

UNITED STATES DEPARTMENT OF COMMERCE

JESSE H. JONES, *Secretary*

The St. Lawrence Survey

PART VI

The Economic Effects of
the St. Lawrence Power Project



N. R. DANIELIAN, *Director*

ST. LAWRENCE SURVEY

Reports of the St. Lawrence Survey

- PART I. History of the St. Lawrence Project.
- PART II. Shipping Services on the St. Lawrence River.
- PART III. Potential Traffic on the St. Lawrence Seaway.
- PART IV. The Effect of the St. Lawrence Seaway upon Existing Harbors.
- PART V. The St. Lawrence Seaway and Future Transportation Requirements.
- PART VI. The Economic Effects of the St. Lawrence Power Project.
- PART VII. Summary Report of the St. Lawrence Survey.

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THE PRESIDENT
THE WHITE HOUSE

Washington, D. C.

MY DEAR MR. PRESIDENT: I have the honor to transmit herewith Part VI of the reports of the St. Lawrence Survey, entitled "The Economic Effects of the St. Lawrence Power Project." This report is complementary to the other reports of the Survey dealing with the navigational aspects of the St. Lawrence. The study of power was undertaken in order to arrive at a total evaluation of the St. Lawrence project, which in its very nature, is a combined navigation and power project.

This report reveals much useful information on industrial development in New York State and the possible effects of the St. Lawrence power project. A summary of the facts and conclusions is given in the letter of submittal of Dr. N. R. Danielian, Director of the St. Lawrence Survey.

Very sincerely,

WAYNE C. TAYLOR,
Acting Secretary of Commerce.

LETTER OF SUBMITTAL

DECEMBER 19, 1940.

The Hon. SECRETARY OF COMMERCE,

Washington, D. C.

MY DEAR MR. SECRETARY: I have the honor to submit to you Part VI of the reports of the St. Lawrence Survey. This part deals with the economic effects of the St. Lawrence power project. It considers principally the availability of a market for the large amount of hydroelectric power latent in the St. Lawrence River and the effect of this low-cost power upon industry and transportation systems of New York State. The report was prepared by the Survey with the generous assistance of Prof. Edgar M. Hoover, Jr., of the University of Michigan, and Mrs. Grace Knott, now with the National Defense Advisory Commission. The maps and charts were executed by Mr. Earl G. Millison, Chief of Graphic Services, and Mr. George Newman, Head Statistical Draftsman, Work Projects Administration. The Survey has been fortunate also in having the advantage of criticisms and suggestions on earlier drafts of this report from the following individuals: Prof. James C. Bonbright, Chairman, and Mr. Gerald V. Cruise, Executive Secretary, of the Power Authority of the State of New York; Hon. Leland Olds, Chairman, and Mr. J. V. Alfriend, Jr., Engineer, Federal Power Commission; and Mr. J. A. Krug, Chief Power Engineer, Tennessee Valley Authority.

Even though the Survey has been concerned principally with the St. Lawrence Seaway, the hydroelectric power aspects were studied because the project has always been considered as a combination seaway and power project; consequently, the net effects of the undertaking could not be evaluated without reference to the influence that hydro power would have upon New York State industry and employment. A final judgment on the benefits of the combined project could not fail to include a thorough consideration of the benefits of cheap hydroelectric power.

In the exploration of future demand for power in New York State, this report considers not only the disposability of St. Lawrence power at the International Rapids Section, but also that which can be obtained through the redevelopment of Niagara River. This latter has been included because it has been an integral part of the plans of the Power Authority of the State of New York, the duly constituted State agency for the exploitation of the water-power resources of the

St. Lawrence River, and also because the draft treaties heretofore considered by the governments of the United States and Canada included provisions for the redevelopment of Niagara River. The effect of the inclusion of additional power at Niagara upon the estimates of this report is to make them highly conservative, for if combined Niagara and St. Lawrence power could be marketed, then surely there would be ample market for St. Lawrence power alone. On the other hand, if St. Lawrence power is developed first, then the estimated effects upon industrial expansion and employment should be reduced, possibly by two-fifths, the proportion of new hydro power at Niagara to the combined St. Lawrence-Niagara system.

The estimates of energy requirements in New York State are carried in this report to the year 1950. This does not imply that it would take 10 years to complete the power project. The year 1950 was selected for several cogent reasons. First, it would allow a period of several years of active operation of the new power system so that the full influence of this economical supply of power upon industry would be felt. In the second place, the year 1950 is a convenient signpost from the point of view of statistical technique, for other studies and estimates dealing with population and demand for power have used that year as a basis of computations.

The selection of the year 1950 does not imply that the development of the project need be delayed until a later date. The estimates of future power requirements in this report were based upon the extension of normal trends in various classes of energy demand. Since the initiation of this study, the national defense program has been unravelled swiftly and in large dimensions. The obvious effect of this program upon demand for electrical energy will be to accelerate and emphasize the amplitudes of growth here indicated. Hence, the anticipated effect should be to telescope time and bring the need for this hydroelectric development nearer than 1950. This will mean, of necessity, expediting the development so as not to be caught with a shortage of power resources in the industrial northeast. The accelerating effect of the national defense program upon power requirements in New York State will be more fully treated in Part VII of the Survey reports.

The present report is detailed and technical. The conclusions, and the facts upon which they are predicated, however, are clear and irrefutable. Even when individual procedures and points of detail may be subject to alternative solutions, the final over-all conclusions and their implications are beyond serious dispute.

Briefly the Survey reveals the following facts:

1. The proposed St. Lawrence-Niagara development is designed to make available to the United States additional hydroelectric generating capacity of 1,100,000 horsepower at the International Rapids

and 787,500 horsepower at Niagara Falls. The area served by the transmission system planned in connection with this generating capacity coincides approximately with New York State, and contains about one-tenth of the population of the United States.

2. New York State as a whole has suffered a definite decline in manufacturing employment over the past 20 years. In 1919 New York State had 1,228,000 wage earners employed in manufacturing, or 13.5 percent of the national total. By 1937 the number had fallen to 996,000, or 11.6 percent of the national total.

3. The Buffalo area, where Niagara power was being exploited on a large scale between 1895 and 1924, has recently been affected by this apparent cessation of industrial growth. The Buffalo Industrial Area's percentage share of the national total of manufacturing wage earners rose from 0.97 percent in 1899 to 1.31 percent in 1923, and by 1935 had fallen to 1.13 percent. In 1937 it was 1.23 percent. The chief industries in which this area specializes are chemicals, metal products, paper, and grain products. In all of these industries, the importance of electric energy costs is relatively high.

4. Since 1924 there has been no further expansion of Niagara hydro generating facilities, and considerable steam generating equipment has been added to take care of the increasing demand. Between 1928 and 1939, steam central-station generating capacity in the Buffalo Industrial Area increased from 252,955 horsepower to 655,324 horsepower, or 159 percent; while in the same interval, hydro capacity has increased only from 624,710 horsepower to 639,758 horsepower, or 2.4 percent. Out of the total increase of 417,417 horsepower in that period, 402,369 horsepower, or nearly 97 percent, was in steam capacity.

5. New York State has expanded its hydroelectric generating capacity much more slowly in the past decade than most other States. While the United States as a whole increased its hydro capacity by 54.7 percent in the decade 1927-37, New York's hydro capacity increased only 12.4 percent. Only 15 States showed a smaller percentage increase in hydro capacity than New York in that period, although New York State is among the most richly endowed in water-power resources.

6. Due to lack of mineral fuels, New York State is at a very substantial disadvantage in steam-power generation as compared with coal- or oil-producing States. Representative large power stations in New York in 1937 paid from 11 to 17 cents per million B. t. u. for their coal, while comparable stations near mines in Ohio, Pennsylvania, and West Virginia paid only 6 or 7 cents.

7. At the present time, the cost of electricity to most representative classes of users is higher in New York State than the United States average.

8. Since about the time Niagara power was fully utilized, industries using relatively large amounts of electric power have expanded in other States and regions more rapidly than in New York State. This is particularly true of certain electrochemical and electrometallurgical industries.

It is fairly clear from this summary of facts that New York State will suffer under an increasing competitive disadvantage so long as available sources of cheap hydro power continue to be neglected. In the Buffalo area, where industry has been based on cheap power to a relatively large extent, the threat of stagnation is perhaps even more serious than in the rest of the State. The proposed St. Lawrence-Niagara hydro development offers a new lease on life to New York State industry, a source of cheap electricity which should make possible the resumption of manufacturing growth.

Based on experience, past trends, and a consideration of the probable future developments, energy consumption in 1950 has been conservatively estimated at almost double that of 1937. The additional generating capacity which must be built during the next decade to supply these estimated requirements is about one-third greater than the entire capacity of the St. Lawrence-Niagara project, which indicates that there is no question of the disposability of the project's output of energy.

As compared with the best possible alternative all-steam plan, the St. Lawrence-Niagara hydro project promises savings on the State's entire power generation averaging approximately 1 mill per kilowatt-hour, plus the provision of 1 billion kilowatt-hours annually at very low rates to high-load-factor industries. The Power Authority of the State of New York estimates that the annual savings in the cost of electricity to New York State consumers as a result of St. Lawrence-Niagara development would be \$26,000,000.

A study of the chief electroprocess industries in New York State leads to the conclusion that this group can absorb at least the additional billion kilowatt-hours tentatively allocated to it on the proposed plans. This degree of expansion would give employment to 7,000 additional men; while in the absence of such new cheap power, the growth prospects of these industries are substantially nil.

The probable effects of a 1-mill power-cost differential on several selected manufacturing industries outside the electroprocess group were likewise investigated. It was estimated that direct savings from such a differential would amount to approximately 0.7 percent annually on invested capital in the chemicals industry, 0.5 percent in the cement industry, and smaller percentages in 15 other industries. Also, on the basis of certain estimates, the total minimum increase in employment in industries outside the electroprocess group, as a result of

the 1-mill differential in power costs, would be at least 18,000 wage earners.

As a general rule there is one wage earner in service occupations for every worker engaged in manufacturing in New York State. The effect of the 25,000 new wage earners in manufacturing employment will probably provide 25,000 additional jobs in such auxiliary occupations. Thus the St. Lawrence-Niagara project will probably create, directly as a result of cheaper power, remunerative employment for 50,000 workers more than the alternative all-steam plan. This estimate does not include derivative employment from the sale of household electrical appliances which experience shows would result from low rate schedules to domestic and farm consumers.

Combining the additional employment prospects for the high-load-factor and other industries, and making allowance for complementary trade and service activities and for population not gainfully employed, the saving in power costs afforded by the St. Lawrence-Niagara hydro-steam plan as compared to the alternative all-steam plan was finally translated into terms of economic support for the equivalent of a community of 125,000 persons.

In terms of demand for transportation, the added freight revenue ascribable to the project is estimated at \$5,500,000 annually, in addition to at least \$3,300,000 spread over the years of active construction.

All these estimates are based on very conservative assumptions, and the result should be considered a minimum. If the past history of Niagara Falls and the more recent experience of T. V. A. is any criterion of what may be expected in New York State as a result of the St. Lawrence-Niagara development, surely the conclusion is justified that this project will be a great boon to the lagging industrial development of New York State, particularly in northern New York. This area, unlike the southern end of the State, is sparsely populated and free from industrial congestion. With access to the St. Lawrence Seaway as a cheap form of transportation, and with unusually low power costs, up-State New York will receive from the proposed project the necessary stimulus for progress which has been lacking since the exhaustion of new hydro power at Niagara.

Very truly yours,

N. R. DANIELIAN, *Director.*
St. Lawrence Survey.

TABLE OF CONTENTS

	Page
INTRODUCTION	1
CHAPTER I.—Area tributary to the proposed power development	4
Section 1. The characteristics of the area.....	4
Section 2. Economic background of the power tributary area.....	7
Trends in population growth.....	8
Trends in manufacturing activity.....	10
Industrial specialization.....	13
Niagara power and industrial development.....	20
Retardation of electroprocess industries in New York State.....	24
Changes in concentration of manufacturing industries, 1929-37.....	29
CHAPTER II.—Electric power supply in New York State	33
Section 1. New York State dependence on steam power.....	33
Lag in hydroelectric development.....	33
High cost of fuel.....	37
Section 2. Comparison of electric rates in New York State and elsewhere.....	41
CHAPTER III.—Estimate of energy requirements of New York State in 1950	48
Section 1. Analysis of 1937 energy sales.....	49
Section 2. Growth in industrial sales.....	53
Number of customers.....	54
Average annual expenditure per customer.....	54
Effect of rate reductions.....	59
Combined estimate for industrial sales.....	60
Section 3. Growth in commercial sales.....	61
Section 4. Growth in farm and residential consumption.....	62
Growth of population.....	62
Number of nonfarm customers.....	64
Number of farm customers.....	64
Average annual farm bill.....	67
Increase in consumption due to lower rates.....	69
Section 5. Growth in miscellaneous classes of consumption.....	78
Section 6. Total estimate of 1950 consumption.....	79
Section 7. Extent of probable rate reduction.....	83
Section 8. Generating capacity requirements.....	93

	Page
CHAPTER IV.—The effects of St. Lawrence-Niagara power on New York State's industrial growth.....	95
Section 1. High-load-factor industries.....	96
Aluminum.....	98
Chlorine and caustic soda.....	102
Electric furnaces.....	104
Artificial abrasives.....	107
Summary.....	108
Section 2. Manufacturing industries in general.....	111
Effect of power-cost differential on rate of profit.....	111
Effect of power-cost differential on the extension of sales.....	114
Section 3. Estimate of total increase in employment.....	120
Section 4. The St. Lawrence-Niagara power project and rail traffic..	121
Estimate of increased freight revenue.....	122
Effect upon fuel requirements.....	122
Transportation requirements in connection with construction.....	125

LIST OF TABLES

	Page
1. Electric energy requirements and consumption in Power Supply Areas 3 and 4, 1938.....	5
2. Data on area, population, and freight traffic of the St. Lawrence power distribution area.....	6
3. Number of manufacturing wage earners in industrial areas and selected counties in New York State, 1937.....	7
4. Population in the United States, New York State, and the Buffalo area, 1870-1940.....	9
5. Percentage rates of population increase in the United States, New York State, and the Buffalo area, 1870-1940.....	9
6. Manufacturing wage earners in New York State and the Buffalo Industrial Area, 1869-1937.....	12
7. Industries arranged according to degree of concentration in New York State, 1929.....	13
8. Industries arranged according to degree of concentration in New York State, 1937.....	15
9. Industries arranged according to degree of concentration in the Buffalo Industrial Area, 1929.....	16
10. Industries arranged according to degree of concentration in the Buffalo Industrial Area, 1937.....	18
11. Employment in selected industries in the Buffalo Industrial Area, 1936.....	19
12. Electroprocess manufacturing plants in the Buffalo Industrial Area, 1936.....	20
13. Employment in electrochemical and electrometallurgical industries in three counties of New York State, 1936.....	21
14. Principal New York State chemical products, 1937.....	22
15. Occupational groups in the city of Niagara Falls, N. Y., 1910-30.....	23
16. T. V. A. energy sales, 1938-39.....	24
17. T. V. A. energy sales to industrial customers, 1938-39.....	25
18. Wage earners and value added in "chemicals not elsewhere classified" industry, United States and New York State, 1919-37.....	27
19. Geographical distribution in the United States of the "chemicals not elsewhere classified" industry according to value added by manufacture, 1929-37.....	28
20. Changes in geographical distribution in the United States of the "chemicals not elsewhere classified" industry, 1929-37.....	29
21. Changes in degree of concentration of manufacturing industries in New York State, 1929 and 1937.....	30-31
22. Changes in degree of concentration of manufacturing industries in the Buffalo Industrial Area, 1929 and 1937.....	32
23. Increase in generator capacity of fuel-burning and of hydroelectric equipment, by States, 1927 and 1937.....	35

	Page
24. Capacity of all central electric stations in the Buffalo Industrial Area, 1927-39.....	36
25. Comparative fuel costs at selected electric generating stations, 1937..	38
26. The five leading power-consuming States and their production of mineral fuels, 1937.....	38
27. Average consumption of coal per kilowatt-hour of generated electricity in public utility power plants in the United States, 1902-37.....	40
28. Power rates according to typical monthly bills, 1939, New York State and the United States.....	41
29. Percentage of total electric current generated by hydroelectric equipment in all central stations, by States, 1937.....	47
30. Ultimate consumers served by New York State electric utilities, by class of service, 1937.....	50
31. Electricity sales in New York State by private and municipal utilities, 1937.....	51
32. Electricity sales in the United States by class of ultimate consumers, 1926-39.....	52
33. Percentage distribution of electricity sales in the United States, by class of ultimate consumers, 1926-39.....	53
34. All "commercial" light and power service in the United States: Customers, sales and revenue, 1926-39.....	57
35. "Small commercial" light and power service in the United States: Customers, sales and revenue, 1926-39.....	57
36. "Large commercial" light and power service in the United States: Customers, sales and revenue, 1926-39.....	58
37. Estimated growth of New York State population, 1937-50.....	63
38. Number of ultimate nonfarm domestic consumers of electric energy, 1937, and nonfarm population, 1935, by regions and selected States..	65
39. Extent of farm electrification by regions and selected States, 1929, 1930, and 1937.....	65
40. Rural electric distribution requirements in New York State, as estimated in 1937.....	67
41. Progress of rural electrification in New York, 1925-39.....	67
42. Cost and use of residential electricity in the United States, 1913-36..	69
43. Nonfarm residential sales by private utilities: Consumption per customer and average price, by States, 1937.....	70
44. Farm sales by private utilities: Consumption per customer and average price, by states, 1937.....	71
45. Calculation of estimated increase in residential electricity sales per customer in New York State, by companies, 1937 and 1950.....	73
46. Electricity consumed according to years of use on 668 New York farms, 1927-37.....	77
47. Consumption and costs of electricity on selected New York farms, 1929-37.....	77
48. Percentage of American dwellings with specified electrical appliances, 1935.....	77
49. Miscellaneous electricity sales to ultimate consumers in the United States, 1926-38.....	78

LIST OF TABLES

XV

	Page
50. Summary of estimates of 1950 energy sales in New York State, by class of service.....	80
51. Bauer-Gold estimates of electricity use in 1950 and 1975.....	81
52. Comparison of changes in electricity rates and sales, 1926 and 1939 and 1937 and 1950.....	82
53. Estimation of nonresidential class demands for allocation of fixed costs.....	88
54. Distribution costs of industrial and commercial electricity in representative systems, 1932-34.....	91
55. Calculation of estimated total 1950 cost of commercial and industrial service.....	92
56. Electric energy consumption in selected industries, 1937.....	98
57. Domestic primary production of aluminum in the United States, 1908-39.....	99
58. Electric-furnace production of ferro-alloys in the United States, 1938.....	104
59. Electric arc furnaces for melting iron and steel, by States, in order of importance, 1937.....	106
60. Prospective power savings in relation to capital investment for selected industries.....	112
61. Estimated savings from 1-mill reduction in electricity costs, in selected New York State manufacturing industries.....	118

LIST OF CHARTS

	Page
1. Coordination of power resources in the State of New York.....	5
2. Population in the United States, New York State, and the Buffalo Industrial Area, 1870-1940.....	8
3. Manufacturing wage earners in New York State and the Buffalo Industrial Area, 1869-1937.....	10
4. Manufacturing wage earners in New York State and the Buffalo Industrial Area as percentages of United States total, 1869-1937..	11
5. Concentration of individual industries in New York State, 1929 and 1937.....	14
6. Concentration of individual industries in the Buffalo Industrial Area, 1929 and 1937.....	17
7. Wage earners in chemical industries not elsewhere classified in New York State as percentage of United States total, 1899-1937.....	27
8. Increase in generator capacity of fuel-burning and of hydroelectric equipment, by selected States, 1927-37.....	34
9. Electric generating capacity in the Buffalo Industrial Area, 1927-39..	36
10. Fuel prices at selected electric generating stations, 1937.....	37
11. Fuel efficiency in steam power generating stations, 1902-37.....	39
12. Average monthly bills for power on a 100 kilowatt-hour basis, by States, January 1939.....	42
13. Average monthly bills for power on a 375 kilowatt-hour, 3 kilowatt demand basis, by States, January 1939.....	43
14. Average monthly bills for power on a 1,500 kilowatt-hour, 12 kilowatt demand basis, by States, January 1939.....	44
15. Average monthly bills for power on a 60,000 kilowatt-hour, 300 kilowatt demand basis, by States, January 1939.....	45
16. Consumption and cost of electricity in "small commercial" service in the United States, 1926-39.....	55
17. Consumption and cost of electricity in "large commercial" service in the United States, 1926-39.....	56
18. Consumption and cost of residential electricity in the United States, 1913-39.....	68
19. Consumption and cost of nonfarm residential electricity, by States, 1937.....	70
20. Consumption and cost of farm electricity, by States, 1937.....	71
21. Estimates of electrical energy in New York State, 1937 and 1950.....	80
22. Distribution costs of industrial electricity in 17 selected communities, 1932-34.....	89
23. Distribution costs of commercial electricity in 17 selected communities, 1932-34.....	90
24. Electric energy consumption per unit of product in selected electrochemical and electrometallurgical industries, 1937.....	97
25. Domestic primary aluminum production, 1908-39.....	100
26. Estimates of growth of energy consumption in selected electrochemical and electrometallurgical industries in the United States.....	110

THE ECONOMIC EFFECTS OF THE ST. LAWRENCE POWER PROJECT

INTRODUCTION

The St. Lawrence development has seldom been considered as solely a seaway project. The power generating capacity of the rapids on the upper St. Lawrence is too well known to be ignored. The amount of power obtainable constitutes one of the greatest natural resources of both New York State and the Province of Ontario. Every comprehensive plan of development of the International Rapids Section of the river has included the ultimate utilization of all the power that can be obtained from the torrential flow of the waters of the Great Lakes over the Galop and Long Sault Rapids.

As the power development is an inherent part of the Seaway project, particularly at the International Rapids Section, a study of the economic advantages and disadvantages of the St. Lawrence project cannot ignore the effects of the utilization of potential hydroelectric energy. In this report an attempt is made to evaluate the need for and the effects of the St. Lawrence power development in New York State. The facts and conclusions of this report are used to appraise the total effect of the St. Lawrence seaway and power development combined on New York State industry and transportation.

The important economic questions involved are the following:

1. Will the project supply power at lower costs than would be feasible without it?
2. Will there be a market for the power developed?
3. To what extent will the power development promote industrial expansion in the area to which it will supply power?
4. Will the power development bring about a net reduction in the use of fuel, thus injuring the coal industry?
5. What effect will the St. Lawrence power development have upon the transportation requirements of its tributary area?

Previous investigations of the International Rapids power project have generally devoted the bulk of their attention to the first of these questions: The relative final cost to the consumer of hydroelectric power as compared with that from alternative sources. This question of costs indeed merits a large share of attention, since it is technically complex and at the same time vital to any sound decision as to the desirability of the project.

The present report does not bring forth any new evidence on the question of costs, but relies primarily on the findings of the Power Authority of the State of New York, as presented in its 1938 Annual Report. The contribution of the present report is rather along the other lines of inquiry indicated above; and an attempt is made to answer these other questions in the light of all pertinent data.

When speaking of St. Lawrence power, those who are conversant with the history of the project generally understand it to include the power potential in the International Rapids Section. In this part of the river the level of the water drops 92 feet over a distance of 48 miles between Chimney Point and Cornwall, Ontario. In this drop, when developed to full head, a maximum of 2,200,000 horsepower can be obtained. It is proposed that this power be divided equally between Ontario and New York State.

In the present report a broader basis of discussion is adopted. Not only New York State's share of St. Lawrence power, but also the additional energy which can be obtained by redevelopment of the Niagara River, is included in the estimates. This is consistent with the plans of the Power Authority of the State of New York which has the statutory responsibility of developing St. Lawrence power in the public interest. The proposed 1938 draft treaty also provided for the development of St. Lawrence and Niagara power under public authority, in line with the policy established by New York State and Federal statutes, which seems to be recognized as the best method of utilizing the enormous power potentialities for the public's benefit. Although for reasons of expediency St. Lawrence power may be developed first, the redevelopment of the Niagara River must be considered a distinct possibility, and hence in this report the combined power development is considered as a single system.

In the discussion of need for power in New York State, the inclusion of Niagara power in the proposed hydroelectric development merely allows a wide margin of conservatism. If there will be a market for the output of the combined project, then there is no doubt that St. Lawrence power alone can be easily absorbed. On the other hand, estimates of future increase in employment, directly traceable to cheap hydro power, may have to be reduced by two-fifths.

As the earlier treaty proposals and the plans of the Power Authority of the State of New York call for a coordinated development, the economic analysis in this report will be used upon the assumption that the joint project will be completed during the course of the present decade. The more immediate need for St. Lawrence power in connection with the national defense program will be considered separately in a subsequent report of the Survey.

The United States portion of the St. Lawrence-Niagara project calls for the construction of hydroelectric generating facilities of

ECONOMIC EFFECTS OF THE ST. LAWRENCE POWER PROJECT 3

1,100,000 horsepower in the International Rapids Section of the St. Lawrence River, and the redevelopment of Niagara River utilization in such a way as to yield 787,500 additional horsepower at Niagara Falls.¹ The project involves also the provision of about 600,000 horsepower of additional steam capacity for standby purposes in order to firm-up the entire 1,887,500-horsepower hydro capacity.² Both the International Rapids and the Niagara developments are to be tied into an augmented transmission network, capable of carrying about 670,000 horsepower as far as the New York City area (see chart 1).

¹ Included in the plan are remedial works designed to check destructive erosion now threatening the Falls, and to enhance the scenic spectacle by a more uniform distribution of flow over the rim.

²Power Authority of the State of New York, *1938 Annual Report*, pp. 141-143.

CHAPTER I

AREA TRIBUTARY TO THE PROPOSED POWER DEVELOPMENT

Section 1

THE CHARACTERISTICS OF THE AREA

The Federal Power Commission has divided the country, for statistical and planning purposes, into several "Power Supply Areas," of which Nos. 3 and 4 together constitute the distribution territory into which Niagara-St. Lawrence power would be fed. This territory is shown in chart 1, which also indicates the transmission system of 287,000 volts to be superimposed according to plans of the Power Authority of the State of New York. Area 3 practically coincides with up-State New York, plus a few counties in northern Pennsylvania.¹ Area 4 includes Westchester, Manhattan, and Long Island.²

There is considerable interconnection and exchange of energy between Areas 3 and 4, but the two together constitute a nearly self-sufficient power supply and power consumption area, except for imports from Canada. Few important connections with other areas in the United States are in existence or projected and very little energy is exchanged with such areas.³ It is appropriate, then, to consider the St. Lawrence project in terms of the supply and consumption of energy in Areas 3 and 4, which for present purposes is practically equivalent to the State of New York.

Some of the principal characteristics of the tributary region thus defined are shown in table 1. The total energy requirements of the region in 1938 were 15.4 billion kilowatt-hours, including 13.0 billion sold and 2.4 billion used by the utilities themselves and lost in transmission. The New York City market purchased 5.8 billion kilowatt-hours and the main up-State market (subarea 3A) 6.9 billion. In New York City, 20 percent of all sales were domestic, but in some of the other major industrial districts of the State the relative importance

¹ This area is in turn divided into subareas 3B (the small isolated network in the extreme northeast corner of New York State) and 3A (the remainder of Area 3).

² Area 4 is divided into subarea 4A (Westchester and New York City, excluding Staten Island) and subarea 4B (the rest of Long Island).

³ Imports of power from Canada have been considerable, amounting in some years to more than a billion kilowatt-hours (Power Authority of the State of New York, *1938 Annual Report*, p. 162). In 1939, they were 1.2 billion kilowatt-hours, while New York State's net interchange with other States was an "export" of 0.05 billion (Federal Power Commission, *Electric Power Statistics, 1939*, table 17, p. 34, and table 18, p. 36). Much of this interstate transfer affected adjacent areas included in Power Supply Area 3.

Chart 1- COORDINATION OF POWER RESOURCES IN THE STATE OF NEW YORK

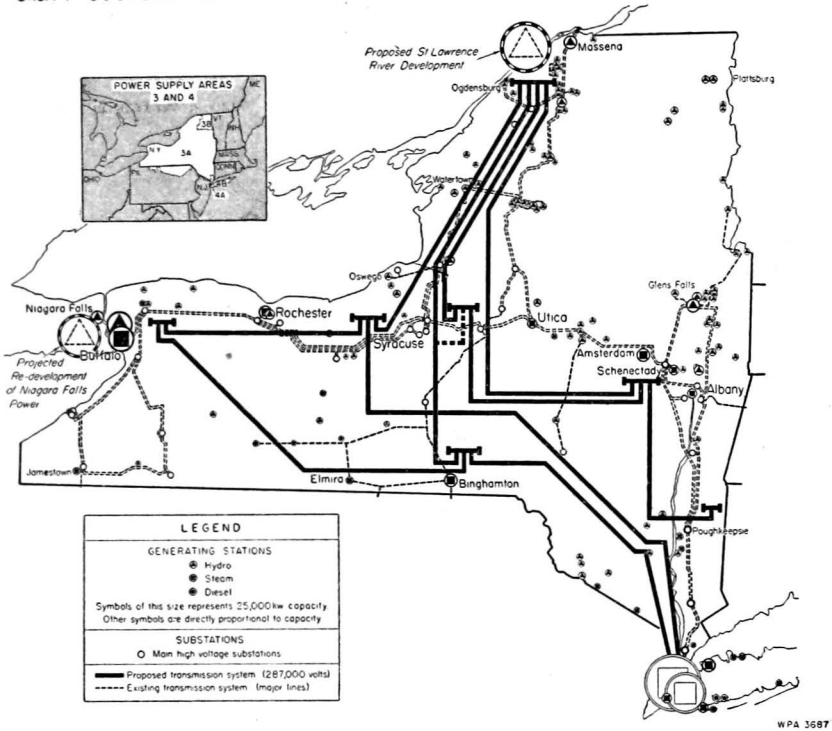


TABLE 1

Electric energy requirements and consumption in Power Supply Areas 3 and 4, 1938

[Millions of kilowatt hours]

Areas and districts	Total energy requirements ¹	Sales of net energy			
		Total	Commercial and industrial	Domestic	Other
Areas 3 and 4.....	15,426.3	13,042.7	9,035.8	2,253.8	1,753.1
Subarea 3A.....	8,271.2	6,923.5	5,627.1	940.0	356.4
Subarea 3B.....	48.0	34.0	23.4	9.1	1.6
Subarea 4A.....	6,714.4	5,768.9	3,255.3	1,173.2	1,340.4
Subarea 4B.....	392.7	316.3	130.0	131.6	54.7
New York City District.....		5,835.9	3,274.1	1,181.8	1,380.1
Albany-Troy-Schenectady District.....		269.9	170.3	70.8	28.8
Buffalo-Niagara Falls District.....		2,932.0	2,633.5	221.0	77.5
Rochester District.....		353.7	214.8	84.3	53.6
Syracuse District.....		165.0	102.4	41.1	21.5
Utica District.....		161.6	125.0	25.7	10.9
Binghamton District.....		121.7	92.8	24.6	4.3

¹ Includes energy losses and electricity used by utility companies.

SOURCE: Federal Power Commission.

of domestic consumption was much less and that of commercial and industrial establishments much greater. The Buffalo-Niagara Falls district stands out from the rest by reason of its enormous industrial consumption. In that district, 90 percent of all consumption was commercial and industrial and less than 8 percent domestic.

Table 2 gives an idea of the general industrial market involved. It will be noted that the population in 1930 was nearly two-thirds urban even if New York City be excluded. The average density of population was 93.3 per square mile excluding New York City, or 243.2 per square mile including New York City. In the depression year 1932 well over a million cars of rail freight originated in the up-State area and a considerably larger number were terminated there.

TABLE 2

Data on area, population and freight traffic of St. Lawrence power distribution area

Items	Within 100 miles of St. Lawrence power site	Within 200 miles of St. Lawrence power site	All New York State trade areas	
			Excluding New York City multiple market	Including New York City multiple market ¹
Area (square miles).....	6, 448	27, 253	49, 674	51, 606
Population, 1930 (thousands).....	196	2, 488	4, 636	12, 552
Rural.....	119	890	1, 638	1, 908
Urban.....	77	1, 597	2, 998	10, 644
Percent urban.....	39. 6	64. 1	64. 6	84. 5
Population, 1930, per square mile.....	30. 4	91. 3	93. 3	243. 2
Industrial plants on class I railroads, 1932.....	324	3, 927	7, 653	9, 218
Cars originated, 1932 (thousands).....	39	651	1, 183	1, 524
Cars terminated, 1932 (thousands).....	59	678	1, 392	2, 274

¹ Exclusive of the New Jersey and Connecticut parts of the New York City multiple market.

SOURCE: Compiled from data in Federal Coordinator of Transportation, *Freight Traffic Report*, Vol. III, analysis 10.3, p. 69.

Particular interest attaches to the first two columns of this table, since the larger part of the projected hydroelectric development is to be on the St. Lawrence River at International Rapids. Practically all of New York State (as well as substantial portions of other States) lies within the 300-mile radius which is at present regarded as the maximum for power transmission.⁴ The territory within 100 miles of the International Rapids site is, as table 2 indicates, much less thickly settled and less industrialized than up-State New York as a whole. But the zone within a 200-mile radius (which includes Rochester, Syracuse, Utica, and Albany) has a 1930 population density of 91.3 or approximately equal to that of the whole State exclusive

⁴ It should be noted that the range of technically and economically feasible energy transmission has been continuously increasing since the birth of the industry. The transmission distance from Boulder Dam to Los Angeles is nearly 300 miles.

of New York City. In 1932 this 200-mile zone likewise accounted for about half the rail freight and a little more than half the industrial plants of the up-State area.

The Buffalo Industrial Area lies slightly more than 200 miles from the International Rapids, but has its own hydro power supply at Niagara. The further development of Niagara power and its coordination with St. Lawrence and other power in a State-wide transmission system are important features of the St. Lawrence project.

The Buffalo Industrial Area is by far the most important in up-State New York, as table 3 shows. In 1937 it had 105,722 manufacturing wage earners or 10.6 percent of the State total and nearly twice as many as the next most important industrial area (Rochester). As has already been indicated, the relative importance of the Buffalo area in the industrial use of electric power is still greater.

TABLE 3

Number of manufacturing wage earners in industrial areas and selected counties in New York State, 1937

Area	Number of wage earners	Percent of State total
New York State.....	995,658	100.0
Industrial areas:		
New York ¹	528,848	53.1
Buffalo.....	105,722	10.6
Rochester.....	57,690	5.8
Albany-Schenectady-Troy.....	37,649	3.8
Counties:		
Onondaga (includes Syracuse).....	28,337	2.8
Broome (includes Binghamton).....	27,646	2.8
Oneida (includes Utica and Rome).....	24,663	2.5
Chautauqua (includes Jamestown).....	15,835	1.6
Montgomery (includes Amsterdam).....	12,829	1.3
Fulton (includes Gloversville).....	10,564	1.1
Total for above industrial areas and counties.....	849,783	85.4

¹ Figure relates to that part of area included in New York State. The number of wage earners in the entire New York Industrial Area was 848,345.

SOURCE: *U. S. Census of Manufactures, 1937*, table 2, pp. 1502-1503; table 3, pp. 1553, 1591, 1604, 1613.

Section 2

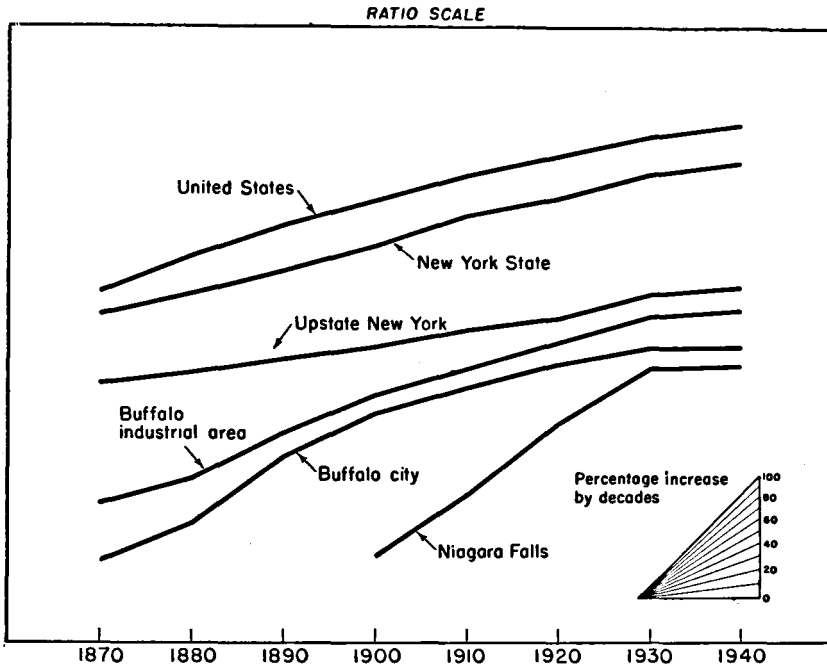
ECONOMIC BACKGROUND OF THE POWER TRIBUTARY AREA

In appraising probable future economic growth and energy consumption in the area tributary to St. Lawrence power, it is necessary to refer briefly to past trends. In this connection, the Buffalo area is appropriately given special attention, not only on account of its importance, but also because of its close relation to the past and present utilization of Niagara hydroelectric power. Here, more than anywhere else in the country, the effect of cheap hydroelectric energy upon industrial development is easily discernible.

Trends in Population Growth.

The population of New York State over the last 60 years has grown, on the average, about as fast as that of the United States. This is apparent in table 4 and chart 2. The timing of the growth,

Chart 2—POPULATION IN THE UNITED STATES, NEW YORK STATE, AND THE BUFFALO INDUSTRIAL AREA 1870-1940



Source: Table 4

WPA 3688

however, has been different. As shown in table 5, up to about the turn of the century New York State was growing much less rapidly than the rest of the country. In 1900 the State had only 9.56 percent of the national population. Between 1900 and 1930, the State maintained its trend of population growth, while the rate of increase for the country as a whole markedly slowed down. The result was that in 1930 New York State had 10.24 percent of the total population. In the 1930-40 decade, due to falling birth rates and the reversal of the tide of immigration, the national increase was the smallest percentage on record, while New York State's rate of increase was even less.

TABLE 4

Population in the United States, New York State, and the Buffalo area, 1870-1940

Year	Total United States	New York State		New York State (excluding New York City). ¹			Buffalo Industrial Area		City of Buffalo		City of Niagara Falls	
	Thousands	Thousands	Per cent of United States	Thousands	Per cent of United States	Per cent of State	Thousands	Per cent of United States	Thousands	Per cent of United States	Thousands	Per cent of United States
1870.....	38,558	4,383	11.37	2,905	7.55	67.2	229	0.596	118	0.307	(?)	(?)
1880.....	50,156	6,083	10.16	3,171	6.33	62.4	274	.548	155	.309	(?)	(?)
1890.....	62,948	6,003	9.55	3,496	5.55	58.2	386	.612	256	.406	(?)	(?)
1900.....	75,995	7,269	9.56	3,832	5.05	52.7	509	.671	352	.464	19	0.026
1910.....	91,972	9,114	9.92	4,347	4.72	47.5	621	.676	424	.461	30	.033
1920.....	105,711	10,385	9.82	4,765	4.51	45.9	753	.713	507	.480	51	.048
1930.....	122,775	12,558	10.24	5,658	4.61	45.0	908	.740	573	.467	76	.062
1940 ²	131,410	13,380	10.18	5,999	4.56	44.8	956	.730	575	.438	77	.059

¹ Excluding the counties now comprising New York City.

² No data.

³ Preliminary figures as given in Census press releases of Sept. 22 and 23, 1940.

SOURCE: U. S. Census of Population.

TABLE 5

Percentage rates of population increase in the United States, New York State, and the Buffalo area, 1870-1940

	1870-80	1880-90	1890-1900	1900-1910	1910-20	1920-30	1930-40
United States.....	30	25	21	21	15	16	7
New York State.....	16	18	21	25	14	21	6
New York State (excluding New York City). ¹	9	10	9	13	10	19	5
Buffalo Industrial Area.....	20	41	32	22	21	21	5
City of Buffalo.....	31	65	37	21	19	13	10
City of Niagara Falls.....	(?)	(?)	(?)	57	79	49	3

¹ Excluding the counties now comprising New York City.

² Less than half of 1 percent.

³ No data.

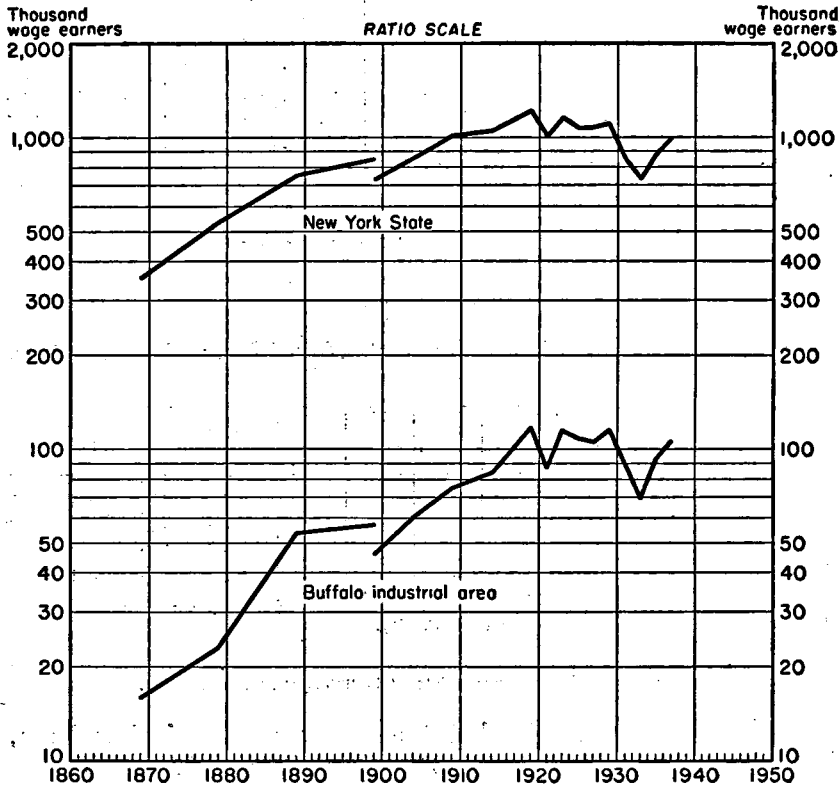
SOURCE: Computed from United States Census data. The 1940 figures are preliminary.

Another striking fact is that the up-State part of New York, during the entire period (1870-1940), has been growing much more slowly than New York City and (except in the 1920's) more slowly than the rest of the country. The Buffalo Industrial Area, on the other hand, grew faster than the country as a whole in every decade between 1880 and 1930, and fell behind only in 1930-40. The area's rapid growth seems to have been due at first (up to 1900) primarily to the growth of the city of Buffalo; but since 1900 the suburbs and adjacent communities (notably Niagara Falls, which quadrupled its population between 1900 and 1930) have increased faster than the city itself. The Buffalo Industrial Area as a whole has been growing at a decreasing rate, and in the 1930's the city itself added only 0.4 percent to its population.

Trends in Manufacturing Activity.

These trends of population increase reflect general economic expansion, chiefly in manufacturing, commerce, and service industries. Turning to the record of wage earners in manufacturing (table 6 and chart 3) a striking difference in the trends is found:

Chart 3 - MANUFACTURING WAGE EARNERS IN NEW YORK STATE AND THE BUFFALO INDUSTRIAL AREA, 1869 - 1937



Source: Table 6

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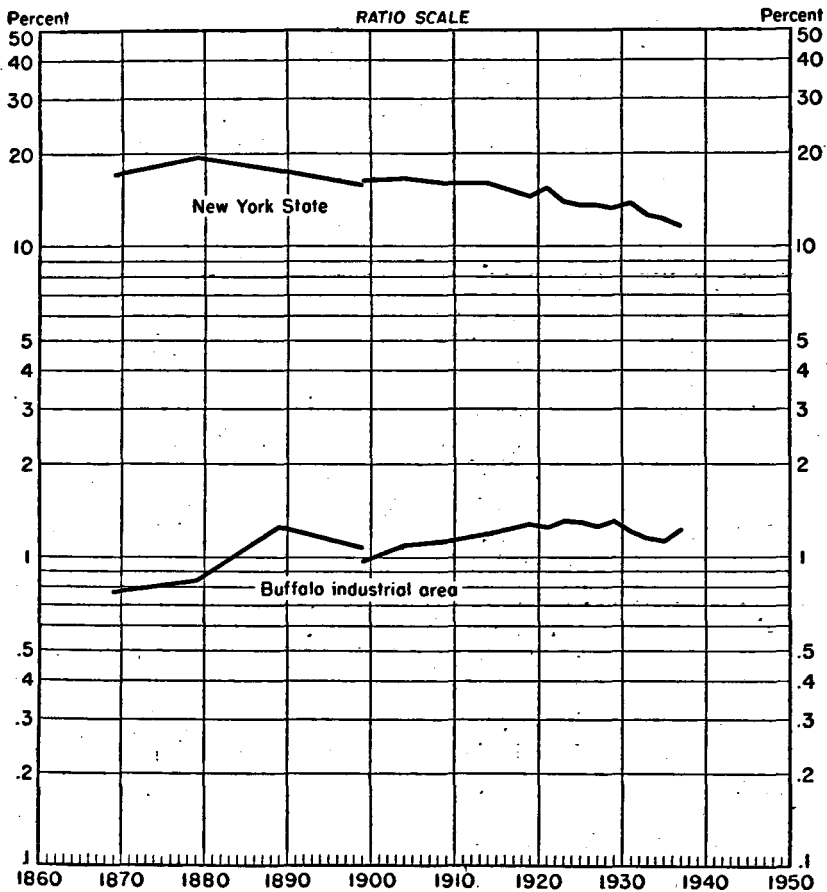
New York State showed a fairly steady growth in number of wage earners until about 1920, when the trend apparently turned downward. In the Buffalo Industrial Area, the trend had a similar but more recent reversal. It would appear that population growth was maintained by a rapid increase in nonmanufacturing activities.

To a large extent the variations in the number of wage earners in manufacturing in the State and the area merely reflect national trends and cyclical movements. In order to throw a clearer light on local factors, both the State and the Buffalo area figures have been

expressed, in table 6 and chart 4, as percentages of the United States total.

New York State's share of the national total of manufacturing wage earners declined from 19.6 percent in 1879 to 13.5 percent in 1919. After a rise to 14.4 percent in 1921, New York State's propor-

Chart 4 - MANUFACTURING WAGE EARNERS IN NEW YORK STATE AND THE BUFFALO INDUSTRIAL AREA AS PERCENTAGES OF UNITED STATES TOTAL, 1869-1937



Source: Table 6

WPA 3690

tion continued to fall to 12.7 percent in 1925. Despite a temporary rise after that, the underlying downward trend continued to a record low of 11.6 percent in 1937, the most recent available figure. The general trend and the timing of peaks and troughs is the same when value added by manufacture rather than wage earners is used as the basis.

TABLE 6

Manufacturing wage earners in New York State and the Buffalo Industrial Area, 1869-1937

Year	New York State		Buffalo Industrial Area	
	Number (thousands)	Percent of United States	Number (thousands)	Percent of United States
1869	352	17.1	16	0.77
1879	532	19.6	23	.84
1889	752	17.7	54	1.26
1899	849	16.0	57	1.07
1899 ¹	727	16.0	46	.97
1904	867	15.7	60	1.10
1909	1,004	15.2	75	1.13
1914	1,058	15.0	84	1.19
1919	1,228	13.5	117	1.28
1921	1,000	14.4	87	1.26
1923	1,151	13.1	115	1.31
1925	1,066	12.7	108	1.29
1927	1,072	12.8	105	1.26
1929	1,104	13.2	115	1.30
1931	848	13.8	79	1.20
1933	733	12.7	70	1.15
1935	879	12.2	83	1.13
1937	906	11.6	106	1.23

¹ Excluding hand and neighborhood industries, from this point on.

Source: New York State data from *United States Census of Manufactures*; Buffalo Industrial Area data from Glenn E. McLaughlin, *Growth of American Manufacturing Areas*, table 21, pp. 98-99.

New York State's percentage of the national total employment in manufacturing consistently rises in years of business recession and falls in years of recovery. It is evident that the State's industries are somewhat less affected by cyclical ups and downs than are those of the United States as a whole. In the Buffalo Industrial Area, on the other hand, where heavy durable-goods industries predominate, the share of the national total of manufacturing wage earners decreases in recession years and increases with recovery.

In order to see beyond these differences in cyclical sensitivity, one should consider the trends of the New York State and the Buffalo area percentages in chart 4. For the State as a whole, the trend over the past two generations indicates an annual decrease in the ratio of about 0.12 percentage points. For the Buffalo area, the trend in the ratio was upward until about 1925 and appears definitely downward since then. The peak census year of the Buffalo area's relative importance was 1923, when 1.31 percent of the Nation's manufacturing wage earners were employed there.

Thus it seems that New York State as a whole has been losing ground relatively to the rest of the country, in the matter of manufacturing wage earners, ever since 1879; and since 1919 the State has been losing manufacturing wage earners in absolute numbers also. The Buffalo Industrial Area, after gaining in number of manufacturing wage

earners faster than the rest of the country until 1923, has lost the momentum of expansion in this respect.

Industrial Specialization.

In order to determine which industries have been most attracted to New York State and to the Buffalo Industrial Area, the "degree of concentration" of individual industries has been measured in 1929 and 1937. This is simply the percentage of the whole industry which is located in the State or the area; the measure used is "value added by manufacture." Thus New York State in 1929 had 33.4 percent of the national total of value added in the cane-sugar refining industry. This indicates a relatively high degree of concentration of the industry in the State, since in all manufacturing industries, the State had only 15.6 percent of the national total of value added in 1929.

Several different types of industries are represented among those whose percentage in New York State exceeds New York's percentage of all manufacturing industries (tables 7 and 8). There is, for

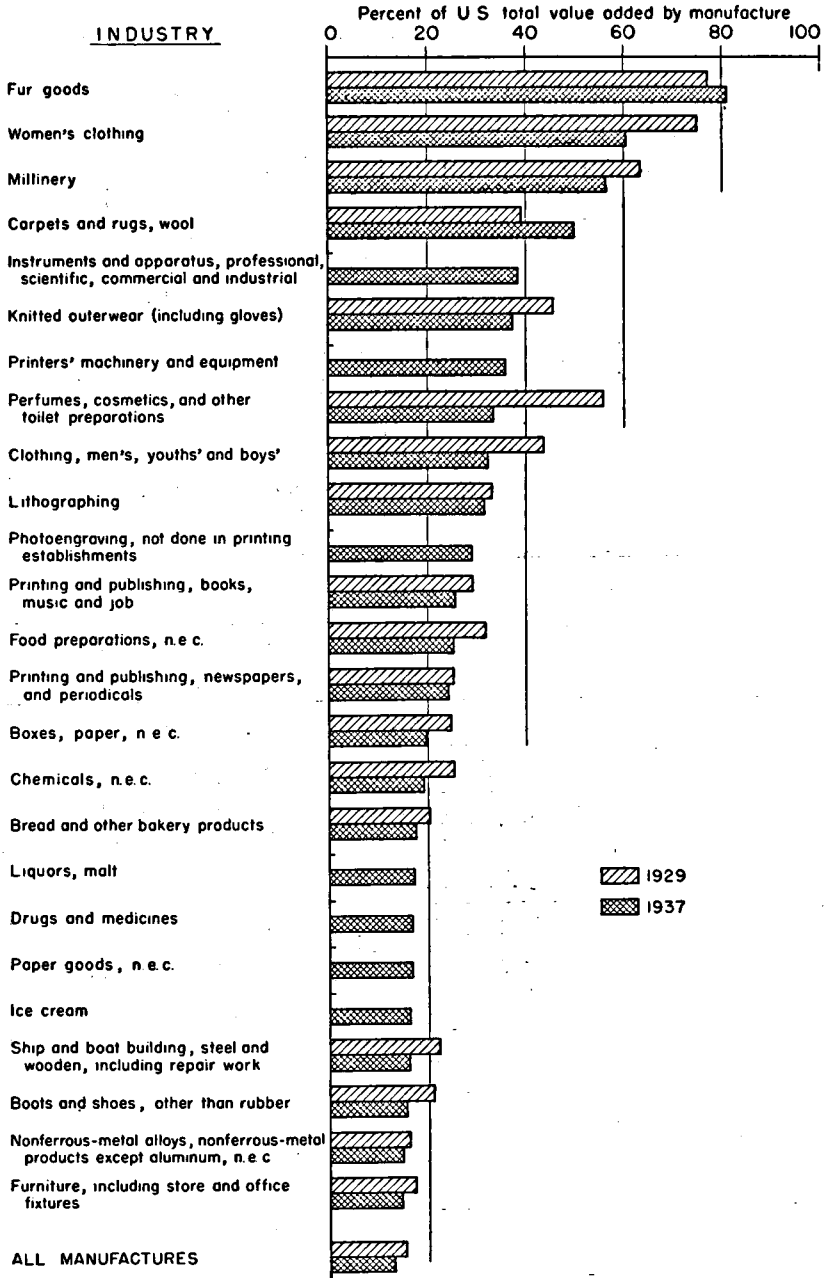
TABLE 7
Industries arranged according to degree of concentration in New York State, 1929¹

Industries	Wage earners	Value added by manufacture	
		Amount (thousands of dollars)	Percent of United States
Clothing, women's, n. e. c.	102,096	582,287	75.1
Fur goods.....	47,638	78,553	72.4
Millinery.....	16,655	61,832	63.4
Perfumes, cosmetics, and other toilet preparations.....	7,026	75,882	56.1
Knitted outerwear.....	11,836	32,682	45.8
Furnishing goods, men's, n. e. c.	10,928	30,389	45.4
Clothing (except work clothing), men's, youths', and boys', n. e. c.	47,210	201,572	43.2
Bookbinding and blank-book making.....	10,126	29,505	41.0
Carpet and rugs, wool.....	14,926	35,404	39.4
Shirts.....	15,072	40,526	36.4
Sugar refining, cane.....	4,352	23,098	33.4
Lithographing.....	6,229	27,338	33.3
Food preparations, n. e. c.	2,225	24,110	32.1
Jewelry.....	5,204	29,750	30.6
Printing and publishing, books, music, and job.....	32,388	221,932	29.4
Lighting equipment.....	5,639	23,304	26.8
Printing and publishing, newspapers and periodicals.....	20,002	344,748	25.6
Chemicals, n. e. c.	13,007	95,818	25.6
Boxes, paper, n. e. c.	12,290	33,555	25.0
Ship and boat building, steel and wooden, including repair work.....	10,811	32,672	22.4
Boots and shoes, other than rubber.....	39,980	96,044	21.2
Bread and other bakery products.....	33,704	159,892	20.3
Furniture, including store and office fixtures.....	25,220	91,799	17.6
Nonferrous-metal alloys and products, not including aluminum products.....	13,901	50,428	16.3
Confectionery.....	9,602	28,050	15.7
Total, above industries.....	615,067	2,451,170	-----
All manufactures.....	1,105,966	4,973,920	15.6

¹ The industries selected are the 25 largest (according to value added by manufacture) of those showing greater than average concentration.

SOURCE: *Census of Manufactures, 1929*, Vol. III, table 12, pp. 358-361.

Chart 5 - CONCENTRATION OF INDIVIDUAL INDUSTRIES
IN NEW YORK STATE, 1929 AND 1937



Source: Tables 7 and 8

instance, a group of "metropolitan" industries (clothing, printing, jewelry, etc.) for which the concentrated market and labor supply of New York City provides the explanation. Again, we find in the list certain specialized industries (such as cane-sugar refining and shipbuilding) dependent on proximity to waterways. Finally, there are other industries (furniture, chemicals, nonferrous alloys, etc.) in which the availability of raw materials, low-cost transportation, and easy access to a concentrated market are important. A comparison of the New York State lists of industrial specialties in 1929 and 1937 shows little change between these 2 years. This is graphically shown in chart 5.

TABLE 8

Industries arranged according to degree of concentration in New York State, 1937¹

Industries	Wage earners	Value added by manufacture	
		Amount (thousands of dollars)	Percent of United States
Fur goods	9,875	39,980	81.2
Women's clothing ²	115,528	295,672	60.5
Millinery	10,608	26,732	57.4
Carpets and rugs, wool	15,424	39,287	50.0
Instruments and apparatus, professional, scientific, commercial, and industrial	6,094	25,643	38.7
Knitted outerwear (including gloves)	9,767	19,018	37.4
Printers' machinery and equipment	4,465	20,868	36.2
Perfumes, cosmetics, and other toilet preparations	4,472	26,369	33.6
Clothing, men's, youths', and boys' ²	44,335	92,665	32.6
Lithographing	7,093	26,605	31.9
Photoengraving, not done in printing establishments	3,450	18,224	29.2
Printing and publishing, books, music, and job	27,266	136,171	25.9
Food preparations, n. e. c.	2,900	19,782	25.4
Printing and publishing, newspapers and periodicals	21,920	244,956	24.5
Chemicals, n. e. c.	12,876	93,070	19.9
Boxes, paper, n. e. c.	13,123	33,858	19.8
Bread and other bakery products	37,269	124,954	17.9
Drugs and medicines	4,556	42,037	17.0
Paper goods, n. e. c.	5,945	19,255	17.0
Liquors, malt	5,944	58,658	16.6
Ice cream	2,198	22,937	16.5
Ship and boat building, steel and wooden, including repair work	8,598	24,183	16.2
Boots and shoes, other than rubber	33,673	56,038	15.9
Nonferrous-metal alloys; nonferrous-metal products except aluminum, n. e. c.	10,664	41,808	15.1
Furniture, including store and office fixtures	20,280	52,006	14.8
Total, above industries	438,313	1,600,776	
All manufactures	965,658	3,316,180	13.1

¹ The industries selected are the 25 largest (according to value added by manufacture) of those showing greater than average concentration.

² Combined industries to obtain classification comparable with 1929.

SOURCE: *Census of Manufactures, 1937*, pp. 1383-1394.

The list of industries concentrated in the Buffalo Industrial Area (tables 9 and 10) is less complete, due to withholding of data by the Census to avoid individual disclosures. It is evident, however, that the area specializes in metal, chemical, paper, and grain products. The most concentrated important industry in the Buffalo area is the "chemicals not elsewhere classified," in which in 1929 the area had

12.78 percent of the national total of value added by manufacture, and 10.90 percent in 1937. Flour milling was a close second in concentration in the area, with 6.17 percent of the United States total in 1929 and 8.90 percent in 1937. These figures stand in contrast to the

TABLE 9

Industries arranged according to degree of concentration in the Buffalo Industrial Area, 1929

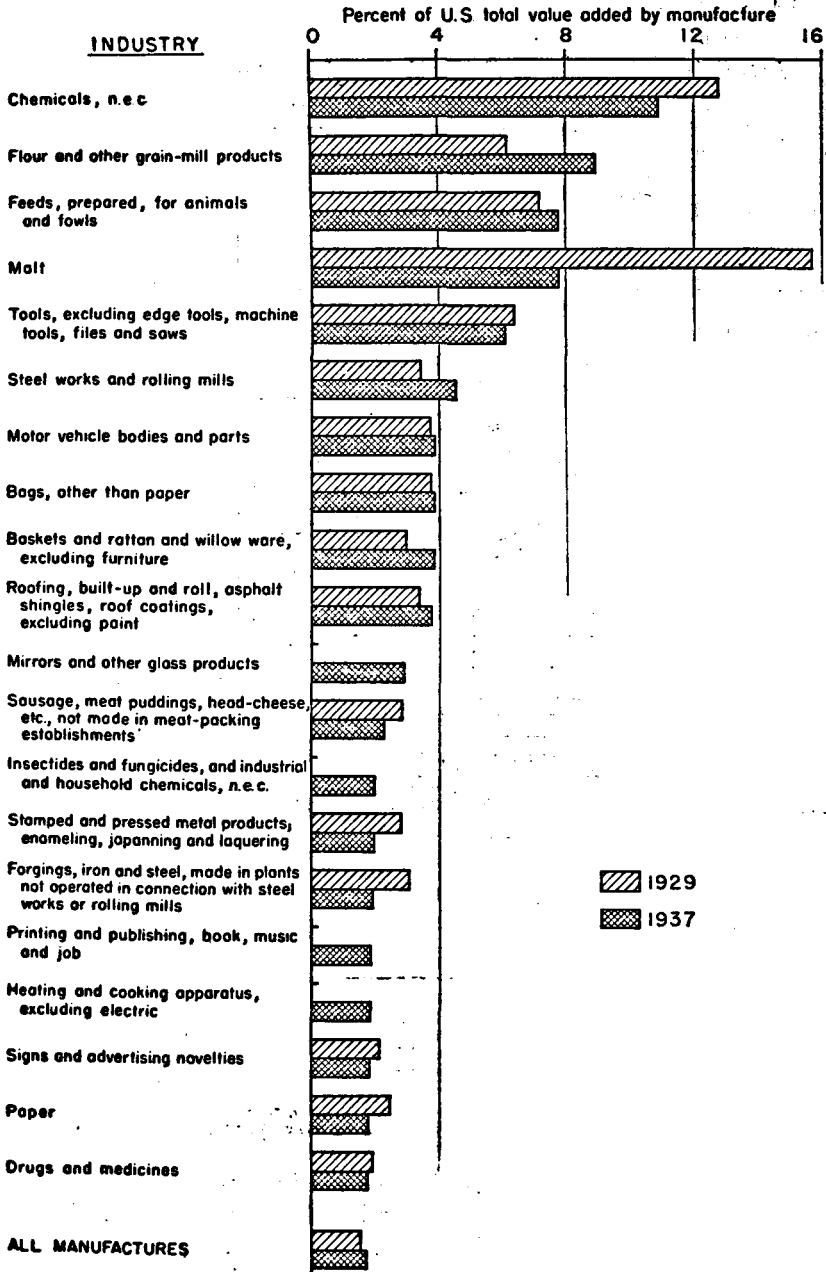
Industries ¹	Wage earners	Value added by manufacture	
		Amount (thousands of dollars)	Percent of United States
Minerals and earths, ground or otherwise treated.....	175	1, 809	21. 35
Malt.....	61	734	15. 69
Chemicals, n. e. c.....	7, 157	47, 862	12. 78
Feeds, prepared, for animals and fowls.....	663	5, 370	7. 19
Tools, not including edge tools, machine tools, files, or saws.....	1, 055	4, 311	6. 40
Flour and other grain-mill products.....	1, 251	11, 762	6. 17
Wall plaster, wallboard, insulating board, and floor composition.....	519	2, 522	5. 95
Bags, other than paper, not made in textile mills.....	383	975	3. 76
Motor-vehicle bodies and motor-vehicle parts.....	7, 129	25, 518	3. 74
Steel works and rolling mills.....	12, 445	50, 322	3. 44
Roofing, built-up and roll; asphalt shingles; roof coatings other than paint.....	197	1, 421	3. 38
Forgings, iron and steel, not made in plants operated in connection with rolling mills.....	618	2, 603	3. 08
Engines, turbines, tractors, and water wheels.....	1, 225	7, 634	3. 00
Baskets, and rattan and willow ware, not including furniture.....	278	419	2. 98
Cleaning and polishing preparations.....	165	929	2. 87
Sausage, meat puddings, headcheese, etc., and sausage casings not made in meat-packing establishments.....	189	760	2. 83
Nonferrous metal alloys and products, not including aluminum.....	2, 255	8, 682	2. 81
Stamped ware, enameled ware and metal stamping, enameling, japanning, and lacquering.....	1, 488	3, 287	2. 81
Boxes, paper, n. e. c.....	1, 458	3, 681	2. 74
Motor vehicles, not including motorcycles.....	6, 060	33, 086	2. 50
Flavoring extracts and flavoring sirups.....	241	1, 831	2. 49
Paper.....	1, 922	9, 660	2. 46
Paints and varnishes.....	433	5, 116	2. 18
Signs and advertising novelties.....	405	1, 742	2. 12
Lithographing.....	448	1, 656	2. 02
Patent or proprietary medicines and compounds.....	469	4, 277	1. 91
Electroplating.....	113	1, 047	1. 84
Pulp (wood and other fiber).....	331	1, 609	1. 79
Bread and other bakery products.....	2, 775	13, 695	1. 73
Envelopes.....	177	523	1. 66
Pumps (hand and power) and pumping equipment.....	246	1, 547	1. 60
Foundry and machine shop products.....	7, 318	27, 196	1. 57
Furniture, including store and office fixtures.....	2, 406	8, 111	1. 56
Grease and tallow, not including lubricating greases.....	72	333	1. 55
Total, above industries.....	62, 128	291, 310	.....
All manufactures.....	115, 212	493, 502	1. 55

¹ The following industries are not reported separately for the Buffalo Industrial Area in the *Census of Manufactures, 1929*, but according to the reports of New York State Department of Labor for 1932 employ a sufficiently large number of wage earners to be considered with those shown above as relatively specialized in this area:

Industries	Wage earners in Buffalo Industrial Area, 1932	
	Number	Percent of State total
Screw-machine products and hardware specialties.....	4, 445	24. 3
Rubber goods.....	2, 151	44. 1
Metals and metal alloys: Smelting, refining and ore dressing.....	719	45. 5

SOURCE: Table from *United States Census of Manufactures, 1929*; note from New York State Department of Labor, *Directory of Manufacturers, 1932*.

Chart 6 - CONCENTRATION OF INDIVIDUAL INDUSTRIES IN THE BUFFALO INDUSTRIAL AREA, 1929 AND 1937



Source: Tables 9 and 10
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Buffalo area's share of value added in United States manufacturing in general which was only 1.55 percent in 1929 and 1.72 percent in 1937. The important specialties of the Buffalo area are shown graphically in chart 6.

TABLE 10
Industries arranged according to degree of concentration in the Buffalo Industrial Area, 1937

Industries ¹	Wage earners	Value added by manufacture	
		Amount (thousands of dollars)	Percent of United States
Chemicals, n. e. c.	6,949	51,700	10.90
Flour and other grain-mill products	1,631	11,864	8.90
Feeds, prepared, for animals and fowls	1,187	5,984	7.80
Malt	130	1,446	7.80
Tools, excluding edge tools, machine tools, files and saws	1,256	2,985	6.09
Steel works and rolling mills	14,384	67,937	4.54
Motor-vehicle bodies and parts	8,379	31,101	3.88
Baskets and rattan and willow ware, excluding furniture	227	372	3.84
Bags, other than paper	377	1,014	3.80
Roofing, built-up and roll; asphalt shingles, roof coatings, excluding paint	250	1,501	3.76
Mirrors and other glass products	614	1,276	2.69
Sausage, meat puddings, headcheese, etc., not made in meat-packing establishments	209	686	2.26
Insecticides and fungicides, and industrial and household chemicals, n. e. c.	31	732	1.97
Stamped and pressed metal products; enameling, japanning and lacquering	1,274	2,826	1.94
Forgings, iron and steel, made in plants not operated in connection with steel works or rolling mills	413	1,128	1.89
Foundry products (gray iron and malleable iron)	2,310	4,781	1.87
Printing and publishing, book, music, and job	2,485	9,627	1.83
Heating and cooking apparatus, excluding electric	1,708	4,687	1.81
Signs and advertising novelties	256	854	1.78
Paper	2,332	6,962	1.75
Drugs and medicines	460	4,307	1.74
Total, above industries	46,902	213,670	
All manufactures	105,722	433,175	1.72

¹ The following industries are not reported separately for the Buffalo Industrial Area in the *Census of Manufactures, 1937*, but according to the reports of New York State Department of Labor they employed in 1936 a sufficiently large number of wage earners to be considered with those shown as relatively specialized in this area. These data exclude all establishments with less than 100 employees:

Industries	Wage earners in Buffalo Industrial Area	
	Number	Percent of State total
Screw-machine products and hardware specialties	3,361	41.8
Metal refining and ore dressing	2,686	46.9
Engines, pumps, air compressors, etc.	1,636	33.8
Smelting, refining and rolling, nonferrous metals	1,111	17.0
Soap	1,004	35.6

SOURCE: Table from *United States Census of Manufactures, 1937*; note from *Journal of Commerce, Directory of New York State Manufacturers, 1937*. Based on 1936 reports of the New York State Department of Labor.

Some further indications of the relative importance of the metal, chemical, paper, and grain-products industries in the Buffalo Industrial Area are given in table 11, based on statistics of the State Department of Labor for 1936. It appears that these four industry groups accounted for nearly three-fourths of all employment, including office

and shop workers, of the manufacturing industries in the Buffalo area, and that the metal and chemical groups alone accounted for well over half.

TABLE 11

Employment in selected industries in the Buffalo Industrial Area, 1936

Industries	Number employed (including both office and shop)	Percent of total
Metals and metal products	58,497	49.05
Metals and metal products, not including machine shops	31,243	27.12
Transportation equipment	15,351	13.33
Machine shops: Machine building, etc.	9,903	8.60
Chemicals and allied products, including composition goods	10,528	9.14
Chemicals and dyestuffs	5,457	4.74
Coal, wood, petroleum products, and distillation	1,139	.99
Soap	1,080	.94
Composition goods	833	.72
Medicines, drugs, etc.	579	.50
Paints, varnishes, printing inks, etc.	519	.45
Vegetable oils	215	.19
Disinfectants, deodorants, and insecticides	177	.15
Animal products	172	.15
Cosmetics and toilet preparations	117	.10
Unspecified	240	.21
Pulp, paper, and paper products	6,900	5.89
Pulp and paper	3,795	3.24
Paper products	3,165	2.74
Grain milling and grain products	3,746	3.25
Grain milling	2,939	2.54
Breweries, including malt and yeast manufacturing	807	.70
Total, above industries	77,671	67.43
Other industries	37,528	32.56
Total, all industries	115,197	100.00

SOURCE: New York Department of Labor data, compiled in the *Journal of Commerce, Directory of New York State Manufacturers, 1937*, pp. 504, 505, 580. The figures for individual industries are in some cases slightly incomplete because no industry figure was published for a county unless at least 100 persons were employed in that industry in that county.

The importance and degree of concentration of the metal products, chemical, and paper industries in the Buffalo area is particularly significant since, as will be shown later, these industries are relatively strongly affected by differentials in power costs. It is probable that a substantial share of the industrial growth of the Buffalo area, and thus of up-State New York as a whole, should be ascribed to the low-cost hydroelectric power supply from Niagara.

While the direct effect of cheap power upon manufacturing development is here stressed, the benefits of low domestic rates to the domestic consumer cannot be ignored. From the point of view of general community welfare, these latter benefits are possibly of even greater importance, and they produce indirectly some stimulation to industrial growth as well.

Niagara Power and Industrial Development.

Niagara power was first utilized for the large-scale generation of electricity in 1895, and from that time until 1924 the generating capacity was intermittently expanded to take care of the rapidly increasing load. The total hydro horsepower already developed is about 500,000, or about 27 percent as much as the total new hydro capacity contemplated under the Niagara-St. Lawrence development plan.⁵ During most of this period of exploitation, the feasible transmission distance was relatively limited, so that the effects of the power development were felt in a much more restricted area than would be true of any future large-scale hydro development.

The most obvious and direct effect of the Niagara hydroelectric development was the creation of a unique electrochemical and electro-metallurgical center at Niagara Falls. Industrial processes requiring large amounts of electric energy naturally found the location advanta-

TABLE 12

Electroprocess manufacturing plants in the Buffalo Industrial Area, 1936¹

[* Indicates firms not heavily dependent on power but closely allied with electroprocess plants]

Firm	Product	Number of employees
ELECTROCHEMICAL PRODUCTS		
*National Aniline & Chemical Co.	Aniline dyes and chemicals	Over 1,000
R. & H. Chemicals Department of E. I. duPont de Nemours & Co., Inc.	Chemicals	Over 1,000
Hooker Electrochemical Co.	do	500-999
Mathieson Alkali Works, Inc.	do	300-499
Oldbury Electro Chemical Co.	do	300-499
Niagara Alkali Co.	do	200-299
Iscro Chemical Division of Innis Speiden Co.	do	100-199
*Linde Air Products Corporation	Chemicals and dry ice	100-199
*Niacet Chemicals Corporation	Chemicals	100-199
Union Carbide and Carbon Co., Research Department.	Chemical research	100-199
Niagara Smelting Corporation	Chemicals	100-199
*General Chemical Co.	Sulphuric, muriatic, nitric acids	100-199
Buffalo Electro Chemical Co.	Hydrogen peroxide	100-199
METALS AND ALLOYS		
Union Carbide Co. (electrometallurgical division)	Ferro-alloys	Over 1,000
Aluminum Co. of America	Aluminum	300-499
Hanna Furnace Corporation	Pig iron	300-499
Vanadium Corporation of America	Ferro-alloys	300-499
Tonawanda Iron Corporation	Pig iron	100-199
Titanium Alloy Manufacturing Co.	Titanium	100-199
ABRASIVES, GRAPHITE, ETC.		
Carborundum Co.	Abrasives	Over 1,000
National Carbon Co., Inc. (unit of Union Carbide and Carbon).	Carbon and carbon products	500-999
Acheson Graphite Corporation (unit of Union Carbide and Carbon).	Graphite and graphite electrodes	300-499
General Abrasive Co., Inc.	Abrasives	100-199

¹ A large number of plants employing fewer than 100 workers each are omitted.

SOURCE: Journal of Commerce, *Directory of New York State Manufacturers, 1937*—based on 1936 factory inspection records of the New York State Department of Labor.

⁵ Imports of Canadian power are contracted to the amount of 82,500 kilowatts (110,000 horsepower) in addition, and considerable Canadian secondary power has been imported. (Power Authority of the State of New York, *1938 Annual Report*, pp. 158-162.)

geous, since it combined the inducements of low-cost power, specialized labor, and easy access to essential material sources and markets.

The extremely rapid growth of the city of Niagara Falls has already been shown (table 5 and chart 2). Further light on the character of industry in this area may be had from the list of chemical, metallurgical, and abrasive concerns in table 12. Most of those listed are carrying on processes requiring large amounts of power and are correctly classified in the intensive electroprocess group. A few, however (starred in the list), are not themselves heavily dependent on power, but are closely allied with electroprocess plants. The abrasives group is particularly interesting in this connection. Bulk abrasives are made in several plants on the Canadian side and shipped across to be fabricated into wheels and other shapes at Niagara Falls and elsewhere in this country.

It is estimated that in 1936 between 11,000 and 12,000 were employed in the industries shown in table 13. This does not appear large in comparison with the 105,722 manufacturing wage earners in the Buffalo Industrial Area or the State total of 995,658, in 1937,⁶ but such a comparison is likely to be misleading. In the first place, these are industries in which manpower is a relatively minor item. In terms of total value of products, or of value added by manufacture, the electroprocess group makes a much more impressive showing.

TABLE 13

Employment in electrochemical and electrometallurgical industries in 3 counties of New York State, 1936

Industry	Niagara County	Erie County	St. Lawrence County	Total
Electrochemical.....	3,649	1,808	—	5,457
Electrometallurgical.....	2,335	—	12,643	4,978
Abrasives, etc.....	3,844	50	—	3,894
Total.....	9,828	1,858	2,643	14,329

¹ Aluminum Co. plant at Massena.

² Exact figures not disclosed because only 2 establishments were involved. One reported less than 10 employees, the other 10-99 employees.

SOURCE: Journal of Commerce, Directory of New York State Manufacturers, 1937.

Furthermore the total effect of Niagara hydroelectric power actual involves many times 12,000 workers. Most of the products of the firms listed in table 12 are for industrial consumption; they are destined either for further processing or to aid in the processing of some other material. This means that the Buffalo area has the materials at hand for a wide range of manufactures. To cite only a few of the more obvious cases, the production of chlorine provides one of the chief essentials of paper making, and calcium carbide

⁶ United States Census of Manufactures, 1937.

enters, in the United States and Canada, into the manufacture of rayon products, films, explosives, and plastics indirectly through the generation of acetylene; and into the manufacture of nitrates, ferti-

TABLE 14
Principal New York State chemical products, 1937

[*Indicates products reported by at least as many establishments in New York as in any other State.
**Indicates products reported by at least as many establishments in New York as in all other States together]

Products	Value of products, United States total (thousands of dollars)	Number of establishments		Other important states ¹
		United States	New York	
*Electric furnace ferro-alloys.....	45,295	22	4	Pa. (4).
Sulphuric acid.....	42,198	157	3	Ohio (12).
Soda ash.....	33,769	17	1	Calif. (4).
*Caustic soda.....	32,028	80	6	Mich. (4).
Phenol-cresol resins.....	16,763	20	6	N. J. (7).
*Glycerin (c. p.).....	13,460	29	3	Calif. (3), Ohio (3).
Nitrocellulose.....	12,526	11	2	N. J. (4).
Cellulose acetate.....	12,199	6	1	N. J. (3).
Calcium carbide.....	9,842	6	1	Iowa (2).
Anhydrous ammonia.....	8,867	12	1	Calif. (2), Mich. (2), Pa. (2).
Methyl alcohol.....	8,619	4	1	Ill. (1), Okla. (1), W. Va. (1).
Glycerin (dynamite grade).....	7,822	22	2	Ohio (3).
Vitreous enamels.....	6,826	13	1	Ill. (3), Ohio (3), Pa. (3).
Sodium silicate (liquid).....	6,787	25	3	Calif. (4), N. J. (4), Pa. (4).
Acetic acid.....	6,607	22	1	Pa. (6).
*Sodium hypochlorite.....	6,274	63	9	Mich. (6), N. J. (6).
*Carbon bisulphide.....	4,754	10	2	Pa. (2).
Phthalic-anhydride resins.....	4,531	10	1	N. J. (4).
Citric acid.....	4,118	4	1	N. J. (2).
*Copper sulphate.....	3,883	15	3	Calif. (3), N. J. (3).
**Hydrogen peroxide.....	3,781	7	4	N. J. (2).
Calcium chloride (flake).....	3,754	5	1	Mich. (2).
Stearic acid.....	3,656	12	1	Ohio (6).
Glycerin (crude).....	3,593	62	5	N. J. (11).
Sodium bicarbonate.....	3,606	5	1	Ohio (2).
Carbon tetrachloride.....	3,068	6	1	Mich. (2).
Nitric acid.....	3,052	30	2	N. J. (6).
Hydrochloric acid (from salt).....	3,048	19	1	Ill. (3).
Mixed acid (sulphuric-nitric).....	2,484	20	2	N. J. (5).
*Ammonium sulphate.....	2,418	18	3	Calif. (2), Ill. (2), Ind. (2), N. J. (2), Pa. (2).
Salt cake (crude).....	2,367	28	1	N. J. (5).
*Sulphur, refined.....	2,333	13	3	Calif. (2), Texas (2).
*Silver nitrate.....	2,285	6	2	N. J. (2).
Ester gum.....	2,213	20	2	N. J. (4).
Ammonium chloride.....	1,821	9	1	N. J. (2), Pa. (2).
Phosphoric acid.....	1,785	10	1	N. J. (3).
Sodium silicate (solid).....	1,568	13	1	Calif. (3).
Sodium sulphide.....	1,530	12	1	N. J. (3).
**Caustic potash.....	1,438	5	3	Calif. (1), W. Va. (1).
*Ammonia (aqua and liquor).....	1,310	34	7	Mass. (7).
**Oxalic acid.....	1,087	4	2	N. J. (1), Ill. (1).
Modified sodas.....	1,051	10	2	Mich. (2), Ohio (2).
**Sulphur chloride.....	994	7	4	Calif. (1), Mich. (1), Ohio (1).
Hydrochloric acid (from chlorine).....	940	11	2	Mich. (4).
Bleaching powder.....	937	14	5	Md. (2).
**Cream of tartar.....	894	4	2	Calif. (1), Mass. (1).
*Aluminum stearate.....	857	11	2	Ohio (2).
Sal soda.....	769	21	1	Calif. (7).
**Potassium bicarbonate and carbonate.....	728	3	3	None.
Calcium acetate.....	727	21	5	Pa. (9).
*Sodium citrate.....	652	5	1	Calif. (1), Mo. (1), N. J. (1), Pa. (1).
Aluminum chloride.....	624	10	2	N. J. (3).
Mercury chlorides.....	604	5	1	N. J. (3).
*Potassium iodide.....	599	8	3	Calif. (2), N. J. (2).

¹ Figures in parentheses indicate number of producing establishments.

SOURCE: U. S. Census of Manufactures, 1937 (Chemicals not elsewhere classified), table 4, pp. 646-663. This list includes all products, valued at more than \$500,000 for the United States as a whole, whose production was reported by any New York establishment.

lizers, paints, lacquers, plastics, rayon, and explosives through cyanamide. Alloys and abrasives are essential for steel, tools, and machinery manufacture. Caustic soda is used in soap manufacture, among other things.⁷ It has already been noted that among the industries most highly concentrated in the Buffalo Industrial Area are the general chemicals industry, several branches of metalworking and machine construction, paper products, soap, and drugs. These closely allied "secondary" industries, included with the others, account for a total of nearly a quarter of the Buffalo area's industrial labor force. Also there are still other industries which, though not in the intensive electroprocess class, use enough electricity to be appreciably affected by rate differentials. Such are flour milling (another leading Buffalo specialty), cement, and paper manufacturing.

TABLE 15
Occupational groups in the City of Niagara Falls, New York, 1910-30

[Figures in parentheses () indicate decrease]

Group	Numbers			Percent increase	
	1910	1920	1930	1910-20	1920-30
Population.....	30,445	50,760	75,460	67	49
Gainfully employed.....	13,920	21,819	31,019	57	42
Manufacturing.....	7,614	12,549	15,152	65	21
Chemical and allied industries.....	481	1,459	2,613	199	82
Paper, printing, and allied industries.....	223	601	1,537	169	155
Iron and steel, machinery and vehicle industries.....	177	246	519	39	110
Metal industries (except iron and steel).....	782	933	763	19	(19)
Food and allied industries.....	126	263	849	109	33
Nonmanufacturing.....	6,306	9,270	15,867	47	71
Transportation and communication.....	1,459	1,718	2,463	18	43
Trade.....	1,302	1,820	3,629	40	99
Public services.....	293	486	836	66	72
Professional services.....	596	1,226	2,456	106	100
Domestic and personal service.....	1,526	1,684	2,962	10	76
Clerical occupations, not elsewhere specified.....	1,075	2,367	3,392	120	43

SOURCE: United States Census of Occupations.

The development of the occupational structure of the city of Niagara Falls is set forth in table 15, based on census data for 1910, 1920, and 1930. It is significant that manufacturing employment in the city increased 64 percent in 1910-20 and only 21 percent in 1920-30, while the corresponding rates of increase for nonmanufacturing employment were 47 percent and 71 percent, respectively. In Niagara Falls, as elsewhere, trade and service activities have tended to outstrip manufacturing. In the latter group, the chemical industries are much the most important, and nearly tripled their

⁷ Table 14 gives a fuller idea of the relative position of New York State in the general chemical field, as of 1937. Important products reported by New York State establishments are there listed in order of value of national output, and the number of establishments making each product is given for the States with the largest number of such establishments. A good schematic diagram of the product and process interrelationships in the electroprocess field is in *Power Requirements in Electrochemical, Electrometallurgical, and Allied Industries* (Federal Power Commission, 1938) facing p. 4.

employment between 1910 and 1920. In the 1920-30 decade all the chief manufacturing groups except iron and steel products grew at a reduced rate, and employment in nonferrous metal industries actually decreased.

Retardation of Electroprocess Industries in New York State.

By 1924, the firm Niagara power available at cheap contract rates had been fully allocated, and additional loads could be met only by new steam plants at higher costs. In view of this situation, the early flocking of electroprocess industries to New York State has ceased, and expansion in those industries in recent years has taken place largely in other regions. So far as the industries using large amounts of electricity are concerned, development in New York State has reached a "ceiling," which cannot be lifted without additional low-cost electric power development.

TABLE 16
T. V. A. energy sales, 1938-39 (years ending June 30)

Type of customer	Energy sold		Revenue		Average revenue per kwh.
	Amount	Percent of total	Amount	Percent of total	
	<i>Million kwh.</i>		<i>Thous. of doll.</i>		<i>Mills</i>
Municipalities, cooperatives, and temporary direct rural service.....	1938 110.6	15.8	699.8	30.4	6.32
	1939 328.4	20.3	1,868.6	34.3	5.66
Industrials.....	1938 368.1	51.2	918.6	39.8	2.57
	1939 901.5	55.7	2,507.4	46.0	2.78
Other utilities.....	1938 62.3	8.9	190.8	8.5	3.16
	1939 192.2	11.9	561.3	10.3	2.92
Interdepartmental sales.....	1938 168.4	24.1	490.7	21.3	2.91
	1939 196.2	12.1	512.8	9.4	2.61
Total, all types.....	1938 699.4	100.0	2,305.9	100.0	3.30
	1939 1,618.3	100.0	5,445.2	100.0	3.36

SOURCE: Tennessee Valley Authority, *Annual Report, 1938*, and *T. V. A.—Its Work and Accomplishments, 1940*.

To some extent firms in Niagara Falls or their affiliates have expanded production in other areas where cheap power is still available. The bulk-abrasive plants in Niagara Falls, Ontario, the expansion of aluminum manufacture in Tennessee Valley and the Pacific Northwest, and several plants of Union Carbide Co. subsidiaries in the Tennessee Valley and in West Virginia are examples. This does not mean that electroprocess plants at Niagara have shut down or moved away. Instead, the continued growth of these industries has been diverted to other areas while activity in those industries in the Buffalo area has not kept pace with national growth. This is especially noteworthy in view of the low level of industrial capital expansion for the last decade, and in the face of uncertainty as to the constitutionality and permanence of T. V. A. contracts until the decision of the United

States Supreme Court in 1939, which removed this doubt.⁸ It would seem to follow that the next period of extensive investment in new chemical and metallurgical plants will lead to a considerably more rapid growth of such industries in States other than New York, unless a new supply of cheap electric power is made available in New York.

TABLE 17

T. V. A. energy sales to industrial customers, 1938-39

[Millions of kilowatt-hours]

	Year ending June 30—	
	1938	1939
Aluminum Co. of America.....	148.2	577.7
Monsanto Chemical Co.....	197.4	229.7
U. S. Engineers Office—Sardis Dam.....	8.8	33.6
Victor Chemical Works.....	3.6	60.5
Total.....	358.0	901.5

Source: Tennessee Valley Authority, *Annual Report*, 1938, p. 69; and 1939, p. 62.

The following list from the July 27, 1940, issue of *Business Week* is indicative of current industrial expansion in the Tennessee Valley:

Aluminum Co. of America. Work is well under way on a \$15,000,000 expansion program, which was begun in 1937, at Alcoa's plant 14 miles south of Knoxville. Employees now number about 5,000. Output of sheet aluminum, vital to plane building, will be approximately doubled when expansion is completed.

Electro-Manganese Co. This new \$150,000 plant, important because it produces manganese to harden and toughen steel, is part of an entirely new industry which uses electricity to process ores.

Electro-Metallurgical Corporation. The first \$1,000,000 unit of this company at Muscle Shoals began operations this year. A \$5,000,000 development is contemplated to expedite the manufacture of ferromanganese, ferrosilicon, ferrochromium, and calcium carbide.

B. F. Goodrich Co. Last December, Goodrich started a new \$1,500,000 plant at Clarksville, Tenn. Production is increasing gradually.

Monsanto Chemical Co. A \$2,000,000 plant, now employing about 500, was established about 2 years ago at Columbia, Tenn. Phosphorus is produced by an electric furnace method for industrial uses. Monsanto has also begun to use a new process of producing manganese. A new, and fourth, electric furnace is to be installed.

⁸ Tables 16 and 17 give some further details on the recent growth of energy sales by the T. V. A. It will be observed that industrial sales, which constitute slightly more than half of the total, increased from 358.1 million kilowatt-hours in fiscal 1938 to 901.5 million in fiscal 1939, and that the bulk of this was due to the increased energy purchases of the Aluminum Co. of America. In fiscal 1939 this one concern bought 577.7 million kilowatt-hours, or nearly four times as much energy as in the previous year.

Stinson Division of Aviation Manufacturing Corporation. Stinson's new \$1,000,000 plant at Nashville is the first major aircraft factory in the South, and because of the national defense program, there are already reports that the plant will be doubled in size.

Tennessee Eastman Corporation. A subsidiary of Eastman Kodak Corporation. This new plant turns out a wide variety of products, including acetate rayon, all kinds of plastics, and flake and granular types of cellulose acetate.

Tennessee Valley Paper Mills, Inc. This company is planning construction of a plant at Savannah, Tenn., to manufacture newsprint from southern pine.

Tennessee Powder Co. Preliminary work is being done on construction of a powder-making plant on a 5,000 acre tract, 10 miles north of Memphis. Estimated cost is between \$15,000,000 and \$20,000,000, financed by the British Government. It will be constructed and operated for the newly formed Tennessee Powder Co. by E. I. du Pont de Nemours & Co.

T. V. A. Nitrate Plant No. 2. Proposals have been made to convert this plant so that it could be used for manufacturing ammonium nitrate and, in addition, to construct an entirely new Muscle Shoals plant designed to produce synthetic ammonia.

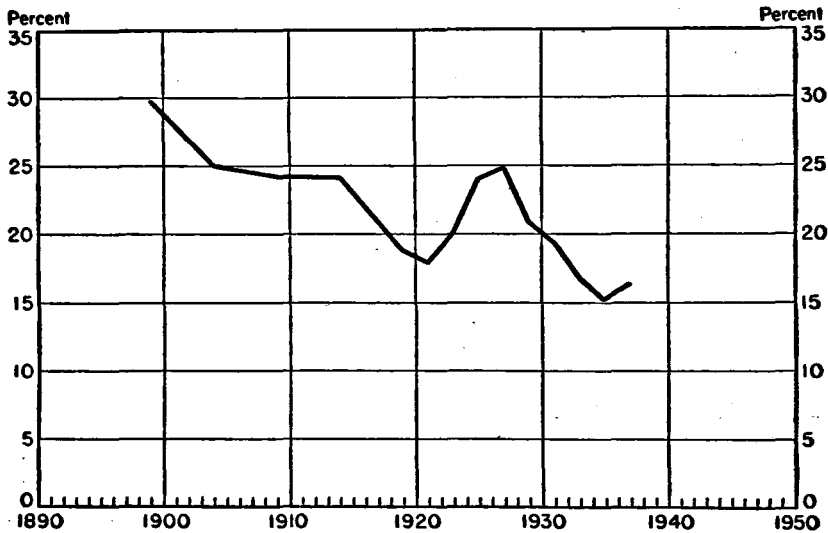
Victor Chemical Co. In 2 years Victor's plant at Mount Pleasant, Tenn., has grown from a \$1,000,000, one-furnace operation to a \$3,000,000, three-furnace plant.

The electrochemical industries form a substantial part of the whole "chemicals" group in New York State. Many chemical establishments, which do not use large amounts of power, depend upon the high-load-factor industries for the supply of materials. The location of such plants would be affected naturally by those supplying their primary materials. It is natural, then, that the whole "chemicals" group in New York State should share to some extent in the trends already indicated for the electro-process industries.

Tables 18, 19, and 20 present evidence on this point, with regard to the Census industry called "chemicals not elsewhere classified."⁹ Table 18 and chart 7 show that in 1927 the State reached its greatest prominence in this Census classification in recent years. It then contained 24.8 percent of the wage earners and 27.6 percent of the value added by manufacture in chemicals not elsewhere classified. In the subsequent decade the State showed a small net decline in the industry, while the United States showed a very large rise (56 percent in wage earners and 81 percent in value added), so that as of 1937 New York State had only 16.4 percent of the Nation's wage earners in the industry and accounted for only 19.5 percent of the value added by manufacture. Plainly, the industry has ceased to grow in New

⁹ This Census classification, as of 1937, excludes drugs, fertilizers, paints and varnishes, perfumes and cosmetics, rayon, soap, animal and vegetable oils, and several other types of products included under the broader category of "Chemicals and allied products."

Chart 7 — WAGE EARNERS IN CHEMICAL INDUSTRIES NOT ELSEWHERE CLASSIFIED IN NEW YORK STATE AS PERCENTAGE OF UNITED STATES TOTAL, 1899-1937



Source: Table 18

WPA 3693

York State, while still growing rapidly in the country as a whole. This is dramatically shown by the decline of percent of New York State wage earners in the industry to the total of the United States.

TABLE 18

Wage earners and value added in the "chemicals, not elsewhere classified," industry, United States and New York State, 1919-37

Year	United States		New York State		Percent of New York State to United States	
	Wage earners	Value added by manufacture (thousands of dollars)	Wage earners	Value added by manufacture (thousands of dollars)	Wage earners	Value added by manufacture
1919.....	71, 249	293, 843	13, 445	68, 640	18. 8	23. 4
1921.....	46, 306	200, 266	8, 290	43, 669	17. 9	21. 7
1923.....	74, 897	313, 969	15, 061	65, 013	20. 1	20. 8
1925.....	55, 694	275, 357	13, 377	74, 911	24. 0	27. 2
1927.....	50, 510	263, 741	12, 507	72, 634	24. 8	27. 6
1929.....	62, 199	374, 472	13, 007	95, 818	20. 9	25. 6
1931.....	48, 522	287, 107	9, 386	63, 790	19. 3	22. 2
1933.....	53, 190	255, 049	8, 923	56, 828	16. 8	22. 3
1935.....	65, 838	338, 564	9, 990	66, 746	15. 2	19. 7
1937.....	78, 591	477, 688	12, 876	93, 070	16. 4	19. 5

SOURCE: *United States Census of Manufactures*. The scope of this Census classification has been altered from time to time, but the percentage figures in the last two columns are much less directly affected by such changes than are the absolute figures.

In table 19 further detail on the geographical distribution of the chemicals not elsewhere classified industry in biennial census years 1929-37 is shown. The most rapid growth (150.5 percent increase in value added) was in the west central part of the country, with very rapid growth (74.8 percent increase) also in the southeastern section. The Middle Atlantic region grew less than any other (only 11.8 percent), while New York State declined 2.9 percent and the Buffalo Industrial Area registered the very moderate increase of 8 percent.

TABLE 19

Geographical distribution in the United States of the "chemicals not elsewhere classified" industry, according to value added by manufacture, 1929-37

Region, State, or area	Value added by manufacture									
	Amount (millions of dollars)					Index (1929=100)				
	1929	1931	1933	1935	1937	1929	1931	1933	1935	1937
United States.....	374.5	287.1	255.0	339.3	477.7	100	77	68	91	128
New England and East North Central ¹	105.1	80.9	73.6	90.4	123.4	100	77	70	86	117
South Atlantic and East South Central ¹	53.5	46.7	38.9	57.6	93.5	100	87	72	108	175
West North Central and West South Central ¹	9.4	9.6	10.3	12.7	23.6	100	102	109	135	251
Mountain and Pacific ¹	15.1	14.0	12.9	18.7	23.1	100	93	85	124	153
Middle Atlantic.....	191.3	135.9	119.4	160.0	213.9	100	71	62	84	112
New York State.....	95.8	63.8	56.8	66.7	93.0	100	67	59	70	97
Buffalo Industrial Area.....	47.9	27.0	28.3	38.4	51.7	100	56	59	76	106

¹ Regions combined to avoid indirect disclosure of individual operations.

Source: *U. S. Census of Manufactures*. See also note regarding source on table 20.

A special tabulation of newly established plants in chemicals not elsewhere classified, obtained by courtesy of Dr. Ralph Danhof of the Bureau of Agricultural Economics and Mr. Harold Kube of the Census Bureau, shows the same trend. As given in table 20, between 1931 and 1937 New York State had only 30 such new plants out of a total of 191 for the country as a whole; the Buffalo Industrial Area had 6 of the 30. These additions represented only 2.4 percent of value added by manufacture in New York State in 1931, and 0.9 percent in the Buffalo Industrial Area, as against 7.5 percent for the country as a whole, 13.2 percent in the far West, and 8.8 percent in the southeast. During the same interval 29 plants disappeared from New York State, leaving a net gain of only one establishment in this classification.

As compared with 1929, however, in 1937 New York State had lost 14 establishments, whereas all other areas gained 64 establishments.

Out of the total net addition of 103 million dollars in annual value added by manufacture between 1929 and 1937 for the country as a whole, the Buffalo Industrial Area contributed 3.8 million dollars, or about 3.7 percent, while New York State declined 2.7 million dollars. These facts establish irrefutably the conclusion that in "chemicals not elsewhere classified" the expansion of the industry through new

plant construction, as well as the growth of existing plants, is taking place largely in areas outside New York State.

TABLE 20

Changes in geographical distribution in the United States of the "chemicals not elsewhere classified" industry, 1929-37

[Figures in parentheses () indicate decrease]

Region, State, or area	Net increase, 1929-37			New establishments reported, 1931-37			Establishments disappearing, 1931-37		
	Estab- lish- ments	Value added		Num- ber	Value added (thou- sands of dollars)	Percent of 1931 value added	Num- ber	Value added (thou- sands of dollars)	Percent of 1931 value added
		Thou- sands of dollars	Percent of U. S. increase						
United States	50	103,216	100.0	191	21,400	7.5	110	9,356	3.8
New England and East North Central ¹	33	18,297	17.7	49	7,438	9.2	26	1,653	2.0
South Atlantic and East South Central ¹	9	40,009	38.8	24	4,092	8.8	12	1,449	3.1
West North Central and West South Central ¹	12	14,191	13.7	21	3,858	4.0	5	241	2.6
Mountain and Pacific ¹	14	8,098	7.8	30	1,843	13.2	13	745	5.4
Middle Atlantic	(18)	22,620	21.9	67	4,170	3.1	54	5,164	3.8
New York State	(14)	(2,748)	(2.7)	30	1,534	2.4	29	969	1.6
Buffalo Industrial Area	2	3,838	3.7	6	242	0.9	2	(²)	(¹)

¹ Regions combined to avoid indirect disclosures of individual operations.

² Withheld by the Census to avoid indirect disclosure of individual operations.

SOURCE: *U. S. Census of Manufactures*. The data on new plants and plants reported out of business were supplied through the courtesy of Dr. Ralph Danhof from his special tabulations of Census schedule data for a forthcoming study of industrial location. "New establishments" includes all establishments which were reported active in 1933, 1935, or 1937 and which had not been reported at the previous Census; it may thus include some establishments which subsequently went out of business. Similarly, "Establishments disappearing" includes all establishments reported active in 1931, 1933, or 1935 and not reported at the subsequent Census. During the period 1931-37 only 4 establishments were reported as having changed their location (between Censuses) from one region to another, and none of these entered or left New York State.

Changes in Concentration of Manufacturing Industries, 1929-37.

To gain a broader picture of the industrial trend in New York State, not only in chemicals not elsewhere classified, but also in other manufacturing industries, a comparison may be made of the extent of concentration of specific industries in New York State and in the Buffalo Industrial Area, between 1929 and 1937. The relative change in the New York State's percentage share of total value added in each industry, will show the variation in the extent of concentration in New York in 1937 over 1929. This is done in tables 21 and 22.

A few examples will clarify the meaning of these tables. In 1929 New York State had 25.6 percent of the national total value added by manufacture in chemicals not elsewhere classified. In 1937 it had only 19.9 percent. This indicates a 22.2 percent decline in relative concentration. In 1929 the Buffalo Industrial Area had 12.8 percent of the national total value added by manufacture in this industry. In 1937 it had only 10.9 percent—a decline in relative concentration of 15 percent.

TABLE 21

Changes in degree of concentration of manufacturing industries in New York State, 1929 and 1937

[*Indicates combined industries to make 1929 and 1937 classifications comparable]

Industries	Relative increase, 1937 over 1929, in New York State's percentage share of total United States value added	Industries	Relative increase, 1937 over 1929, in New York State's percentage share of total United States value added
	<i>Percent</i>		<i>Percent</i>
Blacking, stains and dressings.....	135.0	Gloves and mittens, cloth or cloth and leather combined.....	3.0
Needles, pins, hooks, and eyes, etc.....	130.0	Brushes.....	2.8
Springs, steel.....	109.0	Cutlery and edge tools.....	2.5
Textile machinery.....	89.0	Macaroni.....	2.0
Engines, turbines, etc.....	81.0	Carbon paper and inked ribbons.....	1.9
Surgical and orthopedic appliances.....	80.5	Lumber and timber products.....	0.0
Woolen goods.....	58.9	Baskets and rattan and willow ware.....	0.0
Blast-furnace products.....	52.3	Sausage, etc.....	-0.8
Processed waste.....	47.8	Lace goods.....	-1.5
Pumps and pumping equipment.....	43.0	Wall paper.....	-1.6
Wire, drawn from purchased rods.....	41.1	Mirrors and picture frames.....	-2.5
Screw-machine products and wood screws.....	37.9	Clocks, watches, etc.....	-3.0
Cash registers, adding and calculating machines, etc.....	37.0	Compressed and liquefied gases.....	-3.2
Instruments and apparatus, professional, scientific, commercial, and industrial.....	33.4	Wirework, n. e. c.....	-3.5
Petroleum refining.....	33.3	Electrical machinery, apparatus, and supplies (including radio).....	-3.5
Scales and balances.....	32.1	Lithographing.....	-4.2
Feeds, prepared for animals and fowls.....	30.2	Printing and publishing, newspaper and periodicals.....	-4.2
Drugs and medicines.....	28.9	Bags, paper.....	-4.2
Grease and tallow.....	26.9	Electroplating.....	-4.5
Carpets and rugs, wool (other than rag).....	26.8	Furnishing goods, men's.....	-4.7
Artificial and preserved flowers.....	26.5	Candles.....	-6.2
Steel works and rolling mills.....	25.5	Steam and other packing, etc.....	-6.8
Silverware and plated ware.....	23.0	Nonferrous metal alloys; nonferrous metal products except aluminum, not elsewhere classified.....	-7.4
Watchcases.....	20.8	Engraving, steel, copperplate, etc.....	-7.4
Ice cream.....	20.4	Roofing.....	-7.6
Card cutting and designing.....	19.6	Boot and shoe cut stock and findings.....	-8.0
Glue and gelatine.....	19.2	Cleaning and polishing preparations.....	-8.8
Pottery.....	19.0	Flavoring extracts, flavoring sirups, etc.....	-9.0
Leather goods, n. e. c.....	18.9	Millinery.....	-9.3
Fertilizers.....	18.2	Boxes, wooden, except cigar boxes.....	-9.6
Motorcycles, bicycles, and parts.....	17.6	Plumbers' supplies.....	-10.0
Signs and advertising novelties.....	17.0	Confectionery.....	-10.1
Cordage and twines.....	14.5	Canned and dried fruits.....	-10.4
Musical instruments: Pianos.....	14.1	Hand stamps, etc.....	-10.5
Fur goods.....	12.2	*Cotton manufactures.....	-10.5
Leads and related products.....	11.5	Galvanizing and other coating.....	-11.0
Rubber goods (other than tires, inner tubes, and boots and shoes).....	10.8	Trunks, suitcases, brief cases, etc.....	-11.3
Buttons.....	11.0	Paper goods, n. e. c.....	-11.4
*Embroideries.....	10.2	Printing and publishing, book, music, and job.....	-11.8
Flour and other grain-mill products.....	10.1	Bread and other bakery products.....	-11.8
Hair work.....	9.5	Mattresses and bedsprings, not elsewhere classified.....	-12.4
*Worsted goods.....	9.2	Structural and ornamental metal work.....	-13.0
Leather, tanned, curried, and finished.....	9.0	Glass.....	-13.1
Corsets and allied garments.....	8.7	Ice, manufactured.....	-13.1
Clothing, work, men's.....	8.5	Tools, not including edge tools, machine tools, files, or saws.....	-13.2
Photoengraving.....	7.8	Jewelry and jewelers' findings.....	-13.6
Cereal preparations.....	7.5	Hat and cap materials.....	-13.6
Models and patterns.....	7.1	Stereotyping.....	-14.1
Envelopes.....	5.9	Leather gloves.....	-14.4
Feathers, plumes, and manufactures thereof.....	5.8	Condensed and evaporated milk.....	-14.5
Machine-tool accessories.....	5.0	Boots and shoes, other than rubber.....	-14.9
Chocolate and cocoa products.....	4.5		
Coke-oven products.....	4.0		
Jewelry and instrument cases.....	3.2		

TABLE 21—Continued

[*Indicates combined industries to make 1929 and 1937 classifications comparable]

Industries	Relative increase, 1937 over 1929, in New York State's percentage share of total United States value added	Industries	Relative increase, 1937 over 1929, in New York State's percentage share of total United States value added.
	<i>Percent</i>		<i>Percent</i>
Paper.....	-15.5	Doors, shutters, and window sash, etc., metal.....	-27.4
Tin cans and other tinware.....	-15.6	Cork products.....	-27.6
Concrete products.....	-15.7	Shipbuilding.....	-27.7
Furniture, including store and office fixtures.....	-15.8	Knitted underwear.....	-27.8
<i>All manufacturing industries.....</i>	<i>-16.0</i>	Meat packing, wholesale.....	-27.8
Lighting equipment.....	-16.0	Pipes, tobacco.....	-28.0
Ink, printing.....	-16.9	Wood, turned and shaped.....	-28.2
*Dyeing and finishing textiles.....	-17.1	Sugar refining, cane.....	-28.8
Soap.....	-17.4	Hardware.....	-29.0
Bags, other than paper.....	-17.4	Stamped and pressed metal products; enameling, etc.....	-29.8
Umbrellas.....	-17.6	Caskets, coffins, etc.....	-30.8
Hosiery.....	-18.0	Awnings, tents, sails, and canvas covers.....	-31.0
Knitted outerwear.....	-18.2	Dentists' equipment and supplies.....	-31.2
Hats and caps, except felt and straw, men's.....	-18.6	Sheet-metal work.....	-31.3
Sporting and athletic goods.....	-18.7	Cement.....	-31.7
*Foundry and machine-shop products.....	-19.0	Furs, dressed.....	-32.5
*Women's clothing.....	-19.5	*Wallboard and plaster (including gypsum products).....	-33.7
Machine tools.....	-20.2	Canned and cured fish.....	-34.6
Food preparations, n. e. c.....	-20.6	Motor-vehicle bodies and motor-vehicle parts.....	-34.7
Flags, banners, etc.....	-20.7	Planing-mill products.....	-35.6
Boxes, paper, n. e. c.....	-20.7	Handbags and purses, women's.....	-36.4
Cheese.....	-21.0	Forgings, iron and steel.....	-37.0
Suspenders, garters, and other elastic woven goods.....	-21.0	Bookbinding and blank-book making.....	-37.0
Hats, straw, men's.....	-21.0	Heating and cooking apparatus.....	-37.6
Engraving (other than steel, etc.).....	-21.4	Perfumes, cosmetics, and other toilet preparations.....	-40.1
Marble, granite, slate, and other stone.....	-22.0	Pulp (wood and other fiber).....	-40.2
Clay products.....	-22.0	Shirts.....	-43.4
Handkerchiefs.....	-22.1	Aircraft and parts.....	-47.8
Chemicals, n. e. c.....	-22.2	Paving materials.....	-50.2
*House-furnishings.....	-22.5	Beverages, nonalcoholic.....	-50.4
Oil, cake and meal, linseed.....	-23.0	Malt.....	-50.4
Toys, etc.....	-23.7	Mirrors and other glass products.....	-50.4
Window shades and fixtures.....	-24.2	Agricultural implements.....	-53.6
*Clothing, men's, youths' and boys', n. e. c.....	-24.6	Minerals and earths, ground or otherwise treated.....	-75.6
Paints and varnishes.....	-24.7		
Hats, fur felt.....	-25.6		

SOURCE: Census of Manufactures, 1929 and 1937.

Referring to tables 21 and 22, certain industries markedly increased their degree of concentration in the State and in the Buffalo area. Such cases are grain-mill products, models and patterns, and machine-tool accessories.

In addition, the Buffalo area increased its share of scientific instruments, heating and cooking apparatus, printing, stereotyping, baskets, structural and ornamental metal work, sausages, concrete products, and roofing, all to a greater extent than the increased share of the area in total manufacturing. In five listed industries the Buffalo area increased its share, but to a less extent than for manufacturing as a whole. These were: Prepared feeds, drugs and medicines, clay products, motor-vehicle bodies and parts, and nonpaper bags.

TABLE 22

Changes in degree of concentration of manufacturing industries in the Buffalo Industrial Area, 1929 and 1937

Industries	Relative increase, 1937 over 1929, in Buffalo Industrial Area's percentage share of total United States value added	Industries	Relative increase, 1937 over 1929, in Buffalo Industrial Area's percentage share of total United States value added
	<i>Percent</i>		<i>Percent</i>
Instruments and apparatus, professional, scientific, commercial, and industrial	292.0	Sheet-metal work	-14.5
Heating and cooking apparatus	278.0	Toys	-14.9
Printing and publishing, book, music, and job	86.5	Chemicals, n. e. c.	-15.0
Flour and other grain-mill products	44.0	Signs and advertising novelties	-16.0
Stereotyping	40.8	Beverages, nonalcoholic	-17.0
Models and patterns	38.0	Confectionery	-18.1
Machine-tool accessories	31.0	Canned and dried fruits	-20.7
Baskets and rattan and willowware	28.7	Electrical machinery, apparatus and supplies (including radio)	-21.9
Structural and ornamental metal work	26.4	Awnings, tents, sails and canvas covers	-24.5
Sausage, etc.	25.1	Photoengraving	-26.6
Printing and publishing, newspaper and periodicals	17.0	Paper	-28.9
Concrete products	14.0	Engraving, steel	-29.2
Roofing	11.2	Electroplating	-30.5
<i>All manufacturing</i>	<i>11.0</i>	Stamped and pressed metal products; enameling, etc.	-31.0
Feeds, prepared for animals and fowls	8.3	Lithographing	-31.5
Drugs and medicines	8.1	Meat packing, wholesale	-32.0
Clay products	4.5	Leather; tanned, curried, and finished	-33.4
Motor-vehicle bodies and motor-vehicle parts	3.5	Mattresses and bedsprings, n. e. c.	-34.0
Bags, other than paper	1.0	Furniture, including store and office fixtures	-34.5
Grease and tallow	-2.5	Macaroni	-35.7
Ice, manufactured	-2.5	Forgings, iron and steel	-35.5
Bread and other bakery products	-2.9	Flavoring extracts, flavoring sirups, etc.	-39.0
Hats and caps, except felt and straw, men's	-4.0	Marble, granite, slate, and other stone	-39.6
Tools	-5.0	Paints and varnishes	-39.8
Jewelry and jewelry findings	-10.0	Pumps and pumping equipment	-42.5
		Planing-mill products	-42.6
		Leather gloves	-46.4
		Malt	-49.6

SOURCE: Census of Manufactures, 1929 and 1937.

The most important industries in which the Buffalo area's share declined are paint, steel forgings, furniture, leather, metal stampings and pressings, meat packing, paper, photoengraving, electrical machinery, chemicals, and tools. This list is particularly significant, because it is made up largely of just those industries which are particularly dependent on cheap electric power. This lends some support to the view that the competition of cheaper-power areas is already significantly affecting industrial development in New York State, and its effect is somewhat more in evidence in the Buffalo area since that area originally attracted a relatively large share of the industries using much power, because of the availability of cheap hydroelectric energy. With the exhaustion of cheap contract power, Buffalo has become less attractive to such industries, and they now seek locations in places like the Tennessee Valley and the Pacific Northwest.

CHAPTER II

ELECTRIC POWER SUPPLY IN NEW YORK STATE

The evidence in the preceding chapter proves beyond doubt that over the past decade New York State has failed to maintain its position in manufacturing industry relative to the rest of the country. This is particularly true in electroprocess industries. The same trend is noticeable in other industries not ordinarily classified as electroprocess, but in which electric energy requirements are relatively high.

What are the conditions of supply of electric energy in New York State that may have influenced this tendency? These conditions must be analyzed not only to explain their possible effect upon the trends of the past, but to permit a proper evaluation of St. Lawrence power with reference to the industrial and economic future of New York State.

Section 1

NEW YORK STATE DEPENDENCE ON STEAM POWER

Lag in Hydroelectric Development.

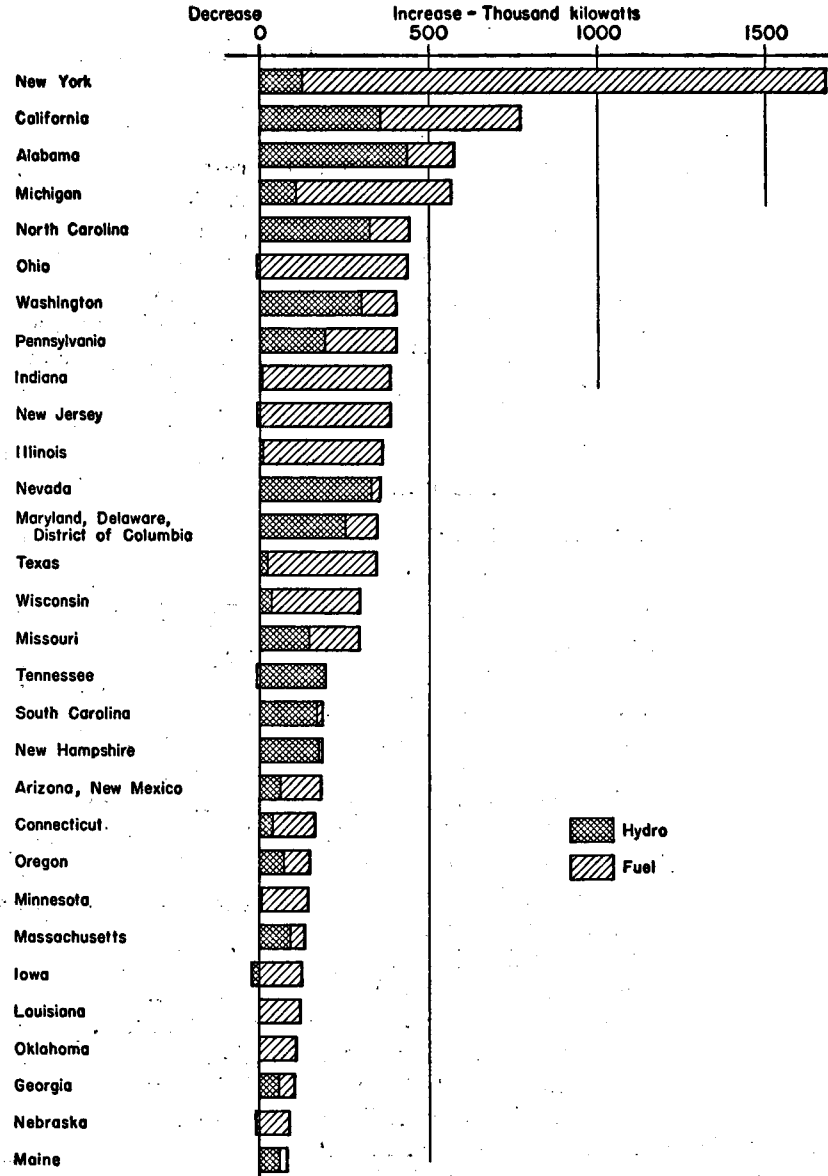
One of the significant factors in the power supply of New York State is its failure to develop hydroelectric resources. In this respect, New York appears to have lagged behind many other States, even though power load increased considerably. Table 23 and chart 8 show that between 1927 and 1937, while the generating capacity of the country as a whole increased 41 percent, that of New York State increased considerably faster (53 percent). The absolute increase in New York capacity was 1,680,000 kilowatts, constituting nearly one-sixth of the national total of capacity added in this period, and more than twice as much as the increase in any other State. However, only 123,000 kilowatts, or about 7 percent, of this New York increase was new hydro capacity; in the Nation as a whole, 37 percent of the added capacity during the period was hydroelectric.

Nor was this due to exhaustion of water-power resources. The United States Department of the Interior has estimated the State's potential hydro resources available 90 percent of the time at about 3,200,000 kilowatts, or 2.3 times the 1937 capacity of installed water-wheels in plants of 100 horsepower or more.¹

Other States are developing their hydro power resources much more rapidly than New York. The largest hydroelectric increases,

¹ National Resources Committee, *Energy Resources and National Policy* (Washington, 1936), table 1, p. 240, and table 2, p. 241.

Chart 8 - INCREASE IN GENERATOR CAPACITY OF FUEL-BURNING AND OF HYDROELECTRIC EQUIPMENT, BY SELECTED STATES, 1927-1937



Source: Table 23

WPA 3694

between 1927 and 1937, took place in Alabama, California, Nevada, North Carolina, Washington, Maryland, Pennsylvania, Tennessee, New Hampshire, South Carolina, and Missouri, each of which added more hydro capacity than New York. Only 15 States showed a smaller percentage increase in hydro capacity than New York.

TABLE 23

Increase in generator capacity of fuel-burning and of hydroelectric equipment, by States, 1927 and 1937

Figures in parentheses () indicate decrease

	Absolute increase (thousands of kw.)			Percentage increase		
	Total	Fuel-burning	Hydro-electric	Total	Fuel-burning	Hydro-electric
United States total.....	10,669.8	6,920.9	3,748.9	41.8	36.4	54.7
New York.....	1,679.8	1,556.5	123.3	53.2	-71.8	12.4
California.....	771.2	414.0	357.2	39.2	63.2	27.4
Alabama.....	573.6	138.6	434.9	164.2	131.1	178.0
Michigan.....	565.4	458.8	106.6	47.6	49.0	42.2
North Carolina.....	440.3	116.8	323.5	79.8	52.4	98.3
Ohio.....	436.2	440.3	(4.1)	25.0	25.5	(25.5)
Washington.....	402.3	104.6	297.7	66.6	104.2	59.2
Pennsylvania.....	402.1	211.1	191.0	15.9	9.1	94.2
Indiana.....	385.3	384.8	.5	59.0	62.2	1.4
New Jersey.....	383.0	385.9	(2.9)	56.0	56.9	(54.7)
Illinois.....	361.1	353.9	7.1	17.7	17.7	17.6
Maryland, Delaware, District of Columbia ¹	346.6	95.3	251.2	69.4	19.9	1,240.7
Nevada.....	355.0	26.5	328.5	2,811.8	1,440.5	3,055.4
Texas.....	343.9	322.9	21.0	55.3	53.0	172.1
Wisconsin.....	295.9	262.1	33.8	47.4	62.8	16.3
Missouri.....	293.5	148.7	144.8	62.1	32.3	1,167.7
Tennessee.....	188.0	(2.7)	190.7	55.6	(1.2)	149.7
South Carolina.....	184.5	16.3	168.2	37.6	13.4	45.5
New Hampshire.....	183.4	10.2	173.2	158.8	19.7	272.9
Arizona, New Mexico ¹	180.9	120.4	60.5	145.0	179.2	89.5
Connecticut.....	163.0	125.3	37.7	39.4	34.9	67.1
Oregon.....	148.1	76.4	71.7	45.9	73.1	60.5
Minnesota.....	143.6	141.9	1.7	38.5	56.9	1.3
Massachusetts.....	133.0	42.7	90.3	12.3	4.5	70.8
Iowa.....	125.6	145.8	(20.2)	26.1	44.3	(13.2)
Louisiana.....	120.3	120.3	.....	58.0	.....	.....
Oklahoma.....	108.7	108.7	.....	47.8	47.8	.....
Georgia.....	103.7	45.2	58.5	27.3	46.5	20.7
Nebraska.....	89.0	91.4	(2.4)	49.2	55.0	(16.7)
Maine.....	80.5	19.8	60.7	44.8	52.5	42.8
Florida.....	79.9	71.0	8.9	27.3	24.7	159.9
Virginia.....	74.5	54.3	20.2	20.4	18.9	26.2
West Virginia.....	74.4	30.2	44.2	13.2	5.9	77.8
Rhode Island, Vermont ¹	68.5	33.1	35.4	20.4	16.0	27.3
Arkansas.....	66.4	10.0	56.4	70.0	18.2	554.0
Kansas.....	60.7	63.8	(3.1)	16.9	18.3	(30.9)
Idaho.....	51.9	1.1	50.8	24.9	30.6	24.9
Kentucky.....	45.0	42.9	2.1	15.1	22.0	2.0
North Dakota.....	37.1	37.1	.....	102.8	102.8	.....
Colorado.....	28.9	17.6	11.3	14.5	12.1	21.1
South Dakota.....	28.4	28.0	.4	59.0	63.8	9.3
Wyoming.....	28.4	14.2	14.2	81.8	43.8	617.3
Utah.....	27.7	31.7	4.0	20.9	85.4	4.2
Montana.....	9.0	2.1	6.9	3.4	21.4	2.7
Mississippi.....	1.5	1.5	.....	2.3	2.3	.....

¹ Combined to avoid disclosure of individual establishments.

SOURCE: Census of Electrical Industries, *Electric Light and Power Industry, 1927 and 1937.*

TABLE 24

Capacity of all central electric stations in the Buffalo Industrial Area, 1927-39 (rated horsepower of engines and turbines)

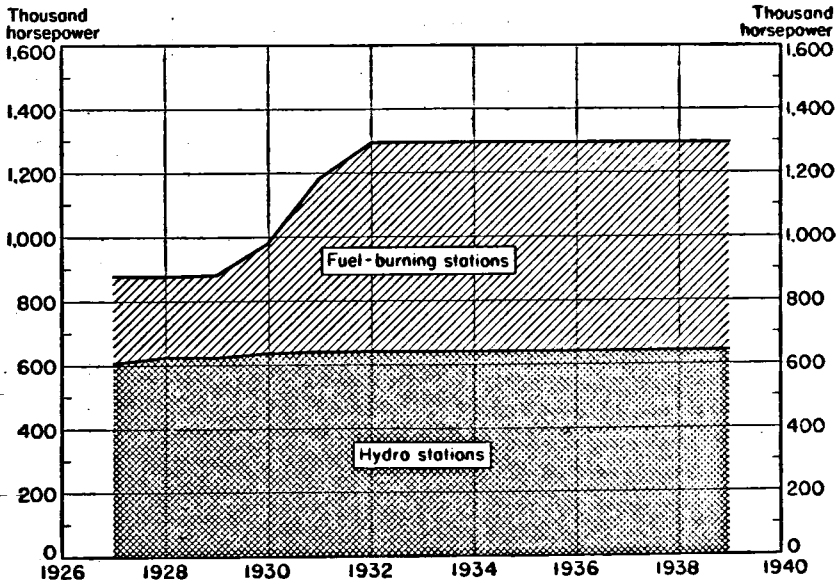
[Figures in parentheses indicate decrease]

Year	Capacity reported			Increase from previous year		
	Fuel-burning	Hydro-electric	Total	Fuel-burning	Hydro-electric	Total
1927	272,253	606,886	879,139			
1928	253,955	624,710	878,665	(18,298)	17,824	(474)
1929	258,673	623,190	881,763	4,618	(1,520)	3,098
1930	340,465	635,823	976,288	87,822	12,633	100,455
1931	547,786	640,163	1,187,949	201,321	4,340	205,661
1932	655,406	640,163	1,295,569	107,620		107,620
1933	655,906	640,292	1,296,198	500	129	629
1934	655,896	640,292	1,296,188			(10)
1935	655,896	640,232	1,296,128	(10)		(60)
1936	655,896	640,185	1,296,081		(60)	(47)
1937	655,324	639,968	1,295,292	(572)	(217)	(789)
1938	655,324	639,758	1,295,082		(210)	(210)

Source: Compiled from annual issues of the McGraw Central Station Directory. In recent years the Buffalo-Niagara Electric Corporation capacity has been given in kilowatts, but erroneously stated as "horsepower" in the directory. This obvious error has been corrected in the present table. A certain amount of obsolete capacity is probably included in the totals.

There was a considerable expansion in total generating capacity in the Buffalo area up to 1932, but virtually all of the increase has been in fuel plants. This appears clearly in table 24 and chart 9. In 1927,

Chart 9 - ELECTRIC GENERATING CAPACITY IN THE BUFFALO INDUSTRIAL AREA, 1927-1939



Source: Table 24

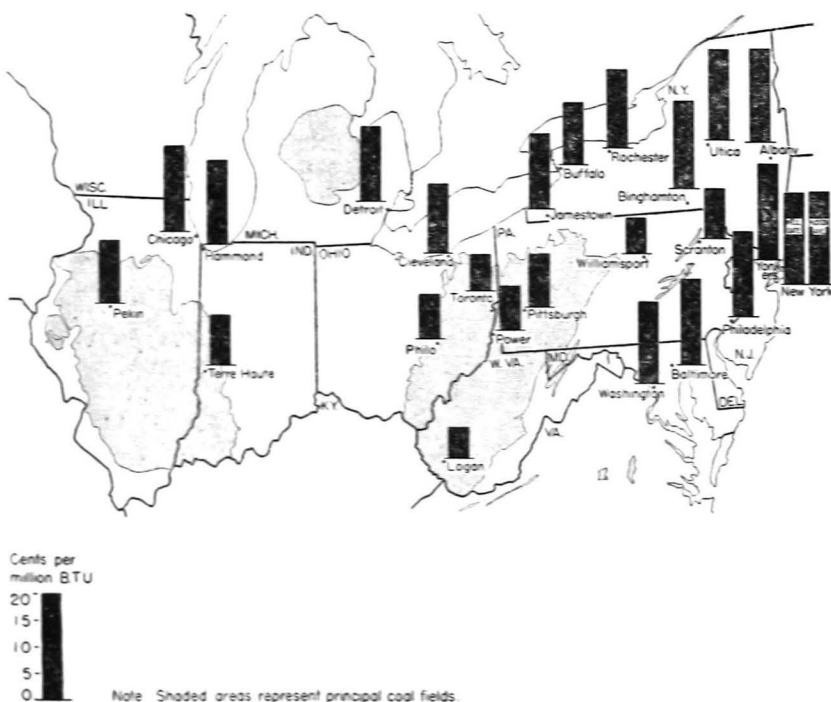
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the rated physical capacity of hydro plants in the area was 606,886 horsepower, which increased to 640,163 horsepower in 1931 and has remained at almost exactly the same level since. Fuel-plant capacity in the Buffalo area, on the other hand, starting at 272,253 horsepower in 1927, increased to 655,906 horsepower (a 141 percent increase) by 1933, and has remained at substantially that level since. A major part of the expansion in steam generating capacity is accounted for by the Huntley No. 2 station at Buffalo.

High Cost of Fuel.

The average cost of electric energy naturally continues to be markedly lower in the Buffalo area than in any other industrial area of the State. This is due partly to Niagara hydro power. In the matter of steam-generated power, however, New York State and the Buffalo area have no advantages. The Huntley No. 2 steam station in Buffalo paid 11.64 cents per million B. t. u. for its fuel in 1937, as compared with representative central-station fuel costs of 14.6 cents in Rochester

Chart 10 - FUEL PRICES AT SELECTED ELECTRIC GENERATING STATIONS 1937



Source Table 25

and well over 17 cents in New York City, Yonkers, and Albany.² These high fuel costs are due, of course, to distances from sources of fuel. A glance at table 25 and chart 10 shows the way in which fuel costs rapidly increase with distance from the coal fields. In the West Virginia coal areas, power stations pay even below 6 cents per million B. t. u.; in Terre Haute, 9 cents; in Buffalo, nearly 12 cents, or about twice as much as at the Logan, West Virginia, station.

TABLE 25
Comparative fuel costs at selected electric generating stations, 1937

City	Plant	Cents per million B. t. u.	City	Plant	Cents per million B. t. u.
Yonkers, N. Y.	Glenwood	17.93	Detroit, Mich.	Connors Creek	14.00
Albany, N. Y.	Riverside	17.43	Cleveland, Ohio	Lake Shore	12.90
New York, N. Y.	Hudson Avenue	17.27	Pekin, Ill.	Powerton	11.80
New York, N. Y.	Hell Gate	17.07	Buffalo, N. Y.	Huntley No. 2	11.64
Utica, N. Y.	Harbor Point	17.00	Pittsburgh, Pa.	Reed	10.00
Binghamton, N. Y.	Westover	16.40	Scranton, Pa.	Suburban	9.36
Baltimore, Md.	Gould Street	16.11	Terre Haute, Ind.	Dresser	9.33
Chicago, Ill.	Crawford	16.00	Philo, Ohio	Philo	8.38
Philadelphia, Pa.	Schuylkill	15.90	Power, W. Va.	Windsor	8.30
Hammond, Ind.	State Line	15.67	Toronto, Ohio	Toronto	6.90
Washington, D. C.	Buzzards Point	15.30	Williamsport, Pa.	Williamsport	6.88
Rochester, N. Y.	Station No. 9	14.60	Logan, W. Va.	Logan	5.83
Jamestown, N. Y.	Steele Street	14.03			

Source: Federal Power Commission.

Although New York State has been meeting growing load requirements primarily by adding new steam capacity, even in the Buffalo-Niagara area, the State is practically devoid of any natural fuel supplies and so must remain at a competitive disadvantage in steam-power production. Table 26 shows the importance of the five chief power-consuming States in mineral fuel production, and strikingly

TABLE 26
The five leading power-consuming States and their production of mineral fuels, 1937 (all figures in percentages of United States total)

	New York	Pennsylvania	California	Ohio	Illinois
Electricity generated in central stations	12.9	8.7	7.9	6.7	6.6
Fuels:					
Bituminous coal		24.9		5.6	11.6
Anthracite coal		100.0			
Petroleum	.4	1.5	18.6	.3	.6
Natural gas	.9	4.8	13.6	1.8	(¹)
Natural gasoline	(¹)	.7	30.2	.4	.1

¹ Less than 0.05 percent.

SOURCES: Census of Electrical Industries, *Electric Light and Power Industry*, 1937, table 24, p. 40, and *Statistical Abstract*, 1939, table 774, p. 754; table 787, p. 762; and table 781, p. 758.

² See table 25. The Huntley No. 2 station has unusually low generating costs as well as low fuel costs, since it is large and relatively new and has a capacity factor (1937) of 46 percent as compared to 23 percent for 13 major up-State steam stations. The Huntley No. 2 station required in 1937 only 14 thousand B. t. u. per net kilowatt-hour, while 11 other up-State steam stations required an average of 21 thousand. This statement is based on Federal Power Commission data given in the 1938 Annual Report of the Power Authority of the State of New York, table P-5, p. 170.

exhibits New York's deficiency in this regard.³ Whereas Pennsylvania, Ohio, and Illinois are leading coal producers and California has a surplus of oil and gas plus water power, New York is relying increasingly on expensively transported fuel as a source of electric energy.

As long as New York State will depend on sources of fuel outside the State, with attendant high costs of transportation, steam-generated electricity will cost correspondingly more than in areas nearer the mine pits.

It is true, of course, that the fuel efficiency of steam-generating equipment has been increasing for many decades. Table 27 and chart 11 show the very rapid increase in the efficiency of fuel plants in conversion of thermal into electric energy. Whereas in 1902 it required 6.4 pounds of coal to produce 1 kilowatt-hour of energy, 3.04 pounds sufficed in 1920, 1.62 pounds in 1930, and 1.44 pounds in 1937. This was the average experience in the country as a whole; there are steam plants of the most modern type which consume less than 1 pound of coal per kilowatt-hour. This progress has brought modern steam turbines so close to the absolute theoretical maximum of conversion efficiency that recent gains have been at a rapidly decreasing rate, and little further improvement is in sight without radical new developments in boilers or the replacement of steam by some better transfer medium. Further gains in efficiency, for either steam plants or hydro plants, are limited, and most of the prospective reduction in costs is likely to arise from bringing old and inefficient plants up to the standards now set by the better plants.

TABLE 27

Average consumption of coal per kilowatt-hour of generated electricity in public-utility power plants in the United States, 1902-37¹

Year	Coal per kwh. ²	Year	Coal per kwh. ²
	Pounds		Pounds
1902	6.4	1927	1.84
1907	5.4	1928	1.76
1912	4.5	1929	1.69
1917	3.47	1930	1.62
1919	3.22	1931	1.55
1920	3.04	1932	1.50
1921	2.73	1933	1.47
1922	2.51	1934	1.47
1923	2.41	1935	1.46
1924	2.22	1936	1.45
1925	2.07	1937	1.44
1926	1.95		

¹ Figures for 1902-17 from a special study by F. G. Tryon for the Brookings Institution, published in *Transactions, Second World Power Conference*, Berlin, 1930, Vol. VI, pp. 244, 245; those for 1919 to 1935, from A. H. Horton, *Division of Power Resources*, U. S. Geological Survey; those from 1936 and 1937 from Bureau of Mines, *Minerals Yearbook*, 1938, p. 692.

² Includes coal equivalent of oil, gas, and wood.

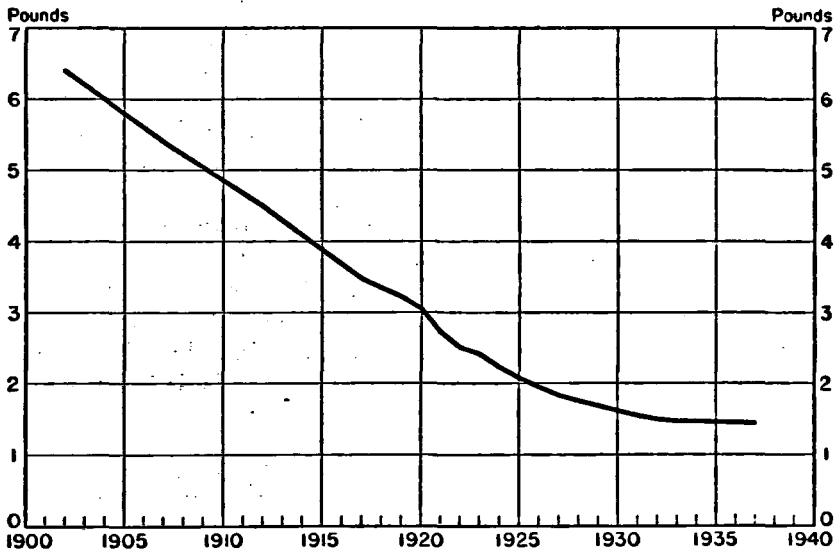
SOURCE: National Resources Committee, *Energy Resources and National Policy*, 1939, p. 375.

³ Cf. D. H. Newland and C. A. Hartnagel, "The Mining and Quarry Industries of New York State for 1934 to 1936," *New York State Museum Bulletin*, No. 319, Feb. 1939, p. 28: "The absence of workable coal seams is perhaps the principal deficiency in New York's mineral endowment."

Insofar as differences in steam generating costs are traceable to differences in fuel costs, they will decrease as less and less fuel is required. This will mean a lessening of New York State's present generating-cost disadvantage as compared with, say, Pennsylvania or central Illinois. It will not mean, however, that this disadvantage will disappear. As long as coal must be used, even a reduced amount of it for an equivalent quantity of electric power, the higher transportation cost to New York over other areas will maintain a condition of relative disadvantage.

Chart 11—FUEL EFFICIENCY IN STEAM POWER GENERATING STATIONS, 1902-1937

COAL CONSUMED PER KILOWATT HOUR GENERATED



Source: Table 27

WPA 3697

The importance of this disadvantage as reflected in costs to consumers is enhanced to the extent that industry uses more and more power per dollar's worth of output. This point is borne out by past experience. For instance, between 1929 and 1937, the coal requirements per kilowatt-hour declined from 1.69 pounds to 1.44 pounds (table 27), but the average New York State manufacturer's energy purchases per dollar's worth of manufactured product rose from 0.69 kilowatt-hour to 0.95 kilowatt-hour. In other words, in 1929, the amount of coal burned in order to generate the electricity bought by the manufacturer to make a dollar's worth of product was 1.69×0.69 , or 1.17 pounds; in 1937 it was 1.44×0.95 , or 1.37 pounds. Evidently the indirect importance of a coal-price differential to the industrial purchaser of power has increased, despite economies at the power house.

Section 2

COMPARISON OF ELECTRIC RATES IN NEW YORK STATE AND ELSEWHERE

Electric energy rates in New York State seem to be higher than the national average. This is shown in the Federal Power Commission's report on average electric bills in 1939 for 12 different types of service, by States. These are presented in table 28 and charts 12, 13, 14,

TABLE 28

Power rates according to typical monthly bills, 1939, New York State and the United States

Class and unit of service (kwh.)	Average rate per kwh			New York rank among States ¹	6 States with lowest average rates	
	United States	New York	New York as percent of United States			
	<i>Cents</i>	<i>Cents</i>	<i>Percent</i>			
Residential {	25-----	6.12	6.49	106.0	25	Tenn., Ala., Ohio, Md., Wash., Calif.
	100-----	4.22	4.57	108.3	27	Tenn., Mich., Wash., Calif., Ala., Oreg.
	250-----	3.04	3.16	103.9	25	Tenn., Calif., Wash., Ala., Oreg., Mich.
Commercial light {	50-----	5.72	6.31	110.3	30	Tenn., Calif., Wash., Mich., Ohio, Md.
	375-----	4.47	4.95	110.7	27	Calif., Wash., Tenn., Ohio, Md., Mo.
	750-----	4.40	5.26	119.5	41	Wash., Calif., Tenn., Ohio, Ind., Md.
Commercial power {	375-----	4.19	4.71	112.4	35	Calif., Wash., Maine, Colo., Oreg., Ohio.
	1,500-----	3.72	4.56	122.5	48	Calif., N. C., Wash., Oreg., Idaho, Mont.
	6,000-----	2.81	3.72	132.4	48	Calif., Oreg., N. C., Wash., Mont., Tenn.
Industrial {	30,000-----	1.89	2.08	110.0	39	Calif., Mont., Oreg., Utah, Wash., Tenn.
	60,000-----	1.68	1.82	108.3	40	Calif., Nev., Oreg., Mont., Wash., Tenn.
	200,000-----	1.49	1.54	103.3	34	Calif., Nev., Oreg., Mont., Wash., Tenn.

¹ In order of cheapness.

SOURCE: Federal Power Commission, *Average Electric Bills, 1939*.

and 15. In 2 of the 12 classes of service (both large-scale commercial power service) in table 28, New York is actually the most expensive State in the Union. By contrast, the Pacific Northwest States and California, Tennessee, North Carolina, Alabama, Ohio, and Maryland have consistently the lowest costs. Each of these States except Ohio generates more than two-thirds of its power from water, whereas the country as a whole generates 37.8 percent from water (table 29).⁴

A still more detailed comparison, which takes some account of differences in rate levels between cities of different sizes, can be made from the same source.⁵ The average rates for each State and for the United States are there classified according to type of service (residential, commercial light, commercial power, and industrial), according to amount of monthly consumption and/or demand, and according to the population of the community served (5 size groups for resi-

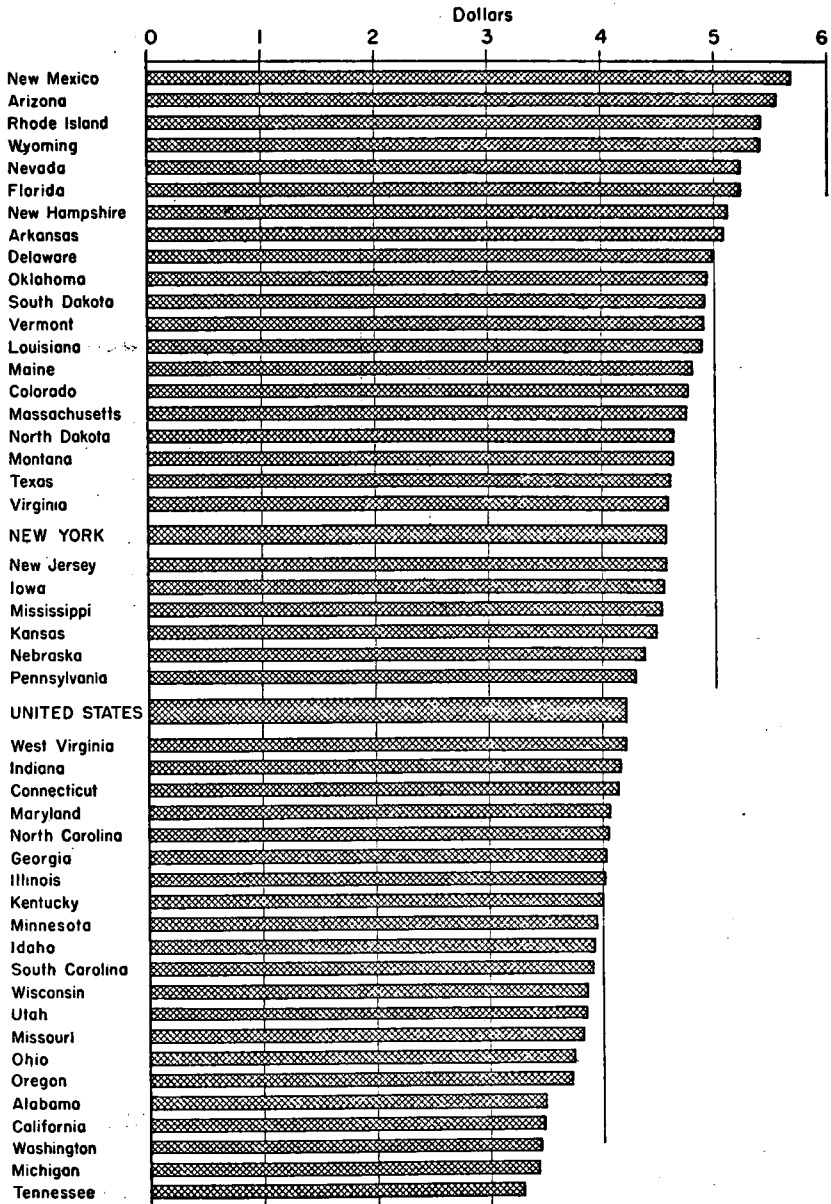
⁴ The different sections of New York State vary considerably, of course, in rate levels. The Buffalo area has rates well below the State average, while in New York City and its environs, rates are very high. Table 45 below gives some idea of this range of variation so far as residential service is concerned.

⁵ Federal Power Commission, *Average Electric Bills, 1939*, appendix, table 1, pp. 44-47.

Chart 12 - AVERAGE MONTHLY BILLS FOR POWER ON A
100 KILOWATT - HOUR BASIS,
BY STATES.

January 1939

RESIDENTIAL SERVICES



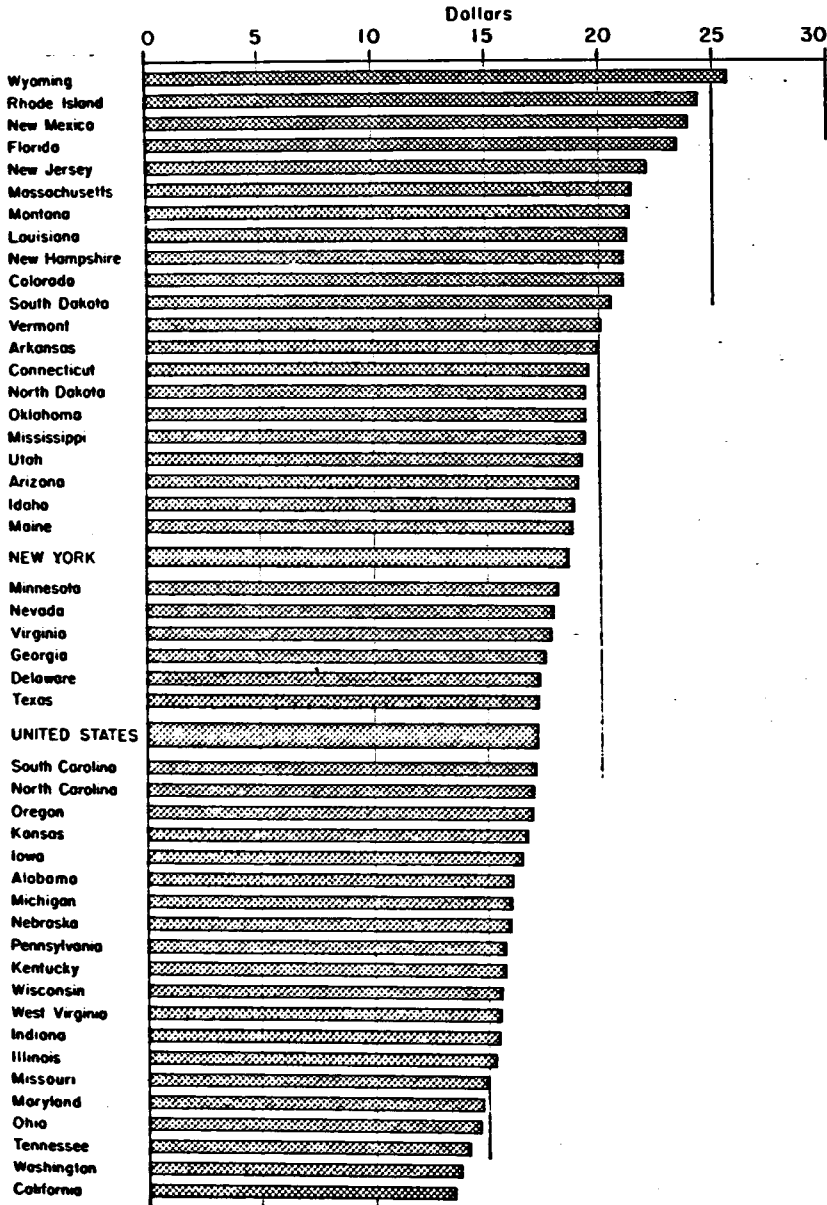
Source: Table 28

WPA 3698

Chart 13 - AVERAGE MONTHLY BILLS FOR POWER ON A 375 KILOWATT-HOUR, 3 KILOWATT DEMAND BASIS, BY STATES

January 1939

COMMERCIAL LIGHT SERVICE

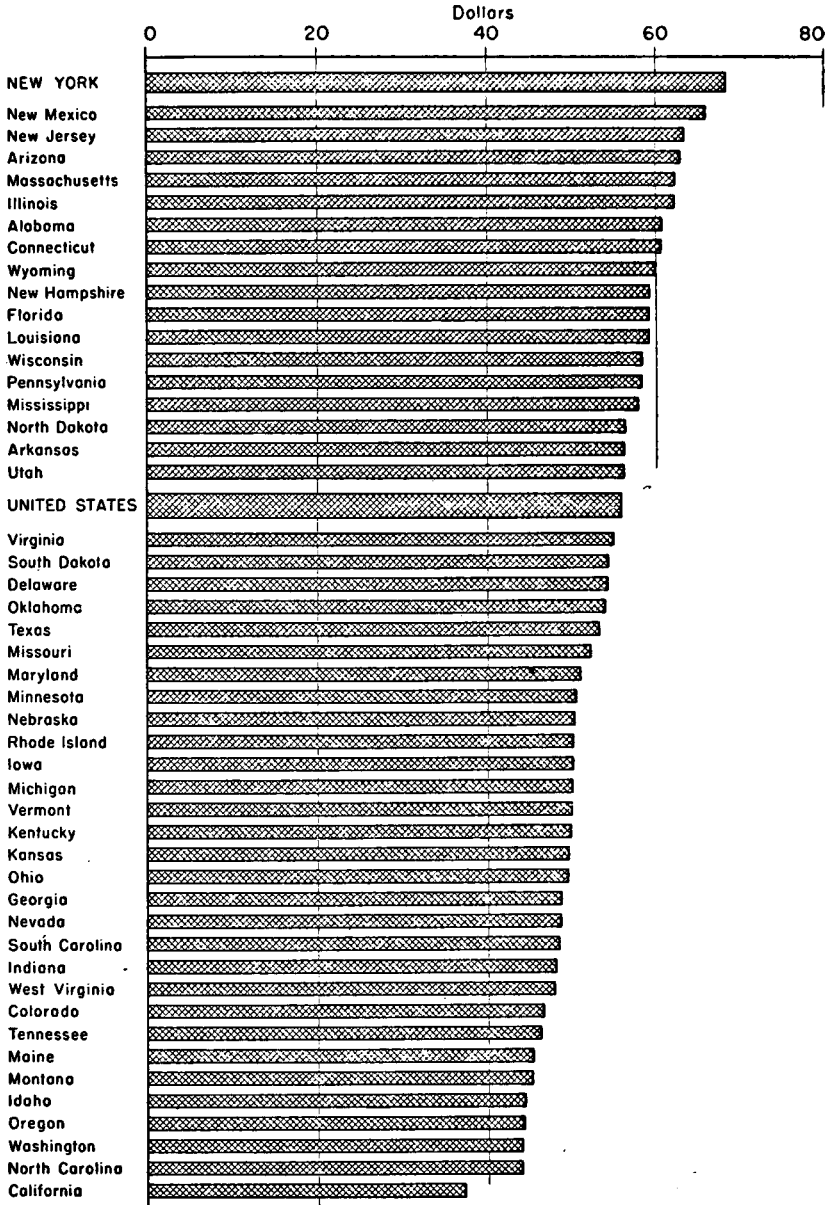


Source: Table 28

Chart 14 - AVERAGE MONTHLY BILLS FOR POWER ON A 1500
KILOWATT-HOUR, 12 KILOWATT DEMAND BASIS,
BY STATES

January 1939

COMMERCIAL POWER SERVICE

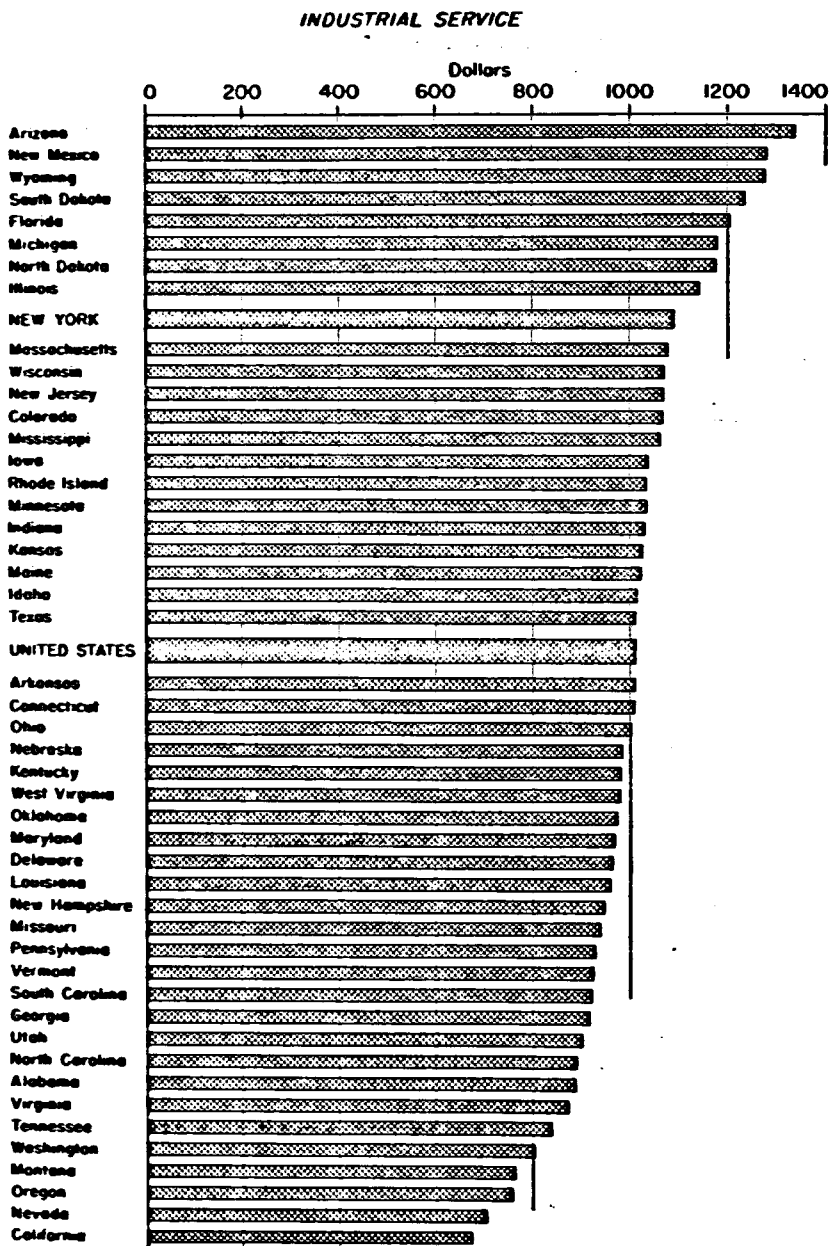


Source: Table 28

WPA 3700

Chart 15 - AVERAGE MONTHLY BILLS FOR POWER ON A 60,000 KILOWATT-HOUR, 300 KILOWATT DEMAND BASIS, BY STATES

January 1939



dential service, 3 for commercial, and 2 for industrial). This information makes it possible to compare 39 particular kinds of rates in New York State with corresponding kinds of rates in the United States as a whole. In these 39 comparisons, the New York rate per kilowatt-hour was above the national average in 30 cases; equal to the national average in 2 cases; and below the national average in 7 cases. In 2 of the above 30 comparisons, the New York figure was the highest of any State.

The 7 comparisons in which New York State showed up favorably in relation to the national average were the following:

Class of service	Amount of energy and/or demand	Population class of communities	Percentage by which New York State average fell below national average
Residential	25 kwh	250-999	5.0
Do	100 kwh	250-999	.2
Commercial light	3 kw., 375 kwh	10,000-49,999	1.4
Do	6 kw., 750 kwh	10,000-49,999	2.7
Commercial power	30 kw., 6,000 kwh	10,000-49,999	3.7
Industrial	150 kw., 30,000 kwh	10,000-49,999	1.0
Do	1,000 kw., 200,000 kwh	10,000-49,999	.7

It is clear that New York State's only relatively favorable showing is in certain types of rates in small communities of the 250-999 and 10,000-49,999 population groups. According to the same Federal Power Commission report (table 2, p. 50), the New York State communities of these two size groups had a combined population in 1930 of only 1,377,573, or about 12.3 percent of the total population of all communities covered in the State. It is not accurate to conclude, however, that all classes of rates in such communities were lower than the national average. There were 8 other instances of rates cited by the Federal Power Commission for communities of these size groups, in 7 of which the New York State figure was higher than the national average.

It is evident from the data presented that in most classes of rates in the different population groups, the New York State average rates are higher than the corresponding national averages.

TABLE 29

Percentage of total electric current generated by hydroelectric equipment in all central stations, by States, 1937

State	Percent hydroelectric	State	Percent hydroelectric
Idaho.....	99.8	Colorado.....	32.3
Montana.....	98.3	Missouri.....	31.0
Maine.....	95.3	Wyoming.....	26.2
Nevada.....	93.6	Virginia.....	26.0
New Hampshire.....	92.6	Massachusetts.....	24.1
South Carolina.....	91.8	Connecticut.....	22.9
Washington.....	89.3	Michigan.....	22.0
Alabama.....	87.1	Pennsylvania.....	19.2
North Carolina.....	87.1	West Virginia.....	12.9
California.....	86.7	South Dakota.....	6.2
Georgia.....	79.8	Florida.....	5.3
Oregon.....	72.2	Nebraska.....	4.6
Tennessee.....	68.9	Indiana.....	4.0
Utah.....	57.9	Texas.....	3.2
Delaware, Maryland, District of Columbia ¹	54.8	Illinois.....	2.8
Vermont, Rhode Island ¹	50.6	Kansas.....	1.7
Arkansas.....	50.0	New Jersey.....	.8
Arizona, New Mexico ¹	47.0	Ohio.....	.5
New York.....	40.2	Oklahoma.....	.2
Iowa.....	38.4	North Dakota.....	.0
Kentucky.....	34.5	Mississippi.....	.0
Wisconsin.....	34.1	Louisiana.....	.0
Minnesota.....	33.7	United States average.....	37.8

¹ Combined to avoid disclosing the operations of individual establishments. The figure for Maryland alone would be much higher than 54.8, since there is little, if any, hydro capacity in Delaware or the District of Columbia. The Conowingo Dam installation in Maryland has a rated capacity of 252,000 kw. (Moody's Manual, *Public Utilities*, 1939, p. 1391) as compared with 271,385 kw. of hydrocapacity for Maryland, Delaware, and the District of Columbia combined, Census of Electrical Industries, *Electric Light and Power Industry*, 1937, table 23, p. 30.

SOURCE: Census of Electrical Industries, *Electric Light and Power Industry*, 1937, table 24, p. 40.

CHAPTER III

ESTIMATE OF ENERGY REQUIREMENTS OF NEW YORK STATE IN 1950

New York State has for many years past depended upon steam power to meet its growing needs for electricity. This, it has been shown in preceding chapters, has placed the State at a disadvantage in relation to other sections of the country where fuel and water power are available at low cost. The question to be analyzed in this chapter is whether New York State will in the near future develop a market which would justify the utilization of the St. Lawrence-Niagara power resources. This question arises particularly because of the magnitude of the power capacity of the joint project with large initial capital outlay. In the next chapter the effect of this power development upon New York State industry is analyzed.

The year 1950 is selected as the basis of estimating future requirements for electric energy because, in the first place, a hydroelectric development of the magnitude of the combined St. Lawrence-Niagara project would normally be inducted into service not all at once, but in several increments spread over a period of years. Secondly, the completion of the International Rapids Section of the combined project is usually estimated to require 6 to 7 years, if work proceeded without special haste. If pressed forward under emergency conditions, according to the Chief Engineers United States Army power can be obtained in 4 years. The installation of various generating units in the powerhouse can, of course, be staggered to meet the growth of the load. In the third place, it is desirable to take a year far enough in the future in order to allow time for the effects of cheap hydro power rates upon consumption to materialize.

A further reason for the selection of 1950 as a basis of future estimates is that several other indices which are used in the course of the following discussion have been projected by other writers to this year. This is true of Thompson-Whelpton population estimates, New York State Power Authority's estimate of energy requirements in New York and Dr. John Bauer's estimate of energy requirements in the United States.

Although 1950 is here considered as the date when the combined project may be fully developed, and its effects in evidence, assuming normal trends, it must be recognized that the national defense program, and the war abroad, have a distinctly accelerating effect upon industrial activity and demand for power. It is inevitable therefore

that if the national defense program continues, the time factor will be telescoped, and the estimates for the year 1950 made in this report will be realized much sooner. This possibility is analyzed in a subsequent report.

The task of forecasting normal trends is made particularly difficult by the fact that the State's future energy consumption and the unit costs of energy are obviously interdependent. In order to estimate the amount of energy consumed it is necessary to know the rates that will be charged—yet in order to determine costs, which are the ultimate basis of rates, the total energy requirements and load must be available. The following escape from this dilemma will be adopted:

1. Total energy consumption and load requirements as of 1950 will be estimated for the different classes of service, using the most reasonable a priori estimates of rate changes which can be accepted. In the case of residential and farm service, the objective rate schedule designed by the Power Authority of New York State will be assumed and adhered to; but for industrial and commercial service it will be necessary to make a provisional guess as to the rate change.

2. When the total energy consumption and load have been estimated for 1950 on the basis of rates as above outlined, they will be checked against other such estimates. Then the cost of generation and transmission will be determined for each class of energy sales, allocating fixed and variable costs on the basis of class demands.

3. The revenues obtained from residential and farm sales under the Power Authority's objective rate schedules will then be calculated, and deducted from the total costs of the system in order to determine how much cost must be covered by revenues from the other types of service.

4. The average rate levels required to make the estimated non-residential sales cover their allocated costs will then be checked back against the rate levels that were provisionally assumed for these types of service. This will indicate whether or not the estimated total energy output can be marketed at rates that will cover its costs.

Section 1

ANALYSIS OF 1937 ENERGY SALES

Since many of the most recent available statistics (including the Census of Manufactures) are for 1937, it is convenient to use that year as a base, and to analyze the various factors of the situation in terms of the percentage of increase between 1937 and 1950.

The various classes of energy consumption differ widely in their characteristics. It is not justifiable to assume that a certain expected rate of population increase will lead to the same increase in industrial or commercial as in residential consumption, nor that the effects of

prospective trends in rates will be uniform as between classes of service. Consequently, it is necessary to estimate the probable 1937-50 increase in sales for each class of service separately, and then recombine these class estimates to obtain the probable increase in total sales.

The first step is to break down New York State's 1937 energy sales into classes: Domestic, farm, industrial, commercial, and other. Table 30 shows the number of ultimate consumers of each class reported to the 1937 Census by New York State utilities, and table 31 shows, in less detail and mainly for private utilities alone, the Census breakdown of sales to ultimate consumers.

The State figures on energy sales and revenue are classified only for privately owned electric utilities. It happens, however, that private utilities do practically all of the business in New York State. As tables 30 and 31 show, they served 97.9 percent of the customers, sold 99 percent of the power and collected 98.7 percent of the revenue.

The following condensation of table 31, therefore, tells substantially the whole story of sales by private utilities:

Class of service	1937 sales by private utilities	
	Millions of kwh.	Percent of total
Nonfarm commercial and industrial.....	9,828	69.5
Nonfarm residential.....	2,021	14.3
Farm (commercial and residential).....	86	0.6
All other.....	2,205	15.6
Total.....	14,139	100.0

TABLE 30

Ultimate consumers served by New York State electric utilities, by class of service, 1937

Class of service	Number of consumers		Private, percent of total
	All utilities	Private utilities	
Residential:			
Farm.....	49,950	46,228	92.5
Nonfarm.....	3,146,258	3,064,552	98.0
Commercial and industrial:			
Farm.....	39,882	38,849	97.4
Nonfarm.....	602,799	590,232	97.9
Public street and highway lighting.....	1,690	1,627	96.3
Other sales to public authorities.....	3,038		
Railroads and railways.....	54	2,976	91.2
Interdepartmental.....	84		
Other.....	87		
Total.....	3,843,842	3,764,464	97.9
Total sales (kwh.).....	14,288,378,744	14,138,740,669	98.9
Total revenue.....	\$317,469,290	\$313,224,535	98.7

¹ Sales to ultimate consumers by private and municipal utilities, which together accounted for all but 20 of the 3,843,842 ultimate consumers.

SOURCE: Census of Electrical Industries, *Electric Light and Power Industry*, 1937, table 20, p. 34, and table 39, pp. 62-66.

TABLE 31

Electricity sales in New York State by private and municipal utilities, 1937

Class of service	Sales to ultimate consumers (millions of kwh.)			Private as percent of total
	Private	Municipal	Total	
All classes.....	14,139	150	14,288	99.0
Residential or domestic.....	2,070	(¹)	(¹)	(¹)
Farm.....	50	(¹)	(¹)	(¹)
Nonfarm.....	2,021	44	2,065	97.9
Commercial and industrial.....	9,865	(¹)	(¹)	(¹)
Farm.....	37	(¹)	(¹)	(¹)
Nonfarm.....	9,828	75	9,904	99.2
Street and highway lighting.....	312	10	322	96.8
All other ²	1,892	(²)	(²)	(²)

¹ Data withheld to avoid disclosure of individual operations.

² Includes sales to "Street and interurban railways," "Electrified steam-railroad divisions," "Inter-departmental," "Other sales to public authorities," and "Other sales to ultimate consumers," not reported separately by States.

SOURCE: Census of Electrical Industries, *Electric Light and Power Industry*, 1937, tables 39-40, pp. 62-72.

Roughly, 70 percent of all power sales in the state were made to nonfarm commercial and industrial customers. A division between sales to manufacturing and to nonmanufacturing enterprises can be obtained by the use of the following Census data on purchases of electric energy by New York State manufacturing enterprises in 1937:¹

Electric energy purchased	Millions of kwh.	Cost
Total.....	(¹)	\$57,346,183
Reported by both quantity and cost.....	6,964	55,374,784
Reported by cost only.....	(¹)	1,971,399

¹ No data.

The average cost of the energy reported by both quantity and cost was 7.95 mills per kilowatt-hour. Applying this unit cost to the \$1,971,399 worth of energy reported by cost only, gives 248 million kilowatt-hours to add to the 6,964 million reported specifically by quantity. This yields 7,212 million kilowatt-hours as the probable total energy purchases by New York State manufacturers.

The high-load-factor² electroprocess industries at Niagara and Massena should be considered separately, since their future growth in the State hinges upon the St. Lawrence project to a much greater extent than does the growth of industry in general. Energy sales to

¹ *Census of Manufactures*, 1937, table 2, p. 1670.

² The most important characteristic of the energy requirement of the electroprocess industries as a group is its relative uniformity, which is expressed in the "load factor." The annual load factor is the ratio of the actual consumption of energy in a year to the consumption that would result if the peak demand were maintained day and night throughout the year. Since there are 8,760 hours in a year, the load factor is calculated by dividing the year's output in kilowatt-hours by 8,760 times the number of kilowatts of peak demand.

these industries in New York State is not precisely known, and varies rather widely from one year to another, but is believed to be about 2 billion kilowatt-hours annually at present. The Federal Power Commission gives the total 1938 output of the Niagara Falls Power Company as 2.1 billion kilowatt-hours, of which "about half" (*i. e.*, slightly over 1 billion) was used by electroprocess industries in the Niagara area.³ At Massena, the St. Lawrence River Power Co. generated 490 million kilowatt-hours for the Aluminum Company of America and imported an additional 470 million kilowatt-hours from Canada for the same customer.⁴ Adding the Niagara and Massena figures, we reach an approximate total of 2 billion kilowatt-hours annually.

The break-down of 1937 sales may now be expanded as follows:

	Millions of kwh.	Percent of total
Industrial (other than high-load-factor).....	5,212	36.9
Nonfarm commercial.....	2,616	18.5
Nonfarm residential.....	2,021	14.3
High-load-factor industries.....	2,000	14.1
Farm (commercial and residential).....	86	.6
All other.....	2,205	15.6
Total.....	14,140	100.0

The six classes of sales tabulated above may henceforth be referred to simply as Industrial, Commercial, Residential, High-Load-Factor,

TABLE 32

Electricity sales in the United States by class of ultimate consumers, 1926-39

[Millions of kilowatt-hours]

Year	Total	Farm	Residential	Commercial		All other ¹
				Small	Large	
1926.....	56,089	723	6,727	9,485	31,993	7,161
1927.....	61,251	861	7,538	10,766	34,539	7,547
1928.....	66,986	1,387	8,420	11,692	37,715	7,774
1929.....	75,294	1,602	9,526	13,106	42,971	8,039
1930.....	74,906	1,789	10,702	13,944	40,148	8,323
1931.....	71,902	1,879	11,373	13,544	36,937	8,169
1932.....	63,711	1,579	11,494	12,106	30,964	7,568
1933.....	65,916	1,633	11,359	11,589	33,857	7,478
1934.....	71,062	1,857	12,233	12,278	36,944	7,770
1935.....	77,596	1,692	13,496	13,588	40,865	7,955
1936.....	90,044	2,138	14,992	15,612	48,655	8,647
1937.....	99,546	2,389	16,875	17,558	53,546	9,178
1938.....	93,894	2,528	18,461	18,316	44,900	9,689
1939.....	107,000	3,320	19,820	19,900	53,400	10,560

¹ Municipal street lighting, street and interurban railways, electrified divisions of steam railroads, municipal and miscellaneous.

SOURCE: Edison Electric Institute, *Statistical Bulletin No. 4* (1937) table I-b, pp. 2-3, and *Annual Statistical Bulletins*, 1938, 1939.

² This includes the output of the 41,250-kilowatt direct-current generators of the Aluminum Company of America in the Schoellkopf station, to which the Niagara Falls Power Company supplies mechanical energy.

⁴ Data supplied by the Federal Power Commission.

Farm, and Miscellaneous. An attempt will be made to forecast for each of these, as accurately as possible, the increase that can be expected by 1950. For purposes of comparison with the preceding break-down of New York State electric energy sales, and to act as a check upon final estimates of 1950 demand by classes of service, tables 32 and 33 are offered; they show sales by classes for the United States as a whole since 1926.

TABLE 33

Percentage distribution of electricity sales in the United States, by class of ultimate consumers, 1926-39.

Year	Total	Farm	Residential	Commercial		All other ¹
				Small	Large	
1926.....	100.0	1.3	12.0	16.9	57.0	12.8
1927.....	100.0	1.4	12.3	17.6	56.4	12.3
1928.....	100.0	2.1	12.6	17.5	56.3	11.5
1929.....	100.0	2.1	12.7	17.4	57.1	10.7
1930.....	100.0	2.4	14.3	18.6	53.6	11.1
1931.....	100.0	2.6	15.8	18.8	51.5	11.3
1932.....	100.0	2.5	18.0	19.0	48.6	11.9
1933.....	100.0	2.5	17.2	17.6	51.3	11.4
1934.....	100.0	2.6	17.2	17.3	52.0	10.9
1935.....	100.0	2.2	17.4	17.5	52.7	10.2
1936.....	100.0	2.4	16.7	17.3	54.0	9.6
1937.....	100.0	2.4	17.0	17.7	53.8	9.1
1938.....	100.0	2.7	19.7	19.5	47.8	10.3
1939.....	100.0	3.1	18.5	18.6	49.9	9.9

¹ Municipal street lighting, street and interurban railways, electrified divisions of steam railroads, municipal and miscellaneous.

Source: Edison Electric Institute, *Statistical Bulletin No. 4* (1937) table I-b, pp. 2-3, and *Annual Statistical Bulletins* 1938, 1939.

Section 2

GROWTH IN INDUSTRIAL SALES

The growth of energy sales to New York State industries may be due to changes in the following factors: (a) The number of industrial customers; (b) the expenditure on power by the average industrial customer; and (c) the average amount of energy furnished per dollar of expenditure.

When each of these changes has been evaluated, the final result (i. e., the expected change in total industrial energy sales) will be calculated by simple multiplication. As an example, if the number of industrial customers is expected to decrease to 85 percent of the 1937 total, and if the average customer is expected to increase his power bill to 150 percent of the 1937 average bill, the total expected expenditure on industrial power in 1950 will evidently be 85 percent times 150 percent, or 127.5 percent, of the actual 1937 expenditure. If each dollar spent is expected to buy 133.3 percent as much energy in 1950

as in 1937, the total expected energy sales in 1950 will be 127.5 percent times 133.3 percent, or 170 percent of actual 1937 sales.⁵

Number of Customers.

The number of manufacturing establishments has been gradually decreasing for many years both in New York State and in the country at large. As they become fewer they also become larger. As a result, industrial consumption of electricity per customer increases. Furthermore, decreases in number of establishments will be partly offset, as in the past, by a rising proportion of manufacturing firms buying electricity. It may be assumed that the number of manufacturing establishments in New York State will be 25,000 in 1950 as compared with 29,749 in 1937⁶ (i. e., a 16 percent decrease) and that the number of industrial power customers will fall perhaps not more than 15 percent.

Average Annual Expenditure per Customer.

The trend in the average bill per industrial customer in New York State is difficult to determine, since there is no extended annual series of State-wide data, and also because industrial and nonfarm commercial sales are ordinarily combined in the reports made by the utilities to statistical agencies such as the Census, the Federal Power Commission, the Edison Electric Institute, and Poor's and Moody's Manuals. Some attempt can be made, however, to trace a trend for the United States as a whole.

The Edison Electric Institute reports two classes of commercial-industrial sales: "Large commercial light and power" and "Small commercial light and power" for the United States, and its data for these two classes, separately and together, are shown in tables 34, 35, and 36 and charts 16 and 17. The average bill for all "commercial" service shows a very slight upward trend, which seems to be due

⁵ This latter step requires more explicit justification. It is clear that if an industrial consumer's energy demand* as of a given time is highly inelastic, his expenditure on power will be less if the price† is low than if it is high. In that case, the calculation of his power expenditure independently of the effect of price reductions would give too high an estimate of probable consumption, because part of the effect of the reductions would be a reduction in his total expenditure on power. On the other hand, if the industrial consumer's demand is highly elastic, the reduction of the average electricity price will increase his total expenditure. In that case, an estimate arrived at by forecasting expenditure and energy-per-dollar independently, and then multiplying, would be over-conservative. Only if demand is of approximately unitary elasticity, with differences in rates being compensated by inversely proportionate differences in consumption, would the total power expenditure per customer be really independent of changes in the average price of energy. Fortunately for our purposes, the individual customer's demand for most classes of electric service appears to be of somewhat greater than unitary elasticity. This means that the procedure adopted—estimating the change in the average customer's bill and the change in the amount of energy purchasable per dollar, and then multiplying—may be counted on to contribute a downward, or conservative bias to the final estimates.

*The demand relationship here referred to is the relation between average price and amount bought, as of a given time and situation with all other factors assumed constant.

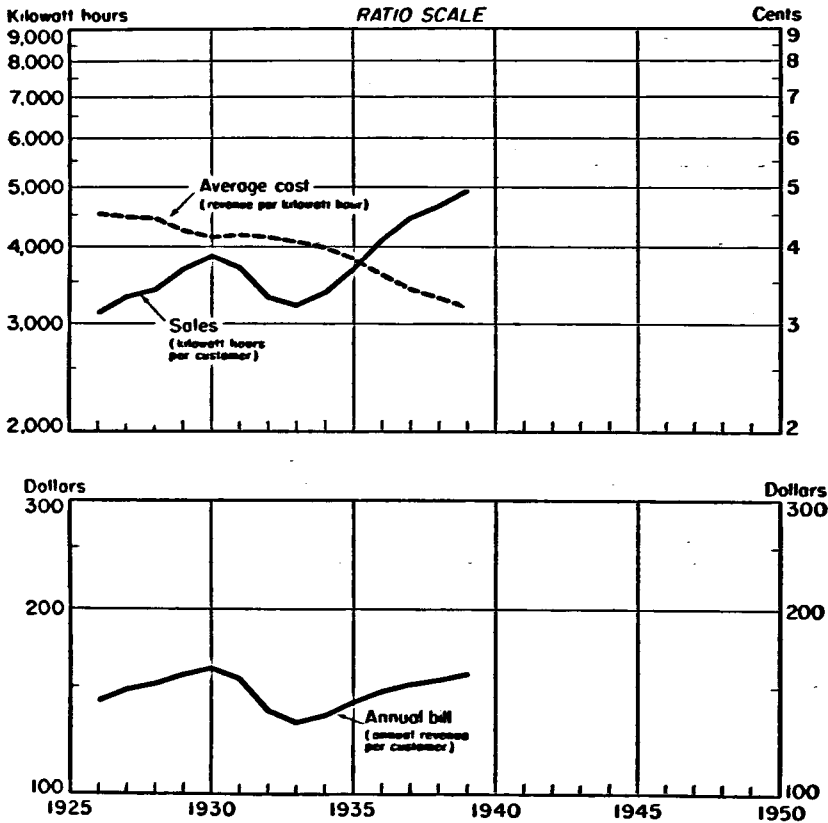
†Average amount paid per kilowatt-hour, as distinguished from rate schedules, which ordinarily are bracketed to provide lowered rates for increased consumption.

⁶ *Census of Manufactures, 1937, op. cit.* This figure excludes gas works, railroad repair shops, and establishments with less than \$5,000 worth of products. It includes the high-load-factor enterprises, but these are almost negligible in number.

mainly to the sharp rise in the "large commercial" bill since 1933. The "small commercial" bill appears relatively constant in size, without measurable trend.

The rise in the average annual bill of "large" customers since 1933

Chart 16 - CONSUMPTION AND COST OF ELECTRICITY IN "SMALL COMMERCIAL" SERVICE IN THE UNITED STATES, 1926-1939



Source Table 35

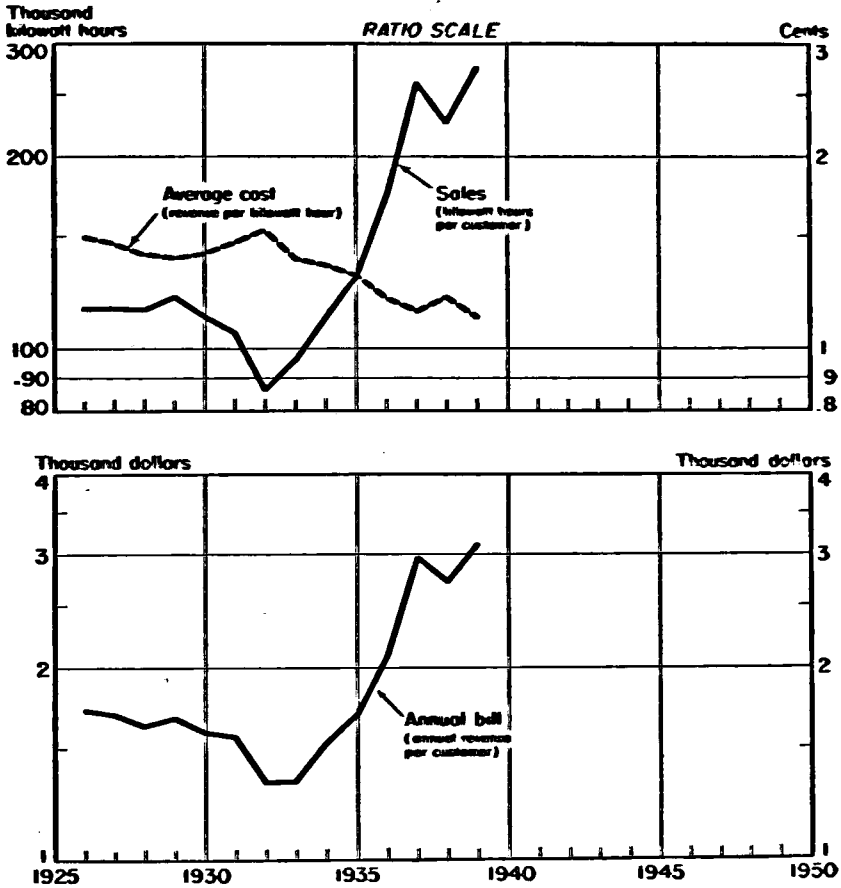
WPA 3702

may apply more properly to manufacturing than to nonmanufacturing customers, since the average manufacturer's 1937 power bill in the United States was about \$2,800.⁷ Further substantiation of this hypothesis is gained from the fact that the "large" bills have much larger percentage cyclical fluctuations, which is what must be expected

⁷ *Ibid.*, table 2, p. 1670, and table 2, p. 19. This figure is only a very crude approximation of the average annual industrial power bill, since industrial customers as a group do not coincide with the group of manufacturing plants reporting to the Census. The purpose here is merely to show that the "large" category of power bills (running around \$2,000 annually) corresponds more closely to the average manufacturing customer than does the "small" bill of around \$1.50 a year.

of manufacturing as against commercial power users. To a large extent, though by no means fully, manufacturers are among the "large" consumers of the commercial-industrial category, and trade and service establishments are among the "small" consumers. As of December 31, 1937, New York State had 41,395 of these "large"

Chart 17—CONSUMPTION AND COST OF ELECTRICITY IN "LARGE COMMERCIAL" SERVICE IN THE UNITED STATES, 1926-1939



Source Table 36

WPA 3703

commercial-industrial consumers⁸ and in 1937 the Census reported only 27,749 manufacturing establishments.⁹ The difference may be explained by the presence of large service and commercial establish-

⁸ Edison Electric Institute, *Statistical Bulletin* No. 5, April 1938, table 9, p. 11.

⁹ *Census of Manufactures, 1937*, table 1, p. 1368. This figure includes only establishments producing at least \$5,000 worth of goods for sale during the year, but may include a few establishments which were not "commercial-industrial" customers.

TABLE 34

All "commercial" light and power service in the United States:
Customers, sales, and revenue, 1926-39

Year	Number of customers	Sales		Revenue		Cents per kwh.
		Millions of kwh.	Kwh. per customer	Millions of dollars	Dollars per customer	
1926	3,437,362	41,478	12,067	903.6	263	2.18
1927	3,668,767	45,305	12,349	986.6	269	2.18
1928	3,868,804	49,407	12,771	1,049.1	271	2.12
1929	3,962,163	56,077	14,153	1,146.7	289	2.04
1930	3,972,390	54,092	13,617	1,142.1	288	2.11
1931	4,072,273	50,481	12,396	1,109.3	272	2.20
1932	3,974,498	43,070	10,837	975.4	245	2.26
1933	3,955,424	45,446	11,490	940.2	238	2.01
1934	3,993,946	49,222	12,324	989.9	248	2.07
1935	4,015,363	54,453	13,561	1,050.3	262	1.93
1936	4,105,313	64,267	15,655	1,143.3	278	1.78
1937	4,151,262	71,104	17,129	1,219.9	294	1.72
1938	4,231,039	63,216	14,941	1,155.2	273	1.83
1939	4,399,553	73,300	16,661	1,241.1	282	1.69
REVISED CLASSIFICATION						
1937	4,268,895	69,435	16,265	1,199.6	281	1.73
1938	4,319,079	62,277	14,419	1,150.8	266	1.85
1939	4,399,553	71,830	16,327	1,233.3	280	1.72

SOURCE: Edison Electric Institute, Statistical Bulletin No. 4 (1937), table I-b, pp. 2-3; No. 7, table I, p. 2, and table A, p. 33. The revised classification of types of service is that adopted to conform to the accounting classification prescribed by the Federal Power Commission as of Jan. 1, 1937.

TABLE 35

"Small commercial" light and power service in the United States:
Customers, sales, and revenue, 1926-39

Year	Number of customers	Sales		Revenue		Cents per kwh.
		Millions of kwh.	Kwh. per customer	Millions of dollars	Dollars per customer	
1926	3,154,530	9,485	3,007	427.4	135	4.51
1927	3,356,140	10,766	3,208	482.1	144	4.48
1928	3,527,489	11,692	3,315	520.0	147	4.45
1929	3,594,115	13,106	3,647	555.6	155	4.24
1930	3,625,653	13,944	3,846	575.6	159	4.13
1931	3,724,013	13,544	3,637	564.5	152	4.17
1932	3,603,668	12,106	3,359	501.0	139	4.14
1933	3,620,812	11,589	3,194	471.8	130	4.07
1934	3,670,419	12,278	3,345	490.4	134	3.99
1935	3,710,771	13,588	3,661	519.2	140	3.82
1936	3,825,289	15,612	4,081	582.1	147	3.60
1937	3,891,584	17,558	4,612	604.8	155	3.44
1938	3,979,466	18,316	4,603	609.3	153	3.33
1939	(1)	20,235	(1)	647.7	(1)	3.20
REVISED CLASSIFICATION						
1937	4,071,633	18,705	4,439	616.4	151	3.41
1938	4,127,357	19,137	4,637	632.1	153	3.30
1939	4,215,254	20,722	4,916	660.7	157	3.19

(1) Not available.

SOURCE: Edison Electric Institute, Statistical Bulletin No. 4, 1937, table I-b, pp. 2-3; No. 7, table I, p. 2, and table A, p. 33. The revised classification of types of service is that adopted to conform to the accounting classification prescribed by the Federal Power Commission as of Jan. 1, 1937.

TABLE 36

*"Large commercial" light and power service in the United States:
Customers, sales, and revenue, 1926-39*

Year	Number of customers	Sales		Revenue		Cents per kwh.
		Millions of kwh.	Kwh. per customer	Millions of dollars	Dollars per customer	
1926.....	282,832	31,993	113,116	476.2	1,684	1.49
1927.....	312,627	34,539	110,480	504.5	1,614	1.46
1928.....	341,315	37,715	110,499	529.2	1,550	1.40
1929.....	368,048	42,971	116,754	591.0	1,606	1.38
1930.....	346,737	40,148	115,788	566.5	1,634	1.41
1931.....	348,260	36,937	106,062	544.7	1,564	1.47
1932.....	370,830	30,964	83,499	474.4	1,279	1.53
1933.....	334,612	33,857	101,183	468.4	1,400	1.38
1934.....	323,527	36,944	114,191	499.5	1,544	1.35
1935.....	304,692	40,865	134,163	531.1	1,744	1.30
1936.....	280,024	48,655	173,753	581.1	2,075	1.19
1937.....	259,678	53,546	206,202	615.0	2,368	1.15
1938.....	251,673	44,900	178,477	545.9	2,170	1.22
1939.....	(1)	52,773	(1)	595.0	(1)	1.13

REVISED CLASSIFICATION

1937.....	197,262	51,360	260,364	583.2	2,956	1.14
1938.....	191,722	43,150	225,013	518.7	2,705	1.20
1939.....	184,299	51,108	277,310	572.7	3,107	1.12

¹ Not available.

SOURCE: Edison Electric Institute, *Statistical Bulletin No. 4*, 1937, table I-b, pp. 2-3; No. 7, table I, p. 2, and table A, p. 33. The revised classification of types of service is that adopted to conform to the accounting classification prescribed by the Federal Power Commission as of Jan. 1, 1937.

ments among the "large" consumers. Furthermore, the distinction between "small" and "large" (supposedly drawn at 50 kilowatts demand) has not always been consistently observed.¹⁰

Nonetheless, the divergence in trends of the two categories appears to be so marked that even a rough allocation is better than none. The average annual bill of the small commercial-industrial users will be assumed constant to 1950, while that of the large users seems to be headed for an annual bill of at least \$4,000 in 1950.

It is now possible to calculate the expected increase in the average of all commercial-industrial bills. Each of the 41,395 "large" annual bills in New York State will rise from about \$2,360 in 1937 to about \$4,000 in 1950, or an increase of \$1,640. This means a total increase in revenue amounting to \$67,887,800 (41,395 × \$1,640). In 1937 the actual total of all nonfarm commercial-industrial revenue in New York State was \$177,302,474.¹¹ The additional revenue of \$67,887,800 would amount then to a 37-percent increase; and since the whole calculation has been based on the 1937 number of bills, the average increase in revenue per bill would likewise be 37 percent.

¹⁰ Edison Electric Institute, *Statistical Bulletin No. 4*, January 1937, p. 15.

¹¹ Census of Electrical Industries, *Electric Light and Power Industry*, 1937, table 39, p. 66, and table 40, p. 72. This figure includes sales by both private and municipal utilities.

Probably a greater share of the general increase should be allocated to the strictly industrial category, so the 1937-50 increase in the average annual industrial bill has been set at 50 percent. Since about 30 percent of the commercial-industrial power revenue in New York State comes from industrial sales,¹² this 50-percent increase in the industrial bill would account for a 15-percent increase in revenue, leaving 22 percent to be accounted for by an increase in commercial bills. The average commercial bill (since commercial revenue is 70 percent of the total) could then increase about 30 percent.

The prospective 37-percent increase in average annual commercial-industrial bills has now been roughly allocated, with the average industrial bill increasing 50 percent and the average commercial bill 30 percent.

Effect of Rate Reductions.

The next step is to determine how much additional energy these augmented power budgets will purchase. As indicated earlier, the procedure will be to set up a provisional estimate of the reduction in average price per kilowatt-hour, determining subsequently whether such reduction would be economically feasible. Due to the almost complete lack of statistics on industrial and commercial service separately, there is no basis for predicting any greater change in price in the one class than in the other; so it will be assumed that the percentage change will be equal for both industrial and commercial sales.

The experience of the 13-year period 1926-39 may furnish some guidance to a reasonable forecast of rate reductions in the 13-year period 1937-50. Taking all commercial-industrial service together, the average revenue per kilowatt-hour fell from 2.18 cents in 1926 to 1.69 cents in 1939,¹³ a decline of 22.5 percent. It seems likely that rates may fall even faster in the period 1937-50, if the St. Lawrence project is put into operation; so a somewhat greater reduction (25 percent) will be adopted as a provisional assumption. At a later stage, when the total energy and load requirements have been calculated, it will be possible to judge the feasibility of a 25-percent reduction.

¹² The 1937 *Census of Manufactures* figure for total cost of purchased energy to New York State manufacturers is \$57,346,183 (table 2, p. 1670). In order to make approximate allowance for the high-load-factor electrochemical and electrometallurgical industries, which are to be considered separately, \$5,000,000 should be deducted from the Census total. This assumes an average price of 2.5 mills per kilowatt-hour to such industries, on 1937 sales of approximately 2 billion kilowatt-hours. See the source note to table 52, below, for evidence on the appropriateness of the average price figure. Deducting the \$5,000,000 of high-load-factor revenue from the Census figure leaves \$52,346,183 as an estimate of total ordinary industrial revenues. The total revenue from all nonfarm commercial-industrial energy sales in New York State, according to the *Census of Electrical Industries (Electric Light and Power Industry, 1937, table 39, p. 66)* was \$175,588,471. Deducting from this the \$5,000,000 estimated for high-load-factor industrial revenue leaves \$170,588,471. Ordinary industrial revenues as estimated above (\$52,346,183) constitute slightly more than 30 percent of this.

¹³ See table 34, p. 57.

Combined Estimate for Industrial Sales.

The three components of 1937-50 growth in industrial power sales in New York State have now been evaluated as follows:

1. The number of industrial customers will be 85 percent as large as in 1937.
2. The average industrial customer's annual bill will be 150 percent as large as in 1937.
3. The average price of electricity to industrial customers will be 25 percent less than in 1937—in other words, a dollar in 1950 will buy one-third more energy than in 1937.

Combining the first and second of these components, the total 1950 revenue from industrial sales will be about 27.5 percent greater than 1937 revenue (85 percent times 150 percent=127.5 percent). No figures are available to check this against past trends in New York State. In the United States as a whole, during the period 1926-39, commercial-industrial revenue increased from 903.6 million dollars to 1,241.1 million, or an increase of more than 37 percent.¹⁴ Revenue from sales to "large" commercial-industrial customers, which come closer to representing genuine industrial sales, seems to have increased at about the same rate.¹⁵

The remaining step is a simple one. As estimated, the manufacturers of New York State will be spending, in the aggregate, 27.5 percent more money on electric power per year in 1950 than in 1937. Furthermore each dollar will at that time buy one-third more energy than it did in 1937. Consequently, the expected 1937-50 increase in total industrial energy sales in the State is 70 percent (i. e., 127.5 percent times 133½ percent=170 percent). This increase, applied to the previously estimated 1937 industrial consumption of 5,212 million kilowatt-hours, gives 8,860 million kilowatt-hours as the expected 1950 level of annual industrial consumption outside of the high-load-factor industries.

It is estimated at a later point that a further effect of the St. Lawrence power rates (as compared with rates under the alternative 1950 all-steam plan) will be the employment of many thousands of additional industrial workers. This of course represents a small addition to the number of men who will be at work in the State's industries in 1950 in any case, but gives further reason for regarding the 70 percent growth estimate as conservative. The estimate is of course contingent upon the reduction of the average kilowatt-hour charge by 25 percent; the feasibility of this will be checked later.

¹⁴ See table 34, p. 57.

¹⁵ See table 36. On account of the change in service classifications it is not possible to compare 1926 and 1939 directly. However, the 1926-38 increase in "large commercial" revenue was 25 percent, and the 1938-39 increase, under the revised classification, was 10 percent. Combining these would give a total 1926-39 increase of 37.5 percent.

Section 3

GROWTH IN COMMERCIAL SALES

Estimates may now be made for strictly commercial sales of energy, which in 1937 amounted to approximately 2,616 million kilowatt-hours, or 18.5 percent of all energy sales in New York State.

The number of commercial customers, as distinct from industrial, seems to be still increasing considerably faster than population. In the United States as a whole, for instance, between 1926 and 1939, the number of commercial-industrial customers steadily increased from 3,437,362 to approximately 4,191,000,¹⁶ or 22 percent. The population increase in the same interval was probably less than 9 percent.¹⁷ Furthermore, the number of "small" commercial-industrial customers has been increasing much more rapidly, while the number of "large" ones is falling. So far as New York State is concerned, there is no reason to believe that any of the growth represents any net increase in *industrial* customers; and in any event the number of industrial customers is a very small part of the total number.¹⁸

It seems possible, then, that the number of nonfarm commercial customers in New York State will increase 8 or 10 percent *faster than population*. At a later point in this report (table 37), the 1937-50 population increase is forecast at somewhat more than 4 percent. A safely conservative estimate of the accompanying increase in commercial electricity customers is 11 percent.

The 1937-50 increase in the average commercial power bill has already been estimated at 30 percent. In 1950, then, there will be 11 percent more commercial customers, each on the average spending 30 percent more money in purchasing energy which will sell for 25 percent less per kilowatt-hour. The result, in terms of 1950 commercial power sales relative to 1937, is an increase of 92 percent (111 percent times 130 percent, divided by 75 percent, gives 192 percent). This 92-percent increase, applied to the previously estimated 1937 New York State commercial consumption of 2,616 million kilowatt-hours, yields 5,023 million kilowatt-hours as the expected 1950 level of annual commercial consumption.

Taking both industrial and commercial consumption together, the expectation is that 1950 consumption may be in the neighborhood of 14 billion kilowatt-hours (8.9 billion plus 5.0 billion). This represents an increase of 77 percent over the 1937 industrial-commercial consumption.

¹⁶ Edison Electric Institute, *Statistical Bulletin No. 5*, April 1933, *op. cit.* table 17, p. 16; *Electrical World*, January 13, 1940.

¹⁷ Based on the Census Bureau's midyear estimate for 1926 (*Statistical Abstract*, 1939, table 12, p. 10) and its press release of September 22, 1940, *Summary of Preliminary Population Figures for the United States, by States, 1940*, p. 1.

¹⁸ Only 166,794 manufacturing enterprises were included in the 1937 Census of Manufactures, for the United States as a whole.

Section 4

GROWTH IN FARM AND RESIDENTIAL CONSUMPTION

The increase to be expected in residential and farm consumption may be analyzed as the resultant of four factors: (a) Growth of population; (b) increase in the number of customers relative to population; (c) increase in the amount the average consumer will spend on electricity; and (d) increase in consumption because of lower rates.

Growth of Population.

The rate of growth of farm and nonfarm population in New York State between 1937 and 1950 is not easy to estimate. In arriving at the results shown in table 37 below, three sources of data have been used: The Census reports of 1930 and 1940, and the estimates prepared by Thompson and Whelpton in 1934 for the National Resources Board.

Probably the best simple estimate of the 1937 total population of New York State is obtained by direct proportional interpolation between the 1930 and 1940 Census figures. This yields a figure of 13,142,000 persons. In order to break this down into farm and nonfarm, however, the Thompson and Whelpton estimates must be resorted to, since at the date of present writing the 1940 Census data do not furnish such a break-down. Thompson and Whelpton give two estimates for each population group at each date: One based on the assumption that there will be no internal migration, the other based on the assumption that the internal migration trends of the 1920-30 decade will continue. For the year 1940, these two estimates are 12,989,000 and 13,709,000 respectively. If the appropriateness of the migration assumptions are checked against the 1940 Census enumeration (13,380,000), neither assumption yields a very accurate forecast; they err almost equally in opposite directions. The no-migration forecast underestimates the State's 1940 population by 391,000 persons, while the continued-migration forecast overestimates it by 329,000. The *average* of the two Thompson-Whelpton estimates for 1940 was 13,349,000, which differs from the actual Census count by only 31,000, or less than a quarter of 1 percent.

Insofar as the 1930-40 experience is indicative, then, a compromise between the alternative assumptions offered by Thompson and Whelpton appears safest. In table 37, such a compromise has been made by simply averaging the subgroup figures for 1940, and the resulting figure for each group of the population has then been raised about one-quarter of 1 percent so as to make the total check with the 1940 Census enumeration. This gives an approximate break-down of the 1940 total into farm and nonfarm groups, and makes it

possible to interpolate between 1930 and 1940 to secure estimates of the population of each of these groups in 1937.

For the year 1950, Thompson and Whelpton give again two forecasts for each group of the population, one based on the assumption of no migration and the other based on the assumption that migration will continue as in 1920-30. The weight of experience seems to favor taking the average of these two forecasts, if only because that worked in 1940. In table 37, accordingly, are shown such "compromise" estimates for 1950, compared with the approximate 1937 totals. It will be seen that the nonfarm population is expected to increase from 12,426,000 in 1937 to 12,987,000 in 1950, or about 4.5 percent; while the farm population is expected to decrease from 717,000 in 1937 to 708,000 in 1950, or a little more than 1 percent. The population of the State as a whole is expected to increase from 13,142,000 to 13,695,000, or 4.21 percent.

TABLE 37
Estimated growth of New York State population, 1937-50

[Thousands]

Enumeration or estimate	Total	Nonfarm			Farm
		Total	Urban	Rural	
1930 Census	12,588	11,868	10,522	1,346	720
1940 Census and Thompson and Whelpton ¹	13,380	12,685	² 11,184	1,481	³ 715
1937, estimated	13,142	12,426	10,990	1,445	717
1950, Thompson and Whelpton ¹	13,695	12,987	² 11,417	1,570	³ 708
Percentage increase, 1937-50	4.21	4.51	3.89	8.65	⁴ (1.26)

¹ See text, pp. 62-3.

² The Thompson-Whelpton figure for "urban" population presumably includes the small urban farm population, which in 1930 constituted 0.107 percent of total New York population. This percentage has been assumed to hold good for 1940 and 1950 also, and accordingly 14,000 persons in 1940 and 15,000 in 1950 have here been shifted from Thompson and Whelpton's "urban" total to the "farm" total.

³ Figures in parentheses denote a decrease.

Sources: Census data for 1930, from *Statistical Abstract*, 1939, table 10, p. 8. Census data for 1940, from Census press release of September 22, 1940, *Summary of Preliminary Population Figures for the United States, by States*, 1940, table 1, p. 3.

Thompson and Whelpton data, from Warren S. Thompson and P. K. Whelpton, *Estimates of Future Population by States*, prepared for National Resources Board, December 1934 (unpagged).

This rate of increase is markedly lower than previous rates, and illustrates the Nation-wide slackening of population growth which was first brought to general public attention by the results of the 1940 Census. As recently as 1938, the Power Authority of the State of New York thought a rate of increase of nearly 1 percent annually was in prospect for the 1940's, and based its load estimates in part upon the assumption of a 10 percent increase in population by 1950. It happens that in spite of this variance in expected population growth, the power load forecasts of the Power Authority and of the present study are in very close agreement.

Number of Nonfarm Customers.

It is difficult to estimate the probable increase in the percentage of the State's population served by electricity, but the available data and the experience of other States with lower electric rates indicate that the saturation point, in terms of numbers of customers, is not yet at hand.

Tables 38 and 39 are illuminating with regard to the degree of electrification in New York State relative to some other States. It appears that the nonfarm population in New York State is much more completely electrified than the farm population. In New York more than one person out of four among the nonfarm group is a power customer, which is a higher ratio than that for the country as a whole, and is not greatly inferior to that of the highest State, California. It would appear that few nonfarm households are without service. It is true that the number of households may tend to increase faster than population does,¹⁹ so the assumption that nonfarm residential customers will increase merely in proportion to population would probably involve a further degree of understatement. It would appear safely conservative to assume, then, that the number of nonfarm domestic customers will increase about 4.5 percent (that is, in the same proportion as nonfarm population does) between 1937 and 1950.

Number of Farm Customers.

On the farms, however, the situation is different. As table 39 shows, only about half the farms in New York State had electric service in 1937, and although this represents a large increase since 1930, the process of electrification has not proceeded so far there as in many other States. In Rhode Island, for instance, about 95 percent of all farms had electric service; in Connecticut and New Jersey, about 68 percent. Going back to 1930 (the latest available data on farm electric motors) we find only 10 percent of New York farms reporting such motors, while in Rhode Island the percentage was 19, and in Massachusetts and New Jersey over 16. The percentage of farms reporting purchases of electricity from power companies in 1929 was approximately half as great in New York as in Massachusetts.

¹⁹ A decrease in the number of persons per household would appear to be the normal accompaniment of a declining birth rate, since a smaller and smaller part of the population consists of children. This relationship is obscured during recession periods, when families double up and marriages are postponed; and the National Resources Committee, in making its forecasts of the number of families in the United States up to 1980, cautiously assumed that the average size of family will remain the same as in 1930 (*Problems of a Changing Population*, 1938, p. 25).

TABLE 38

Number of ultimate nonfarm domestic consumers of electric energy, 1937, and nonfarm population, 1935, by regions and selected States

Region or State	Nonfarm domestic consumers of electric energy, 1937	Nonfarm population, 1935	Nonfarm consumers, percent of nonfarm population
	Thousands	Thousands	
United States.....	21,590	95,720	22.5
REGION			
New England.....	1,988	7,786	25.5
Middle Atlantic.....	5,986	25,341	23.6
East North Central.....	5,189	20,823	24.9
West North Central.....	2,025	8,600	23.5
South Atlantic.....	1,753	10,675	16.5
East South Central.....	747	5,177	14.4
West South Central.....	1,208	7,317	16.5
Mountain.....	580	2,558	22.6
Pacific.....	2,114	7,445	28.4
STATE			
New York.....	3,146	12,106	25.9
California.....	1,554	5,388	28.9
Washington.....	362	1,297	27.9
Wisconsin.....	538	1,977	27.3
Utah.....	98	377	26.0
New Jersey.....	1,001	4,144	24.2

SOURCE: Census of Electrical Industries, *Electric Light and Power Industry, 1937*, pp. 33 and 34, table 20. Estimated total population, 1935 (Census Bureau), less total farm population as reported in Census of Agriculture, 1935 (*Statistical Abstract, 1938*, p. 9, table 11, and p. 607, table 585).

TABLE 39

Extent of farm electrification by regions and selected States, 1929, 1930, and 1937

Region or State	Percentage of farms reporting—			
	Electric motors for farm work, 1930	Electricity purchased, 1929	Dwellings lighted by electricity, 1930	Electric service, 1937
United States.....	4.1	9.1	13.4	19.3
New England.....	11.8	36.4	42.9	53.0
Massachusetts.....	16.7	54.0	62.6	64.5
Rhode Island.....	19.4	50.3	57.5	64.7
Connecticut.....	14.6	44.6	52.7	67.8
Middle Atlantic.....	9.0	24.5	31.9	50.1
New York.....	10.0	27.1	34.4	52.2
New Jersey.....	16.2	45.2	53.0	68.4
East North Central.....	6.8	13.4	21.0	32.5
West North Central.....	4.5	6.5	13.2	10.7
South Atlantic.....	1.1	3.5	6.1	11.5
East South Central.....	.3	1.8	3.0	6.3
West South Central.....	.7	1.7	3.6	5.8
Mountain.....	4.9	16.2	20.4	28.5
Utah.....	4.7	53.2	58.1	73.9
Nevada.....	16.4	23.5	33.1	—
Pacific.....	23.1	47.0	52.9	70.4
Washington.....	15.2	41.0	48.0	—
California.....	32.2	58.1	63.3	88.5

SOURCES: 1929-30 data from Census of 1930, given in *Statistical Abstract, 1938*, tables 586-587, pp. 609-611; 1937 data from Edison Electric Institute, *Statistical Bulletin No. 5, 1937*, table 12, p. 3. The individual States selected include, in addition to New York, the 6 with the highest percentages in the United States in each column.

It would appear, then, that the potentialities of further farm electrification are at least as great in New York as in many other Eastern States, and that the trend of increase in percentage of farms served is an important factor to be reckoned with.

Elaborate studies of the potential rural electricity market in New York State have been made at the College of Agriculture of Cornell University. The results were recently summarized by T. E. LaMont and W. E. Keepper.²⁰ Some leading conclusions applicable to the present inquiry are here indicated.

The percentage of electrified farms to total farms varies from one part of the State to another, just as it does between States. Within New York State, the chief determining factor seems to be the quality of the land, which is closely associated with the ability of the farmer to pay for electric service.²¹

The progress of farm electrification in the State as a whole is shown in tables 40 and 41. It can be seen that the ultimate goal of electrification of all permanent agricultural areas of the State is being rapidly approached. Of the 13,500 additional miles of line required in 1937 to complete the coverage of the permanent farm areas, 3,000 had already been built by 1939. Well in advance of 1950, then, the total mileage should rise to the 44,498 set as a goal.

This could not be assumed to mean an immediate proportionate increase in the number of farms actually served. Up to the present time, to be sure, a proportionate increase has followed. Indeed there has been a slight upward trend in farms served per mile of line as the lines have been extended progressively into new territory. However, as the last untouched districts are tapped, some decline in average density is likely to ensue. If we take LaMont's estimate of 2.4 farms to each mile of line,²² the situation to be reached by 1950 or earlier is:

Total miles of line.....	44,498
Total farms served.....	106,795

It should be noted that this makes no allowance for any further increase in customers in territory now having electric lines, and assumes that the average number of farms per mile of line will fall even below the low point of 1930.²³

²⁰ T. E. LaMont, "Land Utilization and Classification in New York and its Relation to Roads, Electricity, and Reforestation," Cornell Extension Bulletin 372, March 1937. W. K. Keepper, "Consumption, Costs and Uses of Electricity on New York State Farms" (selected tables from unpublished theses), Department of Agricultural Economics and Farm Management, College of Agriculture, Cornell University, 1940.

²¹ LaMont, *op. cit.*, table 18, p. 33.

²² *Ibid.*, table 22, p. 36. This ratio is based on the 11 counties intensively studied.

²³ This estimate has deliberately been kept low in order to counterbalance the slight bias due to ignoring rural residences and rural commercial establishments, churches, and schools. The density of these categories of customers is expected to fall considerably with the extension of new lines into relatively rustic territories.

TABLE 40

Rural electric distribution requirements in New York State, as estimated in 1937

Land class	Mileage of road outside incorporated villages and cities	Estimated mileage of electric lines needed
Superior land (classes III and higher) plus residential	63,957	42,595
Inferior land (classes I and II) outside parks	13,251	437
Adirondack and Catskill Parks	5,865	1,456
Total	83,073	44,498

SOURCE: T. E. LaMont, *Land Utilization and Classification in New York and its Relation to Roads, Electricity, and Reforestation*, Cornell Extension Bulletin 372, March 1937, table 25, p. 39. The criterion for suggested extensions is the eventual servicing of all permanent agricultural areas of the State.

TABLE 41

Progress of rural electrification in New York, 1925-39

Year	Total miles of line ¹	Total farms served	Additional mileage needed to electrify the permanent agricultural areas of the State ²
1925	9,600	25,400	34,900
1926	11,100	30,600	33,400
1927	13,000	33,300	31,500
1928	14,800	37,400	29,700
1929	17,100	43,300	27,400
1930	19,300	47,100	25,200
1931	21,300	53,400	23,200
1932	21,400	54,200	23,100
1933	21,900	55,400	22,600
1934	22,800	57,900	21,700
1935	24,000	61,600	20,500
1936	27,800	71,600	16,700
1937	31,000	85,500	13,500
1938	32,500	91,500	12,000
1939	34,000	97,000	10,500

¹ Excludes about 2,000 miles of line in incorporated cities and villages with population of 2,500 or less.

² The total mileage needed is estimated at 44.5 thousand miles.

SOURCE: W. E. Keepper, *Consumption, Costs, and Uses of Electricity on New York State Farms*. (Selected tables from unpublished thesis) Dept. of Agricultural Economics and Farm Management, College of Agriculture, Cornell University, 1940. Adapted by W. E. Keepper from Report of the Department of Public Service, Public Service Commission, State of New York, 1940.

The total of 106,795 farms served represents a 25-percent increase over the 1937 figure. The expected 1937-50 growth in the number of farms connected may be placed at 25 percent. It is not necessary to take the population trend explicitly into account here, since it enters into the Cornell estimates.

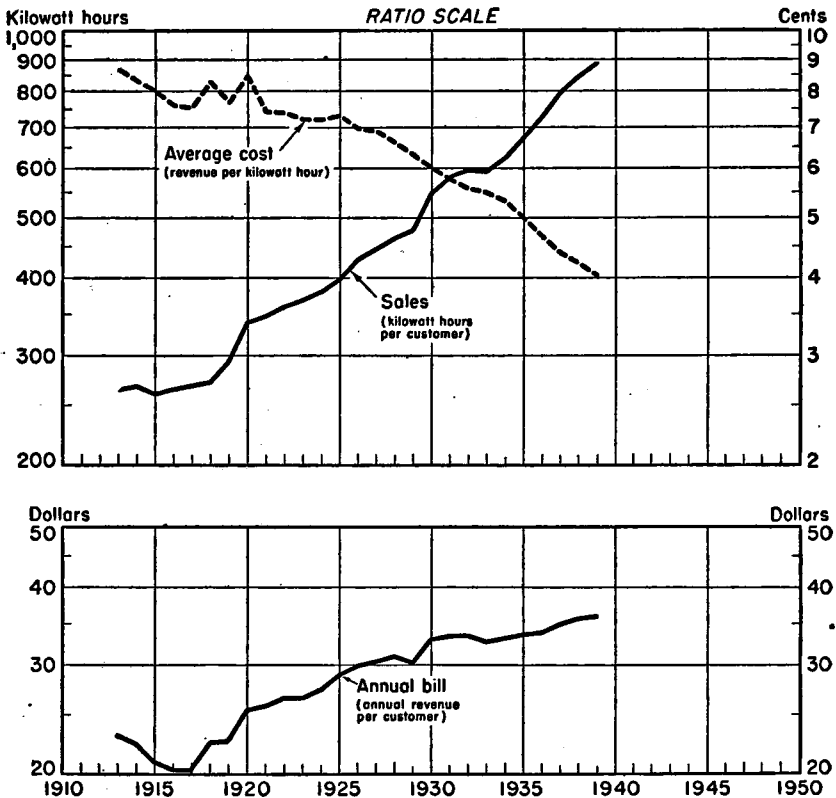
Average Annual Farm Bill.

The estimate of the increase in numbers of nonfarm residential customers is 13 percent, and of farm customers, 25 percent. The

next step is to determine the probable change in average annual electricity bill for each class.

Some evidence upon this factor may be obtained from a study of past trends. Table 42 and chart 18 indicate a steady upward trend

Chart 18 - CONSUMPTION AND COST OF RESIDENTIAL ELECTRICITY IN THE UNITED STATES 1913-1939



Source: Table 42

WPA 3704

in United States average residential bills since 1917 which can be conservatively extrapolated to give an estimated 1950 bill of \$39, or 15 percent more than the 1937 average of \$33.83.²⁴ If the New York State average annual bill, which was \$32.94 in 1937,²⁵ rose to the same extent, it would be \$37.88 in 1950. The average farm cus-

²⁴ Census of Electrical Industries, *Electric Light and Power Industry*, 1937, *op. cit.*, table 5, p. 12. No annual revenue series is available for New York State.

²⁵ *Ibid.*, table 39, p. 64. The 1937 data are for private utilities only.

tomers' bill, however, has shown no distinct trend at all,²⁶ perhaps on account of the relatively depressed condition of agriculture during the period for which data are available. For this class of service, it may be assumed merely that the average bill will by 1950 have returned to the 1926-39 average level, which will represent an increase of somewhat more than 12 percent over the 1937 figure. For New York State, the average annual farm bill will be assumed to rise 12 percent to a 1950 figure of \$50.31.²⁷

TABLE 42

Cost and use of residential electricity in the United States, 1913-36

Year	Average annual use	Average annual bill	Average revenue per kwh.	Year	Average annual use	Average annual bill	Average revenue per kwh.
	<i>Kwh.</i>		<i>Cents</i>		<i>Kwh.</i>		<i>Cents</i>
1913.....	264	\$22.97	8.70	1925.....	398	\$28.90	7.30
1914.....	268	22.25	8.30	1926.....	428	29.87	6.98
1915.....	260	20.80	8.00	1927.....	444	30.19	6.80
1916.....	265	20.15	7.60	1928.....	463	30.76	6.60
1917.....	268	20.15	7.52	1929.....	477	30.05	6.30
1918.....	272	22.50	8.27	1930.....	548	32.88	6.00
1919.....	293	22.55	7.70	1931.....	580	33.29	5.74
1920.....	339	25.25	7.45	1932.....	597	33.25	5.57
1921.....	347	25.65	7.39	1933.....	593	32.56	5.49
1922.....	359	26.50	7.38	1934.....	624	33.07	5.30
1923.....	368	26.50	7.20	1935.....	669	33.38	4.99
1924.....	378	27.25	7.20	1936.....	719	33.72	4.69

SOURCE: Edison Electric Institute, *Statistical Bulletin No. 4*, January 1937, table II, p. 7.

Increase in Consumption Due to Lower Rates.

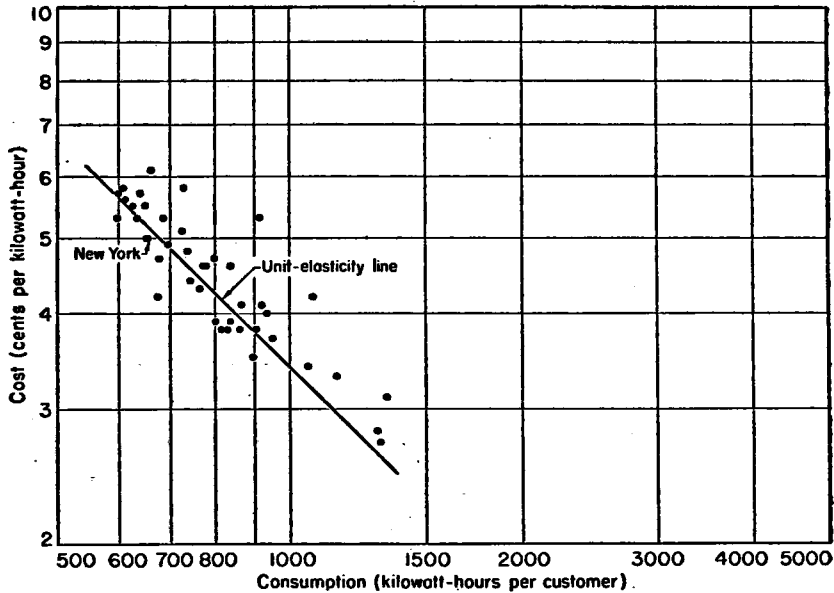
The final question concerns probable increases in consumption per customer as a result of decreased rates. Many attempts have been made to determine the elasticity of consumer demand for electric power; i. e., the relation between percentage changes in consumption and in rates. The answer is difficult to obtain, because of varying types of rate schedule in different communities, and because the effects of any change in rates upon the expenditures on electricity of different economic groups vary greatly.

Due to these complications, it seems advisable to measure the relation between average cost and average consumption as of a particular time in different places. Tables 43 and 44 show average consumption per customer, by States and classes of service, together with average revenue per kilowatt-hour. In charts 19 and 20, the individual

²⁶ Data on farm sales from 1926 through 1939 may be found in the Edison Electric Institute's *Statistical Bulletin, No. 4* (1937), *op. cit.*, table I-b, pp. 2-3, and annual issues for 1938 and 1939, and are the basis for the assertion here made.

²⁷ The data for a small sample of New York State farms, shown in table 47 below, indicate no discernible trend over the period 1929-37. The (unweighted) average for this period was \$59.35, as compared with \$52.80 in 1929 and \$56.40 in 1937. During this period, average annual consumption of electricity per farm rose from 650 to 1,206 kilowatt-hours, or nearly 86 percent. According to the 1937 Census of Electrical Industries (data in table 39, pp. 64 and 66), the average revenue from all farm sales by private electric utilities in New York State was \$44.92.

Chart 19 - CONSUMPTION AND COST OF NON-FARM RESIDENTIAL ELECTRICITY, BY STATES, 1937



Source: Table 43

WPA 3705

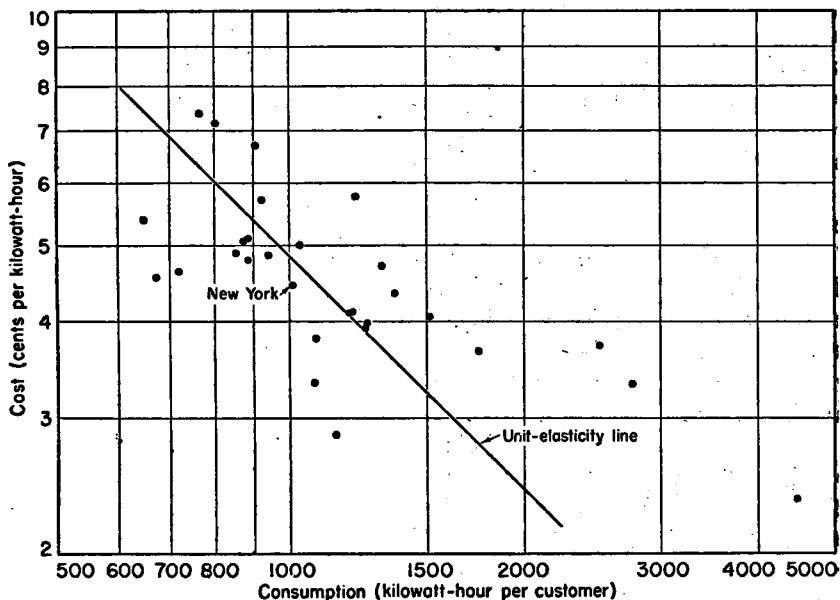
TABLE 43

Nonfarm residential sales by private utilities: Consumption per customer and average price, by States, 1937

State	Consumption per customer		State	Consumption per customer	
	Kwh.	Mills		Kwh.	Mills
Idaho.....	1,334	31	Pennsylvania.....	773	46
Washington.....	1,305	27	Illinois.....	766	43
Oregon.....	1,295	28	West Virginia.....	744	44
South Carolina, Georgia ¹	1,147	33	Texas.....	738	48
Nevada.....	1,073	42	New Mexico, Arizona ¹	730	58
Tennessee.....	1,058	34	South Dakota.....	726	51
Alabama, Mississippi ¹	951	37	Kansas.....	695	49
Montana, Utah ¹	936	40	Oklahoma.....	685	53
Virginia.....	921	41	Indiana.....	677	47
Florida.....	915	53	Kentucky.....	675	42
North Carolina.....	904	38	Wyoming.....	661	61
Michigan.....	897	35	New York.....	655	50
Minnesota.....	867	41	Iowa.....	652	50
Delaware, Maryland, District of Columbia ¹	862	38	New Jersey.....	650	55
Connecticut.....	839	46	Arkansas.....	640	57
Missouri.....	838	39	Maine.....	633	53
Wisconsin.....	832	38	Colorado.....	626	55
California.....	816	38	New Hampshire.....	612	56
Ohio.....	802	39	Vermont, Rhode Island ¹	607	58
North Dakota.....	799	47	Louisiana.....	600	57
Nebraska.....	779	46	Massachusetts.....	597	53

¹ Combined to avoid disclosure of individual operations.SOURCE: Census of Electrical Industries, *Electric Light and Power Industry, 1937*, table 39, pp. 64-65.

Chart 20- CONSUMPTION AND COST OF FARM ELECTRICITY, BY STATES, 1937



Source: Table 44

WPA 3706

TABLE 44

Farm sales by private utilities: Consumption per customer and average price, by States, 1937

State	Consumption per customer	Revenue per kwh.	State	Consumption per customer	Revenue per kwh.
	<i>Kwh.</i>	<i>Mills</i>		<i>Kwh.</i>	<i>Mills</i>
Arkansas, Louisiana ¹	4,490	24	Illinois.....	1,034	50
Oklahoma.....	2,770	33	New York.....	1,012	44
Florida.....	2,510	38	Kentucky.....	943	49
New Jersey, Pennsylvania ¹	1,748	36	Wisconsin.....	925	57
Connecticut.....	1,515	40	Minnesota.....	913	67
Kansas.....	1,365	43	Missouri.....	890	51
Massachusetts.....	1,320	47	Indiana.....	888	48
Delaware, Maryland, District of Columbia ¹	1,260	40	New Hampshire, Rhode Island, Vermont ¹	875	51
Virginia.....	1,253	39	Ohio.....	857	49
Nebraska.....	1,220	57	Iowa.....	806	71
Texas.....	1,205	41	North Dakota, South Dakota ¹	768	74
Alabama, Mississippi ¹	1,190	41	West Virginia.....	721	46
Michigan.....	1,148	29	North Carolina.....	673	46
South Carolina, Georgia ¹	1,085	38	Maine.....	650	54
Tennessee.....	1,079	33			

¹ Combined to avoid disclosure of individual operations.

SOURCE: Census of Electrical Industries, *Electric Light and Power Industry, 1937*, table 39, pp. 64-67. Farm-residential and farm-commercial-and-industrial sales have here been combined. The Mountain and Pacific States are omitted because the use of electric energy in irrigation pumping alters the relationship.

States are plotted as points and show a clearly defined inverse relationship.

The line on each chart has been drawn not to fit the points but to indicate an elasticity of unity; i. e., an inversely proportional relationship between revenue per kilowatt-hour and kilowatt-hours per customer. If this were true, it would mean that a State with average revenue per kilowatt-hour half as high as another State²⁸ would have twice as great a consumption per customer.

This is by no means the case. It is clear from charts 19 and 20 that at lower rates the average consumption figures in many States lie to the right of the unit elasticity curve, which shows that elasticity of demand is greater than unity, i. e., consumption increases at a greater rate than the reduction of price. This is the reason why rate reductions are generally favored by public agencies; at lower rates, proportionately greater amounts of electricity are sold and total revenues are increased.

For the present purposes, it is not feasible to undertake elaborate statistical computations in order to measure the exact demand elasticity curve for electric service. As long as it is known that the elasticity of demand is greater than unity, an assumption of unit elasticity for the purpose of estimating future growth of domestic and farm consumption as a result of lower rates would certainly be conservative.

The effect of prospective rate reductions will be estimated in this report on the basis of an assumed elasticity of unity; that is, reductions in the average retail price of energy will be assumed to lead to proportional increases in average consumption per customer. The further effect of rate reductions in increasing the number of customers will be completely ignored. This conservative assumption will, of course, impart some downward bias to the resulting estimates, which should be kept in mind in appraising them.

For private utilities in New York State in 1937, the average annual revenue per nonfarm residential customer was \$32.94, which comes to \$2.75 per month.²⁹ Data for this class of service by municipally owned utilities are not disclosed, but these are of negligible importance in New York State.

In table 45, data are presented for nearly all of the important operating companies with residential customers, the average monthly bill ranging from \$2.43 for the Yonkers Electric Light & Power Co., to \$4.40 for the Orange & Rockland Electric Co. Such variations are accounted for by differences in rate levels and policies, differences

²⁸ The difference in the rate for any given quantity of energy would of course be less, since the customers in the lower-rate area will benefit more from the low-rate brackets of the schedules. For example, if the whole rate schedule in an area were to be lowered 10 percent, consumption per customer would be expected to increase considerably more, and the fall in average revenue per kilowatt-hour would likewise be considerably greater.

²⁹ Census of Electrical Industries, *Electric Light and Power Industry*, 1937, table 39, p. 64. The average monthly residential bill for 1937 on the basis of reports to the Federal Power Commission, with slight differences in coverage, was \$2.79. This latter is the figure shown in table 45 below.

TABLE 45

Calculation of estimated increase in residential electricity sales per customer in New York State, by companies, 1937 and 1950

Company	Number of residential customers, 1937	Average revenue per kilowatt-hour, 1937	Average monthly bill per customer, 1937	Average monthly sales per customer, 1937 (kilowatt-hours)	Estimated average monthly bill in 1950 (15 percent greater than 1937 bill)	Estimated average monthly sales in 1950 (kilowatt-hours) ¹	Percentage increase in sales per customer, 1937-50
Niagara Hudson Power Corporation:							
Buffalo Niagara Electric Corporation ²	185,400	<i>Cents</i> 2.88	\$2.56	89.2	\$2.04	164	84
New York Power & Light Corporation.....	177,627	4.27	2.84	66.5	3.27	197	197
Central New York Power Corporation ³	157,301	4.72	2.73	57.9	3.14	184	218
Niagara, Lockport & Ontario Power Co.....	41,606	4.14	3.02	73.0	3.47	217	198
Associated Gas & Electric Corporation:							
New York State Electric & Gas Corporation.....	188,600	5.09	3.21	63.0	3.69	239	280
Rochester Gas & Electric Corporation ⁴	117,029	4.89	2.82	57.7	3.24	194	236
Central Hudson Gas & Electric Corporation.....	55,930	4.96	3.27	66.0	3.76	246	274
Rockland Light & Power Co.....	25,333	7.00	3.57	51.2	4.11	281	450
Orange & Rockland Electric Co.....	7,681	5.31	4.40	83.0	5.06	402	385
Total, above up-State companies⁵.....	956,507	4.29	2.90	67.9	3.34	6210	209
Consolidated Edison Co. of New York, Inc.:							
Consolidated Edison Co. of New York, Inc.....	776,281	6.03	2.60	43.2	2.99	150	247
Brooklyn Edison Co., Inc.....	657,378	5.43	2.57	47.4	2.94	145	206
New York & Queens Electric Light & Power Co.....	312,118	5.29	2.86	54.2	3.29	177	227
Westchester Lighting Co.....	120,679	5.40	3.38	62.5	3.89	232	271
Yonkers Electric Light & Power Co.....	42,322	5.78	2.43	42.0	2.79	132	215
Long Island Lighting Co. ⁶	104,988	5.24	3.24	62.0	3.73	217	250
Associated Gas & Electric Corporation:							
Staten Island Edison Corporation.....	40,469	5.93	3.59	60.6	4.13	254	319
Patchogue Electric Light Co.....	6,502	5.46	3.15	57.8	3.62	217	275
Total, above New York City and Long Island companies.....	2,060,737	5.60	2.72	48.7	3.13	7163	235
Total, all above companies.....	3,017,244	5.10	2.79	54.8	3.21	7177	223

¹ A average monthly sales in 1950 were estimated by applying the estimated average 1950 bill (15 percent larger than the average 1937 bill) to the Power Authority's objective rate schedules.

² Incorporated Apr. 1, 1937, so data cover 9 months' operations in 1937. To avoid distorting the averages for all up-State companies and all New York State companies, the revenue and sales figures for this company were expanded to a 12-month basis, by increasing them 1/3.

³ Incorporated July 31, 1937, so data cover 5 months' operations in 1937. To avoid distorting the averages for all up-State companies and all New York State companies, the revenue and sales figures for this company were expanded to a 12-month basis by multiplying them by 1 1/2.

⁴ Rural service included.

⁵ Number of residential customers of the Paul Smith's Electric Light, Power & Railroad Co. not reported, so this small company was omitted.

⁶ Number of residential customers of the Queens Borough Gas & Electric Co., an important subsidiary, was not reported, so this subsidiary was omitted.

⁷ Obtained by averaging the 1950 sales estimates of the individual companies, each being weighted according to number of residential customers.

SOURCE: Federal Power Commission, *Statistics of Electric Utilities in the United States*, for year ended Dec. 31, 1937, classes A and B, Vol. II, pp. 30-32.

in per capita income, and differences in customers' requirements. Average monthly sales per customer, as also shown in table 45, ranged from 42.0 kilowatt-hours for the Yonkers Co. to 89.2 kilowatt-hours for the Buffalo Niagara Electric Corporation. The level of consumption is markedly lower in New York City than up-State (monthly averages were 48.7 and 67.9 kilowatt-hours, respectively), which is due partly to the higher level of rates in New York City and partly to the smaller requirements of city dwellers in restricted living quarters.

It has previously been estimated that the average monthly residential expenditure will increase about 15 percent between 1937 and 1950. Applying this increase to the average bills of 1937 in the chief cities of New York State makes possible an estimate of average monthly residential bills in 1950. In the fourth column of figures in table 45, the estimated 1950 average bill per customer in each company service area appears as 115 percent of the actual 1937 bill for that company.

The next question is how much electricity these expenditures will buy at the proposed objective rate schedules. The schedules, as set forth by the Power Authority, are as follows: ³⁰

	Up-State area	Metropol- itan area
	<i>Cents</i>	<i>Cents</i>
First 15 kwh. or less.....	75.0	85.0
Next 35 kwh. at.....	3.0	3.0
Next 300 kwh. at.....	1.0	1.1
Next 900 kwh. at.....	.5	.6
Over 1,250 kwh. at.....	.75	.8

The resulting figures for 1950 monthly consumption are shown in table 45, and range from 145 kilowatt-hours in Brooklyn to 402 in the relatively small territory of the Orange & Rockland Electric Co. The up-State average, for the companies represented, is 210 kilowatt-hours. In terms of percentage increase between 1937 and 1950, the up-State companies show a 209 percent gain and the New York City and Long Island companies a somewhat larger gain (235 percent). The largest expected gains for individual companies are naturally in those areas where present rates are highest and the prospective rate reduction therefore is most important. The Buffalo Niagara Electric Corporation is assigned a consumption increase of only 84 percent per

³⁰ Power Authority of the State of New York, 1938 Annual Report, op. cit., p. 29.

customer, since its rates are already the lowest for any important utility in the State.

The increase in consumption per customer over the State as a whole, as shown in table 45, is 223 percent. It should be kept in mind that this expected increase includes the effect of two factors—the increase of 15 percent in average expenditure per customer, and the effect of reduced rates in increasing the purchasing power of the customer's dollar in terms of electricity.

The Power Authority's objective rate is designed to apply on farms as well as in the cities, and would involve there a still greater reduction from 1937 rates. It appears decidedly conservative, then, to apply to farm consumption the estimated 209 percent increase in average up-State consumption per customer.

Since, as previously estimated, the number of nonfarm residential customers will be 4.5 percent greater in 1950 than in 1937, the total expected increase in nonfarm residential consumption will be 238 percent (104.5 percent times 323 percent=338 percent). Similarly, in view of the expected 25 percent increase in farm customers, the total expected increase in farm consumption will be 286 percent over 1937 (125 percent times 309 percent=386 percent). Applying these estimated increases to the actual 1937 consumption data, we have (in millions of kilowatt-hours):

Class of service	1937	1950
Nonfarm residential	2,021	6,531
Farm	86	332
Total	2,107	7,163

In order to support this conclusion, it is necessary to adduce reasons for expecting the continuance of the established trends in farm and residential consumption. Unless the saturation point of the market can be shown to be remote, it would be vain to expect that consumers would continue to increase their expenditures on power in the face of declining rates.

It is not difficult to show that saturation is indeed remote. In fact, the demonstration has been so often and so convincingly made that it is hardly necessary to do more here than recall a few outstanding bits of evidence.

First, there is the evidence of consumption increases in other places under the stimulus of low "promotional" rates. In the Tennessee Valley area, under rates somewhat less "promotional" than the New

York objective rate ³¹ and with a lower consumer-income level, many communities have already reached average residential consumptions of about 2,000 kilowatt-hours a year (i. e., 167 per month). In 16 Ontario cities studied by the Power Authority, monthly consumption rose from 21 kilowatt-hours in 1915 to 208 in 1934, ³² and is presumably still going up.

If it be realized that 1950 is still a decade in the future, and that the same sum (\$3.70) which would buy 160 kilowatt-hours a month under T. V. A. rates will buy 240 kilowatt-hours under the New York up-State objective rate, the estimates of average consumption which have been made for New York State areas are seen to be quite in line with proved experience elsewhere. ³³

It has been shown that New York State farms are far from completely electrified. In comparison with the 760 kilowatt-hours which the Power Authority estimates a really electrified farm would use per month, ³⁴ the average New York farm customer in 1937 bought less than 85. ³⁵ As tables 46 and 47 show, however, the average farm use increases rapidly after the service connection is made, particularly on poultry and dairy farms. In the sample of poultry farms studied, monthly consumption rose from 60 kilowatt-hours in the first year to 178 kilowatt-hours in the ninth. On Grade A dairy farms, the monthly average rose from 77 kilowatt-hours in the first year to 174 kilowatt-hours in the ninth.

In the nonfarm residential market, likewise, there is great scope for expansion. Table 48, which applies to the United States as a whole, demonstrates how far the saturation point is in the matter of electric household appliances. In 1935, only about half the wired dwellings had toasters, washing machines, or vacuum cleaners; a third had electric refrigerators; and electric stoves and ironers appeared in less than 1 wired home in 10. There is evidently no lack of ways for the domestic consumer to use additional energy when he is offered more for his money.

³¹ The following comparable monthly bills are taken from the Power Authority's 1938 Annual Report, p. 38:

Rate schedule	Kilowatt-hours per month				
	50	100	150	200	250
New York objective:					
Up-State.....	\$1.80	\$2.30	\$2.80	\$3.30	\$3.80
New York City.....	1.90	2.45	3.00	3.55	4.10
T. V. A.....	1.50	2.50	3.50	4.50	5.00
Bonneville objective.....	1.25	2.25	3.25	4.25	4.75

³² *Ibid.*, table AAA, p. 259.

³³ The Power Authority's estimate of average New York State residential consumption in 1950 is 250 kwh. monthly in the up-State area and 200 in the New York City metropolitan area (1938 Annual Report, p. 149). The corresponding estimates arrived at in table 45 above are 210 kwh. and 163 kwh., respectively.

³⁴ *Ibid.*, p. 31.

³⁵ Census of Electrical Industries, *Electric Light and Power Industry*, 1937, table 39, pp. 64, 66. This figure covers sales by private utilities only.

TABLE 46

Electricity consumed according to years of use on 668 New York farms, 1927-37

Year of use of central station service	Average annual consumption per farm in kwh., by type of farm ¹					
	Poultry	Grade A dairy	Grade B dairy	Cash crop	Part-time	All ²
First.....	725	922	674	504	511	716
Second.....	940	1,005	795	514	629	795
Third.....	1,074	1,125	833	544	623	874
Fourth.....	1,134	1,309	937	615	623	959
Fifth.....	1,340	1,392	1,011	580	659	967
Sixth.....	1,344	1,531	1,065	595	675	1,024
Seventh.....	1,576	1,743	1,065	590	675	1,103
Eighth.....	2,023	1,844	1,153	600	700	1,203
Ninth.....	2,136	2,034	1,247	696	777	1,325

¹ The percentage changes in consumption of electricity from one year to the next were determined for identical farms. By using the consumption for the first year as the base, the consumption for other years was calculated according to these percentage changes.

² Includes a few truck farms and retail dairy farms not shown as individual farm-type averages because of small number of records.

SOURCE: W. E. Keepper, *Consumption, Costs and Uses of Electricity on New York State Farms* (selected tables from unpublished thesis), Department of Agricultural Economics and Farm Management, College of Agriculture, Cornell University, 1940. By courtesy of the author.

TABLE 47

Consumption and costs of electricity on selected New York farms, 1929-37

Year	Number of farms	Average yearly consumption per farm	Average yearly total cost per farm	Average cost per kwh. used
		<i>Kwh.</i>		<i>Cents</i>
1929.....	144	650	\$52.80	8.12
1930.....	216	766	57.72	7.54
1931.....	359	916	62.76	6.85
1932.....	414	989	64.32	6.50
1933.....	391	977	62.64	6.41
1934.....	450	1,076	61.56	5.72
1935.....	485	1,135	61.08	5.38
1936.....	562	1,159	54.84	4.73
1937.....	653	1,206	56.40	4.68

SOURCE: W. E. Keepper, *Consumption, Costs, and Uses of Electricity on New York State Farms* (selected tables from unpublished thesis), Department of Agricultural Economics and Farm Management, College of Agriculture, Cornell University, 1940. By courtesy of the author.

TABLE 48

Percentage of American dwellings with specified electrical appliances, 1935

Particulars	Millions of homes	Percent of total number of dwellings	Particulars	Millions of homes	Percent of total number of dwellings
Families.....	31.0	-----	Electric percolators.....	6.7	26
Dwellings.....	25.4	100	Waffle irons.....	4.2	17
Wired dwellings.....	21.2	84	Electric heaters.....	3.9	15
Electric irons.....	20.6	81	Heating pads.....	3.6	14
Electric toasters.....	10.6	42	Hot plates.....	3.2	13
Washing machines.....	10.4	41	Electric ranges.....	1.4	6
Vacuum cleaners.....	10.2	40	Electric cookers.....	1.3	5
Electric clocks.....	8.8	35	Ironing machines.....	1.0	4
Electric refrigerators.....	7.2	28			

SOURCE: *Dynamic America*, Nov. 1937, p. 12. Percentages computed.

In interpreting table 48 and in judging the predicted average monthly consumption figures, it is helpful to know that lighting and small appliances in an average home use about 50 kilowatt-hours a month; a refrigerator, 50 kwh.; an electric range, 150 kwh.; a water heater, 250 kwh.; and complete space heating, 2,500 kwh.³⁶

Section 5

GROWTH IN MISCELLANEOUS CLASSES OF CONSUMPTION

Some authorities look for an even more rapid increase in the remaining principal uses—primarily street and highway lighting and transportation. In local transportation the use of electricity is on the wane, except for subways; but any substantial progress in either steam-railroad electrification or highway lighting would open up a market many times greater. Bauer and Gold, whose estimates are reproduced in table 51, expect municipal, transportation, and miscellaneous consumption to increase from 9 billion kilowatt-hours in 1936 to 20 billion in 1950—an increase of 122 percent.³⁷ All of these uses together constituted only 10 percent of the total 1936 consumption in the United States, and 15.6 percent of the 1937 New York total; so the exact rate of increase is not of crucial importance.

On the basis of past experience, however, a doubling of consumption in these uses before 1950 seems unlikely. It will be observed (table 49) that miscellaneous consumption has increased only 47.5

TABLE 49
*Miscellaneous electricity sales to ultimate consumers in the United States, 1926-38*¹

Year	Miscellaneous sales (million kwh)	Estimated ² population (millions)	Miscellaneous sales per capita (kwh)
1926.....	7,161	116.5	61.1
1927.....	7,547	118.2	63.8
1928.....	7,774	119.9	64.9
1929.....	8,089	121.5	66.6
1930.....	8,323	123.1	67.6
1931.....	8,169	124.1	65.8
1932.....	7,568	125.0	60.6
1933.....	7,478	125.8	59.5
1934.....	7,770	126.6	61.4
1935.....	7,955	127.5	62.4
1936.....	8,647	128.4	67.3
1937.....	9,178	129.3	71.0
1938.....	9,689	130.2	74.4

¹ Miscellaneous sales here include all classes of sales to ultimate consumers other than farm, residential commercial, and industrial. The chief consumers in this group are municipalities (for street lighting and other uses), street railways, and electrified divisions of steam railroads.

² Census Bureau, midyear estimates from *Statistical Abstract*, 1939, table 12, p. 10.

Source: Edison Electric Institute, *Statistical Bulletin* No. 4 (1937), table I-b, pp. 2-3, and *Annual Statistical Bulletin*, 1938.

³⁶Power Authority of the State of New York, *1938 Annual Report*, *op. cit.*, pp. 30, 325-327. The space-heating figure is the monthly average expense over an entire year, in the climate of the Middle Atlantic region.

³⁷ Bauer, John; and Gold, Nathaniel; *The Electric Power Industry*, Harpers, New York, 1939, p. 107.

percent (from 7.16 billion kilowatt-hours to 10.56) in the 13 years between 1926 and 1939. The smallness of this increase is accounted for by the abandonment of electric railways, which used 9.39 billion kilowatt-hours in 1927 and only 6.86 billion in 1937.³⁸ Municipal uses have shown a steady but hardly spectacular growth.

On the other hand, we may quite confidently expect that growth in the miscellaneous field as a whole in New York will maintain past rates of increase during the next decade. Metropolitan subways are one component of the railway load which is actually growing.

Table 49 shows that, since 1926, the consumption of electricity in miscellaneous uses has tended, despite electric railway abandonments, to grow consistently faster than population, so that per capita consumption has increased, on the average, a little more than 0.76 percent per year.³⁹ Doubtless the correspondence with *urban* population would be much closer, since practically all of this class of power is used in urban places, but we have no adequate population data for testing that hypothesis.

If miscellaneous consumption in New York continues to increase at the same rate per capita, and if the State's population grows 4.21 percent between 1937 and 1950, as has been estimated, the resultant growth in this category of use would amount to 15 percent (104.21 percent times $1.0076^{13} = 115$ percent).

Section 6

TOTAL ESTIMATE OF 1950 CONSUMPTION

The high-load-factor industries are considered separately in a later section of this report, since their future growth in New York State appears to be contingent upon the provision of cheap hydro power to a much larger extent than is true of other classes of service.⁴⁰ The conclusion reached at that point will be anticipated here, in order to make possible a complete estimate of the growth of total energy requirements: It is that with the aid of the St. Lawrence development an increase of 52.5 percent may be looked for in those industries by 1950.

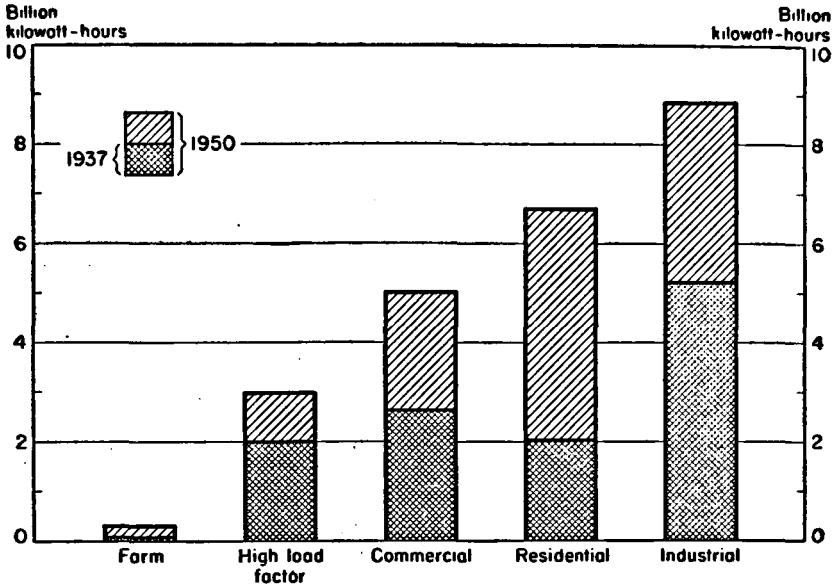
It is now possible to assemble the estimates for various classes of service and reach an over-all figure, which may be presumed somewhat more accurate than the separate class estimates. This is done

³⁸ Census of Electrical Industries, *Electric Railways and Affiliated Motor Bus Operations, 1927, and Street Railways and Trolley Bus and Motor Bus Operations, 1937.*

³⁹ The geometric trend fitted to this series has the equation $Y_t = 64.97 (1.0076)^t$, with t in years from 1932.

⁴⁰ At a run of river development where stream flow is relatively constant, the advantage of hydro power over steam is likely to increase as the system load factor increases, since a higher proportion of the costs of such a hydro system are fixed regardless of variation in consumption. This applies to the St. Lawrence-Niagara development, where, on account of the functioning of the Great Lakes as storage reservoirs, the river flow is remarkably regular.

Chart 21-ESTIMATES OF ELECTRICAL ENERGY CONSUMPTION IN NEW YORK STATE, 1937 AND 1950



Source: Table 50

WPA 3707

in table 50 and is graphically represented in chart 21. The total estimated 1950 level of consumption is 26,632 million kilowatt-hours per year, indicating about an 88 percent increase in the aggregate annual energy purchases of the State between 1937 and 1950.

TABLE 50

Summary of estimates of 1950 energy sales in New York State, by class of service

Class of service	Estimated sales (millions of kwh.)		Increase, 1937-50	
	1937	1950	Millions of kwh.	Percent
Industrial	5,212	8,860	3,648	70.0
Commercial	2,616	5,023	2,407	92.0
Residential	2,021	6,831	4,810	238.0
High-load factor	2,000	3,050	1,050	52.5
Farm	86	332	246	286.0
Miscellaneous	2,205	2,536	331	15.0
Total	14,140	26,632	12,492	88.3

This checks closely with the estimates of Bauer and Gold for the United States and of the Power Authority for New York State, which

were arrived at independently and by quite different methods.⁴¹ All three are higher than the figure given by the Niagara Frontier Planning Board.⁴² This last, however, can hardly be considered an estimate, since it is apparently obtained by pure extrapolation. Two highly dubious statements occur in connection with its presentation. First, the total saving in power costs under the St. Lawrence plan is given as \$22,000,000, with the indication that that is the Power Authority's estimate from its 1939 Report. The true figure is \$26,700,000.⁴³ It is further declared in the Niagara Frontier report⁴⁴ that "since this (Power Authority) plan is based on a demand of 26,870,000,000 kilowatt-hours, any material reduction in that demand would reduce the estimated savings in like manner." Actually, unless firm St. Lawrence power were allowed to run waste, the sum saved would be unaffected by alterations in the amount of increased requirements to be met by steam plants; and, as is pointed out by the Power Authority,⁴⁵ the *percentage* saving would actually be *larger* if somewhat less than 26,870,000,000 kilowatt-hours were used all told, because a larger portion of the total would be hydro power.

TABLE 51
Bauer-Gold estimates of electricity use in 1950 and 1975

[Figures in parentheses () indicate decrease]

Class of service	Billions of kwh.			Percentage increase 1936-50
	1936	1950	1975	
Residential.....	15	30	60	100
Commercial.....	16	30	60	88
Industrial.....	48	90	150	88
Municipal.....	2	10	20	400
Street railways.....	5	0	0	(100)
Railroad.....	1	5	20	400
Rural electrification.....	2	10	25	400
Miscellaneous.....	1	5	15	400
Total.....	90	180	350	100

SOURCE: Bauer, John; and Gold, Nathaniel; *The Electric Power Industry*, Harpers, 1939, p. 107.

⁴¹ The Bauer and Gold estimate (shown in table 51) involves about the same rate of increase for domestic and farm use as for all other uses. The Power Authority, on the other hand, looks for a much larger rate of increase in domestic and farm uses than in the other uses.

The procedure and conclusions of the New York Power Authority are briefly described on pp. 146-149 of its 1938 report. The total estimate for 1950 is 26.87 billion kilowatt-hours yearly. In this 1950 estimate is included a 1.06 billion kilowatt-hour increase for the high-load-factor industries. Growth of domestic and farm demand is allowed for, as well as an over-all 10 percent increase over the 1937 total on the score of population growth, and an increase of 3.48 billion kilowatt-hours for "various sources, including New York City subways, highway lighting, air conditioning, and the displacement of commercial and industrial isolated generating plants."

The chief provision for expansion of industrial and commercial consumption (apart from the high-load-factor industries) appears in the statement that "the population of the State is increasing at a rate slightly under 1 percent a year. As domestic, commercial, local manufacturing, and municipal uses are closely related to population it may be assumed that a 10 percent increase will be obtained from this factor alone,"

⁴² *The St. Lawrence Seaway Project* (Buffalo, 1940), pp. 114-115.

⁴³ Power Authority of the State of New York, *1939 Annual Report*, p. A-9.

⁴⁴ *The St. Lawrence Seaway Project*, p. 115.

and *Danger of Over-development*," p. 115.

⁴⁵ Power Authority of the State of New York, *op. cit.*, p. A-14.

The Niagara Frontier report goes on to state that "during the period 1924-39 there was a decrease in consumer rates practically equivalent to the amount which the Power Authority states would be the future decrease over the 1939 rates." Table 52 will shed some light on this point, comparing the changes in rates and consumption over two equally long periods, 1926-39 and 1937-50. The 1926-39 changes apply to the United States as a whole, and the 1937-50 changes are those estimated in the present report.

TABLE 52

Comparison of changes in electricity rates and sales, 1926 and 1939 and 1937 and 1950

[Figures in parentheses () indicate decrease]

	United States			New York State		
	1926	1939	Percent change, 1926-39	1937	1950 ¹	Percent change, 1937-50
Average revenue per kilowatt-hour (mills):						
Residential and farm.....	65.9	38.6	(41)	50.0	1 18.1	(64)
Commercial and industrial.....	2.18	1.69	(22)	21.8	16.3	?(25)
Annual sales of energy (millions) of kilowatt-hours:						
Residential and farm.....	7,449	23,060	210	2,107	7,163	240
Commercial and industrial.....	41,478	73,300	77	7,828	13,863	92

¹ Revenue calculated as explained on p. 83 below.

² Tentatively assumed as basis for sales estimates in this study.

³ Estimated.

SOURCES: United States data are from Edison Electric Institute, *Statistical Bulletin No. 4*, table I-b, p. 3, and *Statistical Bulletin No. 7*, table I, p. 2. Figures for 1939 are provisional. New York State data for 1937 are from Census of Electrical Industries, *Electric Light and Power Industry*, 1937, table 39, pp. 64, 66. In order to make approximate allowance for the high-load-factor industries, which are to be considered separately, 2 billion kilowatt-hours were deducted from the Census total of industrial and commercial sales, and \$5,000,000 was deducted from the Census total of industrial and commercial power revenue. This assumes an average price of 2.5 mills per kilowatt-hour to high-load-factor electroprocess customers. In 1937, according to the reports made to the Federal Power Commission, the average revenue per kilowatt-hour on industrial sales was 3.37 mills for the Niagara Falls Power Co. (24 customers) and 1.85 mills for the St. Lawrence River Power Co. (sales to Aluminum Co. of America). Federal Power Commission, *Statistics of Electric Utilities in the United States*, for year ended December 31, 1937, classes A and B, Vol. II, pp. 30, 32.

It appears from table 52 that the 1937-50 rate reductions are considerably greater than those of 1926-39, in both the residential-farm and the industrial-commercial classes of service. If the reasonableness of the anticipated rate reductions can be established, then, it seems likely that the period 1937-50 will see even more rapid expansion of energy sales than the period 1926-39.

Unfortunately, no New York State data are available to check on the applicability of past national trends to the State. It can easily be shown, however, that the over-all average revenue per kilowatt-hour has fallen much less in the State than in the whole country. In 1927, the New York average was equal to the United States; in 1932, the New York average was 11 percent higher; and in 1937, it was 22 percent higher.⁴⁶ It seems highly improbable, then, that reductions

⁴⁶ Census of Electrical Industries, *Electric Light and Power Industry*, 1927, 1932, 1937.

in New York State's average price for electricity can have been any more rapid than those of the country as a whole, and the likelihood is that they have been less rapid.⁴⁷

Section 7

EXTENT OF PROBABLE RATE REDUCTION

The foregoing estimates of 1950 energy consumption rested in part upon certain assumptions as to reductions in the average cost of energy to the consumer between 1937 and 1950. For residential and farm service, the objective schedules designed by the Power Authority were taken as the basis, and for industrial and commercial service an average reduction of 25 percent was assumed. No specific rate assumptions have been introduced in the analysis of the other classes of service.

Since it is part of the legal duty and avowed policy of the Power Authority to favor domestic and farm consumption,⁴⁸ it seems best to accept the objective rate schedule as the most probable basis for domestic and residential rates if the St. Lawrence project is put into operation. The question then is, what reductions in commercial and industrial rates might be possible at the same time?

The first step is to see what contribution the residential and farm service makes toward defraying the total costs of the system. Costs not covered by residential and farm revenues must, of course, be covered by the revenues from other types of service.

The revenue brought in by the sale of the estimated 7,163 million kilowatt-hours of residential and farm sales at the objective rates is easily calculated. The number of non-farm residential customers was estimated at 4.5 percent more than in 1937; that is, 3,223,357. It was further estimated that these would each spend in a year, on the average, \$37.88 for electricity, which gives a total of \$122,100,763 a year. For farm sales, 106,795 customers were estimated, spending on the average \$50.31 a year each, which gives \$5,372,856 a year. The total revenue from residential and farm sales under the assumed objective rate schedules, then, will be \$127,473,619 a year.

About half of this, however, must go to meet distribution expenses. The Power Authority, on the basis of an extensive survey of distribution costs under varying conditions, concludes that 3,000 kilowatt-

⁴⁷ It will be recalled that hydro development in the Buffalo-Niagara area had virtually ceased by 1927, and that the State's expansion of hydro capacity between 1927 and 1937 was much slower than that of the rest of the country. See tables 23 and 24 above.

⁴⁸ Cf. 1938 *Annual Report*, p. 203: "The Power Authority Act requires, as a matter of public power policy, the devotion of the benefits to be derived from the development of the St. Lawrence and Niagara resources primarily to the domestic and rural users. The savings made possible under the coordination plan may therefore be largely allocated to domestic and rural service."

hours per year can be delivered to the average customer at an over-all cost of just under \$19.⁴⁹ Although the annual consumption estimated in the present study (table 45) is somewhat lower (2,124 kilowatt-hours for residential service and 3,146 for farm service, or a combined average of 2,157 kilowatt-hours per customer), the figure of \$19 per customer will be taken as affording a wide margin of conservatism. To distribute the entire 7,163 million kilowatt-hours of residential and farm sales yearly, to 3,330,152 customers at \$19 per customer, would cost \$63,272,888 a year.

The total residential and farm revenue of \$127,473,619 can be allocated as follows:

Distribution.....	\$63, 272, 888
Contribution to generation and transmission costs....	64, 200, 731
Total.....	127, 473, 619

This allocation can be carried a step further, however. The total costs of generation and transmission ("power ready to distribute") are partly variable and partly fixed, and it is possible to determine the contribution made by residential and farm service to each of these categories of cost.

Under the Power Authority's plan, the generation and transmission of residential and farm energy is charged 2.0 mills per kilowatt-hour up-State and 2.6 mills per kilowatt-hour in the New York City metropolitan area, where fuel costs and transmission costs from hydro sources are higher. These classes of service are allotted a somewhat higher up-State variable cost than other classes because estimated losses are greater.⁵⁰ If we split the total residential and farm sales between the up-State and metropolitan areas in the same proportion as the Power Authority's consumption estimates (39 and 61 percent, respectively), the total variable cost allocation for the estimated 7,163 million kilowatt-hours of such sales would be \$5,587,140 for the up-State area and \$11,360,518 for the metropolitan area, or \$16,947,658 for the whole State. This calculation is shown in detail below:

Area	Energy sales		Variable costs	
	Percent of total	Million kwh.	Mills per kwh.	Total
Up-State.....	39	2,794	2.0	\$5,587,140
Metropolitan.....	61	4,369	2.6	11,360,518
Total.....	100	7,163	2.4	16,947,658

⁴⁹ *Ibid.*, p. 215.

⁵⁰ *Cf. Ibid.*, pp. 202-203.

That part of the revenues from residential and farm service not allocated to distribution and to variable expenses of generation and transmission constitutes the net contribution of these classes of service toward the defraying of the fixed costs of the generation and transmission system. Thus the complete allocation of costs of residential and farm sales is as follows:

Total revenue.....	\$127, 473, 619
Distribution.....	63, 272, 888
Generation and transmission:	
Variable.....	16, 947, 658
Fixed.....	47, 253, 073

In order to determine the costs which will have to be covered out of nonresidential nonfarm revenues, then, we must subtract the above residential and farm cost allocations from total costs. This is done below. The estimates of total cost are those of the Power Authority, which are here accepted without change on account of the very small discrepancy (0.8 percent) between this study's estimates and the Power Authority's estimates of total energy consumption. It should be noted that the total cost figures cover generation and transmission (i. e., "power ready to distribute"), and include 5½-percent return on public investment, 6-percent return on private investment, amortization at usual rates, insurance, and taxes.⁵¹

Transmission and generation costs are estimated by the Power Authority as \$260,000,000, out of which \$205,639,000 are fixed and \$54,361,000 are variable. Subtracting the amounts already allocated to residential and farm service and covered by the revenues from those classes of service, we obtain the costs allocable to other classes of service, as follows:

	<i>All classes</i>	<i>Residential and farm</i>	<i>All other classes</i>
Total costs.....	\$260, 000, 000	\$64, 200, 731	\$195, 799, 269
Fixed costs.....	205, 639, 000	47, 253, 073	158, 385, 927
Variable costs.....	54, 361, 000	16, 947, 658	37, 413, 342

It has now been calculated that for all nonresidential nonfarm service taken together, the variable costs of generation and transmission will be \$37,413,342 and the fixed costs \$158,385,927. Since the objective is to test the validity of a previous assumption of 25-percent reduction in industrial and commercial rates, the next thing to determine is how much of the above costs should be allocated to the generation and transmission of industrial and commercial power. Variable and fixed costs will be considered separately.

With regard to the variable costs, it will be assumed that there will

⁵¹ *Ibid.*, pp. 21, 201.

be no difference in the per-kilowatt-hour allocation as among different classes of nonresidential, nonfarm service. There must be, however, a difference between up-State and metropolitan variable costs per kilowatt-hour, on account of the difference in fuel costs. Consequently, it is necessary to estimate how much energy will be sold in each of the two areas. The high-load-factor group is of course entirely up-State, and for the remainder of nonresidential, noncommercial service, the total sales estimate has been broken down geographically in the same proportion as the Power Authority's estimate; that is, with 51 percent up-State and 49 percent in the metropolitan area. The estimated distribution of nonresidential, nonfarm sales is as follows:

Area	High-load factor		Industrial, commercial, and miscellaneous		Total, nonresidential, nonfarm	
	Percent	Amount (kwh.)	Percent	Amount (kwh.)	Percent	Amount (kwh.)
Up-State.....	100	3,050	51	8,463	59	11,513
Metropolitan.....			49	8,132	41	8,132
Total.....	100	3,050	100	16,595	100	19,645

It appears, then, that the up-State area will have a nonresidential, nonfarm consumption of 11,513 million kilowatt-hours and the metropolitan area 8,132 million. As previously calculated, these classes of service in the whole State must cover variable costs totaling \$37,413,342; so the next question is to determine the variable cost per kilowatt-hour in the up-State and metropolitan areas separately. It will then be possible to find the total amounts of variable cost chargeable to commercial and industrial service, respectively.

As noted before, up-State variable costs are considerably lower than metropolitan. The Power Authority estimates that they are only 53 percent as great:⁵² in other words, that 1 kilowatt-hour up-State has the same variable cost of generation and transmission as 0.53 kilowatt-hour in the metropolitan area. The variable cost per kilowatt-hour for the metropolitan area may be found by taking the total metropolitan-area sales (8,132 million kilowatt-hours) plus 53 percent of up-State sales (53 percent of 11,513 is 6,102 million kilowatt-hours), and dividing the sum (14,234 million kilowatt-hours) into the total variable cost of \$37,413,342. This procedure gives 2.61 mills per kilowatt-hour as the average variable cost of generation and transmission for metropolitan area nonresidential, nonfarm service, and 1.38 mills (53 percent of 2.61) as the corresponding up-State average.

⁵² Power Authority, *op. cit.*, p. 201. The variable costs there arrived at are 1.44 mills per kilowatt-hour up-State and 2.70 mills in the metropolitan area.

Having now found the amount of variable costs per kilowatt-hour for all nonresidential, nonfarm classes of service, it is possible to determine the total variable costs allocable to industrial and commercial service specifically. In the calculation below, the total State estimate for each of these two classes has been distributed between the up-State and metropolitan areas in the same proportion as the Power Authority's estimate for that class of service.⁵³

	Industrial	Commercial	Industrial and commercial
Up-State:			
Sales as percentage of State.....	65	30	56
Sales in millions of kilowatt-hours.....	5,759	1,959	7,718
Variable cost at 1.38 mills per kilowatt-hour.....	\$7,947,420	\$2,703,420	\$10,650,840
Metropolitan:			
Sales as percentage of State.....	35	61	44
Sales in millions of kilowatt-hours.....	3,101	3,064	6,165
Variable cost at 2.61 mills per kilowatt-hour.....	\$8,093,610	\$7,997,040	\$16,090,650
Total State:			
Sales in millions of kilowatt-hours.....	8,860	5,023	13,883
Variable cost.....	\$16,041,030	\$10,700,460	\$26,741,490
Variable cost in mills per kilowatt-hour.....	1.81	2.13	1.93

It appears that the total variable cost of generation and transmission is \$16,041,030 for industrial service and \$10,700,460 for commercial service. On a per-kilowatt-hour basis the variable costs are 1.81 mills and 2.13 mills, respectively.

Turning to the allocation of the fixed costs of nonresidential, non-farm service, which were estimated at an earlier point as \$158,385,927, the question is raised: How much of this will be charged against industrial and commercial service respectively?

In the allocation of fixed costs there is always room for considerable variation in policy, and the determination of the relative responsibility of different classes of service for the combined system peak load (i. e. the required capacity) is difficult to calculate accurately. In practice, it seems likely that the fixed costs will be allocated roughly in proportion to the peak demands of the respective classes of service, which are estimated in table 53.

On the basis of estimated class peak demands, commercial service should bear 41.9 percent of total nonresidential fixed costs and industrial service 42.2 percent. The total fixed costs allocated to nonresidential service have already been estimated at \$158,385,927; out of this, the allocations to commercial and industrial service would, then, be \$66,363,704 and \$66,838,862, respectively.

By adding the variable and fixed cost allocations we may now obtain

⁵³ Cf. Power Authority estimates, *op. cit.*, pp. 153-154.

the total cost of commercial and industrial power ready to distribute, as follows:

Class of service	Annual sales (millions of kwh.)	Variable costs	Fixed costs	Cost ready to distribute	
				Total	Mills per kwh.
Commercial.....	5,023	\$10,700,490	\$66,363,704	\$77,064,194	15.2
Industrial.....	8,860	16,041,030	66,838,862	82,879,892	9.4
Total.....	13,883	26,741,490	133,202,566	159,944,086	11.5

In order to determine what levels of average revenue might be economically sound, distribution costs must now be added. The studies of industrial and commercial distribution costs made by the Federal Power Commission⁴⁴ seem to afford the best guidance to reasonable estimates here, although the data therein presented apply to 1932 and 1934 and thus leave out of account any subsequent improvements or economies.

The Power Commission studied 22 systems, located in various parts of the country and serving communities ranging from 504 to 1,238,048 in population. Distribution costs were obtained in itemized detail, including all operating costs and fixed charges, with depreciation at 3 percent and, for private systems, taxes. Various rates of return on investment were set up, but for the sake of uniformity with the Power Authority estimates we shall use the distribution cost figures based on a 6-percent return.

TABLE 53

Estimation of nonresidential class demands for allocation of fixed costs

Class of service	Annual sales (millions of kwh.)	Annual class load factor ¹	Class demand (thousands of kw.) ²	Percent of sum of class demands
		<i>Percent</i>		
Commercial.....	5,023	20	2,867	41.9
Industrial.....	8,860	35	2,890	42.2
High-load-factor.....	3,050	80	435	6.4
Railway ³	1,691	44	413	6.0
Street lighting ⁴	468	50	111	1.6
Other public uses ⁵	457	40	130	1.9
Total, exclusive of residential and farm service.....	19,469		6,846	100.0

¹ Power Authority, *1938 Annual Report*, pp. 152-153. In combining the up-State and metropolitan load factors for each class of service, no interarea diversity has been allowed: That is, it is assumed that for any given class of service, the up-State and metropolitan peaks are synchronous. As between the entire demands of the 2 areas, there is some diversity, estimated at 5 percent by the Power Authority (*ibid.*, p. 149); we assume here that this diversity is due primarily to the different relative importance of the various classes of service in the 2 areas.

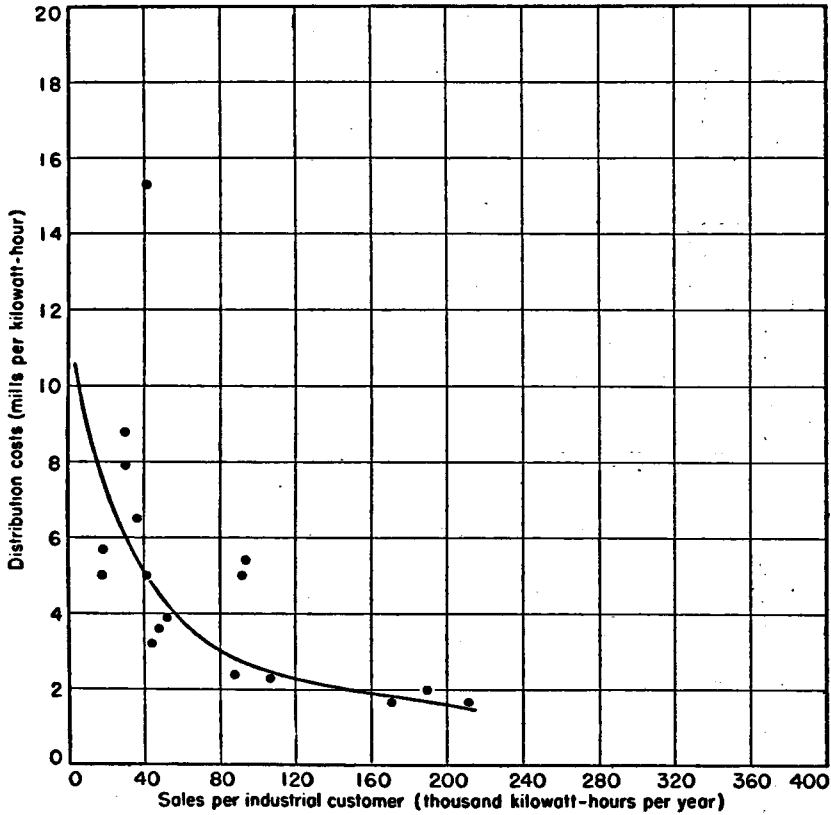
² Obtained by dividing annual sales by 8,760 times the load factor.

³ In the present study, these three classes of services have been lumped together as "miscellaneous," with total estimated 1950 sales of 2,536 million kwh. (table 50 above). For the purpose of obtaining the sum of class peak demands, this 2,536 million kwh. has been distributed among the 3 classes in the same proportion as the Power Authority estimates (*1938 Annual Report*, pp. 152-153).

⁴ Federal Power Commission, National Power Survey, Power Series No. 3, *Cost of Distribution of Electricity*, 1936.

Table 54 and charts 22 and 23 exhibit the relationship between sales per customer and distribution cost per kilowatt-hour. As would be expected, the unit costs of distribution decline rapidly with increasing

Chart 22 - DISTRIBUTION COSTS OF INDUSTRIAL ELECTRICITY IN 17 SELECTED COMMUNITIES, 1932-1934



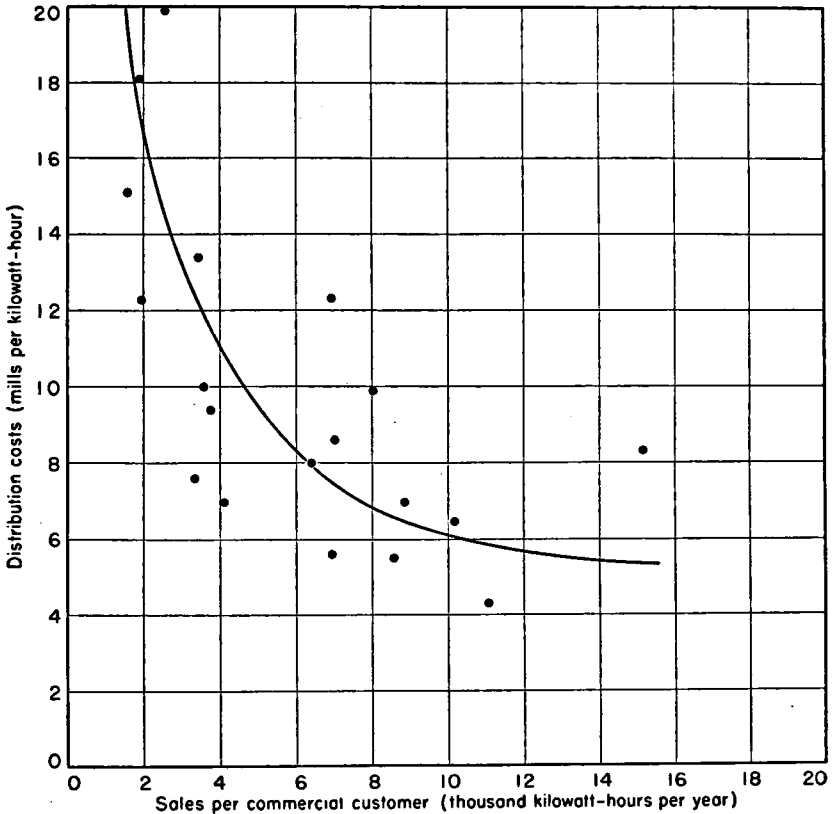
Source: Table 54

WPA 3708

density of consumption and the data for the systems reported follow a sufficiently consistent pattern to justify the use of a fitted trend as a basis for estimates. Industrial distribution costs per kilowatt-hour vary from 8 mills or more, for low levels of consumption, down to less than 2 mills for average annual consumption in the neighborhood of 200,000 kilowatt-hours. Commercial distribution costs run much higher, due to the lower load factor and smaller consumption per customer. For average sales of 2,000 kilowatt-hours a year, they appear to average about 16 mills, while for average sales of 10,000 kilowatt-hours per year they fall to about 6 mills.

Due to the failure of the available data on energy sales to distinguish consistently between industrial and commercial service, it is not easy to determine just what consumption per customer should be assumed for each class of service in New York State in 1950. For the purpose here in hand, however, it is probably best to take the "small com-

Chart 23 - DISTRIBUTION COSTS OF COMMERCIAL ELECTRICITY
IN 17 SELECTED COMMUNITIES, 1932-1934



Source: Table 54

WPA 3709

mercial" category to represent commercial service and the "large commercial" to represent industrial service. In 1937, the average annual consumption per customer, for the United States as a whole, was 4,439 kilowatt-hours for the "small" and 260,364 kilowatt-hours for the "large."⁵⁵ The latter figure will be scaled down to 180,159

⁵⁵ Tables 35 and 36, above. These figures are based on the Edison Electric Institute's revised classification adopted in 1937.

TABLE 54

Distribution costs of industrial and commercial electricity in representative systems, 1932-34 (both underground and overhead systems)

Community ¹	Industrial service			Commercial service		
	Sales per customer	Distribution cost		Sales per customer	Distribution cost	
		Per customer per year	Per kwh.		Per customer per year	Per kwh.
	Kwh.	\$	Mills	Kwh.	\$	Mills
Los Angeles.....	17,945	\$89.90	5.0	8,831	\$61.75	7.0
Washington ²				10,148	65.39	6.4
Seattle ³	93,383	503.03	5.4	6,391	50.93	8.0
Seattle ⁴	91,864	461.22	5.0	15,141	125.97	8.3
Portland, Oreg.....	41,665	207.25	5.0	7,016	60.46	8.6
Portland, Oreg.....	23,949	236.56	7.9	6,916	85.24	12.3
Tacoma.....	188,886	373.12	2.0	11,030	47.14	4.3
Lansing.....	211,079	367.66	1.7	6,915	38.53	5.6
Pasadena.....				8,001	78.53	9.8
Springfield, Ill.....	52,014	201.49	3.9	8,578	47.05	5.5
Nashua, N. H. ⁴	171,105	288.37	1.7	1,550	23.37	15.1
San Joaquin Valley, Calif. ⁴	43,911	138.42	3.2	3,754	35.11	9.4
Superior, Wis.....	18,234	104.22	5.7	3,312	25.31	7.6
Greenfield, Mass. ⁴	41,393	634.35	15.3	3,403	45.50	13.4
Manchester, Conn.....	29,813	263.22	8.8	2,538	50.58	19.9
Helena, Ark.....	108,640	248.00	2.3	3,559	35.44	10.0
Marianna, Ark.....	47,663	173.56	3.6	1,860	33.67	18.1
Bristol, Tenn.-Va.....	87,540	208.37	2.4	4,111	28.76	7.0
Lewisburg, Pa.....	36,117	233.66	6.5	1,911	23.60	12.3

¹ Where the name of a community appears twice, two different distribution systems are represented. The following systems are municipally owned: Los Angeles, Seattle (first one listed), Tacoma, Lansing, Pasadena, Springfield.

² Industrial included with commercial.

³ Small industrial included with commercial.

⁴ Includes very large industrial customers served at primary voltages.

⁵ Service to customers in 24 cities and towns; rural, railway, and wholesale included with industrial.

⁶ High distribution costs in Greenfield are ascribed largely to the unusually scattered location of the industrial customers in that area, with resultant high unit investment in distribution facilities.

SOURCE: Federal Power Commission, National Power Survey, Power Series No. 3: *Cost of Distribution of Electricity*, tables S-4 and S-7, pp. 14-15, 20-21.

kilowatt-hours in order to remove, approximately, the influence of the high-load-factor group of industries.⁵⁶

Assuming these averages to hold good for New York State in 1937, and applying the 73-percent and 100-percent increases in consumption per customer which have previously been estimated for the interval 1937-50,⁵⁷ the following figures for average annual consumption per customer in 1950 are obtained:

	Kwh.
"Small" commercial (i. e., commercial).....	7,679
"Large" commercial (i. e., industrial).....	360,318

From charts 22 and 23, it would appear that the corresponding

⁵⁶ The procedure is as follows: Total 1937 industrial and high-load-factor sales in New York State (7,212 million kwh.) are divided by the United States average sales to "large commercial" customers in 1937 (260,364 kwh.), giving 27,700 as the number of customers. Then the 1937 industrial sales in New York State (5,212 million kwh.) are divided by 27,700, giving 180,159 as the average sales per industrial customer. The number of high-load-factor customers is relatively negligible. This method assumes that the proportion of high-load-factor sales is as high in the United States as in New York State, which is not true; it thus understates the probable average sales per ordinary industrial customer.

⁵⁷ It has been estimated earlier in this section that the annual power expenditure per customer will increase 80 percent for commercial service and 50 percent for industrial service; also that each dollar will buy one-third more energy in 1950 than in 1937. Consequently, the increase in consumption per customer will be 73 percent for commercial service (130 percent X 133 1/4 percent = 173 percent), and 100 percent for industrial service (150 percent X 133 1/4 percent = 200 percent).

average distribution costs are 7.5 mills per kilowatt-hour for commercial service and rather less than 2.0 mills per kilowatt-hour for industrial service. The total costs of rendering these classes of service, including generation, transmission, and distribution, can now be calculated as in table 55.

This table shows the estimated total cost of generation, transmission, and distribution in 1950 to be 11.4 mills per kilowatt-hour for industrial power, 22.8 mills per kilowatt-hour for commercial power, and 15.5 mills per kilowatt-hour for both classes taken together. Rates such as to yield average revenues at these levels, then, would repay all costs, including insurance, amortization, taxes, and a fair return on investment.

It remains to compare this level of average revenue with that prevailing in New York State in 1937, to see whether we were justified in the original assumption of a 25-percent reduction in average commercial and industrial rates. Unless the 1950 average revenue shows at least a 25-percent reduction under the 1937 average revenue, the estimates of increase in energy consumption based on such a reduction must be invalidated.

In the 1937 figures it is not possible to distinguish at all accurately between industrial and commercial service, so the two classes must be taken together. The Census of Electrical Industries reports the following data for private utility sales to nonfarm industrial and commercial customers in New York State in 1937:⁶⁸

Number of customers.....	590, 232
Current sold (kwh.).....	9, 828, 227, 018
Revenue.....	\$175, 588, 471

TABLE 55

Calculation of estimated total 1950 cost of commercial and industrial service

Class of service	Commercial	Industrial	Total
Annual sales (millions of kilowatt-hours).....	5, 023	8, 860	13, 883
Cost of power ready to distribute.....	\$77, 064, 164	\$82, 879, 892	\$159, 944, 056
Distribution cost.....	37, 672, 500	17, 720, 000	55, 392, 500
Total cost, including distribution.....	114, 736, 664	100, 599, 892	215, 336, 556
Cost of power per kwh. (mills) ready to distribute.....	15.3	9.4	11.5
Distribution cost.....	7.5	2.0	4.0
Total cost.....	22.8	11.4	15.5

The above figures, however, include the high-load-factor group of industries. The influence of this group can be removed as indicated in table 52, above, giving approximate average revenue of 21.8 mills per kilowatt-hour for ordinary industrial and commercial sales in 1937. In 1950, it is estimated (in table 55) that average revenue of

⁶⁸ Census of Electrical Industries, *Electric Light and Power Industry*, 1937, table 39, p. 66.

15.5 mills per kilowatt-hour in these classes of service would cover all costs and allow a fair return. This 1950 figure represents a reduction of 29 percent below the 1937 figure. Consequently, we must conclude that the provisional assumption of a 25 percent reduction in industrial and commercial rates, on which the consumption estimates were based, errs if anything on the side of conservatism. A greater reduction, which seems not unlikely, would provide still further stimulus to energy sales as well as to profits.

Section 8

GENERATING CAPACITY REQUIREMENTS

The amount of generating capacity required to deliver the estimated net energy requirements depends on the efficiency of the system and the extent to which the peak demands of different classes of service are diversified or non-simultaneous. An elaborate report on these questions was presented by the Power Authority in its 1938 report, and the efficiencies and load factors there assumed will here be applied to our estimate of 26,632 million kilowatt-hours of energy sales.⁵⁹

First, there is the matter of losses in transmission and distribution, which are assumed to absorb 15 percent of all energy generated. In order to deliver 26,632 million kilowatt-hours, then, there must be generated 31,332 million kilowatt-hours ($26,632 \div 85 \text{ percent} = 31,332$). On the basis of extensive investigations, the Power Authority assumes a 57 percent load factor for the State-wide coordinated system as a whole.⁶⁰ A load factor of 57 percent means that average energy output is 57 percent of peak demand for the system. The generation of 31,332 million kilowatt-hours in a year would mean an average demand of 3.577 million kilowatts, since there are 8,760 hours in a year and $31,332 \div 8,760 = 3.577$. If this average demand of 3.577 million kilowatts is 57 percent of the peak demand, the peak demand, which the system must be ready to provide, is 6.275 million kilowatts ($3.577 \div 57 \text{ percent} = 6.275$).

For the State as a whole, then, the peak load in 1950 is expected to be 6,275,000 kilowatts. At least that amount of capacity must be available to meet peak demands. At 746 watts to the horsepower this is equal to 8,412,000 horsepower.

According to the Power Authority's coordination plan, which is

⁵⁹ Cf. Power Authority, *1938 Annual Report*, appendix 4, sec. 2, pp. 146-156. This load factor of 57 percent for the entire State is obtained from the Power Authority's estimates as follows: Total energy supply is estimated by the Power Authority at 26,670 million kilowatt-hours, which with allowance of 15 percent for losses would call for generation of 31,611 million kilowatt-hours. The peak load is estimated by the Power Authority at 6,300,000 kilowatts (see note 60 below), and dividing 31,611 million by 8,760 times 6,300,000 gives 57 percent as the annual load factor for the whole system.

⁶⁰ *Ibid.*, p. 148. In 1937 the Niagara-Hudson system had a load factor of 76 percent, while that of the Consolidated Edison system was 50 percent. As between the up-State and metropolitan areas there is a diversity of about 5 percent (*Ibid.*, pp. 148-149). In the Power Authority's plan, however, this regional diversity is not taken advantage of.

based on a 1950 peak load of 8,400,000 horsepower, the existing private hydro plants of the State can be counted on for about 1,200,000 horsepower of dependable capacity. Existing steam stations can supply 4,650,000. The remaining necessary capacity, 2,562,000 horsepower according to present estimates, will have to be constructed during the next decade. The Power Authority proposal is to develop 787,500 additional horsepower at Niagara and 1,100,000 in the International Rapids Section, and to contract for enough steam capacity to firm-up all of this new hydro power. The remaining load—about 675,000 horsepower—will be provided for by additional private construction between now and 1950.

In summary, it is clear that the proposed Niagara-St. Lawrence hydro development will supply 1,887,500 horsepower, or not quite three-fourths of the increase in power requirements that can be confidently expected in the next decade.

CHAPTER IV

THE EFFECTS OF ST. LAWRENCE-NIAGARA POWER ON NEW YORK STATE'S INDUSTRIAL GROWTH

In previous chapters it has been shown that New York State's increasing dependence upon steam power, in which it is at a cost disadvantage due to distance from fuel supplies, makes the State unattractive for the establishment of new industries using relatively large amounts of power. The State's competitive position will become worse to the extent that the area's original power-cost advantage will recede as other areas develop cheap hydro power. Unless other developments not now in sight reverse current trends, the State seems unlikely to experience before 1950 any substantial growth in manufacturing employment beyond the levels attained 20 years ago. Whereas other regions are forging ahead, New York State is trying to catch up with its past.

The final appraisal of the benefits of the proposed hydro development must of course turn on a consideration of the economic effects specifically ascribable to the project; and these it is now proposed to measure. It has been established that the development will not threaten existing utility investments; it will supply the increased power requirements of the future. It is now proposed to inquire whether the St. Lawrence-Niagara plan will significantly affect general industrial development in the tributary area as compared with alternatives.

On the basis of its load estimates the Power Authority has calculated the costs of meeting the estimated 1950 demands under two alternative schemes: (a) With the St. Lawrence-Niagara coordinated development and (b) under the best feasible alternative plan of steam generation.

To the extent that any economies of the hydro plan, reflected in lower rates, would affect the growth of consumption, the load of course would actually be different under the two alternatives. For purposes of cost comparison, however, it seems legitimate to set up costs for equal deliveries of power under the two plans as the Power Authority does.

The difference in average generation and transmission costs between the two plans works out at almost exactly 1 mill per kilowatt-hour.¹

¹ Power Authority of the State of New York, *1938 Annual Report*, p. 25. The cost of power "ready to distribute" is computed at 9.66 mills under the proposed St. Lawrence-Niagara plan, as compared with 10.67 mills under the alternative steam plan.

Of course, this takes into account the downward trend of steam as well as hydrogeneration costs. The saving of the St. Lawrence plan as compared with *present* rates, which is nearly 5 mills per kilowatt-hour, should not be used in estimating the effect *specifically ascribable to the project*. It is the difference in the cost of power and rates between the two alternative plans in the future that enters into the present attempt to estimate the degree of industrial expansion that may result specifically from the St. Lawrence project. For this purpose the average saving per kilowatt-hour will be taken as one mill.

This assumption does not apply to the electro-process industries, for which the Power Authority's hydro plan specifically set aside 1.05 billion kilowatt-hours annually, in addition to present requirements. This power would be used in the immediate neighborhood of the hydro plants, at an estimated average load factor of 80 percent as compared with 35 percent for other industries and 20 to 50 percent for the remaining classes of use.³ It is planned to market this specifically allocated part of the power on terms which will bear comparison with such areas as Bonneville and T. V. A.

The analysis which follows will then consider separately the high-load-factor industries, and other manufacturing industries.

Section 1

HIGH-LOAD-FACTOR INDUSTRIES

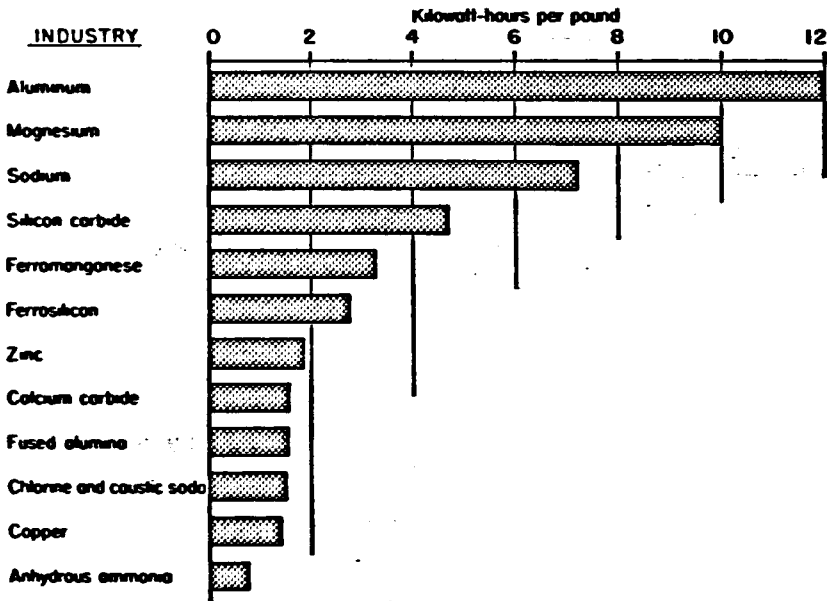
In an earlier section, some consideration was given to the electro-process or high-load-factor industries of the Niagara area. The importance of these industries to the general industrial structure of the area, and their dependence on cheap hydroelectric power, were briefly indicated. It is obvious that these industries, using large amounts of electric energy, are more directly dependent on power costs for their profitable operation than are other types of manufacturing enterprises. The early concentration of the electroprocess industries around Niagara Falls bears sufficient witness to that.

The St. Lawrence power development on the International Rapids Section is designed to operate initially as a run of river plant. The river, furthermore, has a highly even flow, with comparatively slight variations between maximum and minimum. This is because the Great Lakes operate as natural reservoirs. Consequently, the energy generated is, because of its continuous nature, suitable for use either by high-load-factor industries or in the base load of an integrated power system. Both of these uses are contemplated for St. Lawrence power. At this point, the discussion centers on its suitability for high-load-factor industries because of its low generating costs.

³ *Ibid.*, p. 152.

The simplest measure of the importance of cheap power to any given industry is the amount of energy required per dollar's worth of product. Manufacturing industries as a whole, as reported in the 1937 Census of Manufactures, purchased only 0.77 kilowatt-hours of energy for each dollar's worth of product, and probably a little more than one kilowatt was consumed.³ In the electro-process industries, however, energy consumption runs much higher, as shown in table 56 and chart 24. The manufacturer of aluminum, for example, must

Chart 24 - ELECTRIC ENERGY CONSUMPTION PER UNIT OF PRODUCT IN SELECTED ELECTROCHEMICAL AND ELECTROMETALLURGICAL INDUSTRIES, 1937



Source Table 56

WPA 3710

provide 12 kilowatt-hours of energy for each pound of metal produced, which at 1938 prices means 60 kilowatt-hours per dollar's worth of product. At the November 1940 price of 17 cents a pound, 12 kilowatt-hours per pound would be nearly 71 kilowatt-hours per dollar's worth of aluminum.

³ In addition to the 45.9 billion kilowatt-hours of purchased energy reported by quantity, manufacturers bought additional electricity for \$12,800,000, or about 1.3 billion kilowatt-hours, reported by cost only. Further, they generated an unknown amount of energy for their own consumption, which can be only very roughly estimated. In 1928, manufacturers had 12.4 million horsepower of motors driven by such energy, and if this same capacity be assumed for 1937, with an average use of 2,000 hours in the year, this would require 18.6 billion kilowatt-hours of energy (12.4 million x 2,000 x 0.746). Adding this to the estimated 1937 purchases gives a total estimated 1937 industrial consumption of 65.7 billion kilowatt-hours, or 1.66 kilowatt-hours per dollar's worth of manufactured product. The data here used are all from the U. S. Census of Manufactures.

TABLE 56

Electric energy consumption in selected industries, 1937¹

Product	Kilowatt-hours required	
	Per dollar's worth of product	Per pound of product
Silicon carbide.....	128.6	4.69
Ferrosilicon (50 percent content).....	88.6	2.75
Ferromanganese (80 percent content).....	71.0	3.25
Aluminum.....	60.0	11.99
Fused alumina.....	56.1	1.57
Sodium ²	38.3	7.20
Zinc (electrolytic reduction).....	37.1	1.86
Magnesium.....	33.3	10.00
Calcium carbide.....	31.5	1.58
Chlorine and caustic soda ³	27.6	1.50
Anhydrous ammonia.....	17.0	.76
Copper (electrolytic leaching of ore).....	12.8	1.41

¹ Based on data of Federal Power Commission, *Power Requirements in Electrochemical, Electrometallurgical, and Allied Industries* (1938), table 3, p. 14.

² 1.54 pounds of chlorine as byproduct.

³ 1 pound caustic soda plus 0.885 pounds chlorine.

The actual importance of power costs in locating an industry will, of course, depend on the extent to which a power cost differential would compensate for other cost differences between alternative locations. It is obvious, however, that a process requiring 12 kilowatt-hours to the pound, or 24,000 kilowatt-hours to the ton, as in the case of aluminum, will be located with reference to cheap power. A power-cost differential of as little as 1 mill per kilowatt-hour would amount to \$24 on each ton of the product. Savings on the order of \$24 a ton of product would in most instances outweigh differentials in labor, other production costs, or transportation. In cases where electricity consumption is smaller, power costs may still be a very important factor, even if not always predominant, in determining the geographic distribution of the industry.

Aluminum.

In the production of aluminum, New York State has been a leader and possesses two of the four plants now in operation: One at Niagara Falls and one at Massena. The other two plants, more recently developed and extended, are in Tennessee and North Carolina and a fifth plant is being built in the Bonneville area. It is noteworthy that the expansion of aluminum manufacture in the Southeast and in the Pacific Northwest has gone on rapidly subsequent to the exhaustion of the original cheap power possibilities in New York State.

The following statement by the Bureau of Mines, from the *Minerals Yearbook*, 1940 (Bauxite and Aluminum preprint, pp. 10-11) covers some recent developments:

Primary aluminum production in the United States in 1939 increased 14 percent in quantity and value over that in 1938 and was the largest on record. Output would have been greater had

it not been for the unusually low rainfall in certain areas, which reduced the amount of power available. Of the total output, 41 percent was made at Alcoa, Tenn.; 35 percent at Massena, N. Y.; 13 percent at Badin, N. C.; and 11 percent at Niagara Falls, N. Y.

In 1939 the Aluminum Co. of America completed a \$26,000,000 expansion program begun in 1937 and later announced the beginning of other developments to cost \$30,000,000. A new aluminum-reduction plant to be finished about January 1, 1941, at Vancouver, Wash., will utilize Bonneville power and alumina shipped from existing plants, and it will be capable of producing 30,000 short tons of metal annually. This plant, together with a 20-percent increase in capacity of the Alcoa works, will enable the company to produce more than 215,000 tons of aluminum annually. In addition to the development of reduction works, the new program will include: A bauxite beneficiating and drying plant at Paranam, Surinam, of 450,000 tons annual capacity; acquisition of additional ore-carrying vessels by the Ocean Dominion Steamship Co. to take care of increased bauxite shipments from South America; additions to the alumina works at Mobile, Ala., and East St. Louis, Ill.; hydroelectric-station improvements along the Little Tennessee River; improved laboratory facilities; and enlarged manufacturing capacities at Alcoa, Tenn., Cleveland, Ohio, Lafayette, Ind., Los Angeles, Calif., Massena, N. Y., and New Kensington, Pa.

The trend of domestic production of primary aluminum shows a very rapid increase (see table 57 and chart 25).⁴ New uses for the metal and its alloys are being rapidly developed, due to its special properties of lightness, malleability, ductility, noncorrosion, and low

TABLE 57

Domestic primary production of aluminum in the United States, 1908-39

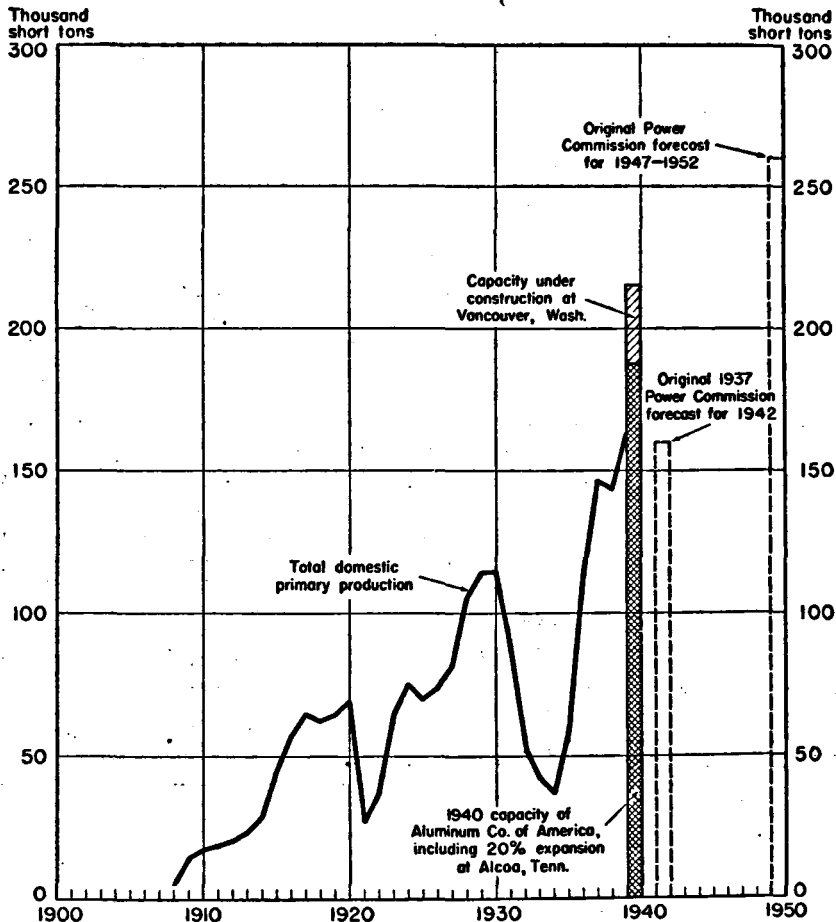
Year	Production in short tons	Year	Production in short tons
1908	5,340	1924	75,282
1909	14,540	1925	70,058
1910	17,701	1926	79,693
1911	19,198	1927	81,804
1912	20,903	1928	105,272
1913	23,640	1929	113,986
1914	28,988	1930	114,518
1915	45,252	1931	88,472
1916	57,554	1932	59,464
1917	64,930	1933	42,562
1918	62,362	1934	37,083
1919	64,238	1935	59,848
1920	69,021	1936	112,465
1921	27,266	1937	146,340
1922	36,816	1938	143,441
1923	64,329	1939	163,645

SOURCE: United States Bureau of Mines; 1908-36 data as given in Federal Power Commission, *Power Requirements in Electrochemical, Electrometallurgical, and Allied Industries*, table 1, p. 20. 1937-39 data from *Minerals Yearbook*, 1940, preprint of "Bauxite and Aluminum" chapter, p. 10.

⁴ The Federal Power Commission estimated an annual production of aluminum of 160,000 tons by 1942, *Power Requirements in Electrochemical, Electrometallurgical, and Allied Industries* (1938), p. 34. This estimate was surpassed in 1939. As a result of the new expansion program, aluminum production by 1942 was estimated at 412,500 short tons. Edward R. Stettinius, Jr., National Defense Advisory Commission, press release, November 28, 1940.

heat-emissivity. Extruded structural shapes, heat-insulation foil, barrels, and tanks, and architectural trim are examples of uses which take advantage of one or more of these properties.

Chart 25—DOMESTIC PRIMARY ALUMINUM PRODUCTION
1908—1939



Source: Table 57

WPA 3711

The greatest market at present is in alloys requiring strength and lightness, for all kinds of transportation equipment, electric cables,⁵ and large mobile parts such as dredge booms and power-shovel dippers where the reduction of dead weight is important.

⁵ About a third of the aluminum consumed in the United States until recently was going into transportation equipment and one-eighth into electric conductors, according to estimates by the Aluminum Co. of America, quoted in Federal Power Commission, *op. cit.*, p. 19. Cooking utensils take about one-sixth of the total. Due to the rapid expansion of the aircraft industry, the proportion of aluminum used in transportation equipment is now much higher and rapidly rising.

The primary basis of the estimates of this study is the trend of normal peacetime demand. In the case of aluminum, however, one can hardly ignore the tremendous additional demand of the air defense program. The following item from the *New York Times*, August 9, 1940, speaks for itself. The figures were originally quoted in pounds but have been converted to short tons in order to facilitate comparisons.

Aluminum Called U. S. "Bottleneck"

The production of aluminum, the largest single ingredient required for airplane manufacture, was pictured yesterday as one of the "bottlenecks" that threaten the production of defense goods. The charge was made by Walter L. Rice, special assistant to the Attorney General in charge of the government's anti-trust suit against the Aluminum Co. of America and 60 other defendants.

Questioning I. W. Wilson, vice president of the company, Mr. Rice brought out that the total capacity of the company's plants this year would be 187,500 short tons of aluminum. Last year's production amounted to 163,500 tons, Mr. Wilson testified.

Mr. Rice then asked how much aluminum was used in the production of a Martin bomber, which was set at 8 tons. To make 50,000 such planes, the number asked by President Roosevelt, Mr. Wilson figured, would require 400,000 tons of aluminum.

Under questioning by defense counsel W. W. Smith, however, Mr. Wilson said he believed the metal produced by the company was sufficient to meet current requirements. Planned expansion will take care of the future, he said. He testified also that a new plant, which will add 30,000 tons a year to production capacity, is nearing completion at Vancouver, Washington. This plant will receive power from the Bonneville Dam.

Another plant, to increase production facilities by another 30,000 tons, is to be built in the Tennessee Valley area, the witness said. That project is expected to be finished by July 1, 1942, according to the testimony.

The inception of an active rearmament program with emphasis on aircraft and mobile equipment thus throws peacetime estimates far into the shade. The severe curtailment of imports (which in 1937 amounted to more than 22,000 tons in crude and semi-crude forms or about one-sixth as much as the domestic primary production of the metal*) will of course call for still further expansion.

The extrapolation of the Federal Power Commission estimates indicates a domestic primary output of 190,000 tons by 1950, and the Commission's report stated that "within 10 to 15 years" (from 1937) an annual domestic primary production of 260,000 tons could be expected, with the continuance of the influences obtaining in 1937. On the basis of developments since then, and the defense program in

* *Statistical Abstract*, 1938, table 737, p. 722, and Federal Power Commission, *op. cit.*, table 1, p. 20. The chief sources were Canada, Switzerland, and Norway, with smaller amounts from France, Germany, and Great Britain (*cf. Foreign Commerce and Navigation of the United States*, 1937).

particular, one may say that the prospects for increased aluminum production in this country have still further improved. It can be confidently expected that primary production will pass the 260,000-ton figure long before 1950. This figure represents an increase of 78 percent over 1937, which was itself a peak year.

Evidence has already been presented to show that New York State cannot expect to share in this 78 percent expansion under the present conditions of power supply. The possibility of importing power from Canada on an increased scale does not offer a solution, since the amount of such power available for export from Canada is likely to decrease as Canadian markets expand, and in any case the contracts would remain terminable on short notice. The proposed Niagara-St. Lawrence development offers an opportunity to put the Niagara and Massena areas back on an equal footing with rival regions so far as power rates are concerned. New York State is at no disadvantage in procuring the necessary raw materials (alumina or bauxite, and Greenland cryolite)⁷; and the opening of the St. Lawrence Seaway might further improve its position, making it possible to bring bauxite up the St. Lawrence. In relation to markets for aluminum, New York State has an advantage over both the T. V. A. and Bonneville areas.

Although it may be hazardous to attempt to predict the policies of an individual firm, it would certainly appear justifiable to expect New York State to get its share of the national growth of the aluminum industry if the Niagara-St. Lawrence development is undertaken.

Chlorine and Caustic Soda.

These two products, obtained by electrolysis of ordinary salt brine, constitute essential materials for a very large number of further processes and products, including water purification, soap, glycerine, pulp and paper, carbon tetrachloride, explosives, solvents, bleaches and cleaners, antifreeze, oil refining, dyes, and rayon. The importance of low power costs in the electrolytic process is shown by the fact that 27.6 kilowatt-hours are required for each dollar's worth of products. In physical terms, 1.5 kilowatt-hours are required for the joint production of 1 pound of caustic soda and 0.885 pound of chlorine.

Caustic soda is also produced by an alternative method, the lime-soda process; but the electrolytic process has been rapidly gaining ground because of the growing demand for chlorine, and in 1937 accounted for 50.5 percent of the total output.⁸ Electrolytic caustic

⁷ At present, South American and Arkansas bauxite are converted to alumina at East St. Louis and Mobile; and cryolite, of which relatively small quantities are needed, is imported through New York City. Experiments in the manufacture of artificial cryolite from native ores have been conducted in the Tennessee Valley.

⁸ *Census of Manufactures, 1937*, table 4, p. 654, and *Chemical and Metallurgical Engineering* estimate for additional electrolytic production in pulp and paper mills for their own use, which is not reported by the Census.

soda production increased from 94,843 tons in 1919 to 266,807 tons in 1929 and 498,919 tons in 1937, the record year to date.

Although caustic soda is used in such growing industries as rayon and petroleum refining, the more important factor in the increase of electrolytic production is, as indicated, the demand for chlorine. The Federal Power Commission report quotes the following estimate of 1936 domestic uses of chlorine, "from a trade source":⁹

	Percent
Chemical manufactures.....	51
Bleaching pulp.....	30
Sanitation.....	6
Bleaching textiles.....	5
All other uses.....	8

The future of these uses is believed to be one of continued expansion, and additional uses are being discovered. The Federal Power Commission estimate made in 1937, was that by 1942 the annual production of electrolytic chlorine would reach 500,000 tons, representing a 21-percent increase over 1936. It seems very probable, as a matter of fact, that production in 1937 was actually in excess of 500,000 tons, though complete data are lacking.¹⁰ By 1950 it seems not unreasonable to expect a repetition of the 1929-37 increase of 87 percent.

New York State is exceptionally well situated with respect to the raw material, being a leading salt-producing State with the principal deposits in the Syracuse area. In addition, many of the expanding markets for chlorine and caustic soda—notably the general chemical industry—are close at hand. However, one very rapidly growing chlorine market (the bleaching of kraft pulp) is developing in the South and seems likely to attract a considerable share of the new chlorine capacity to that section.¹¹ Consequently, the caustic-and-chlorine industry must be regarded as one in which even with cheap power New York State can scarcely hope to hold its full share of national production. Instead of a growth of 87 percent for the period 1937-50, we shall take for New York State the estimate of 50 percent increase in production. Even this represents a substantial amount of added production, since in 1937 the State had 10 of the 40 electrolytic chlorine plants in the United States.¹²

⁹ Federal Power Commission, *op. cit.*, p. 69. "Chemical manufactures" include antifreeze, carbon tetrachloride, chlorinated naphthalene, chloroform, refrigerants, hypochlorites, bromine, ethyl gasoline.

¹⁰ Electrolytic caustic soda production in 1937 was, as previously stated, 498,919 tons. Applying the ratio of 0.885 to 1 to this gives an estimated 441,543 tons of chlorine produced in conjunction with electrolytic caustic soda. In 1936, this process accounted for 86 percent of all electrolytic chlorines (Federal Power Commission *op. cit.*, table 2, p. 66); applying this same ratio in 1937, we reach a total estimate of 513,422 tons of electrolytic chlorine.

¹¹ Federal Power Commission, *op. cit.*, p. 69. Three examples are there given of recently built chlorine plants in the Gulf coast region.

¹² Federal Power Commission, *op. cit.*, p. 65, map and list of producers of chlorine by all electrolytic processes, including 15 pulp and paper mills and 1 oil refinery. Eight of New York's 10 plants were in the Buffalo-Niagara area, 1 at Syracuse, and 1 near Troy.

Electric Furnaces.

The part played by electric furnaces in iron and steel production and the alloys needed for special steels is rapidly increasing. In 1938, 505,024 long tons of steel were made in electric furnaces. This represents less than 2 percent of the total steel output, but in the production of alloy steel ingots and castings, electric furnaces accounted for 332,475 long tons out of a total for the country of 1,476,348, or 23 percent. The Bureau of Mines states that "the bulk . . . of the steel made in the electric furnace is alloy steel. Typically, steels with higher alloy content are made in the electric furnace, and steels with lower alloy content are made by the open-hearth process."¹³

In the making of ferro-alloys themselves the electric furnace is of still greater importance, as table 58 shows. In 1938, a year of relatively low production, 584,724 long tons of ferro-alloys were produced in the United States, of which 244,161 tons, or about 42 percent, came from electric furnaces.

There is a compounding of growth factors in electricity consumption in the making of alloy steels. Steel consumption is increasing, and the demand for special alloy steels is a larger and larger part of the total. Then there is a steady trend toward the use of higher alloy content which means that high-alloy steel production tends to increase still faster. And high-alloy content steels, as noted, are characteristically electric-furnace products. Furthermore, this calls for still more of the necessary alloys which are themselves largely electric-furnace products.

TABLE 58

Electric-furnace production of ferro-alloys in the United States, 1938

Ferro-alloys	Electric-furnace production	
	Amount (long tons)	Percent of total production
Ferrosilicon.....	122,070	48.9
Ferrophosphorus.....	14,000	"Most"
Ferrotungsten.....	442	100.0
Ferromanganese.....	(?)	"Small"
Other.....	100,000	"Very high"
Total.....	244,161	41.8

¹ Total ferrophosphorus production was 15,842 long tons, and "most of the 1938 output was made in electric furnaces" (*Minerals Yearbook*, 1939, p. 569).

² Total shipments of ferromanganese were 223,720 long tons "made at 7 blast-furnace plants and 1 electric-furnace plant . . . the bulk of the output was made in blast furnaces" (*ibid.*, p. 569).

³ Rough estimate on basis of other figures given in table.

SOURCE: All data from U. S. Bureau of Mines, *Minerals Yearbook*, 1939, pp. 534, 568-569. "In 1938, ferro-alloys were made at 12 blast-furnace plants, 16 electric-furnace plants, and 3 aluminothermic plants; in addition, 3 plants made ferrophosphorus, and 1 plant made ferrosilicon, as a byproduct." (*Ibid.*, p. 568.)

¹⁴ U. S. Bureau of Mines, *Minerals Yearbook*, 1939, p. 572.

In iron foundries, electric furnaces in duplex with fuel-fired cupolas offer substantial advantages by way of flexibility and greater ease of control of quality, and this opens the possibility of tremendous expansion of electric energy consumption in low-rate areas where there is a market for iron castings. Improved process control made possible by electric heating has already revolutionized the properties and uses of cast iron.¹⁴

Future developments in the steel industry not yet in even an experimental stage may very radically increase the importance of power costs to the industry as a whole. For instance, if a practicable ingot soaking pit can be developed for electric use, this will open the way to a tremendous market for electric energy. The expansion of electric heat-treating of steel in resistor furnaces since 1920 has been very rapidly applied to pressed-steel automobile bodies, bearings, etc. However, the cost of electric power is not the most important factor in locating these processes, since they are generally part of an integrated series of operations in a larger industry. For this reason, heat-treating in New York State will not be included among the electroprocess industries whose growth depends on the provision of additional cheap power.

The prospects for continued expansion in ferrous electrometallurgy would thus be bright, even without consideration of recent developments in connection with the national defense program. The Federal Power Commission survey forecasted 3 years ago the following percentage increases for the 6-year period 1936-42:¹⁵

	<i>Percent</i>
Electric-furnace iron.....	90
Electric-furnace steel.....	48
Electric-furnace ferro-alloys.....	43
Total.....	46

In view of the vital role played by alloy steels in the national defense program, it is certainly likely that this increase will be redoubled by 1950, which would mean a 1937-50 increase of over 100 percent (146 percent X 146 percent = 213 percent).

At present, New York State is fairly prominent in these industries, by virtue of cheap Niagara power, nearness to markets in the steel and metal-working industries, and water transport of imported and domestic raw materials. Table 59 shows the 1937 distribution of electric arc furnace capacity in the United States, in which New York State accounts for over 9 percent of the national total, with the Buffalo area leading. The submerged-arc furnaces used for ferro-alloys are concentrated in the Niagara area to a much greater extent,

¹⁴ See Federal Power Commission, *op. cit.*, pp. 78-79, with further references there cited.

¹⁵ *Ibid.*, p. 18.

with 4 out of the country's 15 furnace installations located there. The Federal Power Commission states that for the country as a whole, "about 95 percent of the energy . . . for years before 1935 was purchased from utilities supplied largely from hydroelectric sources, and the remainder was generated in the industry's own stations."¹⁰

TABLE 59

Electric arc furnaces for melting iron and steel, by States, in order of importance, 1937

Area (chief centers in each State indicated with percentage of State capacity)	Aggregate capacity (short tons per charge)	Percentage of total United States capacity
Pennsylvania (Pittsburgh 67.0 percent.)	375.4	20.1
Michigan (Detroit 80.0 percent.)	201.9	10.1
Ohio (Canton 77.5 percent.)	290.0	15.5
Illinois (Chicago 83.7 percent.)	173.9	9.4
New York (Buffalo 38.0 percent.) (Albany-Troy-Schenectady area 24.9 percent.) (Syracuse 18.3 percent.) (Dunkirk 13.0 percent.)	169.6	9.1
West Virginia (Charleston 98.5 percent.)	99.5	5.4
California	86.8	4.7
Wisconsin (Milwaukee 75 percent.)	50.2	2.7
Maryland (Baltimore 100.0 percent.)	39.6	2.1
Washington (Seattle 69.4 percent.)	39.0	2.1
Massachusetts (Boston 78.5 percent.)	33.4	1.8
New Jersey	30.8	1.7
Indiana	29.7	1.6
Virginia (Norfolk area 83.9 percent.)	18.5	1.0
Missouri (St. Louis 77.5 percent.)	15.4	.8
Connecticut	14.2	.8
Texas	13.0	.7
Kansas (Atchison 100 percent.)	11.5	.6
All other States ¹	71.9	3.8
United States	1,864.3	100.0

¹ These States in order of importance are Alabama, Minnesota, District of Columbia, Louisiana, Iowa, Colorado, Utah, Tennessee, Arkansas, Georgia, Nebraska, Arizona, Delaware, Nevada, New Hampshire, Oklahoma, Florida, and North Carolina. Each of them constitutes less than 0.5 percent of the total.

SOURCE: Federal Power Commission, *Power Requirements in Electrochemical, Electrometallurgical and Allied Industries*, 1938, pp. 74-75.

¹⁰ *Ibid.*, p. 84.

In induction furnaces, New York State is estimated to have about 4 percent of the ferrous and 8 percent of the nonferrous capacity.⁷

The probable future expansion of electrometallurgy and heat treating in New York State will depend mainly on whether additional cheap power is made available there to meet the competition of the regions which are at present getting all of the expansion in these industries. With the St. Lawrence seaway and power development, the State should certainly be at no disadvantage in regard to power, markets, or water-borne materials. A considerable potential advantage is the presence, within New York State itself, of large magnetite ore deposits, at present being worked by the Republic Steel Corporation and the Chateaugay Ore & Iron Co.¹⁸ The average iron content in 1938 was 67.1 percent, the highest for any State, and about 2 million gross tons, or 7 percent of the national ore output, was mined in New York and at one Pennsylvania mine.¹⁹ Reserves are known to be very large.²⁰ The production of ferromanganese, which is likely to depend increasingly on new domestic sources of manganese ore,²¹ can probably expand in New York State only to the extent that ore can be shipped in by water or beneficiated at the mine, since nearly 2 tons of the ore are now required per ton of ferromanganese.²² On the whole, one would seem justified in expecting the State to retain at least its present share of the electrometallurgical and heat-treating industries and thus expanding them by the same percentage as the country as a whole, or an estimated 100 percent between 1937 and 1950.

Artificial Abrasives.

Though known under many trade names, artificial abrasives comprise only two important products—silicon carbide and fused aluminum oxide—and are all made in electric resistance or arc furnaces. Silicon carbide requires sand, coal, sawdust, and salt as raw materials, while fused aluminum oxide is produced either from the oxide itself or directly from bauxite.

In both cases, the predominant necessity for profitable production is cheap electric power. Two of the three American producers are in Niagara Falls and the third (relatively small in abrasives capacity) is in Alabama. It is interesting to note that no less than six subsidiaries of American concerns were making crude artificial abrasives in 1936 on the Canadian side of the Niagara area, and shipping their product

⁷ *Ibid.* p. 88.

¹⁸ *Minerals Yearbook, 1939, op. cit.*, p. 553.

¹⁹ *Ibid.* pp. 553-555. In order to avoid disclosures, the output of the important Cornwall mine in Lebanon County, Pa. is combined with the New York figure.

²⁰ See D. H. Newland and C. A. Hartnagel, *The Mining and Quarry Industries of New York State for 1934 to 1936, New York State Museum Bulletin*, No. 319, February 1939.

²¹ In 1938, 94.9 percent of all manganese ore used in making ferromanganese in this country was imported, mainly from Russia, Africa, Brazil, India, and Cuba. *Minerals Yearbook, 1939, op. cit.*, p. 569. Domestic deposits are widely distributed over 19 southeastern and southwestern States (Federal Power Commission, *op. cit.* p. 85) and at present are being treated in experimental plants.

²² *Minerals Yearbook, 1939, op. cit.*, table on p. 568.

into the United States in bulk for fabrication into grinding wheels and other finished products.²³

This would appear, then, to be an industry in which the Niagara area has outstanding advantages, provided that additional cheap power can be made available. Energy requirements are very high: 4.69 kilowatt-hours per pound of silicon carbide and 1.57 kilowatt-hours per pound of fused alumina. At 1936 prices, this means that 128.6 kilowatt-hours and 56.1 kilowatt-hours, respectively, are required per dollar's worth of product,²⁴ and a one-mill power-cost differential would mean a 13-percent and a 6-percent differential, respectively, in the total costs of these products.

The Federal Power Commission said in 1937: ". . . it seems reasonable to suppose . . . that the annual energy consumption within the next 5 years may approach the requirements for capacity operation of the three operating plants, or 116 million kilowatt-hours per year."²⁵

The past activity of the industry has followed the fluctuations of machinery production, as may be roughly indicated by comparison with the output of the motor-vehicle and parts industry. The ratio between indices of artificial abrasives production and of motor-vehicle and parts output appears to show if anything a slight upward trend over the period 1926-36.²⁶ Despite the competition of other forms of abrasives, then, it may be expected that the artificial varieties will share in any general expansion of machine production such as is now in prospect. In aircraft production, with highly machined and finished parts, the importance of abrasives is particularly great. At least a 25-percent increase would seem likely during the next decade, and with the St. Lawrence-Niagara hydro development, New York State should be in a good position to take her full share of the gain.

Summary.

It is believed that the industries discussed include the principal possibilities for expansion of electroprocess activity in New York State, contingent on development of further cheap power. Certain other electroprocess products have been intentionally omitted as not yet of great importance: For instance, calcium and lithium. Still others have been omitted because they are nonexistent or insignificant in New York State and because it is not expected that the State will provide a particularly advantageous location even if cheap power is available there: For instance, zinc. No consideration has been given to possible growth in copper refining because in the opinion of experts

²³ Herbert Marshall, F. A. Southard, Jr., and K. W. Taylor, *Canadian-American Industry*, Yale University Press, 1936, p. 75; quoted in Federal Power Commission, *op. cit.*, p. 94n.

²⁴ Federal Power Commission, *op. cit.*, table 3, p. 14.

²⁵ *Ibid.*, p. 95.

²⁶ Based on data in Federal Power Commission, *op. cit.*, p. 95, and Works Progress Administration, National Research Project, *Production, Employment, and Productivity in 69 Manufacturing Industries*, part II, p. 140.

present domestic capacity is sufficient to take care of the probable demand for some time to come.²⁷ Finally, no consideration has been given to the possible expansion of synthetic ammonia and calcium carbide production because of the especially great uncertainties in these fields and the fact that coal is an important necessary material. Other regions will continue to be somewhat better situated than New York State with respect to coal supply.

It can hardly be expected that the high-load-factor industries of New York State (now largely concentrated in the Buffalo area) will show appreciable further growth if no additional low-rate power is provided. On the other hand, the plants already established, with power contracted for at advantageous rates, may be expected to remain. Without the development of St. Lawrence and Niagara power, the most reasonable estimate of 1950 employment in these industries in New York State is, then, approximately the level of recent years.

A fairly close approximation to this figure may be gained from the Directory of New York State Manufacturers (1937), which lists manufacturing firms by products and indicates the number of employees. A list of the larger firms in the chief electroprocess industries in the Buffalo Industrial Area was given in table 12 above, followed by a summary (table 13) indicating total 1936 employment of over 14,000 wage earners in those industries in the Niagara and Massena areas.

As has been indicated in foregoing sections, the provision of a new supply of cheap high-load-factor power may be expected to enable these industries in New York State as a group to share in the national growth. The following estimates of percentage growth from 1937 to 1950 were made:

	<i>U. S.</i>	<i>N. Y. State</i>
Aluminum.....	78	78
Caustic soda and chlorine.....	87	50
Electric furnaces.....	100	100
Artificial abrasives.....	25	25

In chart 26 the estimates for New York State are depicted graphically for comparison with the 1942 estimates of the Federal Power Commission. A logarithmic vertical scale has been used, so that linear slopes represent rates of percentage change.

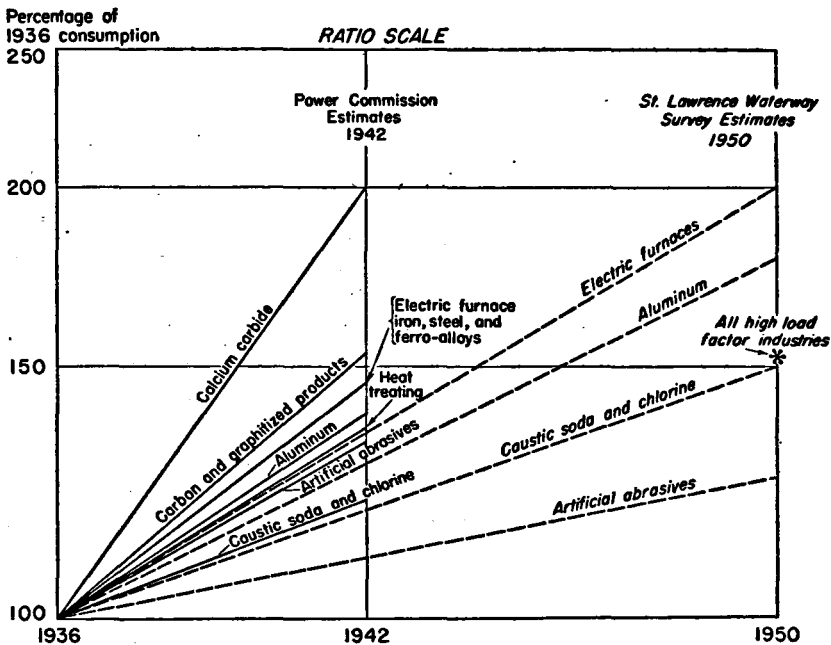
For further comparison there is the New York State Power Authority's estimate of 1.05 billion kilowatt-hours per year which it tentatively allocated to expansion of the high-load-factor group. Since, as has been estimated earlier, the 1937 consumption of these industries in the State was about 2 billion kilowatt-hours, the Power

²⁷ Federal Power Commission, *op. cit.*, p. 46. War demands are likely to upset this forecast, which was made in 1937.

Authority's figure of 1.05 billions additional corresponds to a 52.5 percent increase. This appears decidedly conservative in the light of the more detailed analysis here applied to the principal electro-process industries.

The 52.5-percent figure, although it is quite likely too low, is here adopted. One reason for this step is that the amount of very low-rate power available to the high-load-factor industries depends upon

Chart 26—ESTIMATES OF GROWTH OF ENERGY CONSUMPTION IN SELECTED ELECTROCHEMICAL AND ELECTROMETALLURGICAL INDUSTRIES IN THE UNITED STATES



Estimates for 1942 from *Power Requirements in Electrochemical, Electrometallurgical, and Allied Industries*, Federal Power Commission, Washington, D. C., 1938, p. 18.

Estimates for 1950, see text page

WPA 3712

the sales policy adopted by the public authority administering the sale of the new power. Such an authority will presumably aim at furthering the economic interests of the State as a whole, rather than any particular industrial group; and may, after a certain balance of the load has been reached, decide that greater benefits would accrue to the State from diffusing the remaining hydro power to general industrial, residential and farm use than by assigning it all to a few large-scale users. Such a policy would be to the best interests of New York State, and it is here assumed that it will be followed despite the Power Authority's qualifying statement that "in no sense does this

estimate 1.05 billion kilowatt-hours limit the ultimate use of power for electrothermal purposes. If additional development of such industries can be obtained, the coordinated system will make provision to supply it."²⁸

A 52.5 percent increase in the high-load-factor group would involve additional employment of more than 7,000 persons in the State (52.5 percent of the estimated 1937 employment), as a direct contribution of the St. Lawrence development. This, of course, ignores altogether the effect of growth of electrochemical and electrometallurgical industries upon other industries which use their products.

Section 2

MANUFACTURING INDUSTRIES IN GENERAL

Effect of Power-Cost Differential on Rate of Profit.

In considering the role of power costs in affecting general manufacturing activity, it is worth recalling that New York State at the present time does not have a particularly cheap power supply. It has already been noted in table 28 above, that in 2 out of 12 categories of power rates, New York is actually the most expensive State in the Union, and that in no class of rates is the State as cheap as either the median State or the national average.

When it is realized that the State-wide figures include the relatively low-rate Buffalo area, it is plain that the remainder of the State is still more disadvantageously served than the averages indicate.

A method generally used to show the relative importance of power costs to different manufacturing industries is to compute the ratio of kilowatt-hours purchased to value added by manufacture.²⁹ This procedure gives a rough notion, but is unsatisfactory, for the following reasons:

1. It leaves out of account the electric power generated by the factory for its own use. This constitutes a steadily decreasing share of industrial power consumption but is still important in many industries. The Aluminum Co. of America, for example, purchases relatively little electric energy. At Niagara Falls it purchases mechanical energy (i. e., the right to connect its generators to the power shaft), and at its other plants it generates much of its own hydroelectric power.

2. It does not indicate specifically the relative importance of power rates as compared with such other locational factors as transport costs.

²⁸ Power Authority of the State of New York, *1898 Annual Report*, p. 148.

²⁹ Cf. F. X. W., "Cheap Power and Industrial Migration," *Public Utilities Fortnightly*, August 17, 1939, p. 237.

For these reasons an attempt will be made to measure the influence of power costs on specific manufacturing industries by more appropriate methods. Two approaches are adopted: The first relates power-cost changes to rate of profit on investment, and the second relates them to transport costs and thus to the geographical extent of the market.

In table 60 are shown the calculated rates of average energy consumption per dollar's worth of product in the various selected industries, which makes it possible to express the effect of a 1-mill-per-kilowatt-hour change in energy costs as percentages of value of products.

It is evident that a cost difference amounting say to one percent of the value of the finished product will be much more important to an industry that turns over its capital rapidly than to an industry with a slow capital turn-over. If annual sales are three times the invested capital, a saving of one percent on sales adds profits amounting to three percent on invested capital. On the other hand, if annual sales are only half the invested capital, a one percent saving on sales amounts to only half of one percent in terms of return on capital.

TABLE 60

Prospective power savings in relation to capital investment, for selected industries

Industry	Wage earners in New York State, 1937 ¹		Estimated kilowatt-hours purchased per dollar of sales ²	Average ratio of annual sales to investment 1925-28 ³	Saving from 1-mill power cost reduction as percentage of investment
	Number	Percent of total			
Electrical equipment including radios and phonographs.....	32,982	3.31	0.571	1.02	0.058
Steel works and rolling mills and blast furnaces.....	22,469	2.26	1.476	0.70	.103
Motor vehicles, bodies and parts.....	19,673	1.98	.303	1.71	.052
Paper and cardboard.....	13,158	1.32	2.091	.56	.117
Chemicals.....	12,876	1.29	8.460	.76	.643
Nonferrous alloys.....	10,664	1.07	.922	1.07	.099
Iron and steel forgings and castings.....	7,185	.72	1.179	.68	.080
Silk and rayon woven goods.....	6,691	.67	.849	1.27	.108
Rubber products, excluding tires, tubes, shoes.....	4,878	.49	1.528	1.18	.180
Glass.....	4,747	.48	1.826	1.25	.228
Cotton woven goods.....	4,597	.46	2.621	1.01	.265
Flour and feeds.....	4,229	.42	.674	3.44	.197
Hardware and plumbers' supplies.....	3,555	.36	.662	1.10	.073
Tools, including saws.....	3,186	.32	.684	.77	.053
Clay and stone products, excluding pottery.....	2,192	.22	1.453	1.03	.150
Wire.....	1,825	.18	.571	1.02	.058
Cement.....	1,306	.13	7.091	.56	.397
Cotton yarn and thread.....	774	.08	3.325	1.45	.482
Total, above industries.....	156,987	15.76			

¹ *Census of Manufactures, 1937*. The Census classification of industries does not conform in all cases to that used by Ralph C. Epstein, but an effort has been made to select the closest possible counterparts of the industries specified.

² In most Census industries a small percentage of the energy purchases were reported by value only. Adjustment has been made for this by assuming that the average price per kilowatt-hour was the same for such energy as for that reported by both value and quantity. The range of possible error here is relatively negligible.

³ From Ralph C. Epstein, *Source Book for the Study of Industrial Profits, 1932*.

⁴ Rough estimate, not from Epstein but based on data in *Poor's Manual of Industrial Companies*.

In order, then, to appraise the true relative importance of power costs in different industries, it is necessary to determine the rate of capital turnover per year; that is, the relation between value of product and total capital. Such ratios are presented in table 60, computed from data in Ralph C. Epstein's *Source Book for the Study of Corporate Profits, 1932*, and referring to samples of corporations over the period 1925-28. The number of kilowatt-hours used per dollar's worth of product has then been multiplied in each case by the ratio of value of sales to total capital, thus obtaining the relationship between electric energy consumption and invested capital. On the basis of an average power-cost saving of 1 mill per kilowatt-hour under the projected power development plan,⁸⁰ the savings for individual industries are converted into terms of percentage on invested capital and shown in table 60.

The 18 industries included in this analysis may be ranked as follows on the basis of the effect of power-cost differentials on profits:

1. Chemicals.
2. Cotton yarn and thread.
3. Cement.
4. Cotton woven goods.
5. Glass.
6. Flour and feeds.
7. Rubber products.
8. Clay and stone products.
9. Paper and cardboard.
10. Silk and rayon woven goods.
11. Steel and iron works.
12. Nonferrous alloys.
13. Iron and steel castings and forgings
14. Hardware and plumbers' supplies.
- 15, 16. Electrical equipment and wire.
17. Tools.
18. Motor vehicles, bodies and parts.

The effect of a 1-mill reduction, as shown in table 60, varies from 0.643 percent on capital in the chemicals industry down to 0.052 percent in the automobile and parts industry. While these percentages appear small, they should be appraised with reference to usual earnings percentages. If an industry is making, for example, 6 percent on its investment, an additional 0.6 percent from power-cost savings offers a 10 percent boost in actual returns, which may significantly influence the growth of the industry in the region affected.

⁸⁰ Cf. Power Authority, *1938 Annual Report, op. cit.*, p. 25. It should be remembered that this differential does not apply to the high-load-factor industries, which are separately considered and for which the prospective differential is much larger. Also, any other industry finding it possible to locate near the generating station and to take power at primary voltages might expect a relatively low rate.

Effect of Power-Cost Differential on the Extension of Sales.

Unfortunately, the foregoing method provides no way of determining quantitatively the probable industrial expansion resulting from cheaper electric energy; it merely indicates the probability of substantially increased profits in a number of industries.

An alternative approach has been designed to yield a quantitative estimate of the expansion of New York State manufacturing directly induced by power-cost reduction. The estimate obtained is an exceedingly rough one, and not to be taken as strictly accurate with regard to any single industry, but at least it gives some indication of the order of magnitude of the effect on New York State industry in general.

In order to make clear the logic of the approach, a brief analytical discussion will be necessary. When a manufacturer's potential margin is increased by a reduction in his production expenses per unit, there are three ways in which he may convert this saving into an increase in sales.³¹

1. By passing the saving along to the buyer—i. e., lowering the average factory selling price of his product.

2. By passing the saving along to his advertising department or agency—i. e., increasing his outlays for sales promotion.

3. By passing the saving along to transport agencies—i. e., sending goods to more remote markets and thus paying larger average freight costs per unit.

Since all three methods are usually available, actual policy is likely to involve a judicious combination. Merchandising judgment is in fact devoted largely to deciding how far to go in each of these three directions of outlay in order to increase sales. For some parts of the manufacturer's output, he may concentrate on one method, while for other parts he concentrates on another method.

He is presumably aiming at a certain most profitable combination of policies; and this ideal combination will be attained when it is no longer possible to make any further net gain in sales by shifting a dollar of outlay from one form to another. Suppose at a given time his sales are 1,000 units a day. So long as it is possible to increase this by shifting say \$10 a day from sales promotion to price reduction,³² he has not yet arrived at the optimum combination of policies,

³¹ The assumption that the manufacturer will pass along the differential in one form or another, and take his own gain in increased sales at the same unit profit, might be questioned if a short period of time or a highly monopolistic situation were involved. For the case in hand, however, where reference is had to the longer-run effects of a change known a decade in advance, and where a certain degree of competition is present, the assumption here made seems the reasonable one. See the results of a questionnaire survey on this point in Harrod, Hall, Hitch, "Price and Cost in Entrepreneur's Policy," *Oxford Economic Papers*, No. 2, 1939. Another assumption underlying the present discussion is that the changes in rate of output here contemplated have no effect upon average unit costs. This assumption, too, would be unjustified for the short run, but appears appropriate for the analysis of ultimate results. It is not assumed here that all of a manufacturer's goods are sold at a uniform f. o. b. price.

³² i. e., cutting his advertising outlay by \$10 a day and lowering the price of his product by 1 cent.

and will approach closer to it if he makes the indicated shift. So long as it is possible to increase his sales over 1,000 by shifting say \$10 a day from price reduction to transport outlay,³³ he has not yet attained the optimum combination, and will approach closer to it if he makes the indicated shift. The goal of his policies, then, is a situation in which the *same* net increase in sales could be attained equally well in any of the three ways by the same outlay or sacrifice.

The importance of establishing this principle is that it enables us to consider any *one* of the methods of sales increase—*e. g.*, longer transportation—and to assume that (at any rate for small readjustments) the added sales obtainable by this method would be a fair measure of the added sales he could expect to get by either of the other two available methods, or by a combination of all three.

There is, in the particular case under consideration, a fairly definite cost reduction made possible through cheaper electric power. This gives New York State manufacturers the opportunity to increase sales in any or all of the three ways indicated; and if the cost reduction is relatively small and if we may assume they have been operating under the rational principle of maximizing profits through the best combination of the three policies, then the gain in sales will be approximately the same no matter which way we figure it: As the result of a decrease in price, or of an increase in sales promotion, or of an increase in transportation outlays.

It happens that with the data in hand the only one of these capable of being even roughly estimated is the last. It is not possible to make any well-supported guess as to the elasticity of demand for the seller's product in his market, nor can we predict the response he might get from a given advertising outlay. However, the degree of increase in market associated with a given added expenditure on transportation can be estimated roughly.

To do this precisely would involve making the assumption that the market has a uniform geographic distribution; *i. e.*, that quantity of sales is proportional to area.³⁴ In an individual market situation, this is never more than approximately the case, and sometimes is very far from being the case; but when we seek to find the total result in a great many market situations, the divergences from uniformity tend to cancel out, leaving no strong net bias in the total estimate. That is, some sellers may be able to increase their sales through extra transport out of all proportion to the additional area involved, if they are fortunate enough to break into a concentrated urban market previously just

³³ *i. e.*, by raising the average delivered price by 1 cent and shipping the product enough farther to add an average of 1 cent per unit to his freight bills.

³⁴ In no sense is this intended to imply that manufacturers have exclusive sale territories. The degree of overlap in sales territories varies widely from one commodity to another.

outside their profitable range; others, on the other hand, will not find that addition of market area gives anywhere near a proportional increase in market. For all the sellers taken together, in the typical case, it seems reasonable to assume that market is proportional to market area.

It must be recognized, however, that New York State is not entirely a typical case. It is part of the most densely settled and intensively industrialized section of the country. As a New York State manufacturer extends his sales farther afield, in many directions he encounters territory of decreasing density of demand. To this extent the assumption of proportionality between market area is biased upward.

It is proposed to counterbalance this by another assumption deliberately involving understatement. If a manufacturer could extend his market radially as well as in distance, by absorbing more delivery expense, his market area would increase more than in proportion to his average haul.³⁵ This would hold good regardless of whether the market area is circular, polygonal, or shaped like a piece of pie. However, if extension of market took place along a band or bands of uniform width, in one or more directions, then the area would of course increase only in direct proportion to average haul.

Actually, as one proceeds south and west from New York State, the potential domestic market area widens, so that extensions of area in that general direction may be considered roughly proportional to the square of the average haul.³⁶ The density of demand in that direction, however, probably decreases with distance for most products, so a conservative estimate would perhaps require that we consider the increase in actual market to be proportional merely to average haul, and not to its square.

In the other direction (the New England market), area would appear to increase only in approximate proportion to distance. Here, however, due to the concentration of population and industry in the Boston-Providence region, market would increase at least as fast as area, so we may conservatively assume that market would increase in proportion to average haul.

³⁵ In a circular market area, for instance, the area is proportional to the square of the radius, and the average haul (assuming uniform distribution of demand over the area) is two thirds of the radius. In this case, total demand is proportional to the square of the radius and to the square of the average haul. If demand per unit of area decreases with distance, the average haul is half the radius, and total demand varies just proportionally to each. With areas of other shapes, approximately analogous relationships apply.

³⁶ This would mean that a given small percentage change in average haul would be associated with slightly more than twice as great a percentage change in area. For example, for a 10 percent increase in haul, the area would be 110 percent \times 110 percent, or 121 percent; i. e., a 21-percent increase.

These considerations of course have validity not with respect to an individual commodity and its specific markets—which may be quite localized—but rather to the composite of New York State products in general. The final conclusion which is indicated as a conservative minimum is that any cost saving which would permit New York State manufacturers to pay for a certain percentage increase in average distance of delivery would lead to an approximately equal percentage increase in their total sales, if they devoted the entire cost saving to extra delivery expense. As explained previously, it is reasonable to suppose that this still applies in cases where they devote part or all of the saving to increased sales promotion or to price reductions.

The total industrial power purchases by New York State manufacturers in 1937 have been estimated at 7,212 million kilowatt-hours. (See table 50 above.) If the average price were reduced by 1 mill per kilowatt-hour, a net saving of about \$7,212,000 would be obtained. If the high-load-factor industries are excluded, the total energy purchases are about 5,212 million kilowatt-hours (see table 50 above), and the total saving is about \$5,212,000.

In table 61, an attempt is made to allocate part of this saving by individual industries, so as to determine which branches of manufacturing have the largest stake in energy-cost reductions. Since no statistics are published on electricity purchases by individual industries in New York State, it is necessary to rely partly on United States data. The total value of products in each of the selected industries is shown in table 61, and is then converted to approximate energy purchases on the assumption that an industry's average energy purchases per dollar's worth of product are the same in New York State as in the United States as a whole. This assumption is probably reasonable, for rough estimating purposes, in all of the selected industries with the exception of Chemicals, not elsewhere classified, where New York State's specialization in the electroprocess field makes the ratio of energy purchases to product value undoubtedly much higher in New York State than in the country as a whole. As table 56, above, shows, some products in the electroprocess group require over a hundred kilowatt-hours per dollar's worth of product. Consequently, the figure given in table 61 for energy purchases in the Chemicals, n.e.c., industry in New York State is far too low.

TABLE 61

*Estimated savings from 1-mill reduction in electricity costs, in selected
New York State manufacturing industries*

Industry	Value of products, New York State, 1937 (millions of dollars)	Energy purchased per dollar's worth of product, United States average, 1937 (kilowatt-hours)	Approximate energy purchases, New York State, 1937 (millions of kilowatt-hours)	Estimated savings from 1-mill power-cost reduction (dollars)
Chemicals, n. e. c.	174.8	8.46	1,477	1,477,000
Steel works and rolling-mill products	157.8	1.70	268	268,000
Paper	110.6	2.10	232	232,000
Ice, manufactured	14.2	10.66	151	151,000
Electrical machinery, apparatus, and supplies	182.7	.62	113	113,000
Printing and publishing, newspaper and periodical	369.3	.26	95	95,000
Nonferrous metal alloys; nonferrous metal products, excluding aluminum, n. e. c.	95.1	.92	87	87,000
Pulp (wood and other fiber)	20.1	4.14	83	83,000
Bread and other bakery products	243.8	.31	75	75,000
Flour and other grain-mill products	102.8	.65	67	67,000
Cement	9.0	7.09	64	64,000
Motor-vehicle bodies and motor-vehicle parts	114.9	.50	58	58,000
Printing and publishing, book, music, and job	207.4	.26	53	53,000
Machinery, n. e. c.	106.5	.43	46	46,000
Rubber goods, other than tires, inner tubes, and boots and shoes	29.4	1.62	45	45,000
Ice cream	41.4	1.05	44	44,000
Feeds, prepared, for animals and fowls	100.5	.37	37	37,000
Meat packing, wholesale	174.9	.21	37	37,000
Liquors, malt	89.7	.40	36	36,000
Glass	21.4	1.68	36	36,000
Machine-shop products	49.7	.68	34	34,000
Cotton woven goods, over 12 inches in width	11.5	2.71	31	31,000
Furniture, including store and office fixtures	96.8	.30	29	29,000
Foundry products (gray-iron and malleable-iron)	20.7	1.24	26	26,000
Paints, pigments, and varnishes	62.4	.39	24	24,000
All manufacturing industries	7,314.4	3.99	7,212	7,212,000

¹ This figure is a gross understatement so far as New York State is concerned, since the electrochemical industries are more important in the chemicals group in New York State than in the country as a whole, and therefore the energy consumption per dollar's worth of product in the chemicals group in New York State is certainly higher than the figure 8.46 given above for the United States.

² Based on actual New York State figures, as given in the Census of Manufactures, 1937, table 2, p. 1670, and table 3, p. 20. Adjustment has been made, as in table 50 above, for purchased energy reported by cost only.

SOURCE: *Census of Manufactures, 1937*, table 1, pp. 1388-1394; table 1, pp. 1656-1668; and table 4, pp. 22-33. Last 3 columns calculated. It is possible that some industries for which no New York State production figures are published would rank higher in estimated energy consumption than some of the industries here shown.

Ranking high in the list of energy consumers and potential beneficiaries of energy-cost reductions are such other important New York State industries as steel, paper, printing, baking, flour milling, automobile bodies and parts, machinery, and meat packing.

The estimated savings accruing to each industry from a 1-mill-per-kilowatt-hour energy cost reduction are shown in the last column of table 61, and represent simply the estimated energy purchases times 1 mill. To the extent that the actual reduction resulting from the St. Lawrence-Niagara development would be less than 1 mill for some industries and more than 1 mill for others, some further inaccuracy is here introduced into the estimates.

New York State manufacturers might use this advantage in various ways to increase their sales—by increased transportation outlay to reach more distant markets, by increased sales promotion outlay, or by price reduction. Some idea of the magnitude of the probable effect may be obtained from an estimate of the extra transportation mileage which could be paid for out of the saving in energy costs.

Unfortunately, no statistics are available on the amount of transportation costs incurred in delivering New York State manufactured products to their destinations. However, the Interstate Commerce Commission has estimated that in 1936 the rail freight revenue on class I roads in the United States amounted to 8.5 percent of the total value of all goods transported.³⁷ The total value of New York State manufactured products in 1937, as reported to the Census of Manufacturers, was \$7,314,446,524.³⁸ If we assume that the ratio of transport costs to value of products was the same in New York State as for the country as a whole, then the total transport costs involved in delivering New York State manufactures to their destinations in 1937 may be estimated as in the neighborhood of \$600,000,000 (i. e., 8.5 percent of \$7,314,446,524).

If transport costs are \$600,000,000 and the power-cost saving is \$5,212,000, it follows that the power-cost saving is equivalent to 0.84 percent of total transport costs. The average New York State manufacturer, with a saving of 1 mill per kilowatt-hour on his energy purchases, could thus afford to absorb an 0.84 percent increase in transport costs.

If transport costs were on a uniform mileage basis, this would mean an 0.84 percent extension of market radius. However, transport costs are far from proportional to distance. It appears from an examination of typical progressions of transport charges, as presented in reports of the Federal Coordinator of Transportation and the Interstate Commerce Commission, that for small extensions of prevailing average lengths of haul, a given percentage increase in freight expenditure will purchase about two and one quarter times as great a per-

³⁷ Interstate Commerce Commission, Bureau of Statistics, Statement No. 3747: *Freight Revenue and Value of Commodities Transported on Class I Steam Railways in the United States, Calendar Year 1936*, Washington, 1937. The total value of manufactured products as reported to the Census contains a large proportion of duplication in the sense that the products of one establishment may be used as materials in another establishment and constitute part of the value of the product there also. The transportation cost factor is thus more important than the ratio 8.5 percent would imply, since its effects are felt cumulatively at several stages of manufacture. The ratio of transportation costs to total value of finished consumers' goods would give a fairer indication of the actual importance of transportation costs in production. The Twentieth Century Fund, for example, estimating on such a basis, arrives at a figure of 13 percent (*Does Distribution Cost Too Much?* p. 211). However, in the present case the purpose is to compare the influence of energy cost savings with that of transportation costs, and precisely the same adjustment would be required for one as for the other. It is simpler, then, to omit the adjustment in both cases.

³⁸ *Census of Manufactures, 1937, op. cit.* table 1, p. 1388.

centage increase in distance.³⁹ This relation varies, of course, according to the commodity, region, and type of carrier; but the factor of 2.25 seems reasonably representative.

It would appear, then, that the 1-mill-per-kilowatt-hour power-cost saving in New York State, which would amount to about 0.84 percent of the total transportation bill, would have the effect of extending the markets of New York State manufacturers on the average about 2.25×0.84 percent, or 1.89 percent.

The number of manufacturing wage earners in the State in 1937 was 995,658, and total manufacturing wages were approximately \$1,236,048,000.⁴⁰ Even without allowance for any trend of increase of these figures between 1937 and 1950, then, one could anticipate that the direct effects of the 1-mill power-cost saving would include the employment of well over 18,000 additional manufacturing wage earners, with an added payroll (assuming 1937 average earnings) of more than \$23,000,000.⁴¹

Section 3

ESTIMATE OF TOTAL INCREASE IN EMPLOYMENT

The final approximate estimates of the increases in employment ascribable to St. Lawrence power are, in the high-load-factor industries, 7,000 wage earners, and in other lines of manufacturing industry, 18,000 wage earners. Small further increases could be expected in the electric power industry itself and in the manufacture of electrical machinery, but these have not been estimated. The total directly induced employment, then, is taken as roughly 25,000.

In terms of total social and economic effect this is of course only a beginning. These 25,000 extra wage earners will spend probably well over \$30,000,000 each year,⁴² mainly on New York State products and services, which will provide a basis for additional employment in

³⁹ Federal Coordinator of Transportation, *Freight Traffic Report*, Vol. III, Analyses 49.9-49.12, pp. 157-160; Interstate Commerce Commission, Bureau of Statistics, Statement No. 3719, *Progression in Freight Rate Mileage Scales*, Washington, 1937.

⁴⁰ *Census of Manufactures, 1937, op. cit.*, table 3, p. 20.

⁴¹ The following considerations suggest that the estimate is if anything highly conservative. Rail transportation is here taken as the basis, because of the availability of data and because the selected products are all of the type which travel largely by rail. However, water or highway transport is used and will continue to be used where it is more economical. In such cases, actual transport costs are less than rail rates, and more miles could be purchased for the given saving.

The calculations were based on freight charges as of 1936. Any improvements which lower the costs of transportation by rail or alternative means will increase the importance of power costs relative to transportation costs.

The calculations were based on energy consumption in 1937. It is common knowledge that the use of power in manufacturing is rapidly increasing, and this increase is reflected in increased purchases from central stations. Consequently, in 1950 the relative energy consumption will be much larger than in 1937, and importance of power-cost differences correspondingly greater.

The stimulation of any one industry also stimulates other industries which supply it with materials or services.

⁴² This assumes average annual earnings somewhere near the 1937 level (\$1,240) in New York State manufactures. *Census of Manufactures, 1937, op. cit.*, p. 20.

ever widening circles. The probable character and extent of the secondary employment thus created will depend upon the circumstances of the time, but some idea of the final outcome may be gained from the distribution of occupations in the population. About one-half of the gainfully employed urban population of New York State is in manufacturing and the other half in nonmanufacturing activities. To a very large extent these other activities are dependent and resultant upon manufacturing.

Roughly, then, any increase in manufacturing employment provides the basis for an equal further increase in trade, service, professional, and other urban nonmanufacturing employment. As a further effect of the 25,000 extra manufacturing jobs created by the St. Lawrence power project, there will probably be about 25,000 additional urban nonmanufacturing jobs as well, or a total of 50,000 jobs.

Finally, to each two gainfully employed persons there are three who are not gainfully employed—housewives, children, aged, and other dependents. The proportion of gainful employment to population, that is to say, is consistently around 40 percent.⁴³ Corresponding to 50,000 urban jobs, on this basis, we have two and a half times that number of persons provided for—or 125,000 all told. The St. Lawrence-Niagara power project is thus estimated to provide directly and indirectly the means of support of the equivalent of a city about the size of Albany or Trenton.

In viewing this interpretation it is important to remember that we are dealing in terms of ultimate effects and long-run trends. It is not suggested that in 1950 a new city, complete with industries and institutions, will appear in some vacant spot; but merely that the effect of the St. Lawrence-Niagara power development will be such as to lift the trend of the State's economic growth by the indicated differential above where it would be in the absence of that development. Cyclical and other fluctuations about the trend will naturally still occur but these ups and downs will occur at a somewhat higher level.

Section 4

THE ST. LAWRENCE-NIAGARA POWER PROJECT AND RAIL TRAFFIC

One of the functions of the Survey being conducted by the Department of Commerce is to determine the effect of the St. Lawrence Seaway upon railroads. This problem is analyzed in another report of the Survey. However, if the power development is considered as a coordinate part of the whole, then the final influence of this project

⁴³ This represents the ratio of "gainfully employed" persons, according to the Census of Occupations, to total population. Many persons report themselves as gainfully employed, however, who are temporarily out of work. Actual employment often runs considerably lower than 40 percent of population.

upon the railroads cannot disregard the effects of the power development, specifically, upon railroad traffic. In this brief section an attempt will be made to give an estimate of the possible effects of the construction of the St. Lawrence project, and of the industrial development that may result from the power phase of the project, upon rail traffic.

Estimate of Increased Freight Revenue.

The following data covering all up-State New York trade areas for 1932 show the relation between population and railroad load:⁴⁴

Urban population.....	2, 998, 000
Freight cars originated, 1932.....	1, 183, 000
Cars originated per 1,000 urban population.....	395

It is advisable to bring these figures up to 1937, in order to make them comparable with the data on manufactures taken from the Census. Between the 1930 population Census and 1937, the total urban population of the up-State New York trade areas may have increased as much as 8 percent; while between 1932 and 1937 the number of carloads of revenue freight originated in the United States as a whole increased 57.2 percent.⁴⁵ Applying these adjustments, we get the following estimates for 1937:

Urban population.....	3, 238, 000
Freight cars originated.....	1, 860, 000
Cars originated per 1,000 urban population.....	575

The approximate present relationship between urban population and revenue carloadings in up-State New York, then, is 575 cars annually per 1,000 urban population. The 1938 average revenue of all "manufactures and miscellaneous" carload traffic per car originated in the Eastern District⁴⁶ was \$115. The probable carload freight revenue per 1,000 urban population was \$66,125 ($575 \times \$115 = \$66,125$).

An increase of 125,000 in urban population, then, could be expected to produce 125 times that amount of added carload freight revenue, or \$8,265,625, on the basis of 1937 carload freight per 1,000 population and 1938 average freight revenue per carload freight. In view of the fact that L. C. L. freight has been left out altogether, an estimate of 8.5 million dollars hardly seems excessive. It should be kept in mind that this is based on data for recent years and makes no allowance for future trends in population growth or for diversion of carload rail traffic to other carriers.

Effect Upon Fuel Requirements.

Not all of this 8.5 million dollars represents a net gain in freight revenue, however, since insofar as the hydroelectric development

⁴⁴ Federal Coordinator of Transportation, *Freight Traffic Report*, vol. III, *op. cit.*, p. 69.

⁴⁵ This is for all classes of freight combined. The 1932-37 increase in originations of cars of "manufacturing and miscellaneous" freight was 81.9 percent.

⁴⁶ I. C. C. *Statistics of Railroads*, 1938. Average revenue per originated car of all carload freight was \$126.

takes the place of alternative steam capacity there might be less growth in coal traffic to power stations than under the all-steam plan. This possibility will be briefly explored.

The Power Authority gives the following estimates of fuel costs in 1937 and under the alternative 1950 plans. Dollar figures have here been converted to tons at the assumed average price of \$4.00 a ton, probably a rather low figure for 1937.⁶⁷

FUEL EXPENDITURES OF POWER PLANTS

	Total cost	Tons	Increase over 1937 (tons)
1937-----	\$23, 493, 467	5, 873, 367	-----
1950:			
Hydro-steam plan-----	38, 128, 000	9, 532, 000	3, 658, 633
All-steam plan-----	54, 082, 000	13, 520, 500	7, 647, 133

It will be seen that while the all-steam plan calls for an increase of 7,647,133 tons annually over the 1937 consumption, the coordinated hydro-steam plan including the St. Lawrence-Niagara project would call for an increase of only 3,658,633 tons, in order to generate the same quantity of energy.

It does not follow, however, that the amount of fuel consumed in New York State power stations would actually increase 4 million tons less under the hydro plan than under the steam plan. As previous sections have indicated, a considerable fraction of the hydro output will serve demands which would not exist without the low power rate; only the remainder may be considered as taken away from possible steam generation. It is possible to make a rough estimate here, taking the average over-all rate differential between the St. Lawrence-Niagara and the alternative steam plans as about 1 mill per kilowatt-hour.⁶⁸

In 1937, the cost of power ready to distribute in New York State constituted about 65 percent of the average retail price.⁶⁹ On this basis, the 10 percent saving in generation and transmission cost afforded by the coordination plan would constitute a 6.5 percent saving on the total cost of distributed power. This leaves wholly out of account any narrowing of the distribution margin brought about by the coordination plan, and is thus certainly a minimum estimate of the prospective average saving to the consumer. We may say then that the average price of energy to the final consumer

⁶⁷ The Power Authority's fuel cost estimates (1938 Annual Report, op. cit., pp. 171, 173) assume coal prices the same in 1950 as in 1937.

⁶⁸ The respective costs of producing power "ready to distribute" were estimated by the Power Authority as 9.65 and 10.67 mills respectively.

⁶⁹ Average cost of power ready to distribute in 1937 was about 14.5 mills (Power Authority, 1938 Annual Report, p. 26 and Appendix 7), and average revenue on sales to ultimate consumers in New York State was 22.2 mills (Census of Electrical Industries, Electric Light and Power Industry, 1937, tables 39 and 40, pp. 62 and 70).

will be at least 6.5 percent lower under the coordination plan than under the steam plan.

We have already seen that consumption in most classes of use varies more than in inverse proportion to rates. A 6.5 percent average rate difference, then, would produce a difference in consumption amounting to more than 6.5 percent. An assumed increase of 7 percent in consumption as a result of the lower cost of hydro is highly conservative. The total power consumption of the State in 1950, exclusive of high-load-factor industries, will be in the neighborhood of 25 billion kilowatt-hours. Seven percent of this amounts to 1.75 billion kilowatt-hours, and the high-load-factor growth of 1.05 billions must also be added. We thus reach a total of 2.8 billion kilowatt-hours as the *difference* between consumption under the all-steam plan and consumption under the St. Lawrence plan. This accounts for 28 percent of the entire anticipated output of the St. Lawrence-Niagara development.⁵⁰

Since only 72 percent of the St. Lawrence-Niagara power will really replace any possible steam alternative, the true picture with regard to coal consumption is probably more nearly as follows:

Fuel consumption of power plants

	Tons	Increase over 1937 (tons)
1937-----	5, 873, 367	-----
1950:		
Hydro-steam plan-----	9, 532, 000	3, 658, 633
All-steam plan-----	12, 403, 720	6, 530, 353

The difference between 1950 power-plant fuel consumption under the two plans is here 2,871,720 tons, or 72 percent of the difference as estimated by the Power Authority.

The hauling of bituminous coal in the Eastern District of the United States in 1932 brought the railroads an average revenue of 0.68 cents per ton-mile, and the average ton was hauled 151 miles in the district;⁵¹ the revenue per loaded ton would then be \$1.025. If we assume that all coal consumed by New York State power plants in both 1937 and 1950 is carried an average of 151 miles by rail, the tonnage figures may be converted to freight revenue, as follows:

⁵⁰ The total anticipated energy supply of the St. Lawrence-Niagara public power system, including the auxiliary steam necessary for dependability, is 10 billion kilowatt-hours. Power Authority, *1938 Annual Report*, p. 23.

⁵¹ Coordinator of Transportation, *Freight Traffic Report*, Vol. III, *op. cit.*, pp. 125-126.

Freight revenue from fuel hauled to power plants

	Revenue	Increase over 1937
1937-----	\$6,020,201	
1950:		
Hydro-steam plan-----	9,770,300	\$3,750,099
All-steam plan-----	12,713,813	6,693,312

Under the coordinated power plan, then, the annual revenue on coal hauled to power stations in the State will increase by \$3,750,099, while under the all-steam plan it would increase \$6,693,312. The difference, \$2,943,513 is to be offset against the extra gains in freight revenue which the hydro-steam plan would bring, which have previously been estimated at \$8,500,000. Making this deduction, we may say that annual freight revenues will increase by about \$5,500,000 more under the coordinated hydro-steam plan than under the all-steam alternative plan.

The above figure, \$5,500,000 per year, represents a contribution of the hydro plan to the railroad systems of New York State and immediately adjacent territory.⁶²

Transportation Requirements in Connection with Construction.

In appraising the probable effect of the St. Lawrence-Niagara project upon the demand for transportation, it is necessary also to take into account the construction of the project itself.

The Bureau of Labor Statistics has broken down the original engineers' cost estimates into total values of the various materials that will be required at the construction site.⁶³ From these it is possible to estimate the number of ton-miles of transportation needed to assemble these materials and the resulting gross railroad revenue if all materials were to be hauled by rail.

The Bureau of Labor Statistics value figures were first converted into tonnage, for each commodity or group, by using Interstate Commerce Commission data on 1936 value per ton at point of production⁶⁴ wherever available. The machinery group was considered as a single item, with a value of \$751.27 per ton (the I. C. C. figure for "Machinery and Boilers"). In several cases precisely comparable commodity data were unavailable, and the closest approximation had to be taken. The value per ton for "hardware" and "other iron and steel products" was arbitrarily assumed equal to the average value for the other commodities in the iron and steel group for which figures were available.

⁶² These estimates of revenue were based on average length of the entire haul, and of course some of the haul, for fuel and for commodities in general, takes place outside the State.

⁶³ This was done by detailed comparison of the records of similar projects done under public contract.

⁶⁴ I. C. C., Bureau of Statistics, Statement No. 3747. *Freight Revenue and Value of Commodities Transported on Class I Steam Railways in the United States*, calendar year 1936, Washington, 1937.

The estimated tonnage of each commodity was next multiplied by the corresponding average carload-rail haul in local traffic in the Eastern District in 1932, as given by the Coordinator of Transportation.⁵⁵ Next the ton-mile figure for each commodity was multiplied by the corresponding average revenue per ton-mile in local traffic in the Eastern District in 1932.⁵⁶ The very large item "sand and gravel" was left out altogether, under the assumption that these materials could probably be obtained locally. It would have quadrupled the ton-miles and nearly tripled the revenue to include it.

The item "all other materials," since it amounted to 9.52 percent of the cost of the specifically itemized materials (excluding sand and gravel) was assumed to contribute that same percentage to the tonnage, ton-mile, and revenue figures. The final estimates are 1,712,700 tons, 191,678,000 ton-miles and revenue of \$3,315,700. It would be safe to say, then, that the St. Lawrence project would directly contribute well over \$3,000,000 to railroad freight revenue during the construction period, over and above the \$5,500,000 annually which it would contribute indirectly in New York State through stimulation of industrial development there.

⁵⁵ *Freight Traffic Report*, vol. III, *op. cit.*