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FRONT COVER: George Sundborg describes Grand Coulee Dam's boisterous beginnings and awesome impact in his article beginning on page 28. Details about the area shown on the cover appear on page 37.

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Hot-Water District Heating WORKS WELL FOR WILLMAR, MINN.

Willmar's steam district heating system showed its more than three score and 10 years of operation. Steam billowed from leaks (top) and tunnels, piping and insulation had deteriorated (bottom). Photos by Jeff Kimpling, Willmar Municipal Utilities Commission

by MICHAEL NITCHALS, CLARENCE KADRMAS and MICHAEL BARNES

THE NATION'S FIRST MUNICIPAL hot-water district-heating system has replaced a steam district-heating system in Willmar, Minn.

Willmar, about 100 miles west of the Twin Cities, provided steam district heating for more than 70 years. Low-pressure steam, supplied primarily by extraction from electrical generating turbines, was distributed to 120 customers, including about 80 in the downtown business district.

The old steam system was similar to those found in many Midwestern communities, with typical problems: little condensate return, high heat losses and numerous leaks. Annual sales were often as little as 50 percent of steam send-out. By 1980 it became clear the steam system had a limited remaining life. The downtown business district was slated for a major renewal, including paving, sidewalks, and underground electrical service. This combination of downtown renewal and technological obsolescence of the steam system clearly provided an opportunity.

Early in 1981, the Municipal Utilities Commission directed its staff to prepare a study to aid in determining the best heating system. The study considered three options:

- Abandon the steam system and allow customers to convert to alternate fuels (i.e., natural gas);
- Replace the existing steam system with a new steam heating system; and
- Replace the steam system with a new hot water district heating system.

These options were obvious, and the decision to limit the study this way allowed it to be completed quickly and in-house.

The staff reviewed the many recent studies concerning modern hot-water district heating. They showed the costs of converting to natural gas (the lowest-cost alternate fuel) and hot-water heat were nearly the same in the first year of operation, with steam heat being somewhat more costly. However, natural gas was forecast to cost nearly 65 percent more than hot-water heat after 10 years.

Nitchals and Kadrmas are, respectively, controller and superintendent of operations for the Willmar (Minn.) Municipal Utilities Commission. Barnes is president of Scantec.

Following review of the report the Municipal Utilities Commission held a public hearing in April 1981, and the following month adopted the hot-water district-heating option.

Being the first municipal hot-water district heating system in the nation meant experienced assistance could be difficult to obtain. Three problems became immediately obvious:

- locating hot-water design consultants;
- converting the customers' internal steam heating systems to hot water; and
- preparing an acceptable financial plan for the hot water project.

In October 1981, the commission selected a joint venture team to design the project. Headed by Scantec Inc. of St. Paul, Minn., it included FVB of Sweden and Park Engineering. The design team began work in December 1981 and completed the piping network bid package in March 1982.

Scandinavian Design Modified

The distribution system design is based on conventional Scandinavian practice modified to account for local practices and needs. It uses pre-insulated pipe protected by a high-density polyethylene jacket combined with prefabricated and pre-insulated Ts, bends and valves. The structure of the pipe insulation allows transfer of some expansion forces to the surrounding backfill. No anchors or compensators were necessary and only one underground vault, for valving, was installed. The piping system includes an internal alarm system that alerts plant operators to any leakage or physical damage and allows them to locate such faults.

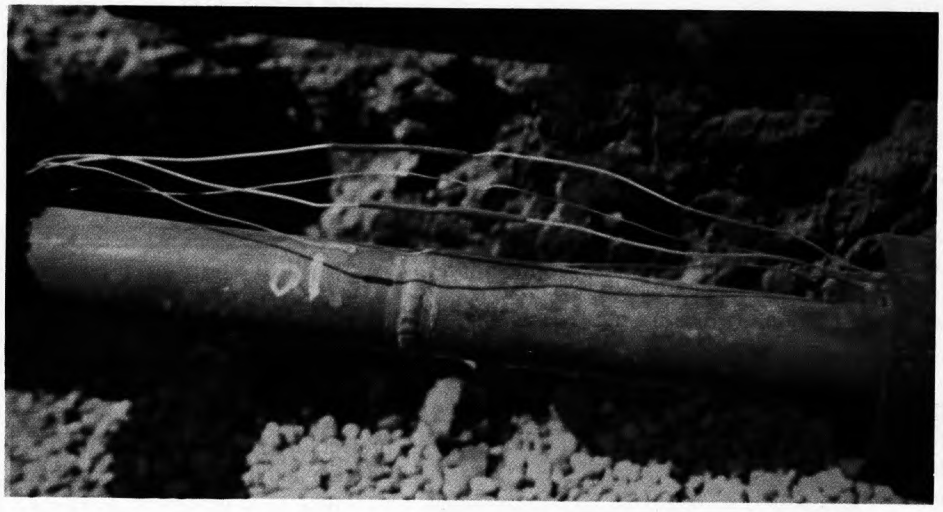
These techniques, proven in more than 50 major systems in Scandinavia, yielded the low costs required for financial feasibility. The products required for the project are available from a variety of suppliers and bidding was close. All products except heat meters were available from both U.S. and European suppliers.

The steam-to-water conversion plant was 'fast-tracked' with several long-lead-time mechanical components specified and bid before the building design and layout were completed.

This steam-to-hot water conversion process uses conventional shell and tube heat exchangers to condense the steam extracted from the generating turbine. The district heating system's circulating water is heated by this condensation. The conversion system is designed to assure that system pressure is maintained at the proper level and that thermal expansion of the water is properly compensated. The water send-out temperature is automatically controlled from the outside temperature and ranges from 235 F at –20 F outdoor temperature to 175 F at 40 F or warmer. Operation is automatic with all monitors available to the power plant operators. The piping alarms for leaks and physical damage are also displayed.

The ends of the joint sleeve were sealed with a heat-shrink material to keep groundwater from entering the insulation.

The wires above the butt-joint weld are part of Willmar's leak-detection system, which locates leaks before they are visible above ground.



The commission responded to the customer-conversion problem by preparing cost estimates and discussing feasibility and costs with property owners at numerous public meetings. Mechanical contractors experienced in conventional steam-to-hot water conversions (a fairly common practice) were asked to share their experiences with the local contractors. The consultant team also assisted local contractors with conversion concepts and system requirements. This reduced conversion costs. Open communication, among the utilities staff, building owners, and consultants, built and maintained confidence in the new technology. The Willmar Housing and Redevelopment Authority developed a program to aid in financing building conversion. This program offered loans at 12 percent interest as part of the downtown redevelopment process.

The commission and its financial advisor, Springsted of St. Paul, Minn., investigated many alternative financing plans before deciding on revenue-supported general-obligation bonds to fund the project. A $2.09 million general obligation bond issue was successfully sold in July 1982. The bond proceeds were used as follows:

Distribution system	
materials	$364,966
installation	$962,232
Heat-conversion station	
materials	$75,389
installation	$325,813
Engineering	$175,000
Contingency, capitalized	
Interest and financing	$186,600
TOTAL	$2,090,000

Willmar's new district heating system serves primarily commercial loads, and the persons who built the system were never far from a good lunch.
Photo Courtesy Minnesota Department of Energy, Planning and Development

System Built In One Summer

Construction of the entire system was completed during the short Minnesota summer of 1982. After a learning period in which numerous welds were rejected the contractor became fairly proficient and the pipe was installed at a rate meeting or exceeding that achieved in Scandinavia.

The system was filled and put into immediate service during the last week of September 1982. Many mundane initial problems were found within the converted buildings, but the system itself was essentially flawless. During the first season of operation there have been no leaks or forced outages.

A cost-based rate for district heating prices hot-water heat and steam heat on an equivalent price per million BTUs. The rates for 1983 are $7.25 per 1,000 pounds of steam and $.025 per kWh of hot-water heat. (Hot-water heat meters read in kWh). These rates are competitive with the actual effective rates for natural gas. (District-heating customers are billed only for energy actually used; there is no conversion 'efficiency'.)

Eighty-two customers, including five single-family residences, are located in Willmar's central business district, which has been converted to hot-water heat. The remaining 44 steam customers will be converted to hot-water heat later, depending on the useful life remaining in their steam-heating system. Inquiries from potential customers—including several senior citizen housing developments, a four-story medical clinic, a state-owned mental health care facility, commercial and single family residences—indicate a strong interest in hot-water heat.

'Municipal utilities have an inherent advantage in an open decision-making process.'

In conjunction with the downtown renewal project, the new hot-water district-heating system and its associated economies and advantages have generated downtown construction and expansion on a major scale. The municipal system expects to continue expansion indefinitely and is developing long-term plans to serve the entire city when economics are favorable.

Summary and Conclusions

Five conclusions can be drawn from Willmar's experience:

1. The modern hot-water district heating system in Willmar is economically competitive with natural gas. However, since at least 60 percent of the heating rate is related to debt retirement, the economic attractiveness of district heating is strongly dependent on system cost. Scandinavian design practices offer a low-risk method of achieving required low costs. Because European suppliers have developed products for hot-water district heating and modern production facilities, there will likely be competitive bidding for such systems' equipment. Each community will need to balance its responsibilities to ratepayers against 'buy American' feelings when awarding contracts. In Willmar, the lowest-bid American pipe was much more costly than the most expensive European product; domestic heat exchangers were slightly higher.

2. Because hot-water district heating is perceived as new and untried, it is most important that a utility involve prospective customers and members of the community in an open decision-making process. Municipal utilities have an inherent advantage in this respect and will probably continue in the forefront of district heating implementation.

3. The conversion of existing building-heating systems to hot-water district heating is neither as expensive nor as difficult as anticipated. Nevertheless a utility must be prepared to provide customer service from the start, both for consumer satisfaction and to guarantee proper operation of the system. Many projects are considered economically unfeasible because of a lack of understanding and technical experience.

4. Study and evaluation prior to any decisions to proceed with installation are necessary. A utility will need a certain amount of courage and tenacity to move a district-heating project to the point where a timely, informed decision can be made.

5. Unlike almost all other proposed district-heating projects, the system in Willmar involved no federal or state grants or loans. Since it was based on conventional municipal utility practices and financing, it could be replicated in many communities.