Energy Efficiency Office
DEPARTMENT OF ENERGY

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For further information contact:
Enquiries Bureau
Building Research Energy Conservation Support Unit (BRECSU)
Building Research Establishment
Garston, Watford WD2 7JR
Tel No: 0923 664258
Fax No: 0923 664097

Energy Efficiency Demonstration Scheme
Expanded Project Profile 279

Condensing Boilers in Smaller Homes

Potential users
All those providing heating in public and private sector housing, both new and refurbished.

Payback period
3-6 years

Savings achieved
7-14 GJ/a depending on type of dwelling (average 10 GJ/a), worth £26-53 (average £35/a), at gas price of £3.6/GJ (38p/therm).

Host organisation
Vale of White Horse District Council
Abbey House
Abingdon
Oxon OX14 3JE
Tel No: (0235) 20202

The aims of the project
Gas fired condensing boilers have a wide potential for application in both new and existing housing. A previous demonstration examined the energy and cash saving potential, seasonal efficiencies and system design factors for condensing boilers applied to 4-bedroomed housing in Manchester (Expanded Project Profile 284). Annual efficiencies have been shown to be relatively robust to the influence of system design. The parameter of most influence in attaining the cost-effective performance of individual condensing boiler installations is the period of boiler operation.

This demonstration, hosted by the Vale of White Horse District Council at Drayton, Oxfordshire, examined the type of building and occupancy pattern most likely to benefit from the installation of the current range of gas-fired condensing boilers. Specifically, the aims of the project were to examine the variations in space heating and domestic hot water load and the effect of building fabric insulation on these loads. The project also examined some of the sociological factors contributing to energy use and the economics of condensing boiler systems in smaller, fairly well insulated housing.

Monitoring contractor
W S Atkins Energy
Woodcote Grove
Ashley Road
Epsom
Surrey
KT18 5BW
Tel No: (0372) 726140

Equipment manufacturer
JLB (Trisave) Group Ltd
Aber Park Industrial Estate
Flint
Clwyd
CH6 5EX
Tel No: (035 26) 62061

Houses at Drayton.

How energy was saved at Drayton

The improved operating efficiency of the condensing boiler leads to a direct saving on annual fuel bills, averaging about 22% for 4-bedroomed homes. The earlier demonstration proved the technology for condensing boilers installed in larger housing. Their use in smaller homes, and particularly flats, raised questions about their economic viability in these circumstances. A new housing development in the village of Drayton, owned by the Vale of White Horse District Council, provided the opportunity for further investigation of a condensing boiler application, particularly in relation to the above points.

The first phase of the new development at Drayton comprised 21 dwellings of 7 different designs, ranging from 3-bedroomed houses to single bedroomed flats. All were built to the standards of the 1985 Building Regulations, but in addition the external doors and windows were double glazed. The Vale of White Horse District Council have a policy of installing gas-fired heating whenever possible. It is also usual to specify an open hearth with flue for the living rooms as an alternative source of heat, if required.

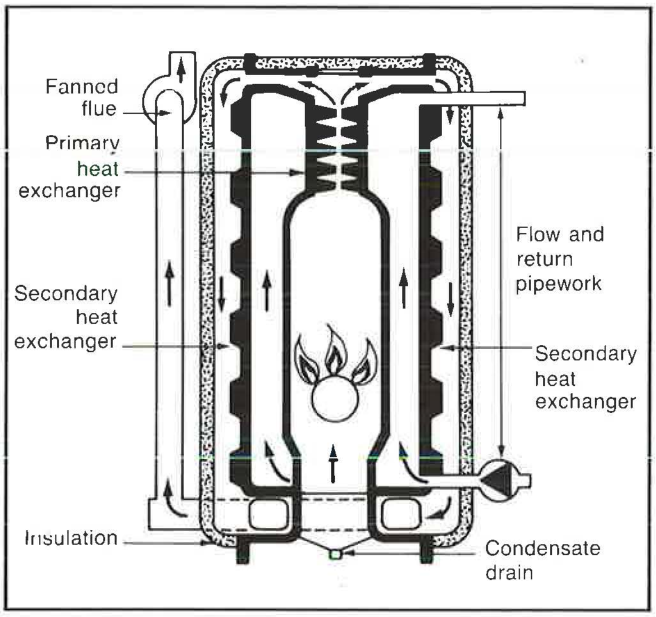

Figure 1. Section through a JLB (Trisave) Turbo T30 condensing boiler.

The heating system, designed and installed by British Gas Southern, comprised a full, wet central heating system, sized on the NHBC basis (with a 10% over-sizing of radiators for rapid warm up), a flow temperature of 82°C, a return temperature of 71°C and a differential of 11°C. Domestic hot water was provided via a storage cylinder fitted with a high efficiency coil. A JLB (Trisave) "Turbo T30" condensing boiler (figure 1) was installed in each home to provide both space heating and domestic hot water. Figure 2 shows the arrangement of the heating system.

The T30 is a wall hung, balanced flue boiler with an output of 8.5 kW, the smallest domestic boiler manufactured at the time of construction, late 1986. Table I shows the relationship between design heat loss for each dwelling type and boiler size ratio (the ratio of boiler output to the design heat loss of the building).

The project was supported under the Energy Efficiency Office Demonstration Scheme, a grant being provided to meet 25% of the cost of the boilers. W S Atkins Energy was appointed as independent monitoring contractor to monitor the scheme on behalf of BRECSU, who managed the project.

The monitoring programme required the regular recording of boiler efficiency, energy consumption and internal temperatures. Interviews with the tenants were conducted to obtain background sociological data, information on the use of controls and control settings and to explain any anomalies that occurred during the physical monitoring. Details of installation problems and maintenance were also collected. The BRE Domestic Energy Model (BREDEM) was used to supplement the physical data collected and to assess standard boiler performance. A "control" group of similar homes was not available for comparative monitoring.

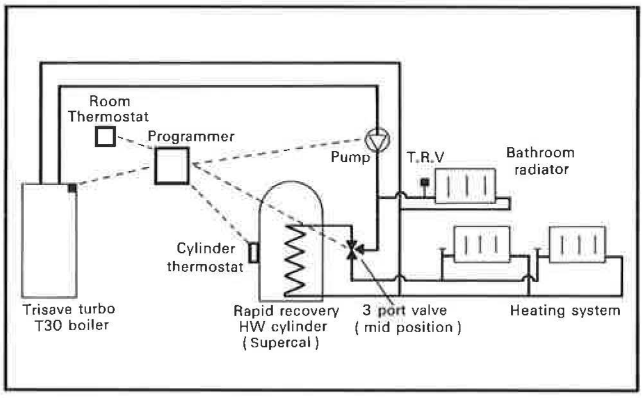

Figure 2. Heating and hot water circuit used at Drayton.

Table I. Different dwelling types and boiler sizing

Description	Design heat loss (kW)	Boiler size ratio
3 bed house	5.5	1.5
2 bed house	5.0	1.7
2 bed house	4.7	1.8
1 bed flat (ground)	3.9	2.2
1 bed flat (first)	5.0	1.7
2 bed flat (ground)	4.4	1.9

The monitoring programme also examined the economic viability of the scheme in relation to boiler over-costs and energy savings achieved, compared with conventional gas boilers.

Compact, well insulated dwellings impose less demand on space heating than larger, less well insulated designs. A higher proportion of the boiler load is devoted to domestic hot water and the contributions from incidental gains are more significant. These factors tend to reduce the space heating load as well as reducing the duration of the heating season. But despite this the project showed substantial and worthwhile energy savings and a good economic case for condensing boilers, even in smaller dwellings.

The results of monitoring (over two heating seasons) revealed that the average annual system efficiency for the houses was 84%. The figure for the larger 3-bedroom houses was 86% and that for the smaller flats about 80%. The annual efficiency for the flats was expected to be lower because the T30 is over-sized for these dwellings and therefore operates on a lower part load. A smaller boiler is recommended, for example the T22 having a 6.4 kW output which was not available at the start of the project. Figure 3 shows the seasonal efficiency observed for each dwelling. It can be seen that the performance of the heating system in the flats is not as good as that achieved in the houses.

The boiler output of 8.5 kW is best matched in the larger 3-bedroomed houses. In the other dwellings boiler sizing is generous and in the case of the flats excessive. A greater proportion of the boiler firing time occurs with higher temperatures, and hence slightly lower efficiencies because the

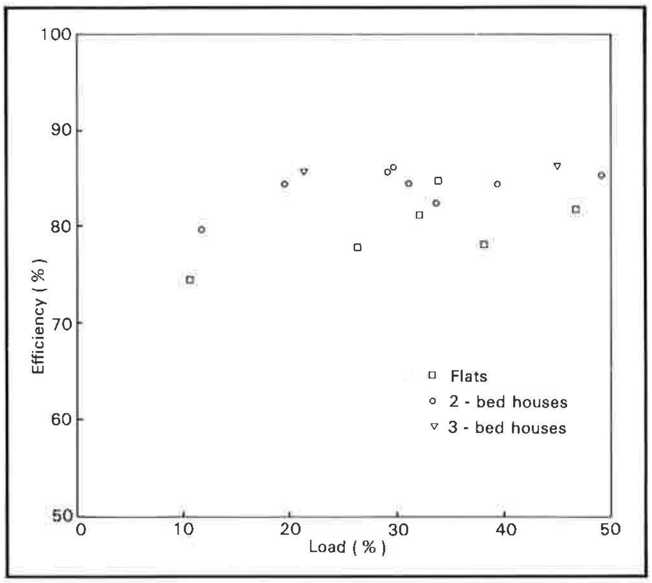

Figure 3. Seasonal efficiencies for each dwelling.

boiler is not operating in the condensing mode. It is still making an energy saving because it is always more efficient than a standard boiler.

Even so, for the smaller flats, the results are lower than expected. This is probably due to the persistently poor setting of controls in some homes. One such erroneous setting occurred when the boiler thermonstat was set below the required temperature of the domestic hot water. This situation caused the boiler to cycle continuously in an effort to satisfy the domestic hot water demand.

In general the condensing boilers met with a favourable response from both the installers and the tenants. A general lack of awareness on the use of heating controls was encountered with the tenants. This is common with all types of heating systems and is not confined to condensing boiler systems. The economic operation of heating systems requires that time clocks and temperature controls are properly set and that occupants are instructed in their correct use.

There is a need to site the flue terminal with some care because at Drayton the 'plume' from the boiler flue could, under certain weather conditions, be blown towards a window in the upstairs flat. Most of the time the plume was unobtrusive.

The sample of tenants ranged from the single elderly to young families. Some of the elderly tended to choose low comfort levels (around 16°C) and tended to heat only the living room. These tenants made low demands on the boiler. By contrast, families with young children tended towards higher comfort levels (around 20°C), had a greater requirement for hot water and occupied the house for a greater part of the day, making more use of their heating.

The overall load factor of the boiler is the principal factor influencing the annual efficiencies in the houses at Drayton. An important result emerging from the monitoring of this scheme, however, is the consistently high efficiencies obtained despite the occupants' different use patterns.

Energy savings and economic benefits

At the time of construction the over-costs associated with the use of these condensing boilers (additional plant cost + installation of condensate drain) was estimated to be £250 per house. However, since the completion of the demonstration the over-cost of the boiler has almost halved and is currently about £130. The annual energy savings for each group of dwellings is shown in Table II. The savings range from £26 for the flats to £53 for the 3-bedroom houses, with an average of £35 per annum for the whole group, based on the gas price of £3.60 per GJ. The simple payback period (the time taken to recover the over-cost) for the group averages about 4 years, and ranges from nearly 6 years for the flats to under 3 years for the larger houses, which is well within the 15 year lifetime of the boiler.

Table II. Energy savings and payback

Description	Energy use (GJ/a)	Condensing system efficiency (%)	Conventional system efficiency (%)	Energy saving (GJ/a)	Cash saving (£)	Simple paypack (yrs)
Flats	35	80	66	7.2	26	5.8
2 bed houses	46	84	68	10.6	38	3.9
3 bed houses	66	86	70	14.7	53	2.8
Average	**43**	**84**	**68**	**9.7**	**35**	**4.3**

Turbo T30 installed

The savings are smaller than for the 4-bedroomed houses monitored in Manchester (EPP 284). Nethertheless substantial energy and cash savings have been made. The performance of the flats (hence the whole group, on average) could have been improved if the T22 boiler had been available. The effect would have been to reduce initial capital costs leading to a shorter payback period for the flats. In addition the boilers would have operated at a higher load for more of the time giving a higher efficiency, and energy savings would have been correspondingly greater.

Replication potential and environmental benefits

It is estimated that in the UK some one million boiler replacements per year will be required by the early 1990's. Most of these replacements should be able to benefit from the installation of a condensing boiler. But assuming an initial market share of 10%, the energy saving could amount to 1 PJ per year (assuming an average saving of 10 GJ per house per year). This saving is worth about £3.6 million at the July 1989 gas price. Over a period of several years the energy savings accumulate and the market share will undoubtedly increase. By the year 2,000 the energy saving could be at least 5 PJ per year, which is worth over £18 milion per year at current gas prices.

Not only is there an energy saving benefit from condensing boilers but the wide deployment of these appliances will help to reduce the build up of carbon dioxide in the atmosphere. Carbon dioxide is one of the main gases responsible for the 'greenhouse' effect. Natural gas produces about 0.055 million tons of CO_2 for each PJ of gas burned. Based on the predicted replication potential for replacement boilers in housing it should be possible to save annually nearly a third of a million tons of carbon dioxide from entering the earth's atmosphere. This reduction in atmospheric pollution should be achievable within the next 5-10 years. If condensing boilers are deployed to their full market potential (about 25% of the total market) then the saving in atmospheric pollution will be much greater, approaching 0.7 million tons by the end of the centuary.

Many boilers installed during the late 1960's and early 1970's – the boom years for the gas installation industry – will soon be in need of replacement having reached the end of their useful life. Replacement with a more efficient heating appliance will reduce carbon dioxide emission as well as save the nation's fuel.

Vale of White Horse District Council

The Vale of White Horse District Council is a rural local authority with headquarters in Abingdon. The district council is currently responsible for a population of over 110,000 people in Oxfordshire. The housing stock of over 5,700 homes is situated mainly in small towns and villages. The area, in common with other parts of the region, is expanding. As transport and other services improve there is increasing industrial settlement, making greater demands on housing.

Vale of White Horse District Council's experience

The Vale of White Horse District Council has always maintained a forward looking attitude to innovation, particularly in connection with energy efficiency. Several initiatives have been undertaken to improve the energy performance of the existing housing stock, including programmes of loft and cavity wall insulation, double glazing doors and windows and draught-stripping.

During the design of the Drayton scheme, gas-fired condensing boilers were largely untried and untested as far as the UK was concerned. The installation of these appliances in a new development represented a high risk to the Council. The demonstration grant enabled this risk to be shared with the Department of Energy, thereby encouraging the Council to specify condensing boilers for the first phase of the development.

Despite some initial problems (common with most new technologies), the condensing boilers have saved energy and helped to reduce the tenants' fuel bills. However, one area which does need serious consideration is maintenance. In our experience condensing boilers are perceived by the industry as difficult to maintain. This can lead to higher charges for annual maintenance contracts – in some cases higher than old, conventional boilers. The reason for this higher charge is obscure. Condensing boilers should be no more complicated to maintain than conventional boilers. Nevertheless the attitude persists amongst some service engineers and could be a serious setback to widescale condensing boiler use.

Since the first phase of the Drayton Scheme two subsequent phases have been completed. In subsequent phases, JLB (Trisave) T22 condensing boilers have been specified. Whether or not the Council is prepared to continue using condensing boilers will greatly depend on the cost of maintaining these appliances.

Mr C Gorton
Assistant Director of Housing (Technical)
Housing Department
Vale of White Horse District Council
Abingdon, Oxford

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 Energy Efficiency Enquiries Bureau at the Building Research Energy Conservation Support Unit, (BRECSU), Building Research Esblishment, Garston, Watford WD2 7JR. Tel No: 0923 664258.

Information on participation in the Best Practice programme and on energy efficiency generally is also available from your Regional Energy Efficiency Office.

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