# Fixed and Customised Benchmarks for Building Energy Performance Certificates based on Operational Ratings

R. Cohen[1], W. Bordass[2] and J. Field[3]

[1] Energy for Sustainable Development, Overmoor, Neston, Wilts SN13 9TZ. robert@esd.co.uk
[2] William Bordass Associates, 10 Princess Road, London NW1 8JJ. BilBordass@aol.com
[3] Target Energy Services, 18 Ravenslea Road, London SW12 8RY, UK. jfield@targ.co.uk

## ABSTRACT

The EPLabel project is developing a 'graduated response' to address the EPBD Article 7.3 requirement for 'Public Buildings' over 1,000 m² to display an Energy Performance Certificate prominently. The idea is that assessments can be at different levels of detail (within a cohesive framework) in order that they can be adaptable to the knowledge available in each country for each building sector and the level of resources an organisation is able to apply. Central to this is a unified scheme for benchmarking Operational Ratings at three progressive levels:

1. Simple (e.g. from statistics)
2. Corrected (for special energy uses)
3. Customised (to take closer account of what the building does).

The Level 1 and 2 benchmarking may well be sufficient for more standard buildings, whilst the Level 3 approach will allow more meaningful and fairer assessments of more complex buildings. Level 3 may first be introduced by sector or sub-sector as voluntary good practice procedures, allowing experience and confidence to be gained before it becomes part of statutory national implementations of Article 7.3.

## KEYWORDS

Operational, energy, certificate, benchmark, public, building.

## BACKGROUND

The EPLabel project addresses the EU Energy Performance of Buildings Directive (EPBD) Article 7.3: the requirement for 'Public Buildings' over 1,000 m² to display an Energy Certificate prominently, OJEC (2003) and is supported by the EC's Intelligent Energy for Europe (EIE) SAVE programme. It started in January 2005 and finishes in early 2007 and involves nineteen countries, ten with full Partners[1]. The project's main technical objective is to develop a methodology for energy benchmarking and certification based on Operational Ratings (actual annual energy consumption). It covers six sectors: Public administration offices, Universities, Schools, Sports facilities, Hospitals and Hotels.

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## A GRADUATED RESPONSE METHOD OF APPROACH

There are five key steps to energy certification based on an Operational Rating:

1. Collect data to calculate the building's Energy Performance Indicator (EPI).
2. Identify appropriate benchmarks with which the EPI can be compared.
3. Compare the EPI with the benchmarks to Grade the building's energy efficiency.
4. Identify cost-effective energy saving measures.
5. Collate all the relevant information onto the energy performance certificate.

Each of these steps can be undertaken with different degrees of rigour. The EPLabel project is developing a 'graduated response' which allows a robust yet pragmatic progressive introduction of EPBD Article 7.3 to suit the knowledge available in each country or region for each building sector and the level of resources an organisation is able to apply. An easy entry level is proposed for cases where detailed information is hard to get or may be less rewarding, whilst more detailed assessment is suggested where the need and scope for improvement is greater, all within a cohesive framework which makes assessments at different levels as mutually consistent as possible.

## ENERGY PERFORMANCE BENCHMARKS FOR BUILDINGS IN USE

What are benchmarks for? There are two fundamental purposes:

1. To identify if a building's energy performance is good, average or poor with respect to other buildings of its type. This is a robust indicator of whether the building should be prioritised for action. For this purpose, **empirical** benchmarks derived from energy statistics for (or analysis of) the stock are applicable.
2. To identify if a building's energy performance matches its potential and if not by how much it might be improved cost effectively. For this purpose, a realistic **model** of the building and its systems is theoretically more applicable[2].

### Empirical Benchmarks

Empirical benchmarks fall into two categories: 1) The conventional type are obtained from bulk statistical data, often corrected for climate. 2) Less common but arguably more insightful are parameterised benchmarks, such as in ECON 19, Action Energy (2003), which set normative standards (Good Practice and Typical) for each energy end-use in the building. The values are derived from detailed studies of typically 20 to 100 buildings per sector involving energy audits and sometimes sub-metering. Parameterised benchmarks can be used as robust fixed benchmarks in place of statistics: ECON 19 has been the de facto benchmarking standard for UK offices since 1990[3]. Furthermore, they lend themselves to being customised to the activities and use of an individual building. However, this does not mean that customised benchmarks for heating and cooling energy reflect the form and fabric of the building; they deliberately are related purely to the area of each activity and its hours of use.

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[2] A rapid, initial benchmark for this purpose would be the energy performance from, say, the two previous years of operation

[3] The use of both parameterised and statistical benchmarks in the UK has created some confusion: people assume the Typical value in ECON 19 is based on the median of bulk statistics (with which - subject to the effects of the building type classification - it has proved to be relatively consistent over 16 years), but misinterpret the ECON 19 Good Practice level as the top (lowest energy) quartile. In fact ECON 19 Good Practice (although verified by case study data from low-energy offices of relatively straightforward designs) is achieved by few buildings (less than 10%) because the criteria apply to all energy end uses and few buildings are Good on all fronts.

### Modelled benchmarks

In theory a model of a building's energy use should be able to imitate reality and enable a forensic examination of any inefficiencies in its operation and the scope for improving its fabric and services. Such models have been under development for three decades and modern computing power does make this prospect tantalisingly close. An Asset Rating assumes a standard external climate, that the building's activities have a standard use, only calculates the energy needed for HVAC, hot water and lighting; and uses standard assumptions for the performance of automatic controls and management, according to the controls that are present. However, especially for the more complicated existing buildings, the information required as input to even a basic Asset Rating model can be difficult and expensive to obtain[4]. Nevertheless, once such a model is built, it is simple to compare the actual building with a notional building ie a customised reference having the same form as the actual building but with different 'U' values or plant efficiencies, and produce a grade.

It is a quantum jump to extend an Asset Rating model to calculate a benchmark for an Operational Rating, as here it must be able to replicate to a satisfactory tolerance the measured energy performance of a building. This 'validated' model must take account of the actual use of the building, the actual indoor environment, the actual external climate, the actual operation and control and represent all energy end uses. If achievable, such a model might be used for benchmarking and to predict the benefits of a package of operational and investment energy saving measures, in an approach akin to that currently recommended by the relevant draft CEN Standard[5].

## EPLABEL'S APPROACH TO BENCHMARKS

Central to the graduated response proposed by EPLabel, Cohen et al (2006), is a unified scheme of empirical benchmarks for Operational Ratings at three progressive levels, along the lines suggested by the Usable Buildings Trust (2005):

1. Simple (e.g. Derived from stock statistics or analysis)
2. Corrected (for special energy uses not included in the simple benchmarks)
3. Customised (to take closer account of what the building does).

The Level 1 and 2 benchmarks may well be sufficient for smaller, simpler and more standard buildings and be adopted in initial statutory implementations of Article 7.3. For more complex buildings, the Level 3 benchmarking approach will be available to allow more meaningful and fairer assessments of a building's energy use and $CO_2$ emissions. Level 3 benchmarking may first be introduced by sector or sub-sector as a voluntary good practice procedure, allowing experience and confidence to be gained before it becomes part of a national system.

### Level 1 Benchmarks for Operational Ratings

Usually, the 'population' of a particular building type is divided into bands containing equal numbers of buildings e.g. many UK publications for benchmarking buildings

[4] Often up to date plans and sections of the building and drawings of the mechanical and electrical plant may not exist.

[5] The validated calculation model is a recommended but not mandatory procedure to assess the energy effectiveness of possible improvement measures in CEN prEN 15203 (2005).

have used quartiles. Performance in the best quartile is often termed Good Practice, and the worst quartile is regarded as Poor. Although statistical benchmarking is practical where good quality bulk data are available, problems include:

- Getting started. Few countries[6] have reliably measured energy data available for more than a very small sample of a sector's building stock.
- Getting the contextual data right, in terms of the classification of the building, its systems and its use, though this is eased where the stock is relatively homogeneous in its purpose and use (e.g. primary schools).
- Data quality: in our experience many records near both ends of the distribution include faulty data. Although lessened by large sample sizes, such problems mean that medians are more robust than quartiles, deciles, or averages.

**Level 2 Benchmarks for Operational Ratings**

In the UK at present, more complex buildings (e.g. a secondary school with a swimming pool) tend to be given different benchmarks from the basic versions. However, while school pools can differ widely in size, there is just one benchmark. The project has therefore introduced the concept of corrected benchmarks to examine such unusual areas and energy end-uses explicitly, and take account of what is actually there. Special energy uses (not included in the benchmark reference) are identified by measurement (e.g. survey or sub-metering) and are usually deducted before making the benchmark comparison. Occasionally, a 'special' may be low in its energy use (e.g. unoccupied space or an unheated store room), requiring a deduction from the benchmark value.

**Level 3 Benchmarks for Operational Ratings**

*Tailored Benchmarks*

William Bordass Associates (2002) developed a "Tailored Benchmarking" (TB) system for offices which could take into account simple schedules of accommodation, servicing systems, occupation and use. The major variables defining the office space are:

- Four types of office area: cellular, open plan, call centre, and dealing room. Each one can be naturally-ventilated, air-conditioned or mixed-mode, have different workstation densities, weekday, Saturday and Sunday occupancy hours, and percentage areas with good daylight.
- Circulation/support space within the net lettable area (NLA) and common parts outside it. These also have selectable HVAC options and daylit percentages.
- Percentage of heating, hot water and humidification (if any) provided by electricity and cooling by chilled water.
- Energy-consuming (and often energy-intensive) areas and items which are often found in offices and can significantly affect the energy consumption (and sometimes the areas). Specific items include:
    - Catering - both central kitchens and local/vending facilities.
    - Computer, communications and file server rooms.
    - Lifts - where the storey height of a given area of building affects its consumption index.

[6] Denmark and Finland are exceptions.

The system is backwardly compatible[7] with the UK's fixed benchmarks for offices in Action Energy (2003). The TB workbook was incorporated directly in the prototype energy certification software for offices developed by EPLabel's forerunner, the Europrosper project, Cohen (2004).

*The Approach in EPLabel*

The customised benchmarking approach implemented in EPLabel software derives directly from the procedure developed by Field and Bordass (2001) to benchmark the energy use in UK sports facilities. The principles of the process are as follows:

1. A building is divided into a schedule of accommodation which comprises a set of up to about ten different activity areas (see examples in Figure 1). A default schedule for each building sub-type provides the user with a starting point for customising the areas to the building being assessed.
2. Each activity area is associated with Good Practice and Typical parametric benchmarks per m² for all the energy end uses needed in that area, with electricity and heating fuel treated separately.
3. Additionally, special energy uses (not included in the parametric benchmarks) can be added. Often these also have Good Practice and Typical benchmarks per unit of their size.
4. The software then simply sums the electricity and heating fuel identified for each end use in each activity area to produce the building's total electricity and fossil fuel (heating) benchmarks.
5. The customised benchmarks are shown graphically, broken down by either energy end use or activity area (see Figure 2).

The parametric benchmarks (in step 2 above) for each energy end-use (e.g. lighting) in each activity area are built up using an energy tree diagram, which goes down to the roots of consumption – separating out the asset (standards and efficiencies), and operational (use, control and management) elements of energy use, as described in Field (2006). Benchmark values can then be reported not just for each energy end use in each activity area, but also, for their components eg lighting W/m²/100 lux, ventilation W/l/s, small power W/workstation or W/m², etc.

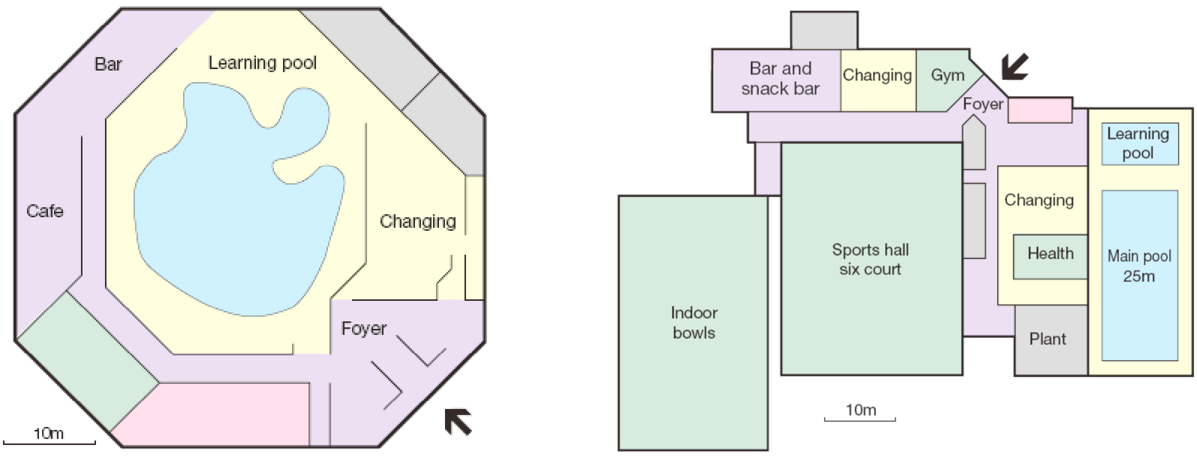
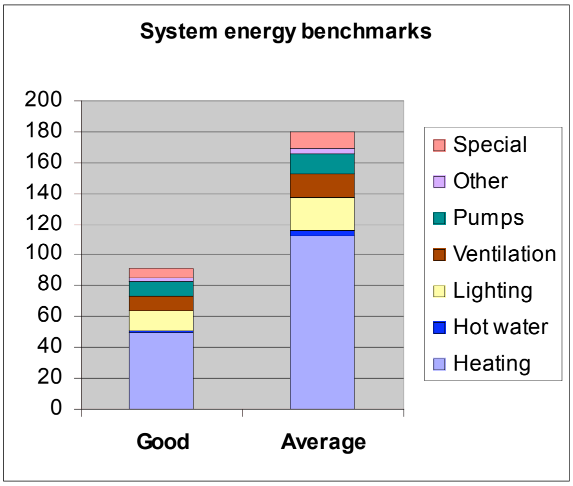



Figure 1 Illustrative graphics of the activity areas in two types of sports facility.

[7] The underlying logic is the same, so insertion of the technical, occupation and use characteristics of say a "Type 3" standard air-conditioned office will generate tailored benchmark values which are very similar to the Type 3 benchmarks published in ECON 19; and not just for each fuel, but for its breakdown into end uses too.



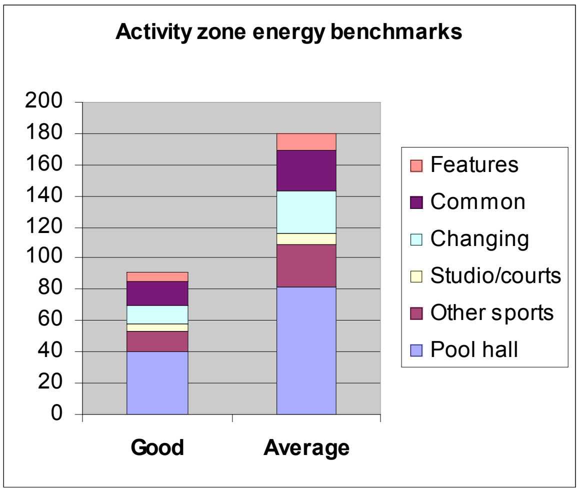




Figure 2 Example customised benchmarks (in kg $CO_2$/m²/yr) split by energy end use and activity area.

The method also allows the energy benchmarks for each activity area to be customised for the intensity and hours of use, where these can be demonstrated to deviate from standard values.

## CONCLUSIONS

The assessment, benchmarking and improvement of the operational energy performance of public buildings over 1,000 m² is the primary objective of EPBD Article 7.3. The EPLabel project's graduated response offers a low cost yet robust procedure for grading a building in relation to its peers in order to identify whether it should be prioritised for energy saving actions. Combined with a standard list of improvement measures for each building type, this process can constitute a pragmatic initial energy certification procedure for a country's stock of public buildings, and does not require energy experts. Identifying cost-effective energy improvement measures for specific buildings does require expertise but this is in short supply in many countries. Whilst technical capacity is being built up, experts should focus their attention on the buildings identified by the proposed assessment and benchmarking procedure to have the greatest potential for improvement.

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