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An Econometric Model for Forecasting Industrial Electrical Sales for Indiana

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Major Professor ________

AN ECONOMETRIC MODEL FOR FORECASTING INDUSTRIAL ELECTRICAL SALES FOR INDIANA

A Thesis

Presented to

the Faculty of the Graduate School

Butler University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Economics

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by

Ronald E. Clarke

July 1972

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Chapter 1

INTRODUCTION

Projections of electrical energy sales constitute the foundation for planning in the electric utility industry. Every distributor of electric energy, large or small, wholesaler or retailer, should have sales forecasts available upon which to base its physical and financial planning. Others associated with the industry, such as regulatory agencies and suppliers, also need such forecasts.

The purpose of this paper is to develop an econometric model for forecasting annual industrial kilowatt-hour sales for the State of Indiana. The model is designed so that State agencies, suppliers and individual companies can use the model.

STATE AGENCIES

Regulatory agencies need kilowatt-hour sales forecasts and an understanding of the basis on which these forecasts are made in the performance of their regulatory functions of rate review, facilities evaluation, purchased power agreements, merger review, etc. Forecasts will also help them to compile statistical data for the information of the public, legislative and other governmental bodies, academic institutions and manufacturers.

A survey conducted by the Public Service Commission of Indiana showed that during the next five years ending 1975, the five investor owned electric utilities in Indiana will spend over $2.5 billion on construction. Since the Public Service Commission must approve these construction programs, accurate forecasts of future sales would be an invaluable tool in evaluation of these programs.

State agencies can also use a forecast of industrial kilowatt-hour sales as an indicator of industrial activity in the State. The model will point out the industries that have a significant economical impact on Indiana.

SUPPLIERS

Manufacturers and other suppliers to the electric utility industry rely on forecasts in order to plan the manufacturing capability required for the production of generators, turbines, transformers, line materials and other utility plant equipment. Fuel suppliers are also guided by sales forecasts. Continued growth in the use of electric power has demanded and produced new technological developments in all components of electric utility plant. It is through the use of forecasts that the industry can anticipate the limitations of equipment currently in use and engage in the necessary research and development to make equipment available to meet future requirements.

COMPANIES

The purpose a company has for a forecast usually determines the time period to be covered. The model in this paper will deal with short-term forecasts (1 to 2 years) and intermediate-term forecasts (4 to 6 years).

Short-Term Forecasts

For the short-term forecasts, as for the forecasts for the immediate future, the fixed costs for generation and transmission have been established. However, in addition to being the basis for budgeting and planning operations for the lowest incremental energy costs, the short-term forecast is used for establishing maintenance schedules, for determining budget allocation for fuel and purchase power and for adjustments to construction programs.

Intermediate-Term Forecasts

The intermediate-term forecast covers the most critical time span in terms of planning of physical facilities, since lead time for adding generating capacity is generally of this length. Therefore based on this forecast the final commitment to build generating plants must be made.

This involves such decisions as where and what kind of facility to build, whether to contract for power purchases or sales with neighboring utilities, and, if a facility is to be built, securing permits, licenses, etc. Sales forecasts can also be useful in outlining distribution needs, performing rate and economic studies and undertaking associated corporate planning.

Reliance on a dependable supply of electricity has been an important element in the evolution of the living habits of Americans as well as the country's industrial operations. The reliability of service demanded by the American people requires that power be available for use whenever the demand occurs and whatever its magnitude. The fact that there may be equipment failure or natural disturbances that render certain equipment inoperative is seldom considered an acceptable reason for the interruption of the bulk supply of electric power. As a result, the industry must plan reserve and standby systems for such contingencies.

Accurate forecasts play an essential part in providing effective reserve and standby arrangements.[1] The needs for additional generating, transmission and distribution facilities, the carrying cost of which represents a major portion of the total annual cost of a utility system, are largely determined from forecasts. Provision of adequate service to the consumer at the lowest cost compatible with maintaining an adequate net income for the utility system depends heavily on accurate sales forecast. Substantial forecasting errors, therefore, can lead to inadequate service, unduly high costs to the consumer and inadequate income for the system.

Because of the critical role intermediate-term forecasts play, the consequences of error in such forecasts are the most serious. Forecasts which are too low could result in the use of heavily loaded transmission and distribution facilities with associated higher line losses and reduced reliability. Low forecasts could require purchases of higher cost power from neighboring utilities and could even result in curtailment of load. Forecasts which are too high, on the other hand, cuase problems of equal severity. This could lead to the construction of unneeded generation, transmission and distribution facilities and thus to higher cost electric service.

Forecasts are also the starting point for financial planning. The capacity and fuel strategies discussed on the preceding pages are based on these forecasts and in turn are translated into financial requirements. The carrying charge on plant and the cost of fuel are major costs of

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[1] Load Forecasting Methodology Committee, The Methodology of Load Forecasting, A Report to the Federal Power Commission (Washington D. C.: Federal Power Commission, 1969), Chapter 2, p. 7.

operating an electric utility. Estimates of many of the remaining costs are also based on sales forecasts, as are estimates of revenue. Sales forecasts are the basis of revenue planning. Together these factors form a financial plan. In addition, they are used to make rate analysis and to develop a comprehensive marketing plan.

Chapter 2

CURRENT FORECASTING METHODS

The number and kinds of forecasting methods used vary considerably from utility to utility. Several methods are commonly used. Differences in methods result in part from variations in economic and geographic conditions, system characteristics, and composition of sales in the utility areas, and in part from variations in knowledge of forecasting methods.

There are two basic quantities to forecast in the electric utilities industry, peak demand and total energy sales. Peak demand is defined as the maximum load on an electrical system during a specific time period. Usually this time period is an hour. Energy sales are defined as the quantity of electricity that a consumer uses and are expressed in kilowatt-hours.

FEDERAL POWER COMMISSION SURVEY

In order to determine the present state of forecasting in the electric utility industry, the Federal Power Commission in 1969 conducted a survey.[2] The sample of companies was selected with the objective of including all types of systems, all areas of the country and all types of forecasting methodology rather than on a random basis.

About half of the reporting utilities prepare energy sales forecasts as the primary forecasts, with peak demands obtained by use

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[2] Load Forecasting Methodology Committee, The Methodology of Load Forecasting, A Report to the Federal Power Commission (Washington, D.C.: Federal Power Commission, 1969).

of a load factor relationship. The other half prepare peak demand forecasts directly.

About a third of the reporting utilities indicate use of simple methods of forecasting which include graphic projections and the use of historical growth rates. Their forecasts are usually intermingled with judgment and influenced by considerations of the business cycle and other economic factors. Depending on the sales and growth characteristics of the system, such methods often can be effective.

Another third of the utilities reported use of mathematical methods involving logarithmic curves and exponential growth curves. These are simple mechanical methods of extrapolation with the ultimate results being influenced by judgment. Other companies select the type of curve based on the relationship of its mathematical characteristics to the growth characteristics of the system. A few utilities reported use of correlation or models through which customers and sales are related to demographic and economic factors.

QUANTITATIVE METHODS

Current quantitative forecasting methods can be grouped into two general categories: extrapolation and correlation. Extrapolation is based upon the assumption that future growth will be a continuation of past patterns of growth. Specific methods include compound rates of growth, annual increments, fitting of mathematical growth curves and use of graphs of historical data. Extrapolation often produces acceptable results because electrical loads exhibit stable growth over rather long periods. However, companies relying predominantly upon this method may fail to recognize underlying changes which eventually will affect future growth.

Correlation relates electric power sales to selected associated factors. Correlation methods include scatter diagrams, simple correlation, multiple correlation and simple or complex models. Results from these techniques, especially the more sophisticated methods, cannot be accepted at face value but must be evaluated in terms of the theories underlying the techniques. Correlation analysis does provide insight into the causes of past growth and its variations and quantifies relationships between sales and factors which affect sales. This leads to a clearer understanding of the factors which cause growth and of their relative importance. Further, when forecasts deviate from actual loads, the correlation approach is helpful in identifying causes of deviation.

One problem associated with correlation methods is the need to obtain and select forecasts of these associated factors, i. e., independent variables such as population, employment, etc. There is no assurance that this can be done with any greater accuracy than forecasting electric sales directly. Despite this difficulty, correlation is useful because it forces the forecaster to consider and analyze future sales in a context of factors which affect sales rather than as a completely independent event.

It is important, however, that companies avoid the mistake of drawing conclusions from correlations which have a high degree of statistical significance but no logical relationship.

SPECIAL INFORMATION AND JUDGMENT

Although extrapolation and correlation are fundamental tools of sales forecasting, they are not generally sufficient to assure the best results. Two additional ingredients that are often important to the development of a sound sales forecast are the use of special information and the exercise of informed judgment.

Special information is used to modify or reinforce the forecast. Examples include opinions of industrial plant managers as to probable future sales, predictions of business activity and area national electric power forecasts. Such information is not only an important indication of definite future planning for electric consumption by others, but also it is a stimulant to the company in thinking about the possibility of new trends.

Chapter 3

METHODOLOGY OF FORECASTING MODEL

This chapter will describe the methodology to be used in the forecasting model. A multiple regression equation will be developed for each of the investor owned electric utilities in the State. After examining graphs of industrial sales for each of the companies, a linear equation was selected as the best type of equation to be used in forecasting. These five multiple regression equations will be the basis for forecasting industrial electrical sales for the State. In 1970 the companies listed below accounted for 17,507,000 megawatt-hour sales to industrial customers in Indiana. This represents 96% of the total industrial power sales in the State. The other 4% represents concerns that generate their own electrical power. The five investor owned electric utilities are listed below:

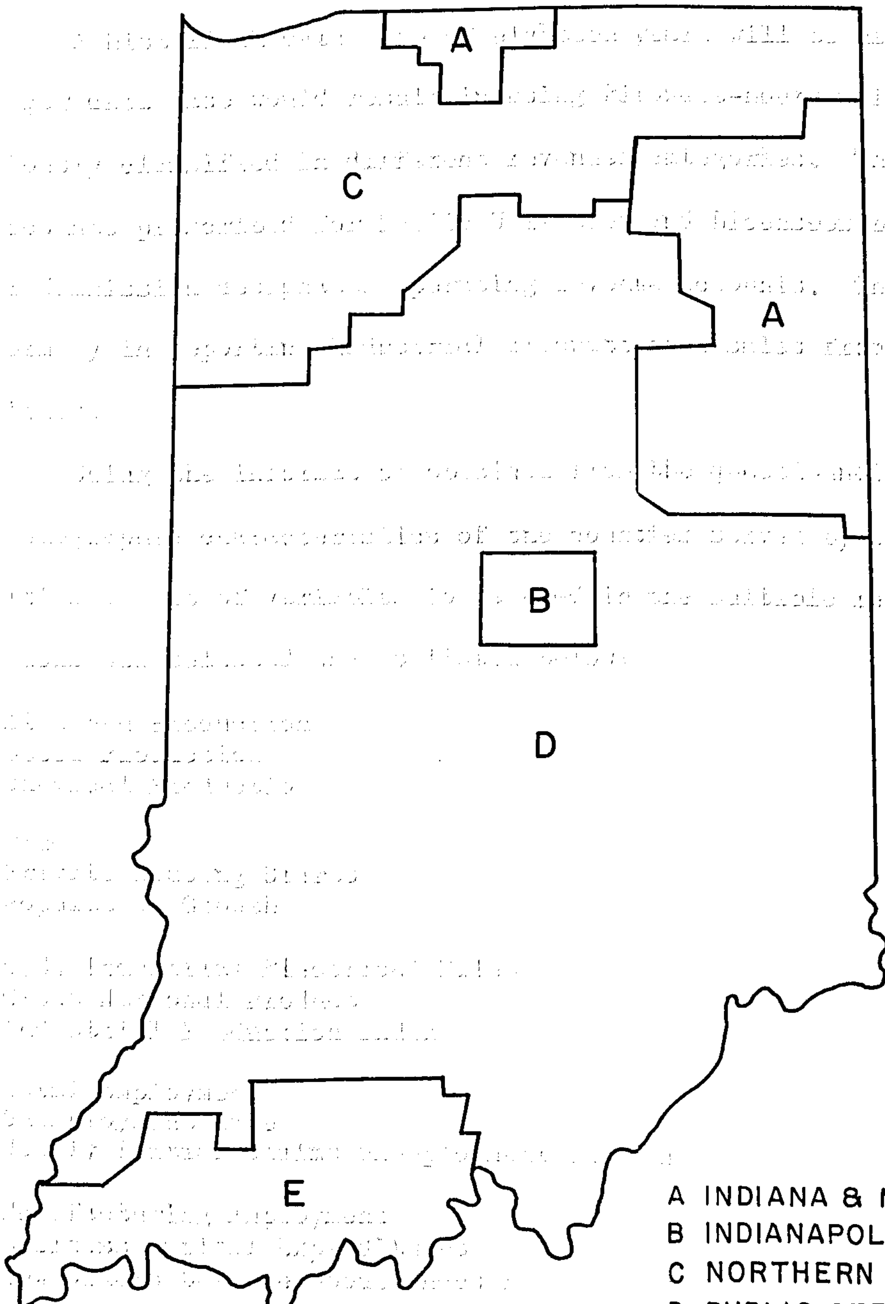
Indiana and Michigan Electric Company
Indianapolis Power and Light Company
Northern Indiana Public Service Company
Public Service Company of Indiana, Inc.
Southern Indiana Gas and Electric Company

The map on the following page shows the territories serviced by each of the companies.

A questionnaire was sent to each of these companies in order to determine the industrial composition of their service territories, current forecasts methods used by the utilities, and expected industrial sales growth in their territories. Listed on page 12 are the questions that were asked.

CHART I

SERVICE TERRITORY OF THE INVESTOR OWNED ELECTRIC UTILITIES IN INDIANA



A INDIANA & MICHIGAN
B INDIANAPOLIS POWER & LIGHT
C NORTHERN INDIANA
D PUBLIC SERVICE INDIANA
E SOUTHERN INDIANA

1. The ten largest, in terms of kilowatt-hours sales, types of industries, as defined by the Commerce Department standard industrial codes, that your company served in 1971 and also the kilowatt sales these same industries had in 1962.

2. Your company's forecast for industrial sales for 1972 through 1976. Also a short description of how your forecasts are developed.

The results of this questionnaire will be discussed in Chapter 4.

A historical data base of eighteen years will be used. To use a larger data base would result in using kilowatt-hours sales that were previously classified in different revenues categories. The Uniform System of Accounts prescribed for Public Utilities and Licensees by the Federal Power Commission designates operating revenue accounts. This insures uniformity in reporting industrial kilowatt-hour sales from electric utilities.

Using the information obtained from the questionnaire and also the demographic characteristics of the counties served by each of the utilities a list of variables to be used in the multiple regression equations was selected and is listed below:

Aluminum Production
Steel Production
Chemical Production

Time
Private Housing Starts
Population Growth

U.S. Industrial Electrical Sales
Gross National Product
Industrial Production Index

Total Employment
Unemployment Rate
Weekly Initial Claims Unemployment Insurance

Manufacturing Employment
Business Capital Expenditures
New Orders Durable Goods Industry

Factory Sales - Autos, Buses, Trucks
Construction Contracts, Commercial and Industrial
Contracts and Orders, Plant and Equipment

Because of the availability of both historical and forecasted data national statistics will be used.

In order to forecast industrial sales in Indiana for the next five years, forecasts for the independent variables in the multiple regression equations had to be obtained. A number of organizations publish forecasts of various segments of the national economy. Perhaps the most widely used source in the electric utility industry is the McGraw-Hill publication Electrical World in which forecasts of a group of related indicators are presented each September.

The multiple linear regression equation will be developed by a step-wise regression method. Standard statistical tests for significance of the regression and closeness of fit of the regression equation will be used. The major ones used are listed below along with a short description.

Coefficient of Determination - The percent of variation in the dependent variable associated with variation in the independent variables.

Partial Correlation Coefficient - Measures the net effect of changes in the individual independent variables, with the other held constant.

Tests Using the F Distribution - An over-all test of whether or not the regression is significant.

Tests Using the T Distribution - A test of whether the regression coefficients are significantly different from zero.

Standard Error of Estimate - A measure of the dispersions of the observed points about the regression equation.

The variables selected for inclusion into the final equations for each of the utility companies were the ones with the highest percent of variation in sales which was associated with variation in the independent variables. Also the availability of reliable forecasts for the independent variables played an important part in selecting the final variables to be included into the equaticns.

The historical data used in each of the multiple regression equations was unadjusted. Companies may want to adjust kilowatt-hour sales to make them uniform in definition and coverage in order to increase their usefulness in forecasting. Significant changes in sales resulting from local strikes, plant shut-dowms or other sales interruption can be added back to determine what the total sales might have been.

Chapter 4

FORECASTING EQUATIONS

This chapter will present the multiple regression equations for forecasting industrial kilowatt-hour sales for each of the investor owned electric utilities. Also the analysis used to select the variables in each of the equations will be presented.

INDIANA AND MICHIGAN ELECTRIC COMPANY

Indiana and Michigan's service territory covers the northeastern portion of Indiana and also a small portion of the extreme northern part of Indiana. Within these two areas are two major metropolitan areas; Fort Wayne and South Bend. In the 1970 census these two cities had a total population of 177,671 and 125,580 respectively. The total population in Indiana and Michigan's service territory is approximately 1,120,000. This represents about 23% of the total population of the State.

Industrial Characteristics

To analyze Indiana and Michigan's current industrial characteristics and the trend that has occurred in the past, a table showing the 10 largest, in terms of kilowatt-hours sold, types of industries that Indiana and Michigan served in 1970 and also the sales these same industries had in 1965, is presented on the following page.

Table 1

Ten Largest Types of Industries Served by Indiana and Michigan

	Industry	1970 KWH Sales (000's)	1970 Percent Of Total	1965 KWH Sales (000's)	1965 Percent Of Total
1.	Transportation	827,394	23.9%	853,602	30.5%
2.	Electric Machinery	514,444	14.8	418,146	15.0
3.	Fabricated Metals	468,862	13.5	210,374	7.5
4.	Primary Metals	465,489	13.4	392,927	14.1
5.	Stone, Clay & Glass	253,173	7.3	176,869	6.3
6.	Rubber & Plastic	236,878	6.8	179,112	6.4
7.	Machinery	191,359	5.5	177,925	6.4
8.	Food & Kindred	176,819	5.1	119,249	4.3
9.	Chemical	102,699	3.0	59,988	2.1
10.	Paper Products	102,284	2.9	62,413	2.2
	Total	3,339,401	96.2%	2,650,605	94.8%
	Total Industrial Sales	3,468,000	100.0%	2,796,000	100.0%

As can be seen by the above table Indiana and Michigan's industrial sales are highly related to the transportation industry. This is indicated in the table where in 1965, a boom year in car sales, this industry accounted for over 30% of total industrial power sales and in 1970, a slack year for car sales partly because of the strike at General Motors, this industry accounted for only 24% of total industrial power sales. The South Bend area's economy during the mid fifties was linked almost entirely to the automobile industry, however today, with Studebaker no longer producing cars, they are more closely related to the machinery industry. The Fort Wayne area is becoming known as a distribution center. There are 20 large centers located in the metropolitan area,

Forecasting Equation

Using the analysis on the preceding page different combinations of independent variables listed on page 12 were selected and tested in a stepwise regression program. Listed below is the multiple regression equation that explained the highest percent of the variation in industrial sales for Indiana and Michigan.

Table 2

Multiple Regression Analysis of Industrial Power Sales for Indiana and Michigan

Independent Variables	Regression Coefficient	Computed T-Value	Partial Correlation Coefficient
Time	49.444	4.756	.786
FRB Production	2.503	8.236	.911
Factory sales autos, trucks, buses	0.027	2.151	.499

Coefficient of Determination = .996

Intercept = -262.553

Standard error of estimate = 53.904

The regression is significant using the F distribution at .05, F = 1242.925

The residuals that this equation produces are listed on the following page along with a forecast of industrial sales for Indiana and Michigan for 1972 through 1976. Actual sales along with the regression equation forecast and the Company forecast are charted on page 19.

Table 3

Table of Residuals for Indiana and Michigan

Year	Actual Sales	Estimated Sales	Residuals
1954	1325	1260	65
1955	1573	1543	30
1956	1587	1598	-11
1957	1676	1675	1
1958	1564	1569	-5
1959	1853	1834	19
1960	1931	1948	-17
1961	1938	1979	-41
1962	2214	2205	9
1963	2370	2387	-17
1964	2514	2572	-58
1965	2796	2856	-60
1966	3128	3103	25
1967	3135	3170	-35
1968	3358	3408	-50
1969	3566	3567	-1
1970	3467	3466	1
1971	3720	3574	146

Table 4

Regression Equation Forecast for Indiana and Michigan

Year	Kwh
1972	3799
1973	4006
1974	4238
1975	4486
1976	4696

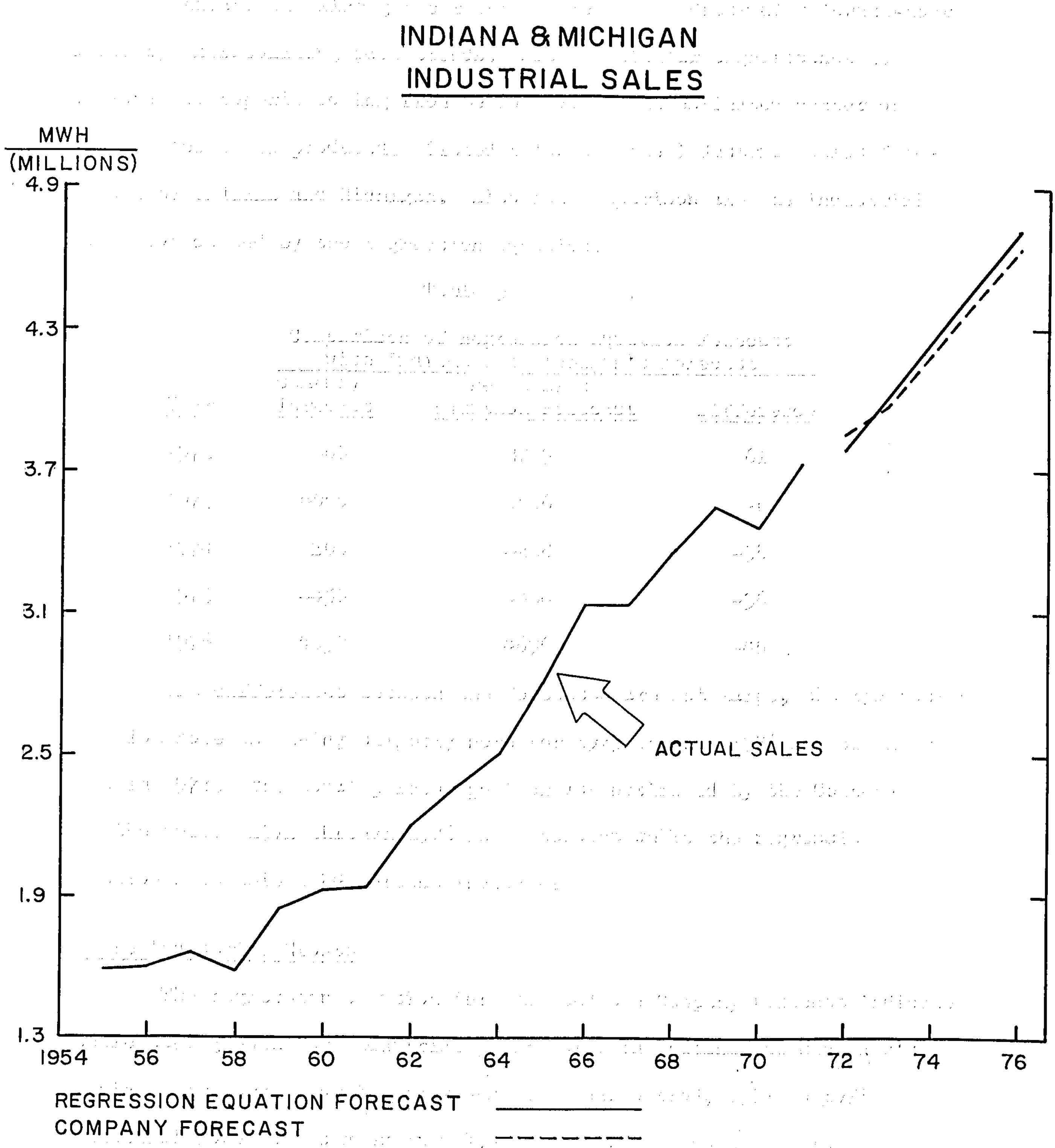
Sources of forecasts for independent variables:

Time

FRB Production Index - Leonard M. Olmsted, "22nd Annual Electrical Industry Forecast," Electrical World, Vol. 176, No. 6, Sept. 15, 1971, p. 44.

Factory Sales Autos, Trucks and Buses - Automobile Mfrs. Association

CHART 2


INDIANA & MICHIGAN
INDUSTRIAL SALES
MWH
(MILLIONS)
4.9
4.3
3.7
3.1
2.5
1.9
1.3
1954
56
58
60
62
64
66
68
70
72
74
76
ACTUAL SALES
REGRESSION EQUATION FORECAST
COMPANY FORECAST

Current Forecasting Method

Indiana and Michigan currently forecasts industrial kilowatt-hour sales by extrapolating past trends. Also particular significance is attached to reports coming from Detroit as to the estimated number of automobiles to be produced. Listed below are the industrial sales forecasted by Indiana and Michigan. Also for comparison are the industrial sales forecasted by the regression equation.

Table 5

Comparison of Regression Equation Forecast with Indiana and Michigan's Forecast

Year	Company Forecast	Regression Equation Forecast	Difference
1972	3860	3799	61
1973	4000	4006	-6
1974	4200	4238	-38
1975	4450	4486	-36
1976	4650	4696	-46

The differences between the forecasts are not large, the regression equation forecast being slightly more for 1973 through 1976 and slightly less in 1972. The total percentage increase estimated by the Company for the period 1972 through 1976 is 21 percent while the regression equation forecasts a 24 percent increase.

Future Industrial Growth

The regression equation forecast and the Company forecast indicate accelerated growth for industrial power sales in Indiana and Michigan's service territory. For the previous five year period, 1967 to 1971, industrial power sales grew at a 4.4 percent annual compound growth rate. The regression equation and the Company forecast growth rates of 5.5 percent and 4.8 percent, respectively, for the period 1972 to 1976. In the future, as in the past, fluctuations in industrial sales for Indiana and Michigan will largely be determined by the activity of the auto industry. Current estimates by the Indiana Employment Security Division indicate that employment in the State in the transportation equipment industry will, from 1967 to 1975, decrease from 99 thousand to 97.7 thousand, a decrease of 8.4 percent.[3] This might explain the moderate forecast of industrial power sales for Indiana and Michigan.

SOUTHERN INDIANA GAS AND ELECTRIC COMPANY

Southern Indiana's service territory covers the southwestern portion of Indiana. The majority of its population is in and centered around Evansville. Total population served is 281,900. This represents approximately 5 percent of the total State population. Its service territory covers all or part of seven counties and is bounded on the south by the Ohio River and on the west by the Wabash River.

Industrial Characteristics

To analyze Southern Indiana's current industrial characteristics and the trend that has occurred in the past, a table showing the 10 largest, in terms of kilowatt-hours sold, types of industries that Southern Indiana served in 1971 and also the sales these same industries had in 1962, is presented on the following page.

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[3]Martin W. Heller, Indiana Manpower Projections, 1967-1975 (Indianapolis: State of Indiana, Indiana Employment Security Division, 1970), p. 7.

Table 6

Ten Largest Types of Industries Served by Southern Indiana

	Industry	1971 KWH Sales (000's)	1971 Percent Of Total	1962 KWH Sales (000's)	1962 Percent Of Total
1.	Primary Metals	242,242	24.9%	9,097	2.4%
2.	Electric Machinery	138,881	14.3	79,817	21.3
3.	Chemical	137,428	14.1	25,383	6.8
4.	Coal Mining	118,104	12.1	55,144	14.7
5.	Food and Kindred	71,260	7.3	47,668	12.7
6.	Fabricated Metals	61,894	6.4	19,410	5.2
7.	Rubber and Plastic	54,154	5.6	19,001	5.1
8.	Petroleum and Coal	32,375	3.3	35,175	9.4
9.	Machinery	28,777	3.0	33,515	9.0
10.	Furniture	9,175	1.0	6,142	1.6
	Total	894,290	92.0%	330,352	88.2%
	Total Industrial Sales	974,476	100.0%	374,219	100.0%

As the above table indicates primary metals account for nearly 25 percent of Southern Indiana's total industrial sales in 1971. This industry has shown tremendous growth since 1962 when it accounted for less than 3 percent of total industrial sales. The Alcoa aluminum plant located in Evansville has accounted for a large part of this growth. Chemical products and fabricated metal products also show substantial increases. Coal mining, electric machinery, and food and kindred products show an increase in kilowatt-hours sales but show a declining percent of total industrial sales.

Forecasting Equation

Using the analysis on the preceding page different combinations of independent variables listed on page 12 were selected and tested in a stepwise regression program. Listed below is the multiple regression equation that explained the highest percent of the variation in industrial sales for Southern Indiana.

Table 7

Multiple Regression Analysis of Industrial Power Sales for Southern Indiana

Independent Variables	Regression Coefficient	Computed T-Value	Partial Correlation Coefficient
Time	-42.984	-2.528	-.560
Aluminum Production	0.245	2.004	.473
Chemical Production	4.033	1.395	.350

Coefficient of Determination = .969

Intercept = -315.782

Standard error of estimate = 46.298

The regression is significant using the F distribution at .05, F = 144.841

The residuals that this equation produces are listed on the following page along with a forecast of industrial sales for Southern Indiana for 1972 through 1976. Actual sales along with the regression equation forecast and the Company forecast are charted on page 25.

Table 8

Table of Residuals for Southern Indiana

Year	Actual Sales	Estimated Sales	Residuals
1954	284	286	-2
1955	306	317	-11
1956	298	326	-28
1957	323	295	28
1958	304	240	64
1959	320	349	-29
1960	338	349	-11
1961	376	303	73
1962	374	365	9
1963	415	422	-7
1964	456	482	-26
1965	489	541	-52
1966	560	619	-59
1967	686	706	-20
1968	677	732	-55
1969	953	890	63
1970	910	908	2
1971	974	915	59

Table 9

Regression Equation Forecast for Southern Indiana

Year	Kwh
1972	1018
1973	1137
1974	1268
1975	1416
1976	1564

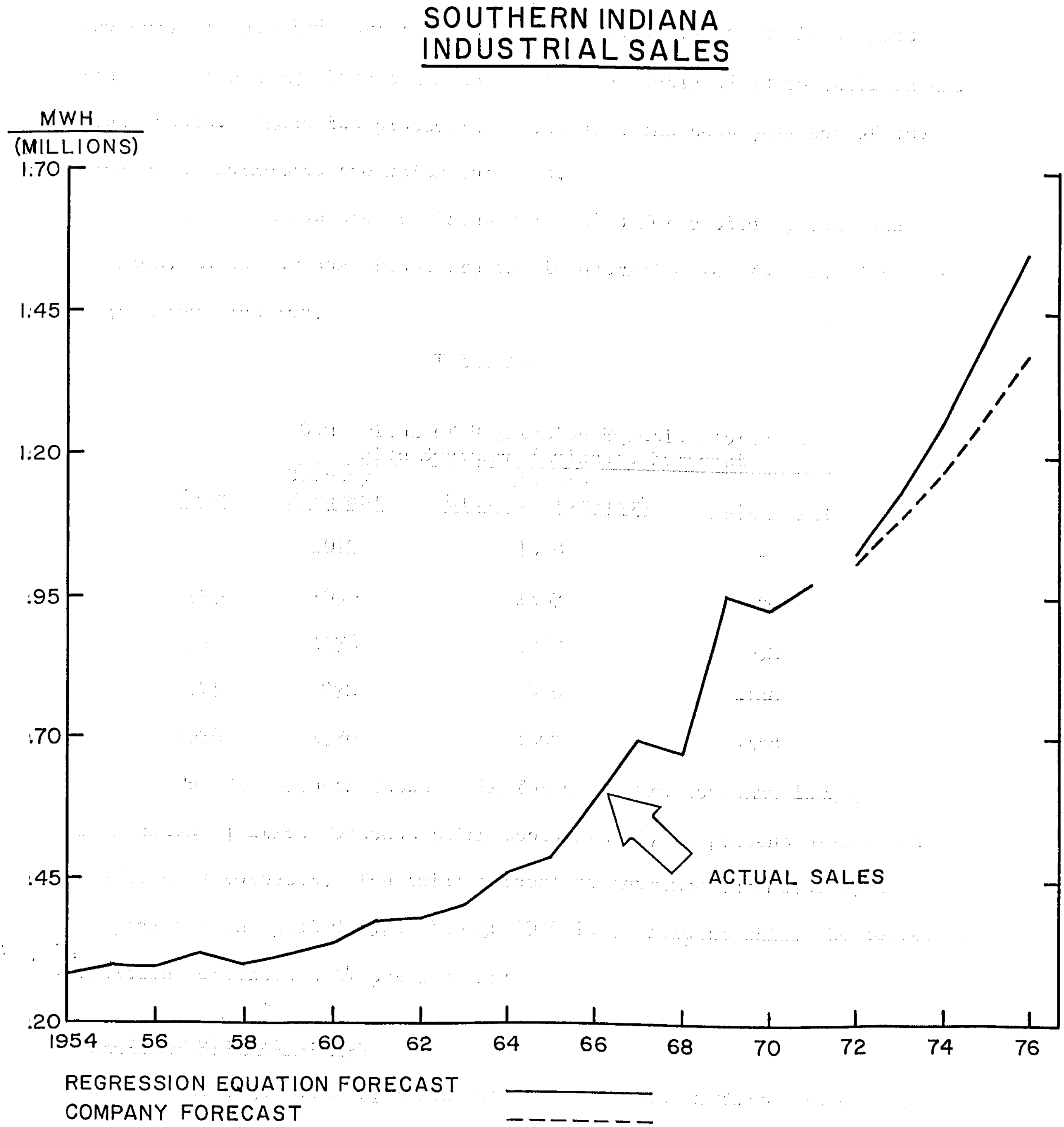
Sources of forecasts for independent variables:

Time

Aluminum Production - Olmsted, p. 44.

Chemical Production - McGraw-Hill Publications Company Economics Dept.; "25th Annual McGraw-Hill Survey, Business' Plans For New Plants and Equipment, 1972-75," April 28, 1972, p. 17.

CHART 3


SOUTHERN INDIANA
INDUSTRIAL SALES
MWH
(MILLIONS)
1.70
1.45
1.20
.95
.70
.45
.20
1954
56
58
60
62
64
66
68
70
72
74
76
ACTUAL SALES
REGRESSION EQUATION FORECAST
COMPANY FORECAST

Current Forecasting Method

The marketing department develops the energy forecasts for Southern Indiana. Future industrial sales are forecasted on the basis of past trends. Also large industrial customers are contacted as to their future power needs. These two procedures along with the best judgment of the management formulate the sales forecast.

Listed below are the industrial sales forecasted by Southern Indiana. Also for comparison are the industrial sales forecasted by the regression equation.

Table 10

Comparison of Regression Equation Forecast with Southern Indiana's Forecast

Year	Company Forecast	Regression Equation Forecast	Difference
1972	1012	1018	-6
1973	1090	1137	-47
1974	1176	1268	-92
1975	1272	1416	-144
1976	1376	1564	-188

The differences between the forecasts are somewhat large, the regression equation forecast being approximately 10 percent higher than the Company forecast. The total percentage increase estimated by the Company for the period 1972 through 1976 is 36 percent while the regression equation forecasts a 54 percent increase.

Future Industrial Growth

The regression equation forecast indicates a faster rate of growth for industrial power sales in Southern Indiana's service territory for the next five years. For the previous five year period, 1967 to 1971, industrial power sales grew at a 9.2 percent compound rate of growth. The regression equation and the Company forecast growth rates of 11.3 percent and 8.0 percent, respectively, for the period 1972 to 1976. Southern Indiana is the only company of the five investor owned utilities in Indiana where the marketing department develops the forecasts. They may consider their forecast as a goal, and a low one at that, rather than a forecast for planning purposes of what industrial sales might be in the future. Southern Indiana's future industrial sales growth will largely depend on the aluminum industry. This one industry accounts for over one fourth of Southern Indiana's total industrial power sales.

PUBLIC SERVICE INDIANA

Public Service Indiana's service territory, the largest of the five investor owned electric utilities in Indiana, covers the central and southern portions of Indiana. In the 1970 census some of the counties showing the largest population increases are the ones surrounding Marion County. All these counties are served by Public Service Indiana. Public Service Indiana serves a population of 1,600,000. This represents 30 percent of the total population of the State.

Industrial Characteristics

To analyze Public Service Indiana's service territory industrial characteristics and the trend that has occurred in the past 10 years, a table showing the 10 largest, in terms of kilowatt-hours sales, types of industries that Public Service Indiana served in 1971 and also the sales these same industries had in 1962, is presented on the following page.

Table 11

Ten Largest Types of Industries Served by Public Service Indiana

	Industry	1971 KWH Sales (000's)	1971 Percent Of Total	1962 KWH Sales (000's)	1962 Percent Of Total
1.	Primary Metals	849,914	19.9%	381,440	17.4%
2.	Chemical	494,444	11.5	187,948	8.6
3.	Transportation	452,842	10.6	214,575	9.8
4.	Stone, Clay & Glass	429,087	10.0	280,908	12.8
5.	Electric Machinery	272,745	6.4	133,690	6.1
6.	Machinery	232,763	5.4	92,739	4.2
7.	Food and Kindred	222,043	5.2	126,826	5.8
8.	Rubber & Plastics	164,085	3.8	104,698	4.8
9.	Fabricated Metals	158,621	3.7	65,953	3.0
10.	Paper	149,329	3.5	80,014	3.6
	Total	3,425,873	80.0%	1,668,791	76.1%
	Total Industrial Sales	4,281,628	100.0%	2,194,439	100.0%

In analyzing the 10 years from 1962 through 1971, primary metal production is the largest user of electrical power in Public Service Indiana's territory accounting for 19.9% of total industrial sales in 1971 and 17.4% in 1962. Chemical production, transportation equipment production, electric machinery production and machinery production show substantial increases, while stone, clay and glass products, food and kindred products, rubber and miscellaneous plastics production show decreasing percentages. The above table indicates that the trend in industrial sales for Public Service Indiana is towards more sales in the durable goods industries.

Forecasting Equation

Using the analysis on the preceding page different combinations of independent variables listed on page 12 were selected and tested in a stepwise regression program. Listed below is the multiple regression equation that explained the highest percent of the variation in industrial sales for Public Service Indiana.

Table 12

Multiple Regression Analysis of Industrial Power Sales for Public Service Indiana

Independent Variables	Regression Coefficient	Computed T-Value	Partial Correlation Coefficient
Time	-45.636	-1.934	-.460
Aluminum Production	1.228	8.507	.916
Factory sales autos, trucks, buses	0.054	2.077	.486

Coefficient of Determination = .984

Intercept = -437.137

Standard error of estimate = 128.558

The regression is significant using the F distribution at .05, F = 277.491

The residuals that this equation produces are listed on the following page along with a forecast of industrial sales for Public Service Indiana for 1972 through 1976. Actual sales along with the regression equation forecast and the Company forecast are charted on page 31.

Table 13

Table of Residuals for Public Service Indiana

Year	Actual Sales	Estimated Sales	Residuals
1954	1695	1666	29
1955	1910	1887	23
1956	2016	1859	157
1957	1783	1792	-9
1958	1624	1533	91
1959	1878	2050	-172
1960	1919	2139	-220
1961	2020	1894	126
1962	2194	2192	2
1963	2359	2434	-75
1964	2656	2693	-37
1965	2914	2992	-78
1966	3161	3168	-7
1967	3298	3420	-122
1968	3716	3450	266
1969	4031	4035	-4
1970	4081	4111	-30
1971	4282	4224	58

Table 14

Regression Equation Forecast for Public Service Indiana

Year	Kwh
1972	4587
1973	5010
1974	5474
1975	5973
1976	6510

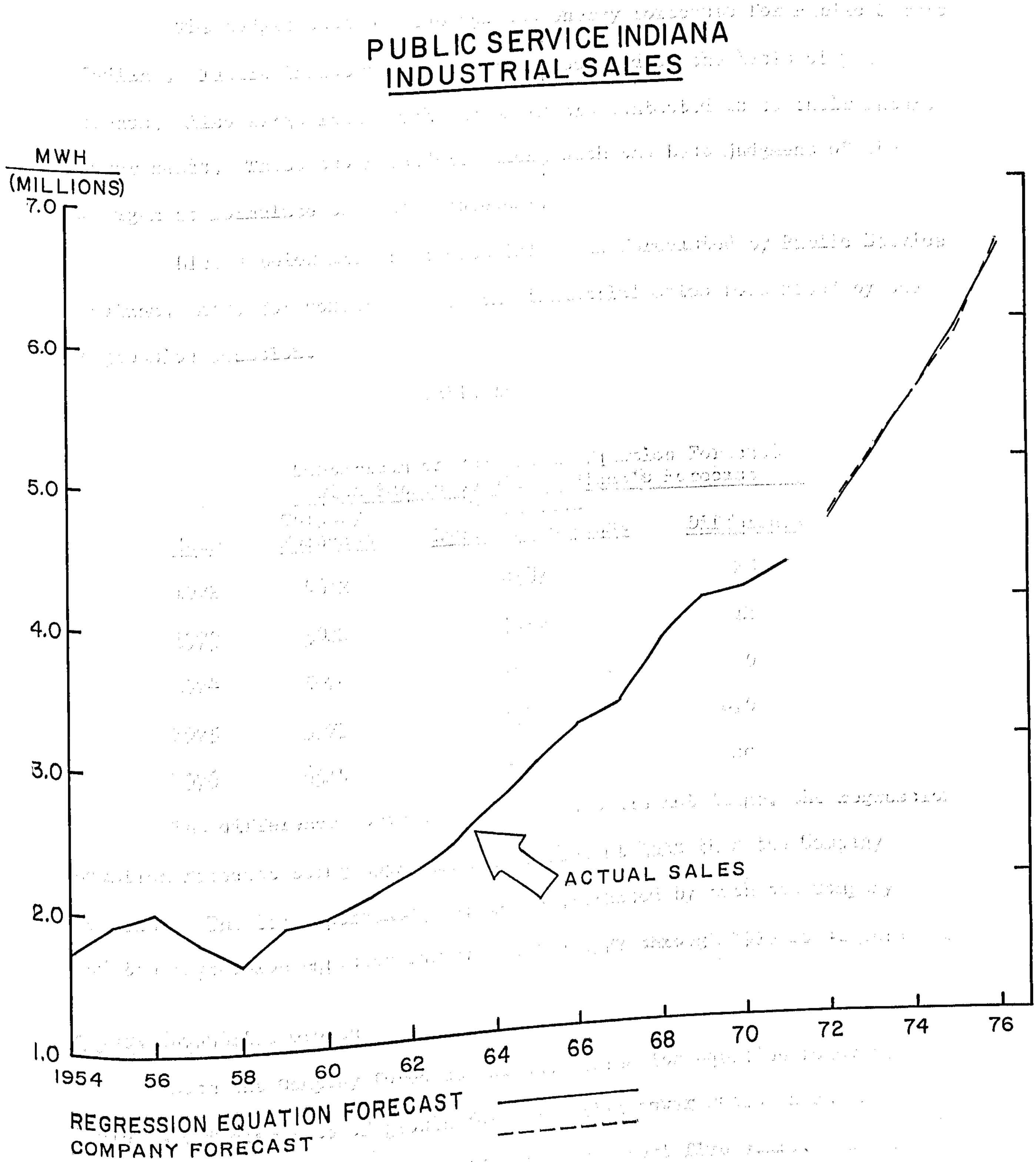
Sources of forecasts for independent variables:

Time

Aluminum Production - Olmsted, p. 44.

Factory Sales Autos, Trucks and Buses - Automobile Mfrs. Association

CHART 4


PUBLIC SERVICE INDIANA
INDUSTRIAL SALES
MWH
(MILLIONS)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
1954
56
58
60
62
64
66
68
70
72
74
76
ACTUAL SALES
REGRESSION EQUATION FORECAST
COMPANY FORECAST

Current Forecasting Method

The budget section develops the energy forecasts for Public Service Indiana. Future industrial sales are forecasted on the basis of past trends. Also large industrial customers are contacted as to their future power needs. These two procedures along with the best judgment of the management formulate the sales forecast.

Listed below are the industrial sales forecasted by Public Service Indiana. Also for comparison are the industrial sales forecasted by the regression equation.

Table 15

Comparison of Regression Equation Forecast with Public Service Indiana's Forecast

Year	Company Forecast	Regression Equation Forecast	Difference
1972	4612	4587	25
1973	5022	5010	12
1974	5474	5474	0
1975	5973	5983	-10
1976	6510	6482	28

The differences between the forecasts are not large, the regression equation forecast being approximately 1 percent less than the Company forecast. The total percentage increase estimated by both the Company and the regression equation for the period 1972 through 1976 is 41 percent.

Future Industrial Growth

Both the Company forecast and the regression equation forecast indicate a faster rate of growth for industrial power sales in Public Service Indiana's service territory during the next five years. For the previous five year period 1967 to 1971 industrial power sales grew at a 6.8 percent annual compound rate of growth. Both the regression equation and the Company forecast a growth rate of 9.0 percent for the period 1972 to 1976. Future growth in industrial power sales will largely depend on the activity of the primary metal industry and also other durable goods industries. With the availability of an abundant supply of land for industrial expansion, Public Service Indiana has the potential for high industrial power sales growth. The counties surrounding Marion County which have already experienced a large population increase in the past 10 years may in the future experience a similar expansion in industrial activity.

INDIANAPOLIS POWER AND LIGHT

Indianapolis Power and Light Company's service territory is the smallest of the five investor owned electric utilities covering only Marion County. Total population served is approximately 750,000. This represents 12 percent of total State population.

The Indianapolis area has long been recognized as having a broad economic base with an abundant supply of labor.

Industrial Characteristics

To analyze Indianapolis Power and Light's service territory industrial characteristics and the trend that has occurred in the past 10 years, a table showing the 10 largest, in terms of kilowatt-hours sales, types of industries that Indianapolis Power and Light served in 1971 and also the sales these same industries had in 1962, is presented on the following page.

This table exemplifies Indianapolis Power and Light's broad economic base. The 10 largest types of industries accounted for only 52 percent of total industrial power sales in 1971. This is the lowest among the Indiana companies.

Table 16

Ten Largest Types of Industries Served by Indianapolis Power and Light

	Industry	1971 KWH Sales (000's)	1971 Percent Of Total	1962 KWH Sales (000's)	1962 Percent Of Total
1.	Transportation	631,167	18.4%	397,085	14.1%
2.	Electric Machinery	322,075	9.3	193,666	6.9
3.	Food and Kindred	183,321	5.3	94,853	3.4
4.	Chemical	182,237	5.3	146,374	5.2
5.	Primary Metals	170,046	4.9	91,270	3.2
6.	Machinery	114,595	3.3	69,981	2.5
7.	Petroleum	61,229	1.8	40,169	1.4
8.	Fabricated Metals	58,967	1.7	40,798	1.4
9.	Rubber & Plastic	48,128	1.4	44,968	1.6
10.	Printing	39,116	1.1	18,362	0.7
	Total	1,810,881	52.5%	1,137,526	40.4%
	Total Industrial Sales	3,457,000	100.0%	2,820,000	100.0%

In analyzing the 10 years from 1962 to 1971 the transportation industry has remained the largest user of electrical power. This is no surprise. The Indianapolis area has long been linked to the highly volatile automobile industry. As the above table indicates the transportation industry in 1971 accounted for a higher percentage of total industrial kilowatt-hour sales than in 1962. Other types of industry showing substantial increases in the 10 year period are: electric machinery, food and kindred products and primary metals. Chemical products still account for about the same percent of total sales as they did in 1962.

Forecasting Equation

Using the analysis on the preceding page different combinations of independent variables listed on page 12 were selected and tested in a stepwise regression program. Listed below is the regression equation that explained the highest percent of the variation in industrial sales for Indianapolis Power and Light.

Table 17

Regression Analysis of Industrial Power Sales for Indianapolis Power and Light

Independent Variable	Regression Coefficient	Computed T-Value	Simple Correlation Coefficient
Real G.N.P.	0.686	35.021	.994

Coefficient of Determination = .987

Intercept = -1825.221

Standard error of estimate = 93.270

The regression is significant using the F distribution at .05, F = 1226.502

The residuals that this equation produces are listed on the following page along with a forecast of industrial sales for Indianapolis Power and Light for 1972 through 1976. Actual sales along with the regression equation forecast and the Company forecast are charted on page 37.

Table 18

Table of Residuals for Indianapolis Power and Light

Year	Actual Sales	Estimated Sales	Residuals
1954	1020	968	52
1955	1158	1181	-23
1956	1228	1236	-8
1957	1307	1280	27
1958	1285	1244	41
1959	1487	1441	46
1960	1530	1522	8
1961	1614	1587	27
1962	1813	1811	2
1963	1937	1956	-19
1964	2088	2163	-75
1965	2300	2415	-115
1966	2545	2691	-146
1967	2680	2809	-129
1968	2944	3024	-80
1969	3174	3148	26
1970	3293	3116	177
1971	3457	3269	188

Table 19

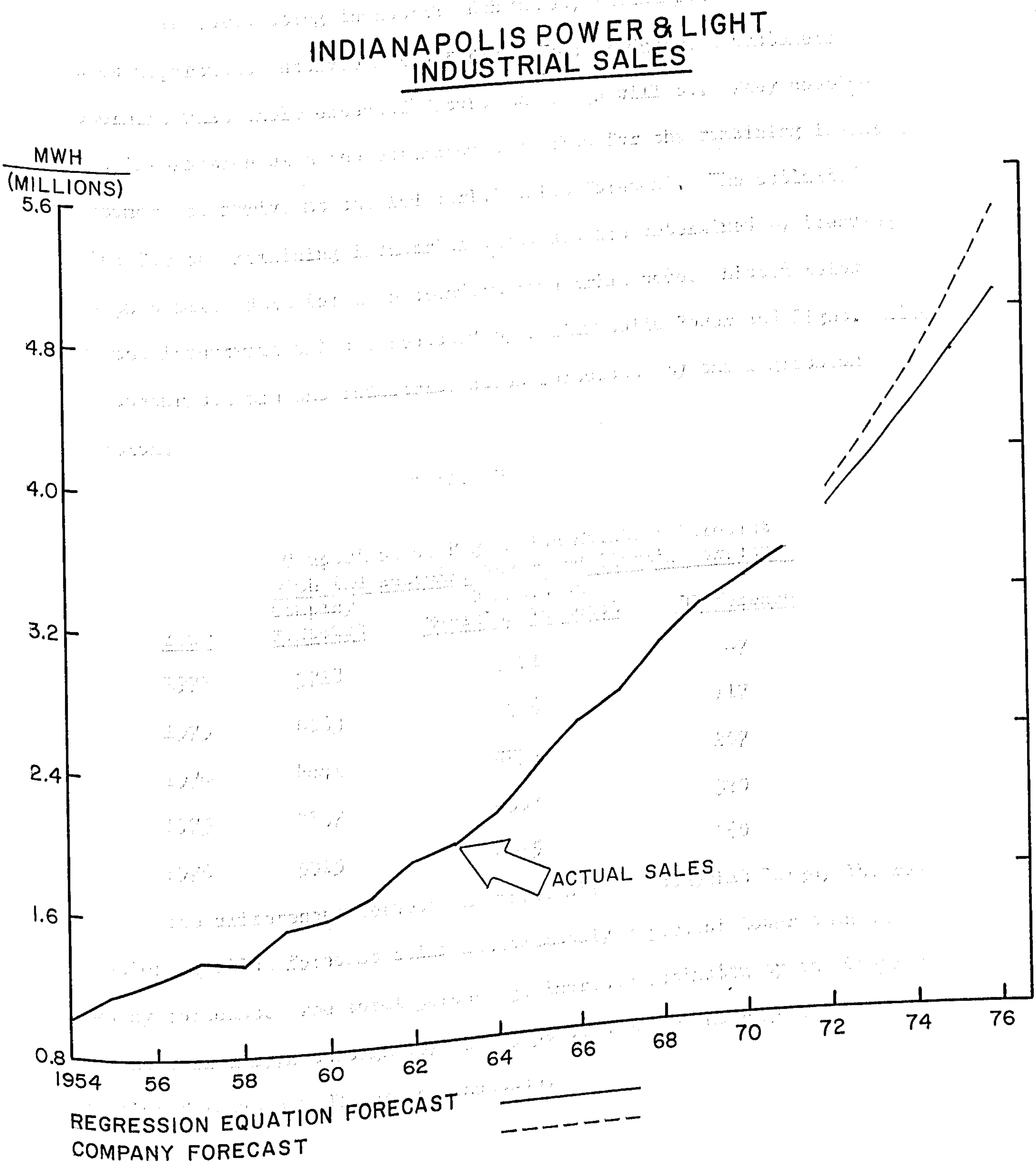
Regression Equation Forecast for Indianapolis Power and Light

Year	Kwh
1972	3671
1973	3946
1974	4234
1975	4537
1976	4855

Source of forecasts for independent variable:

Real G.N.P. - Olmsted, p. 43.

CHART 5


INDIANAPOLIS POWER & LIGHT
INDUSTRIAL SALES
MWH (MILLIONS)
5.6
4.8
4.0
3.2
2.4
1.6
0.8
1954
56
58
60
62
64
66
68
70
72
74
76
ACTUAL SALES
REGRESSION EQUATION FORECAST
COMPANY FORECAST

Current Forecasting Method

In forecasting industrial Kwh sales, Indianapolis Power and Light sales department interviews the fifty largest industrial customers to determine what their expected future Kwh usage will be. They combine this information with the estimated Kwh sales for the remaining industrial customers to arrive at the industrial sales forecast. The estimated sales for the remaining industrial customers are determined by trending the past sales data for each standard industrial code. Listed below are the industrial sales forecasted by Indianapolis Power and Light. Also for comparison are the industrial sales forecasted by the regression equation.

Table 20

Comparison of Regression Equation Forecast with Indianapolis Power and Light's Forecast

Year	Company Forecast	Regression Equation Forecast	Difference
1972	3718	3671	47
1973	4063	3946	117
1974	4441	4234	207
1975	4857	4537	320
1976	5315	4855	460

The differences between the forecasts are somewhat large, the regression equation forecast being approximately 7 percent lower than the Company forecast. The total percentage increase estimated by the Company for the period 1972 through 1976 is 43 percent while the regression equation forecasts a 32 percent increase.

Future Industrial Growth

For the previous five year period, 1967 to 1971, industrial power sales grew at a 6.6 percent annual compound rate of growth. The regression equation and the Company forecast growth rates of 7.2 percent and 9.3 percent, respectively, for the period 1972 to 1976. The higher rate of growth forecasted by the Company may be the result of known industrial expansion by management. Indianapolis Power and Light's broad economic base is exemplified by the fact that only the G. N. P. is used to forecast its industrial sales. Although the transportation industry accounts for a large percentage of total industrial sales, it is not a significant variable for forecasting electrical power sales. The types of transportation industries in Indianapolis are mainly suppliers to the industry, and do not exhibit the cyclical variation that the total auto industry experiences. The one thing that may dampen industrial growth in Indianapolis Power and Light's service territory is the unavailability of land for industrial expansion. Companies may find the land surrounding Marion County more plentiful and less costly.

NORTHERN INDIANA PUBLIC SERVICE COMPANY

Northern Indiana's service territory covers the northern third of the State, serving a population of about 1,000,000. This represents approximately 25 percent of total State population. Five of the largest steel companies in the world have major plants in northern Indiana and have allocated in excess of $2 billion for new construction in that area.

Industrial Characteristics

To analyze Northern Indiana's service territory industrial characteristics and the trend that has occurred in the past 10 years, a table showing the 10 largest, in terms of kilowatt-hour sales, types of industries that Northern Indiana served in 1971 and also the sales these same industries had in 1962, is presented on the following page.

Table 21

Ten Largest Types of Industries Served by Northern Indiana

	Industry	1971 KWH Sales (000's)	1971 Percent Of Total	1962 KWH Sales (000's)	1962 Percent Of Total
1.	Primary Metal	3,403,294	57.5%	1,749,368	62.0%
2.	Chemical	758,137	12.8	236,458	8.4
3.	Fabricated Metal	154,137	2.6	69,670	2.5
4.	Petroleum	135,930	2.3	110,296	3.9
5.	Transportation	118,852	2.0	109,918	3.9
6.	Machinery	72,973	1.2	30,652	1.1
7.	Paper	69,273	1.2	64,899	2.3
8.	Food and Kindred	57,487	1.0	36,791	1.3
9.	Stone, Clay & Glass	56,694	1.0	39,979	1.4
10.	Electric Machinery	55,065	0.9	36,552	1.3
	Total	4,881,842	82.5%	2,484,583	88.1%
	Total Industrial Sales	5,919,882	100.0%	2,819,871	100.0%

In analyzing the 10 years from 1962 to 1971 the primary metal industry has remained the largest user of electrical power. Over 57 percent of Northern Indiana's industrial sales are to this industry. This is the highest concentration of one particular industry for any of the companies in Indiana. This is no surprise. The area around Lake Michigan is one of the largest steel producing centers in the nation. Chemical production is the only other type of industry that has shown substantial growth. The other eight industries represent a relatively small percentage of total industrial power sales.

Forecasting Equation

Using the analysis on the preceding page different combinations of independent variables listed on page 12 were selected and tested in a stepwise regression program. Listed below is the multiple regression equation that explained the highest percent of the variation in industrial sales for Northern Indiana.

Table 22

Multiple Regression Analysis of Industrial Power Sales for Northern Indiana

Independent Variables	Regression Coefficient	Computed T-Value	Partial Correlation Coefficient
Time	303.680	15.424	.970
Steel Production	.010	1.376	.335

Coefficient of Determination = .972

Intercept = -635.858

Standard error of estimate = 310.763

The regression is significant using the F distribution at .05, F = 261.980

The residuals that this equation produces are listed on the following page along with a forecast of industrial sales for Northern Indiana for 1972 through 1976. Actual sales along with the regression equation forecast are charted on page 43.

Table 23

Table of Residuals for Northern Indiana

Year	Actual Sales	Estimated Sales	Residuals
1954	914	383	531
1955	1176	919	257
1956	1207	1208	-1
1957	1346	1491	-145
1958	1479	1573	-94
1959	1803	1943	-140
1960	2292	2294	-2
1961	2494	2522	-28
1962	2820	2893	-73
1963	3046	3285	-239
1964	3231	3733	-502
1965	3569	4073	-504
1966	4154	4398	-244
1967	4707	4645	62
1968	5306	4984	322
1969	5891	5367	524
1970	5756	5591	165
1971	5920	5810	110

Table 24

Regression Equation Forecast for Northern Indiana

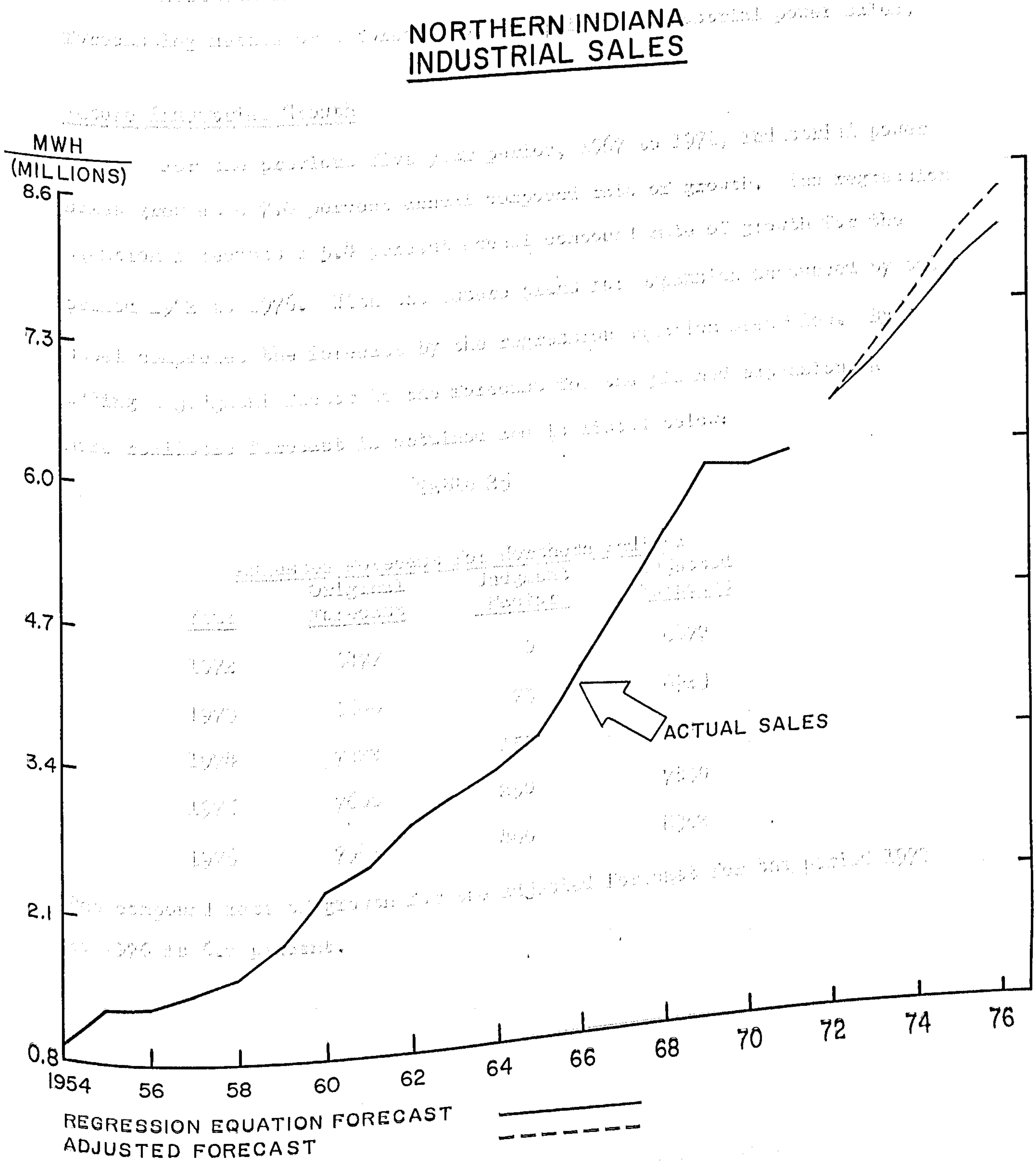
Year	Kwh
1972	6477
1973	6848
1974	7222
1975	7600
1976	7982

Sources of forecasts for independent variables:

Time

Steel Production - McGraw-Hill, p. 17.

CHART 6


NORTHERN INDIANA
INDUSTRIAL SALES
MWH
(MILLIONS)
8.6
7.3
6.0
4.7
3.4
2.1
0.8
1954
56
58
60
62
64
66
68
70
72
74
76
ACTUAL SALES
REGRESSION EQUATION FORECAST
ADJUSTED FORECAST

Current Forecasting Method

Northern Indiana did not furnish a description of their current forecasting method or a forecast of their future industrial power sales.

Future Industrial Growth

For the previous five year period, 1967 to 1971, industrial power sales grew at a 7.4 percent annual compound rate of growth. The regression equation forecasts a 5.4 percent annual compound rate of growth for the period 1972 to 1976. With the future plans for expansion announced by the steel companies the forecast by the regression equation seems low. By adding a judgment factor to the forecast for the planned expansion, a more realistic forecast is obtained and is listed below:

Table 25

Adjusted Forecast for Northern Indiana

Year	Original Forecast	Judgment Factor	Adjusted Forecast
1972	6477	0	6477
1973	6848	75	6923
1974	7222	150	7372
1975	7600	250	7850
1976	7982	400	8382

The compound rate of growth for the adjusted forecast for the period 1972 to 1976 is 6.7 percent.

Chapter 5

CONCLUSION

This chapter will summarize the multiple regression equations forecasts for each of the companies into one forecast for the State and speculate on future uses of and methods for forecasting industrial power sales.

Listed below is the combined forecast for the State. Also listed for comparison are power sales for the U.S. On the following page these data are charted.

Table 26

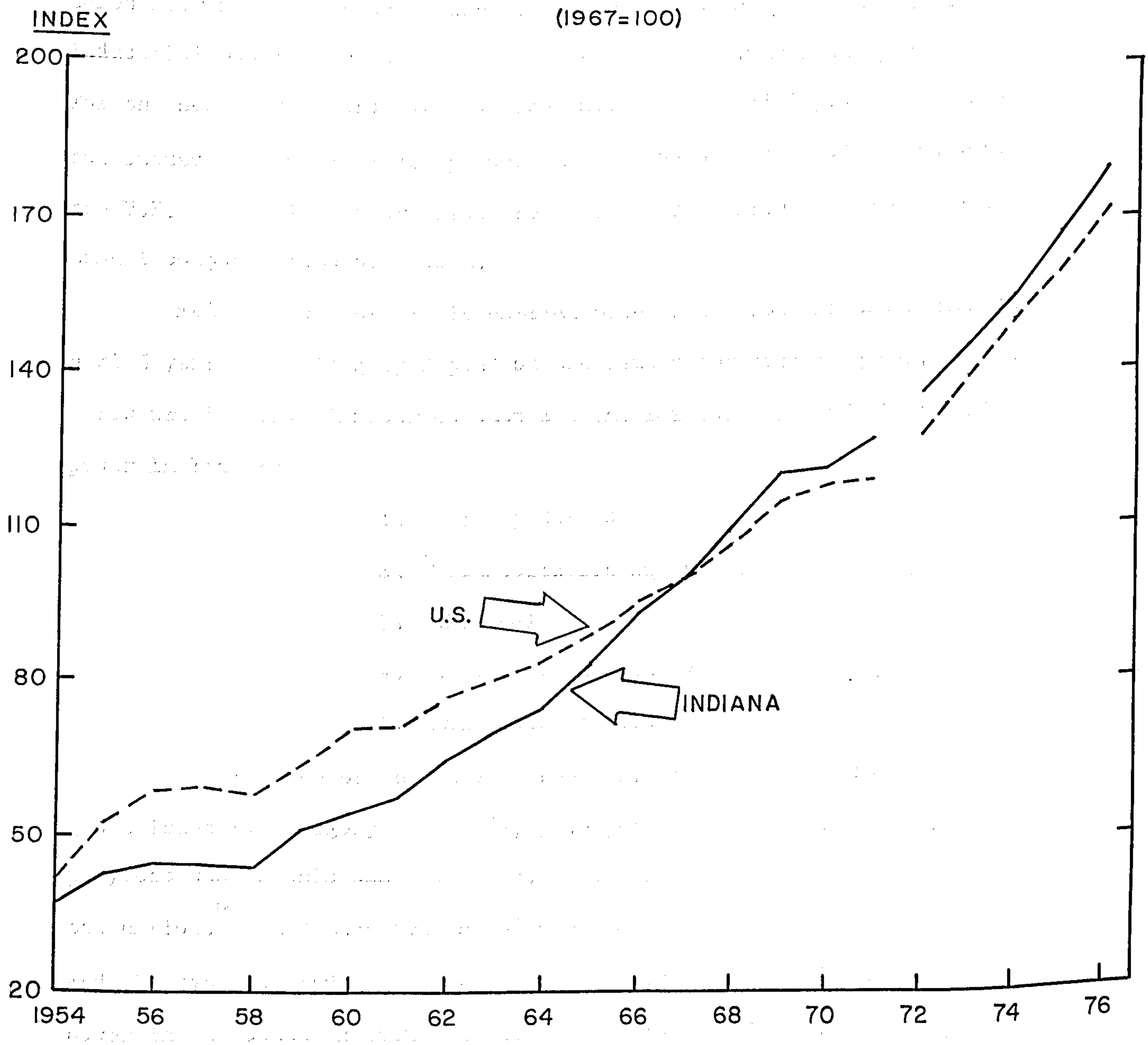
Indiana and U.S. Industrial Electrical Sales

Year	INDIANA KWH (Millions)	INDIANA % Inc.	U.S. KWH (Millions)	U.S. % Inc.
1954	5238	-2.3	203919	5.3
1955	6123	16.9	257937	26.5
1956	6336	3.5	285760	10.8
1957	6435	1.6	291914	2.2
1958	6250	-2.8	283847	-2.8
1959	7341	17.5	312618	10.1
1960	8009	9.1	344799	10.3
1961	8442	5.4	347427	0.8
1962	9415	11.5	373916	7.6
1963	10127	7.6	388399	3.9
1964	10945	8.1	409356	5.4
1965	12068	10.3	433365	5.9
1966	13548	12.3	465077	7.3
1967	14506	7.1	486043	4.5
1968	16001	10.3	518834	6.8
1969	17615	10.1	557220	7.4
1970	17507	-0.6	572522	2.8
1971	18353	4.8	592700	3.5
Absolute Average		7.9		6.9
1972	19552	6.5	620200	4.6
1973	21022	7.5	675600	8.9
1974	22586	7.4	727600	7.7
1975	24272	7.5	779900	7.2
1976	25979	7.0	830400	6.5

CHART 7

INDIANA AND U.S. INDUSTRIAL ELECTRICAL SALES

(1967=100)



	1954	56	58	60	62	64	66	68	70	72	74	76
INDIANA	36	44	43	55	65	75	93	110	121	135	156	179
U.S.	42	59	58	71	77	84	96	107	118	128	150	171

SOURCES: INDIANA - REGRESSION EQUATIONS
U.S. - OLMSTED, p. 47.

As the chart on the preceding page indicates Indiana industrial power sales will increase at a slower rate than U.S. industrial power sales. For the previous five year period, 1967 to 1971, Indiana industrial power sales grew at a 6.1 percent annual compound rate of growth while U.S. industrial power sales during this same period grew at a 4.4 percent. For the next five years 1972 to 1976 Indiana industrial power sales are forecasted to grow at a 7.4 percent annual compound rate of growth while the U.S. industrial power sales are forecasted to grow at a 7.6 percent annual compound rate of growth.

Future increases in industrial power sales for Indiana during the next 5 years will largely depend on the demand for durable goods. Listed below are the five industries that are the largest users of electrical power in Indiana.

1. Primary Metals
2. Transportation Equipment
3. Chemical
4. Electrical Machinery
5. Fabricated Metals

All but one of the above, chemical, are in the manufacturing durable goods industry category. In 1967, 31.9 percent of Indiana's total employment was in this same category. This compares with 17.3 percent for the nation.[4] This high percent of employment in durable goods manufacturing and the types of industries that are the largest users of electrical power in the State explain the greater fluctuation (as indicated by the table on page 45) in Indiana industrial power sales when compared with the U.S.

[4]Heller, p. 4.

In summarizing the results from the questionnaire, none of the responding companies uses regression analysis to forecast industrial power sales. All the companies employ about the same methods, extrapolating past trends with a management judgment factor. The fact that none of the companies uses more advanced techniques is not surprising. A survey conducted by the New York chapter of the Planning Executive Institute concluded that American business as a whole is failing to use newer, more sophisticated mathematical techniques for planning.[5]

The regression analysis technique proposed in this paper offers an alternative to methods previously used. It is not intended that regression analysis totally replace current forecasting methods, but be used in conjunction with current methods to identify factors affecting growth in industrial power sales. Also the model in this paper offers a common method for forecasting industrial power sales for each of the five investor-owned electric utilities. Regulatory agencies, suppliers and other interested parties can use the model without knowing a great deal of detailed information about the company. The Illinois Regulatory Commission has already declared that it was time to give a forward look to the regulatory process by considering the future rate base and revenue needs of companies based upon data projections.[6]

During the next five years electric utilities of Indiana will be required to expend huge sums of money because of new standards of

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[5]Richard J. Coppinger and E. Stewart Epley, "The Non-Use of Advanced Mathematical Techniques," Managerial Planning, Vol. 20, No. 6, May/June 1972, p. 15.

[6]William Kenworthy, "The 'Forward Look' in Rate-Making," Electric Light and Power, April 1972, p. 23.

environmental control. If the utilities are to meet these standards and also provide the lowest cost reliable service to the residents of Indiana, accurate and advanced forecasting methods are essential.

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