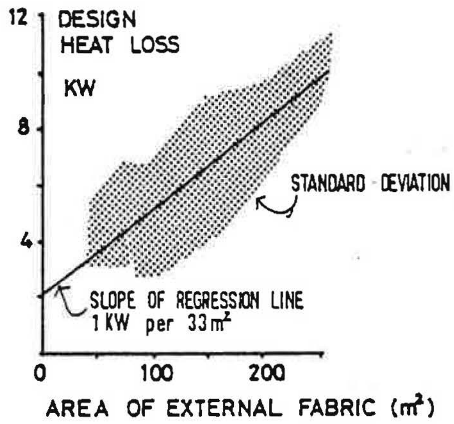
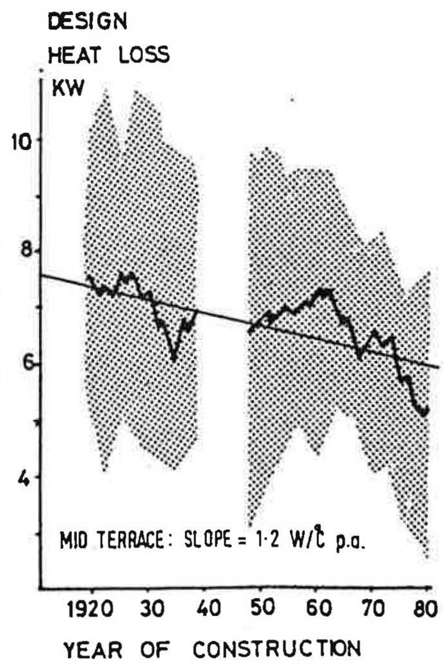
THE ENERGY IMPROVEMENT KIT

The Department of the Environment has produced an 'energy improvement kit' to enable housing managers and their technical staff to determine which measures can most effectively improve the energy efficiency of their housing stock. This article describes the project which involved the production of the kit.

The Energy Improvement Kit project (EIK) ran from 1979 to 1982 and was initiated by the DoE to complement the Better Insulated House (BIH) programme.[1] Although BIH was primarily concerned with recent public sector houses it indicated that energy savings in older houses were likely to be more difficult to attain in practice. To further test this belief the DoE together with the City of Birmingham Housing Department (assisted by the City Architect, Engineer, and Polytechnic) collaborated on this project using a sample of Birmingham's stock of 150,000 local authority homes.





The principal aims were:

- to gain better information about the energy characteristics of the stock,
- to investigate methods for improving the energy efficiency of such centrally managed stocks.

EIK had two phases. The first consisted of a survey of a four per cent random sample (6000), and for the second, energy improvements were made to 25 different but representative dwellings. Monitoring took place before and after the improvements with no change in tenancy.

The survey characterised energy aspects of the stock in such a way as to inform management decisions. In some respects it was an early example of the planned maintenance surveys now being carried out by some local authorities.

The field trials were not so much concerned with testing specific energy efficiency measures but with assessing the whole process of survey, specification and installation. It was envisaged that this would enable the production of a package of guidelines and recommendations—referred to as a 'kit' in the project title.

Fuller reports of the findings of EIK are available[2] and the results are now available on a computer database.[3] The discussion draws heavily from more recent studies notably those carried out by the Building Research Establishment[4] and the Department of Energy's Energy Efficiency Demonstration Scheme.[5]

This was the first survey in the UK specifically about energy. Information was collected from each dwelling on form, fabric, services and occupancy (dimensions, construction, type etc.). These data yielded descriptive statistics such as areas of windows, types of heating systems, as well as derived information such as U-values and Design Heat Loss.*

Many of the findings will be peculiar to Birmingham although the methodology is viable to any computer based approach to housing maintenance. For example 23 per cent of dwellings had non-masonry walls—reflecting the massive building programme of the 60's. However statistics such as 0.4 per cent never heating living rooms and 44 per cent never heating bedrooms will have wider interest. The finding that 55 per cent of households comprise only one or two people, whereas only 17 per cent of homes are designed for this, confirms a widely recognised phenomenon.

The energy-related data were statistically analysed in an attempt to rationalise an otherwise unmanageable range of information. It emerged that calculated Design Heat Loss rates were strongly related to ten building forms and 16 construction types. Of the numerous possible combinations a few (25) accounted for most (85 per cent) of the stock. Similarly, only 11 types of heating system accounted for 75 per cent of installations. Thus it was feasible to categorise the stock in a manageable number of 'energy stereotypes', suggesting a management tool for forming investment priorities.

Slightly surprising was the strong relationship between DHL and a few easily obtained parameters, notably the total area of external surface and the presence or absence of loft insulation. Conversely the date of construction was not a significant factor until very recently, when legislation substantially improved thermal insulation, and a larger proportion of small buildings began to be constructed.

The analysis confirmed that smaller samples (around one per cent) are accurate enough and that a relatively small number of 'types' account for most of the stock suggesting that surveys might usefully identify these types for both local and national housing management.

**Design Heat Loss—DHL—is the heat loss rate of the dwelling in watts with assumed internal and external temperatures of 19 and –1°C respectively.*

One each of the 25 dwelling types identified by the survey were selected for monitored field trials of energy retrofits. Design studies evolved a specific package of EEM's for each dwelling. This took account of the dwelling characteristics and one of there retrofit strategies, namely:

- First-aid: immediate and low cost measures, eg draught-proofing.
- Optimal: measures regarded as near the practical and/or economic limit eg cavity wall insulation, secondary glazing.
- Refurbishment: measures that would be most practical as part of whole house modernisations eg solid wall insulation.

All improvements were executed and paid for by the City of Birmingham housing department using usual procedures. Although the field trials were effectively 25 separate case studies, fuel records from groups of eight identical dwellings confirmed the sample as 'typical'. Taken in the context of housing stock management, therefore, it is possible to generalise from the findings.

A third storey flat in this block had its balcony glazed in as part of the Birmingham improvements.

It is possible to illustrate the relationship between the calculated reductions in Design Heat Loss and the annual space heating energy savings. The reduction in DHL averaged one kilowatt (20 per cent) but varied from 0.5 kw (7 per cent) for houses with minimal ECMs to 2.0 kw (33 per cent) with insulation to all walls, roofs and windows. Space heating fuel savings ranged from zero to 8700 kilowatthours pa (32 per cent), and averaged 2500 kilowatt hours (16 per cent).

On average, a calculated reduction in the Design Heat Loss of one kilowatt produced a fuel saving of about 2500 kilowatt hours pa. When allowance is made for the differing efficiencies of heating systems this relationship agrees well with other trials which showed a saving of about 2100 kilowatt hours pa per kilowatt reduction in DHL in gas centrally heated dwellings.[6]

Such general agreement may be encouraging to managers and policy makers but, as with other studies, the spread for individual houses is such that we must conclude that savings cannot be predicted with much confidence. In fact, of the 25 dwellings in this study, five had savings less than 50 per cent of that predicted while another five had savings in excess of 150 per cent of that predicted.

BIH showed a lower saving of 1500 kilowatthours net pa per kilowatt reduction in DHL. This is roughly equivalent to 1930 kilowatthours for comparison—a lower figure than EIK but not greatly so, and easy to explain.

Costs spread

Capital costs (1984) showed a similar spread ranging about a mean of £840 from £90 to £3420. Considering only the cost of insulation ECMs this averaged £770, with the same spread, and was little related to the calculated reduction in DHL (see fig. 2) confirming that ECM costs and options derive from their constructional rather than their energy characteristics.

The cash value (1984) of energy savings averaged £25 pa ranging from £2 to £105 pa. The simple pay back period averaged 19 years ranging from five to 87 years. This excludes three dwellings where the payback was more than 150 years owing to specific technical difficulties which precluded any generalisation from these.

The economics appear depressing but when homes which were retrofitted to 'first-aid' or 'optimal' levels are considered separately from those subjected to refurbishment retrofits, the results indicate an average capital cost and payback of around £370 and 15 years. This reflects the high cost of items such as scaffolding and new heating systems, much of which would be off-set in a *general* refurbishment programme.

Integration

In a more recent project[7] the ECMs have been integrated into a housing renewal scheme. In addition to the reduction in DHL resulting from the usual renewal works a further reduction of 2 kilowatts was achieved with an additional capital expenditure of around £800 and the pay back period was 15 years. In the EIK project such a reduction in DHL required an expenditure of about £3000 with a consequently longer payback period.

Thus in broad terms a comparison with BIH suggests that in existing houses the achieved energy saving relative to calculated reductions in DHL may be greater than for new houses but owing to the greater cost of ECMs relative to reductions in DHL the payback periods are much longer (BIH averaged eight years reflecting a large proportion of cost effective cavity fill insulation).

In addition to fabric improvements most of the dwellings received modifications to their hot water supply system. This consisted of a wind-up timer unit to electric immersion heaters and additional cylinder insulation. The average cost was £32 per dwelling with energy savings averaging £20 pa with an average payback of five years. This reflects the high cost of water heating by 'on-peak' electricity and indeed in 2 cases where this was replaced by a gas multipoint the capital cost of £310 was also recovered in 5 years. Thus it would seem that water heating measures are more economically viable than fabric insulation, although they are particularly sensitive to lifestyles, in that hot water consumption varies enormously between households.

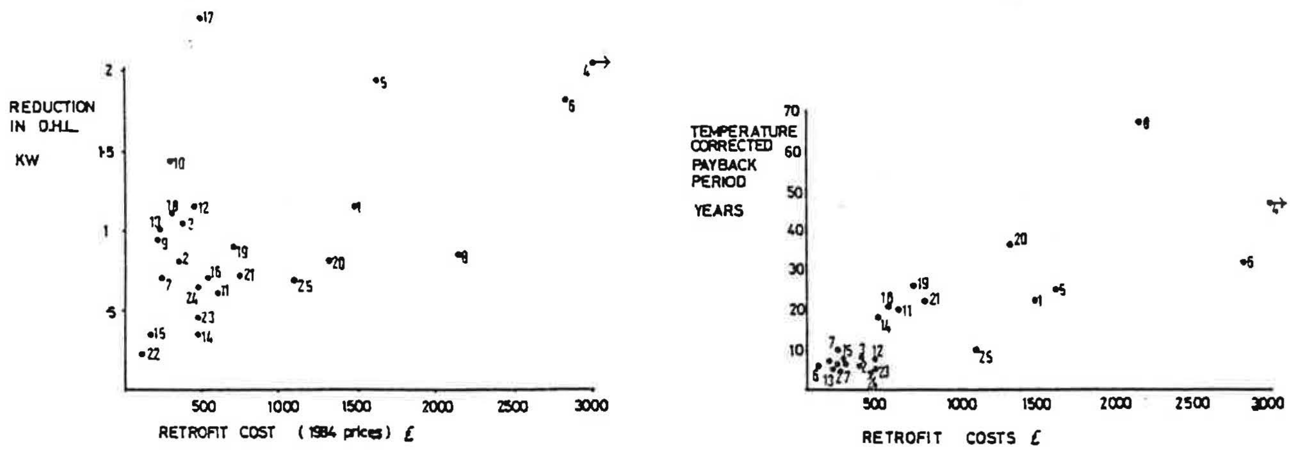
Evidence

The evidence from EIK, namely achieved energy savings and on-site experience, indicated that relatively simple or single measures tended to be trouble-free and produce close to expected energy savings. On the other hand more complex and/or combinations of competing measures tended to produce greater installation problems and substantially less than expected savings. Paybacks for the rest are erratic and high. This 'cost effective' group had ECMs limited to draughtproofing, loft insulation, cavity wall insulation, and hot water supply measures. The average cost per home was £240 and their payback was nine years.

The EIK project revealed the relationship between calculated and actual energy savings to be complex and indicative of how energy savings may be increased in future.

A principle factor is the effect that insulation has on internal temperatures. In EIK the average rise was about 1°C. This is lower than reported elsewhere but its effect on energy savings must not be underestimated. Estimates of fuel savings assuming no rise in

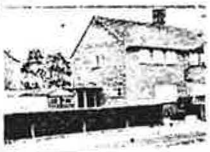
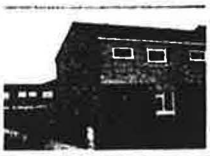
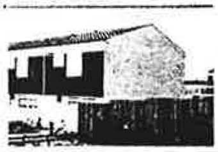
Average cost of energy saving measures: £240
Payback period: Nine years



temperature suggest 3600 kilowatt hours pa per kilowatt reduction in DHL (40 per cent higher than the observed).
There was a wide spread in temperature changes ranging from a drop of one to a rise of 4°C. In general dwellings which were warm beforehand and/or had thermostatically controlled central heating systems showed lower increases. There were larger increases in dwellings with manually controlled heating and/or low temperatures before.

Comfort not cash
Thus it appears that occupants of cooler dwellings elected to take some of the benefit of the ECMs as comfort rather than cash—to be expected of those who could not afford this standard before.
However the absence of thermostats can mean that it is difficult to prevent overheating by heating systems which become oversized when insulation is improved. It was clear that in most cases a substantial part of the rise in temperature was due to slower cooling of the dwelling with little if any change in the demand temperature maintained in occupied periods and spaces. Unlike voluntary increases in comfort and overheating due to poor thermostatic control, this effect is unavoidable, as is that attributable to warm air movement around the house which can not be controlled.

Air infiltration
Other factors which can often explain discrepancies in achieved energy savings are the air infiltration and ventilation characteristics of the dwelling, which despite recent advances remain the aspects of energy performance least amenable to calculation and measurement. In EIK, five similar dwellings were subjected to pressure testing before and after retrofitting which included draughtproofing of windows and doors as well as cavity fill insulation in each case. This showed a 40 per cent reduction in leakage. This is substantially more than achieved from other studies of draughtproofing[7] and can be explained by the poorly fitting windows and large number of permanent ventilators which were sealed. Where the initial windows had a small crack width then these were hardly affected by draughtproofing.
The detailed monitoring allowed estimates to be made of the energy saving from the air leakage reduction. These varied from £5 to £38 pa and, surprisingly perhaps, had a payback of five to 33 years since some of the sealing measures (eg porches) had a very high cost. Nevertheless even simple draughtproofing of windows and doors cost around £110 per dwelling and had a seven year payback on average. Similar results which challenge conventional assumptions have been reported elsewhere and are related to the fact that less than half of a dwelling's air infiltration is associated with opening components. The balance is through more obscure leakage paths which are very specific to individual dwellings (eg gaps around flues, skirting boards, electrical conduit etc.). The effective location and sealing of these is something as yet not properly tested by field trials.
Most dwellings had an invididual room heating regime but in two cases with central heating, difficulties arose from the altered balance of room heat losses due to the ECMs. These emphasise the need to consider the losses and gains in the context of controls.
In one case double glazing the lounge which contained the only thermostat led to a reduction of heat output to other uninsulated rooms. Fortunately the warm air system was amenable to rebalancing by

		DESCRIPTION	ECMs	Cost £ (1984)
1.		Type Semi-det. 3 bed. 1931. 9" solid brick wall, slate roof with 50 mm ins., timber suspended and solid ground floor. Services Solid fuel (liv) room heater with electric healing to landing and bed 2. Gas cooker	80mm roof ins (50- 130) Draughtstrip, fill airbricks Hardboard line liv. floor Front lobby Replace louvre windows with casement 100mm ins. to HWC (25- 100) New room heater and 3 rads. Underfloor draught and servicing	53 142 60 123 126 22 965
2.		Type Semi-det. 3 bed. 1948. Cavity wall, tile roof with 100 mm Ins. Ground floor concrete and boarding on battens on concrete. Services Gas fire both livs. DHW electric immersion (25mm ins). Gas cooker	75mm cavity fill Draughtstrip, fill airbricks 75 mm ins. to VC (25- 75) Servicing to appliances	139 191 7 13
3.		Type Semi-det. 3 bed. 1953. B.I.S.F. tubular steel frame, render on expanded metal lower floor, steel trough sheeting upper. Steel roof with 100mm ins. Concrete floor. Services Gas fire in liv. flueless gas convector then Feb 1980 paraffin in bed 2 DHW electric immersion (no ins). Gas cooker	(Rockwool to ext. walls (Feb '80) Draughtstrip Close unused flue HWC Boxed inc 50mm ins (0- 50) Wind up timer for DHW Balanced flue gas heater to hall Servicing to gas appliances	324 169 65 40 48 111 10
4.		Type Semi-det. 3 bed. 1928. 9" solid brick wall rendered upper floor, slate roof (no ins). Tember suspended and concrete ground floor. Services Gas fire in liv, electric heater in bed I. DHW electric immersion (no ins). Gas cooker	100mm ins. to roof (0- 100) 50mm ext wall ins Draughtstrip, fill air bricks Hardboard line liv. floor Front porch 100mm ins to HWC (0- 100) Wind up timer to DHW Servicing gas appliances	46 2306 153 56 843 7 48 10
5.		Type End terr. 2 bed. 1951. Cavity walls, tile roof with 100 mm ins. Concrete floor. Services Gas fires in liv. and bed I, flueless gas convector in hall. DHW electric immersion (100mm ins). Gas cooker.	50mm cavity fill Double glazing to liv. and bed I Draughtstrip, fill airbricks Entrance porch 75mm ins to HWC (100- 75) Wind up timer for DHW Servicing gas appliances	139 706 188 552 7 48 20
6.		Type End terr. 3 bed. 1970. No fines concrete walls, tile roof with 25mm ins. concrete floor, gasket weatherstripping to windows. Services Gas warm air unit, outlets in kit, liv, hall, roomstat and timeclock. Electric heater in bed I. DHW electric immersion (25mm ins). Inst electric shower. Gas cooker	80mm roof ins (25- 105) 50mm external wall ins Draughtstrip, fill airbricks 75mm ins to HWC (25- 100) Servicing gas appliances	52 2074 90 7 13
7.		Type End terr. 3 bed. 1969. Timber frame with 25mm ins. Clad with plywood at ground floor, tile hanging at Ist floor, brick at gable end; tile roof with 25mm ins. Concrete floor. Services Gas warm air unit, outlets in every room, roomstat and timeclock. DHW electric immersion (25mm ins). Gas cooker	100mm roof ins (25- 125) 25mm ins. to bottom panel of liv. window Draughtstrip, fill airbricks 75mm ins to HWC (25- 75) Time clock for DHW Servicing gas appliances	73 13 129 7 54 13
8.		Type Mid terr. 2 bed. pre 1900. 9" solid brick walls, slate roof with 30 mm ins. Timber suspended and solid ground floor, 'tunnel' entry to rear. Services Gas fire in liv. I, paraffin heater in liv. 2. DHW electric immersion (12"mm ins). Gas cooker	80mm ins. to main roof (30- 110) 50mm ext. wall ins. to rear entrance 'tunnel' Flush door replacing gla ed door Dryline front bed. (50mm ins) Draughtstrip, fill airbricks Hardboard line ground floor Gas back boiler for DHW 75mm ins. to HWC (12- 89)	52 1598 68 161 162 92 292 7

Some of the homes used for the DoE survey.

adjustment of room registers. In another case with wet central heating thermostatic radiators were installed together with lounge double glazing and roof insulation. Although this was effective in preventing any temperature increase it did lead to some initial confusion with the user especially since the original central thermostat had been left in the lounge.

Difficulties for users

This highlighted another issue namely the occupants' understanding of their dwelling, the heating system and their fuel use. Most systems, including central heating, were manually controlled (no time clocks or thermostats). The limited evidence from these trials is that automatic controls can generate difficulties for users and the implications of this for housing management and maintenance should not be underestimated. In any energy improvement programme it will be necessary to provide some form of education for the occupants, not only about controls but also including ventilation and condensation. Heating system efficiencies were not measured, but it is sometimes argued that EEMs will lead to a loss of efficiency due to more 'part-load' operation. Whilst EIK cannot usefully contribute to this debate it did reveal the paucity of data on the performance of heating systems relative to information on, for example, insulation. In a few cases the efficiency of a system was suspected as being very low but little quantative data could be summoned. (For example an open fire or electric underfloor heating). These findings confirm that for ECMs to be fully effective they must include consideration of the heating system and its control.

Heat balance

Of additional interest was the heat balance of the dwellings. On average only about 50 per cent of heat loss was met by the heating system with 25 per cent from heat gained from other fuel uses such as hot water, cooking, lights etc and the remainder from people and solar gain. Thus a reduction in a dwelling's heat loss would have a disproportionately larger reduction in purchased space heating fuel. Consequently, it is possible to reduce the heat loss to a point where the incidental heat gains dominate and the scope for further savings in purchased heat will reduce. Others have suggested that this point corresponds to a DHL of about four kilowatts for a family home. This 4 kW level is a misleading milestone. Incidental gains must always be considered, and where they provide most of the heat, heating methods, controls and tenants' education should match. Since most space heating was by gas and other uses by electricity, space heating savings represented a lower proportion of the total fuel bill (6 per cent), and most tenants did not report cash savings as the most notable feature of the improvements.

The points above provide an insight as to why achieved savings were less than the possible maximum. Temperature related effects, including heating system design and control, dominate. However the much more variable incidental heat gain and ventilation effects can also limit savings. These are important and complex issues for the designer of energy efficient and cost-effective retrofits for houses. This task can be further compounded by technical and management implications

Technical and management issues were also assessed since these are as important to specifiers and policy makers as the energy savings themselves.
Selection of the EEMs was hindered by inadequate information, especially related to air infiltration and heating services. For example house average temperatures varied from 13 to 21°C, but this could not be known at the specification stage. This and other information to emerge during monitoring reveals the performance of EEMs to be very sensitive to individual dwelling characteristics. Whilst some of these (eg implications of fixed fittings for internal wall insulation) are amenable to detection by a simple survey, others are not (eg air leakage routes). Thus whilst it is true that we cannot predict energy savings for individual dwellings with much confidence it is debatable whether this can be improved at the design stage since survey costs would be prohibitively high. However, it is still hoped that other research will yield reliable 'rules of thumb' related to house types, which will allow individual house surveys to be avoided.

Few difficulties

Workmanship presented few difficulties if one or more of the following conditions were fulfilled:

- the EEM was straightforward and relatively independent of the dwelling eg loft insulation.
- the part of the dwelling receiving the EEM was in sound condition eg window frames being draught-proofed.
- the work was carried out by a specialist contractor eg cavity filling.

If these did not apply, then problems arose:

- draught-strips had to be carefully matched to the opening, if gaps were to be filled, and fixings to be robust.
- cavity wall insulation had to be cancelled when one cavity was revealed to be unacceptably bridged by mortar droppings.
- external wall insulation fixings and detailing around openings proved difficult for the non-specialist contractor.
- secondary glazing was troublesome if the existing window was incompatible with the contractor's standard system.

Many of these manifested themselves as increased cost and/or reduced energy savings. For example, external wall insulation proved to be more expensive than anticipated and in one case compression of the insulation during fixing was suspected to have spoilt its performance. Similarly, some secondary double glazed units failed to provide a good air seal to the room thus negating some of their potential energy savings. Additionally, in one or two cases, the existing EIK dwelling was found to need significant repair or preparation work to allow the introduction of the EEM, eg draughtproofing to seized sash windows.

Many of these difficulties will have been eased since EIK, as specifiers, suppliers and contractors have all gained experience. However, the general difficulties associated with fitting a new piece of hardware with limited dimensional tolerance to an existing dwelling component still remains.

Since most of these difficulties were encountered with EEMs that would normally be installed as part of a refurbishment exercise this must strengthen the view that such measures should only be contemplated as part of such a broader house improvement exercise.

20 per cent of the households reported an increase in window condensation. Much of this was due to the draught-proofing being so effective that it eliminated air movement near the glass and did not allow condensate to drain out through the opening joint, where present. Work elsewhere[8] has shown that the use of trickle ventilators can reduce or eliminate this difficulty without any noticeable energy penalty, although the installation cost is significant.
In common with other projects, EIK exposed the weakness of ignoring the heating system among other energy improvements. Heating systems were only touched where the existing ones were inadequate, or where dangerous ones had been imported by the occupant, so the authority felt obliged to put things right. Otherwise nothing was done to them.

One of the major issues is that a landlord who invests in improving the energy efficiency of dwellings does not receive the immediate benefits. This can lead to such improvements being considered 'non essential' and therefore hard to justify. Further, the fact that any disbenefits will be the responsibility of the housing management is, perhaps, even more important than the absence of any direct financial gain to them. This is most likely to be in increased maintenance and it is preferable that any EEMs are compatible with existing maintenance procedures and at worst represent only a marginal increase in commitment.
At present, however, many rented dwellings are seriously under-insulated, fail to provide affordable warmth and comfort and hence are under-heated also. In such circumstances insulation can both make them more habitable and save the expense of repeatedly putting right condensation damage—an advantage to the landlord as well as to the tenant.

Escalation of costs

If a local authority is to introduce ECMs into their stock independently of other works then they will face the problem of having to implement concomitant repairs. This will necessitate individual treatments to dwellings with an associated escalation of costs, and with an effect on subsequent maintenance programmes. However if ECMs are included within existing programmes of modernisation then there is the difficulty that ECMs will be deployed according to modernisation and not energy efficiency criteria.
In addition to the above management problems the local authority would have to accept that specifying ECMs not only spreads the resources less widely but requires additional design and supervision time. This brings back into focus the issue of financing the improvements. It would appear that unless the local authority can indeed see benefits in terms of reduced maintenance then it is likely that such improvements would remain a low priority. That this must also be true for new houses has been masked by the modifications to the building regulations which do not apply to house modernisation. If the cost of the EIK improvements had to be financed by rent increases then this would have added between £0.20 and £6.90 per week to rents. Tenants would only accept such penalties if the fuel savings were very apparent and the experience of this project confirms this to be a difficult condition to fulfil for every household.

CONCLUSIONS

The Energy Improvement Kit project revealed that an apparently daunting variability in the housing stock can be characterised by a relatively few common types. Identifying and then collecting more information concerning the energy characteristics of these types would be an efficient method of informing management decisions regarding housing stock energy management. This approach follows that which is increasingly common in other aspects of housing maintenance whereby coarse decisions regarding allocation of resources are made on a basis of general information about 'types'.

The project demonstrated average energy savings equivalent to 2500 kilowatthours pa per kilowatt reduction in calculated Design Heat Loss. This was substantially lower then the maximum owing to relatively small temperature rises. Improvements should be sought in the design, specification, and installation of EEMs so as to limit these temperatures rises.

Improvements to heating systems and their controls are perhaps the most notable development that could be made, given that they can be shown to be effective.

Many EEMs are very sensitive to individual dwelling conditions and the behaviour of occupants (notably the temperature levels; ventilation patterns; incidental heat gains; etc). These combine with the effect of temperature rises to introduce a large spread in savings achieved in individual dwellings such that it is not possible to predict individual savings with much confidence— though to predict average savings is easier.

Technical problems were limited to ECMs of a more complex nature and/or those installed where the house, or part of it, was in a poor condition.

The introduction of ECMs demands less commonly available skills and requires additional design and supervision time, by personnel with both the required practical and theroretical knowledge.

As a general rule the simple, low cost, non-disruptive ECMs such as loft insulation, cavity fill etc presented few problems and yielded reasonable payback periods. Conversely, more complex, sophisticated and expensive ECMs such as external wall insulation, showed greater under-achievement which substantially increased payback periods while nevertheless sometimes desirable. This was especially true when ECMs were competing for energy savings, as for example in the case where improved insulation reduces the potential saving from thermostatic controls.

Most management problems relate to the fact that the tenant has the benefit from an investment by the housing management who also have to meet any increased maintenance costs. This is compounded by the advisability of installing all but the simplest ECMs as part of wider improvement works since the objectives of improvement and energy/saving may conflict. For example the requirement for long life and low, or zero, maintenance may be incompatible with certain ECMs, eg external wall insulation.

This project provided much detailed insight into the thermal performance of houses and how this changes following energy retrofits. This has been shown to be more complex than for new houses. Whilst many of the problems are now understood and accepted by the industry, continued research and development is required especially when it is realised that over 80 per cent of the dwellings that will exist in the year 2000 are already built.

Recommendations

The recommendations relate primarily to large housing stocks of tenanted properties but many have wider application, and they are:

- Simple and relatively non-disruptive ECMs such as loft insulation, draughtproofing, cavity wall insulation, and improvements to hot water supply systems, can be implemented by separate improvement programmes. Other, more complex ECMs can only be contemplated as part of a broader house improvement programme. This is to reduce their cost by offsetting some overheads and to ensure that the host systems are in an appropriate condition.
- Measures aimed at reducing air leakage need to take account of the fact that most air leakage occurs at places other than windows and doors. Heating system design and control should be considered along with fabric insulation. The substantial impact that occupants can have on energy savings suggests a parallel programme of education and advice.
- The specification of ECMs should reflect individual house characteristics. While there are practical limitations to wholly individual treatment, a standard methodology can accommodate some variations such as, for example, heating system controls.
- The stock can be classified into a few types with a limited number of energy related characteristics. Further information and feedback on these can inform broad management decisions. However, the introduction of ECMs into an existing stock can have many implications for current management policies and maintenance procedures. These need to be fully resolved as part of the specification.

In summary, the experience of this and other projects is to 'keep it simple'. Cost effective savings can be achieved with tried and tested techniques. Resources should be concentrated on identifying such appropriate ECMs rather than developing new ones.

Finally, it should be noted that EIK has added to a substantial and rapidly increasing body of 'case-history'. Full use should be made of this experience. This is relatively unusual condition for the housing industry where in many cases innovation has proceeded without helpful research and development work.

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