About Your House

North Series 3

Snowshoe Inn, Fort Providence Co-Generation Model

Introduction and Background

Primary energy sources, such as oil and diesel fuel, are becoming less accessible, more costly and are being over-utilized. Co-generation, also known as combined heat and power, provides a means of conserving energy by using existing energy sources more efficiently.

Fort Providence is a community of approximately 1,000 residents on the North bank of the MacKenzie River, 233 air kilometers southwest of Yellowknife, Northwest Territories. The co-generation project constructed around the Snowshoe Inn is one of the first models developed in the North. The system is over 20 years old, still functions fully and uses simple components. This report covers the initial installation which serviced a 1,672 m^2 (18,000 sq. ft.) 35-room motel, a 743 m^2 (8,000 sq. ft.) restaurant, a 557 m^2 (6,000 sq. ft.) warehouse, a greenhouse and two private homes. Other components have since been added, and additional space is serviced by these.

At the time of installation, a self-contained diesel-electric generating plant, put in place as a total system, was expected to reduce estimated energy costs by at least 50%, and pay for itself in four to five years (see Cost Savings section). In the end, energy savings were greater than 50% and the system paid for itself in less than two years. The theory employed by this system still applies. However, many of the system components are now obsolete and unavailable. But the concept has proven to be one which can be replicated in the North (Note 1).

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How the System Works

This simple system was installed in 1973. By self-designing the entire system, Sieg Phillips, the Snowshoe Inn Ltd owner, realized large cost savings. The main portion of the system provides power through three generators (specifications listed in Note 2). Generators have optimal operating temperatures which often means devising cooling mechanisms to cope with waste heat. Co-generation uses this waste heat captured in both the cooling water and the exhaust gases from the generators. Therefore, the generators perform two functions: power and heat for hot water and space heat.

The energy used to operate the generators represents:

- 35% converted into electrical power
- 25% released as heat (dealt with by the cooling circulating water system)
- 4% released as heat into the lubricating oil (not able to be re-captured)
- 36% released as heat in the exhaust gases.

Sixty-three per cent of the generator's output is potentially wasted. Co-generation systems can capture most of this energy through re-use of waste heat. Therefore, more energy can be re-captured through use of the waste heat, than is used for power, while allowing the generators to operate optimally.

Original Generator System—Still in Operation

Heat Exchanger (cast iron, biomass Converter furnace)

Recovery of Waste Exhaust Gas Heat

The generators produce exhaust gases of 500ºC. While most of the heat is recovered from the generators by the circulating water system (Figure 1), these hot gases are used in three ways. First, they are used at the generator to heat the circulating water which passes through a water jacket incorporated into the exhaust manifold. This not only reduces risk of fires by cooling the system—the majority of fires in generating plants are caused by hot exhaust air—this heat transfer to the circulating water prevents "cold" shock to the generators. Second, the gas is piped to the heat exchanger (an old cast iron boiler) where it provides additional heat for the circulating water system. And third, from the heat exchanger, it is used to heat one of the buildings (more under "heating").

Recovery of Waste Heat Through a Circulating Water System

The generators are cooled by water circulated through a "jacket" on the generators. In this system, the approximately 21,400 litres (about

Figure 1: Schematic of Generators' Jacket Water and Exhaust Heat Recovery Systems

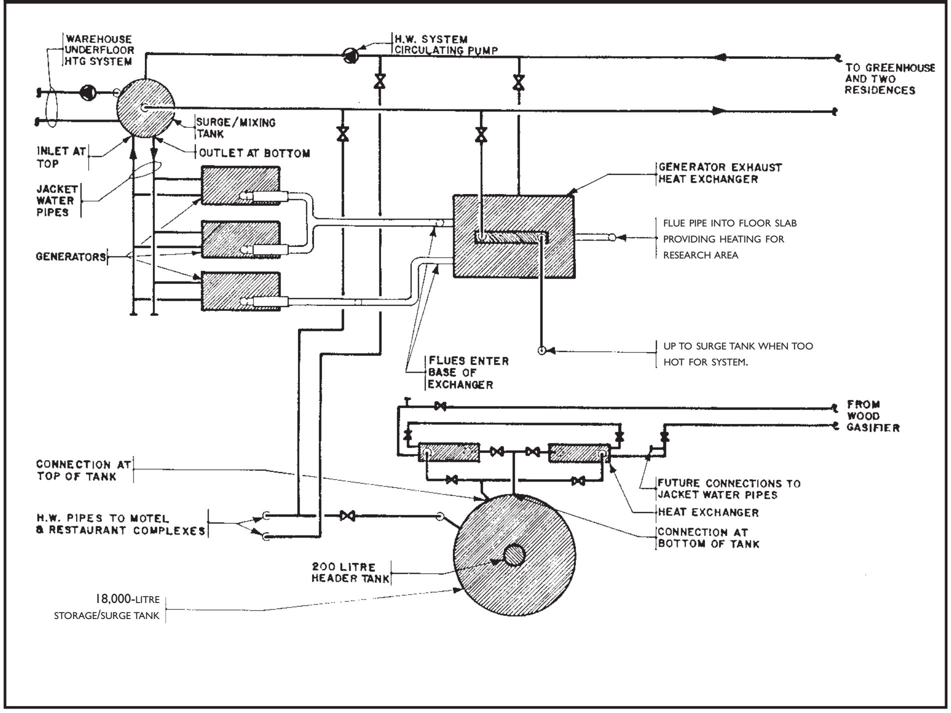
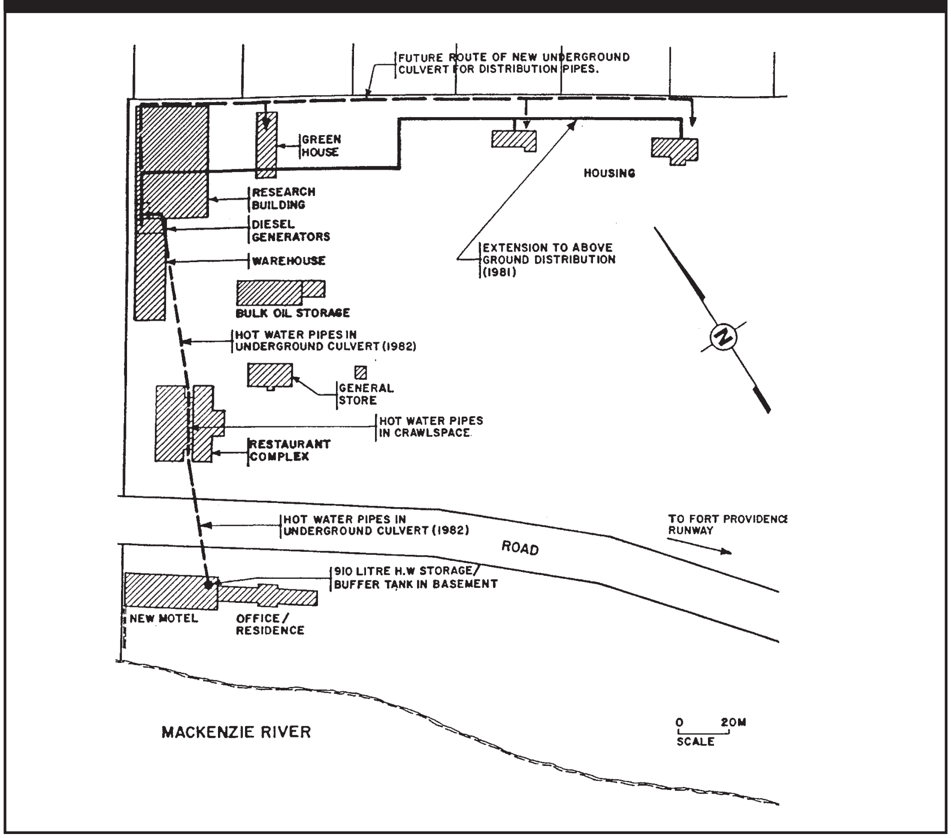


Figure 2: Snowshoe Inn Site Upgraded Hot Water Distribution System



7,500 gallons) of water are part of an "open" heating system operating at 75 kPa (11 psi maintained by a 200-litre header tank, connected to the cold water supply to maintain system capacity). A single pump (Bell & Gossett, 4 L/S at 36 kPa head, ½ HP motor) handles the system flow. The 80°C water leaves the generator jackets and goes into a "buffer tank" which mixes this hot water with the cooler water returning from the heating system. This drops the water temperature to about 27°C.

Manual values control the flow of the water. During the summer, when demand for heat is low, the water will go straight from this tank into the heating system. When more heat is needed, the water from the buffer tank is passed through an exhaust heat exchanger (an old cast iron boiler). Generator exhaust gases (as described above) provide additional heat at this point. An 18,000-litre (4,755 gal.) storage/surge tank holds this water, keeping the system temperature constant.

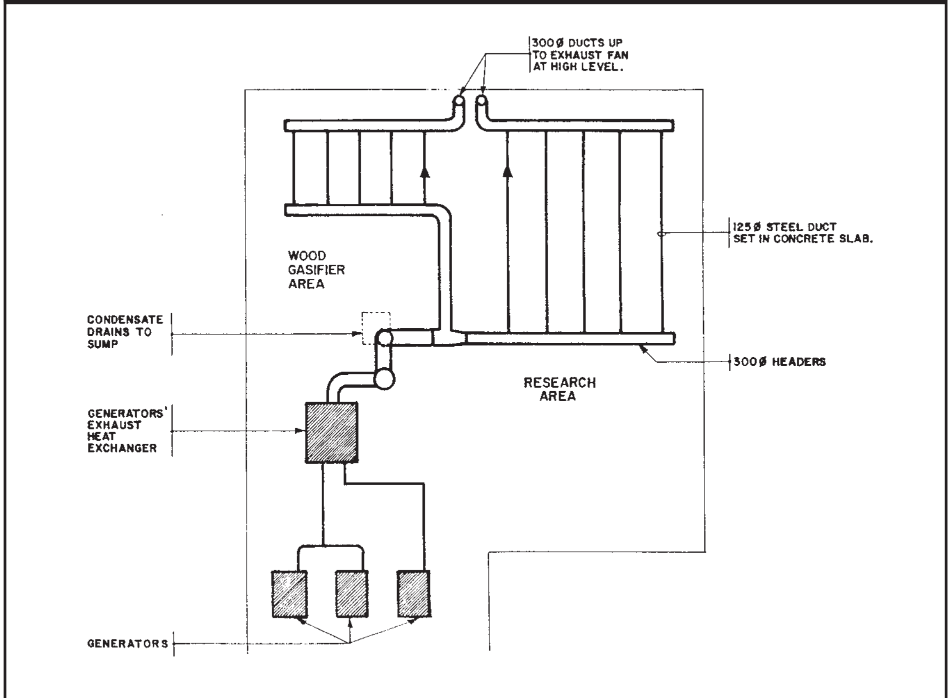
Most of the system is manual, and includes simple control components: valves, thermometers and alarms. It is monitored at least twice a day and can be adjusted for system requirements.

Distribution System

The means of transporting heat to the multiple buildings serviced by the system has evolved over the years. Originally, a utilidor was used successfully, until it became necessary to cross a road, when advantage was taken of the unique soil conditions. In Fort Providence, there is glacial till to a depth of about 5½ m (18 ft.) and an additional 1.5 m (5 ft.) of clay beneath the till. Because of the ice-stable soils, basements and underground systems can be used.

Now, although above-ground distribution pipes run to two residences, the remainder of the buildings are serviced by a 1,000-mm galvanized steel culvert which houses two 50-mm polybutylene hot water pipes (see Note 3). These are not insulated and there is no glycol in the system. Rather, a chemical compound maintains a pH level of 8-10 and prevents corrosion, especially where steel floor slab heating pipes are used. Additionally, the circulating warm water prevents freeze-up.

Figure 3: Research Building Heating From Exhaust Waste Heat



Exterior Shot of Warehouse Heated With Hot Exhaust Gas From Generator

Heating

This waste heat from the power system warms up water for heat and hot water for six main areas; five use a water-based system and the sixth, the warehouse, uses the exhaust gases.

Warehouse

The warehouse is heated directly by the waste gases after they pass through the heat exchanger where they provide additional heat for the water system serving the five other areas. From the heat exchanger, the gas temperature is about 100°C. These feed into 13 steel ducts embedded in the warehouse floor which provide total heating for the 557 m^2 (6,000 sq. ft.) building. The hot air is drawn through by an exhaust fan which discharges it at a high level. Condensation from the gases drains into a sump where it is periodically pumped out.

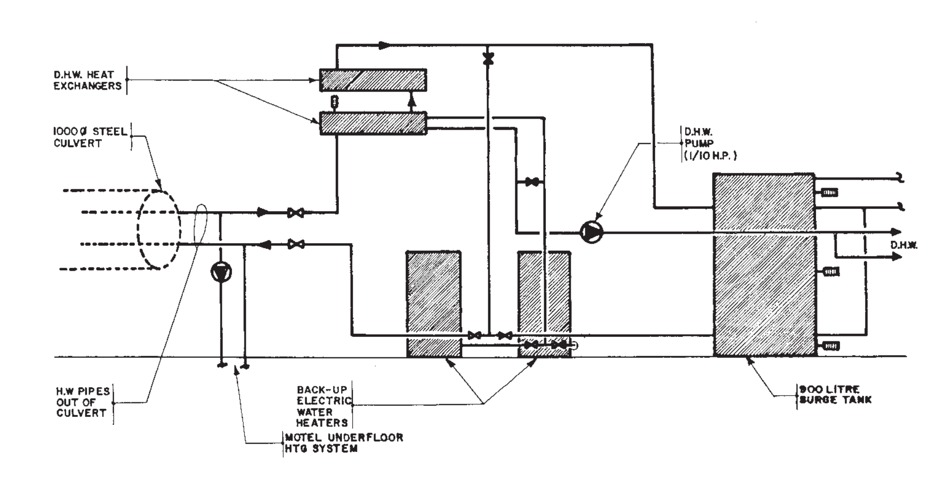
Motel

The 1,672 m^2 (18,000 sq. ft.) motel was designed for low grade waste heat using steel frame construction with concrete slab floors. It is suitable for both warm air and slab heating systems. The 50-mm polybutylene pipes (described in Note 3) enter the motel and provide hot water for the slab heating system, the two make-up air units and the hot water heat exchangers (before continuing on to service the office and a residence).

Slab heat is in the basement only, using a single circuit, 1,875 m long of 25-mm polyethylene piping. The water is 38°C upon entry, and 21°C at exit. This heats the three levels of the motel to 15°C. Electric baseboard heating is provided in each room, with a thermostat, to fine tune the temperature level.

At each of the three levels, warm air is discharged providing both make-up

Figure 4: Schematic of Motel Domestic Hot Water and Underfloor Heating Systems



air for bathroom fans as well as maintaining positive pressure, thus reducing uncontrolled air infiltration.

Domestic hot water uses the largest portion of the waste heat hot water. Two heat exchangers bring the domestic hot water to 38°C. Two 4.5 kW electric hot water heaters are used if extra heat is needed. Uninsulated copper pipes are used to circulate this water to the rooms.

Motel Office and Residence

The office and residence were originally heated with an 82-kW propane-fired boiler. Now, a 900-litre (238 gal.) surge tank in the motel feeds into copper pipes which lead to this boiler. It is used only as a standby in case of a leak or failure of the main pump.

The under-floor heating system consists of 15-mm polybutylene pipes over wood flooring, held in place by secured chicken wire, and covered with 32 mm of concrete and a finished floor surface. Five circuits, 50 m each in length, are modulated by their own control value and thermostat.

Restaurant/Cocktail Lounge/Crafts Shop

This 743 m^2 complex represents the area of greatest activity. It was originally heated by a propane-fired forced air system. With the availability of hot water, heating coils were installed in the return air inlet of the furnaces, and two make-up air units now provide heat distributed through floor grills or ceiling diffusers. The restaurant exhaust fan provides large amounts of make-up air. The circulation of the water, however, prevents it from freezing despite having no glycol in the system. The "head" in the warehouse maintains pressure, but a stand-by pump is also provided.

The system does not provide hot water for the restaurant complex as water of at least 15°C is required for cleaning kitchenware. Electric water heaters serve this function.

Greenhouse

No longer in use—Fort Providence was unique in that it once maintained both a greenhouse and operated a chinchilla breeding facility. This luxury was affordable because not only was the heat free, but the exhaust fans for the heating system operation drew out excess moisture. The greenhouse now houses a 64,000-litre (17,000 gal.) waste oil storage tank used to fire the boiler, entailing substantial savings.

Slightly different in construction, 38-mm supply pipes from the heating plant fed into 25-mm steel pipes laid 450 mm on centre within a gravel floor (steel was used as better protection against damage). Two circulating pumps were installed (one as a standby) as the water passed from the greenhouse to two residences.

Family Residences

Two family residences are serviced by an overground system of 25-mm polyethylene pipes wrapped in fibreglass and polyethylene leading from the greenhouse. The homes are on four circuits of 25-mm polyethylene pipe laid out in circles; the outside circuit only serves the perimeter of the homes to maintain adequate heat. Again, a stand-by pump is provided should the main pump fail.

Like the office and other residence, these homes also use in-floor heat resulting in 15°C room temperatures which can be fine-tuned by use of electric baseboard heating.

Cost Savings

A government report was prepared, including estimated cost benefits of the model (see Note 4), about 10 years after the system was installed. Since then, further modifications to the system, such as the addition of a second boiler which uses either wood, or the waste oil stored in the former greenhouse, continues to reduce costs.

(Left to right) Residence, Office and 35-Room Motel whose Heat and Hot Water are Supplied by the Hot Water Produced by the Co-gen System

Because detailed figures are not available, the report used best estimates regarding cost savings. In 1982, had all the areas been serviced by electrical power provided by a utility company, it was estimated that it would have cost $163,000. Heating fuel would have comprised an additional $20,000 in costs (estimated). In contrast, the annual cost for fuel and oil for this co-generation system was $59,678. The capital costs of installing the co-generation system (generators, piping, distribution system and labour), was approximately $50,000. Savings were greater than $2,500 per month (and, as fuel and power prices increased, so did savings). Therefore, the payback period of the co-generation systems was less than two years—and the savings continue to accrue over these 28 years.

Acknowledgments:

Information was gathered through on-site tours with Courtney Hurgott, system manager in Fort Providence and interviews with Sieg Phillips, creator of the unique system in 1999. Jeff Phillips (Sieg's son) also assisted. The 1982 report cited in Note 4 was used for additional reference; the four figures in this text were reproduced from this report.

Note 1:
A 1982 report prepared by Ferguson, Simek, Clark Ltd. for Northwest Territories Public Works and Energy Mines and Resources Canada concluded:

"There is no doubt that this project has been a huge success. The fact that the motel manager (Sieg Phillips) had such a strong background in the mechanical engineering field, meant that he was able to design and direct the complete installation of the generators and distributions system. He also devoted countless hours to maintenance and the many problems that crop up over the years.

With this in mind, if that knowledge and dedication are available in a similar community, the option of a similar sized complex to generate its own power and use the waste heat for a number of buildings, is certainly worth the consideration."

To this end, we have seen similar work in Fort McPherson and Arviat.

Other related articles include "District Heat Generates Power, Wealth in Remote Community" (Grassy Narrows, North Ontario example) published in "Frostline" in 1997 and extensive work done in Oujé-Bougoumou, Quebec.

Note 2:
These generators are either no longer available, or not available affordably for use. Similar ones can be researched. These are the generators still in place in Fort Providence:

#1 Tamper generator, Canron Ltd: 75 kW capacity powered by a naturally aspirated, GM diesel engine

#2 Tamper generator, Canron Ltd: 100 kW capacity powered by a naturally aspirated, GM diesel engine

#3 Brown Boveri: 175 kW capacity powered by a turbo-charged, GM diesel engine (installed at a later date as extra stand-by capacity).

Note 3:
Use of polybutylene pipe is more common in Europe. Because of the danger of fire spread with this material, it should only be used where the pipe contains water under pressure. Further, if exposed to ultra-violet light, carbon black should be used to protect the pipe. Otherwise, the pipe has demonstrated excellent chemical resistance; no susceptibility to stress cracks; ease of fitting and joinery; little friction and flow rate loss; resistance to hydraulic shock and damage from freezing and bending.

Note 4:
Ferguson, Simek, Clark Ltd. prepared the Fort Providence Waste Heat Recovery Report as part of the Canada/Northwest Territories Conservation and Renewable Energy Demonstration Program for Northwest Territories Department of Public Works and Energy, Mines and Resources Canada. It appears to have been completed in 1982.

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Printed in Canada
Produced by CMHC
02-01

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