

INDUSTRIAL ORGANIZATION.

THE POWER PLANT.

Graduate School of Business Administration, Harvard University

Syllabus of Lecture of Nov. 8, 1916.

ISOLATED PLANT vs BUYING POWER:

Influence of size of plant.

Influence of relative amounts and times of demand for light, power, heat, process steam, etc.

✓ Insurance of service.

Interest, depreciation, and maintenance.

Night service, break-down service.

THE PROBLEM:

1. A building has been designed to be used by a single concern as warehouse, factory, salesrooms, and offices.

2. The building is large enough to warrant consideration of an electric power plant for providing light and power, but final plans have not been made and the study of the electric light and power and steam systems has been scarcely begun.

3. In order to complete the construction drawings, preliminary to actual construction work, it is desired to know whether or not an engine and generator plant shall be installed or electric light and power shall be bought from the local electric light company.

THE REQUIREMENTS:

In General:

1. The requirements include:

(a) Electric lighting of very different types on different floors, owing to the different uses to which the floors are to be put;

(b) Electric power for operating elevators, fans, shaving exhausters, wood-working machinery, sewing machines, etc.;

(c) Steam for heating the building, for heating service water, and for process purposes.

2. It is possible to determine by inspection that the most important items are the lighting and the heating.

The Lighting Loads:

1. The connected lighting load in K. W.'s may be estimated by the study of the lighting requirements for each department and the assumption of the style of and amount of illumination for each. Comparison with existing installations is helpful only as regards general magnitudes, on account of the great variation in modern practice. Estimate is 175 to 200 K. W.

2. The peak load in K. W.'s may be estimated by studying the probable amount of illumination which will be required by each department on a dark winter's afternoon or by assuming a "peak load factor" for each department or for the whole building by which the corresponding connected load is to be multiplied. Estimate is 150 K. W.

3. The yearly load, in K. W. hours, may be estimated by the study of the amount and time of illumination required by each department for average days in each season of the year and adding. The policy of the management in the use of light would cause large variations. Estimate for frugal use of light is 200,000 K.W. hours per year; for liberal use of light is 400,000 K. W. hours per year.

The Power Loads:

1. The connected peak and yearly power loads may be estimated by determining the number and size of motors and studying the probable maximum horse-power required simultaneously and the average horse-power and number of hours of use. The elevator motor loads are determined by the known elevator capacities and the assumed number of trips and average weights carried. The estimates are: peak load 100 K.W.; yearly load 155,000 K.W. hours.

Total Estimated Electrical Loads:

1. The estimated lighting and power peak loads combined are 250 K. W.

2. The estimated lighting and power yearly loads combined are 355,000 K. W. hours to 555,000 K. W. hours.

The Steam Loads:

1. The process steam load is neglected as less than probable errors in estimating the heating load.

2. The heating load, in square feet of radiation, may be estimated by a study of the type of building construction, its size, the total "glass", the "exposure", etc. The estimate is 21,000 sq.ft.

(3)

COST OF OPERATION IF POWER IS BOUGHT:

In General:

1. Estimate must include (a) Light Company's bills; (b) Interest, depreciation and maintenance on the cost of installation of the steam plant; (c) cost of operation of the steam plant.

Light Company's Bills:

1. The charges of the Light Company are in two parts; (a) In proportion to the "demand" or peak; and (b) In proportion to the K. W. hours or yearly load.
2. The "demand" charge is on the following basis:
 - (a) \$60.00 per year per K. W. up to and including 15 K. W.;
 - (b) \$36.00 per year per K. W. exceeding 15 K.W. and up to and including 55 K. W.;
 - (c) \$30.00 per year per K. W. exceeding 55 K. W.
3. The "demand" charge on the above basis would be as follows:

Total "demand"	=	250 K. W.	
Charge for		15 K. W. at \$60.	= \$900.00 per yr.
Balance		<u>235</u>	
Charge for		40 K. W. at \$36.	= 1440.00 " "
Balance		<u>195</u> K. W. at \$30.	= 5850.00 " "
Total "Demand" Charge =			<u>\$8190.00</u> per yr.

4. The K. W. hour charge is on the following basis:
 - (a) 5¢ per K. W. hr. up to and including 18,000 K. W. hrs. per year;
 - (b) 3¢ " " " " above 18,000 and up to and including 66,000 K. W. hrs. per year (48,000)
 - (c) 1½¢ " " " " above 66,000 K. W. hrs. per year;
 - (d) ½¢ " " " " deduction if lamps are not provided.

5. The K. W. hour charge on the above basis would be as follows:

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	Minimum Estimate K.W.Hrs. per Year.	Maximum Estimate K.W.Hrs. per Year.	Minimum Est.Charge per Year.	Maximum Est. Charge per Year.
Total K. W. Hrs.	355,000	555,000		
	18,000	18,000	at 5¢ \$900.00	\$900.00
Balance	<u>337,000</u>	<u>537,000</u>		
	48,000	48,000	at 3¢ 1440.00	1440.00
Balance	<u>289,000</u>	<u>489,000</u>	at 1½¢ 4335.00	7335.00
Total			<u>\$6675.00</u>	<u>\$9675.00</u>
Deduction for Omission of Lamps	355,000	555,000	at ½¢ 1775.00	2775.00
Net Total			<u>\$4900.00</u>	<u>\$6900.00</u>

6. The total charge of the Light Company would be as follows:

	Minimum Basis	Maximum Basis
Demand Charge	\$8,190.00	\$8,190.00
K. W. Hr. Charge	4,900.00	6,900.00
Total Charge	<u>\$13,090.00</u>	<u>\$15,090.00</u>
Avg. Charge per K. W. Hr.	\$.0368+	\$.0272

Interest, Depreciation &
Maintenance Charges on
Steam Plant:

1. Cost of installation of steam plant may be estimated by comparison with other work and by obtaining contractor's estimate based on sketches and outline specifications. The estimate is \$29,500.
2. Interest, depreciation, and maintenance charges will vary according to judgement. Basis assumed is 15%.
3. 15% on \$29,500.00 = \$4,425.00

Cost of Operation of Steam Plant:

1. The estimates of coal, labor, supplies, etc. may be determined from experience and by comparison with other plants aided by direct calculation from the estimated loads of the coal to be burned.
2. The estimates are:

(a)	Coal, 835 tons at \$4.50 =	\$3,758.00
(b)	Labor	3,400.00
(c)	Supplies, water, etc.	300.00
		<u>\$7,458.00</u>

Total Cost of Operation
If Power Is Bought:

1. The summary of the above estimated costs is as follows:

	Minimum Basis	Maximum Basis
(a) Light Company's Charges	\$13,090.00	\$15,090.00
(b) Interest, Depreciation & Maintenance	4,425.00	4,425.00
(c) Operating Cost	7,458.00	7,458.00
Total Cost	<u>\$24,973.00</u>	<u>\$26,973.00</u>

COST OF OPERATION IF ISOLATED
PLANT IS INSTALLED:

In General:

1. Estimate must include (a) interest, depreciation, and maintenance on the cost of the entire plant; (b) cost of operation of the plant.

Interest, Depreciation,
and Maintenance:

1. Cost of installation of the plant may be estimated after number and type of engines and generators are determined by obtaining prices from manufacturers on the machinery and from contractors on the piping, accessories, etc. with the aid of sketches and outline specifications. The estimate is \$53,500.00 minimum.

2. Interest, depreciation, and maintenance charges will vary according to judgement. Basis assumed is 15%.

3. 15% on \$53,500.00 = \$8,025.00

Cost of Operation of the Plant:

1. The estimate of coal includes a study of load curves so that the proportion of exhaust steam which can be used for heating shall be considered. The estimate must be on both the minimum and the maximum assumptions for K. W. hours.

2. The labor, supplies, etc. may be estimated from experience and by comparison with other plants.

3. The estimates are as follows:

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		Minimum		Maximum
		K.W. Hrs.		K.W. Hrs.
{a}	Coal 1700 tons at \$4.50	\$7,650.00	2300 tons at \$4.50	\$10,350.00
{b}	Labor	6,550.00		6,550.00
{c}	Supplies, water, etc.	700.00		900.00
	Total	<u>\$14,900.00</u>		<u>\$17,800.00</u>

Total Cost of Operation If
Isolated Plant is Installed:

1. The summary of the above estimated costs is as follows:

	Minimum K.W. Hr. Basis.	Maximum K.W. Hr. Basis.
{a} Int., dep. & maint.	\$8,025.00	\$8,025.00
{b} Operation of plant	14,900.00	17,800.00
Total	<u>\$22,925.00</u>	<u>\$25,825.00</u>

COMPARISON OF COST OF BUYING POWER
WITH COST OF GENERATING POWER:

1. The comparison of the relative costs of operation with and without a power plant, follows:

	Minimum K.W. Hr. Basis.	Maximum K.W. Hr. Basis.
Buying Power. (Annual Cash Outgo)	\$24,973.00	\$26,973.00
Generating Power (Annual Cash Outgo)	<u>14,900.00</u>	<u>17,800.00</u>
Cash Saving	\$10,073.00	\$ 9,173.00
Fixed Charges for Generating Power	<u>8,025.00</u>	<u>8,025.00</u>
Net Saving in favor of Generating Power	\$2,048.00	\$1,148.00

ADDITIONAL CONSIDERATIONS:

1. Expert accountant states that 20%, instead of 15%, should be charged for interest, depreciation, and maintenance.

2. The engineers state that the minimum basis is probably nearer the truth than the maximum basis.

QUESTIONS:

1. If you were manager what decision would you make?
2. Why?