THE POWER AUTHORITY
OF THE STATE OF NEW YORK

Report on Cost of Distribution of Electricity

To

THE PRESIDENT OF THE UNITED STATES
THE GOVERNOR OF NEW YORK
THE CHAIRMAN OF THE FEDERAL POWER COMMISSION

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THE POWER AUTHORITY OF THE STATE OF NEW YORK
STATE OFFICE BUILDING—80 CENTRE STREET
NEW YORK CITY

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TABLE OF CONTENTS

APPENDICES

ILLUSTRATIONS

NOTE

Preliminary mimeographed copies of this report were found to contain certain errors and omissions which have been corrected in the printed edition. These corrections result in slight changes in certain figures but in no way affect the conclusions.

APPENDIX I

COST OF CURRENT READY TO DISTRIBUTE
(Consolidated Gas Companies Serving New York City)

COST OF CURRENT READY TO DISTRIBUTE

(Consolidated Gas Companies Serving New York City)

The five system electric companies controlled by the Consolidated Gas Company, supplying service to customers within the city limits, report the following investment in facilities other than those covered in the distribution survey:

	Book Value Dec. 31, 1933
Generating Station Equipment	
Boiler plant equipment	$70,459,318
Prime movers, etc., steam	.....
Turbo-generators, steam	40,754,312
Electric plant, etc	44,997,329
Miscellaneous power plant equipment	1,941,170
Total	$158,152,129
Substation Equipment	
Substation equipment	$57,706,130
Storage battery equipment	7,689,674
Total	$64,395,804
Other Capital Items	
Land	$15,531,517
Structures	104,599,524
General equipment	9,352,058

In order to include all items of fixed capital required to furnish current ready to distribute at the low tension bus of the distribution substations, the transmission cables which were excluded from the distribution system and also the apportionment of duct value must be added.

The "other capital items" shown include the apportionment of general property which has been made in the valuation of the distribution system and the municipal street lighting system.

Generating Facilities

The steam generating facilities reported by stations and the tentative 1934 assessments are shown as follows:

Station	Kw Capacity	Assessed Value	Assessed Value per Kw
New York Edison Co.			
East River	280,000	$32,880,000	$117.00
Waterside A	214,000	10,445,000	48.80
Waterside B	152,200	10,120,000	66.50
United El. Lt. & Pr. Co.			
Hell Gate	605,000	56,500,000	93.50
Sherman Creek	151,000	10,800,000	71.50
Brooklyn Edison Co.			
Hudson Avenue	770,000	49,730,000	64.70
Gold Street	122,000	7,660,000	62.70
66th Street	62,500	4,217,000	67.40
Total	2,356,700	$182,352,000	$77.40

If the three large modern stations are taken as a group the average assessed value per Kw would be $84 per Kw for 1,655,000 Kw of capacity, or a total assessment of $139,110,000.

Substation Facilities

The companies report a total of 81 substations, which presumably include all high voltage, alternating current and direct current facilities, both at the generating plant sites and at individual locations throughout the territory served. The total capacity of 2,072,840 Kva is reported.

Allocation of Other Capital Items

A study of "Power Supply Economics" by Justine and Mervine suggests the allocation of land and structures to generating and substation facilities on the basis of the equipment representing approximately 70% of the total cost including land and structures. On this basis the investment of the Consolidated Gas Companies serving New York City in generating and substation plant would be as follows:

	Generating Plants	Substations	Total
Land	$22,600,000	$9,200,000	$31,800,000
Structures	45,200,000	18,400,000	63,600,000
Equipment[96]	158,152,129	64,395,804	222,600,000
Total	$226,000,000	$92,000,000	$318,000,000
Capacity	2,356,700 Kw	2,072,840 Kva	
Unit value	$95.80	$44.40	

The total of land and structures assigned in this manner is $95,400,000. This would leave the following as elements in general fixed capital:

Remainder of land and structures	$24,731,041
General equipment	9,352,058
Total	$34,083,099

Of this amount the sum of $15,178,450 has been already allocated as distribution share of general fixed capital, and in addition some apportionment to the municipal street lighting distribution is necessary, leaving a balance of general property which should theoretically be covered in the cost of the current.

Valuation of Generating Stations

The assessed valuation of $77.40 for the total of 2,356,700 Kw of generating capacity which the companies carry on their books represents a valuation of $182,352,000, which is some

[96] 1933 Book Values.

$43,000,000 less than the book value obtained by allocation of real estate to the various property items. The $43,000,000 may be logically assumed as a reasonable estimate of depreciation which would be considered in fixing the various assessments.

This investment in generating capacity, however, should be scrutinized further before it is accepted as a charge against consumers of electricity.

It should be recalled that the steam power plants of the Consolidated Gas System are not only completely interconnected, but also that some $10,000,000 has recently been spent on a transmission line down the Hudson River, connecting them with the hydroelectric plants of the Niagara Hudson system. This was justified on the ground that it would save building additional surplus capacity in New York City.

Justine and Mervine, in their "Power Supply Economics", discuss the reserve requirements of such an interconnected system as follows (page 63):

> In power systems supplied by more than one plant, the plants being interconnected with adequate transmission lines, reserve is usually provided against the largest single unit in the system. This reserve may represent 10 to 25 per cent of the total installed capacity. It is not provided in any one plant, but enough capacity is installed in all the plants so that the margin of capacity above the load requirement will equal the desired reserve. * * *

The following facts afford a basis for determining the legitimate generating capacity to be charged to customers of the Consolidated Gas electric system:

(1) The peak load on the generating facilities of the entire system reached the highest point in 1931 when there was a 30 minute load of 1,240,000 Kw to be carried by the plants plus purchased energy.

(2) The largest single generator units in the system are rated at 160,000 Kw.

(3) Reserve provision equivalent to two of these largest units, one for Brooklyn and Queens, and one for Manhattan and the Bronx, would require a total installed capacity of only 1,560,000 Kw or 800,000 Kw less than the capacity at present carried on the books.

(4) This capacity would be provided with a considerable margin to spare by the three big modern plants of the system (the East River plant of the New York Edison, the Hell Gate plant of the United Electric Light & Power, and the Hudson Avenue plant of the Brooklyn Edison) with a total value of $139,110,000.

(5) Two new 160,000 Kw capacity generating units were set in service in the Hudson Avenue station of the Brooklyn Edison Co. in January and May, 1932, without any evidence of intent to withdraw equivalent generating facilities rendered obsolete by such modernization.

Furthermore, in reference to the system peak load of New York City, and the justification of the 160,000 Kw high-voltage transmission line interconnecting the Consolidated and Niagara Hudson systems, J. D. Whittemore, Executive Engineer of the New York Power & Light Corporation, stated:

> To begin with, the New York City system, that is the system serving the metropolitan area, has a somewhat different load characteristic from almost any other system in the country and certainly different from any other system in New York State. One of the most noticeable characteristics of that load is that during the month of December for a period of two to three hours a day the demand for power exceeds the demand for power at any other time of the year by something over 200,000 kilowatts. That means that apparatus has to be ready in New York to handle that short, sharp peak and yet that apparatus is practically unused at any other portion of the year save during that 60 to 90 hours in the month of December.

(6) Examination of the report of the companies to the Public Service Commission, indicates that (a) the Kingsbridge plant of the New York Edison Co. is not being used at all; (b) the 66th Street plant of the Brooklyn Edison Co. is similarly out of service; (c) the Gold Street plant of the Brooklyn Edison Co. is operated at such low capacity factor and high fuel cost as to be uneconomical and unnecessary; (d) the Sherman Creek plant of the United Electric Light & Power Co. could be dispensed with as superseded, its fuel cost being high; (e) the Waterside plants of the New York Edison Co. are operated at low capacity factor and high fuel cost, and in view of this excessive capacity of the system, must be considered an unwarranted burden on consumers of electricity in the system.

(7) This fact of power plant obsolescence is covered by Justine and Mervine as follows (page 93):

> The time when a power plant will become absolete cannot be predicted. Perhaps the effect of obsolescence and its cost can be anticipated in a degree by an arrangement of equipment and flexibility in design, so that rehabilitation at a later date may be relatively simple. And yet obsolescence has been more influential than any other factor in causing supersession of old plants by new. Advances in the art of power generation have been so rapid that power plants seldom have had the opportunity to wear out. Therefore, although obsolescence cannot be anticipated, the engineer must take cognizance of the fact that plants seldom wear out but become obsolete, and estimate a rate of depreciation in the fixed charges, one not entirely based on the functional life of the apparatus and plant, but one which, from experience, company records or other sources, will reflect the expected life of the plant, regardless of the forces causing it to be no longer useful.

Elsewhere the authors say, referring to the installation of new equipment which renders the old obsolete:

> If proper provision has been made by the utility company for obsolescence, this can be done without any hardship.

It may be noted that in 1933 only three generating stations, in addition to the larger and more modern one noted above, produced any current, as follows:

(1) The Waterside plants of the New York Edison produced 277,504,900 kilowatt hours, the operating and maintenance expenses alone amounting to 0.977¢ per kilowatt hour without taking fixed charges into account. If produced at the East River plant these expenses would have been cut to 0.326¢ per kilowatt hour, offering a saving of at least $1,800,000.

(2) The Sherman Creek plant of the United Electric Light & Power Co. produced 222,036,051 kilowatt hours, with operating and maintenance expenses amounting to 0.55¢ per kilowatt hour. At the Hell Gate station these same kilowatt hours would have been produced for expenses totaling 0.40¢ per kilowatt hour or at a saving of at least $331,000.

(3) The Gold Street Station of the Brooklyn Edison produced 40,311,000 kilowatt hours at an average expense, excluding fixed charges, of 1.34¢ per kilowatt hour. This amount would have been produced at the Hudson Avenue Station for an expense of 0.25¢ per kilowatt hour.

It should be recalled that the three modern stations could have met the peak requirements with a wide margin to spare. In addition the transmission line down the Hudson River provided a tie in with Niagara Hudson water power plant. Apparently the obsolete plants were operated largely to justify the contention that they belonged in the capital account.

Taking all these facts into consideration it appears that a total investment of approximately $140,000,000 is all that the Consolidated Gas System can legitimately claim as a charge against its electrical customers for generating capacity. The fixed charges on this at 12½% would amount to $17,500,000.

Production Expenses

The companies' reports to the Public Service Commission for 1933 reveal production expenses, including operation and maintenance, totaling $17,304,375 for generating 4,503,944,239 kilowatt hours, or about 0.385¢ per kilowatt hour. This appears to be a reasonable figure. It might have been reduced, however, by about $2,582,000 if the out-of-date plants had been abandoned. This would have reduced it to $14,722,375.

Purchased Energy

During the year 1933 the system companies purchased from the New York Power & Light Corporation, over the new high-voltage

transmission line interconnection, a total of 511,000,000 Kwh for $1,028,000, or about 0.2¢ per Kwh. This amount of energy represents a factor of 36.4% on the capacity of the line.

Valuation of Substations

Substations, including an allocation for land and structures, as indicated above, would be valued in accordance with the company books at approximately $92,000,000, or $44.40 per Kva of capacity. Investigation suggests that this is at least 40% in excess of their legitimate value.

The application of average unit prices for modern alternating and direct current substations to the reported capacities substantiates this reduction. On this basis it may be tentatively assumed that an allowance of $66,000,000, or $31.80 per Kva, would be more than ample for all the useful substation capacity serving customers in New York City. On this basis fixed charges at 12½% would amount to $8,250,000.

Substation Expenses

Expenses for operating and maintaining substations are reported as approximately $2,500,000, or about 0.05¢ per Kwh.

Valuation of Transmission System

The transmission system in New York City includes 10,757,083 feet of underground cable, ranging up to 132,000 volts rating. The apportionment of book value in underground conduits to transmission was $6,760,000 and of duct rentals $1,052,000 as set forth under "Details of Allocation" for the distribution system.

The total investment value in transmission is approximately $17,000,000 for which fixed charges and operating expenses at a composite rate of 12½% would amount to $1,788,000 per annum.

In view of the fact that the entire transmission system is underground this allowance is ample. In this connection it might be said that transmission expenses are in the nature of a fixed charge.

General Property

Summarizing the above values of production, substation and transmission property, the following table shows the total valuation as a basis for allocation of general property:

Item	Valuation
Generating station	$140,000,000
Substation facilities	66,000,000
Transmission system	17,000,000
Total	$223,000,000
General property 8%	18,000,000
Total	$241,000,000

The fixed charges on $18,000,000 of general property at 11½% would amount to $2,075,000 per annum.

General Expenses

General and administrative expenses, including operation and maintenance of general property, as developed for distribution costs, amounted to $5,313,000. Some further allowance is necessary for allocation to cost of distribution for other classes of service. In all, this amount should not exceed $5,500,000 and on the basis followed would represent 60% of total general expenses. The corresponding 40% would amount to $3,670,000 or about .87 mills per Kwh sold.

Summary

A summary of the foregoing items, representing the total cost elements of current ready to distribute in New York City in total amount and per Kwh sold based on a total reported sales in 1933 of 4,229,000,000 Kwh follows:

Fixed Charges	Amount	Per Kwh Sold
Generating facilities	$17,500,000	0.414¢
Substation facilities	8,250,000	0.195
Transmission system [97]	1,788,000	0.042
General property	2,075,000	0.049
Total fixed charges	$29,613,000	0.700¢
Expenses		
Production	$14,722,375	0.349¢
Purchased current	1,028,000	0.024
Substations	2,500,000	0.059
Duct rentals	1,052,000	0.024
General	3,670,000	0.087
Total expenses	$22,972,375	0.543¢
Total cost of power	$52,585,375	1.243¢

It should be recalled, however, that total system sales for 1933 are slightly less than for 1931, and for the three years are reported as follows:

Year	Total Kwh Sales	% Change
1931	4,311,164,386	.....
1932	4,219,077,063	—2.14%
1933	4,228,682,654	+0.20

If the fixed charges shown above, of $29,613,000 are divided by total sales for 1931, the unit costs per Kwh sold will be reduced from 0.700¢ to 0.686¢, and a betterment of capacity factors or system load factors would still further reduce this unit cost. In

[97] Includes expenses.

this connection it may be recalled that the total capacity of the three large stations and the hydro interconnection is 1,815,000 Kw and 1931 sales only represent a capacity factor of 32.3% on this basis.

As a brief but conclusive check on the validity and reasonableness of the above analysis, the following facts are cited:

1. Analysis of large power rates available to any large consumer in New York City offers no other possible conclusion but that the companies are convinced that they can profitably undertake the generation, transmission and transformation of large blocks of power, under conditions equivalent to the load of a distribution substation, for less than one cent per kilowatt hour.

2. The obsolete and inefficient transit power plants in New York City can apparently operate and maintain their property and pay all charges for generation, transmission and rotary transformation, under conditions at least not more favorable and possibly more complex than the electric utilities face, for a charge of one cent or less per kilowatt hour.

Variation in Fixed Charges Due to Load Factor

The development of cost of power to any one class of service usually takes into account the fact that fixed charges are a constant per unit of demand or capacity and variations in use of demand should be reflected as a penalty for low use and a bonus for high use or load factor.

This refinement is made by calculation and apportionment of system class diversity factor benefit, after which each class can be treated separately on the basis of average class or individual load factors.

The method of calculating system class diversity factor was outlined in the previous appendix and the application to the Consolidated system is shown in the following table. Load factors and intra-class diversity factors are estimated after consideration of known data for the system and comparable data at hand for other large cities. Total system sales by classes are for the year 1930, as determined by engineers of the Interdepartmental Board from reports to the Public Service Commission.

Calculation of System Class Diversity Factor-Consolidated Gas Companies Year Ended Dec. 31, 1930

Class of Service	Sales M Kwh	Average Annual Load Factors [98]	Intra-Class Diversity Factor	Class Peak Demand M. Kw	Average Class Load Factor
Residential	971,174	20%	1.25	444	25.00%
Commercial[98]	801,204	15	1.10	555	16.50
Industrial power	1,035,736	25	1.15	409	28.90
Flat-rate	2,628	25	1.25	1	31.25
Mun. st. ltg.	97,647	50	1.00	22	50.00
Misc. mun.	111,159	50	1.00	25	50.00
Railroad	280,642	45	1.00	71	45.00
Wholesale power	893,117	35	1.10	269	38.50
Total	4,193,307	.....	.....	1,796	26.7%

The system load factor of the Consolidated companies has been given as 45% and the relation of this system load factor to the weighted average class load factor of 26.7% is the system class diversity factor of 1.69.

In the previous appendix an analysis was presented of the cost of power ready to distribute to domestic customers outside of the metropolitan area. The basic data were as follows:

Average annual use	600 Kwh
Average demand measured at line transformers	.274 Kw
Load factor on transformer demand	25%
Intra-class diversity factor	1.25
Average share of class peak demand	.219 Kw
Class load factor	31.25%

The average domestic consumption in New York City has been about 450 Kwh and an adjustment of system class diversity factor can be made to reflect the results of an increase to 600 Kwh per annum on the above basis.

1.	Total domestic sales would be increased one-third to	1,294,899 M. Kwh
2.	Total sales would increase by the difference to	4,517,032 M. Kwh
3.	At the new average class load factor of 31.25% the domestic class peak demand would increase to	473 M. Kw
4.	The total of all class peak demands would increase to	1,825 M. Kw
5.	The weighted average class load factor would increase to	28.3%
6.	The effect on the system load factor would be to increase the percentage to	47.5%
7.	The system class diversity factor would then be	1.68

The calculation of the proper charge for power ready to distribute in New York City may then be made by modifying fixed charges per average Kwh sold in proportion to the relation between individual class load factors and the weighted average load factor of all classes, obtained by dividing the system load factor by the class diversity factor.

[98] Commercial service to office buildings and stores is characterized by a sharp coincidental class lighting peak in December, and low demand on Sundays and holidays.

[99] Measured at line transformers or customers' substations except for municipal and railroad sales.