District Heating & Cooling

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The United Kingdom's First District Heating System Delivers "Green Heat"

Stephen Brooks, Development Manager, Sheffield Heat and Power Ltd.

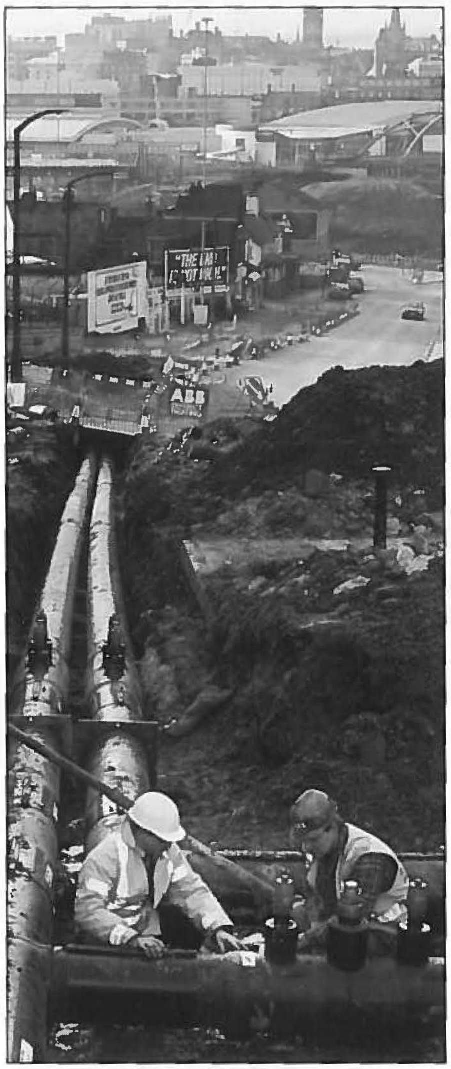
The United Kingdom is a relative latecomer to district heating in downtown areas. While the system has been successfully applied for 20 years or more in many European and North American cities, there has been little real interest or commitment to its use in this country. Indeed, while the benefits have been accepted in principle, the general view has been that the obstacles to district heating implementation in major British cities are just too great.

Yet the foreign experience has been good. Cities like Copenhagen, Paris, Frankfurt, Berlin and New York have successfully implemented district heating systems over the years and have found them to live up to expectations. System failures have been relatively few and far between and, where problems have occurred, the necessary lessons have been learned and put to good use.

Although there have been a number of interesting experiments on Britain's doorstep, the earliest of which dates back to a small system built in Glasgow in 1908, there has been no real attempt to follow the European example with a widespread commitment to district heating systems — despite their strong economic and ecological advantages.

Against this background, the vision and determination of Sheffield in implementing the first city-scale system in the United Kingdom is even more impressive.

The city has accumulated extensive experience over the past few years. It has planned and constructed a combined heat and power system using the community's waste. It demonstrates that, despite the challenges to be met and overcome, it is perfectly possible to follow European experience in Britain.



Workers inspect a bend in the district heating system piping in Sheffield.
Courtesy of Sheffield Heat and Power, Ltd.

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Sheffield has proved that efficient heating installations require long-term planning. Yet so does the environment. The issue has become one of global importance; the two are inextricably linked. With combined heat and power, Sheffield's waste now becomes Sheffield's future heat — "Green Heat."

Where Did It Begin? Where Is It Going?

Combined heat and power did not come quickly to Sheffield, a city three hours northwest of London with a population of 525,800 (1990). In 1988, a five-year study and economic appraisal was completed recommending a private limited company be founded to own, operate and finance a city-wide combined heat and power system. Based on the study, the Sheffield City Council issued an open invitation to suitable private sector developers with a proven track record in the implementation and operation of a city-wide combined heat and power system. The system was to be the first of its kind in the United Kingdom. After consideration of the various proposals, EKONO Oy of Finland was invited to form an independent company with the Sheffield City Council in which EKONO Oy, an international engineering group, would be the majority shareholder. It was the beginning of Sheffield Heat and Power Limited.

This was the first company established under the Sheffield Partnership Initiative. The company's board of directors is comprised of The Lord Ezra, chairman of the board of directors; three senior vice presidents from EKONO; and three City Council chief officers.

In April 1992, British Gas, one of the world's leading energy supply and distribution companies, paid in the region of £3 million (US $4.69 million; Can $5.85 million) for a third share in the company, with EKONO and the City Council rationalizing their shareholdings so that all three partners hold one third each.

The company has also formed a subsidiary to own and operate the country's first independent commercial Clinical Waste Incineration Plant to service the needs of the Sheffield and area regional Health Authorities. The plant, which was completed in March 1991 at a cost of £1.5 million (US $2.35 million; Can $2.93 million), is fitted with heat recovery equipment to allow the heat energy produced in the process to be used in the district heating network.

The investment capital, which currently stands at over £7 million (US $10.9 million; Can $13.6 million) was raised on a limited recourse financing basis with the Bank of Tokyo International, i.e., the borrowing is not supported by financial guarantees or underwritten by the shareholders.

The system has been operating on a commercial basis for over four years and is competing successfully with the existing energy utilities.

The company objective is to use operating surpluses to reinvest in system expansion to create further cost efficiencies and then to reduce energy costs to the consumer. It is expected that £125 million (US $195 million; Can $244 million) will be spent over a 20-year period of time.

Alternate Energy Form is Positive for Environment

Sheffield Heat and Power Ltd. purchases steam from the City Council's Bernard Road Incinerator Plant, a plant that processes 120,000 tons of refuse each year. This steam is then converted into hot water at temperatures between 85 degrees C and 120 degrees C (185 degrees F and 248 degrees F), by two 18 MW and one 25 MW heat exchangers. In addition, there are also three standby/peaking boiler plants connected to the network at Norfolk Park (1 x 6 MW gas/gas oil), Park Hill (4 x 4 MW gas oil) and Bernard Road (2 x 6 MW gas/gas oil). As the demand connected to the network increases, it is expected that the standby/peaking capacity will also be increased.

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The hot water is distributed at a maximum pressure of 16 bar (232 psi) through a network of pre-insulated underground steel pipes to the consumer's building where it is connected to a stainless steel heat exchanger. This heat exchanger is installed in place of a conventional boiler, and unlike a boiler produces no fumes, no noxious or poisonous gases, is silent in operation and requires virtually no maintenance or operation.

The consumer can then take advantage of an economical, safe, reliable and environmentally friendly source of heat which can be used in their existing heating and domestic hot water systems.

As well as providing a viable form of alternative energy which is less expensive for the consumer to own and operate, it is also helping to improve the environment. Since the company was formed in April 1988, over 160 million kWh of fossil fuel energy have been saved. This not only represents an enormous saving to the nation in our energy reserves, it also means that over 30,000 tonnes of carbon dioxide, a primary "greenhouse gas" that would have been produced by the combustion of fossil fuels, have also been withheld from our atmosphere.

This first viable alternative energy source for Sheffield is fast becoming the first choice for an increasing number of companies who see the economic and environmental advantages of switching to "Green Heat." Many are beginning to see waste as a valuable resource.

Phased Development Proves Successful

The combined heat and power network in Sheffield was planned in phases, the first two of which have now been completed.

Phase I, completed in April 1988, consists of over 11 kilometers of underground pipeline and serves 15 main developments covering more than 3,500 dwellings and shops and totaling 30 MW.

Phase II, completed in February 1990, consists of 6.5 kilometers of underground pipeline and serves major downtown civic and commercial premises totaling more than 27 MW.

Two of the newest customers to come on line in late 1993 and early 1994 will be the Crown Courts and offices (3.5 MW) and the new Sheffield Hallam University (15 MW).

Encouraged by the success of the system so far, Sheffield Heat and Power is now planning Phase III. This could involve installing another 5 kilometers of pipeline and associated equipment representing an investment of about £5.8 million (US$9.07 million; Can$11.20 million). An ambitious plan to construct a combined cycle combined heat and power station will make available a further 120 MW of heat for the heating network as well as 120 MW of electricity to be sold into the national grid. This alone represents a potential investment of £70 million (US $109.5 million; Can $136.6 million) — a confident plan built on the proven success of the existing scheme to date.

The experience on Phase II of the Sheffield project allows system developers to claim confidence that district heating mains can be installed in downtown areas.

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The I. C. Moeller division of ABB Power acted as main contractor to Sheffield Heat and Power Ltd., the joint venture company owned by Sheffield City Council and EKONO, in constructing the city-wide system. I. C. Moeller's extensive experience across Europe proved invaluable throughout planning and construction.

Sheffield is the fourth largest city in the country and, like Rome, is built on seven hills.

The most important factor, however, was the total team effort displayed by all involved. There were many difficulties to overcome, and the work simply could not have been carried out were it not for everyone's cooperation and support — from the Local Authority and client at one end, to the public utilities whose help we needed in locating mains and cables on our route, to the general public and potential customers.

Construction Details and Planning Make a Difference

Before talking about the practicalities of laying the main through the heart of the city, here is just a word about the pipes which are used for the distribution of the hot water within Sheffield's district heating project.

The pre-insulated pipes widely used today have proved themselves to be thoroughly reliable, resistant to corrosion, leakage and other damage. Their correct installation is absolutely vital. This is the key to the system having a long trouble-free life. Installation techniques have been perfected to such an extent that in Sheffield the trenches were prepared, the pipes laid and tested and trenches backfilled in record time.

Yet getting pipe installed in Sheffield was no easy task. Sheffield is the fourth largest city in the country and, like Rome, is built on seven hills. Phase II of the project, described earlier, was aimed right at the heart of the city.

A trench 1.5 meters wide, up to 2.0 meters deep and 3.0 kilometers long had to

The piping was strategically designed to negotiate the utility interferences often found beneath the streets.
Courtesy of Sheffield Heat and Power, Ltd.

be dug along and across some of the city's busiest thoroughfares. It went alongside public buildings, churches, theatres and across a railway line. All with the minimum of disruption.

The one prerequisite above all others was to gain the cooperation of everyone concerned. Starting with the highway authority and the police, a schedule of work had to be drawn up and permission granted for closing parts of the busiest thoroughfares. To keep disruption to a minimum, some very strict disciplines were imposed.

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Some roads could only be worked on at night or on weekends; on others, only one lane could be closed at peak times, leaving very little room to maneuver. Whatever happened, work had to be completed on time both for the job as a whole and for its individual elements.

The only way to win cooperation of all parties affected was to maintain a dialogue with them, to win their support and to build relationships.

Regular weekly meetings were held with the highway authority and the police. All problems and grievances were discussed and plans were strategized.

Whenever possible the construction team talked to anyone else who would be affected by the plans and kept them in touch as the project went along. This, of course, was not only necessary for the progress of the job itself, but for building positive relationships with the potential customers of Sheffield Heat and Power's end product.

One of the greatest unknowns of the entire job was the location of other underground services — the utilities, British Telecom, and others — whose pipes, cables and mains we would have to work around.

Despite careful study of the utilities plan, we knew that there would be many underground services which were not marked. Furthermore, the plans which we did have did not give us any real clues as to the depth at which we would find things.

We started by accumulating all the known information and communicating with all the other services to update that information as far as we could. We dug an ample number of trial holes. Overall this policy worked well. But as you might expect, there were a number of surprises. In one place where we expected to encounter a single 30-inch gas main, we actually found two. What was worse, there was no indication as to which one was live.

Elsewhere we encountered a nest of 42 cables where the plan showed just one. We also discovered an unmarked sewer. In total, we effected 3,000 utility crossings on our route.

There were a few surprises, as indicated, but with the cooperation of everyone concerned, no serious holdups.

There were only a few minor incidents. We did pull out one 11kVA cable and GPO cable; the former was not shown on the plan, the latter was shown but not where we found it.

All in all, these are minor problems which strengthen the view that working around the multitude of services in a busy downtown area can be done if approached properly.

Keeping the Traffic Flowing

Keeping the traffic flowing is another, but equally important, matter. It won't come as a surprise to anyone to hear that a small holdup on a major thoroughfare of a town like Sheffield at the start of the rush hour can take two or more hours to clear. No one will thank you for being

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the cause of that delay, and the local authorities are simply not going to tolerate it.

Once again, planning is the essential ingredient. Working closely with the police and highway authority, we were able to be very flexible and responsive to traffic management requirements on a day-to-day basis.

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In some places, such as a road with 100 bus movements daily, only a night shift was possible. The trench had to be filled in every morning and uncovered again at night so that the road was open during the daytime.

On other roads, we were restricted to just one lane's working width during the busy periods.

We had to dig 40 meters of tunnel across a dual carriageway highway allowing for a 6 meter drop in level from one end to the other; in route we encountered the foundations of an old cinema.

The route took us alongside the Crucible Theatre as well as two churches and cathedrals. These places posed a different kind of problem. At times, such as evenings and weekends, when, generally speaking, our work would cause the least inconvenience to most people, these places were especially sensitive both to the noise of work and ease of access.

Close liaison with the people concerned enabled us to ensure that nobody suffered. Access was maintained at all times, indeed, we had 200 meters of steel plate always close to site to lay down for vehicle tracks when necessary.

In another instance that required careful handling and liaison, we found ourselves working around the War Memorial in the downtown on Remembrance Day.

Ironically one of the areas where we had most difficulty was on land that, on the face of it, was the least crowded and most accessible. It was space belonging to British Rail (BR) with two infrequently-used railway lines running across it. The trench had to go beneath one of the lines.

Although this posed no technical problems, it did require careful handling and cooperation in dealing with BR to get permission and satisfy their requirements.

In another case, a building developer was very reluctant to have our pipeline running straight through his building site. Again, we managed to satisfy everyone concerned by laying the pipe at a level and on a route that will be safe in the future.

The highest safety standards were maintained. The local authority is very strict on safety standards and, indeed, maintaining these was viewed as an integral part of the overall quality control discipline.

Logistical planning is essential. In Sheffield we maintained the civil engineering equivalent of "just in time" manufacturing. That is to say, no stocks of pipes were held on the construction sites themselves. The pipes and materials were delivered when and where they were needed. This not only saved valuable space on site, it also reduced the risk of damage and maintained a very important operating discipline.

The pipes are delivered in 12 meter lengths, and were scheduled to arrive on site when they would cause the least disruption to road users. This usually meant bringing them in last thing at night or first thing in the morning.

Sheffield was very much a pioneering project for the United Kingdom. It was well planned and implemented. It proves conclusively that such work can be carried out even in Britain's busiest cities.

There can be little doubt that there will be much greater interest in district heating systems in more cities; this recent experience will be invaluable in the coming years.

The work that has been done to date is quite literally groundwork for the 21st century. The Sheffield system will be supplying community heat with the minimum of trouble for many decades to come. The mains that have been laid have adequate capacity for expansion, we have confidence in the equipment and the installation and we have diagnostic systems capable of identifying faults very precisely so that repairs can be made quickly and cheaply.

Quality Management Right From the Start

There are obvious reasons for maintaining the highest quality standards. No one wants to end up excavating the pipeline once it has been laid — the costs and disruption would be totally unacceptable.

It is not just a matter of digging and filling trenches. Line and level must be maintained to enable speedy installation with particular attention being paid to where the joints fall. The correct materials must be used for the trench base and backfill.

The use of the right bedding material removed the risk of sharp stones damaging the outer casing of the pipes and imported granular backfill material reduces the problems and costs associated with trench settlement and its presence acts as an early warning to other utilities when working in the vicinity.

Also, a very good standard of highway reinstatement was maintained.

The systematic approach to district heating construction ensures that the same attention to detail is applied to every aspect of the job — from traffic management to safety, from mechanical engineering to civil engineering.

The Sheffield system proves that what has been done on the European continent and in North America for so many years can also be done in Britain.

Thorough planning, good organization and cooperation at all levels is imperative to bring "Green Heat" to other cities through the United Kingdom. IDHCA

***Stephen Brooks**, the development manager for Sheffield Heat and Power, is a qualified building surveyor with extensive experience in municipal housing and civil engineering both in the U.K. and abroad. Brooks was formerly employed by Sheffield City Council where he was the youngest assistant director in the country. He became part of the original team established by Sheffield City Council to form Sheffield Heat and Power, joining the company in February 1989.*