Persistence of Energy Savings of the UK's Energy Efficiency Best Practice Programme for Buildings

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Abstract
The Energy Efficiency Best Practice Programme is the United Kingdom's independent information dissemination programme on energy efficiency and was established in 1989. The programme is jointly managed on behalf of the Department of the Environment, Transport and the Regions (DETR) by the Building Research Energy Conservation Unit (BRECSU) and the Energy Technology Support Unit (ETSU). BRECSU, part of the Building Research Establishment, is responsible for energy efficiency in buildings whilst ETSU is responsible for the programme's industrial processes component. This paper is concerned solely with the buildings element of the programme – referred to as the EEBPP throughout. The aim of the EEBPP is to advance and spread ways of improving the efficiency with which energy is used in UK buildings. Under the programme information on energy use and energy saving measures is gathered and disseminated through publications, workshops and other events. Annual assessment is made of the total energy savings resulting from the programme including, in particular, its influence in each of thirteen building sectors in which the programme is active. To date energy savings have been cumulatively added, year on year. However, now that the programme is relatively mature, it is important to account for any lack of persistence/sustainability of energy savings that may occur in practice. It is generally accepted that the persistence of savings attributed to energy conservation programmes is difficult to monitor and evaluate due to the numerous variables that affect the reliability of savings and the practical challenges to measuring these variables. This paper reviews the international research of persistence of savings in energy conservation programmes and discusses a recent initial study for specific application to the UK's EEBPP. The study resulted in the development of a matrix system of standard persistence factors. These factors relate the frequency of occurrence and the severity of the reduction in persistence. One factor is selected for each measure and for each particular building sector for each year of the EEBPP impact assessment. Although the values are tentative at this stage, due to the lack of research in this field, the study has resulted in a system which can now be applied to the programme's cumulative savings and thus start to take account of persistence effects.
Keywords: Energy efficiency, impact assessment, persistence, sustainability.

1 Background to the study

The Energy Efficiency Best Practice programme for Buildings (EEBPP) is managed by BRECSU (the Building Research Energy Conservation Support Unit) on behalf of the UK's Department of the Environment, Transport and the Regions (DETR). The programme is the UK's largest information dissemination programme for buildings, with an annual budget of around £7M. The programme aims to:

- Generate information on new and proven techniques for reducing energy use in buildings, establishing what represents good practice
- Present information in different forms for different target audiences
- Disseminate guidance to all target groups through documents, seminars, workshops, etc.

In order to measure the effectiveness of the programme in stimulating real energy savings, BRECSU has developed an impact assessment methodology for the programme and undertaken an annual impact assessment survey every year since the programme's inception in 1989. Essentially this establishes what energy saving measures have been installed in buildings in each sector through clear influence of the EEBPP. Results so far estimate the cumulative primary energy savings to the end of 1996/7 at 86PJ/year, compared to the programme's current target of 1 10PJ/year by the end of the year 2000.

In producing cumulative savings, measures installed in a particular year are assumed to continue to deliver the same savings each year thereafter. As the programme matures, it is necessary to recognise that, for many measures, this is an over-optimistic assumption. Savings in fact are likely to reduce over time. This is the concept known as the persistence of energy savings. This paper details the initial study into the issue of persistence and raises questions which are likely to require further investigation.

2 Definitions

One problem is that the term "persistence" gets used in many senses: the whole concept ie the persistence effect; or the attribute of a particular measure. So that when you say 'persistence decays', you are using the term differently to 'persistence is the phenomenon under which energy savings vary over time'. Service life is only one aspect affecting the persistence of energy savings.

2.1 Persistence

As the purpose of this study was to develop a methodology that could allow persistence to be taken into account in the EEBPP's impact assessment analysis, it is essential to be clear on what is meant by the term 'persistence' in the context of this study. For this study 'persistence' means 'sustaining the level of energy savings produced by the energy conservation measures installed as a direct result of the EEBPP, as identified by the programme's annual impact assessment'. Impact Assessment of the EEBPP involves estimating the likely realisable energy saving produced by measures installed as a direct result of the programme. The savings analysis therefore accounts for non-ideal aspects of installation and operation ie that the full technical potential for savings is unlikely to be realised. Persistence issues apply to energy savings produced by the energy conservation measure from the post-installation stage onwards.

For example, lack of persistence includes:

- Known effects of intrinsic deterioration of energy efficiency where this reduces the level of efficiency used for the initial energy saving calculation (eg Argon gas leaking from double glazed units over time)
- Reductions in efficiency due to changes in management, maintenance and use post-installation.

However, persistence does not include:

- Nationally applied changes in the periods and intensity of use of energy saving measures (eg longer opening times) or annual variations in the area of application of the measures (eg different floor area figures due to closing of classrooms or wards) as these are currently taken into account
- Reductions in efficiency due to normal standards of manufacture, design, installation, commissioning, management, maintenance and use (normal standards can be expected to be less than perfect and only normal levels of energy saving will have been taken into account when setting the levels for calculation in the impact assessment)
- Intrinsic deterioration of energy efficiency that is normally allowed for in design calculations (eg gradual light output reduction of fluorescent lamps).

2.2 Service life

The study recorded the service life of measures where the information was available, although this is not the whole picture and only one issue affecting the persistence of energy savings. If an item reaches the end of its service life and is replace by a similar item, the saving of energy will not be affected. The service life does affect the estimates of persistence of energy savings, however, in cases where:

- The item is not replaced at the end of its service life (eg heat recovery wheels)
- The replacement is less efficient (eg ordinary air filled double glazed units replacing argon filled low emissivity glass units)
- The replacement is more efficient (eg new beer chiller systems rather than the recommended old systems currently being installed in many pubs).

3 Practical issues related to persistence of energy savings calculation

3.1 Relevance and availability of data

An accurate measurement of persistence is very difficult. It requires measurements to be made over a long period during which other things, that might upset the measurement, remain static (eg measurement can be upset by different use of spaces, by changes in equipment and security measures or even by growth of sheltering trees). Researchers have generally avoided this area because of the length of time required for research projects; they are wary of the constantly changing conditions and the large number of variables found in practice.

Besides being difficult to measure, there is a positive disincentive to make measurements. Manufacturers and organisations promoting energy saving do not generally want to publicise decay in persistence in products, few developers want to know about the decline in performance to be expected after the building is handed over. The difficulty of carrying out research and some reluctance to investigate persistence have resulted in a lack of data. In many cases this study has had to rely on anecdotal information and assumptions.

3.2 Basis for EEBPP calculation of energy savings

The EEBPP impact assessment for 1996/7 was based on an assessment of savings made in 13 building sectors by **71** energy savings measures recommended by the programme (not all measures apply to all buildings). Every year the survey collects data on the floor areas to which each of the measures has been applied during the past year. The calculation of energy savings is based upon grossing up to the national stock based upon floor areas. The basis for savings calculated from a particular measure may vary from year to year to account for:

- Changes in regulations (only measures above the baseline provided by regulations or 'standard' practice are counted)
- Changes to the floor space within each building category (eg transfer of social to private housing or closure of hospital wards)
- Number of contributing measures (to ensure that added values are reasonable)

In assessing the savings allowance is made for some of the practical issues that, in real life conditions, reduce the theoretical savings that could be achieved. These issues include:

- The finding in previous surveys that not all improvements in energy efficiency result in energy savings (eg occupants preferring the 'comfort' of warmer rooms rather than all the potential fuel savings from energy measures being realised)
- Normal standards of installation and maintenance (recognising that many measures will not be installed and maintained in a way that achieves maximum efficiency)
- Normal standards of use and management (recognising that use and management often fail to optimise the potential savings from measures).

The calculation of persistence must start from where the impact assessment assumptions stop eg if the analysis assumes monthly cleaning of filters in a ventilation system then annual cleaning could make the system less efficient and would represent a lack of persistence. Therefore the assumptions underpinning the energy savings estimates must be recorded.

4 Working method

4.1 General approach

The study had a number of phases:

1. Literature review of published information on the persistence of energy savings
2. Investigation of persistence issues related to the measures included in the EEBPP's impact assessment, including numerous contacts with manufacturers, building professionals and researchers
3. An investigation into the persistence of energy savings in one building category – health care
4. Development of a method to account for the lack of persistence, for application to the EEBPP's impact assessment
5. Extension of the study to suggest how the method should be applied to all EEBPP building categories.

4.2 Study of previous work on persistence

A literature review showed that almost all references to persistence in the use of energy and buildings were from North America and related to electricity supply policies. Enquiries about persistence of energy savings from building research organisation in Scandinavia, Australia and Japan drew a blank. When the study was explained to one set of research staff who were preparing and issuing guidance on energy saving, said "well, we wouldn't want to know about that – it would threaten our funding". Subjects related to persistence, such as deterioration in thermal performance, were available from some sources in the UK and abroad.

In the UK the Chartered Institution of Building Services Engineers (CIBSE) has embarked on the updating of its 10-40 year old figures for service life. Reliable data in life expectancies are seen as important supporting information in demonstrating the feasibility of a project and potential cost savings.

4.3 Gathering information on measures

In addition to consulting EEBPP publications and others giving guidance and experience on measures, information was gathered from researchers, managers, manufacturers and others on the practical issues related to testing, installing and operating measures.

4.4 Investigation of persistence in health care buildings

In order to develop a methodology for assessing persistence, one building sector was initially chosen for detailed investigation – NHS-Trust buildings. The study involved:

- A study of the EEBPP package of Good Practice Case Studies and Guides on health care buildings and other relevant published material
- Consultation with the EEBPP health care manager, with the Department of Health and with several consultants working in the health care category
- Consultation with seven NHS Trust energy managers.

The aims were to:

- Find whether the managers had evidence of lack of persistence
- Seek reaction to suggested persistence factors relevant to health care
- Gather information on energy management
- Discover the place and status of energy saving within the sector

4.5 Development of a method to account for lack of persistence

A method was chosen that would provide a means to account for the lack of persistence that could take account of whatever data was available without suggesting unrealistic precision. The method would then allow adjustment of impact assessment savings for previous years, whilst allowing the basis for these adjustments to be seen and for changes to be made as additional data becomes available.

4.6 Extension of the study to all building categories

Following development of a methodology for health care buildings, it was widened to incorporate all 13 building categories and developed in order to provide decay factors for a period of 15 years.

5 Findings related to measures

5.1 Persistence of measures generally

No regular pattern of persistence decay was found – each measure must be considered on its own and often in the context of different building categories. Decay does not occur regularly over time. It may be more rapid at first or speed up towards the end of service life, as happens with swimming pool covers. Commonly, however, decay affects measures at a particular time eg when a building is refurbished or when an energy manager is removed.

5.2 Changing views on persistence in North America

There is a wealth of American material on this subject, which cannot be adequately covered in a few paragraphs. However, a 1992 paper by Edward Vine [1] provides a good starting point. It presents a conceptual framework for analysing persistence of energy savings, summarises the limited experience of what was known, and provides guidance for retrospective and prospective studies, suggesting strategies for both conducting research and developing policies and mechanisms to help ensure the persistence of savings.

In American studies, persistence has a wider meaning than in this study, because the North Americans have been concerned with energy saving programmes where approvals are sought at the design stage and lack of persistence can also occur between the initial approval of a proposal for saving energy and what is actually installed, while this study only looks at persistence in relation to installed measures.

Throughout the 1980s, persistence of energy and demand savings became important to many stakeholders. Resource planners needed to know if the energy saved through energy efficiency programmes was off-setting generating resources. Utility shareholders needed to know if financial incentives based on measured energy savings were continuing. At the time of the Vine paper, persistence of energy savings was probably the single largest, unanswered question in the consideration of 'Demand Side Management'. It was assumed to be relatively constant and most analyses of persistence relied on engineering estimates of measure life. The limited empirical research, at this date, raised questions about the validity of using manufacturer's claims for physical measure lives. To answer the above questions and concerns, researchers have focussed on: exploring evaluation techniques, gathering case data, teasing out relevant influences on persistence, and developing realistic models for everyday use.

The introduction of competition in the USA has shifted areas of interest to parallel those in the UK. International accords such as that at Rio have heightened the importance of being able to accurately include the persistence of energy measures contributing to national CO_2 reduction programmes. Vine identified two dimensions of persistence, which most subsequent papers have taken up: Measure lifetime and operation, and total and net Programme energy and peak demand impacts. These are inter-related in that Programme persistence includes Measure persistence, as well as other factors. This paper was valuable in ascribing equal importance to technology and behaviour. They both affect persistence, they often interact, and they are difficult to separate, particularly behaviourally – dependent measures such as cleaning refrigerator coils and resetting HVAC time clocks, to accommodate occasional unplanned occupancies. As the field has been explored in greater depth so the ideas that simple solutions would be found have receded. For instance, reasons for a lack of persistence were cited by Hicks [2] as not solely about measure failure but related to market factors – remodelling cycles, operational factors and technical degradation.

6 The results of the UK study

6.1 Application of persistence factors to building categories generally

The persistence of measures will vary between building categories. For example, when compact fluorescent lamps are used within housing it is estimated that a large proportion of them will be replaced with tungsten lamps (this is supported by retail sales figures and is probably due to unfavourable customer reaction to the appearance and the-delayed start up of energy efficient lamps). Building categories vary- in three respects:

1. Their construction; eg categories such as offices, with fully glazed facades have more need of shading and cooling than new housing
2. Their management; eg buildings with sophisticated equipment and control systems require management that is capable of optimising their operation
3. The way they are used; eg measures installed in buildings that are in continuous use can produced greater savings than in buildings of the same floor area that are only used occasionally.

Each of these variables must be taken into account when assessing persistence factors for both new and existing buildings.

For some measures refurbishment or change of use is likely to affect persistence because the measures may be removed or made less effective by alteration work or change of usage (eg heating zone controls when the building is differently subdivided, point of use water heaters when sanitary facilities are rearranged, or energy policy when a new firm takes control of the building). It follows that the shorter the period to refurbishment in a particular building category, the greater the likelihood that persistence will decay. In the UK approximately 4% of the total building stock is refurbished each year, although there is a wide variation in the periods of refurbishment even within the same building category.

6.2 Application to health care and other building sectors

Details of application of the methodology to the Health Care sector will be presented at the conference. There is not space for a detailed summary here. However, detailed investigation of and consultation with representatives within this sector enabled a matrix system of standard persistence factors to be developed. These -factors relate the frequency of occurrence of decay in energy saving over time and the severity of the reduction in persistence. One factor is selected for each measure and for each building sector for each year of the EEBPP impact assessment, making 887 persistence factors for 1996/7 alone. These factors have been developed for a period of 15 years, allowing retrospective application to the EEBPP and some forward application in years to come.

7 Conclusions

This study has developed a systematic means of accounting for any potential lack of persistence of EEBPP savings for all 13 building sectors promoted by the programme. The factors consider energy savings post-installation. Therefore future impact assessment of the EEBPP will include the following persistence methodology:

1. A base figure of the energy expected to be used in a typical building of a particular category
2. The potential savings that could be expected from the introduction of measures under ideal conditions

3. The saving that is likely to be achieved in real conditions (based upon 2 but taking account of design, installation, maintenance and use)
4. The annual savings that can be expected when factors related to changes in savings over time are included (including deterioration of products, downgrading of management staff and different uses for part of a building)

We are some way towards this ultimate system, but it must be noted that the lack of data on performance of energy measures over time means that the persistence factors can only be tentative without more research. Nevertheless, we have developed a system which can now be applied to the programme's cumulative savings and start to take account of persistence effects.

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