CEN-CE
CEN EPB Standards Certified Experts

New EPB standards and system design

CEN-CE scheme is not only yet another collection of lessons on energy performance calculation standards. It aims at giving professionals full control of the topic and to leverage the information provided by the energy performance to improve sizing and optimisation of buildings and technical systems. The innovative approach is the integration of sizing and energy performance calculation methods.

Keywords: EPBD, CEN, standards, sizing, design

LAURENT SOCAL
Consultant
socal@iol.it

Sizing versus energy performance calculation

The design activity always includes the "sizing", that is determining the size of the components and appliances that need to be installed to fulfil the design objectives.

Sizing is based on the expected worst-case conditions and the criteria is "the system must make it". Fearing a fail, a lot of safety factors are introduced whilst potential favourable factors are ignored, all figures are rounded-up and finally the available commercial sizes of components are a limited number and you round-up again. For a pipe you have the choice in the list of the available DNs, if it is a radiator you select the number of elements. The consequence is that installations are oversized.

Another design phase, which is not always done, is checking how the selected (sized) components behave in everyday operating conditions. This should be done anyway because there are two risks, especially with HVAC systems:

- as a consequence of the sizing phase, components and appliances are selected for an operating condition (the maximum expected load) which will seldom occur, if ever; so they nearly always operate in a condition which was not the base for their selection!
- part load operation is an issue for most appliances and components.

CEN-CE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 785018. The sole responsibility for the content of this project lies with the authors. It does not necessarily reflect the opinion of the European Commission.

The heat load calculation is the first task in the design of HVAC systems which has been standardised and subjected to regulatory requirements. This happened about half a century ago in Europe (years 1970…1980). At that time the goal was to size the emitters and the heat generator (a boiler) so that the building would be kept warm even in the coldest days. Energy conservation was not a primary issue.

In the years 1990…2000, several European countries introduced regulatory requirements on the energy performance for heating. This required an energy performance calculation, that is the evaluation of the performance in the average operating conditions along a reference season. In the last decade this has been extended to all the comfort services covered by EPBD and it becomes more and more challenging to take into account all the interactions between building envelope and systems and the effect of controls in the context of well insulated buildings (in practice, "NZEBs" are well insulated buildings where we pretend all comfort services using little resources…).

A first consequence and the new burden, is that the energy performance is now part of the design objectives: calculating the energy performance is a design tool. It is not enough to size components; you have to verify that the designed building and systems will operate efficiently. You might have to correct your design because you don't meet the performance requirements, even if the sizing looks correct.

A second consequence is that the energy performance calculation should be performed at the same time of the sizing calculation. Using the same input data would give the advantage of describing only once the building and get both results. This is (nearly) already the case for heating where it is easy to calculate the heat load and the energy needs with the same description of the building envelope, e.g. surface and U-value of building elements, length and linear transmittance of thermal bridges, etc.

In the meanwhile, technology progressed and a more accurate sizing is required. Sizing some radiators and a boiler is an easy task. Sizing a heat pump or optimising the sizing of emitters for a condensing boiler is more demanding.

The progresses in energy performance calculation methods is bringing-up a great opportunity: the energy performance calculation can provide very useful information for the accurate sizing of components and appliances. The new EN-EPB standards did big steps and provide a lot of new opportunities in that sense.

These concepts and context explain two basic choices of the CEN-CE training scheme.

Of course, CEN-CE scheme is based on EN-EPB because they are European. CEN EPB standards are also the most advanced concerning the opportunities to link energy performance calculation and sizing. Even if now they are explicitly used only in few countries, several others are close and this is the natural convergence point with time and the concepts.

Another choice is not to limit the teaching to the bare understanding of the standard. Each module includes:

- the underlying fundamentals of the topic covered, which are universal and essential to understand properly what is covered by the standard, how it is covered and the limitations as well;
- of course, the detailed description and analysis of the corresponding standard;
- application examples, that cover optimisation of energy performance calculation but also applications to design and sizing.

These choices allow trainees to get the most to support their everyday design work with a energy performance calculation standards, not only for energy performance itself but also to support sizing and optimisation activities. Even if trainees are working with similar national standards, they will still benefit of the acquired knowledge.

In the following you will find a few examples of the potential use of the energy performance calculation according to EN-EPB standards to assist sizing and optimisation of technical systems. Some features are still potential developments but they are already worth mentioning, indeed.

Heat load or energy performance for sizing?

The first example is about heat load. It has been successfully used to size emitters and boilers since decades. However, it is well known that the heat load brings a lot of oversizing because heat gains are neglected, the ventilation rate is assumed to be the maximum, etc.

If sizing heat emitters, some oversizing is no harm if there is a good room temperature control system. It could be even beneficial if it is identified and exploited by reducing the operating temperatures.

If sizing a condensing boiler, a slight oversizing will force a modulating boiler to operate at reduced power, which is again beneficial for efficiency.

If sizing a heat pump, there are several reasons to avoid oversizing:

- the specific initial cost of the heat pump in €/kW, which is about 3…5 times higher than that of a boiler;
- high power electric connections are more demanding than equivalent gas connections;
- for air source heat pumps, when the external temperature is reduced, the load decreases and the available maximum power increases, therefore the load factor falls quickly to very small values and efficiency drops.

Presenting the results of energy need calculation as a design energy signature, as suggested by EN ISO 52016-1 and discussed in the CEN-CE module about measured energy performance, provides a graphic evidence of the right sizing of the heat pump, as shown in **Figure 1**.

For this building, the heat load is 8.8 kW at –5°C. The design energy signature (red line) is based on the daily aggregation (blue dots) of hourly needs and shows that the design condition is 5.2 kW at –2.6°C. A correctly sized air to water heat pump would have the power output shown with the green line, that is less than 5 kW at –5°C. The oversizing using the heat load is about 80%. This is not relevant if the smallest available boiler has a power of 15 kW, it is indeed when selecting a heat pump. The reason for that big difference is that the heat load ignores heat gains and ventilation losses are evaluated with the maximum flow rate. An optional correction of the heat load according to gains has been introduced in EN 12831 as well but it is not supported by a specific calculation.

Of course, such a tight sizing implies communication with the customer who has to be instructed on how to use correctly the building, that is never turn off the heating during the colder months and do not open the windows if you have a mechanical ventilation! Not to speak about the correct insulation of the building.

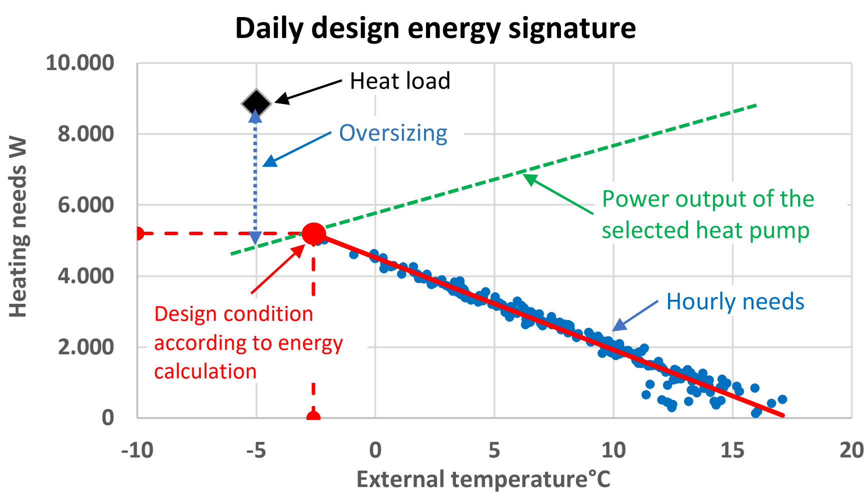

Figure 1. Relationship between heat load and energy performance-based sizing.

Domestic hot water power versus storage volume

The challenge when sizing a domestic hot water system is the correct balance between the power of the domestic water heater (heat generator and/or heat exchanger) and the volume of the store. This can range from highest power with no storage volume (instantaneous systems, that is 24 kW for a single shower) to minimum power and very large volume (accumulation systems, that is 300…400 W average power per average building unit) and there is plenty of intermediate solutions. This sizing is usually based on empirical correlations and/or rules of thumb.

EN 12831-3 standard includes a specific simulation method to test the reaction of a defined configuration (available power, storage volume, control strategy) under a design load profile.

The hourly method defined in EN 15316-5 can be used on a shorter time-interval for the same purpose and with similar results. The advantage of the latter is that it natively includes consideration of any simultaneous heating need and the description of the storage is the same for sizing and energy calculation.

Concerning domestic hot water, this is half the story. The second half is providing representative design load profiles.

Thermal solar and storage

EN 15316-4-3:2007 only had a monthly method based on components data. Being monthly, it couldn't capture issues like storage overheating and system lock-down. This implied the hidden assumption that the system always worked fine. Additionally, the fundamental equation is a correlation derived for extensive simulations on a representative configuration. This made the method suitable for most energy performance calculation but useless for the sizing of components or to check special configurations.

The new EN 15316-4-3:2016 contains an hourly calculation method coupled with the hourly calculation of the connected storage. CEN-CE team added some custom development, that is part of the training, that enables to identify the overheating of the solar circuit and take into account possible issues due to insufficient storage volume, oversized systems, wrong settings or low use. The result is that the same calculation method can be used both for improved energy performance calculation and to check the sizing of the system. An example of identifying an overheating condition (e.g. insufficient storage volume and/or oversized collectors) is given in **Figure 2** which shows the results for three days of hourly calculation of a solar collector loop. In the first day on the left, the solar radiation is low (cloudy day) and the collector loop is working. In the next two day after seven hours

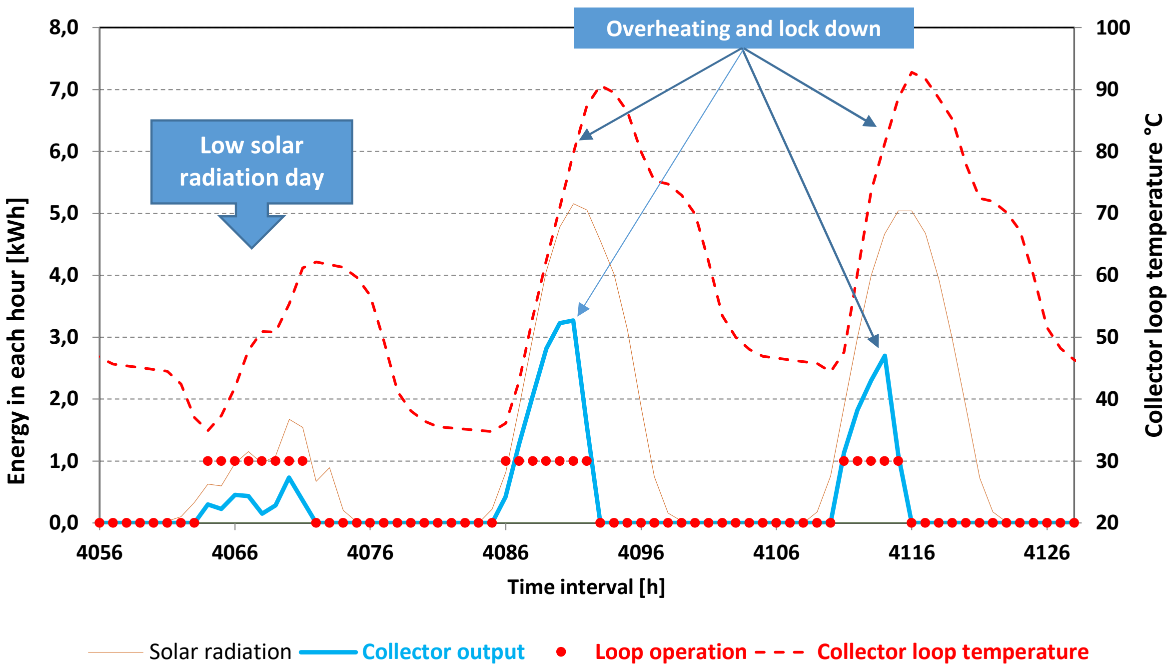

Figure 2. Identifying overheating and lock-down of collector loop.

of operation, the collector loop locks down. On the third day, the collector loop locks-down after three hours because the store was hotter (previous day complete heating). Data on back-up energy use will then indicate if the issue is low storage volume or collectors oversizing.

Operating temperature calculation

The efficiency of condensing boilers and heat pumps depends on the operating temperatures, return temperature to the boiler for the condensing boiler, flow temperature for the heat pump. In turn, these temperatures depend on the sizing of the emitters, on the type of hydraulic connection and on the control options. The general module for heating systems, EN 15316-1:2017, includes a systematic approach to calculate the operating temperature in all sections of the heating and domestic hot water system.

This allows one step further the basic design, which would use the heat load to determine the size of emitters. You may now check, based on the actual heating power that will be required in each calculation interval, the operating temperature and the efficiency of the heat generator. So, the design of emitters can be based on the desired maximum temperature of the heating fluid. **Figure 3** shows the result of such an approach.

The emitters are radiators and they have been sized so that the flow temperature will never exceed 45°C because the generator is a heat pump. The calculation shows that the return temperature to the generator is higher than the return temperature of emitters and distribution system because the flow rate in the generator is higher than in the distribution. This is no harm for a heat pump, it is for a condensing boiler, indeed.

This information comes from the energy performance calculation and is quite useful for the design.

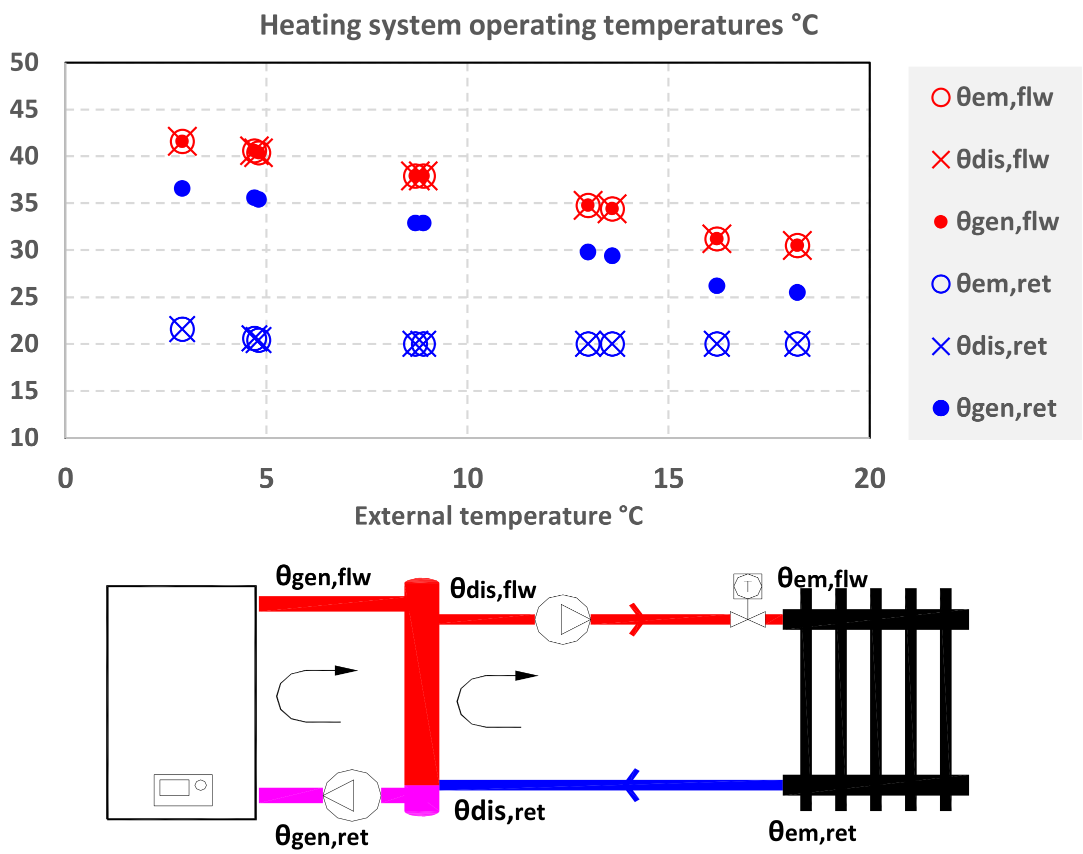

Figure 3. Operating temperatures of a heating system as a function of external temperature.

Cooling

Dynamics cannot be ignored when dealing with cooling in the mild European climate. It is common practice to use tabulated time series distributions of gains to determine the cooling load. This is effective but necessarily based on a limited number of precalculated time series. To be on the safe side, oversizing cannot be avoided.

EN 52016 allows a dynamic calculation which is specific for the building configuration and use, which may lead to less oversizing. Also, the test profile is not limited by the assumption of repeating the same cycle every 24 hours. A typical weekly profile can be used to include into the design analysis the recovery after a step-back in the week-end.

Again, the advantage of using EN ISO 52016 for the calculation of the cooling load is that this the same description of the building used for the energy performance calculation, both heating and cooling.

Ventilation and air conditioning

Sizing a ventilation and AIRCO system is everyday work. Introducing energy efficiency features and functions (free cooling, VAV, etc.) is more and more common practice.

However, very seldom the energy performance of the ventilation and air-conditioning system is investigated under all operating conditions. Some examples for that.

It is common practice to size the ventilation flow rate, the ducts, etc. Then a heat exchanger is installed to recover heat and maybe a by-pass for free cooling operation, which are both energy conservation measures. It is recent practice to evaluate how much energy will be saved by the heat exchanger, how much energy will be used by the fans to achieve that and the energy calculation method is still very rough. Trying to calculate how much energy is saved by the free-cooling depending on the control strategy is not that common.

In the Mediterranean climate in summer you may need more dehumidification than sensible cooling. You install AHUs with dehumidification function and then you may have fan-coils that can also contribute to dehumidification. The consequence is that you may have several control options. It is far from common calculating the behaviour of the whole, which has to be handled hourly.

The new EN-EPB package of standards has been designed natively to support hourly calculations. This allows to perform a representative calculation of the behaviour of technical systems. The calculation can be easily extended to design conditions for sizing purpose, you just need to define a "sizing profile" and run it (it could be a "design week") to be able to check if the system will made it and the load factor during the peak. You can do both a reasonable sizing and the energy performance calculation for legal purpose using the same description of the building, and this is good news.

Of course, there are more advanced modelling and simulation tools that are already used for research purpose and to solve special issues on important buildings. The real progress is when a technology is available to everybody and used. EN-EPB standards can bring the hourly calculation of all EPB services into the daily routine and make use of the same description of the building for sizing, energy performance calculation and compliance check, all in one.

It's an opportunity worth considering.

Conclusion

EN-EPB standards calculation methods cover both the building envelope and technical systems using the monthly or the hourly method. The energy performance calculation also provides a lot of information for the sizing. The nice thing is that it does not require an extra input effort: the amount of data is the same for the hourly and monthly approach and the most time-consuming task is describing the building envelope. You just need to avoid doing the same mistake as people reading a quotation: they go directly to the last figure at the bottom of the last page. The energy performance is the last figure at the bottom of the last page of an energy performance calculation report: there is a whole world of information inside. Don't miss it.

The CEN-CE training scheme is based on EN standards, it is not just a training scheme on these specific standards. CEN-CE scheme is designed to enable professionals to fully leverage the amazing amount of information that can be extracted from the energy performance calculation. That's why fundamentals and sizing and optimisation application were included in the course contents. ■