Energy Efficiency Office
DEPARTMENT OF ENERGY

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Energy Efficiency Demonstration Scheme
Expanded Project Profile 284

Condensing Boilers in Local Authority Family Housing

A demonstration of the energy savings achievable from the installation of gas-fired condensing boilers for the provision of heating and domestic hot water in new, family housing.

Potential users
All those providing housing in the public and private sectors

Investment cost
From £250 at 1987/88 prices

Payback period
3-4 years with standard sized radiators

Savings achieved
21-24 GJ/year, worth £77-86/year at a gas price of £3.60/GJ (£0.38/therm)

Host organisation
Manchester City Council
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The aim of the project
The use of condensing boilers in place of conventional gas-fired boilers offers the potential for energy savings and correspondingly reduced fuel bills through increased combustion efficiency. This project investigated the installation and cost effectiveness of condensing boilers in some of Manchester City Council's family housing on an estate at Collyhurst, near the centre of the city. As well as determining the energy savings the scheme investigated the cost effectiveness of maximising efficiency by over-sizing radiators and examined other related issues such as the installation and maintenance of these appliances.

The project commenced with prototype condensing boilers manufactured by Stelrad (UK) Ltd. These were later replaced by the company's current production model, the "Ideal Turbo". The production models performed similarly to the prototype models and led to a minimum energy saving worth £77 per year for a heating system with normally sized radiators and standard controls. Slightly better savings were achieved with an enhanced system, comprising radiators over-sized by 100% and more complex controls, but at a greater over-cost.

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How energy was saved at Collyhurst

The condensing boiler differs from a standard boiler because of the inclusion of an enlarged (or secondary) heat exchanger. The function of this heat exchanger is to extract both additional sensible heat from the hot flue gases and, under suitable conditions, latent heat from the condensation of the water vapour generated during the combustion process.

Conditions within the boiler have to be correct to recover latent heat. The return water temperature must be below the dew point, about 54 °C. Fig. 1 shows the effect that return water temperature has on boiler efficiency. One way to ensure reduced return temperatures is to over-size the radiators, but such a scheme has a higher over-cost than a scheme with standard radiators. Even if latent heat is not released the boiler will still be more efficient than a standard boiler because it is recovering extra sensible heat all of the time. But due to the increased complexity of the condensing boiler there is an inevitable over-cost associated with the appliance itself.

In 1983 Manchester City Council set aside thirty newly built, 4-bedroomed, 7 person houses on the Collyhurst Estate about a mile north-west of the city centre. The houses were built by the Council's Direct Works Department to the Building Regulation requirements of the day, with no additional energy efficient fabric, insulation or other measures employed.

For the purposes of the demonstration the houses were divided into three groups of 10 houses. Group A was the 'control' group, and each house was fitted with a modern, conventionally flued, cast-iron, standard boiler to provide space and domestic hot water in a fully pumped central heating system. The second group, group B, comprised a similar heating system but in place of the standard boiler a room-sealed, wall mounted Stelrad condensing boiler was installed, fig. 2. The third group, group C, comprised identical condensing boilers to group B but an enhanced heating system consisting of radiators that were over-sized by 100%, together with a high efficiency hot water cylinder and more sophisticated heating controls. The boilers had a rated output of 12 kW to match the design heat loss for the dwellings of 7.7 – 8.3 kW, depending on house type and orientation, some over-capacity being available for domestic hot water generation.

The use of condensing boilers in the UK was considered sufficiently novel to warrant support by the Energy Efficiency Office under their Energy Efficiency Demonstration Scheme. The boilers were provided by the manufacturer, so a grant to the local authority was not appropriate.

The City Architect's department in collaboration with the British Gas Watson House Research Station designed the heating system and Manchester's Direct Works Department carried out the installation. The buildings were extensively monitored by the Department of Building Engineering, University of Manchester Insitute of Science and Technology, over a period of three years. British Gas Watson House Research Station also advised on some aspects of the monitoring and loaned monitoring equipment.

The monitoring of the scheme involved the comparison of energy use for space and hot water heating, and internal comfort conditions within the three groups of houses. To support the physical monitoring a social survey of the tenants was undertaken. The purpose of the survey was to obtain demographic data and to ascertain the tenants' views of their homes and the heating provided.

The main aim of the monitoring scheme was to establish the potential for energy savings, and other benefits, associated with the condensing boiler. In addition the demonstration examined the relative merits of the over-sized and standard sized heating systems, and compared the results with the non-condensing system of group A.

The monitoring programme showed that in both the condensing boiler groups significant amounts of energy were saved, without any detrimental effects such as reduced internal comfort conditions, or increased boiler maintenance. The tenants in groups B and C were generally well pleased with their heating systems and content with the heating bills. The tenants in all groups were generally satisfied with their internal comfort levels.

The installation of the condensing boilers was almost as straight forward as that of standard boilers. However, in condensing boiler installations it is essential to provide a condensate drain connection to the household waste.

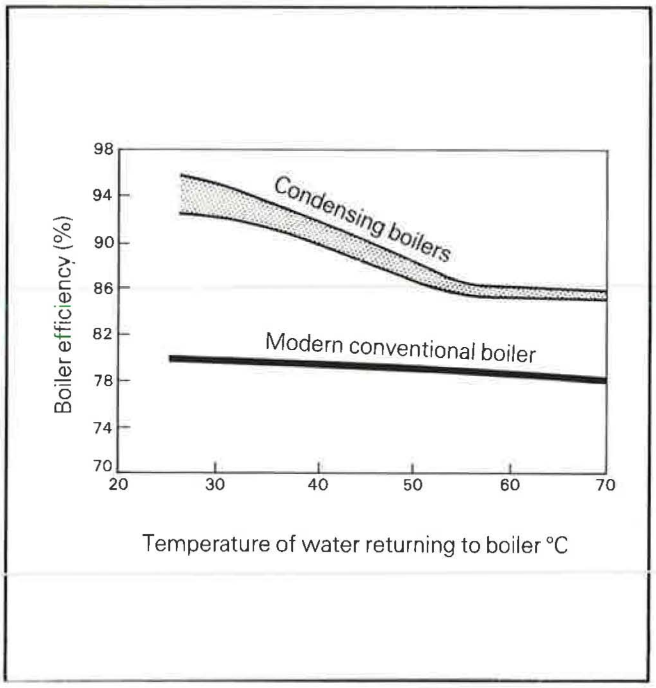

Fig. 1. Effect of return water temperature on boiler efficiency.

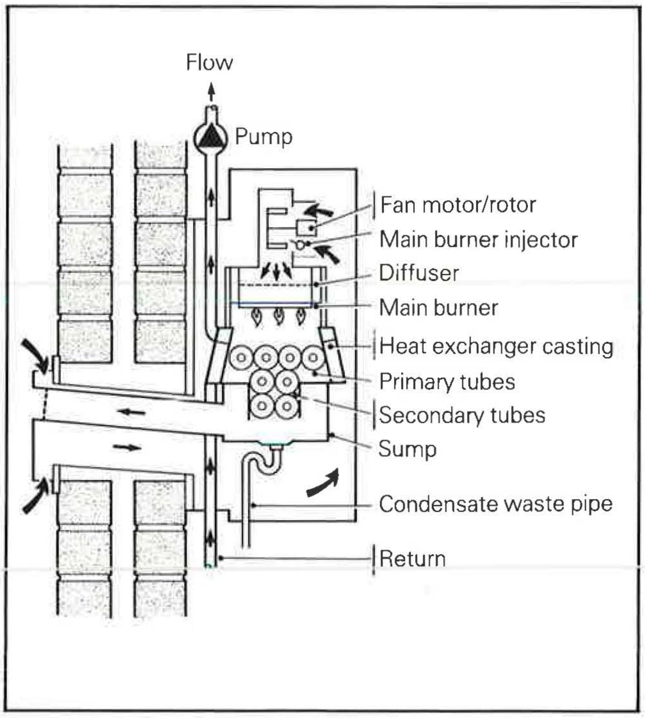

Fig. 2. Stelrad "Ideal Turbo" condensing boiler

Energy savings and replication potential

Fig. 3 shows the relative savings made by the two test groups (B and C) compared with the 'control' group. Group C showed the highest savings over the monitoring period, averaging 24 GJ per year (25%), while group B showed a slightly smaller but nevertheless still worthwhile saving of 21 GJ over the same period (22%). These energy savings are equal to annual cash savings of £77 and £86 for groups B and C respectively. During the monitoring period the annual system efficiencies averaged 86.5% and 88.9% for the test groups B and C compared with 67.2% for the 'control' group. The relationship between boiler input and efficiency for each of the three groups is shown in fig. 4. The condensing boiler groups are relatively unaffected by load, except at very low loads, but the efficiency of the standard boilers quickly falls as the load decreases.

Group B has the shortest payback period (3.2-3.7 years) because the only over-cost is that of the condensing boiler (£250), the heating system in all other respects is standard. Group C with the enhanced system and over-sized radiators has the far longer payback (5.6 – 7.4 years) because the over-cost is much greater (£500).

To conclude, condensing boilers lead to substantial gas savings and corresponding reductions in fuel bills. When used in conjunction with a standard heating system (normally sized radiators) the over-costs are lowest and can be recovered in less than 4 years. Houses with larger annual fuel bills should make greater savings and the payback would be correspondingly quicker. The indications are that the maintenance requirements and long term reliability of condensing boilers are similar to those of standard boilers.

The use of condensing boilers is recommended in both new installations and as a retrofit with existing radiators. If some over-cost is acceptable a further small saving in gas is possible using over-sized radiators.

The potential for condensing boiler installations in the UK is large. Heating systems installed in the late 1960's and early 1970's are nearing the end of their useful life and will soon require replacement. It is estimated that some 900,000 replacement gas-fired boilers will be required annually in the UK by the early 1990's. At least 25% of these should be capable of replacement by a condensing boiler. If this potential market is captured in this way there should be a substantial reduction in the UK's annual domestic energy demand. A saving of about 20 GJ per year per household could lead to a national saving through replacement replication worth about £15-20m per year by the mid-1990's, at current gas prices.

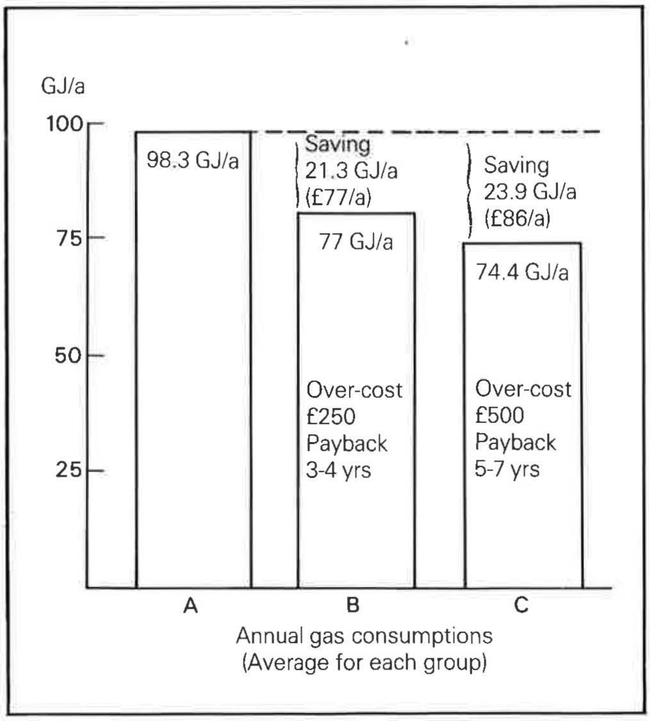

Fig. 3. Relative savings compared with group A.

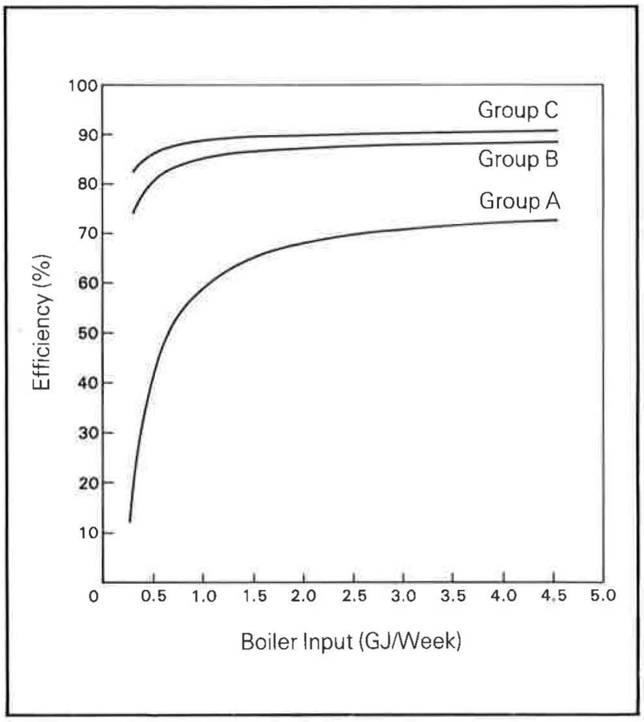

Fig. 4. Boiler efficiency against input for each group

Manchester City Council

Manchester City Council has responsibility for a housing stock of the order of 96,000 dwellings. The Council has been very active in improving the efficiency of its existing housing and has undertaken many energy efficient initiatives. In recent years the Council has adopted a policy of low-energy design for the fabric of new build housing (see Expanded Project Profile 89, E.E.O., July 1986), and has a continuing programme of heating and insulation improvements to its existing housing stock.

Manchester City Council's Experience

Following the successful completion of the earlier demonstration which featured the energy efficient fabric measures for low-energy design, Manchester City Council adopted a policy for new build which incorporated most of these features. The City Architect's Department subsequently looked at other cost effective options for reducing energy consumption in the City's housing stock. Even though fuel prices are rising more slowly than a few years ago, the cost of heating can still be a major worry of some tenants. This is especially true for families with low incomes, and many local authority tenants will have incomes well below the national average. It helps no one if householders cannot afford to heat their homes adequately.

The results of the earlier demonstration highlighted some areas which had not been addressed and one was the use of high efficiency heating plant. The study carried out by UMIST on behalf of the Energy Efficiency Office addressed this issue, filling a gap that would otherwise exist in the City Council's research programme. The results of the condensing boiler demonstration have shown that these high efficiency heating appliances can be used with confidence and should lead to worthwhile energy savings for the tenant. Alternatively, the tenant has the option of raising comfort levels at the same running cost. The Council benefits too, because by providing heating at more affordable prices the tenant should be encouraged to take better care of the home, and ultimately of the immediate environment.

It is for each Authority, Architectural or Engineering Services practice to decide upon the relevance of the results to their own situation. From the City's viewpoint specific areas have been identified which are particularly suitable for condensing boilers, namely: large houses, homes that are categorised as 'hard to heat', flats, bungalows and special needs housing (including homes for the elderly and handicapped).

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Best Practice programme

The work described here was carried out under the Energy Efficiency Demonstration Scheme. The Energy Efficiency Office has replaced the Demonstration Scheme by the Best Practice programme which is aimed at advancing and disseminating impartial information to help improve energy efficiency. Results from the Demonstration Scheme will continue to be promoted. However, new projects can only be considered for support under the Best Practice programme.

For copies of reports and further information on this or other projects, please contact the Enquiries Bureau at the:
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Information on participation in the Best Practice programme and on energy efficiency generally is also available from your Regional Energy Efficiency Office.