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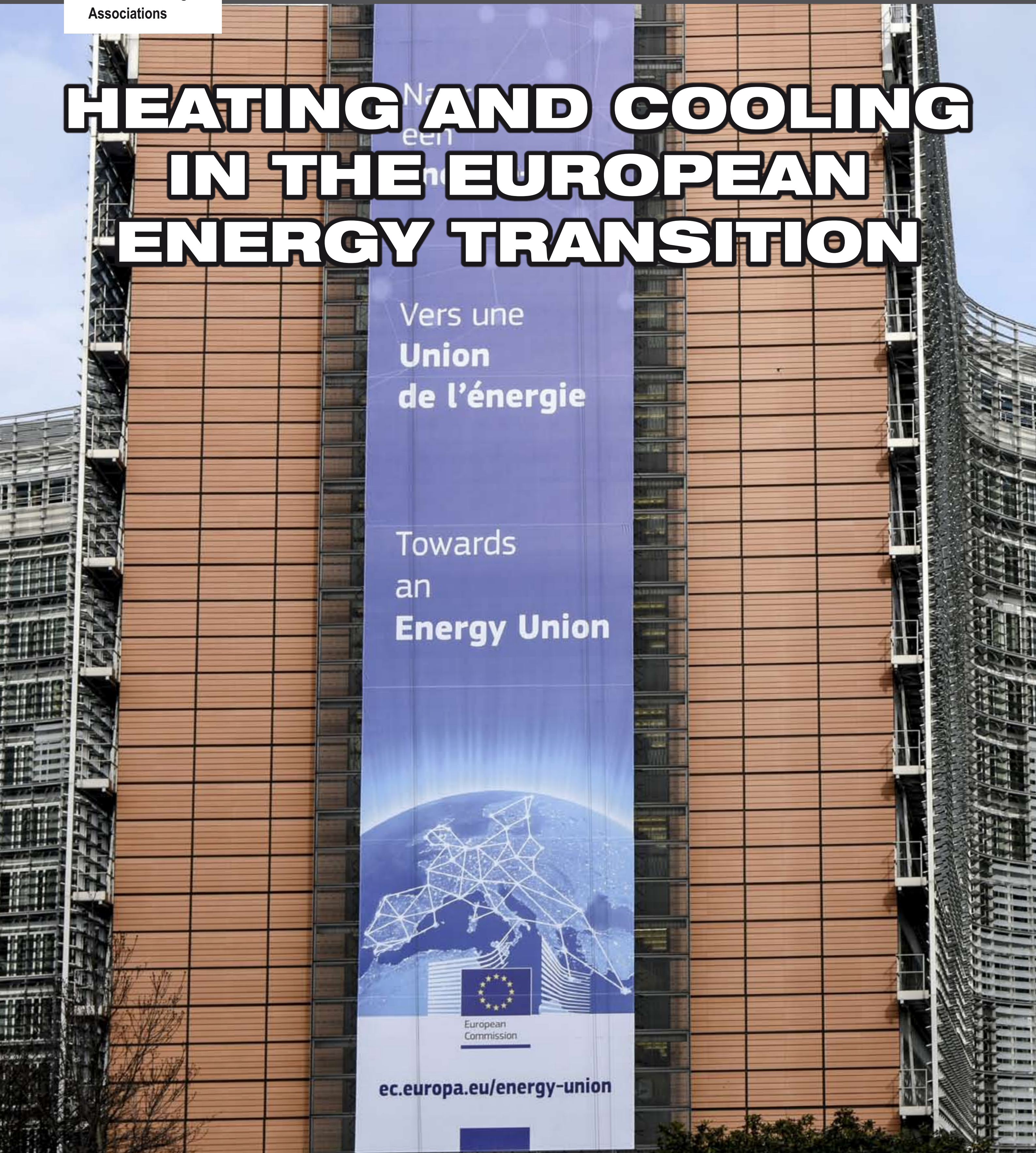
HEATING AND COOLING IN THE EUROPEAN ENERGY TRANSITION



Articles

Comparison between Energy Performance Directive related CEN-standards, EU Member States legislation and actual residential buildings consumption

Keywords: Heating systems, CEN standards, Energy performance, Calculation methods, DHW, Building monitoring.

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Abstract

Since the introduction of the EPBD (Energy Performance in Buildings Directive) in Europe, member states (MS) have developed a great deal of codes, procedures, rules and software tools. The European Union (EU) devotes many resources to harmonizing all these codes among MS, such as the Concerted Action (CA) and the CEN (European Committee for Standardization) standards. However, few countries follow the complete CEN standards and there is uncertainty about the current situation. This paper compares, through a practical case, the CEN standards with codes created in Spain on the basis of a measured building. The conclusion is that at least in the Spanish case there is a mismatch with CEN, regarding the losses in the HVAC distribution sub-systems, which should be fixed. Finally, the results presented can be useful for other countries which are trying to implement similar codes to improve their energy efficiency in the building sector.

In 2003 the European Commission (EC) issued a Directive, 2002/91/EC [8]. On 19 May 2010, a recast of the Energy Performance of Buildings Directive [9] was adopted by the European Parliament and the Council of the European Union in order to strengthen the energy performance requirements and to clarify and streamline some of the provisions from the 2002 Directive it recasts.

The objective of this directive is to promote the improvement of the energy performance of buildings within the community, taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness. For new and existing buildings this requires a calculation of the energy performance of the building including heating, ventilation, cooling and lighting systems, based on primary energy. Each building must have an energy certificate and regular inspections of heating, cooling and ventilation systems must be performed. This directive required all member countries to implement the directive in the building codes at the national level by January 2006. Until now this has only been implemented fully in a small number of countries and partially in some others.

As the November 2008 Commission Communication for the original proposal states, buildings have significant untapped potential for cost effective energy savings "which, if realized, would mean that in 2020 the EU will consume 11% less final energy." The question arises as to whether this goal is actually achievable.

This paper analyses or more precisely investigates the extent to which the MS codes and procedures adhere to the new European CEN standards related to EPBD and MS by using the case of Spain as an example. It is our hope that the conclusions will be extrapolated to other MS.

In the past, the CEN norms related to EPBD began to appear. Some authors (Bjarne et al. [10]) obtained results from the published CEN drafts. This article extends widely their results since the calculations are done with the definitive version of CEN and the results are compared with real consumption.

The building energy demand and consumption is estimated by the Spanish software tools and by the CEN standards. Furthermore, both are compared with measured values from one real building made up of two blocks which share a common heating facility.

The interest in establishing the comparison is threefold:

- On the one hand, the goal is to determine if the results from the energy certification scheme are of some utility to the user.
- On the other hand, when inspecting or auditing a building, the expert needs to know beforehand the order of magnitude of the HVAC systems seasonal efficiency and its decomposition into the generation, distribution, emission and control sub-systems. By comparing those with measured values the expert is allowed to issue a report including the advice about improvements.
- Lastly, could it be stated that the effort employed by the expert in issuing an energy certificate and the building model created in the official software tool can be used safely in bi-lateral contracts between energy service companies and state owners, in order to ensure energy savings?

CEN- standards

The European Commission has given CEN the responsibility of developing standards to support the MS to implement the EPBD directive.

The computation of a building's energy efficiency is based on the building and its surrounding characteristics and on the technical systems installed to provide heating, cooling, lighting, ventilation and domestic hot water, services.

This paper focuses on heating and domestic hot water (DHW). The input data is the heating energy demand for the winter period and the DHW energy needs obtained using the Spanish official calculation tool named LIDER [1].

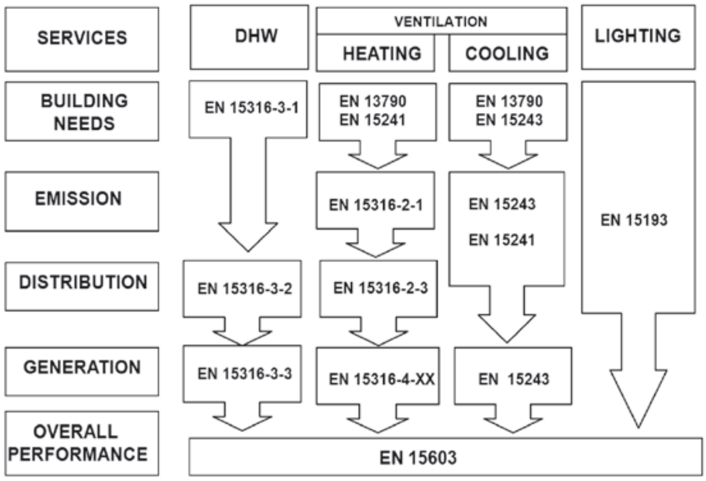


Figure 1. General system structure CEN- standard. Source www.iee-cense.eu

In their present state, in our opinion, the cooling aspect of buildings is not as well and deeply treated by CEN standards as the heating. We therefore excluded the cooling in this analysis.

In particular EN 15316:2007 has been used; the emission is dealt with in part 3-2 [2], distribution in 3-2 [3] and 2-3 [4] and generation is dealt in 3-3 and 4-xx [9 and 10].

The CEN calculation methods work on a per sub-system basis: emission to the final user, distribution and generation. CEN computes the energy loses at each sub-level. This allows the comparison of sub-systems and gives the expert an insight on the measures to achieve better energy performance in the building.

The energy loses split into actual loses, auxiliary energy and recoverable loses. Within the latter category, we have included those that have actually been recovered.

For the heat generation sub-system CEN establishes three procedures: by typology, by efficiency or by the cyclical method.

Typology procedure is the less accurate. The first one is less accurate. It simply divides the estimated energy demand by a seasonal efficiency obtained by multiplying the nominal efficiency by some correction factors according to the type and operating mode of the boiler.

The efficiency procedure is based on an average efficiency computed based on manufacturer data (in fact full and partial load data) and an estimation of the real load charge of the boiler in the actual building.

Finally, the cyclical method assumes a consumption of final energy by the generator and formulates a hypothesis about its partial load ratio and iterates until both converge and give the same consumption (normally two iterations are enough).

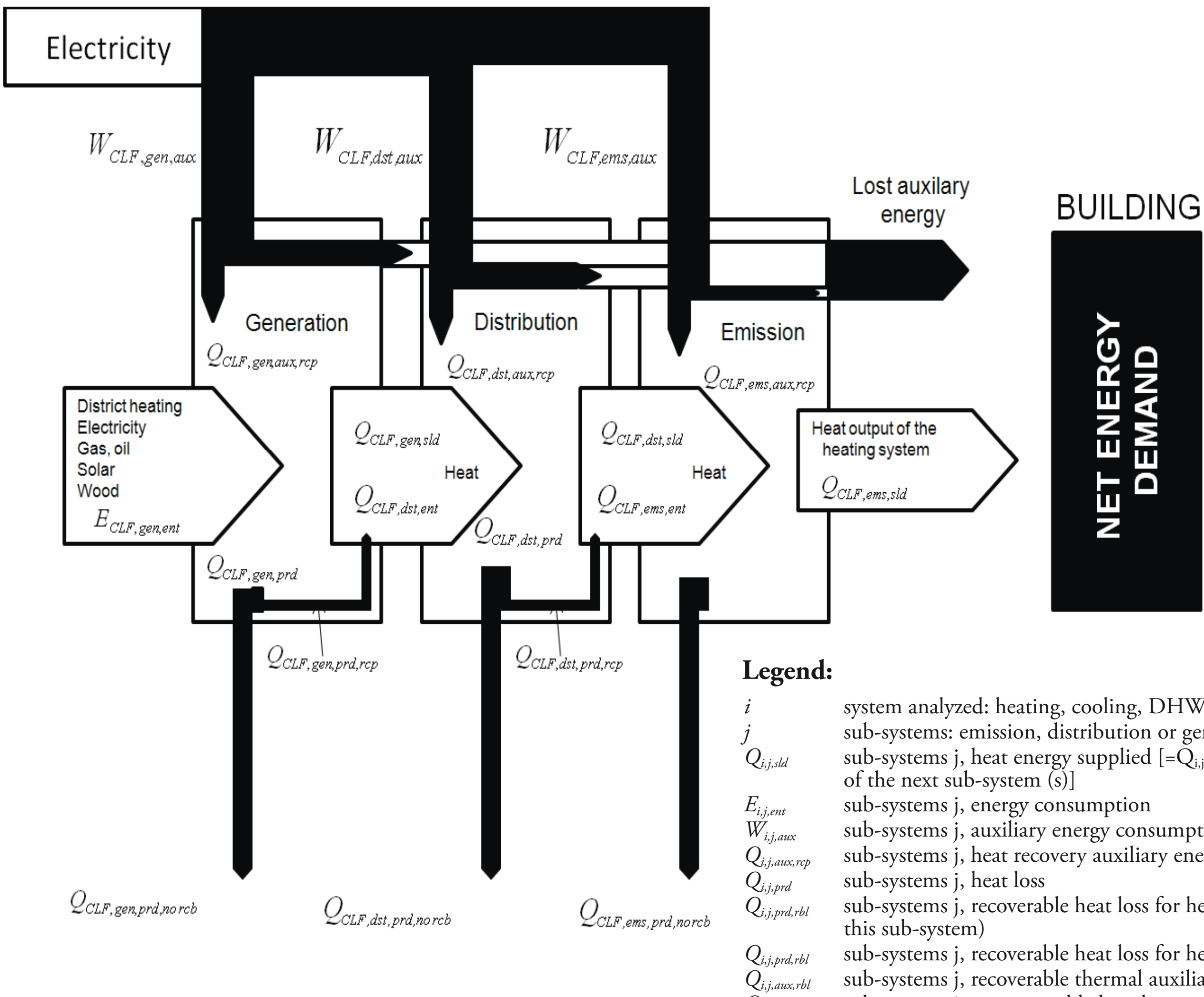
Member states. The Spanish case

In Spain the normative abides by the following European Directives:

- Directive 2002/91/CE [8], its recast Directive 2010/31/UE [9] about energy efficiency in buildings.
- Directive 2006/32/CE about the efficiency of the final use of energy and energy services reformulated in Directive 2012/27/UE.

Spain issued the following Royal Decrees:

- Royal Decree 314/2006 approves the Spanish Technical Building Code (known as CTE, following its Spanish name) and Order FOM/1635/2013 from 10 September 2013, which updates the basic document DB-HE on energy savings. It includes six sections:
  - DB HE-0, Primary non-renewable Energy consumption limitation of buildings.
  - DB HE-1, Energy demand limitation of buildings.
  - DB HE-2, Technical buildings system code. Minimum requirements. (Known as RITE).
  - DB HE-3, Artificial lighting energy systems efficiency.
  - DB HE-4, Minimum solar energy or equivalent non-renewable contribution to domestic hot water (DHW) (achieving the same primary energy savings and fossil CO_2 emissions).
  - DB HE-5, in tertiary sector buildings, the amount of electricity coming from photovoltaic panels.



Legend:

i	system analyzed: heating, cooling, DHW.
j	sub-systems: emission, distribution or generation
$Q_{i,j,sld}$	sub-systems j, heat energy supplied [= $Q_{i,j+1,ent}$ heat input of the next sub-system (s)]
$E_{i,j,ent}$	sub-systems j, energy consumption
$W_{i,j,aux}$	sub-systems j, auxiliary energy consumption
$Q_{i,j,aux,rcp}$	sub-systems j, heat recovery auxiliary energy subsystem
$Q_{i,j,prd}$	sub-systems j, heat loss
$Q_{i,j,prd,rbl}$	sub-systems j, recoverable heat loss for heating (not in this sub-system)
$Q_{i,j,prd,rbl}$	sub-systems j, recoverable heat loss for heating
$Q_{i,j,aux,rbl}$	sub-systems j, recoverable thermal auxiliary energy
$Q_{i,j,prd,no\,rbl}$	sub-systems j, unrecoverable heat loss
$Q_{i,j,aux,no\,rbl}$	sub-systems j, non-recoverable auxiliary thermal energy

Figure 2. System data i, sub-systems j. Source EN 15603

- Royal Decree 47/2007 about Energy Certification of new buildings, substituted by Royal Decree 235/2013, which includes existing buildings.
- Royal Decree 1027/2007 approves RITE and its modifications in Royal Decree 238/2013.

Thus, the minimum requirements of energy efficiency of the EPBD are split into; primary non-renewable energy, energy demand, technical systems, lighting, DHW and photovoltaic limits. All are mandatory constraints.

- Energy Consumption (CTE DB HE-0) RD 235/2013 establishes more efficient construction and rehabilitation of buildings and the need to inform the clients or state holders about the energy status of their building or house.
- Energy demand (CTE DB HE-1) substituted the old NBE CT-79. It sets limits on heating and cooling demand as a whole thus avoiding just dealing, avoiding comply with legislation, with very efficient HVAC systems and consumers of renewable energy.
- HVAC systems (RITE) deal with the design, sizing, installation, maintenance and periodic inspection of the cooling and heating generators. It also limits the efficiency of these facilities from below.

Additionally, HE-4 imposes the need to employ renewable energy for DHW and the heating of swimming pools.

- Artificial lighting (CTE DB HE-3) is the minimum energy efficiency of artificial lighting systems measured by the VEEI ratio ($W/m^2/100$ lux). The limit depends on consumers' activity and maximum installed power. It also establishes aspects about the natural lighting.
- Renewable electric energy (CTE DB HE-5) is a function of the total occupied area.

Summarizing, the code imposes limits and constraints at the architecture level and at the HVAC system level.

Figure 3 shows three buildings (let us name them: A, B and C) with the same consumption. Only B fulfils the present legislation, since it fulfils both the limit consumption (point P), the maximum energy demand (dotted line) and the minimum HVAC systems efficiency (vertical line passing through P). The permitted region is thus that below the dotted line and to the right.

Point P fixes the maximum non-renewable primary energy consumption. Building A has a forbidden low HVAC system efficiency while building C has a forbidden high energy demand. Notice that although it seems paradoxical, both A and C have lower energy consumption than the maximum allowed (horizontal line passing through P).

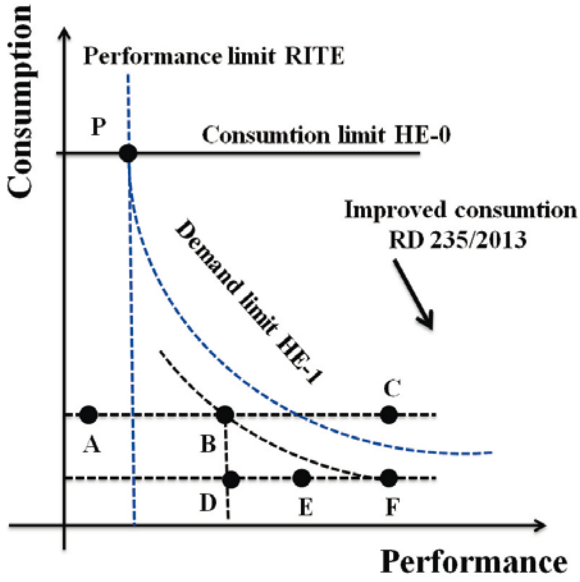


Figure 3. Minimum consumption requirements for new buildings.

Energy Certification (RD 235/2013) is the mechanism in charge of achieving a driving force to more efficient buildings. For instance, building D (see **Figure 3**) can be reached from B just by means of improving the energy need. Reaching building F can be achieved by improving the HVAC efficiency. Building E may be reached from B if both thermal performances of the building and HVAC systems are improved.

In Spain the official tools to study these aspects are the following:

a) **General option**, or performance option, you have two programs called: CALENER VyP or CALENER GT. The last one is for large tertiary buildings. It is valid for new and existing buildings. It requires a 3D modelling of the building and its surroundings. It constitutes an hourly dynamical multi-zone method.
b) **Simplified option**, the "simplification" comes from the input method. In this case no 3D model of the building is defined. This does not mean necessarily that the internal computation method is simplified, although it could be. At present there are four recognized methods: CERMA (single zone hourly method), Ce1, Ce2 for dwellings, Ce3, and CE^3x all types of buildings.

Table 1. Legislative Matrix to meet building energy legislation in Spain.

<table>
<tr><th>Option</th><th colspan="3">GENERAL</th><th colspan="3">SIMPLIFIED</th></tr>
<tr><td>Building type</td><td>Housing</td><td>Little tertiary</td><td>Large tertiary</td><td>Housing</td><td>Little tertiary</td><td>Large tertiary</td></tr>
<tr><td rowspan="5">New</td><td rowspan="8" colspan="2">CALENER VyP</td><td rowspan="8">CALENER GT</td><td>Ce1</td><td>CES PT*</td><td></td></tr>
<tr><td>Ce2</td><td></td><td></td></tr>
<tr><td colspan="3">Ce3*</td></tr>
<tr><td colspan="3">CE3x*</td></tr>
<tr><td rowspan="2">CERMA</td><td rowspan="2" colspan="2">–</td></tr>
<tr><td rowspan="3">Existing</td></tr>
<tr><td colspan="3">Ce3</td></tr>
<tr><td colspan="3">CE3x</td></tr>
</table>

* Yet to be recognized by the Spanish administration.
These are not listed programs derived from the additional capabilities and unique solutions

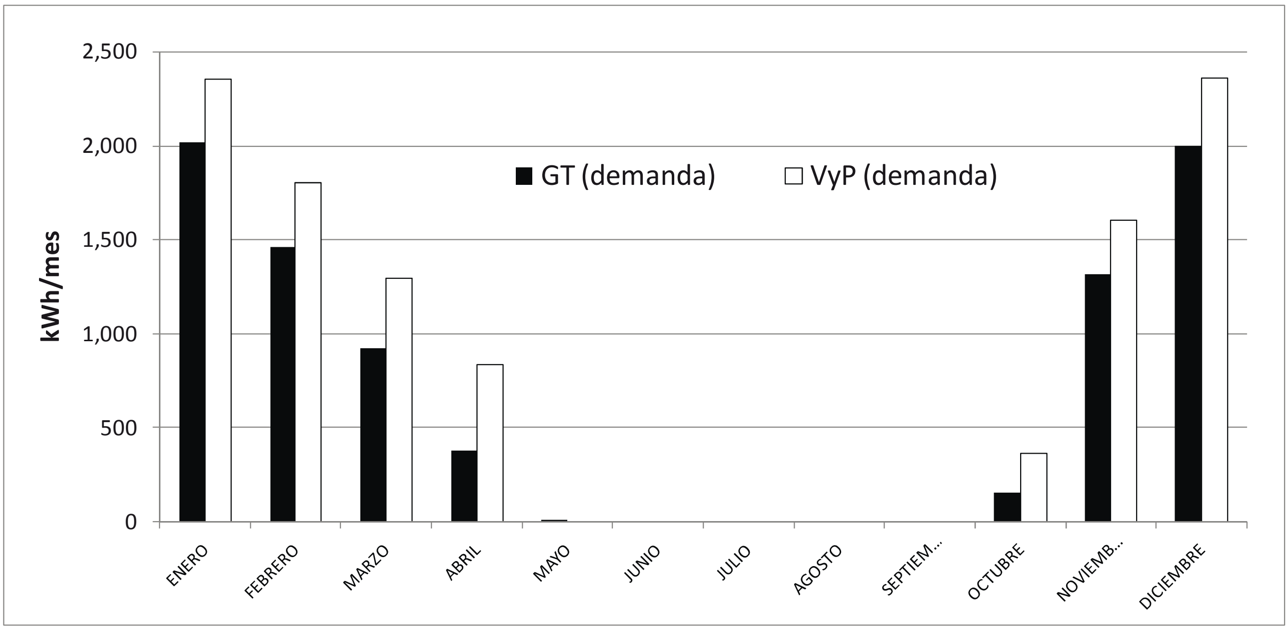


Figure 4. Net energy demand for space heating VyP (LIDER) vs GT.

CALENER VyP is taken as the reference and all other methods should yield the same or worse results than CALENER VyP. Ce3 is a simplification of CALENER GT, since it removes the definition of the hydraulic circuits.

CALENER VyP and CALENER GT are dynamical simulation programs, but their kernel is different. CALENER VyP is an extension of LIDER (energy limit tool CTE DB HE-1 2006), which uses another tool (in Java) named ESTO2.

In the case of CALENER GT, both energy demand and HVAC consumption are computed using the DOE2.2 calculation kernel. However, since the building must fulfil the energy demand limit, it must first be run with LIDER and then the model is exported to CALENER GT.

Comparison of the CEN standards and the Spanish code

The study of a building in Madrid is shown in this section. The building has a rectangular section of 80 m² (861.14 SQFT), has two floors and each floor has height 3 m (9.84 FT). The CEN and CALENER tools have been employed in the calculations.

The first problem comes from the fact that CALENER GT and CALENER VyP do not give exactly the same energy demand since the kernel is different. Another problem which arises is that the occupancy and internal gains schedules are closed in CALENER VyP [5], i.e. are not editable. Since these are editable in CALENER GT the same values of CALENER VyP have been used in CALENER GT. The weather files are the same for both.

With these particularities CALENER GT in general gives smaller energy demand values than CALENER VyP[1]. (See **Figure 4**)

[1] Probably because CALENER GT did not consider thermal bridges bound.

The consumption in CALENER VyP is done by correcting the nominal performance values of each generator at an hourly rate, using algebraic equations. The correction depends just on the part load ratio of the generator (energy demand divided by the nominal power). It does not take into account the start/stop loses or the stand-by loses.

Although CALENER VyP does ask for the outlet generator temperature, this variable is not used to correct the performance of the boiler. Distribution losses and regulation sub-systems are not taken into account.

Regarding the emission sub-system, only the thermal power of the emitters is asked. It does not take into account their location within the thermal zone, control or type. Therefore the losses associated to this information are disregarded.

In conclusion CALENER VyP, does not take into consideration the loss due to the distribution or emission sub-systems. For the generation sub-systems only its performance at part load is taken into consideration.

It seems obvious that if the energy consumption is compared between both methods (CALENER VyP and CEN), then the CEN-standards, which do take all of these into account, will return different results than the CALENER VyP, although the energy demand is the same.

Figure 5 shows monthly consumption obtained using the three CEN methods (typology, efficiency and cyclical) and the one obtained from CALENR VyP. The energy demand used as input value is also shown in this figure.

CALENER VyP values are closer to the demand since the losses from distribution and emission are not considered. This means that the expert will not see the effect in efficiency from low temperature systems or improve the thermal isolation of the distribution system or a better or shorter distribution layout or control, for example.

CEN provides much higher values than CALENER VyP, because the losses are considered. As will be shown below, the results are also closer to actual measured values.

The CEN procedure, allows quantifying how much the consumption of the generator is increased due to each of its downstream sub-systems. The values are just added. This would allow the expert to provide more accurate advice to the building owner.

Figure 6 shows the results obtained from the three CEN methods. It is of note that the energy requirement or demanded by the distribution sub-system to the generator is the same. The three methods only affect the generator calculation.

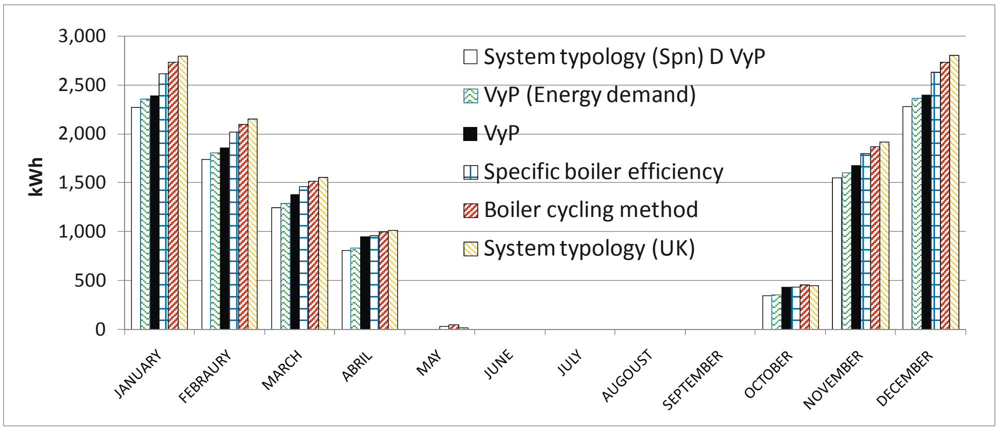


Figure 5. Consumption of heating in CALENER VyP vs standard CEN.

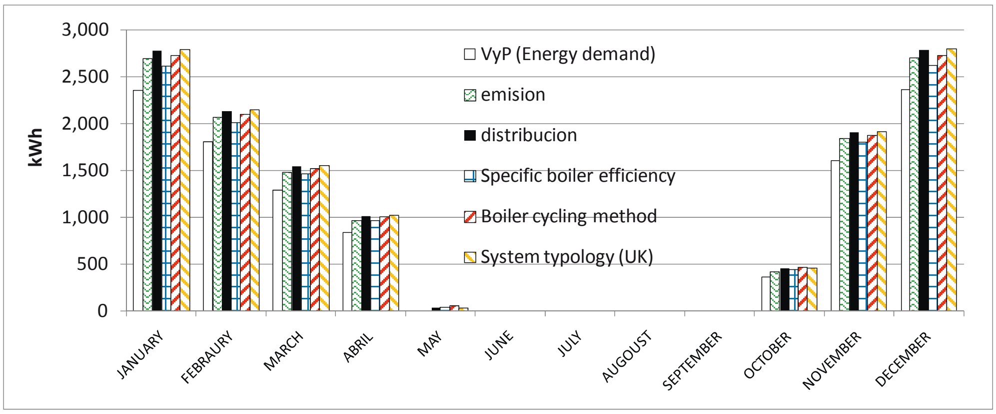


Figure 6. Consumption for an emission, distribution and generation sub-system.

As in the case of CALENER VyP the energy consumption computed by CALENER GT is done by correcting the nominal performance values on an hourly basis.

However, CALENER GT allows for a more detailed definition of the sub-systems than CALENER VyP. It allows the definition of the hydraulic circuits namely hot water, chilled water, condensation, double pipes, etc. Unfortunately, it does not ask for the length of the piping work, which spaces are crossed by the network or its level of thermal isolation. In short, it basically suffers from the same problems as CALENER VyP.

Figure 7 shows the consumption obtained by the three CEN[2] methods and that from CALENER GT. The energy demand is also shown here.

Figure 7 also shows that the conclusions drawn before from the comparison between CEN and CALENER VyP are also valid for CEN and CALENER GT, and the deviations are kept.

Moreover, CALENER GT gives lower consumptions than CALENER VyP, probably because, as noted above, the energy demands computed by VyP and GT are different.

From the two previous comparisons, it can be concluded that for CALENER the present definition of the heating system is not accurate enough if they should be comparable with CEN standards. It is likely that the lack of CALENER leads to an underestimation of the actual energy consumption of the buildings. This will be checked in the next section.

[2] Calculation performed with the demand obtained CALENER GT rather CALENER VyP.

Measured consumption

A multifamily house building, situated in Bermeo, in northern Spain, was measured and the same strategy of comparison used in the previous section was employed.

The sensors placed in the building provided us with the following records:

- Total consumption of natural gas boilers delivered (bills).
- Domestic hot water meters for each of the dwellings (in m³)
- Thermal energy meter for each housing (see **Figure 8**).

Energy meters for each dwelling indicate the input energy to the emission subsystem ($Q_{CLF,ems,ent} = Q_{CLF,dst,sld}$) and the volumetric water consumption yields approximately the amount of energy demand DHW for service (Q_{DHW}).

In first place, the consumption is computed by CALENER and CEN methods.

In second place, the measured values are compared with the previous results from CEN and CALENER.

The building has two blocks, each of them containing five floors. There is a central heating and a DHW system with solar collectors. The boiler room is placed below one of the blocks.

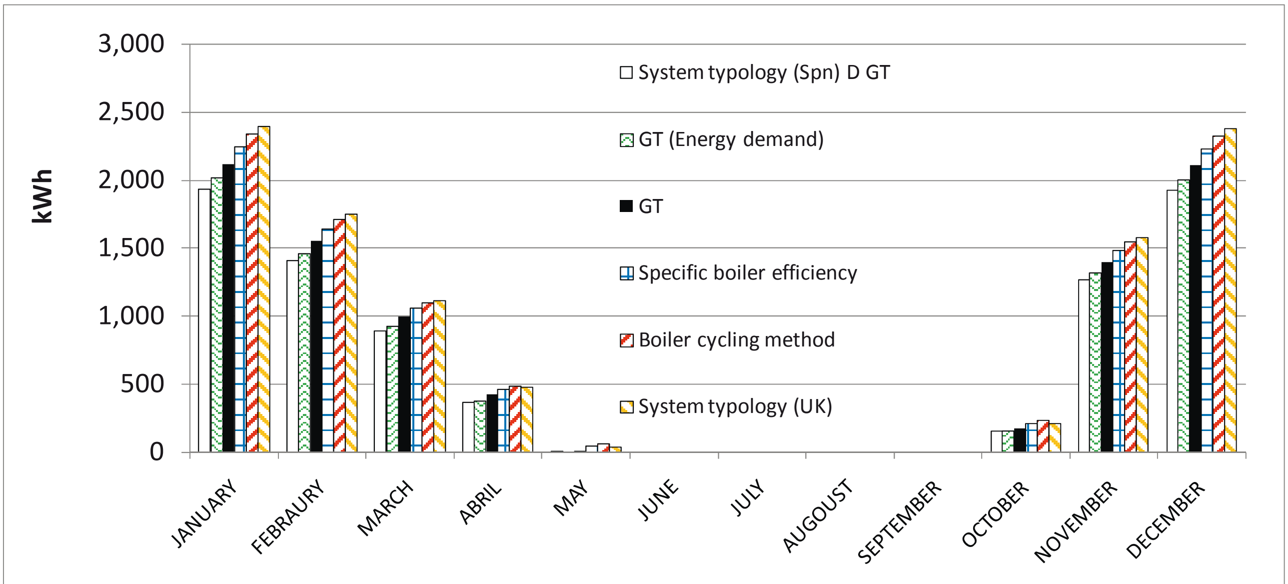


Figure 7. Consumption of heating in CALENER GT vs standard CEN.

The energy demand has been obtained from LIDER (i.e. CALENER VyP) but has been corrected for the actual occupancy of the buildings.

For this amount of demand values from the hourly data delivered by the postCALENER program demand values obtained for an ambient temperature above 18°C (labelled for control of the generation system and decide by the designer and maintainer) were excluded (not joined) and not satisfying hours that are within the schedule heating (Community agreement is from 8 to 21 h inclusive) were excluded.

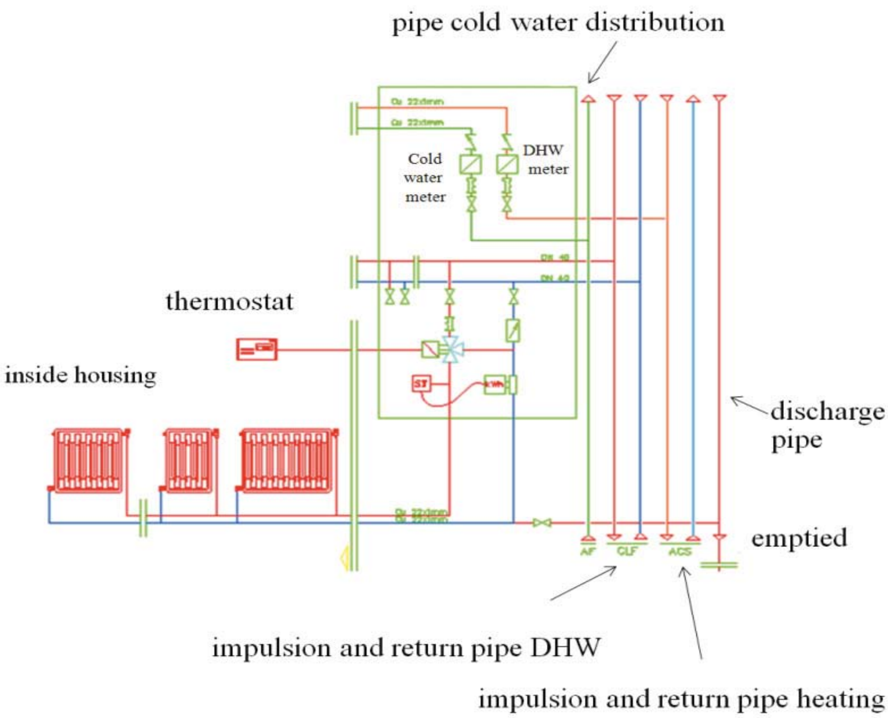


Figure 8. Regulation scheme housing. AF Cool Water.

This choice is taken well to fit the actual time of heating the building and to try to calibrate (adjust) the energy estimation of CEN standards to bring the estimated consumption to actual consumption. If this is not done well, the initial monthly demand for calculation (accepting the default values assigned to the residential program) would be approximately 15% higher.

When using the CEN standards two assumptions have been employed. In first place, it has been assumed that the input information of the buildings coincides with that needed by the CEN standards. For instance, the length of the piping work is estimated using CEN correlations and not using the actual measured values or the actual places they cross. Second, the CEN has been employed but now using the actual measured values and right places that the piping network crosses.

CEN gives the consumption for heating and DHW and for the emission, distribution and generation subsystems separately.

In order to take into account the increase of energy demand for the distribution sub-system ($Q_{i,dst,sld}$) due to the emission sub-system, the following variables should be considered:

- Regulation of the zone temperature.
- Mean logarithm temperature difference with an internal reference temperature of 20°C.
- Location of the radiator elements.
- Type of terminal unit
- Free height of the zone.

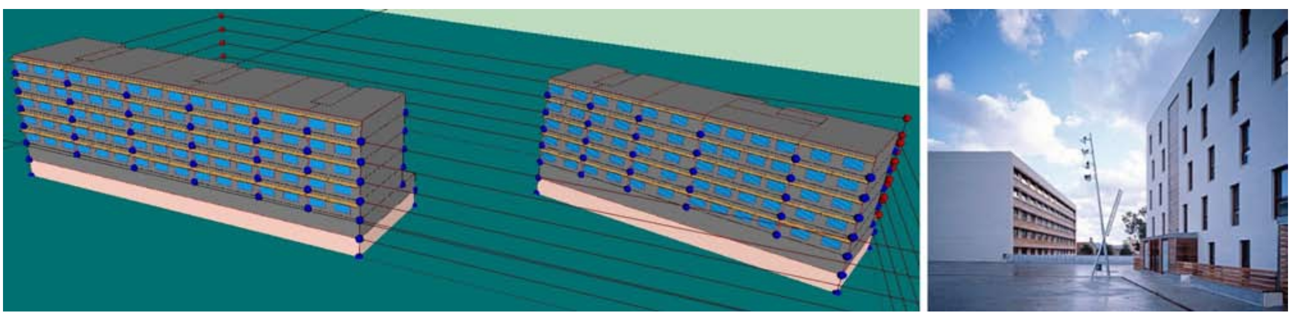


Figure 9. Images of the building under study. Left image LIDER. Right real image.

The electric consumption of the auxiliary systems can be neglected ($W_{CLF,aux}$ = 0) since in dwelling (as in this case) is zero because the regulation is done with thermostatic valves.

To compute the increase in the demand of energy to which the generator sub-system is submitted ($Q_{i,gen,sld}$) by the distribution sub-system, CEN points out the following variables:

- Electric power of the circulation pumps.
- Mean temperature of the distribution network.
- Length, section and thermal isolation thickness and location of the pipes through the buildings spaces.
- Regulation of the secondary systems: ON-OFF, two-way or three-way valves.

When applying the CEN standards a challenge arises when the distribution sub-system was taken independently for the computation of the thermal loses, regarding: actual length of the piping, assigning a mean temperature of the fluid inside the pipes for each calculation period.

In case of the generator it seems logical to compute its consumption based on its nominal capacity and efficiency and correcting those values as a function of the part load ratio and the outlet temperature of the water.

Nevertheless, the generator loses due to its hot body and to the stop-start cycles during the stand-by periods should be included (and are not in CEN standards).

This separated evaluation allows to point out what is responsible for the greater consumption and therefore to focus the saving measures (if it is profitable) towards that element or sub-system. The results are shown in **Table 2**.

As **Table 2** shows, the worst result comes from the distribution sub-system for both services. The generation sub-system, in contrast, has quite a good performance. Therefore the saving measures should be focused in first place on the piping network.

If the CEN and measured values are compared, then it seems that both are quite similar using any assumption; the estimations proposed by CEN (first assumption) starting from general geometric data and using the actual measured values (second assumption).

It can be concluded that the CEN standards in our samples give a consistent result. They yield (in this case) slightly higher values than the actual ones. In the worst case, that is, assuming the parameterized values of CEN (first assumption), they are 26% higher *(starting from the corrected energy demand from LIDER)*. (See **Table 3**).

Figure 10 shows the monthly values of actual measured consumption and those computed by CEN ($E_{CLF\text{-}ACS,ent,THEORITICAL}$ is for the second assumption and $E_{CLF\text{-}ACS,ent,REAL}$ refers to the first assumption).

In the previous section the results for the first building in Madrid (section three of this article) pointed that CALENER VyP gives smaller consumptions than CEN standards.

As mentioned, it is due to the lack of emission and distribution sub-systems. In the building of Bermeo this represents more than 50% of the losses of the heating system (with respect to the computed demand).

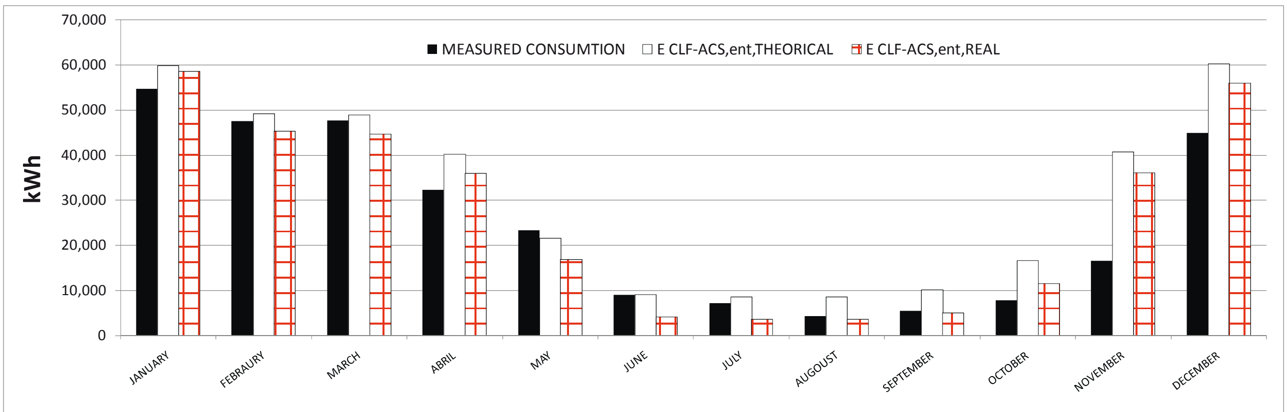


Figure 10. Measured consumption vs CEN with theoretical and real values.

Running the Bermeo building model in CALENER VyP gives **Table 4**.

The actual consumption of the building is much bigger (301,081 kWh > 263,739 kWh) than the results from CALENER VyP, even starting with a higher (and unreal) energy demand (since CALENER VyP does not allow to change the schedules).

Figure 11 shows the consumption computed with CALENER VyP compared with the measured values on a monthly basis.

In this case the schedules and thermostats are editable. The actual values of the Bermeo building have been used. The occupancy from 8 PM until 9 PM, and the availability of the heating system have been used. This is why the results from CALENER GT are even smaller than those of CALENER VyP (default means more hours of operation).

Table 5 illustrate the running the Bermeo building model into CALENER GT [5].

Table 2. Consumption estimated by the CEN standards subsystem (assuming two real values).

Sub-system	CLF (kWh/m²)	η (%)	DHW (kWh/m²)	η (%)
Q_i	41.4	-	13.1	-
$Q_{i,ems,sld}$	48.0	86.2	-	-
$Q_{i,dst,sld}$	56.9	84.4	16.4	79.9
$Q_{i,gen,sld}$	57.6	98.8	16.8	97.6
$E_{i,ent}$	57.6	71.9	16.8	78.0

Table 3. Measured consumption vs CEN with theoretical and real values.

MEASURED CONSUMPTION (kWh/year)	THEORETICAL CEN Assumption ONE (kWh/year)	REAL CEN Assumption TWO (kWh/year)
301,081	380,561	325,819
% CEN/REAL	**126**	**108**

Table 4. Measured consumption vs CALENER VyP.

MEASURED CONSUMPTION (kWh/year)	CALENER VyP (kWh/year)
301,081	263,739
$\%_{VyP/REAL}$	**88**

Table 5. Measured consumption vs CALENER GT

MEASURED CONSUMPTION (kWh/year)	CALENER GT (kWh/year)
301,081	147,294
% GT/REAL	**49**

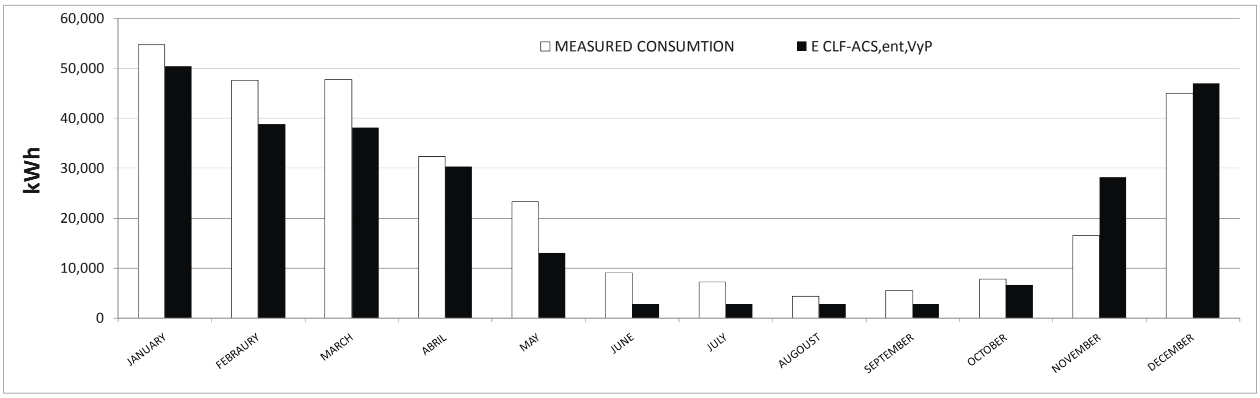


Figure 11. Measured consumption vs CALENR VyP.

The measured values are much higher than the computed ones (301,081 kWh > 147,294 kWh). The CALENER GT results are approximately 51% smaller than reality despite the possibility of adjusting the schedules. In much the same way as with CALENER VyP, this is due to the lack of a model for the distribution and emission sub-system.

Figure 12 compares CALENER GT and measure measures results per month.

Figure 13 compares the measured values with those of CALENER and CEN.

Conclusions

Energy consumption in Spain is based on Royal Decree (RD) 235/2013. In this case it does not take into account the emission, distribution sub-systems and stand-by loses of the generator. The CEN standards do take into account these loses thus leading to energy consumptions which are likely closer to the actual ones.

Figure 12 demonstrates that it is possible to obtain quite good approximations to the energy consumptions of buildings (in this case with a deviation below 8%), using the CEN standards and a corrected energy demand computed using a dynamical hourly method.

This indicates that it is crucial to be able to edit the schedules, HVAC availability, occupancy, etc.

In the case of Spain the national computation tool CALENER does not allow the estimation of actual energy consumption. Moreover, it disregards important sub-systems. It results in smaller energy consumption than reality (even in the case of CALENER VyP where the schedules are not editable).

In the case of the DHW service, whose demand is very stable, during the summer period the difference between the computed values and the actual measured ones is very different. This is due to the fact that CALENER does not consider the recirculation thermal losses. This does not happen with the CEN standards.

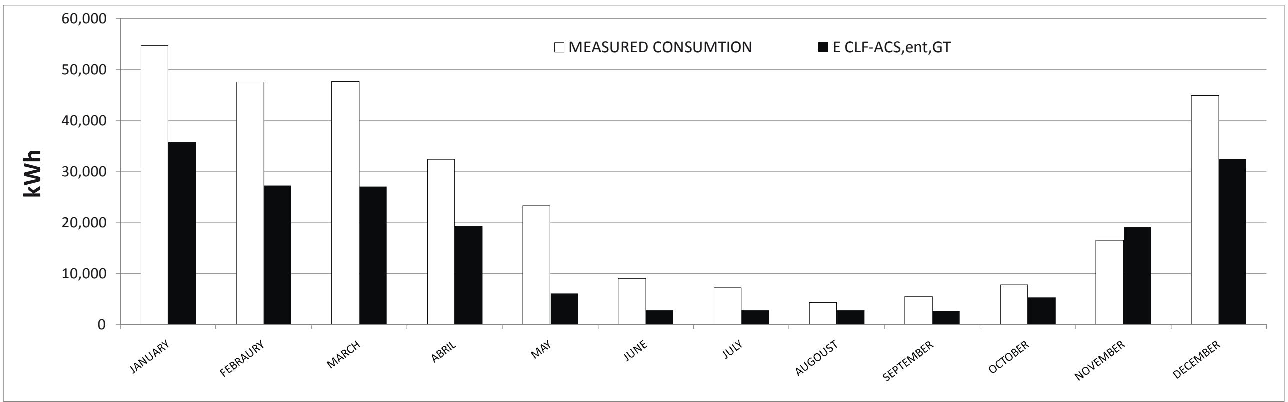


Figure 12. Measured consumption vs CALENER GT.

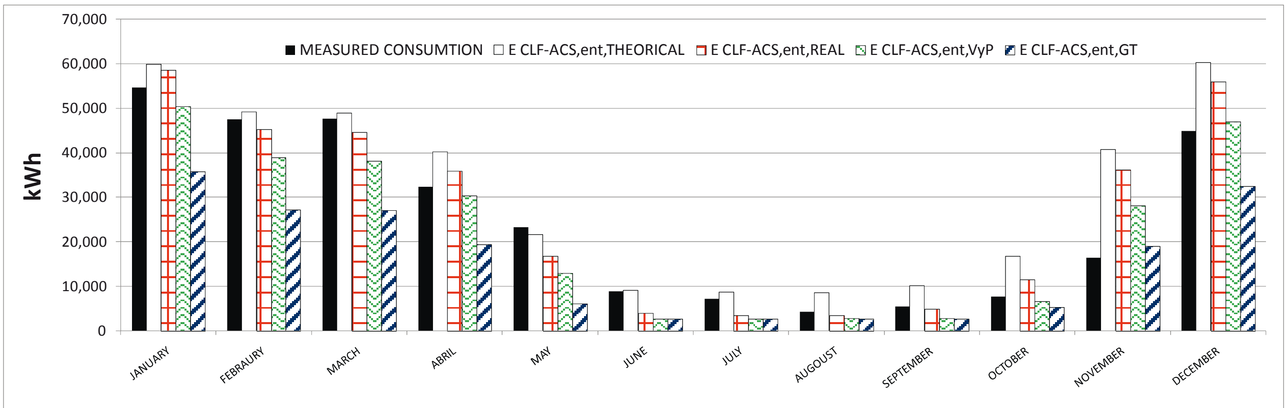


Figure 13. Measured consumption vs estimated.

CEN standards give an accurate estimation of the actual consumption using the computed and corrected energy demand. If the actual sizing of the piping network is used, the deviations are around 25%. Moreover it splits the consumption responsibility.

CALENER is used as the reference. That is to say, other recognized software must be compared with respect to CALENER and this poses a drawback.

The loses of the emission sub-system constitute around 15% of the energy demand, while the distribution losses represent 8% of the energy supply to the emission sub-system and more than 50% in recirculation sub-systems in DHW. The losses of the boilers when they are in stand-by due to their hot body and chimney are not considered by any method.

All these problems detected in the case of Spain are likely to be present in other MS. Therefore, they should be detected and fixed if the goal of better energy performance of buildings as well as a harmonised legislation are to be achieved in Europe. ■

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