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*It should be taken into  
account that a change  
in a building's  
occupier and/or the  
occupier's activities  
and/or the way the  
building is used is  
likely to change a  
measured energy  
indicator.*

## Measured or operational energy performance of buildings

Procedures for defining measured energy use and operational ratings and for presenting measured energy performance results on building energy certificates.

CEN standards EN 15603 and EN 15217 describe how to assess the overall operational energy use of a building, the calculation of measured energy ratings in terms of primary energy, CO<sub>2</sub> emissions or weightings defined by national energy policy and how the results should be expressed on a building energy certificate.

### 1 > Why measured energy is important

Improving the energy efficiency of the existing building stock, much of which will still be in use in 2050, must be tackled urgently to deal with climate change, energy security and peak oil. In practice, calculations cannot capture the effects of buildings and services which do not behave exactly as designed or the complexities of the occupier's equipment, operation and maintenance regime. Nor can they account for controls that don't work properly or any lack of understanding by users. For non-domestic buildings, calculated ratings can be both expensive to perform and of limited accuracy and insight and report only virtual improvements (which post-occupancy experience reveals are normally optimistic).

Measuring the total energy used by a building over a year is by contrast relatively easy and inexpensive. It accurately quantifies the environmental impacts of the building energy use and it encourages energy management activities which make immediate reductions in energy use and CO<sub>2</sub> emissions.

An energy certificate based on measured energy is particularly appropriate for existing buildings where it must be on permanent and prominent display to the public. Renewal of a measured energy certificate each year is a practical and cost effective method to motivate management, building operators and occupiers to improve their operational performance and to obtain public recognition of these efforts in the next year's certificate.

For organisations with a portfolio of buildings, certificates based on measured energy provide a simple, low cost means to prioritise which buildings should be targeted for more detailed assessment of their energy saving potential.

### 2 > What measured energy assessments provide

Unlike a calculated (asset) rating, a certificate based on measured energy captures the energy use by non-building related items, such as office equipment and electrical appliances, and forces management attention to fall on these, as well as the building itself and the so-called regulated emissions. A measured energy assessment presents a summary of the

overall energy use per unit of useful floor area of a building based on the delivered and exported energy and accounting for energy generated in the building.

The total weighted energy (or its components such as the electricity or fossil fuel use) can be compared with suitable benchmarks to rank the building against its peers and/or to place it in an energy efficiency class defined at the national level, eg A to G.

The assessment should be accompanied by recommended measures for improving the energy efficiency of the building cost effectively.

### 3 > How to assess and report measured energy

Measured data must be adjusted to 365 days, taking account of the weather dependency of energy used for heating and cooling, so there should be a tolerance level imposed for the measurement period. For buildings using more than one energy carrier, there needs to be a synchronicity requirement for the measurement period of each energy carrier ie a minimum number of common days.

The annual energy consumption of a building might include energy used by a special energy use not common in a given category of building and hence not taken into account in the building's benchmark. If this special energy is metered, it can be deducted from the total before making the comparison with the benchmark.

The total overall energy use of the building can be expressed as a single parameter using units of primary energy, carbon dioxide emission or other energy carrier weightings defined by national policy. For buildings with active renewable energy sources, it is recommended to report as a supplementary value the energy that would be used if there were no renewable energy generated within the system boundary. The total energy used by the building systems, including any renewables, defines the building's energy efficiency.

### 4 > Benchmarks for measured energy assessments

A taxonomy of building categories must be developed for the specific purpose of benchmarking measured energy. Ideally energy data would be collected from a statistically significant sample of each building category over a trial year to generate up to date and robust benchmarks. The benchmarks can be further developed to take account of climate, hours of use and the density of occupation: it is not fair to penalise a densely occupied or 24/7 building nor to favour a half empty one or one used for only 10 hours per week.

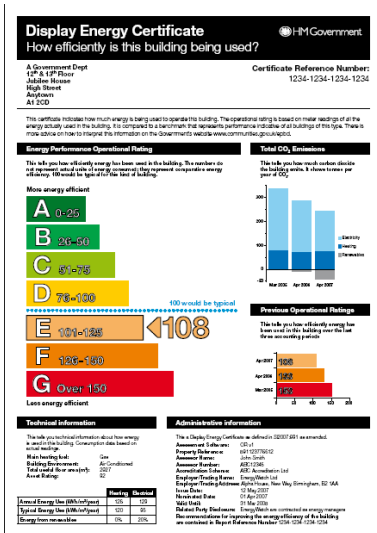
Benchmarks should be expressed in terms of delivered energy used per unit of floor area (kWh/m<sup>2</sup>), separately for electricity and non-electrical energy. The conversion factors for energy weighting are defined separately as the benchmarks are specified in energy terms.

To improve the comparison of the actual energy use with the benchmark, the benchmark can be brought into line with the metered building by adjustments for weather and for occupancy duration, if valid data are available and the occupied hours are greater than the values expected for the benchmark building.

If data on delivered energy to buildings is collected by public authorities (together with heated surface and supplied services, i.e. heating and/or dhw and/or cooling...), a simple statistical analysis will identify the high energy consuming buildings. The highest consumption buildings, for example, the top decile or quartile depending on resources, should be prioritised to receive a detailed energy audit, as they are the most likely to have considerable opportunities for cost effective energy conservation

*Energy certificates based on measured energy can show the following energy performance indicators:*

- > The total weighted energy normalised per unit floor area eg kg CO<sub>2</sub>/m<sup>2</sup>/year
- > A numerical rating as a non-dimensional index relative to a benchmark and/or as an absolute value
- > A class or grade eg on an A to G scale
- > The total use of electricity in kWh/m<sup>2</sup>/year and a rating relative to a benchmark
- > The total fuel and thermal energy use in kWh/m<sup>2</sup>/year and a rating relative to a benchmark
- > The total absolute weighted energy eg tonnes CO<sub>2</sub> per year
- > The energy performance for previous years



Energy certificate based on measured energy use displayed in public buildings in the UK. The headline rating is based on the “energy efficiency of the building”, defined as the ratio of the actual CO2 emissions compared with a benchmark applicable to that building category. The certificate also shows the total CO2 emissions, in tonnes per year, and how the rating and emissions have changed over the last three years.

measures.

5 > Mixed use buildings and multi-building sites

For mixed-use buildings, ie those comprising more than one benchmark category, the whole building’s metered energy consumption should be compared with a whole building benchmark comprised of an average of all the categories weighted by floor area. This is especially useful when buildings include high energy intensity uses such as retail outlets, restaurants or swimming pools.

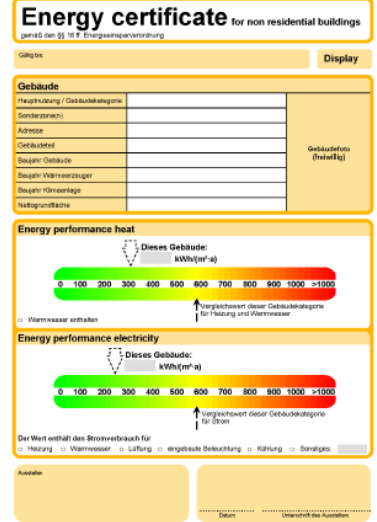
By the same principle, CEN Standard EN 15217 states that an energy certificate can be applied to a group of buildings, served by common energy systems and meters, if no more than one building has an area of more than 1,000 m<sup>2</sup>. Whole-site energy certificates have much merit. The procedure captures the total carbon footprint of the site, aligns the system boundary with the supplier’s energy meters and subjects the whole site to energy efficiency scrutiny. By contrast, a methodology which covers only those buildings over 1,000 m<sup>2</sup>, omits the rest. Furthermore, whole-site energy certificates can be displayed in the public reception areas for the site and give the most meaningful information to the public.

6 > How to improve measured energy performance

Reductions in the energy used by buildings (and the resultant carbon emissions) are possible through fine-tuning and better control, management and maintenance by managers, users and contractors.

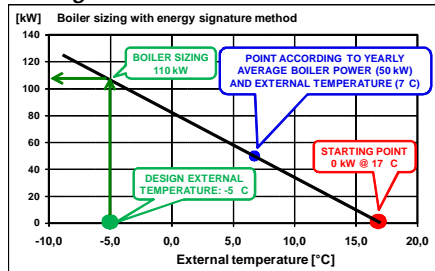
A significant contributor to the poor energy performance of commercial buildings is the relatively devalued role of the building manager, resulting from the often inadequate priority given to it by the building’s owner/agent. The person responsible for a building’s energy efficiency needs enthusiasm, commitment, motivation, charisma and authority to make sure energy efficiency happens. If sustainable operation of buildings is made a critical key performance indicator, and if far greater priority is given in terms of resources, this would turn around operational performance.

In all buildings, but especially simple ones, encouraging energy-wise occupant behaviour is the first step (and reflects the need for the charismatic energy manager). At the same time, energy cost accounting needs to ensure that those making savings see a financial benefit. The next thing to tackle is incorrectly or inefficiently programmed HVAC and lighting controls. Problems are legion: poor commissioning, lack of understanding of design intent, set points adjusted liberally in response to complaints or one-off events and not reset, unmanageable complexity, etc. Sustaining these no- and low-cost measures is also crucial, and reinforced by an annual renewal of the energy certificate. Lastly, a gradual programme of investment in new, more efficient plant, controls and even fabric should be rolled out to deal with inefficient equipment, bad design, unmaintainable plant, poorly located or insufficient sensors, poor zoning, conflicts or self-contradictions in design intent and so on.



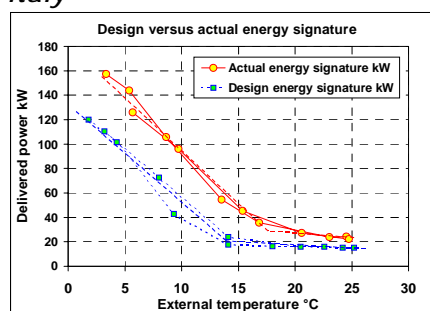
Energy certificate based on measured energy use displayed in public buildings in Germany (partly translated). The certificate shows information on the building, the issuer and separate energy performance indicators for fuel/heat and electricity, together with benchmarks, on a dashboard style scale.

## Application example: sizing the heat generator



The energy signature shown in the main text has been used to size the heat generator. The old generator was 250 kW, the new one is 116 kW.

## Application example: checking the design - 40 flats in northern Italy



The comparison between design energy signature and actual operating data shows that the designed performance has not been reached. At 5 °C the expected power according to design is 95 kW whilst the actual power is 140 kW, that is 40...50% more.

Changes in the energy signature after any energy conservation measure gives visual evidence of their effectiveness (or not).

### CENSE partners:

TNO (NL; coordinator), CSTB (FR), ISSO (NL), Fraunhofer-IBP (DE), DTU (DK), ESD (GB), FAMBSI (FI), EDC (IT)

### Associated partners:

HTA Luzern (CH), BRE (GB), Viessmann (DE), Roulet (CH), JRC IES (EC)

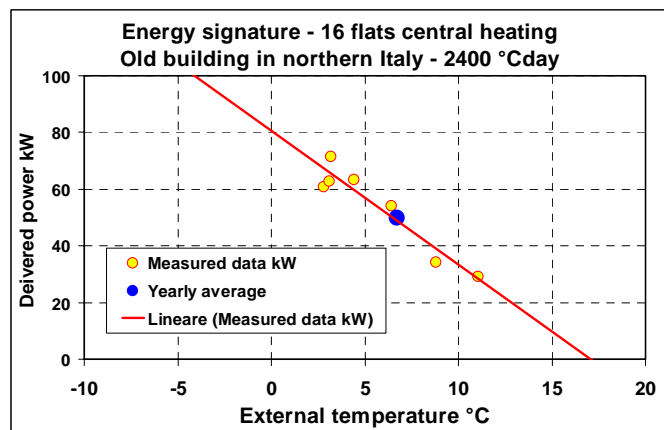
Link: [www.iee-cense.eu](http://www.iee-cense.eu)

Original text language: English

## 7 > A practical tool to report and check measured energy

Annex B of EN 15603 contains a practical tool to help identify the actual energy performance of buildings, separate the influence of weather and help with energy conservation measures follow-up. It is called the energy signature method.

Basically, energy signature is a plot of average delivered power to the building versus average external temperature. An energy signature can easily be produced based on some readings of the energy meters. An example of such a plot is given below.



The input data consists of some readings of the fuel and/or electric energy meters and corresponding actual climatic data. Based upon this technique, several performance metrics can be diagnosed:

- > The generator sizing can be checked by extending the energy signature plot up to the design external temperature;
- > The effect of any operational change, energy conservation measure or alteration of the building and systems can be graphically and quantitatively highlighted;
- > A "design energy signature" can be calculated according to monthly design data. Plotting actual operation points on the design energy signature shows graphically if the design objectives have been reached.

## 8 > References

1. EN 15603 Overall energy use and definition of energy ratings, January 2008
2. EN 15217 Methods for expressing energy performance and for energy certification of buildings, June 2007



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