THE EUROPEAN
GREEN BUILDING PROGRAMME
Benchmarking

Author:
Benke, Georg
Austrian Energy Agency

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1 Introduction

Benchmarking the energy performance of buildings is a good starting point for building owners and operators to develop targets for energy savings measures. Benchmarking also helps to monitor progress and to identify buildings that may need extra effort to reduce energy consumption.
It is simple to produce benchmarks but it is not so simple, however, to use them in a correct way. Be prepared for the fact that there will always be a discussion on the correctness of figures. Maybe there will never be one correct answer.
There are numerous tools and methods for benchmarking the energy use of buildings. Currently, there is no common benchmark systems available in Europe. But within the GreenBuilding project there should be a common understanding of the use of benchmarks.
This guideline describes issues related to the benchmarking of the energy consumption of non residential buildings and it gives guidance for an appropriate use of benchmark systems.

2 Background

Usually, energy performance benchmarking is the comparison of the energy consumption of a certain building and a set of similar buildings. It provides a useful starting point for individual energy audits and to single out buildings for energy-saving measures in multiple-site audits.
In some cases it might be of interest to compare only parts of the energy consumption, i.e. just parts of the infrastructure like lighting, AC-systems or ventilation.
Benchmarking is of interest and practical use to a number of experts. Energy service companies (ESCOs) and energy performance contractors use “typical” and “best-practice” benchmarks for the communication of energy saving potentials while energy providers directly can track the energy use and combined data from building complexes. Benchmarking is also useful for the design of a new buildings or for retrofit projects as it helps to find the solution with the best energy performance. Energy managers and building owners are increasingly interested in benchmarking. Large companies, schools, and government institutions with a large number of buildings they have to manage also use benchmarking methods to compare their buildings to each other.

3 The art of benchmarking

The results of a benchmarking analysis may help to identify buildings with a poor energy performance, but interpreting the data can be the real challenge. There are a lot of factors that affect the use of energy in buildings, including occupancy, fuel choices, energy-using equipment, climate conditions and building design. Comparing buildings only by electricity intensity (annual kWh per sqm) can make some buildings appear more efficient than they in fact are. Just an example: An office building with lots of vacant offices will show a low energy intensity, but that does not mean it is efficient.
Ideally, benchmarking data can be evaluated using four factors that you can’t be influenced and other factors that are variable — such as occupancy behaviours, operating hours, existing equipment and the use of the equipment. The

comprehensive assessment of the impact of all these factors requires an in-depth analysis. Once an initial benchmarking analysis is done, a facility manager might decide to invest in an audit and some temporary data loggers to further investigate and monitor a building. If such a data logger isn't in place already, adding an meter, which measure the consumption every 15 minutes (or even less) will give you an important data source for benchmarking the energy performance at several points of times.

3.1 Selecting an appropriate measure

Comparing buildings based on annual energy expenditures (annual energy costs/sqm) is useful if the energy prices for those facilities are the same. It is advisable to benchmark the energy consumption like kWh/sqm, to remove the distorting that comes from varying fuel prices and energy rate systems.
Relating the energy consumption of buildings to their floor area (sqm) provides an energy intensity measure that allows the comparison of buildings of different sizes. But floor area is also a source of error in the calculations as it is frequently declared in a wrong way.
There are different ways of defining floor area and there are inconsistencies in the way it is calculated. It is important that your definition of floor area is consistent within the comparison (benchmark) data. There are different kinds of declared areas and the mode it is calculated can influence the result significantly. It should be clear to all partners, which definition of floor area is used. The difference of different solutions can be up to 20 % and even more.

- gross floor area
- rented floor area
- net floor area
- heated floor area
- ……

But it is not only the kind of floor area definition that is used. For example, the area for parking sometimes is included in the calculation of floor area and sometimes it is not.

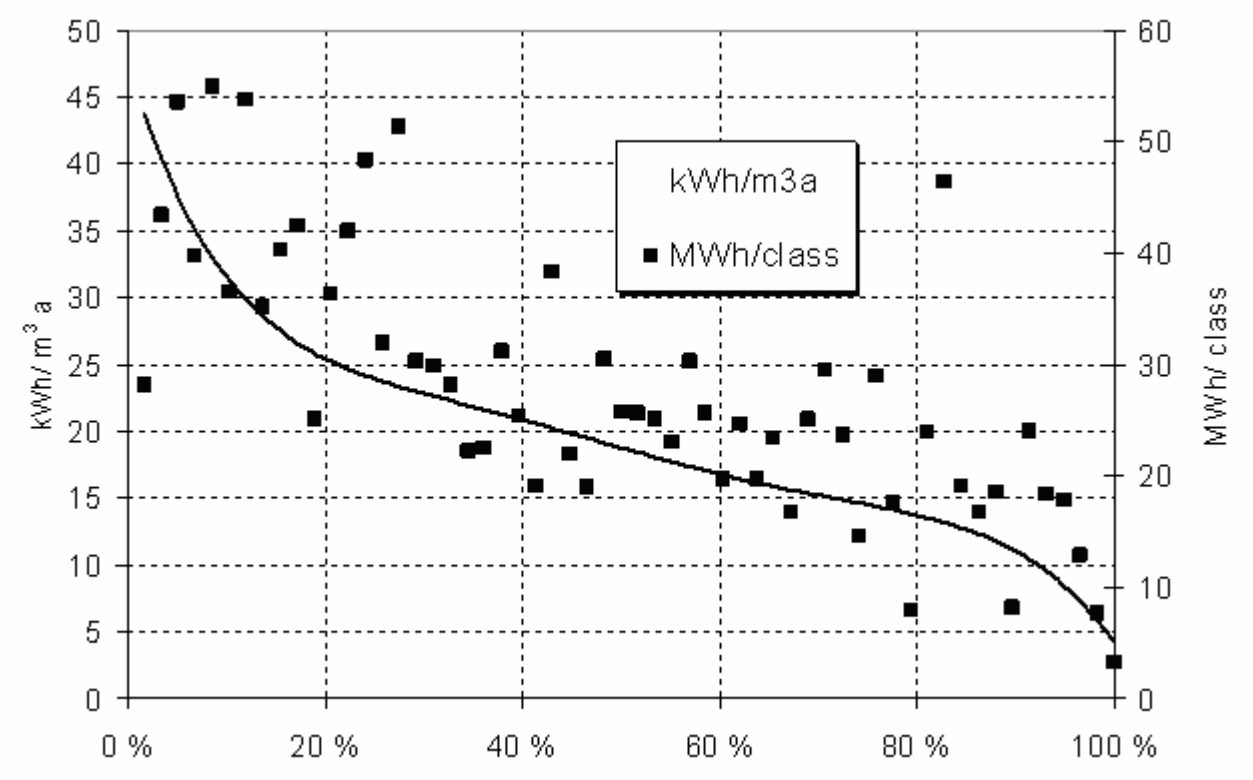
Additionally, energy intensity also can be calculated on the basis of variables like:

- number of overnight stays (hotel)
- number of student (school)
- number and size of classrooms (school)
- number of employees (company)
- production of goods (company)
- surface of swimming pools (swimming hall)

It is recommended not to focus on only one relevant figure like floor area or number of employees. Using multiple kinds of benchmarks can produce different results.
EXAMPLE: About 100 grammar schools in Vienna (Austria) were compared according to their heat energy consumption. Energy consumption per unit gross volume (kWh/cum) and energy consumption per class rooms (MWh/class) were calculated. Both measures showed different results. The graph below shows that more than 40 % of these schools need more than 21 kWh/cum per year (line). One

school, however, which is one of the best 20 % compared by kWh/m3 has one of the highest energy consumption level per class (black dots). If only the energy consumption per gross volume would have been used, nobody would have realized that there is also a very high energy consumption (and maybe energy saving potential, too) according to the number of classes.

Graph: Benchmarks of different Viennese Grammar Schools: Different kinds of benchmarks lead to different results



3.2 Energy consumption data

In most cases data only are available for final energy consumption – like electricity or gas – for the whole building are available. Energy data can be provided by meters or by energy bills.

Hence, in many cases you can start with two energy benchmarks: one for electricity and one for heat. It does not make any sense to add these two kinds of energy. The only meaningful way would be to add the energy cost to one figure and to make an energy cost benchmark (EURO/sqm).

3.3 Time period

It is of high importance that benchmark are made for a similar period of time. Usually, this will be one year. If the energy consumption is available for a longer or a shorter period than one year only, figures have to be corrected. You should take care, if the time period with missing consumption data is winter or summer. If information is missing from summer, usually less energy per day should be added than the average daily energy consumption from the period where data are available.

However, it also makes sense to compare data on energy consumption per month or even per week. In Norway, there exists quite a lot of experience working with weekly benchmarks. In this case, it is possible to compare the energy consumption per week of a single building.

In Austria, it is recommends to calculate benchmarks from January on and from July on. This is a very simple solution to get information about the annual trend of the energy consumption of a building. These kinds of benchmarks help to see the different levels of energy consumption of a building during the year.

3.4 Climate conditions

To compare the energy consumption with other buildings it is necessary to consider the climate conditions. Temperature can be different year to year and this is why the annual energy consumption can be different too.
In the case of data corrections due to different climate conditions the relation of energy used for heating to energy used for hot water is of big importance as energy for hot water is not influenced by the climate conditions. Usually, this quantity is not considered when calculating the heat energy demand.
The California Energy Commission divides California into sixteen climate zones. As CEUS contains zip codes, these can easily be linked to climate zones. Depending on the sample size in each climate zone, it may be necessary to group these into four or five larger zones.

4 How to use benchmarks

If you have produced different benchmarks about your building, you always should have in mind that:

a) The size of the benchmarks does not give any information, if the energy consumption in the building can be reduced. The benchmark is one starting point to think about the fact why buildings consume more or less energy compared to another time period or compared to other (similar) buildings.
b) Due to high differences in the use of buildings, even buildings with the highest benchmark the energy management can have an optimal energy performance.
c) Be aware to compare the same figures. Do the energy costs include VAT, what kind of relevant figures are used (kind of floor are etc.)?
d) Maybe another relevant figure can produce better information.
e) The benchmark may depend on the type of heating system installed. If the building is supplied with district heating, the transformation losses are less compared to a central heating system.

It is recommended to aim at a reduction of energy intensity 20 to 30 per cent below the average value. A cautionary note: the reduction of energy consumption does not always go hand in hand with lower expenditures. The result highly depends on the fuel type used and the equipment installed. When natural gas is cheap gas-burning equipment can be cheaper than electric alternatives even though the gas technology may use more energy. For example, stovetop gas burners in a restaurant kitchen

produce more heat losses than electric burners but they may have less operating costs.

5 Existing Tools

In recent years, several benchmarking tools emerged on the market. Some of them were developed by energy providers or ESCOs as a service for customers. There are also a number of online tools, many of them are available free.

The following list should give an overview about existing tools:

5.1 UK

In Great Britain studies were conducted according Best Practise and Benchnmark in Buildings.

A simple-to-use online tool allowing energy managers to calculate the energy performance of a building periodically, such as once a year, and compare it against benchmarks for similar buildings within the Government's Estate of UK.
Useful information about energy efficient measurements is available on this webpage, too.

http://www.thecarbontrust.co.uk/energy/pages/page_66.asp

5.2 Germany:

In Germany during the last years a Benchmark system was established for the hospital sector. This service is offered by a technical office, but is very successful and is becoming common in hospital sector[1].

5.3 Norway:

The Norway building sector is using a well developed benchmark system within the national program building network. In Norway a group of building owners cooperate in a team and compare the energy consumption of their buildings on weekly base. Heat and electricity are added to one energy figure.

5.4 Australia:

http://www.abgr.com.au/new/default.asp
The Australian Building Greenhouse Rating (ABGR) Scheme is an initiative to help building owners and tenants across Australia benchmark their greenhouse performance. A simple version.- which can be downloaded, too – needs only less than 10 data to make a first performance report. On the website of the ABGR there is a lot of information about energy efficiency measurements available. Also you will find a list of buildings rated between 1 and 5 stars.

[1] See: Rainer Tippkötter: Rationelle Energienutzung in Krankenhäusern/ October 2003, ISBN 3-528-057871-4; Vieweg Verlag

5.5 USA

Energy Star

The Energy Star Portfolio Manager software (available free at www.energystar.gov=> https://www.energystar.gov/istar/pmpam/) can be used to analyze the Office Buildings, Grocery, Education (primary and secondary schools), Hotel, and Hospital sectors. Ranking systems for more building types are being developed, including convenience stores, warehouses, and healthcare buildings. It is necessary to log in. This free tool is built around CBECS data, and it can show you where you stand relative to the demonstrated energy performance of existing buildings in the States during the past several years. By entering your building information, you can compare performance with similar

Further information about Benchmarking

US/Canada

- Arch http://poet.lbl.gov/arch/ -- Building benchmarking tool based on CBECS data
- Cal-Arch -- California version of above utilizing CEUS data
- CBECS -- Commercial Buildings Energy Consumption Survey, from the US DOE Energy Information Administration
- Compare-IT -- Commercial load profiling tool by RLW Analytics. See also Shape-IT.
- CustomNet -- Benchmarking tool for PG&E business customers
- e.Review -- Online comparisons and energy efficiency information from BC Hydro (Canada)
- EMCOR Energy Edge -- Services include free online benchmarking tool
- Energy Profiler Online -- Integrated commercial services for large organizations including benchmarking from ABB Energy Interactive.
- EPA Energy Star Label for Buildings -- Environmental Protection Agency benchmarking and labeling program
- Labs21 -- Laboratory benchmarking project at LBNL
- LEED -- Green Building Rating System for Existing Buildings, from US Green Buildings Council
- One-2-Five -- Commercial energy benchmarking tool by Energetics/EnVinta
- Oak Ridge benchmarking tools -- by Oak Ridge National Laboratory. Includes customizable spreadsheets, special tools for Iowa, Colorado, & Florida schools.
- SiliconEnergy -- Integrated commercial services for large organizations including benchmarking.
- SitePro -- Commercial load profiling tool by Regional Economic Research (RER).
- SnoPUD benchmarking -- Online tool is free for everyone, but zip code must be within Snohomish PUD service territory.
- Utiligraph -- Take tour of benchmarking tool for customers of Tacoma Utilities.

Asia/Pacific

- Asia/Pacific Energy Study -- Asia/Pacific commercial and industrial benchmarking
- e-Energy -- Online benchmarking tools from the National University of Singapore
- Energy and Technical Service -- New Zealand benchmarking project to develop a benchmarking database.
- Steps to benchmark energy use -- Guidelines and evaluation tool from the Australian government. See also Australian Greenhouse Rating Scheme.

Europe

- Energy Benchmarking at Company Level -- Austrian Energy Agency (EVA)
- Higher Education Sector -- Publications and energy management benchmarking software for higher education institutions in the UK
- Target Energy Services -- British firm supplying free energy benchmarking tool.