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District Heating Reviewed

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*The author looks at experience with district heating (in the United Kingdom) since the war and concludes that large schemes can now be designed with confidence.**

As early as 1911 there was a district heating scheme in this country: steam was distributed from the Bloom Street Power Station in Manchester to several large office blocks and warehouses. In Manchester also, housing estates at Gorton and Blackley had centralized hot water supplies in 1919. Unfortunately, these schemes had to be abandoned due to mains failure.

Dundee had two schemes, installed in 1920 and 1922, in both of which coal fires in the living rooms were for topping-up. Glasgow, in 1922, had a scheme serving 97 flats; and in Chesterfield, from the twenties there was a scheme where some 2000 houses were supplied with hot water heated by exhaust steam from a colliery engine.

There were, of course, a number of other schemes serving various military establishments and industrial estates such as Treforest in South Wales and Hillington in Glasgow, as well as many flat blocks in major urban areas.

In 1941 the Ministry of Works encouraged the establishment of committees to investigate and report on major problems which were likely to affect peace time building. Two of these reports became *Post-War Building Studies No 31 and 32, "District Heating."* Today, both make interesting reading, and one cannot help but be struck by the familiarity of the arguments put forward at that time. They are, without exception, those advanced in the Rothschild Study published in 1974. The 1941 Report dealt with a number of ambitious schemes.

In the immediate post-war years, several thermal-electric schemes were examined and all but Pimlico fell by the wayside. Unfortunately, all the brave talk and enlightened thinking came to practically nothing. A number of small group heating schemes were designed and installed but all the larger and more ambitious schemes were abandoned, including those for the first generation of new towns which should have proved ideal.

It was particularly tragic that a number of the schemes installed were fraught with trouble and in some instances were abandoned, failure of the distribution systems being the main cause. Fortunately, that particular horror is now past, but great care must be exercised to ensure that internal corrosion does not take over the role of destroyer. The position at one time was so bad that virtually no Local Authority would dare to put forward a scheme for loan sanction.

Resurgence of Interest

Events which led to a resurgence of interest in district heating included the Clean Air Act, The Parker Morris Report which advocated warm homes, high-rise, high-density housing, and the Area Electricity Boards brilliantly marketing the concept of cheap off-peak heating. The gas industry received a kiss of life from oil-fuel feedstocks and came into the domestic market with individual warm air heaters. The oil industry, particularly through Shell Mex and BP's Mrs. 1970 advertizing campaign, conditioned everyone to accept that it was no sin to have a warm comfortable home and to be able to bathe in more than a few inches of water. The race for the domestic market was on. King Coal saw with concern a rapidly contracting domestic market and hit back with district heating.

The scheme at Billington became a mecca and was visited by many who marvelled at the practically unattended boiler house, pumping out heat 24 hours a day, seven days a week to houses, shops, offices, a technical college, factories, etc. The major oil companies quickly came on the scene with both group heating and central oil distribution schemes. The attitude of government changed. I remember, at the meeting, being told by an engineer of the Ministry of Health (who used to vet schemes for the Ministry of Housing and Local Government) that the official view had moved from open hostility to one of benevolent neutrality. With the advent of the District Heating Association, the number of proposals submitted increased and has continued to do so. There are now many schemes, well planned, designed, engineered and operated.

An important factor now facing designers is to work on common temperatures and pressures, so that when the existing district, group and block heating schemes are to be linked together they are compatible.

**Abstracted from a paper written for presentation at "Design For Living," the U.K. District Heating Association's First National Conference held in Brighton in April 1975.*

Post-War Design

The earliest post-war schemes were designed very much on a traditional basis, with temperature drops and water velocities that would not be used in modern practice. Terminal equipment was generally cast-iron radiators, return temperature controllers, differential pressure and volume controllers being unheard of or considered unnecessary. The hydraulics took charge of the designers, not as it should be, the designer being in control of the hydraulics.

Hot water became the accepted medium for the distribution of heat, and over the years there emerged an almost standard maximum flow temperature of 94 C (200 F) and 60 C (140 F) return. In many of the newer continental schemes these are also the preferred temperatures. If anything, the move is to even lower flow and return temperatures.

Early jobs, where higher flow temperatures were used, required either calorifiers or some kind of mixing vessel to reduce the temperature to the user.

A common mistake made by engineers was the extensive use of three-way valves, which directed water at flow temperatures into the return main, raising its temperature so that the planned temperature drop was not achieved. Mains losses, particularly where concrete or brick ducts were employed, increased rapidly, in some instances to a point where the economic viability of the scheme was effectively destroyed.

Some schemes, where the secondary circuit temperatures were reduced to 82 C (180 F) flow and 71 C (160 F) return, attempted to use individual Bthu meters to measure the heat used by individual consumers. They encountered difficulty, particularly where a weather compensation valve was used to reduce the flow temperature and no attempt was made to control the return temperature. A situation could easily arise where the temperature drop was not 11 C but only 2 or 3 C; with accuracies of ± 1 C on the temperature probes, the readings made nonsense. I believe, even now with greater knowledge of the hydraulics of a system, a fully reliable individual Bthu meter is still some years away.

Warm Air Heating

When the coal and oil industries became active in district and group heating, practically all house plans, both high and low rise, seemed to be planned around a warm air heater unit with stub ducts discharging warm air into some of the rooms; in many instances, bedrooms were not included. Engineers were, therefore, required to design systems incorporating warm air units. Some units were fitted with simple propeller fans and achieved unreasonably high outputs due to a chimney effect, even with the fan at rest. Of course, various types of dampers were devised in an attempt to combat this. Other units used centrifugal fans and were more efficient. Problems naturally arose from noise, and drop in output, when batteries became coated with household dirt; they were very difficult to clean even with an industrial vacuum cleaner.

A number of these schemes were designed for temperature drops of 11 C or higher, return temperature limiters being used to control and maintain the return temperature. Again, problems arose from hunting of the controller. The degree of the problem also depended on the type of battery, those with headers causing the most difficulty. If the header were out of the air stream, it could take several minutes for the water to cool sufficiently to allow the controller to open; during this period the unit continued to blow cool air, much to the annoyance and discomfort of anyone sitting in the room.

I am convinced that engineers were generally unhappy about having to design such schemes. They were in a dilemma, keen to get district and group heating underway, and fighting very hard to reduce capital costs (because the only way a scheme would get through the watch dogs of the Ministry was to show a cost-in-use advantage to the tenant) without straying from the design standards that had become second nature over the years. Methods of carrying out the cost-comparison exercise were very crude, and the efficiencies allowed for individual appliance were quite wrong. Even today I do not think proper costs for the replacement of the individual combustion appliances are taken into account. I think it says much for the designers that they were able to overcome most of the problems and provide reasonably effective schemes in a difficult market.

Metering was considered quite easy with warm air units, either by use of electricity prepayment meters giving so many units of electricity equated to "hours run" of the fan, or by the use of hours-run meters. The trouble was, of course, that both forms were easily shorted out. One also heard tales that some tenants used the domestic hot water (which was unmetered) to supply a once-through radiator system.

Wet Systems

Warm air heating went out of favour, and there was a return to what have become known as wet systems. There were certainly fire and smoke risks with warm air heating, which was also more expensive if an attempt was made to provide a proper duct system for whole-house heating.

Designers tried all types of terminal equipment from under floor coils, skirting heating, convectors of various types and a variety of radiators. The most popular terminal item has been the radiator. But again, there were problems. To achieve the designed temperature drop meant very low flow rates and with radiators using the traditional top-bottom opposite-end connections, stratification of the water took place, leading to complaints that only half the radiator worked. Single-connection radiators and mixing devices have overcome this annoyance.

Immediately post-war, and up until about 12 years ago, engineers were at variance on whether to use three- or two-pipe systems. Four-pipe systems meant that either the domestic hot water was produced centrally, or that a separate pair of mains was provided to generate hot water at local heat exchangers; both methods, I believe, being throwbacks to the earlier training of engineers. The intention was, of course, that the space heating mains coúld be shut down during the period euphemistically described as summer. It was also thought that it would be easier to achieve balancing of the circuits.

The three-pipe system was an attempt to reduce cost by having the space heating and primary domestic hot water returned in a common main, while still being able to isolate heating during the summer.

Either of these systems would only be suitable, if at all, on fairly minor schemes. With an increase in knowledge and experience, engineers came to accept a two-pipe distribution as the most suitable and economical.

Control of the secondary domestic hot water temperature has been achieved in two ways: a return temperature limiter or a direct-acting two-port valve. The use of a return temperature limiter on individual cylinders has proved very successful, although I think a number of control manufacturers considered it to be cheating, as they would have preferred a more definitive form of control. The latest development is the use of an instantaneous water heater; results obtained on tests are most encouraging. There is a potential saving to be made in both capital costs and space.

The post-war building studies referred to earlier suggested that control and regulation would be carried out by manual adjustment of valves. On a district or group heating scheme this is impossible, and it is in the area of hydraulic control of the system that the greatest advances have been made.

Schemes were designed using fixed-speed pumps, with a three-way weather-compensated mixing valve in the boiler house to vary the out-going or flow temperature in accordance with weather conditions. A low limit was set to ensure that there was always an adequate flow temperature to give domestic hot water. The degree of compensation that could be applied to an installation with warm air units was, of course, much less than could be applied to an installation using radiators. Circulating pumps were sized on the calculated summer and winter loads. Various combinations of pumps were experimented with, and a number of clever schemes developed to switch pumps in and out as required.

For smaller schemes, I am convinced that if fixed-speed pumps are to be used, they should be belt driven and that the impeller speed should be kept to 900 rpm or below. Larger schemes are now tending to be designed with variable-speed pumps, the speed being automatically controlled from a monitored pressure drop on the index circuit.

Engineers now have a greater appreciation for the needs of heat stations. The use of return temperature limiters is now commonplace, and the difficulties associated with their use all understood. There is a growing tendency to improve the degree of control which is allowed to individual tenants.

Pressure differential and volume control are now understood. Their importance, particularly on larger schemes, is appreciated; and the improvement in diversity that their use brings about is enabling engineers to design more economically. I now feel that there is sufficient experience to go forward to the design of much larger schemes with confidence. ✸

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