THE FEASIBILITY OF THE INSTALLATION OF A
HEATING AND POWER PLANT IN THE
LANSING STATE SAVINGS BANK BUILDING

A Thesis Submitted
to
The Faculty
of
Michigan Agricultural College

By

R. M. Davies

R. M. Leddick

Candidates for the Degree of
Bachelor of Science

June, 1920.

THESIS

TABLE ON CONTENTS

THE FEASIBILITY OF THE INSTALLATION OF A
HEATING AND POWER PLANT IN THE
LANSING STATE SAVINGS BANK BUILDING

The Lansing State Savings Bank Building is an eight story, office building located on the Southeast corner of Michigan and Washington Avenues. It was built during 1916-17, is of modern brick and stone, fire-proof construction and has been fully occupied since its completion.

When the building was built it was the intention of the owners to purchase power and heat from the nearby central heating and power plant. Before the building was completed however, it was decided to install several low pressure heating boilers to furnish the heat. This was done and at present therefore the bank is furnishing most of its own heat and purchasing electrical power, both direct and alternating current, from the City. All of the hot water used in the building is heated by steam which is purchased from the nearby power plant.

The ventilation of the building, which has been found to be very unsatisfactory, is provided for by having ventilation flues or ducts starting at the second story and continuing up through the roof. No attempt was made in the original construction of the building to provide ventilation for the basement or the first floor. As an apparent after thought, the basement, which is occupied for the most part by the Peninsular Cafeteria, has been provided with an exhaust fan. This fan draws air from the Cafeteria but as no provision has been made to introduce fresh air, it is not proving to be very satisfactory.

Electricity is used in the building for lighting, for the motors driving the two elevators and for all other motors in the building. Dentists having their offices in the building also use direct current in their work. All these motors run intermittently.

The present heating equipment consists of two Ideal Down-draft Smokeless cast iron sectional boilers. During part of the year (viz., late spring and early fall) heat is purchased from the nearby power plant for a short period of the day. Each of the present boilers is rated at a capacity of 5500 sq. ft. of steam radiator surface. A floor plan of the present basement and equipment will show all the details that have any bearing on this investigation.

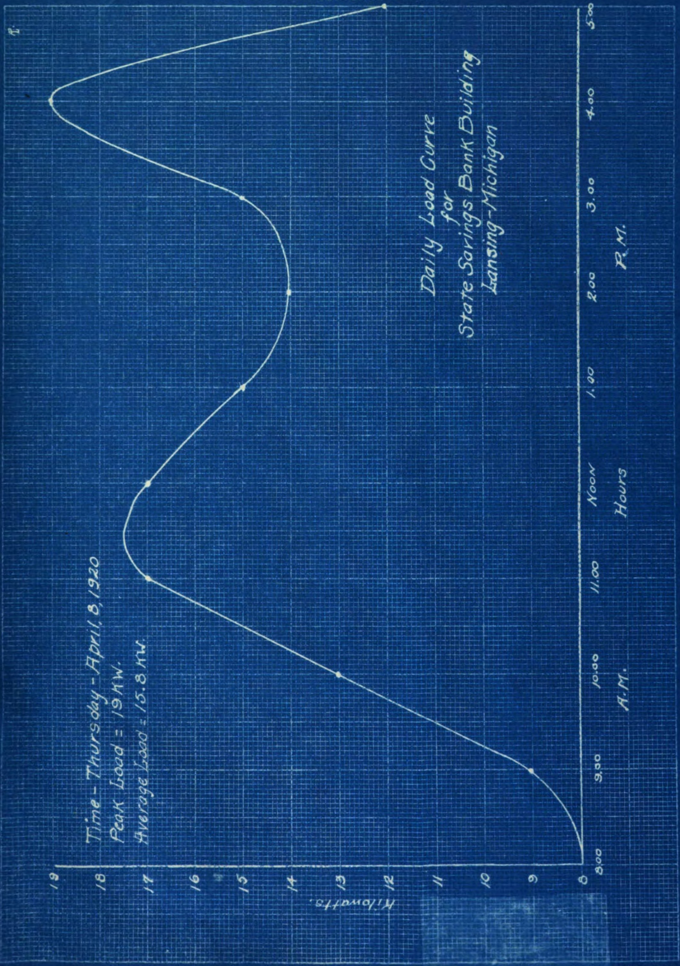
Our purpose in this investigation is to determine whether or not it would be economical to install a small power and heating plant in the building in place of the present equipment. To arrive at a conclusion we have obtained data on past costs of the lighting and heating, and on the maintainence of the same and have balanced these against the costs of the proposed installation. We have tried to obtain actual figures wherever possible and have made assumptions only where necessary.

COSTS OF LIGHTING AND POWER DURING YEAR 1919.

The following data has been tabulated from meter readings which were taken from the Building's electric meters in the year 1919. The number of KW hours of current used month by month is as follows:

Month	DC used by elevators	DC Used by Dentists	AC Used by Offices	AC Used by Offices	Bank	Total
Jan.	2442		1750	1134	334	5660
Feb.	2775		1735	1162	375	6047
Mar.	2458		1301	873	317	4949
Apr.	2546	4	1007	1004	402	4914
May	2584	53	1486	1125	407	5617
June	2675	79	1008	1013	403	5087
July	2675	17	787	666	470	4615
Aug.	2997	55	1036	945	543	5576
Sept.	2225	100	1349	1128	339	5241
Oct.	2488	21	1546	359	377	4781
Nov.	3050	24	1946	2229	448	7677
Dec.	2540	38	1847	1749	369	6543
Totals	31277	391	16798	13387	4884	66717

The total cost of lighting and power during the year 1919 after allowing a discount of 10% for cash, was $2003.92. This shows an average monthly cost of $166.91. A curve on page 9 shows the variation in the monthly consumption of power during the year.

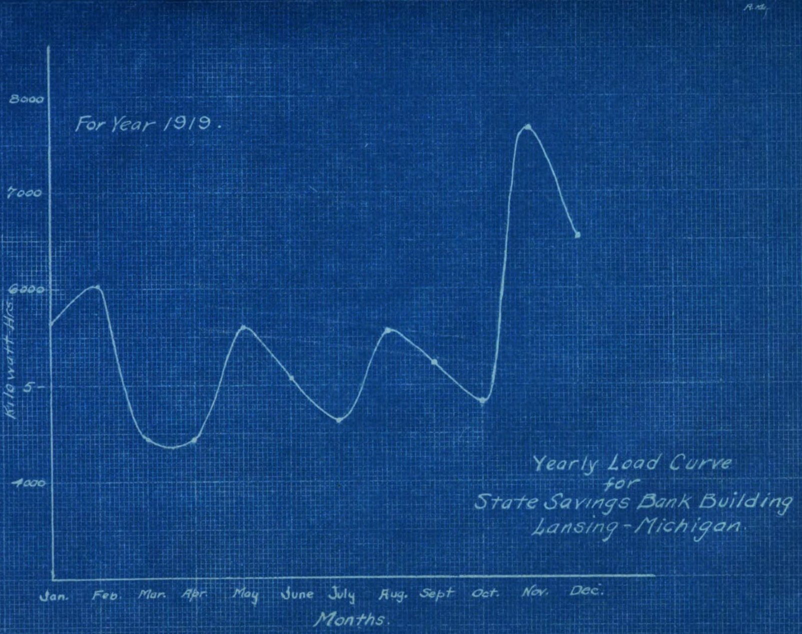

Daily Load Curve
for
State Savings Bank Building
Lansing-Michigan
Time-Thursday-April 8, 1920
Peak Load = 19 KW.
Average Load = 15.8 KW.
Kilowatts.
19
18
17
16
15
14
13
12
11
10
9
8
8.00
9.00
10.00
11.00
NOON
1.00
2.00
3.00
4.00
5.00
A.M.
Hours
P.M.

The lights in the building, exclusive of those in the bank and the halls, have a total consumption of 21,570 watts. For the use of these lights, the bank receives a monthly sum of $56.41 from its tenants, or a total of $676.92 yearly.

As the bank pays out $166.91 per month (average for 1919), and receives $56.41 per month, the actual cost of light and power to them each month averages $110.50. The direct and alternating current used is purchased from the city at the same rate. The alternating current being used exclusively for lighting and the direct current for running the motors in the building.

The rate at which power is consumed during the day was determined both from the preceding data and by actual readings taken from the meters. Taking the total number of kilowatt hours used during the year 1919 as 66,717 and dividing it by the number of days in a year, we get an average daily consumption of 182.7 KW hours. If we assume that most of this power is consumed in a period of 9 hours we get an hourly consumption of 20.7 KW.

On April the 8th, 1920 when the weather was typical of a spring day in this climate, one not exceptionally bright and yet not too dark, we took readings on the meters. The object of this was to determine the peak load and other characteristics of the load curve. This curve is plotted and shown on page _6_. The curve together with the date on page _5_ shows that the greatest amount of power was used by the elevators, and that the peak load occurs when the elevators are busiest viz., between 10:30 and 11:30 in the morning and between 3:30 and 4:30 in the afternoon.


R.M.
8000
7000
6000
5-
4000
Kilowatt-Hrs.
For Year 1919.
Yearly Load Curve
for
State Savings Bank Building
Lansing-Michigan.
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept
Oct.
Nov.
Dec.
Months.

There are two elevators in the building each run by direct current motors and the dentists having their offices in the building also use direct current in their work. A small direct current motor is used to operate a booster pump which raises the water pressure so that the water will reach the top floor. The ventilating fan used for ventilating the basement is run by a direct current motor. All these motors run intermittently.

HEATING EQUIPMENT AND SPECIFICATIONS

There are in the building at present two cast iron sectional boilers made by the American Radiator Co., and known as their Ideal Smokeless Down-draft Boilers, No. 4118-S. They each have a rating of 5500 square feet of direct steam radiation and are capable of evaporating 1375 pounds of steam per hour. This is approximately 40 Horse Power per boiler. This heating system operates on two pounds pressure and the bank people have experienced no difficulty in keeping the building warm in the winter.

The following table shows the Square Feet of Steam Radiating Surface in the Building.

Basement	870
First Floor	1134
Mezzanine Floor	295
Second to Seventh Floor (Inclusive)	4308

Eighth Floor	833
Total	7440

The heat necessary for heating the building in the coldest weather would therefore be 7440 Sq. Ft. times 250 Btu. per Sq. Ft. of radiating surface or 1,860,000 Btu.

From the preceding data in regard to the present steam radiating surface which is supplied with low pressure steam, the boiler horse power required is easily calculated.

Steam under a pressure of 2 pounds gage has a heat of evaporation of 965.6 Btu. per pound. Dividing the heat necessary per hour to heat the building or 1,860,000 Btu. by 965.6 Btu. gives the amount of steam required as 1920 pounds per hour. Then assuming that the condensate enters the boiler at a temperature of 150 deg. F., the amount of heat necessary to raise it to the boiling point would be 219 degrees minus 150 degrees, times one pound or 69 Btu. 1920 pounds per hour times 69 Btu. equals 132,500 Btu. Thus the total heat that the boilers must supply would amount to 1,992,000 Btu. This is equivalent to 59.5 boiler horse power required to supply the radiators with the necessary heat. As the present boilers are approximately 40 boiler horse power each, it is apparent that the capacity of the present installation is too large, especially as low pressure steam can be purchased at any time by the owners of the building. If they had installed smaller units and depended upon them running to their capacity, they could have purchased heat at any time when they found the smaller unit not capable of handling the load.

HOT WATER HEATING SYSTEM

Hot water is supplied to all the lavatories in the bank building and to the Cafeteria located in the basement of the building, by the owners of the building. The system used to heat the water the year round is to purchase exhaust steam from the nearby power house, the steam being metered by a heat meter. This exhaust steam costs the bank owners on an average $60 per month or a yearly cost of $700. This is too large a price to pay for the heating of water and is one of the defects in the design of the mechanical equipment of the building at present.

On the average it may be said that during the period from November 1st until June 1st, there is usually some heat required in the building to keep it comfortable. The last winter may be taken as an example of an average winter in this climate, while it was a long winter it was never unusually cold. Previous to November 21st, there was never any fire in the furnaces, but it was necessary to turn the low pressure steam from the power house into the steam mains for a short time every day. This according to the bank officials was more expensive than if a furnace had been started for several hours each morning. From November 21st until the present time the fires in the furnaces have never been

allowed to go out. The present date is May 21st and the daily coal consumption for the past two weeks, or for the average spring weather is about 550#. From the bank records, which are daily records made by the fireman, the following figures are taken:

From Nov. 21st to Feb. 2nd, 72 days, coal consumed was 87.3 tons.

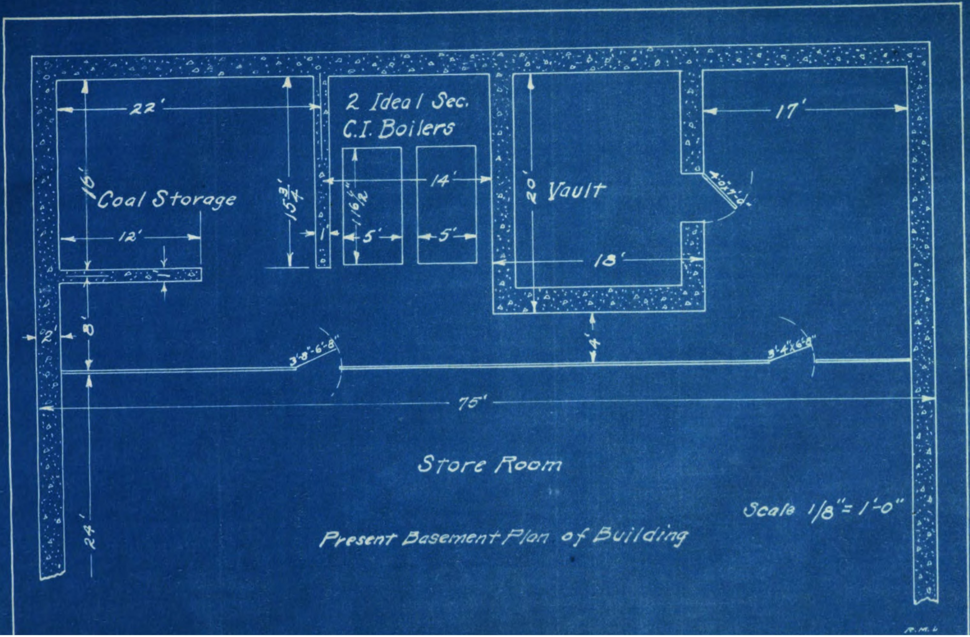
From Feb. 2nd to Apr. 6th, 62 days, coal consumed was 65.7 tons.

This shows the total coal used in 134 days during the worst part of the winter, as 153 tons. There remain about 76 days in which it is necessary to heat the building to some extent. Assuming the coal consumption as 550# daily during this time which according to the bank's figures it appears to be, the coal used would be approximately 21 tons, and this would bring the yearly consumption up to a total of 174 tons. This is approximately what the bank figures their coal consumption will be. They contracted for all their coal last year at a price of $7.00 per ton of 2000 pounds storing it in a yard of their own and bringing it to the bank as needed. It is safe to say then that their coal cost them $7.50 a ton delivered or a total for an average year of $1305.00. Under the present system the building manager takes care of the furnace, and so it is rather hard to arrive at any definite figure of the cost of furnace attendance, but we may safely assume it to be about $500 per year.

A summation of the average yearly costs of the power

heating and ventilating of the building at present would be as follows:

For lighting and power	$2003.92
For heating water	720.00
For Coal, 174 tons at $7.50 per ton	1305.00
For labor charges	500.00
Depreciation at 5%	200.00
Value of present heating equipment (capitalized at 5%)	144.00
Total yearly cost	$4872.92



Present Basement Plan of Building

THE PROPOSED EQUIPMENT FOR PROVIDING POWER

At present we find in the building both direct and alternating current in use, but it would be entirely satisfactory to have only direct current for all purposes. In the proposed equipment direct current would be the only kind furnished.

To supply sufficient current, it is necessary to have a generator or generators of ample capacity to handle the maximum consumption of electricity in the building. From the daily load curve, shown on page 6, it will be seen that the maximum peak load that day was 19 KW. It is very probable that on the darkest days of winter, during the time when the elevators are busiest and the lighting load in the building is at a maximum, this peak load may reach 25 KW. During the spring and summer months the average load would be about 16 KW. To provide this current, we propose to install two direct connected direct current generating sets of 20 KW. capacity each made by the B.F. Sturtevant Company of Boston, Mass. The following is a description and the specifications of one of these units.

The operating steam pressure of the engine to be 100 pounds gauge. The engine, field frame and out board bearing pedestal resting and bolted to a common cast-iron sub-base. This unit would also include a Chicago Automatic Hydrostatic Lubricator, one set of wrenches, anchor bolts, one set of soft packing, a field rheostat, and an extra set of brushes.

The voltage of the above set would be 125. The speed would be 400 R.P.M. When operating under 100 pounds steam pressure and a back pressure of 3 pounds, the water rate per horse power per hour at full load rating would be 39 1/2 pounds. The water rate per Kilowatt per hour would be 65 pounds. The efficiency of the generator under the various loads would be as follows:

1/2	3/4	Full	1-1/2
82.5%	84.5%	85%	84%

The net weight of the unit would be 5250 pounds.

The question as to whether or not it would be cheaper to have just one unit like the above and install a double-throw emergency switch whereby current could be purchased in case of a break down was considered. The city of Lansing, which owns the power plants in the city, charges a price of $5 per month for maintaining the switch in the building. The current if used would be furnished at the following prices:

$3.30 per KW. Hr. for first 100 hours.

then $0.01 1/2 per KW. " the next 250 hours at a rate of 35 KW. per hour.

It is stated, however, that none of the above current would be furnished for lighting purposes and the city could not supply direct current as their Direct Current machines are already over taxed. Therefore they would be unable to supply any more consumers. So we propose the installation of two generating units of the aforespecified type, each of which would be able to handle all the ordinary loads. Both units could be operated to carry the absolute peak loads if necessary. In the event of a breakdown of one unit the other could handle an over load of 25% for a period of 2 1/2 hours without any damage to the unit. It is probable that a load of 25 KW. would not exist for any period longer than that.

These units are of the type usually used in an installation of this kind because of the minimum amount of attention needed. Their automatic lubrication makes them especially valuable for an installation of this kind where the attendant must operate the generating sets as well as fire the boilers.

THE PROPOSED BOILERS

Because of the fact that during part of the year there is no heating load and that we wish to provide an economical and cheap plant, we would propose installing two return-tubular boilers of 40 Boiler Horse Power each. Another reason for choosing this type of boiler is the limitations in head room in the basement of the building. The following is a description of the boilers we propose to install.

The boilers are 48" x 12' - 0" return-tubular made by the Wickes Boiler Company of Saginaw, Mich. The boilers are designed for 125 pounds pressure and each nominally rated at 40 horse power. They are equipped with full flush fronts, plain grates, damper frames and plates, quadrant type rear arch bars, gallows frames for suspension support in battery without columns in the dividing wall, box type steel casing for battery setting. The following trimmings come with each boiler:- pop safety valves, steam gauge, water column with high and low alarm, water gauge and cocks, check and globe valves for feed, and blow-off cock.

The boilers would be set at a height not to exceed 36 inches above the grates. As the engines to which the boilers supply steam are run under a normal pressure of 100 pounds, it was thought advisable to install boilers designed for a pressure of 125 pounds so as to afford a reasonable leeway.

The overall dimensions of the battery would be 17'-4" x 14'-4"

The principal dimensions of each boiler are as follows:

Diameter of tubes	inches.	3 1/2
Number " "		28
Heating surface	sq. ft.	466
Width of grates	inches	42
Length of grates	inches	48
Grate area	sq. ft.	14
Blow-off diameter	inches	1 1/2
Steam opening	inches	3

THE PROPOSED EQUIPMENT FOR PROVIDING HEAT

The proposed plan for heating the building would be to have the above mentioned generating units exhaust into the heating system. The units would operate under a back pressure of 3 pounds gauge which is approximately the pressure that the present system uses. Reducing valves from the boilers must necessarily be installed so that high pressure steam from the boilers could be turned into the system if the particular generating unit in use did not supply enough exhaust steam to heat the building.

The following data shows the economy of the present system as compared with the proposed system. (Assuming that the average daily lighting load in winter to be 20 KW.)

20 KW x steam economy per KW (65 pounds) = 1300 pounds of exhaust steam at 3 pounds pressure. The latent heat of

evaporization at this pressure is 965.6 Btu. per pound of steam. Therefore,

1300 x 965.6 Btu. = 1,251,000 Btu. of heat available per hour.

From the foregoing it will be seen that one unit operating under a 20 KW load will not supply enough heat to heat the building when figuring a maximum heating load. It is probable however that the amount of heat furnished or available will be sufficient under ordinary weather conditions.

As has been mentioned before, if the heat which is supplied by the exhaust steam is not sufficient to maintain a comfortable temperature in the building, high pressure steam from the boilers will be furnished thru reducing valves to make up this deficiency.

The following results are calculated on an average lighting load and a maximum heating load.

The deficiency of heat units that must be supplied thru reducing valves by reducing the high pressure steam direct from the boiler to a pressure of three pounds equals 1,860,000 Btu. (maximum heat units which are to be supplied) minus 1,251,000 Btu. (heat units available from exhaust steam) equals 609,000 Btu. per hour. Dividing this figure by the latent heat of evaporization of steam at 3 pounds pressure gives 630 pounds of steam to be supplied direct from the boilers. Therefore, the total amount of steam supplied per hour would

be 1300 pounds (exhaust steam) plus 630 pounds (reduced pressure steam) equalling 1930 pounds.

In order to reduce this figure to B.H.P. we have figured out the factor of evaporation. This figure is that number by which the pounds of water evaporated must be multiplied to get the equivalent evaporation or the number of pounds of water that would be evaporated from and at 212 degrees F.

Assuming the feed water temperature to be 150 degrees F. and the steam pressure 100 pounds gauge.

If q = the heat of the liquid at 150^{o}F. = 117.86 Btu.

q'= " " " " " " 100# Pres. = 309 Btu.

r = heat of vaporization at 100 # Pres. = 879 Btu.

then q'-q= 309-117.86 or 191.14 Btu.

then the total heat = 191.14 plus 879.5 = 1070.6 Btu.

This figure divided by the latent heat of evaporation at 212^{o}F. gives a Factor of Evaporation of 1.1. That is the evaporation of 1 pound of water from a feed water temperature of 150^{o}F. and 100 pounds pressure is equivalent to evaporating 1.1 pounds of water from and at 212^{o}F. Thus 34.5 pounds (Equivalent Evaporation from and at 212^{o}F.) divided by 1.1 equals 31.4 or the pounds of water which would be evaporated under the assumed conditions as stated above.

Boiler horse power required for heating and lighting the building can be readily calculated by dividing 1930 pounds (the amount of steam to be supplied) by 31.4. This gives a result of 61.5 Boiler Horse Power. One boiler rated at 40 B.H.P. will carry the load easily at an overload of 53.7%.

Comparing the boiler horse power required for heating and lighting the building with the boiler horse power required for heating, it will be seen that it takes 59.5 boiler horse power to heat the building alone while with the proposed installation it only takes 61.5 B.H.P. to both heat and light the building.

A COMPARISION OF THE COSTS OF THE PRESENT AND PROPOSED SYSTEM

Present System

The average yearly charges for heating, lighting, and power in the building as stated before are $4872.92.

The value of the present equipment, consisting of two low pressure cast-iron sectional boilers is approximately $2880.

Proposed System

Cost of Power Equipment:

Following is the price of 2 B.K. Sturtevant 20 KW. Direct Current Generating Sets as previously specified. The cost if installation has been also included.

2 Units at $2290 each	$4580.00
Cost of foundations & Installation	282.00
Freight and haulage charges	150.00
Total Cost	$5012.00

The price of the proposed boiler installation, having

the specification as noted before, are quoted by the Wickes Boiler Company of Saginaw, Mich., as being $3133.00 f.o.b. Saginaw. The probable cost of installation, including brick-work and the breetching was figured from the formula.

$$\$ = 140 \text{ plus } (2 \times \text{B.H.P.})$$
$$= 140 \text{ plus } (2 \times 40) = \$220$$

Allow $250 for setting the boilers.

The cost of shipping the boilers from Saginaw to Lansing, Michigan, the shipping weight being quoted as 29,000 pounds, would be about $150.

The total cost of the boilers and installation would be as follows:

Cost of boilers and equipment	$3133.00
Cost of setting	250.00
Freight and haulage charges	200.00
Miscellaneous expenses	150.00
Total	$3733.00

A small motor driven centrifugal pump would be the correct type to install for a feed water pump. The pump should have a capacity of 1500 pounds per hour of 180 gals. per hour. A pump with a capacity of about 50 gals. per min. is about the smallest build and would fill all the requirements. The pump would be direct-connected to a small Direct Current Motor. The water is delivered to the pump under a pressure of 50 pounds from the city mains and the duty of this pump is to boost the pressure up to 135 pounds. A unit of the above capacity is built by the Union Steam Pump Company of Battle Creek, Mich., and would cost approximately $100.00

Cost of Piping, pipe covering, valves:

The cost of pipe, pipe covering and valves has been estimated at $10.00 per Boiler Horse Power. This gives $800.00 for this item.

YEARLY COST OF COAL UNDER THE PROPOSED PLAN

Assuming that the coal burned has a heat content of 12,000 Btu. per pound and that the combined efficiency of the boiler, furnace and grate is 60%, we have calculated the approximate yearly coal consumption of the proposed plant.

COAL CONSUMPTION UNDER THE PROPOSED SYSTEM

To figure the coal consumption of the proposed plant, first figure the data of last year's coal consumption and from the total number of KWs of power used.

Coal used for heating in 1919	174 tons
66,717 KW hours at 10# coal per hour, 667,170#	334 "
or a total consumption of	508 tons

If we assume that the proposed plant would save 100 tons of coal per year because of its utilizing the exhaust steam for heating purposes, the consumption of the proposed installation would be about 408 tons per year.

During the winter of 1919-1920 from November 21 to April 6 inclusive, or for a period of 134 days, the coal consumption was 153 tons. Then the approximate number of heat units required in a similar period or during the worst part of the winter would be

153 x 2000 x 12000 x .60 = 2,205 million Btu. or the average heating load per hour would be

2,205,000,000 divided by (153 x 24) or 600,000 Btu. per hour heat load per hour during the period from November 21 to April 6th. As the heat units in the exhaust steam available for heating purposes is 1,251,000 Btu. per hour, we need only figure the coal consumption from the amount of coal necessary to produce the electrical energy that the building requires.

The KW hours power consumption from November 1st to May 1st in the year 1919 was 35,790. If we assume that 75% of it was used during a 10 hour period of these days, then 26,829 KW hours was used in 181 x 10 or in a total of 1810 hours. This is at a rate of 14.8 KW per hour.

Assuming a coal consumption of 15# of coal per KW hours per then the coal consumption for the period would be

15 x 14.8 x 1810 = 402,000 pounds.

Ther for the remaining 14 hours per day of this period the average consumption would be as follows:

35,790 - 26,820 = 8,970.

8,970 divided by the number of hours remaining = 3.41. The coal consumption for this period of time would be

15 x 14.8 x 2534 which equals 129,600 pounds.

From May 1st to November 1st, the total KW hours consumption was 30,927. Assuming as before that 75% of this was used in a 10 hour period each day, the 23,200 KW was consumed at a rate of 23,200 divided by (184 x 10) or 12.62 KW per hour. The coal consumption during this time would be 15 x 12.62 x 1840 = 348,000 pounds.

The remaining 7,727 KW hours were consumed at a rate of 7,727 divided by (184 x 14) or 3.0 KW per hour. The coal consumption at this rate would be 15 x 3 x 2576 = 116,700 pounds.

The total yearly coal consumption would then be the sum of the foregoing amounts or 996,300 pounds or 498.1 tons.

At a cost of $7.50 per ton the yearly cost for coal would be 498.1 x $7.50 = $3,755.

LABOR CHARGES FOR PROPOSED PLANT.

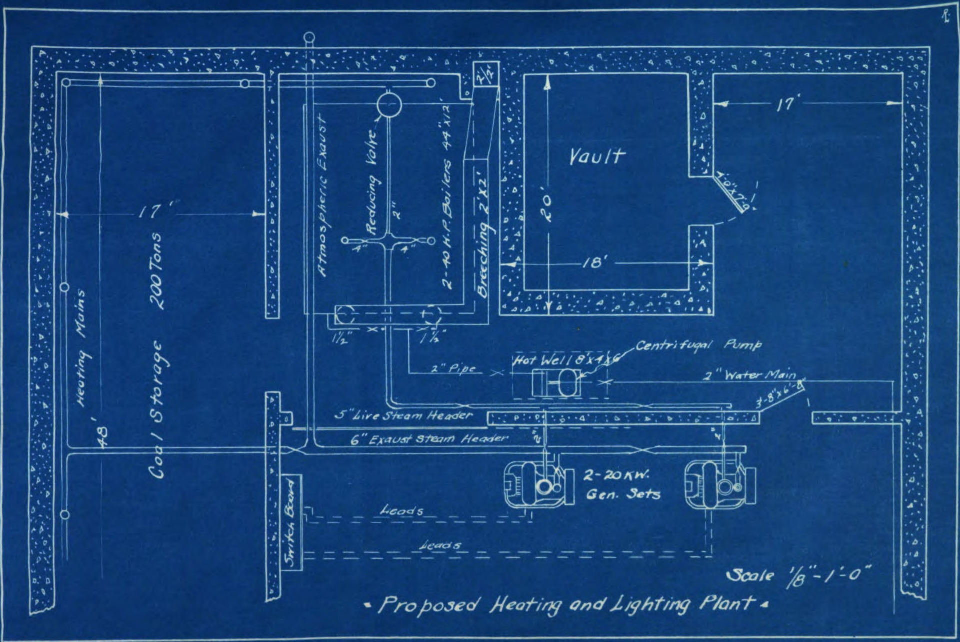
Labor charges for the proposed plant would consist in the payment of salary to 2 attendants. Each man would work on a 12 hour shift and would receive $1500 a year which is a fair wage. Thus labor charges for a year would total $3000.

Summarizing the above costs, we have

Generating Sets and Installation	$5,012.00
Boilers and Installation	3,733.00
Boiler Feed Pump	100.00
Pipe, pipe covering and valves	800.00
Total Cost	$8,645.00

Operating Expenses

498 tons of coal at $7.50 per ton	$3,755.00
Attendance of 2 men at $1500 each	3,000.00
Oil, waste and packing	75.00
Water for steam supply, etc.	50.00
Value of above equipment (Capatilized at 5%)	435.00
Total yearly cost	$7,315.00


Vault
17'
20'
18'
7'-0"x7'-0"
17'
Coal Storage 200 Tons
48'
Heating Mains
Atmospheric Exaust
Reducing Valve
2"
4"
4"
2-40 H.P. Boilers 44"x12'
Breeching 2'x2'
2'x2'
1½"
1½"
2" Pipe
Hot Well 8'x4'x6'
Centrifugal Pump
2" Water Main
3'-8"x6'-8"
5" Live Steam Header
6" Exaust Steam Header
2-20 KW. Gen. Sets
Switch Board
Leads
Leads
Scale 1/8"-1'-0"
Proposed Heating and Lighting Plant

CONCLUSIONS

Making a comparison of the operating charges of the proposed plant exceed the present charges by almost double or to be exact $2,442.00. This shows that the plant as proposed would not be feasible.

Numerous items account for this. One is the greatly increased cost of attendance that is, from $500 to $3,000 per year. Another item is that light and power cannot be furnished very efficiently during the summer months on account of the small size of the units.

In computing the operating costs of the proposed installation it will be noticed that the cost of heating water is not considered. This would probably increase the operating expenses a small amount but would not materially change the results, because during the summer months the exhaust steam from the engines would be, for the most part, wasted. Only that utilized to heat the water would be used. During the time that a heating load is carried, we have figured on a maximum heating load which would be true for only several weeks of time at the most. For the balance of the time we have assumed that the difference in the heat units between the maximum heating load and the average heating load would be sufficient to heat the water.

The largest difference in operating costs between the present and proposed plant would be the cost of coal. Under the present plan the cost of coal is figured as being $1305 per year, while the cost for the coal in the proposed plan would be, as we have figured it, $3,755. This is a difference of $2,450 per year and we cannot figure the proposed coal consumption any less unless we assume an unusually high operating efficiency.

We think that if the building were larger so that the power consumption was about four times the present consumption, a private power and heating plant would pay. This would be because of the greater economy in the production of power which it is possible to obtain in larger generating units.

It seems probable also, that the proposed plan would pay in this case during the winter months, if the power could be purchased for a reasonable amount during the time that a heating load was not carried.