DISTRICT HEATING

WEIGH THE ALTERNATIVES

4TH QUARTER 1981

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Duluth District Heating

by Harvey E. Sandstrom, Manager, Duluth Steam Cooperative Association.

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THE DULUTH STEAM COOPERATIVE ASSOCIATION

The Duluth Steam Cooperative Association operates the steam plant located in the heart of downtown Duluth, Minnesota. The steam plant and underground network of high pressure steam lines were constructed during the depression years of 1931-1932, and this plant has provided steam to a major portion of Duluth’s central business district for the past 50 years.

Duluth is located in a section of this country that experiences great fluctuations in temperature with highs in the 100°F. range to lows of -35°F to -40°F. The annual degree day load for Duluth is 9767° day degree days.

The existing steam generating facility includes four Edgemoor Iron Company pulverized coal-fired steam generators. The forced draft fans, the induced draft fans, the feedwater pumps and coal pulverizers are driven with steam turbines. One pulverizer is equipped with an electric motor drive to permit a cold start. The exhaust steam from the turbines is used to preheat and de-aerate the feedwater. Condensate from the heating system is not returned; consequently, 100 per cent of the feedwater required to replace this lost condensate is supplied by Lake Superior. The combustion gases are cleaned by mechanical multiclone collectors and a recently installed baghouse, and the collected fly ash is trucked to a municipal land fill disposal site. The induced draft fans supply draft to overcome the pressure drop of the steam generators, air heaters, mechanical collector, baghouse and duct work. The combustion gases are discharged into a single 240 ft. chimney for release to the atmosphere.

Technical Data

- Four Edgemoor boilers, each rated at 100,000 lbs. steam per hour at 250 psi and 406°F. The capacity of three boilers is required to supply peak load demand. One boiler is held in reserve.
- Maximum input to each boiler is 122 million btu per hour at a fuel burn rate of 8,600 lbs. of Eastern coal per hour.
- Western Precipitation mechanical multiclone fly ash collectors—84 per cent efficiency.
- I.C.A. Model 7—10,800, Series 8—7 compartment Fabric filters—to bring emissions within 0.4 lbs per million btu as required by state law.
- Boilers must be shut down for manual removal of bottom ash. This is about 20 per cent of the total ash.
- Combustion gases at outlet of I.D. fans:
  - Temperature at maximum load, F—460°
  - Maximum flow per unit, ACFM—47,800

- Steam distribution system at 150 psi consists of approximately 50,000 lineal ft. of underground, insulated pipe line, with strategically located loop interconnections for dependability in event of local disruption.

Operating Reliability

Since the supply of steam from the plant to the distribution system must be continuous, a spare steam generator is available to replace one shut down for ash removal or maintenance. A spare feedwater pump is also provided, and the distribution system is kept under pressure at all times.

History of the Duluth Steam Plant

Duluth Steam Corporation was spawned in the depression of 1932 and has existed on a rather spartan diet since. (The original plant was constructed at a cost of $1,500,000 with about a 50-50 split between the plant and the distribution system.) During the first eight years of its operation the company accumulated a severe operating deficit and it was not until twenty-two years after its inception that accumulated net earnings of the company were adequate to offset these early losses. The average earnings for the first twenty-seven years of existence amounted to ¾ of 1% of the original invested capital, and the company struggled through its first eighteen years without paying any dividends to its stock holders.

In May 1962 the General Waterworks Corporation of Philadelphia purchased all of the common stock of the Duluth Steam Corporation. In September of 1976, Duluth Steam and General Waterworks were notified by the Minnesota Pollution Control Agency (MPCA) of inadequate particulate emission control and resulting non-compliance with State air pollution control regulations at the Duluth Steam Plant. Duluth Steam and the MPCA signed a stipulation agreement to either install adequate pollution control equipment or close the Steam Plant by July 1, 1978. Engineering calculations estimated a cost of 1.25 to 2.00 million dollars for baghouse filters of a size and design adequate to treat combustion gases to MPCA standards. Subsequent discussions between General Waterworks and their steam customers indicated a lack of support for the rate increases required to pay for the necessary pollution control equipment, and the ultimate result was a decision by General Waterworks to abandon the Duluth Steam system as of July 1, 1978.

Over the years the Duluth Steam district heating system had become an accepted dependable and effective institution in the Duluth central business district. Most older buildings had abandoned or removed old coal burning
equipment, and most new buildings had no provision or space for boilers of any sort. Therefore, when General Waterworks began contemplating abandonment of the central steam plant there was a good deal of concern on the part of the city government and the downtown building owners. In response to the concern over possible system abandonment, the Mayor of Duluth created an Energy Advisory Committee made up of city officials and building owners and managers. The consulting engineering firm of Black & Veatch was retained to provide technical and financial advice regarding alternatives for consideration. The following is from their report, which considered alternatives to the operation of the existing steam plant.

**DULUTH DISTRICT HEATING SYSTEM EVALUATION**

**Introduction**

The problems and opportunities relating to the supply of steam to the district heating customers currently served by the Duluth Steam Corporation have been investigated in this study. The problems are complex, but two major factors are apparent:

1. Stringent federal and state environmental regulations have become a significant factor leading to higher costs of steam production.

2. Actions of foreign energy suppliers have “destabilized” fuels markets, establishing a trend toward higher fuel costs.

A wide range of possibilities for improvement of the steam supply situation for Duluth Steam Corporation customers have been investigated. The more promising of these possibilities have been investigated as “plans.” These plans and the consequences of their investigation are summarized in the following.

**Summary of Important Information**

Information that has been especially pertinent to the study and its conclusions is as follows.

1. The traditional fuels which have been used by Duluth Steam Corporation (DSC)—Eastern Coal and natural gas—have risen in cost significantly above historical levels. Natural gas is subject to increasing curtailment, and is projected to be unavailable beyond 1980.

2. Fuels which have been considered as possibilities for future steam production are:

   - Eastern Coal
   - Western Coal
   - Oil
   - Wood Wastes
   - Municipal Wastes
   - Electricity
3. Among these fuels (above), electricity is comparatively costly when considered as a replacement energy source for steam production fuel or as a replacement for steam use at the users' sites. Electricity may be used advantageously in specific situations to offset steam needs. However, in comparison to the other alternatives considered in this report, it is not attractive as a general replacement for steam or steam production fuel.

4. The following plans for district steam supply were investigated:

Plan 0—Operation of existing facility without change. (This is a "base" plan for comparison purposes only; not feasible because of environmental requirements.)

Plan 1—Equip DSC plant to burn oil as supplementary fuel in quantities sufficient to satisfy particulate emission criteria. Eastern coal would continue to be used.

Plan 2—Modify DSC plant to permit utilization of Western coal.

Plan 3—Construct new steam plant capable of burning wood wastes, municipal wastes, and Western coal (2-200,000 lb per hour boilers).

Plan 4—Obtain surplus steam from the Western Lake Superior Sanitary District incineration plant which is currently under construction. Steam pipeline would be required to interconnect with DSC system.

Plan 5—Construct new steam plant as in Plan 3, however, initial installation of single boiler (1-200,000 lb per hour) would be made with provision for later addition of a second unit. Existing DSC plant would be used as backup and for supply peak demands.

5. The capital investment requirements of each of the foregoing plans have been estimated to be as follows, based on projected initial operation in 1980. The estimated time requirements for implementation of the plan are also shown. (See Estimated Capital Costs.)

**ESTIMATED CAPITAL COSTS**

<table>
<thead>
<tr>
<th>Investment Requirement</th>
<th>Estimated Time Requirement for Implementation*</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1000</td>
<td>years</td>
</tr>
<tr>
<td>Plan 0 (none)</td>
<td>—</td>
</tr>
<tr>
<td>Plan 1 1,079</td>
<td>1½</td>
</tr>
<tr>
<td>Plan 2 9,206</td>
<td>2½</td>
</tr>
<tr>
<td>Plan 3 35,765</td>
<td>4</td>
</tr>
<tr>
<td>Plan 4 5,368</td>
<td>1½**</td>
</tr>
<tr>
<td>Plan 5 22,383</td>
<td>4</td>
</tr>
</tbody>
</table>

*From date of project of authorization.
**1½ years, or more depending on installation schedule of equipment at WLSSD incineration plant.

The foregoing plans were evaluated based on conditions of either public tax exempt financing or private ownership. The expected results have been determined on a comparative basis as follows.

**PERCENTAGE COMPARISON OF PRESENT WORTH OF 10-YEAR PLAN COSTS***

<table>
<thead>
<tr>
<th></th>
<th>Tax Exempt Financing</th>
<th>Private Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan 0 Base</td>
<td>+11%</td>
<td>+14%</td>
</tr>
<tr>
<td>Plan 1 1⅓%</td>
<td>+21%</td>
<td>+46%</td>
</tr>
<tr>
<td>Plan 2 1⅓%</td>
<td>+56%</td>
<td>+14%</td>
</tr>
<tr>
<td>Plan 3 1⅓%</td>
<td>+15%</td>
<td>+30%</td>
</tr>
<tr>
<td>Plan 4 1⅓%</td>
<td>+45%</td>
<td>+98%</td>
</tr>
</tbody>
</table>

*Estimated total costs including amortization, taxes and insurance, operation and maintenance, and fuel.

In addition to the foregoing plans for continued steam supply from central facilities, comparative estimated costs of steam from customer owned steam generation facilities were determined. A comparison of these costs with current DSC steam costs, and with costs that would apply to DSC steam if the plant were modified in accordance with Plan 1, is given in Estimated Annual Steam Costs. The table shows that, based on current oil costs, steam users who have existing oil-fired boilers and who have current annual steam costs of several thousand dollars or more, can probably realize savings by reactivating their boilers. The table also shows that the largest users could perhaps obtain savings through the use of oil-fired on site boilers even if they were required to install new boilers, although the margin of prospective savings is relatively small. As a practical matter, when the likelihood of higher oil prices than have been used in this study is considered—and also the prospect of future oil shortages—it appears that in most cases there would not be sufficient incentive to warrant the installation of new oil-fired boilers.

If, however, existing boilers are available for reactivation, it appears that reactivation of these boilers may be warranted where annual DSC steam costs exceed approximately $2,000 per year. That is, where the DSC steam cost to a single user (or block of users served at a single point) have an annual cost exceeding $2,000, reactivation of existing oil-fired boilers may be economical if such reactivation can be accomplished without incurring excessive cost. Each such prospective situation would require individual consideration.

**Conclusions**

Based on the investigations of this study with respect to investigation of steam generation from the DSC plant, it is concluded that:

1. The construction of a new plant to generate steam for the system is not economically justified.
2. The lowest cost future alternative irrespective of ownership is the plan (Plan 1) which requires minimal change to the existing facilities and minimal investment. No other plan promises to provide substantially lower costs for any set of circumstances which are considered to be likely.

*Based on DSC steam charges applicable during the July 1, 1975 through June 30, 1976 period.
## Comparative Estimated 10-Year Costs for Alternative Steam Supply Plans

(Thousands of Dollars)

<table>
<thead>
<tr>
<th></th>
<th>Tax Exempt Financing</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Private Ownership</th>
<th></th>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plan 0</td>
<td>Plan 1</td>
<td>Plan 2</td>
<td>Plan 3</td>
<td>Plan 4</td>
<td>Plan 5</td>
<td>Plan 0</td>
<td>Plan 1</td>
<td>Plan 2</td>
<td>Plan 3</td>
</tr>
<tr>
<td>Amortization Costs</td>
<td>0</td>
<td>1,278</td>
<td>10,890</td>
<td>35,460</td>
<td>6,354</td>
<td>22,194</td>
<td>0</td>
<td>2,313</td>
<td>19,764</td>
<td>65,061</td>
</tr>
<tr>
<td>Taxes &amp; Insurance‡</td>
<td>0</td>
<td>110</td>
<td>920</td>
<td>3,580</td>
<td>540</td>
<td>2,240</td>
<td>0</td>
<td>110</td>
<td>920</td>
<td>3,580</td>
</tr>
<tr>
<td>Operation &amp; Maintenance</td>
<td>4,591</td>
<td>4,591</td>
<td>6,113</td>
<td>4,591</td>
<td>4,201</td>
<td>6,113</td>
<td>4,591</td>
<td>4,591</td>
<td>6,113</td>
<td>4,593</td>
</tr>
<tr>
<td>Total 10-Year Costs</td>
<td>34,536</td>
<td>38,259</td>
<td>41,714</td>
<td>54,110</td>
<td>39,710</td>
<td>50,345</td>
<td>34,536</td>
<td>39,294</td>
<td>50,588</td>
<td>83,713</td>
</tr>
<tr>
<td>Present Worth of Tax Exempt 10-Year Cost† Financing</td>
<td>20,296</td>
<td>22,480</td>
<td>24,485</td>
<td>31,695</td>
<td>23,313</td>
<td>29,527</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Percentage Ownership</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>18,510</td>
<td>21,045</td>
<td>27,005</td>
<td>44,503</td>
</tr>
<tr>
<td>Comparison of Present Worth of 10-Year Costs</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Private Ownership</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Tax Exempt Financing</td>
<td>—</td>
<td>+11%</td>
<td>+21%</td>
<td>+56%</td>
<td>+15%</td>
<td>+45%</td>
<td>—</td>
<td>+14%</td>
<td>+46%</td>
<td>+140%</td>
</tr>
</tbody>
</table>

*Plan 0 (continuation of current operation in the present mode) is not a feasible plan; costs are for purposes of comparison only.

‡On additions

† 1979 Present Worth; 10 per cent present worth factor for tax exempt financing, 12 per cent factor for private ownership.

## Estimated Comparative Annual Steam Costs

<table>
<thead>
<tr>
<th>Quantity Consumed pounds</th>
<th>Current DSC Rates $</th>
<th>DSC Rates with Plan 1 Modifications $</th>
<th>New Boilers $</th>
<th>Existing Boilers $</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100,000</td>
<td>1,000,000</td>
<td>10,000,000</td>
<td>100,000,000</td>
</tr>
<tr>
<td></td>
<td>518 (5.18)</td>
<td>591 (5.91)</td>
<td>1,734 (17.34)</td>
<td>652 (6.52)</td>
</tr>
<tr>
<td></td>
<td>5,001 (5.00)</td>
<td>5,701 (5.70)</td>
<td>6,294 (6.29)</td>
<td>3,270 (3.27)</td>
</tr>
<tr>
<td></td>
<td>45,090 (4.51)</td>
<td>51,403 (5.14)</td>
<td>48,046 (4.80)</td>
<td>26,700 (2.67)</td>
</tr>
<tr>
<td></td>
<td>398,203 (3.98)</td>
<td>453,951 (4.54)</td>
<td>372,394 (3.72)</td>
<td>254,900 (2.55)</td>
</tr>
</tbody>
</table>

Steam cost in “dollars per thousand pounds” are shown in parentheses ()..

* Rates are for 1975-1976 heating season.

** It is estimated that the overall cost to customers of DSC would be approximately equal for Plan 1 with either (1) continued private ownership and financing of improvements or (2) tax exempt public purchase and financing of improvements.
3. Public tax exempt financing can provide lower costs than private ownership, particularly for alternatives where large capital investments are involved. Consideration of the prospect of individual customers using oil-fired boilers revealed that for users who have existing boilers suitable for reactivation—and where annual steam costs are in excess of $2,000—such boiler reactivation may be worthwhile. The installation of new oil-fired boilers is, in general, not sufficiently attractive to be worthwhile in view of the economic risks involved.

This report confirmed that the operation of the existing steam plant should continue. The alternative of converting the plant to burn fuel oil versus the installation of equipment to meet air quality requirements was evaluated and it was decided to proceed with a plan which would meet the air quality requirements.

CITY'S PURCHASE DECISION

Prior to the City's agreeing to acquire the steam plant and to make the improvements, customers utilizing approximately 70% of the steam plants output agreed to continue to utilize steam for the next ten years. Due to litigation which prevented the sale of bonds and after considering the timing on the transactions, the City of Duluth elected to acquire the steam plant from the Duluth Steam Corporation utilizing surplus cash from the general fund. The purchase of the plant facilities and inventory of coal and supplies, less certain credits, amounted to $723,423.90.

The next step was to have Legislation passed by the State of Minnesota to accomplish the following three main objectives:

1. The first objective was to authorize the City of Duluth to issue bonds to reimburse the general fund of the City the amount expended for the acquisition of the Duluth Steam Corporation, plus interest, and to provide working capital. The desired objective was to have the steam utility customers pay for, through their rates, the cost of acquisition of the facility. Without this legislation, the City would be unable to reimburse the general fund; consequently, all citizens of the City of Duluth would pay for the purchase of the Steam Plant rather than the Customers.

2. Secondly, the Legislation authorized an annual payment from the City’s utility fund to the general fund. This payment is in lieu of the franchise fee and real estate tax which the City formerly received from the Duluth Steam Corporation. The maximum amount which would be permitted to be transferred is two percent of the Steam Utility’s gross revenues. This provision employed the same concept as is presently utilized in the operation of the City’s Gas Department.

3. Third, the Legislation permitted the City Council to delegate to a private management organization the authority to contract for purchases of materials and supplies and for performance of maintenance on the Steam Utility. The Duluth Steam Cooperative Association and the City Administration believed that such a provision would permit a more efficient operation of the utility. All contracts are subject to the procedures required by the Uniform Municipal Contracting Law.

This Legislation was approved by the State of Minnesota on May 21, 1979.

DULUTH STEAM ACQUISITION
### District Steam System Forecast Cash Flow

(Thousands of Dollars)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Working Capital (Beginning Balance of $75,000)</td>
<td>75</td>
<td>234.4</td>
<td>346.1</td>
<td>456.5</td>
<td>557.7</td>
<td>662.2</td>
<td>767.1</td>
<td>883.2</td>
<td>957.1</td>
<td>1,104.2</td>
<td>1,207.6</td>
</tr>
<tr>
<td>Net Revenue</td>
<td>104.3</td>
<td>82.9</td>
<td>58.1</td>
<td>29.8</td>
<td>(3.2)</td>
<td>(70.0)</td>
<td>(144.2)</td>
<td>(282.7)</td>
<td>(380.9)</td>
<td>(489.7)</td>
<td>(609.5)</td>
</tr>
<tr>
<td>Revenue Future Increases in Base Rates (1)</td>
<td>156.5</td>
<td>(2) 380.1</td>
<td>399.2</td>
<td>419.6</td>
<td>456.5</td>
<td>523.8</td>
<td>613.5</td>
<td>747.1</td>
<td>844.2</td>
<td>945.0</td>
<td>1,049.7</td>
</tr>
<tr>
<td>Adjusted Net Revenue</td>
<td>260.8</td>
<td>463.0</td>
<td>457.3</td>
<td>449.4</td>
<td>453.3</td>
<td>463.8</td>
<td>469.3</td>
<td>464.4</td>
<td>463.3</td>
<td>455.3</td>
<td>440.2</td>
</tr>
<tr>
<td>Other Revenue Requirements Principal and Interest Capital Construction from Revenues</td>
<td>93.4</td>
<td>342.3</td>
<td>337.9</td>
<td>338.2</td>
<td>337.8</td>
<td>336.9</td>
<td>340.2</td>
<td>337.9</td>
<td>339.8</td>
<td>335.9</td>
<td>336.5</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>Ending Balance</td>
<td>234.4</td>
<td>346.1</td>
<td>456.5</td>
<td>557.7</td>
<td>662.2</td>
<td>767.1</td>
<td>883.2</td>
<td>957.1</td>
<td>1,104.2</td>
<td>1,207.6</td>
<td>1,294.3</td>
</tr>
<tr>
<td>Debt Service Coverage</td>
<td>—</td>
<td>1.35</td>
<td>1.35</td>
<td>1.33</td>
<td>1.34</td>
<td>1.37</td>
<td>1.38</td>
<td>1.37</td>
<td>1.36</td>
<td>1.36</td>
<td>1.31</td>
</tr>
</tbody>
</table>

(1) Rate Increase Over Previous Year’s Base Rate 10% 13% 0 0 1% 3% 4% 6% 4% 4% 4%

(2) 1978 revenue from increase in base rate reflects full year effect of a 10% increase during 1978

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Cooperative Agreement

The City entered into a management agreement with the Duluth Steam Cooperative Association on August 28, 1978.

The pending purchase of the steam plant necessitated taking the following immediate actions:

(1) Labor Contract

The Duluth Steam Corporation had made an agreement that their last contract signing stating that the labor contract would be binding upon successors. This labor contract stipulation plus the fact that the existing city employees were Civil Service Employees, who were also under a residence requirement, were in the foreground when the decision to have an outside group operate the steam plant was made. The small group of specialists who operate the steam plant would have been almost impossible to blend into the City Civil Service organization. The procedure for posting and replacing a Civil Service employee is so time consuming that it is almost a full year before a vacancy can be filled.

Fortunately Duluth Steam was able to obtain a contract extension for the balance of the contract life (until January 31, 1979). This four months gave them time to negotiate and rewrite a new contract. In this new contract they were able to eliminate a lot of meaningless language and procedures that had crept in over the previous 20 years.

(2) Fuel Contract

Coal is delivered to the plant by railroad cars or trucks which discharge directly into the loading pocket. A stock pile of approximately 200 ton is kept for emergency use, primarily in case of a winter storm which might delay deliveries. The city purchasing procedure requires annual bidding for coal supplies. The successful bidder purchases and stores the coal at his dock and delivers as needed to the plant. Annual usage is approximately 31,000 ton of Eastern Bituminous coal.

The late purchase date for the plant caused additional problems. The advertising time, bid evaluation time and awarding time placed us in a position where the potential freezing of the Great Lakes might have prohibited delivery to Duluth from the Eastern Lake Ports. As it turned out the last boat had to break ice to get into the coal dock slip.

However, Duluth Steam did get an exceptional bid which lowered fuel costs by nearly 10%.

(3) Working Capital

A loan was arranged with the City of Duluth Water and Gas division to provide for the necessary funds to operate until bonds could be sold, or until Duluth Steam was able to generate enough cash from steam sales. Fortunately there was an early cold winter and sales were good the first heating season.

(4) Rate Schedule

It was decided to keep the same rate that the old company was using for the balance of the calendar year. This gave time to instigate a rate study and incorporate several changes in the new rates for the ensuing year.

Plant Modifications

The final designs of the modifications required to meet Air Quality regulations were the next order of business, and continued as per schedule. The Duluth Steam Cooperative had to assume that the State of Minnesota would pass the necessary Legislation enabling the City of Duluth to sell the necessary General Obligation Steam Revenue Bond. Construction bids were received and, as soon as the Legislation was approved and the bonds sold, a contract was awarded to the contractor. Design drawings were completed and fabrication started immediately.

The Consulting Engineering firm of Black & Veatch was then asked to do a plant betterment study. The results of this study follow.

PLANT BETTERMENT STUDY

The current performance of the Duluth Steam Plant has been revised based upon daily operator log sheet data from the month of January 1979. This January 1979 data reflects winter operation on coal only. During the summer months the reduced system demands are presently met by firing natural gas in Boilers 2 and 3. Due to the anticipated limited availability of natural gas in the future, this analysis is based on coal-fired operation only. The important information and conclusions based on the January 1979 operating data are as follows:

Summary of Important Information

(1) The daily average mass flow rate of vent steam over a wide range of plant operating conditions ranged from 2,700 lb/h to 8,300 lb/h with a monthly average of 5,300 lb/h.

(2) Plant steam consumption and corresponding steam vented to atmosphere was approximately 3,000 lb/h greater with Unit 2 on-line than with Unit 2 out of service.

(3) The daily average range of vent steam mass flow rates previously stated do not reflect plant operations with Unit 1 out of service. With the Unit 1 electric motor driven coal mill out of service, the plant steam consumption and corresponding amount of steam vented to atmosphere would increase by 2,000 to 3,000 lb/h.

The steam vented to atmosphere represents a substantial loss of energy from the cycle. As future operations are to be similar to the January 1979 conditions, the plant steam consumption needs to be reduced by approximately 5,000 lb/h to obtain the optimum steam cycle balance.

The Duluth Steam Plant had a very seasonal load model since it primarily serves heating customers. The January 1979 data analyzed represents substantially higher plant steam demand than would be typical for the summer months. Graphical analysis indicates that lost vent steam increases with decreasing total steam generated. Although this effect can be minimized by keeping the minimum number of boilers online to meet the system demand, it is anticipated that the maximum steam-vent condition will...
MONTHLY DISTRIBUTION OF ANNUAL STEAM USE FOR DULUTH, MINNESOTA

STEAM (per cent)

<table>
<thead>
<tr>
<th></th>
<th>JUL</th>
<th>AUG</th>
<th>SEPT</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUNE</th>
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</thead>
<tbody>
<tr>
<td>Profit Month</td>
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<td></td>
<td></td>
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<td>Loss Month</td>
</tr>
<tr>
<td></td>
<td>4.1</td>
<td>3.3</td>
<td>4.1</td>
<td>5.6</td>
<td>9.6</td>
<td>14.7</td>
<td>16.7</td>
<td>13.4</td>
<td>13.1</td>
<td>6.8</td>
<td>4.6</td>
<td>3.9</td>
</tr>
</tbody>
</table>

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Your business depends on energy, our business depends on conserving it.
occur during the summer months when coal is burned instead of natural gas.

**Modifications Considered**

The Plant modifications evaluated include the following:

1. **Replacement of Coal Pulverizer Drive Turbines.**
   - When operating two steam driven coal pulverizers at design load, the resulting reduction in plant steam consumption by upgrading the coal pulverizer drive turbines would be approximately 5,430 lb/h.

2. **Replacement of Induced Draft Fan Drive Turbines.**
   - When operating two I.D. fans at 75 per cent of fan test block load, the resulting reduction in plant steam consumption by upgrading the I.D. fan drive turbines would be approximately 500 lb/h.

3. **Replacement of Forced Draft Fan Drive Turbines.**
   - When operating two F.D. fans at 75 per cent of fan test block load, the resulting reduction in plant steam consumption upgrading the F.D. fan drive turbines would be approximately 800 lb/h.

4. **Restoration of Boiler Feedwater Pump No. 2**
   - Since the installation of Boiler Feedwater Pump No. 1 in 1965 and No. 2 in 1970, no maintenance had been performed on their respective turbine drives. For high reliability of the steam plant, the minimum parts and service information required to restore these units to their installed performance was obtained.

5. **Replacement of Feedwater Pump Turbine.**
   - As an alternative to restoration of Boiler Feedwater Pump No. 2 drive turbine to its installed performance, improving the performance by increasing its speed was considered. At its full design load, this would result in a reduction in steam consumption of approximately 850 lb/h.

6. **Atmospheric Vent Condenser.**
   - Installation of an atmospheric vent condenser to eliminate the steam plume presently being vented to the atmosphere was evaluated. Based on a design maximum vent steam flow of 10,000 lb/h and city water entering at 50°F and discharging to the sewer at 100°F, the city water requirements would be approximately 200,000 lb/h or 400 gpm.

The economic comparisons of the proposed plant modifications are presented in the following table.

**Conclusions**

Replacing the drive turbines on the Units 2, 3, and 4 coal pulverizers is economically feasible for a total capital cost of $127,700. The reduction in plant steam consumption would be approximately 5,430 lb/h.

Replacing the I.D. fan drive turbines on all four units is not economically feasible. In addition, the solid wheel turbines presently installed are more suitable to the service than bladed wheel turbines.

Replacing the F.D. fan drive turbines on all four units is economically feasible for a total capital cost of $157,800. The additional reduction in plant steam consumption would be approximately 1,000 lb/h.

Boiler Feedwater Pump No. 2 can be restored to its as-installed performance for a total capital cost of $16,700. For an additional capital cost of $2,700, the operating speed can be increased resulting in a reduction of full load steam consumption of 850 lb/h. However, no operating savings has been claimed since this is a standby unit.

Installation of an atmospheric vent condenser would have no appreciable effect on reducing the amount of steam vented to atmosphere, unless once-through city water is used as the cooling medium. Based on January 1979 operating data using once-through city water would double the present total plant water consumption.

**Recommendations**

1. The drive turbines on the Units 2, 3, and 4 coal pulverizers should be replaced as soon as practical.
2. After the coal pulverizer turbine drive modifications have been completed, it can be determined from operating data whether additional reductions in plant steam consumption would be required to eliminate the venting of steam.
3. If the average flow of steam vented to atmosphere continues to exceed 1,000 lb/h, the forced draft fan drive turbines should be replaced.
4. If the average flow of steam vented to atmosphere is less than 1,000 lb/h, the insulation should be

**ECONOMIC COST COMPARISON OF PROPOSED PLANT MODIFICATIONS**

<table>
<thead>
<tr>
<th>Cost</th>
<th>Turbine Drive Modifications</th>
<th>Feedwater Pump Modifications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coal Pulverizers</td>
<td>ID Fans</td>
</tr>
<tr>
<td>Capital equipment cost</td>
<td>$ 61,300</td>
<td>$ 88,700</td>
</tr>
<tr>
<td>Installation cost</td>
<td>40,900</td>
<td>59,100</td>
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<tr>
<td>Installed equipment cost</td>
<td>$102,200</td>
<td>$147,800</td>
</tr>
<tr>
<td>Indirect cost</td>
<td>15,300</td>
<td>22,200</td>
</tr>
<tr>
<td>Contingency</td>
<td>10,200</td>
<td>14,800</td>
</tr>
<tr>
<td>Total Capital Cost</td>
<td>$127,700</td>
<td>$184,800</td>
</tr>
<tr>
<td>First Year Operating Savings</td>
<td>$117,600</td>
<td>$10,900</td>
</tr>
<tr>
<td>Rate of Return</td>
<td>101%</td>
<td>6%</td>
</tr>
<tr>
<td>Payback Period</td>
<td>1.1 yrs.</td>
<td>14.1 yrs.</td>
</tr>
</tbody>
</table>

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removed from the city water supply line to the City Water Storage Tank, the tank itself, and the water lines to Feedwater Heaters No. 1 and 2. (This modification should only be undertaken after evaluation of the potential for sweat damage.) The feedwater heater vessels and feedwater lines to the boiler feed pumps should be insulated. After this modification is completed, the forced draft fan turbine drive modifications should be re-evaluated.

(5) The 4,051 rpm Worthington turbine installed on the standby Boiler Feedwater Pump No. 2 should be overhauled and new gearing installed for operation at 4,760 rpm. This modification will lower the full load steam rate to correspond to full load steam rate of the primary unit, Boiler Feedwater Pump No. 3.

(6) The replacement of the induced draft fan turbine drives and installation of an atmospheric vent condenser is not recommended.

After evaluation of this report it was decided to immediately proceed with the replacement of the coal pulverizer turbines and drives. This would provide for a near steam balance in the plant and eliminate the problem of excess exhaust steam being vented to the atmosphere.

**OTHER MODIFICATIONS**

It was decided to install Oxygen Trim equipment on the boilers to provide for automatic control of excess air. This installation was estimated to provide a 4% reduction in quantity of fuel required.

New boiler controls are being phased in and all but one boiler has now been modernized. Solid state temperature monitoring equipment has been installed which allows the operator to determine conditions in the plant by a touch of a button.

Automatic blow down equipment has been installed on one boiler to see if solids in boiler water can be controlled by this type of equipment. This has not worked satisfactorily but testing is continuing.

A 150 KW diesel generator was obtained as Air Force Surplus and has been installed to replace a condemned 150 KW steam turbine driven generator. Duluth Steam now can operate without outside electrical power supply. Quite often there are power interruptions during severe electrical storms. Just a near strike could interrupt our electrical circuits and the boiler safety equipment would activate and the boilers would shut down.

There were a number of employees near retirement age who elected to retire soon after the plant was sold. These retirements allowed Duluth Steam to hire replacements who had different skills which were desperately needed in the plant such as instrument technicians, welders, boilermakers, and plant electrician. The Chief Engineer also retired. Some of these positions were filled by promotion from within, but a majority were obtained from the area labor market.

It was decided to use the installation of the new equipment as a training ground for these new employees. This has worked remarkably well. The person that installs a steam turbine and drive feels sure of himself when he has to do maintenance on that piece of equipment.

**Plant Operating Statistics**
The feasibility study that recommended the purchase of the steam plant estimated a growth of 5% per year for the first 5 or more years. This has not happened, primarily due to the national energy emergency and the skyrocketing of fuel costs. Steam sales have remained nearly level for the past four years. Duluth Steam has had growth, but they have had real economizing on the part of the customers. As an example of this, the Federal Post Office cut their requirements for steam by 35%.

The most significant figure is steam sold versus steam produced. This has increased from 62-63% to 68% which amounts to a 7% improvement.

A concentrated effort has been made to eliminate sources of steam loss. Examples of areas that were changed are:

1. Eliminated 2,000 feet of steam line that was being held in reserve for a potential customer.
2. The replacement of bad traps and insulation of piping and valves that had bad or no insulation. An infrared scan was used to detect areas that were suspected of excess heat losses.
3. Watching boiler demand so if an extra boiler could be eliminated it would be cut off. About 10,000 lbs of steam per hour is required for each boiler's auxiliaries. This also helped to control steam balance in the plant. As an example, assume 120,000 lb/h as system demand.
   
   \[ 3 \text{ boilers} = 30,000 + 120,000 = 150,000 \text{ lb/h} \]
   
   \[ = 50,000 \text{ lb/h per boiler} \]
   
   \[ 2 \text{ boilers} = 20,000 + 120,000 = 140,000 \text{ lb/h} \]
   
   \[ = 70,000 \text{ lb/h per boiler} \]

   This saving of 10,000 lb/h is further helped by better combustion efficiency at the higher range on the boilers.

In addition the accuracy of measuring units was checked. As an example the plant use steam flow meter was changed to a size that would register in the middle of the meter's range rather than the previously oversized unit which was at the bottom of the chart.

By re-checking the steam generated meters it was found that incorrect conversion factors had been used. The plant had theoretically been rated at 250 psi, but in reality was operated at 235 psi so recorded amount generated was not accurate.

**Water Treatment**

This plant had been criticized as being inefficient because it doesn't return condensate. There are a number of reasons to believe that the operating success is partially because the plant does not return condensate.

1. The Lake Superior water is a good source of treated make-up water.
2. They don't have a duplicate underground piping system to maintain. A number of Minnesota central heating plants have been abandoned due to
DISTRICT STEAM SYSTEM
FÖRECAST STEAM SALES

STEAM SALES
MM/LBS.

1977 '78 '79 '80 '81 '82 '83 '84 '85 '86 '87 '88
ESCALATION RATE %  5%  5%  5%  5%  5%  2%  2%  2%  2%  2%  2%

TOTAL STEAM

PURCHASE DATE (9-28-78)

STEAM GENERATED

STEAM USED IN PLANT

STEAM UNACCOUNTED FOR

STEAM SOLD

1941  1976  '77  '78  '79  '80  '81
(EST.)

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deteriorated condensate lines. The increased pumping costs are also an item to be considered.

(3) Steam is treated so condensate in customers' lines is not acidic. A neutralizing amine is used for this purpose. The previous owners had decided condensate treatment was too expensive so consequently a number of unsatisfied customers were inherited.

The current boiler water treatment program is very satisfactory. Duluth Steam is able to operate for a full season (approximately 225 boiler days) without having to take a boiler down for cleaning. At one time 60 days was tops and then tubes had to be turbined and much sludge was found in the boiler, along with many plugged tubes. Last summer they were averaging about 2 five gallon pails of sludge per boiler without any plugged tubes when the boilers were cleaned. Western Chemical Company of Kansas City supplies the chemicals. The following are used:

(1) Caustic soda for pH control in boilers.
(2) Trisodium Phosphate to soften calcium hardness in make-up water.
(3) Western's 202B for sludge conditioner.
(4) Catalyzed oxygen scavenger to neutralize free oxygen in make-up water.
(5) Coravol MS-30 neutralizing amine for neutralizing the acidic effects of carbon dioxide in condensate.

Condition of Plant
The author has had an opportunity to personally inspect the complete system. The boiler plant and distribution are in good to excellent condition. Fifty years of operation with acceptable maintenance indicates that twenty or more years of useful life remain in this operation. The steam distribution line, operated at 150 psi and 358°F all year around, looks as good as the day it was installed. There is maintenance to do on some of the zone valves, but that would be considered normal maintenance.

Fuel Supplies
The plant was designed for and is operating on Eastern bituminous coal in the 13,500 BTU/lb range. The possibility of using various types of fuel has been investigated:

(1) Western Coal
(2) Wood Refuse
(3) Peat
(4) Municipal Wastes
(5) Grain Dust

The most promising at this time is Western Coal but a number of problems would have to be overcome before this would be feasible:

(1) High freight cost plus uncertain future
(2) Low BTU value causing boiler de-rating
(3) Fire hazard in storage
(4) Dust problems in storage
(5) Boilers not being designed for this type of coal

Duluth Steam will continue to evaluate the possibility of burning these alternative fuels as well as investigating the possibility of co-generation.

One of the possibilities was to use a gas fired turbine which would be exhausted into the existing boilers. At the present time there are no turbines that are capable of being operated at a low enough demand so the boilers could utilize this exhaust heat.

However, the study indicates that if the customers' load would increase enough, a conventional turbine would be feasible. This would mean the turbine exhaust would be used to heat water which would be circulated as a hot water heating system. Currently the price for natural gas is unreasonably low and our potential customer load will remain with gas until deregulation occurs.

The following chart showing Comparative Energy Costs assumes 65% efficiency in the utilization of fuel oil and natural gas. The price for steam is our average selling price for each calendar year.

Financial Condition
Duluth Steam has had to increase the selling price for steam approximately 26% to cover the cost of the plant improvements and for increased fuel and labor costs during the first 2 1/4 years of operation. They have increased rates an additional 5% for 1981. These increases seem high to their customers, but considering that inflation has been in the double digit area for the past three years, the necessary improvements have been made and rates have remained below the inflation level.

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ACKNOWLEDGEMENTS

Particular recognition for the success in making the transition from the Duluth Steam Corporation ownership to the City of Duluth should go to the following persons:

David Peterson—Former Director of the Duluth Department of Water and Gas
Robert Bowman—Building Owners and Managers Association
Robert Prescott—Building Owners and Managers Association
Arthur M. Dahl—Former Manager, Duluth Steam Corporation
Mayor’s Citizen Advisory Committee

References

District Heating Supply Steam Study—1977
Black & Veatch, Consulting Engineers
Capital Improvement Study—1978
Black & Veatch, Consulting Engineers
Plant Betterment Study—1979
Black & Veatch, Consulting Engineers

DISTRIBUTION OF TOTAL REVENUE

FUEL 54%
LABOR 13%
POWER 1%
WATER 1%
CHEMICALS 1%
MATERIALS & SUPPLIES 4%
ADMINISTRATION & GENERAL 5%
TAXES 2%
DEPR. & AMORT. 1%
BOND REDEMPTION 12%
MARGIN 6%
Coordinator of Bus Transport
Larry E. Tuck
Boston Edison Co., MA

Tuesday Night Dinner in Old Quebec City
Donald and Joan Dawson
York University, Downsview, Ont.

President's Reception
Gerardus and Carla Pregel
The ECE Group
Don Mills, Ont.

President's Banquet
Fred and Jean Carson
McMaster University
Hamilton, Ont.

Master of Ceremonies
John S. Sudbury
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The International District Heating Association represents those companies and individuals engaged in the concept of supplying thermal energy in the form of steam, hot water, and chilled water for heating, cooling and process use in organized communities. It represents the industry throughout the United States and Canada, and has affiliates throughout the world.

The membership is involved in and greatly concerned with the most efficient use of energy, the planning and development of central cities and other high density areas, the conservation and encouragement of investment in the industry, and the protection of the environment in an intelligent and rational manner.

The IDHA, by the very nature of the industry, supports clean air and protection of the urban sector because these efforts are best achieved by central energy distribution methods. It is opposed to an emotional atmosphere in environmental matters resulting in unnecessarily costly constrictive or ambiguous governmental controls. It supports safety programs that are proven concepts with economically justified benefits.

The Association's objectives are to collect, coordinate and disseminate ideas and information, on efficient methods of producing, distributing, marketing and utilizing central energy systems, and on the accounting and administrative methods employed in the industry; to advance knowledge and learning, and to stimulate invention and research; and to cooperate with other organizations and agencies by interchange of ideas and information.

The annual dues bills have been sent out. Please check for any changes in address or Company Representative. If you have not previously joined a committee please note the area of your interest. Thank you for your assistance in bringing our records up to date.

**Necrology**

Peter Mørch, export manager for I.C. Møller a/s, died on June 6, 1981. Mr. Mørch had been a member of IDHA since 1978.