Impact Evaluation of the UK's Energy Efficiency Best Practice Programme for Buildings

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Synopsis

Recent investigations into the survey reliability and level of attribution of energy savings to the UK's Energy Efficiency Best Practice Programme for buildings.

Abstract

The Energy Efficiency Best Practice Programme is the United Kingdom's principal, independent information dissemination programme on energy efficiency and was established in 1989. The part of the programme directed at buildings is run on behalf of the Department of the Environment by the Building Research Energy Conservation Support Unit. Programme evaluation and feedback is an important priority, with an annual impact assessment being undertaken for each of the seven years since programme initiation. Annual assessment is made of total energy savings and, in particular, the programme's influence in each of thirteen building sectors in which the programme is currently active. These sectors cover a wide range of domestic and non-domestic buildings. It is generally accepted that impact evaluation of information programmes is particularly complex. Recent progress in the development of the EEBPP's evaluation procedures, a combination of written questionnaire responses (from building owners, occupiers, and architects) and building audits, has produced interesting insights into attitudes and uptake of energy efficiency in the UK. This paper presents the current state of play of energy efficiency uptake and associated cost savings, both due to the EEBPP and for the UK as a whole. The results of recent investigations, via a series of complementary building audits, into the relative reliability of respondents and the written questionnaire responses is presented for the first time, together with associated implications for the statistical robustness and optimisation of the programme's evaluation methodology.

1. Introduction

The Department of the Environment's (DoE) Energy Efficiency Best Practice Programme was launched by the UK Government in 1989 to stimulate the take-up of energy efficient good practice throughout the economy. The programme is jointly managed on behalf of the DoE by the Building Research Energy Conservation Support Unit (BRECSU) at Watford and the Energy Technology Support Unit (ETSU) at Harwell. BRECSU is responsible for energy efficiency in buildings whilst ETSU is responsible for the programme's industrial component. This paper refers to the buildings part of the programme.

1.1. Background

The Energy Efficiency Best Practice Programme (EEBPP) is an information dissemination programme, producing a wide range of publications, workshops and seminars on energy efficiency in both domestic and non-domestic buildings. These programme components are directed at the whole range of people concerned with the use of energy in buildings: building professionals, owners, managers and occupiers. The DoE has a remit to check that Government expenditure on the programme is achieving its aims at a sufficiently rapid pace, and to monitor progress in order to improve the tactics and techniques used. In order to achieve these objectives, it is necessary to define and implement a programme of continuous assessment, and each year BRECSU is required by the DoE to estimate the value of energy efficiency improvements stimulated in buildings by the EEBPP. The results are

then used to identify how well targets are being met and additional feedback from the studies can be applied to improve the performance of individual programme strategies. All impact assessment work is undertaken within a budget of 2% of total programme expenditure - this is in line with UK Government good practice RD&D programme guidelines.

1.2. Scope

An essential part of evaluation of the EEBPP is an annual written questionnaire survey to assess the extent of the programme's impact. The survey and analysis procedure enables estimates to be made of the energy efficiency improvements achieved across all building sectors for the first time in the year in question. Savings are then added, year on year, for a cumulative picture of energy efficiency savings since the start of the programme in 1989. The annual survey provides useful feedback on the payback and investment requirements of respondents, who include building owners and designers, and other building professionals, plus a vast amount of information on the current levels and trends of uptake of energy efficiency measures in different building sectors. This paper discusses the survey findings of energy savings introduced in 1995 and, in particular, the results of recent survey confidence assessments undertaken as part of a recently introduced series of complementary building audits. Estimates of the take up of energy efficiency measures in the UK are presented along with the results of building audit investigations into the reliability of the written questionnaire responses by different respondent groups. In addition, this paper presents the results of analysis of face-to-face interviews to investigate the amount of UK energy savings that can reliably be attributed to the EEBPP.

2. Methodology

Two respondent groups were interviewed for 1995. The first group, comprising building Owners and/or Occupiers, was surveyed for existing buildings in order to assess energy efficiency improvements in existing buildings. This group was also surveyed for new buildings. In contrast, the second group, consisting of building Designers, were just surveyed for new buildings ie those completed and occupied in 1995. Hence new buildings were surveyed twice, the reasoning being that as each respondent group has different levels of knowledge about the building in question it might be expected that a mean of the two groups will provide a better estimate of energy efficiency uptake than either group alone. For example, designers are more likely to have information on building structure thermal transmittance values (*U*-values) than occupiers of the building yet, conversely, the owners have a more up to date knowledge of the extent of installation of energy efficiency measures such as compact fluorescent lighting. However, surveying two respondent groups rather than one is more costly, using valuable resources that could be used to investigate other issues. Thus a series of building audits were introduced into the survey methodology for the first time for 1995, enabling the relative reliability of each new building respondent group to be investigated as well as allowing the investigation of other survey confidence issues. The general methodology and data processing details for the main annual survey plus corresponding information about the building audits is presented below.

2.1. Survey

This section describes the main impact assessment survey methodology plus the aims and method by which the series of building audits were conducted. Brief details are given of the analysis routines for each component.

2.2.1. Main Survey

The 1995 EEBPP impact assessment study had the following aims:

- To identify the value of energy efficiency improvements resulting from energy efficiency measures being implemented for the first time in buildings in the current year of assessment.

- To undertake face-to-face interviews to identify where decision makers turn for information on energy efficiency, and how great a role the EEBPP plays in their decisions.

- To undertake building audits to provide confidence estimates of survey responses compared to what is actually in the buildings, and to compare the two respondent groups for new buildings in order to find out which provides the most reliable estimate of energy efficiency measure uptake.

Two types of survey are undertaken, in each of the thirteen sectors listed below. The thirteen building sectors reflect the main areas of current EEBPP activity. The first survey type is for buildings completed in 1995 and the second survey type is for pre-1995 stock.

The building sectors surveyed for 1995 are:

Social Housing	Multi residential Housing
Private Housing	Health Care
Schools	Higher and Further Education
Sports and Recreation	Public Offices
Public Houses	Retail
Commercial Offices	Hotels
Industrial	

(Only part of some of these building sectors are surveyed, in order to reflect the EEBPP's dissemination activity to date; ie only new private housing is included as the programme does not specifically target existing private housing, and hotel chains, multiple pub operators and NHS Trust hospitals are the surveyed portions of the hotels, public houses and health care sectors respectively).

The survey sample frame is contained in Table 2-1. Stratified random sampling from lists including sector annual reviews and directories is used. Table 2-1 shows that many of the main building sectors have subsectors that are sampled and surveyed independently. This is because the subsectors have different information dissemination mechanisms and/or behavioural characteristics that affect their uptake of energy efficient measures. To be truly representative of the main sector the subsector results are then weighted accordingly.

Table 2-1. Survey Sample Frame

Building sector and subsectors	Survey sample sizes			
	Owners -existing build	Owners -new build	Designers -new build	Sector totals
Private housing	-	75	75	150
Social housing				
Local authorities		75	-	-
Housing associations	75	100	100	
total	150	100	100	350
Multi residential housing				
Sheltered housing	50	30	30	
Student accommodation	50	30	30	
Hostels	50	30	30	
Nursing homes	50	30	30	
Others	50	30	30	
total	250	150	150	550
Health Care				
NHS Trusts	100	100	100	300
Schools				
Primary	75	50	50	
Secondary	75	50	50	
total	150	100	100	350
Higher & further education				
Higher education	75	50	50	
Further education	75	50	50	
total	150	100	100	350
Sports & recreation	100	50	50	200
Public offices	100	50	50	200
Pubs				
Multiple pub operators	50	50	50	150
Commercial offices	200	150	150	500
Industrial	175	100	100	400
Retail				
Department stores	30	30	30	
Supermarkets	30	30	30	
Food retail	30	30	30	
Retail services	30	30	30	
Non-food retail	30	30	30	
total	150	150	150	450
Hotels	100	50	50	200
Totals	1 650	1 175	1 175	4 000

Each questionnaire is administered in two parts: an initial telephone call identifies the correct individual within the organisation with responsibility for energy, before the written survey is sent out. A covering letter on DoE headed paper accompanies each questionnaire. Potential respondents are assured of the confidentiality of the survey and the fact that data is only presented in an aggregated format and is for use solely within the DoE. Over 95% of people contacted agree to participate in the written survey, thereby ensuring that minimal response bias is introduced at this stage of the survey.

The written questionnaire seeks information on the measures installed for the first time in 1995, details of floor space and sources of energy efficiency information the respondent has used. Coloured pictures of the front covers of series of EEBPP literature are included for recognition purposes. Care is taken to emphasise that only recognition of particular *series* of literature, rather than individual publications, is required.

The written questionnaires ask for information on three main subject areas:

(1) Administrative details eg name and address of respondent.

(2) The proportion of each of the new and existing building floor space under the respondent's control that has been fitted with each of a range of energy efficiency measures *for the first time in 1995* and the total floor space to which the responses refer. (Particular care is taken to ensure that the existing floor area is representative of the proportions of those who have and those who have not undertaken refurbishments to their buildings).

(3) The sources of information on energy efficiency in buildings which the respondent uses and series of publications that they may have read or used.

Responses to (2) are used to identify the total value of energy efficiency improvements in all buildings throughout the UK. Responses to (3) are used to attribute part of the total value of energy efficiency improvements to the EEBPP. These can be used to identify both areas of greatest success and scope for improvement in the programme. Survey data is grossed up by floor area to be representative of the UK building stock.

2.2.2. Building Audits

The purpose of the building audits is three fold:

(1) to assess the accuracy of the written questionnaires responses from the main survey
(2) to identify whether either of the two respondent groups for new buildings provides more accurate data
(3) to determine how well the current method of attribution of energy savings reflects the actual influence of the EEBPP.

Building audits were undertaken for 209 new buildings, corresponding to about 8% new building written questionnaire returns. Unlike the main survey, two questionnaires, one for each respondent group, were received for each audited building. The energy efficiency measures that had been taken were checked and the owner was interviewed about their use of advice and information relating to energy efficiency.

2.2. Data processing

2.2.1. Main Survey Analysis

This section outlines the procedure used to calculate the value of energy efficiency improvement for each sector.

- The data for each energy efficiency measure listed on the questionnaire is collated.
  The questionnaires are tailored to ask about those measures which are most appropriate to each sector. Questions relating to roof, wall and floor insulation ask for the proportion of floor space fitted to standards higher than that required by Building Regulations. Measures which become standard practice or are required by Build-

ing Regulations are removed from the survey. Additional measures are added where significant and appropriate, and Combined Heat and Power plants are not included, in order to avoid double-counting, as this measure is included in ETSU's impact assessment. In this manner, the number and type of measures continually changes as measures become standard practice and new technologies emerge.

- outliers, in terms of building floor areas, are identified and removed from the datasets.

- Each measure is assigned a typical percentage energy efficiency improvement based on BRECSU data and experience. The values are specific to both each type of energy efficiency measure and each building sector. An adjustment is also made for multiple energy efficiency measures. Energy efficiency improvement figures are typically 1, 2, 5, 10, 20% of the energy consumption in the consumption categories listed below.

- Using an estimate of the annual specific energy consumption for the particular building type, the amount of energy saved by applying the measure in question is calculated for each measure within the energy consumption category in question. This process is repeated and the energy efficiency savings are summed.

- The energy consumption categories considered are:
  - Energy Management measures
  - Heating measures
  - Cooling measures
  - Lighting measures

- For the measures which reduce heating load, the sum of the energy savings is reduced to account for the non-additive nature of savings achieved from, for example, fitting a condensing boiler and additional wall insulation. However, the other categories have considerably fewer measures and so this scaling down of savings is not as necessary.

- In order to gross-up the energy efficiency improvements identified in each of the samples, to those of the whole of the UK floor space, the value for each sample is multiplied by the ratio of the relevant total UK floor space to the sample floor space.

- Data on new UK floor space are estimated for each non-domestic sector using a method based on the value of construction output. For each building sector the value of construction output for the UK is obtained from Housing and Construction Statistics (HMSO 1996), supplemented by BSRIA information (BSRIA 1990) on refurbishment levels.

- The difference between the total value of construction output and the value for refurbishment yields the value of construction output for new buildings. The Buildings Cost Information Service Quarterly Review (Royal Institution of Chartered Surveyors 1995) lists for each sector the price of newly built floor space per unit area. This is updated on an annual basis. The amount of new build floor space (m^2) then follows from simple division of these two quantities.

- The energy savings estimated to have been achieved in all buildings in the UK for the current year are then translated into delivered energy, primary energy, carbon dioxide and carbon emissions, and financial savings. Energy savings are also calculated separately for electricity and fossil fuels.

In order to attribute a proportion of the energy efficiency improvements to the EEBPP, the whole analysis procedure is repeated twice for those who have found the EEBPP useful, using the mean of:

(1) the energy savings of respondents who say they have used information from any one of the sources of: BRECSU, the UK Government's Energy Efficiency Office (EEO, now known as the Environment and Energy Management Directorate of the DoE), or the EEBPP; and
(2) the energy savings of respondents who say they have used one or more EEBPP series of publications.

2.2.2. Building Audits Analysis

Analysis of the building audits involves the following stages:

- a comparison of the written questionnaire replies from the two respondent groups with those from the audits, enabling the average error in the surveyed proportion of floor area to be identified for measures reported by these groups.

- assessment of the accuracy of the building floor areas reported on the written questionnaires.

- calculation of the standard deviation of the questionnaire responses in order to estimate the relative reliability of the two respondent groups (using t-tests to generate confidence limits where sample sizes were under 30).

- assessment of whether the written questionnaires accurately reflect the use of the EEBPP, for both respondent groups in each sector.

- using information from interviews with the building owners, the degree of attribution of measures to the EEBPP is weighted in order to reflect the extent of the EEBPP's influence.

3. Results

This section presents the results of the main questionnaire survey with results of the complementary series of building audits and face-to-face interviews.

3.1. Survey Results

A written questionnaire response rate of 56% was achieved for the 1995 impact assessment survey. Work undertaken in conjunction with the UK Office for National Statistics indicates that survey accuracy is of the order Å30% at a 90% confidence level. It is estimated that total new energy efficiency savings worth almost £410m per year (at 1990 prices) were achieved overall in UK buildings in 1995. The £410m figure breaks down as about £370m in existing buildings and £35m in new buildings. This is only slightly less than the 1994 overall figure for UK buildings of £425m worth of annual savings (at 1990 prices), of which about £380m were introduced in existing buildings and £45m in new buildings.

The savings in the previous paragraph refer to total UK energy savings introduced in any one year. Of these savings, some are due to the EEBPP. Thus cumulative annual savings achieved to the end of the financial year 1995/96 by the EEBPP for buildings are estimated at 45PJ of delivered energy (64PJ primary energy), equivalent to 4.2mtCO_2 emissions and 1.1mtC, and worth £370m at 1990 prices (of the £370m cost equivalent of savings, £320m applies to existing buildings and the remaining £49m applies to new buildings). Primary energy savings are split as 46% electricity savings and 54% fossil fuel savings. This compares favourably with the programme's targets, being about 25% ahead of the primary energy target set in 1992 for the programme. New 1995 EEBPP energy savings are compared to those of 1994 in Table 3-1.

Table 3-1. EEBPP Energy Cost Savings for Existing & New Buildings in 1995 Compared to 1994 - at 1990 Prices

Sector	Savings in existing buildings, £m		Savings in new buildings, £m	
	1995	1994	1995	1994
Social housing	61.19	3.83	3.01	1.32
Multi residential housing	9.27	1.27	0.84	0.67
Private housing	-	-	3.19	1.80
Health care	18.28	13.13	0.33	0.27
Schools	4.45	2.64	0.27	0.07
Higher & further education	7.65	0.04	1.00	0.62
Sports & recreation	4.02	0.62	0.68	0.23
Public offices	5.33	0.45	0.67	1.91
Pubs	1.62	1.71	0.09	-
Retail	10.33	0.15	2.38	1.70
Commercial offices	5.10	3.12	0.77	0.37
Hotels	3.68	1.64	0.01	0.02
Industrial	12.95	7.97	0.32	0.13
Totals	143.87	36.57	13.56	9.11

Cumulative energy savings of the EEBPP are shown in Table 3-2.

Table 3-2. Cumulative Annual Savings of the EEBPP, £m, at 1990 Prices

Major Sector	Survey for the Year							
	1988	1989	1990	1991	1992	1993	1994	1995
Housing	91	105	130	144	152	159	169	247
Public buildings	-	-	-	9	22	39	59	102
Commercial buildings	4	9	17	19	23	31	39	63
Industrial buildings	8	19	23	28	31	39	47	61
Total	12	134	170	200	228	266	315	473
Less savings prior to start of EEBPP (1988)	103	103	103	103	103	103	103	103
Cumulative total for EEBPP	0	31	67	97	125	163	212	370

3.2. Audit Results

Figure 3-1 shows the 95% confidence range in which the average responses to the written survey fall when compared to the audited building ie in 95% of cases the average deviation from the actual measure incidences will fall within the bands shown. This shows that the owners/occupiers group responses are more reliable as they are closer to the measure incidences actually found in the buildings.

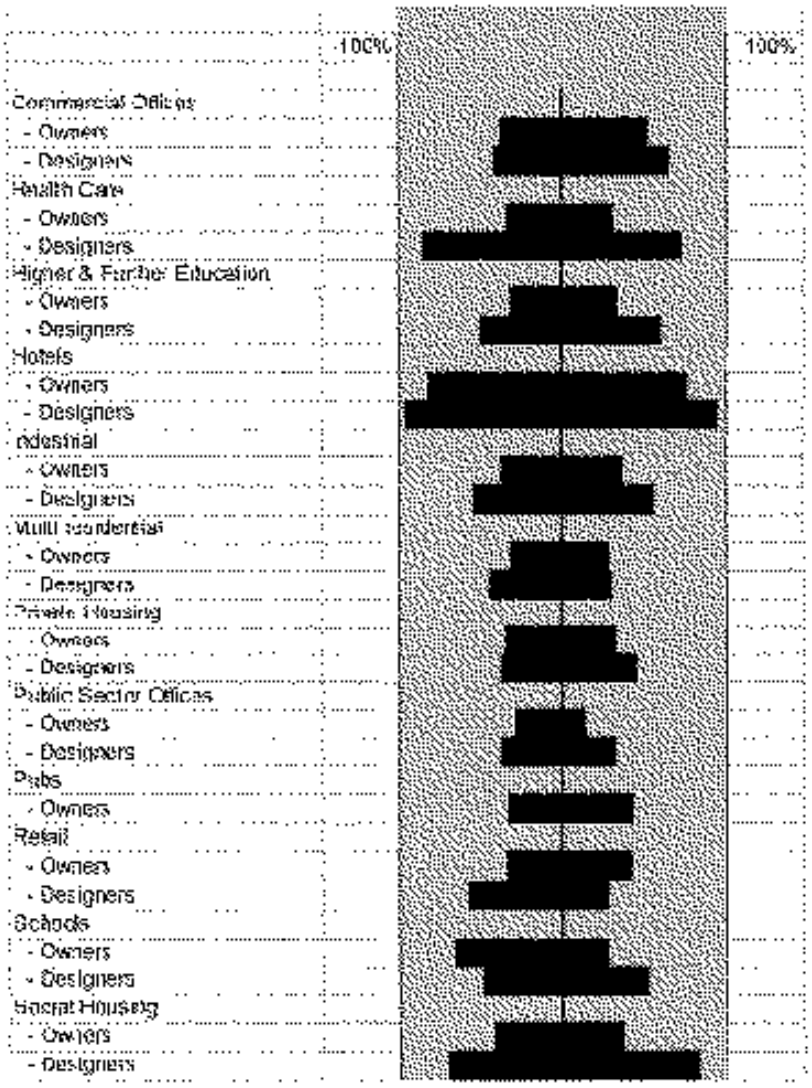

Figure 3-1. Survey Accuracy Compared to Audits: 95% Confidence Limits for Owners and Designers

T-test analysis was made of the accuracy of the survey responses of each respondent type. For public offices, for example, both respondent groups were fairly accurate in the overall building floor area they were responding for (the owners/occupiers group overestimated by +2%Å10% and the designers group overestimated by +1%Å11%). However, the owners/occupiers group replies were more accurate in the proportion of building floor area to which measures were applied, with an overall underestimate of -7%Å21% having less spread than the underestimate of the designers group at -2%Å34%. In general the audits show that respondents in most building sectors were accurate to within Å10% in their responses for both floor area and measures implemented.

Attribution levels were investigated as part of the face-to-face interviews conducted during the building audits. Both respondents were questioned, firstly unprompted then prompted, about the sources of energy efficiency advice they used. The value of EEBPP influence was assessed using a weighted scale of:

(1)	no value	weighting 0.0
(2)	prompted low value	weighting 0.1
(3)	unprompted low value	weighting 0.25
(4)	prompted high value	weighting 0.75
(5)	unprompted high value	weighting 1.0

Each of categories (1) to (5) was checked to ensure that the analysis would not put undue emphasis on any one category weighting. The weighting factors were selected as conservative yet realistic expectations of the value of EEBPP influence. The influence of each sector was calculated, with the resulting overall weighted influence of the EEBPP being estimated at 62% of the survey attribution level (as calculated from the mean of the written questionnaire responses on sources of advice and publication recognition - described in section 2.2.1). The impact assessment results for 1995 were therefore adjusted accordingly.

4. Conclusions

The 1995 assessment of the impact of the EEBPP shows that cumulative programme carbon savings are about 25% above the target for the programme and increasing steadily year on year. The series of complementary building audits introduced for the first time for 1995 has provided several interesting insights into issues such as survey confidence and attribution levels. In particular, the audits showed that the owners/occupiers respondent group gave responses more representative of what is actually in new buildings. Therefore future impact assessment surveys shall just use the one respondent group for new buildings. The audits and face-to-face interviews will remain as an essential component of the survey methodology, providing the opportunity of a face-to-face interview and enabling further investigations of survey accuracy and the level of energy savings that can be reliably attributed to the programme.

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