	0.1321
(7)	Ag Proc & Misc Mfg	0.5730	0.1612	0.0272	0.0207	0.0277	0.0239	1.7401	0.0452	0.0704
(8)	Retail Trade	0.7071	0.8130	0.5232	0.4100	0.5475	0.4317	0.6113	1.2734	0.6764
(9)	Fin, Ins, Real Estate	0.1526	0.1677	0.1139	0.0837	0.1204	0.1128	0.1322	0.0577	1.1424
(10)	Bus & Pers Services	0.0562	0.0684	0.0430	0.0287	0.0461	0.0374	0.0514	0.0194	0.0766
(11)	Prof & Soc Services	0.0710	0.0643	0.0559	0.0402	0.0519	0.0526	0.0530	0.0276	0.0816
(12)	Households	1.0458	0.9642	0.8424	0.6089	0.7876	0.7951	0.7859	0.4034	1.2018
(13)	Government	0.0987	0.0957	0.0853	0.0519	0.2583	0.0999	0.0796	0.0394	0.1071
(14)	Coal Mining	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
(15)	Thermal-Elec Generation	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
(16)	Pet Exp/Ext	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
(17)	Pet Refining	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Gross Receipts Multiplier		4.4931	3.6851	3.0284	2.4430	3.0534	2.7901	4.4509	2.0871	3.6778

TABLE A2. INPUT-OUTPUT INTERDEPENDENCE COEFFICIENTS, BASED ON TECHNICAL COEFFICIENTS FOR 17-SECTOR MODEL FOR NORTH DAKOTA (CONTINUED)

Sector	(10) Bus & Pers Service	(11) Prof & Soc Service	(12) Households	(13) Govt	(14) Coal Mining	(15) Thermal-Elec Generation	(16) Pet Exp/Ext	(17) Pet Refining
(1) Ag, Livestock	0.0384	0.0571	0.0674	0.0000	0.0376	0.0251	0.0159	0.0145
(2) Ag, Crops	0.0152	0.0229	0.0266	0.0000	0.0285	0.0321	0.0062	0.0057
(3) Nonmetallic Mining	0.0043	0.0050	0.0057	0.0000	0.0032	0.0019	0.0045	0.0037
(4) Construction	0.0546	0.0787	0.0902	0.0000	0.0526	0.0328	0.1148	0.0929
(5) Transportation	0.0118	0.0100	0.0093	0.0000	0.0084	0.0048	0.0180	0.0172
(6) Comm & Public Util	0.1104	0.1192	0.1055	0.0000	0.0712	0.0378	0.0510	0.0444
(7) Ag Proc & Misc Mfg	0.0237	0.0362	0.0417	0.0000	0.0618	0.0782	0.0097	0.0089
(8) Retail Trade	0.4525	0.6668	0.7447	0.0000	0.3995	0.2266	0.1838	0.1675
(9) Fin, Ins, Real Estate	0.1084	0.1401	0.1681	0.0000	0.0771	0.0977	0.0388	0.0358
(10) Bus & Pers Services	1.0509	0.0455	0.0605	0.0000	0.0289	0.0201	0.0139	0.0127
(11) Prof & Soc Services	0.0497	1.1026	0.0982	0.0000	0.0493	0.0301	0.0210	0.0195
(12) Households	0.7160	1.0437	1.5524	0.0000	0.6666	0.3973	0.3205	0.2951
(13) Government	0.0774	0.0881	0.1080	1.0000	0.0511	0.0444	0.0280	0.0285
(14) Coal Mining	0.0000	0.0000	0.0000	0.0000	1.0000	0.1582	0.0003	0.0002
(15) Thermal-Elec Generation	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000
(16) Pet Exp/Ext	0.0000	0.0000	0.0000	0.0000	0.0138	0.0084	1.0981	0.8227
(17) Pet Refining	0.0000	0.0000	0.0000	0.0000	0.0168	0.0102	0.0000	1.0000
Gross Receipts Multiplier	2.7133	3.4159	3.0783	1.0000	2.5664	2.2057	1.9245	2.5693

TABLE A3. GROSS BUSINESS VOLUME TO EMPLOYMENT (PRODUCTIVITY) RATIOS, BY ECONOMIC SECTOR, NORTH DAKOTA, 1958-1984

Year	(1) & (2) Ag	(3) Nonmetallic Mining	(4) Const	(5) Trans	(6) Comm & Pub Util	(7) Ag Proc & Misc Mfg	(8) Retail Trade	(9) FIRE	(10) Bus & Pers Service	(11) Prof & Soc Service	(12) Households	(13) Govt	(14) Coal Mining	(15) Thermal-Elec Generation	(16) Pet Exp/Ext	(17) Pet Refining
1958	9,444	53,846	6,486	1,768	10,644	19,169	19,939	29,783	5,122	4,798	--	3,030	2,894	--	8,828	39,104
1959	9,290	54,330	6,259	1,687	10,035	17,659	18,451	26,617	4,597	4,304	--	2,787	2,610	--	12,611	39,692
1960	8,887	55,284	7,409	1,624	9,760	17,353	17,593	24,713	4,275	4,045	--	2,660	2,610	--	19,568	39,682
1961	9,414	52,307	7,188	1,779	10,824	18,846	18,451	25,166	4,288	4,159	--	2,729	3,403	--	23,296	41,311
1962	11,016	69,565	6,986	2,168	13,605	18,827	23,753	30,488	5,179	5,102	--	3,260	3,937	--	27,786	42,229
1963	12,872	77,981	7,999	2,344	14,551	19,251	24,422	31,894	5,361	5,161	--	3,238	3,561	--	29,850	43,706
1964	12,649	82,300	8,972	2,503	16,086	18,583	25,087	33,178	5,523	5,566	--	3,286	4,297	--	30,516	46,014
1965	15,406	71,111	9,135	2,656	16,060	19,562	25,420	32,893	5,807	5,437	--	3,169	5,190	--	27,822	50,375
1966	17,930	77,037	11,896	2,933	17,673	21,005	28,358	36,465	6,543	6,012	--	3,414	5,649	23,404	30,742	53,007
1967	18,988	78,906	12,355	2,853	16,765	21,745	27,589	33,397	6,189	5,451	--	3,086	9,855	43,298	31,613	55,263
1968	19,376	84,800	14,093	3,046	17,968	21,858	29,140	35,118	6,561	5,654	--	3,071	13,056	63,730	37,650	58,203
1969	22,584	88,235	16,356	3,428	20,153	27,370	32,433	39,220	7,325	6,322	--	3,376	13,230	59,693	29,449	61,133
1970	27,374	129,545	26,968	4,002	24,828	28,071	36,472	46,044	8,012	6,987	--	4,036	16,167	57,740	45,862	71,296
1971	28,922	106,060	16,353	3,992	24,964	29,513	36,402	45,721	7,842	6,739	--	4,096	17,647	70,281	50,458	77,777
1972	38,088	134,108	17,549	4,932	30,102	32,432	42,244	54,486	8,816	7,804	--	4,923	17,914	79,553	55,781	85,500
1973	61,728	190,625	23,762	7,042	41,942	42,699	59,244	77,240	11,984	10,545	--	7,071	18,750	68,683	64,096	92,822
1974	66,322	200,000	25,637	7,763	45,645	44,746	63,783	81,936	12,619	11,207	--	7,736	23,876	71,794	99,225	113,930
1975	59,977	171,333	21,977	7,356	44,515	36,673	56,823	72,700	11,346	10,288	--	6,932	24,413	61,676	83,949	125,870
1976	52,517	151,923	16,800	7,019	41,584	43,572	50,590	64,487	10,626	9,483	--	6,424	42,996	109,039	81,215	137,128
1977	46,259	146,583	16,377	6,615	39,361	40,263	49,143	58,964	10,220	9,038	--	6,207	42,737	129,329	66,699	147,058
1978	59,804	170,303	17,481	7,264	42,991	42,946	57,438	66,303	11,471	9,996	--	7,057	43,665	180,165	48,564	154,368
1979	70,488	192,012	20,660	7,904	45,971	48,201	62,930	72,542	12,019	11,058	--	8,013	57,794	248,913	60,578	233,696
1980	74,811	215,297	28,091	8,903	50,255	55,070	70,394	78,103	12,793	12,253	--	9,014	69,524	311,139	84,707	360,075
1981	85,034	243,533	36,367	10,977	58,170	57,768	83,851	89,267	14,125	13,439	--	10,594	67,983	282,730	134,764	618,212
1982	84,080	218,788	30,620	10,309	55,042	53,484	77,073	82,571	12,691	11,723	--	9,826	64,293	292,948	144,954	642,088
1983	93,635	240,042	31,356	11,662	64,527	58,772	87,188	92,571	14,018	12,973	--	11,007	77,439	327,880	195,633	586,323
1984	89,744	235,691	39,630	11,188	63,537	58,285	83,311	90,558	13,280	12,710	--	10,987	84,996	350,310	174,591	558,256

SOURCE: Coon et al. 1985.

TABLE A4. ESTIMATES OF PERSONAL INCOME AND DIFFERENCES IN ESTIMATES, NORTH
DAKOTA, 1958-1984 (THOUSAND DOLLARS)

Year	Department of Commerce Estimate	I-O Analysis Estimate	Percent Difference
1958	--	1,022,412	--
1959	1,008,057	978,420	- 2.94
1960	--	942,488	--
1961	--	1,011,462	--
1962	1,460,980	1,285,790	-11.99
1963	--	1,353,864	--
1964	--	1,521,191	--
1965	1,497,762	1,470,129	- 1.84
1966	1,555,539	1,662,394	6.87
1967	1,595,042	1,573,010	- 1.38
1968	1,643,964	1,684,451	2.46
1969	1,850,417	1,890,973	2.19
1970	1,913,283	2,117,319	10.66
1971	2,158,416	2,156,642	- 0.08
1972	2,676,385	2,601,416	- 2.80
1973	3,841,862	3,674,738	- 4.35
1974	3,739,859	4,104,667	9.75
1975	3,755,431	4,009,827	6.77
1976	3,828,880	3,860,970	0.84
1977	3,982,404	3,829,503	- 3.84
1978	4,798,839	4,481,331	- 6.62
1979	5,228,461	5,187,221	- 0.79
1980	5,657,789	5,390,502	- 4.72
1981	7,123,641	6,899,460	- 3.15
1982	7,306,383	6,305,332	-13.70
1983	7,936,951	7,223,150	- 8.99
1984	8,479,079	7,324,837	-13.61

Absolute Average Difference   5.47

Mean = -1.875 (S.D. = 6.626)

Theil's U_1 Coefficient = .066

APPENDIX B
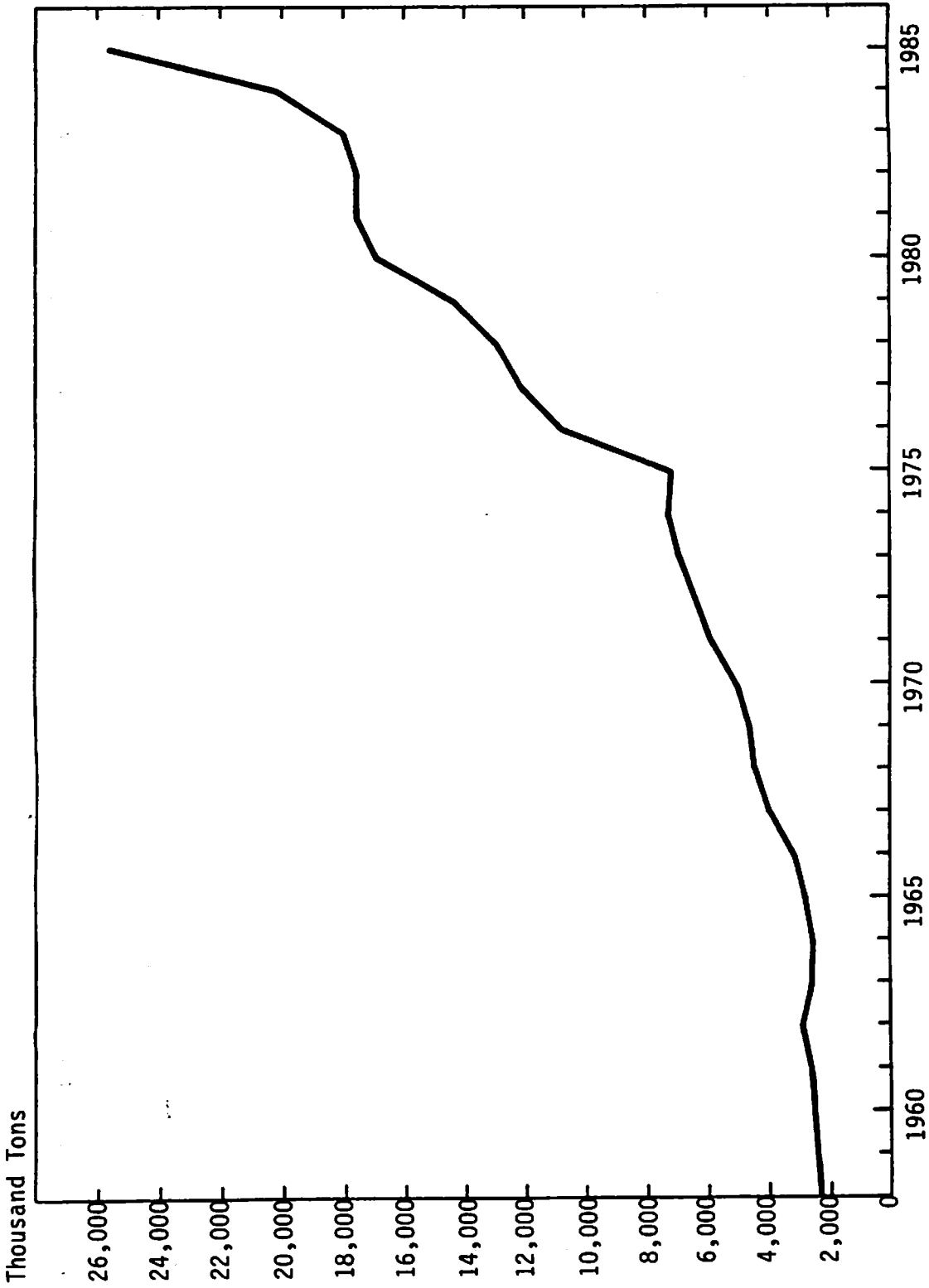
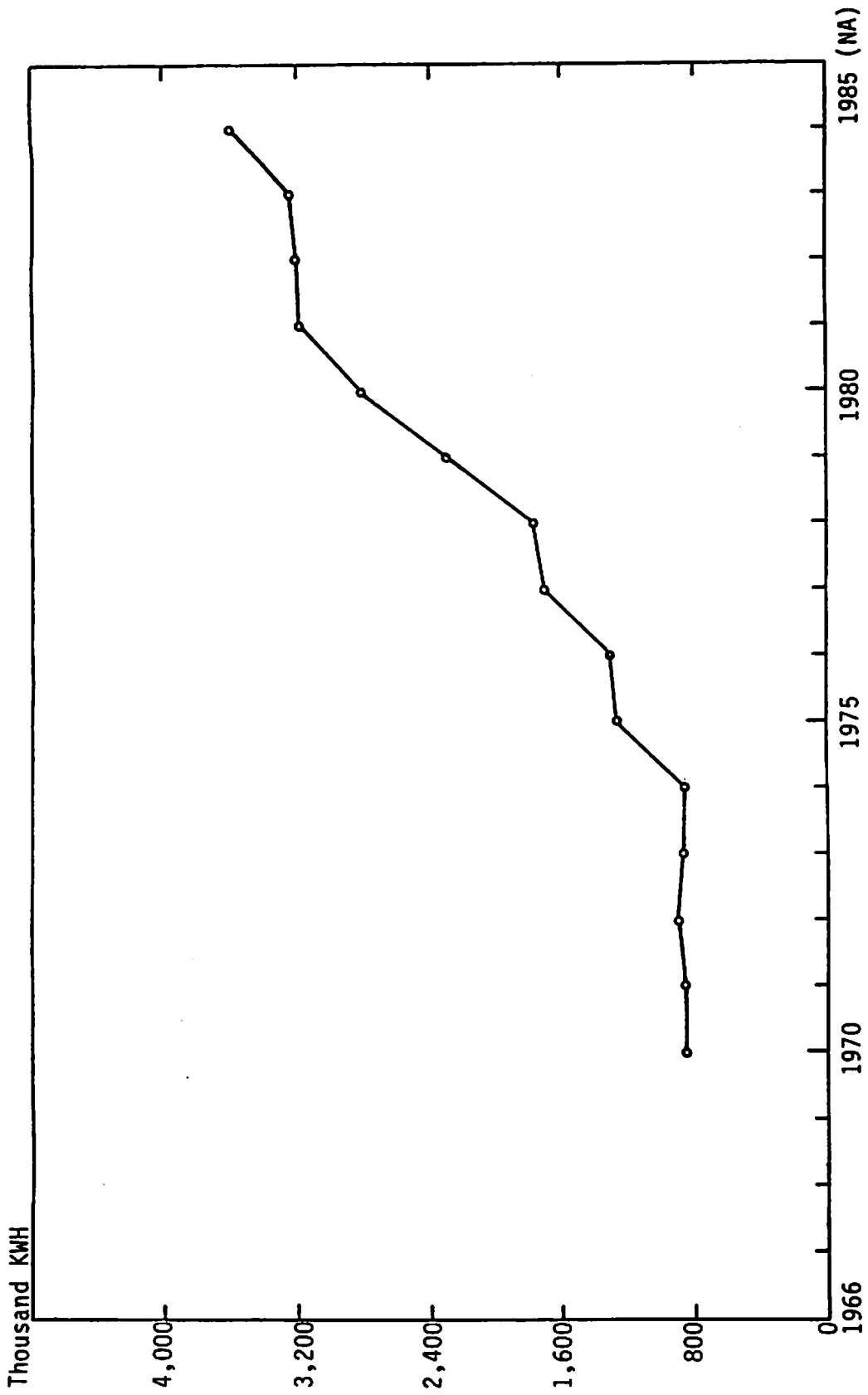Figure 1B. Production of Lignite Coal in North Dakota, 1958-1985

Figure 2B. Coal-Fired Thermal-Electric Generating Capability in North Dakota, 1969-1985
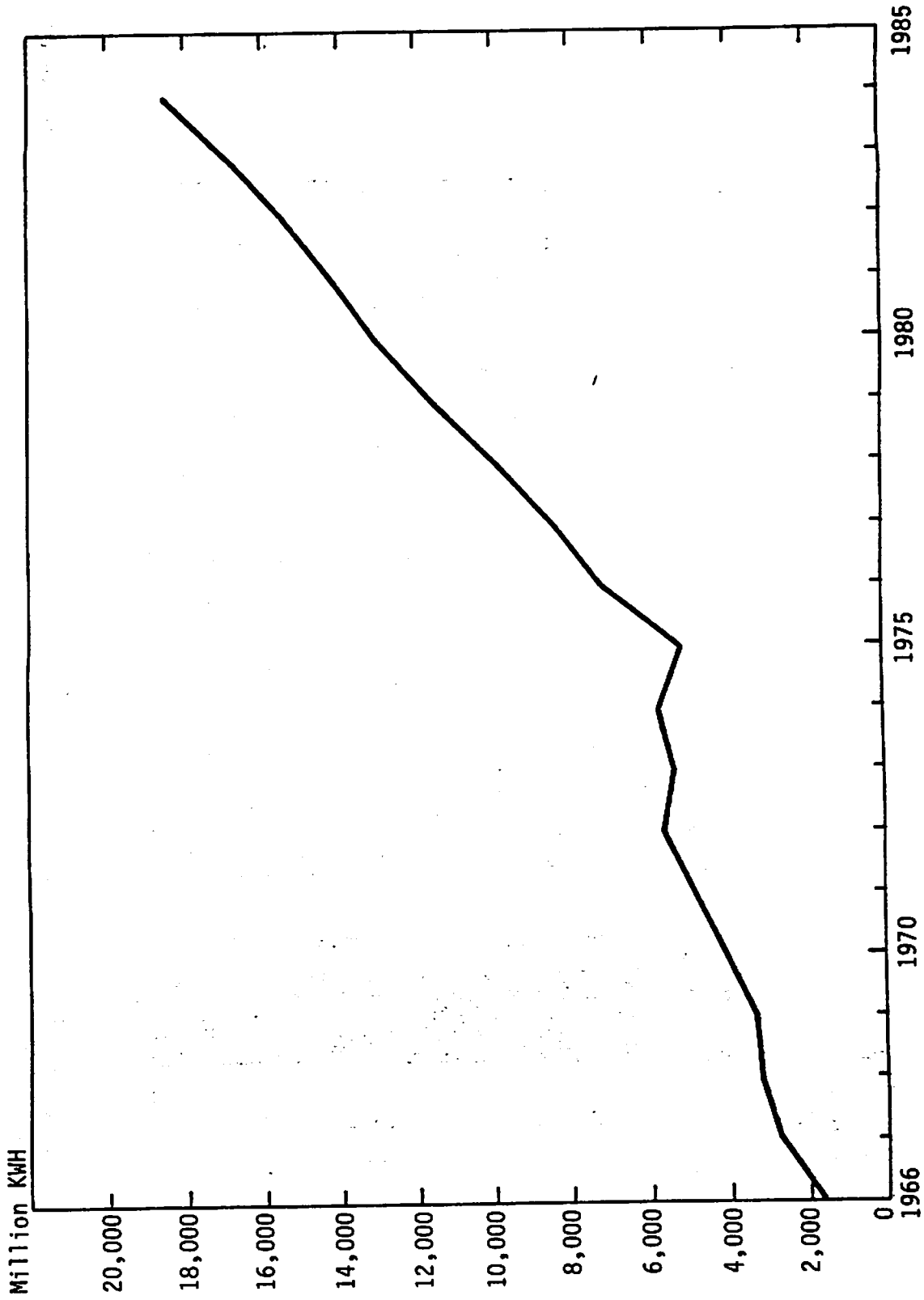
Figure 3B. Coal-Fired Thermal-Electric Generation in North Dakota, 1966-1985
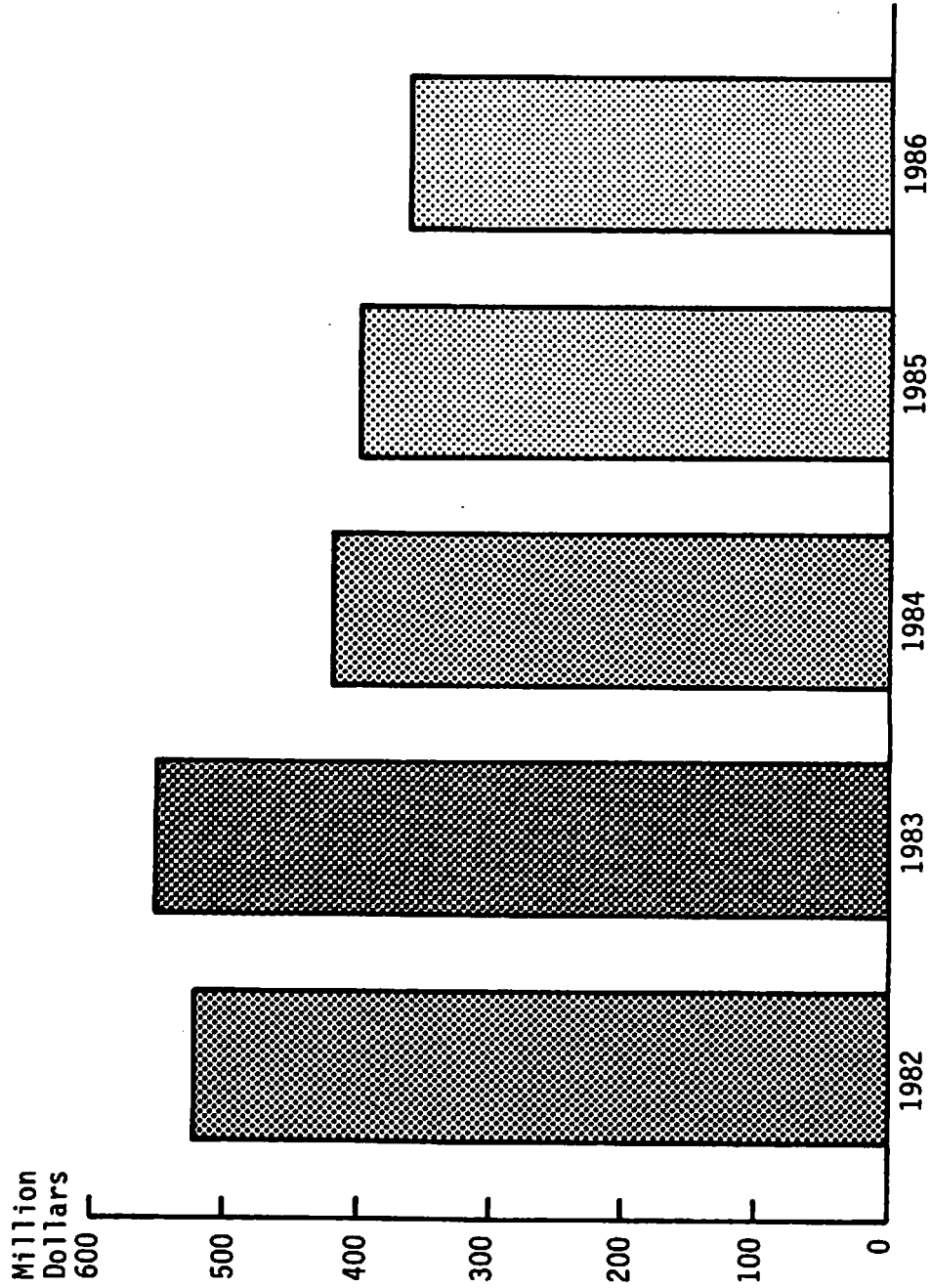
Figure 4B. Estimated North Dakota Expenditures for Companies Involved in Lignite-Related Activities, 1982-1986
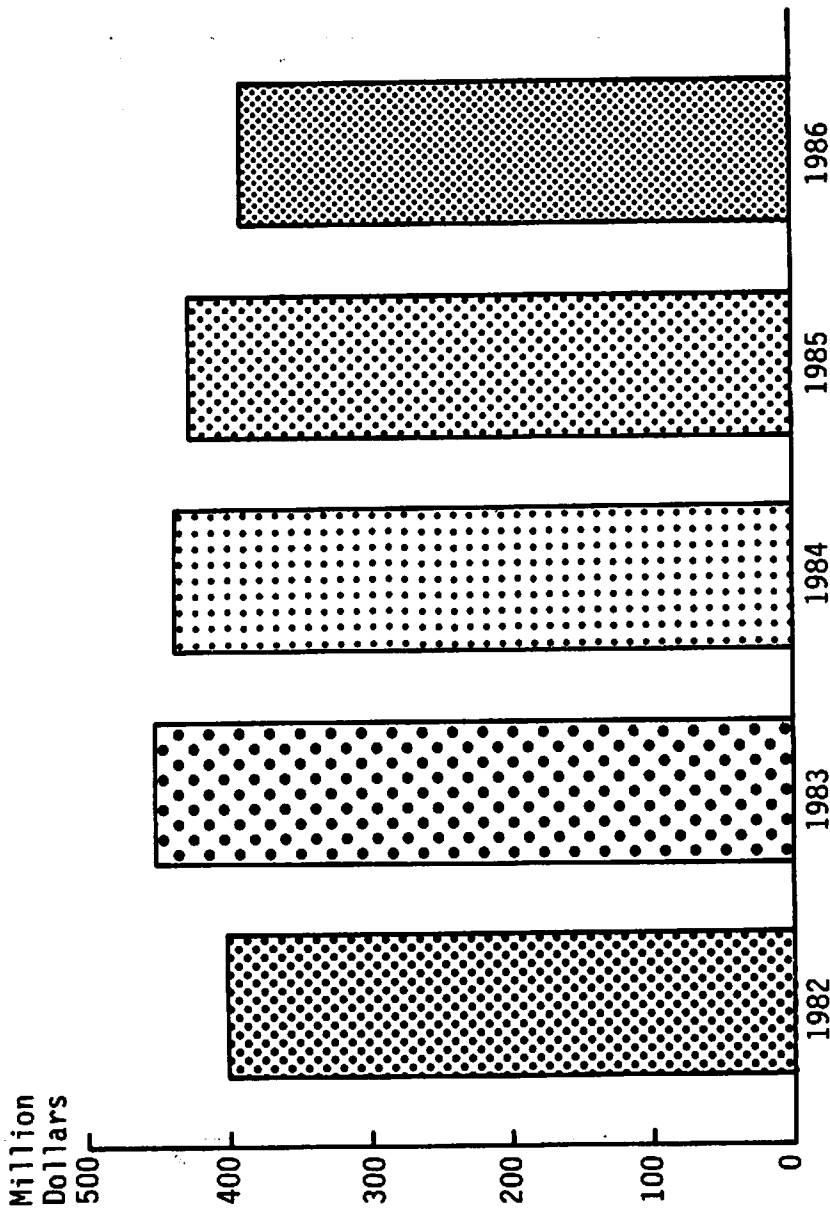
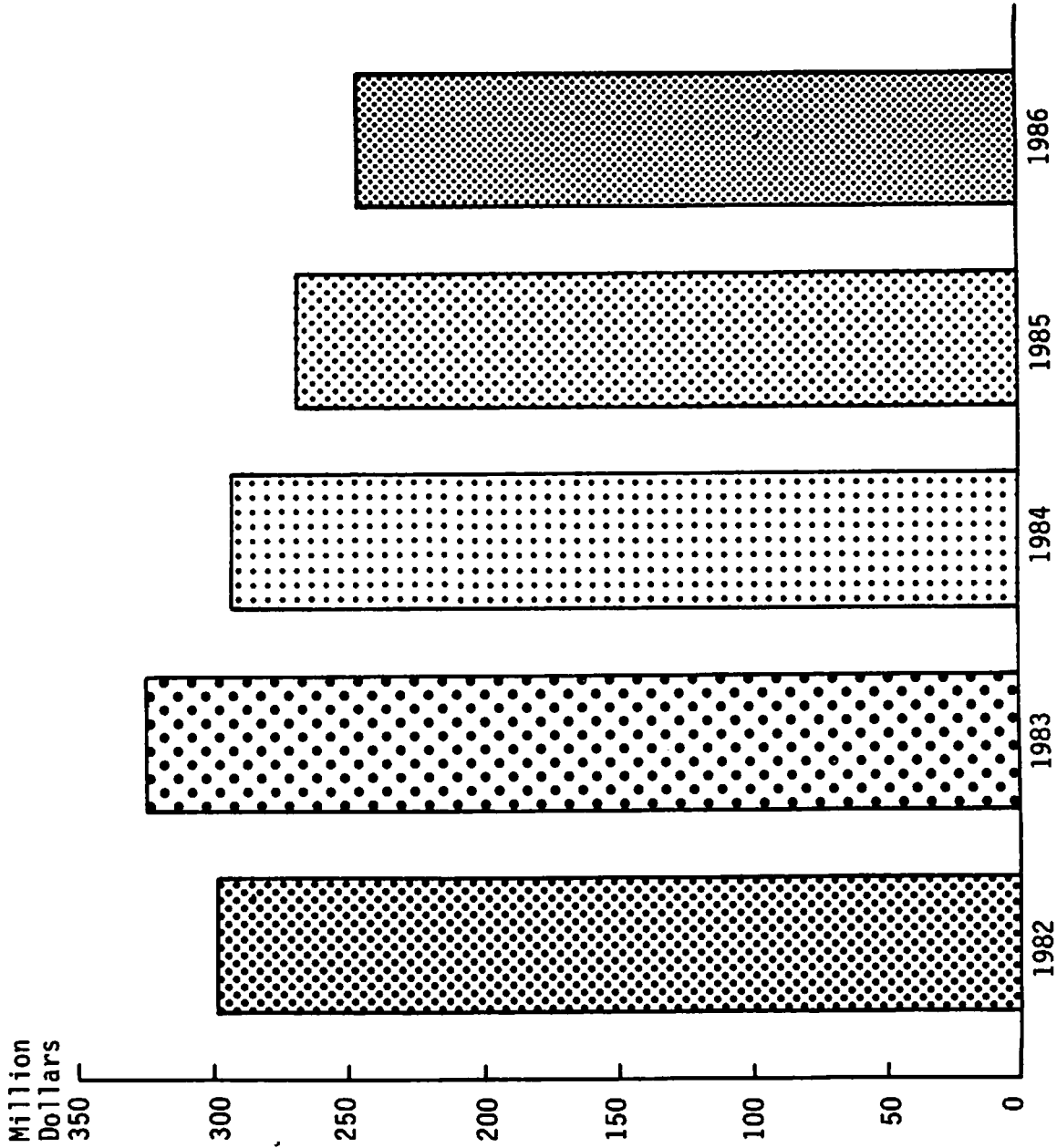Figure 5B. Estimated Personal Income Associated with Lignite-Related Activities in North Dakota, 1982-1986

Figure 6B. Estimated Retail Sales Activity Associated with Lignite-Related
Activities in North Dakota, 1982-1986
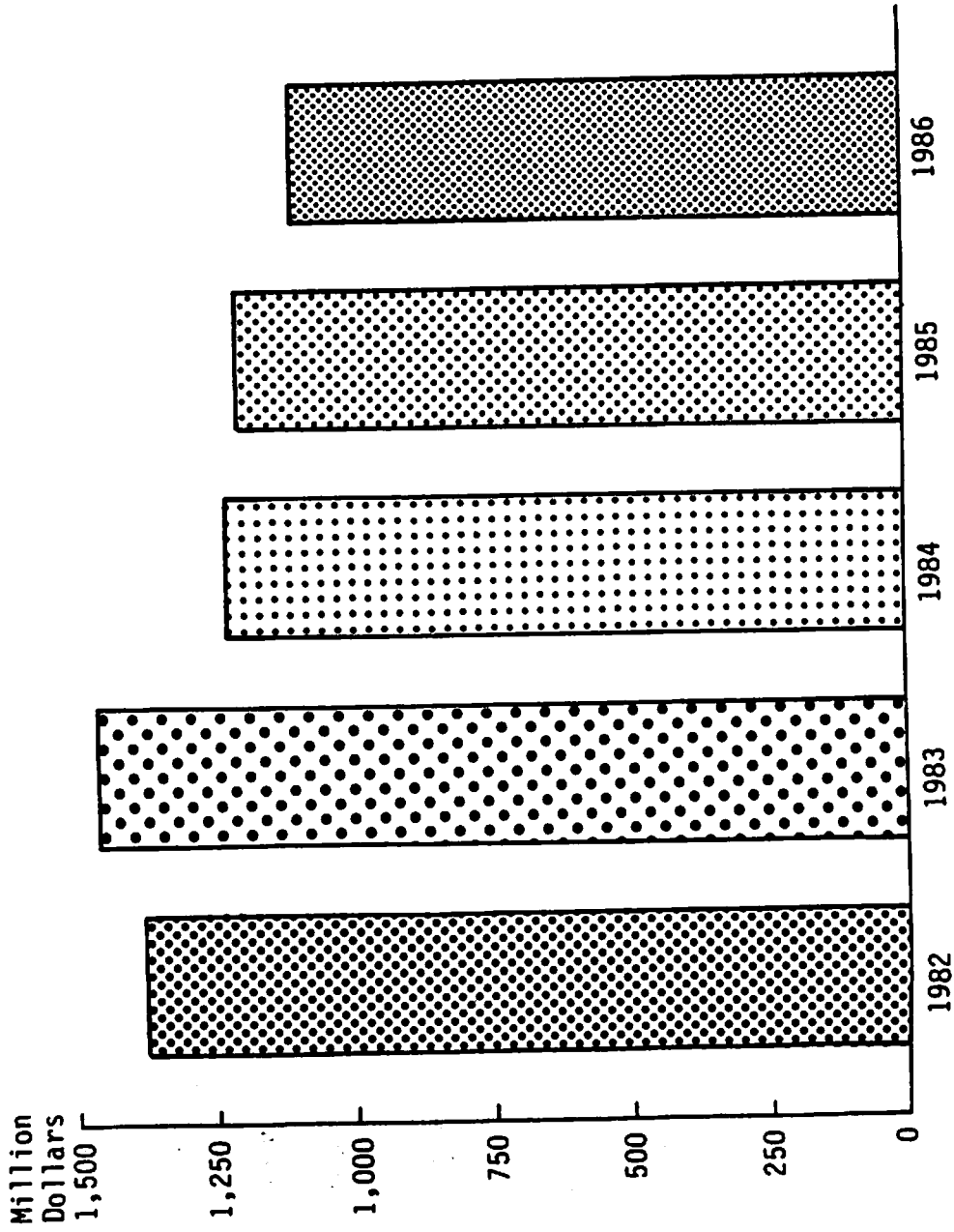
Figure 7B. Estimated Total Business Activity Associated with Lignite-Related Activities in North Dakota, 1982-1986
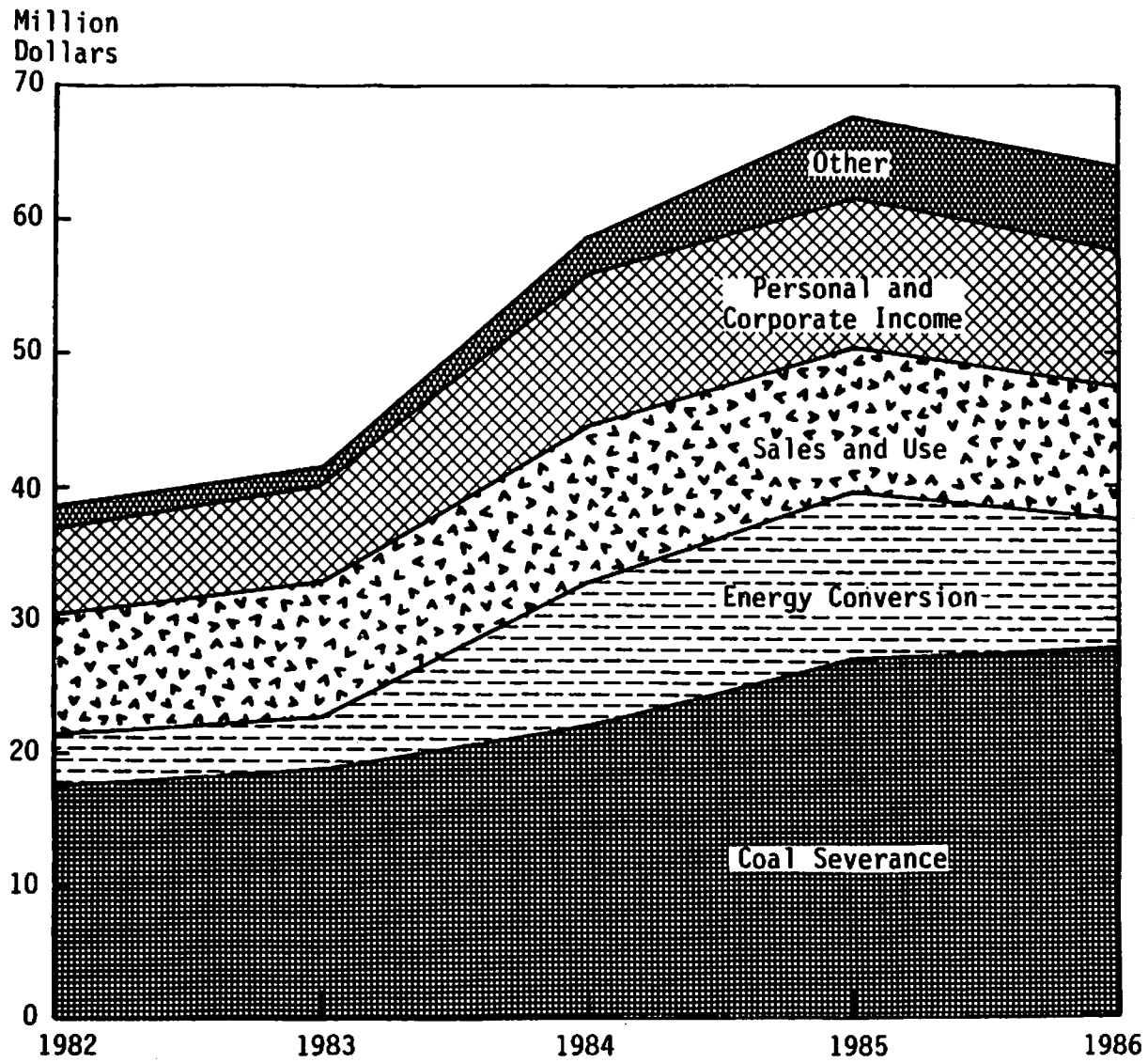
Million
Dollars

Figure 8B. Tax Revenues in North Dakota as a Result of Lignite-Related
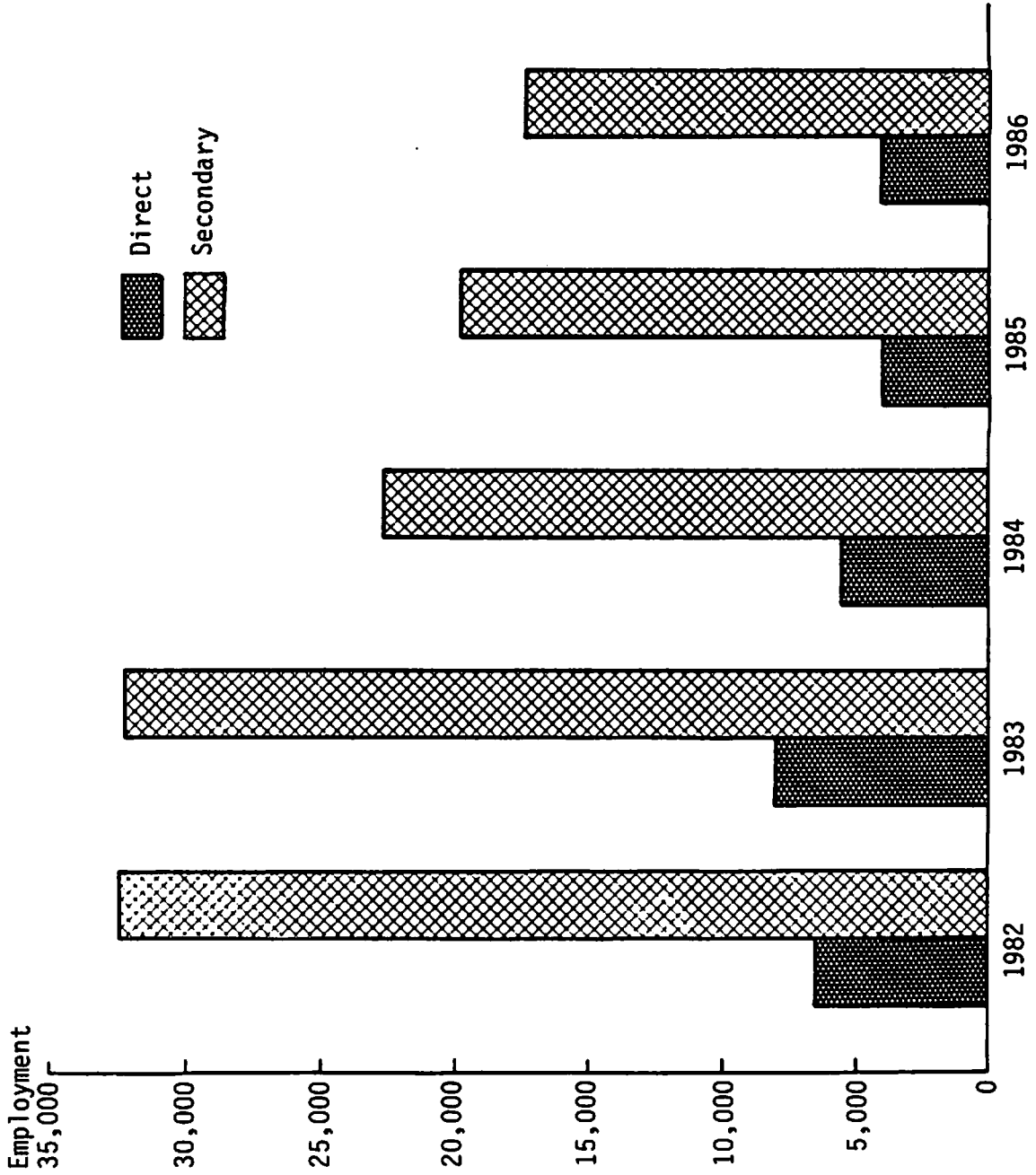Activities, 1982-1986

Figure 9B. Estimated Direct and Secondary Employment Totals for Companies Involved in Lignite-Related Activities, 1982-1986

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