Integrated thermal energy storage extended to group heating applications

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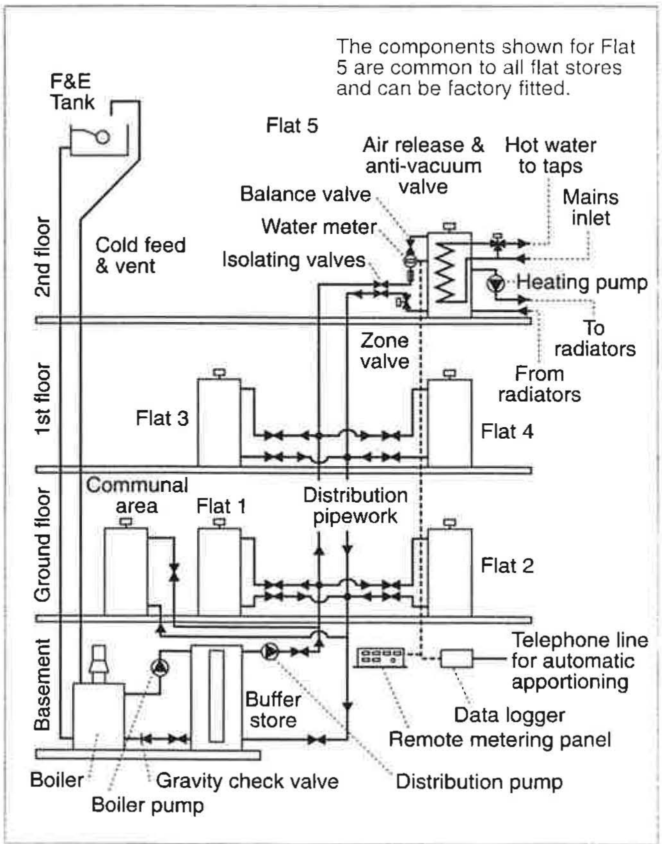
Although the great majority of British dwellings are heated by individual gas systems, there are some instances, particularly in blocks of flats and retirement homes, where individual gas appliances cannot be specified.

In these buildings the alternative to individual systems is a group heating scheme whereby a central boiler plant supplies hot water to each flat for heating and domestic hot water.

In the past, group heating systems have not always been successful. Comparative results show that energy use of group heating systems is, on average, 50% higher than that of individual systems. There are two main reasons for the higher running costs. The first is the absence of heat metering. Effective heat metering is relatively costly and has not been widely adopted. As a consequence, there is no incentive for occupants to save energy, either in the heating of their dwelling or in the use of hot water. The second reason is the high distribution heat loss which can account for a significant proportion of the annual energy used.

Recently there has been a resurgence of interest in group heating both for existing and new buildings, especially where individual gas systems are precluded.

Figure 1: Schematic lay out of the group heating schemes for five flats and communal area (water meter apportionment).



Thermal energy storage and group heating

To meet this market need, the concept of integrated thermal energy storage, originally developed for individual systems, has been extended to group heating applications. The principle of thermal energy storage involves the interpositioning of a thermal energy store between the boiler and the heating circuit, which decouples the heat generator from the heat demand. It is the thermal store that responds to the heat demand whilst the operation of the heat generator is governed by the energy level of the store. The advantages are higher annual efficiencies, low installation cost, rapid warm-up and a reduction in peak gas demand by virtue of the smaller installed boiler capacity, whilst hot water can be generated at mains pressure from heat exchangers within the store without the need for extensive safety controls. However, the principal benefit derived from the concept of thermal storage based group heating is the ability to specify a low cost method of apportioning running costs according to the energy used.

The new approach to group heating is shown in Figure 1. Each individual dwelling or apartment has its own integrated thermal energy store from which space heating and domestic hot water are provided. When the store is depleted, the integral thermostat opens the zone valve, allowing water from the distribution circuit to recharge the store. The inclusion of a buffer store between the boilers and the distribution mains also

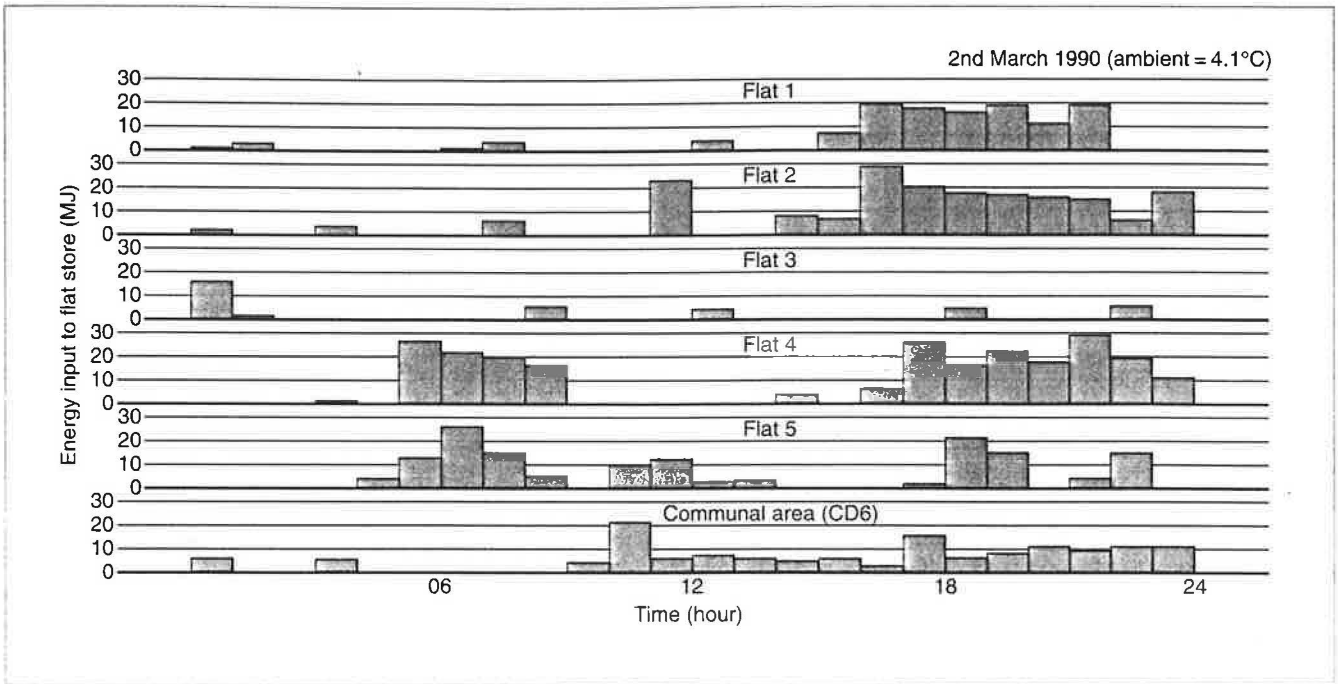


Figure 2: Energy requirement of each flat on a typical day.

gives a number of operational advantages. With this arrangement, the system can be split into three independent circuits. The thermal storage unit in each individual flat operates independently; the central boiler plant reacts solely to the state of charge of the buffer store; and the third constituent, the distribution network, connects the buffer store with the individual thermal stores. The operation of each constituent circuit can be optimised without direct reference to either of the others.

A thermal energy storage based group heating system makes the apportioning of inexpensive running costs possible. The flow temperature of the individual stores is kept stable by the buffer store whilst the return temperature is governed by the thermostat on each thermal store. Since each thermostat is pre-set in the factory to the same value, the mean return temperature over the charging cycle of the thermal store is essentially the same for each store.

Thus, by maintaining essentially constant temperatures, the energy supplied is proportional to the volume of the water required to recharge the stores. This can be measured with a water meter.

The water meters can be read manually flat by flat, or the output from the meters can be fed to a centralised remote read-out panel. As a further refinement, the metering signals together with a signal from a pulsed output gas meter can be stored on a data logger. The information can then be sent by a modem over the telephone network to a remote data processing unit where software automatically produces statements that are apportioned for dispatch to the customers.

Apart from providing a financially advantageous alternative to full heat metering, thermal energy storage group heating offers other opportunities to reduce capital costs.

Smaller and cheaper

With conventional group heating systems, the central boiler plant and the distribution network have to be sized to accommodate the maximum demand for space and water heating. With thermal energy storage, however, only the time-average heat demand has to be satisfied by the central boilers, hence boilers and pipework can be smaller and therefore cheaper. There are 30 systems in operation in the UK and some have been extensively monitored to provide data on the performance of the systems, components and running costs. One of the main advantages of thermal storage group heating is that it gives each occupant complete autonomy over their heating and hot water system. This is illustrated in Figure 2 which shows the hourly energy demand of each flat and the communal area in a house converted into flats. Each of the tenants has a different requirement for energy varying from a small demand through the day to a large demand concentrated in the evening. Only a thermal

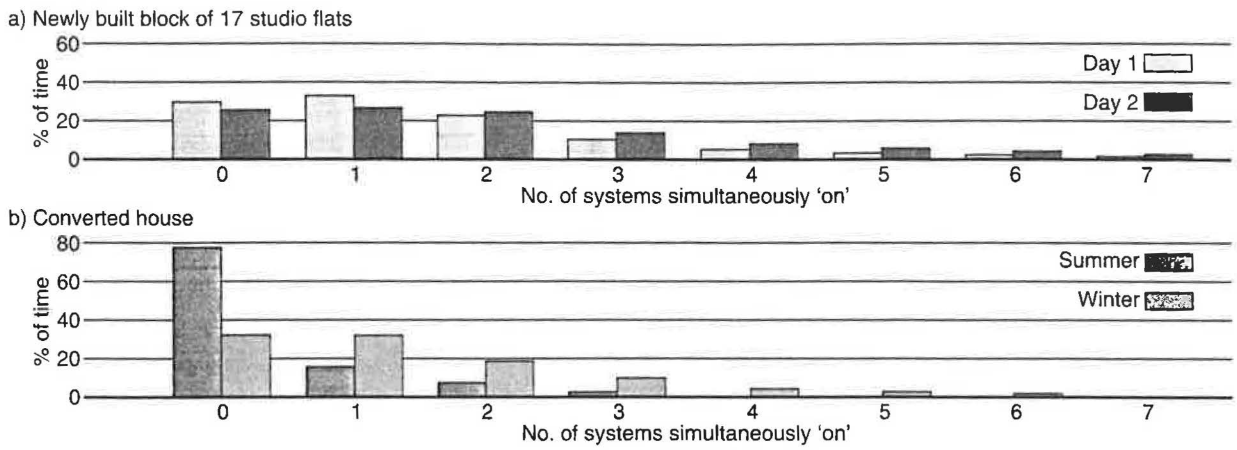


Figure 3: Diversity of use.

storage system can give this degree of flexibility without seriously compromising the accuracy of energy apportionment.

Buffer stores

Installing a buffer store between the boiler and distribution main has the advantage that when the buffer is satisfied the boiler turns off, and the buffer alone can then recharge a number of individual stores before the boiler needs to be re-energised. Measurements at one site show that the boiler cycles approximately 11,000 times per year. Reduced boiler cycling not only increases the efficiency of the system, but also reduces the wear of components.

At this site the distribution pump is on for 18 hours per day in winter reducing to 5.5 hours in summer. The intermittent use of the pump reduces the heat loss from the distribution pipes from an estimated 85 MJ/day to 31 MJ/day. To these savings must be added the reduced cost of electricity to run the pump. The heat loss from the buffer store (350 W) is more than compensated for by the increase in boiler efficiency by reduced boiler cycling.

Diversity of use

Figure 3 shows for a block of 17 flats, the amount of time that more than one thermal store called for heat simultaneously. It shows that the maximum number of stores requiring heat at any one time is seven whilst for 85% of the time three or less required heat. Even in the smaller, six flat, converted house, 80% of the time less than three units call for heat simultaneously. These results indicate that due to this diversity in demand there is scope, particularly in large schemes, for reducing boiler plant and distribution network sizes by at least 20%.

Customer satisfaction

Of particular importance to the customer are the performance of the system and the running costs. In the sites monitored there have been no complaints by the occupants of inadequate heating or hot water. Running costs depend on the building and, as would be expected, they are lower in the newer, better insulated properties than in the converted house. Typical average weekly running costs range from GBP 2.10 up to GBP 4.10 for a large house converted into flats.

Conclusion

Thermal storage group heating has been developed to meet the need for a system suitable for providing heating and hot water to blocks of flats from a centralised boiler plant with a cost-effective method of apportioning running costs. Thirty systems are currently working with more at the design stage. Field trial results show that the need is being met.

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