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USERS' BEHAVIOR AND ENERGY PERFORMANCES OF NET ZERO ENERGY BUILDINGS

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ABSTRACT

This paper proposes to study the role and the user in the operation of the building and its impact on energy performance of buildings.

Some comparisons of the energy consumption and production of the buildings were calculated during the design stage are made against the measured data of the consumption and production of the buildings when they are being utilized. It indicated that the differences between the design calculations and the measurements can be up to 50%.

The method used in this study is to restart the process of calculation for the energy balance that was adopted during the design phase and to establish the right hypothesis on the schedules, utilization of appliances, and comfort level of the building that lead to a good evaluation of the energy consumed in the actual buildings operation. This feedback on the tools used by the design offices will allow making improvements in these tools.

INTRODUCTION

User’s behavior in high performance buildings

Energy performance in buildings is directly linked to their operational and space utilization characteristics and the behavior of their occupants. The user has influence due to his/her presence and activities in the building, but also his/her control actions to improve his thermal and visual comfort. In passive buildings, indoor comfort (thermal and visual) should be achieved thanks to free natural resources of energy such as sun and wind and active energy consuming systems used at a last resort. Consequently, the users’ behavior has a high impact on the final energy use depending on his utilization of the active systems when it is not necessary.

In the design phase, as in building performance simulation, this effect has only recently been recognized. Building performance simulation has become an accepted method of assessment during the design process. With increasing complexity of building designs and higher performance requirements on sustainability, use of building simulation will become inevitable.

For a standard type of office building, the internal heat gain was found to be an important and sensitive input parameter when applying a building performance simulation tool to assess the building performance (Hoes et al., 2009). The internal heat gain has a direct relation with user behavior.

Therefore it is assumed that user behavior is one of the most important input parameters influencing the results of building performance simulations. Unreliable assumptions regarding user behavior may have large implications for such assessments. This effect will become more important when the design under investigation contains improved passive energy-efficiency measures.

In building simulations it is common practice to use standardized occupant behavior and internal gains. Although this is a valid approach for designing systems, the probabilistic nature of these boundary conditions influence the energy demand and achieved thermal comfort of real systems (Saelens et al., 2011).

Importance of user’s behavior in NZEBs

In the framework of the IEA SHC Task 40 / ECBCS Annex 52 that concerns Net Zero Energy Buildings, 50 buildings in different countries and climates have been chosen as case studies. The goal is to study all the buildings to highlight the innovative solution sets of NZEBs.

In this study, four of the buildings that are in the database of Task 40 will be assessed to show the importance of user’s behavior in NZEBs. The idea is to compare the energy performance of the buildings that were predicted during the design phase and the measurements that were run during the operation of the building. The difference for some type of use is sometimes very important, it can be either positive or negative, and it is often due to wrong hypothesis in the simulation program on users.

TESTED CASE STUDY BUILDINGS

Primary school in Paris suburb

The primary school of Limeil-Brevannes was inaugurated in 2007 being the first zero energy school in France (Lenoir et al., 2011b). It is composed of 12 classes for a net floor area of 2,800 m².

The study of the energy consumptions was conducted from September 2008 until August 2009. Figure 1 shows the comparison of the simulation and measurement for energy consumption.

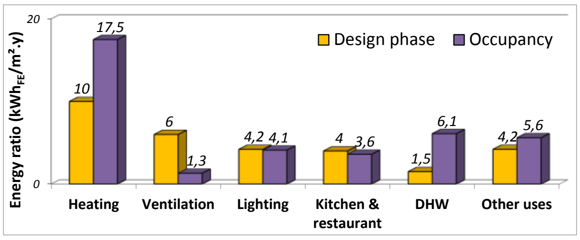

Figure 1 Energy performance of a net zero energy school in Paris suburb. Comparison between design phase and occupancy.

It can be noted that on figure 1 the energy needs for heating are much higher than predicted during design phase (+75% compared to estimations). This difference can be explained by a set point temperature above 19 °C in the rooms. This value was used to run the simulations during design phase. Some temperature measurements were conducted during the winter season and shows that the inside air was between 20,5 °C and 21 °C. This occured because the occupants were not feeling comfortable with an air temperature of 19°C. For a passive building in which the heating needs should not be high, an increase of 2 °C in the set point temperature has a huge impact in the energy performance of the building.

This assessment shows that the users have a direct impact on the performance of buildings. The simulations carried out during the phase study are often too ambitious and not realistic enough and big surprises can occur when compared with measurements in actual occupancy.

The other differences between design phase and occupancy occur from other reasons. For the ventilation consumption, which is much lower than predicted, the building manager wonders if the system is working correctly. Indeed the ventilation is running with presence detectors and CO_2 sensors, the users can not control the system. As for DHW, the difference can be explained by the fact that the system is centralized with a very long network to feed all the parts of the building.

Elithis Tower

The Elithis Tower was inaugurated in 2009. After one year of occupancy of the building, it has been possible to establish a first energy report (Leysens, 2010). Figure 2 gives a comparison between the design phase and the real energy use. The forecast gave a prediction of 65 kWh/m².y (primary energy) but measurements during the first 12 months of occupancy (8 months of measurements, 4 months extrapolated) showed a ratio of 96 kWh/m².y (primary energy).

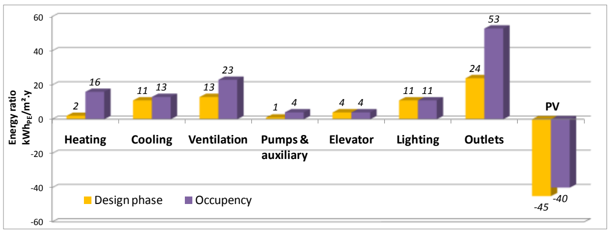

Figure 2 Comparison of energy performances between design phase and occupancy for the Elithis Tower

The high difference in consumption for heating can be explained by two main reasons:

- Higher set point temperatures than the one used in the design simulations; and
- The building was partly used therefore the internal charges were less important than predicted (100 instead of 150 persons for the building)

To carry out the calculations of the thermal simulation of the building, the engineers made the assumption that the average indoor air temperature is 20 °C in winter. On a daily basis, employees have found the theoretical temperature was too low, and have called for more heat than expected. The measured temperature in winter allowing comfort for the users on the first year of operation was actually 22 °C.

In a building with high insulation in which heating requirements are reduced to a minimum value, a slight temperature change implies a significant change in consumption. This difference of 2 °C, between theory and practice, was the main cause of the very high value of the measured consumption compared to the simulations.

For the future, the director of Elithis Group hopes to make its employees work in an environment of 21 °C in winter. A full occupancy of the building is also expected to obtain additional heat gains and allow, according Elithis, to stretch the use of the heating to 0.

After one year of measurements, the consumption of plug loads turned out to be twice that was predicted in design. One explanation is the fact that the hypothesis was made in the simulations that all computers would be turned off at night. In reality, although the users were sensitize with energy performances, many of them leave their computers on during night hours.

With the example of the Elithis Tower, it can be seen that the huge impact of the users have on the final energy performances. This impact is visible on the real use of the systems that can be different to the ones predicted during simulations or on the occupancy that can be different what was estimated in the design phase.

NREL Research Support Facility

The construction of the National Renewable Energy Laboratory's (NREL) new 20,000 m² Research Support Facility (RSF) was completed in June 2010 (Crawley et al., 2009).

There is not yet a full year of data to determine if the model was accurate or not for the whole year, but it is possible to compare the results for a given month. For example, figure 3 represents the power density due to artificial lighting during January 2011 (Pless et al., 2011).

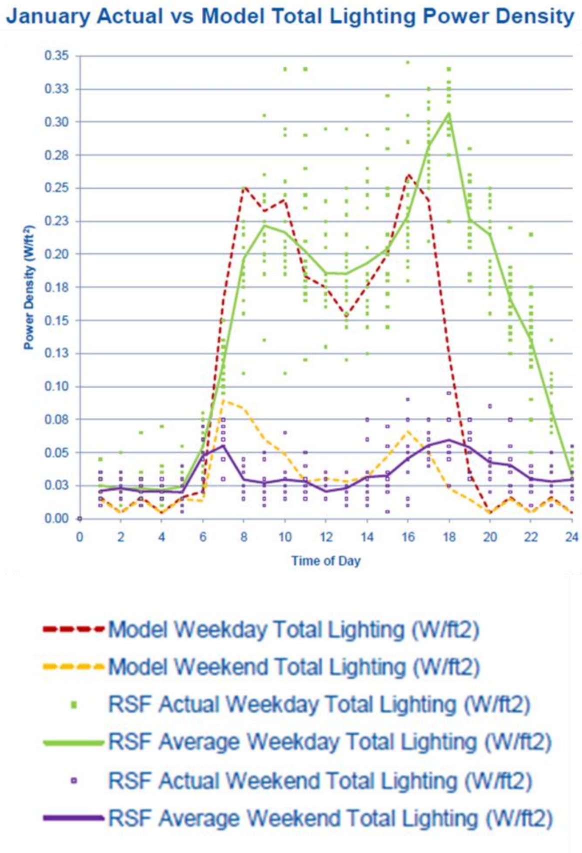

Figure 3 January actual vs model total lighting power density for RSF[11]

The red curve (higher dash dot line) represents the model for weekdays and the green one (continuous line) is the measurements. It can noticed that the simulation is rather similar to reality in terms of the occupancy scenario (the hours are matching) and of density (peak height) during the morning. But the simulation predictions and the measured data are different in the late afternoon. This difference was explained by several reasons. First, the occupants are staying later than expected at work and consequently they need more artificial lighting. But more imporatantly, the cleaning takes place after 5pm and the housekeeping staff are lighting all the offices when working. During the first months, they were not sensitized to the energy performance of the building and they did not turned off the lights when leaving a space. Fortunately, there is a 2-hour time delay for the lighting (coupled with presence detectors) so the lighting was off after two hours, but the consumption of the lighting was still higher than predicted during simulations. When noticing this fact, the building manager asked the housekeeping staff to turn off the lights after finishing cleaning. The energy consumed in the next months is a little lower.

Because the artificial lighting consumption incurred from the cleaning is not negligible, the building manager is thinking to move cleaning to daylight hours.

ENERPOS Building (Reunion Island)

ENERPOS (French acronym for POSitive ENERgy), the first zero energy building of La Reunion was inaugurated in January 2009 in the University Campus of Saint-Pierre. Reunion Island is a French overseas department located in the Indian Ocean, close to Mauritius Island; the climate is humid tropical.

ENERPOS is a two-storey university building (split into two parallel wings separated by a vegetated patio, underneath which there is a car park) composed of an administration zone (7 offices and a meeting room), 2 computer rooms and 5 classrooms and has a total gross floor area of 739 m².

The main feature of the building is to use passive means and natural resources such as sun and wind to achieve thermal and visual comfort in the building. Active energy consuming systems such as air-conditioning and artificial lighting should be used as a last resort (Garde et al., 2006). All rooms and spaces are naturally cross-ventilated and equipped with high efficient ceiling fans. Solar shadings have been designed and optimized thanks to 3D simulations. The building is fully monitored with energy meters by energy end- use.

Figure 4 gives the energy consumption results for all energy end-uses for the period from March 2010 to February 2011.

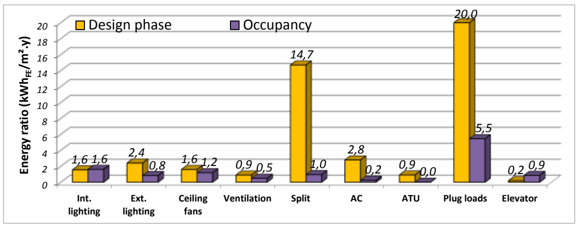

Figure 4 Energy consumption for the ENERPOS building. Comparison between design phase and occupancy.

The consumption has been rather over estimated during the design predictions (45 instead of 12 kWh/m$^2_{GFA}$.y, final energy).

Two major errors were made during the design phase to predict the energy consumption of ENERPOS:

- those concerning the split systems (used to cool the two technical rooms); and
- the plug loads.

These mistakes will be explained in the next Section.

The overall consumption of this NZEB is around ten times less than the consumption of a standard university building in La Reunion (approx. 112 kWh/m².y, final energy).

METHOD FOR ENERGY SIMULATIONS OF THE ENERPOS BUILDING

The goal is to compare the different simulations ran to calculate the energy performance from the early design to the real occupancy of the building from the measurements of one year of use in the ENERPOS building.

Methodology

The methodology used by the design office (ENERPOS, 2009) to forecast the consumption of a building in the design phase is rather basic but simple to establish.

It consists in listing all the equipment, appliances and systems installed in the building, use an assumed use scenario (number of hours of use per day and number of days per year) and to multiply by a diversity factor that takes into account the fact that all equipment is not used at the same time and not using the maximum load.

There are several sources of errors in this method being concerned with the equipment installed, the use scenario or even on the diversity factors that comes predominantly from the design office's previous experiences.

The goal of this section is to explain the different errors made during the design phase to predict the energy consumption of the building. Then the idea is to calculate the energy consumption again with the same methodology, but with the new hypothesis in terms of equipment loads and occupancy scenarios.

Table 1 shows the energy consumption forecasted during early design with the method explained in the previous paragraph. Table 2 shows the same results with the actual installed equipment and more realistic occupancy scenarios (based on the observation of the use of the building).

Ventilation and Air-conditioning

The Air-Conditioning (AC, VRV group) and the Air Treatment Unit (ATU) are installed in the offices and in the two computer rooms. During the design phase, a dynamic thermal model of the building was undertaken in the DesignBuilder simulation tool. Using Givoni's comfort diagram on a psychometric chart, it was possible to predict the different operational periods for natural ventilation, ceiling fans or air-conditioning (Garde et al., 2011). The offices were supposed to be air-conditioned for 1.5 months and the computer rooms for 3 months (15 days in December and from the start of February to mid-April which represents 42 working days). The energy index due to air-conditioning was thus supposed to be 2.8 kWh/m².y.

In fact, after three summer seasons, the air-conditioning in offices was nearly not used at all (approx. 1 week/year). A thermal comfort study was carried out with surveys for the users of the building and they answered that they were feeling comfortable nearly all year long thanks to natural ventilation and ceiling fans (Lenoir et al., 2011a). Also, due to the computer rooms not yet being equipped, it is not useful to turn the air-conditioning on in those rooms.

Table 2 shows the same calculation used in table 1 with another hypothesis for the use of air-conditioning. The energy index becomes 0.5 kWh/m².y which is closer to the one measured (0.2 kWh/m².y).

Concerning the two units split systems (one of 1780 W and the second one of 700 W), it was supposed to cool two technical rooms equipped with computer hardware. In fact, only one technical room houses switchgear cubicles, thus only one split system (700 W) is turned on to cool it. In table 2, the calculation was done with this load value. The energy index founded in this case is 4.1 kWh/m².y which is closer to the measurements (1 kWh/m².y), but the difference is still very large. In this case, the diversity factor must be too high. Future work will be undertaken to take some other measurements on split systems to have a better idea of the load curve of such systems and to calculate the diversity factor that should be used to predict the energy consumption with the maximum load.

Lighting

As for the interior lighting, the energy index found during design phase was the same as the one measured (1.6 kWh/m².y), see table 1 and figure 4.

Nevertheless, this calculation entails several mistakes that were corrected in table 2. At first, the actual installed load for lighting in the building was counted and it turned out to be 3.3 kW instead of 3.7 kW. Secondly, the occupancy scenario used during design was for 624 hours of electric lighting in a year. A new scenario was proposed taking into account the fact that the administration is occupied nearly all year (236 workdays), whereas the classrooms are used about 150 days per year. It gives a total of 686 hours of lighting a year and then an energy index of 1.5 kWh/m².y.

For the exterior lighting, the use scenarios proposed during the design phase is not the same as the what is used in reality.

During the design phase, the patio lights (0.3 kW) were scheduled to be used one hour per day all year long and the front outside lights were proposed to be turned on 4 hours a day.

In fact, only the useful outside lights (ie on the passageways and the patios) are turned on (which represent 0.7 kW) for 3 hours during summer season (from 7pm to 10pm) and for 4 hours during winter season (from 6pm to 10pm). The calculation done with these hypothesis gives an energy index of 0.8 kWh/m².y which is the same as the measured usage.

Plug loads and UPS

During the design phase, an Uninterruptible Power Supply (UPS) was proposed to be set in the building, particularly for the two computer rooms. Nevertheless, for now, there is no UPS in the building and moreover, the two computer rooms are not equipped with desktops, but the students are coming to the building with their own laptops.

This change between the design and the reality explains the large difference of energy consumption for plug loads (20 kWh/m².y instead of 5.5 kWh/m².y for the measurements).

Table 2 shows the calculation done with the actual installed equipment on plug loads (about 2.8 kW including 15 laptops or nettops, two printers and one copy machine). A more realistic occupancy scenario is used assuming that the administration is occupied nearly all yearlong (which corresponds to 236 days/year instead of 156 days during design). These hypotheses give a result 5.7 kWh/m².y that is close to the measurements (5.5 kWh/m².y).

Of course, this result represents the plug loads for the building as it was occupied during the year 2010-2011, it should change in the future if the computer rooms are equipped. However, it shows that the method used can provide correct results if the hypothesis is accurate.

Lift

The lift of the building has a maximum load of 4.5 kW. In the spreadsheet used to calculate the consumption, the lift was supposed to be used one hour per day with a diversity factor of 0.2 taking into account the fact that the lift does not work at maximum load all the time. These hypothesis gave an energy index of 0.2 kWh/m².y during design.

For the first months of monitoring in the building (March and April 2010), the lift was responsible for nearly 15% of the overall energy used by the building (about 120 kWh/month). This high consumption is due to the fact that the lights inside were constantly on without any standby mode. A standby was set up in May 2010 and therefore in the next months, the consumption has decreased of half (about 50 kWh/month). Figure 5 shows the energy used by the lift before and after the standby was initiated. Looking at the energy use (green dash dot line), we can see that the slope decreased to half. The same conclusion appears if we look at the load curve which is around 170 W before the standy mode was activated and that decreases to 70 W afterwards.

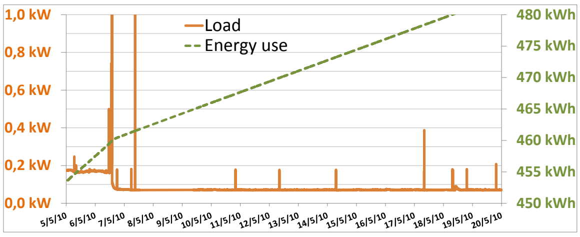

Figure 5 Load and energy use for the lift before and after the standby mode was activated (on the 6th of May 2010)

With figure 5, it is also possible to point out the fact that the lift is used about once a day and that its energy consumption comes from the standby more than from the actual use of the lift.

In the case of the lift, the method used during design to predict the energy consumption is not accurate. The hypothesis was that the lift would be used one hour per day with a diversity factor of 0.2 (table 1).

In fact, if we only take into account the sleep mode load of the lift (70 W) over all the hours of the year (8 760 hours), the energy index becomes 0.8 kWh/m².y which is close to the monitored value (0.9 kWh/m².y).

Ceiling fans

During the design (table 1), the hypothesis was that the ceiling fans would be used from November to April, 8 hours per day. This gave an energy index of 1.6 kWh/m².y.

The maximum load value used during design was the one given by the manufacturer (80 W). But measurements on the ceiling fans gave a maximum load of 70 W (Lenoir et al., 2011a). The total load for the 55 ceiling fans of the building becomes 3.8 kW instead of 4.4 kW.

The monitoring of the building checked that the hypothesis on the period of use of the ceiling fans was correct. Figure 6 shows the energy use per month for the ceiling fans in the building from June 2010 to May 2011. The ceiling fans are used from November to March.

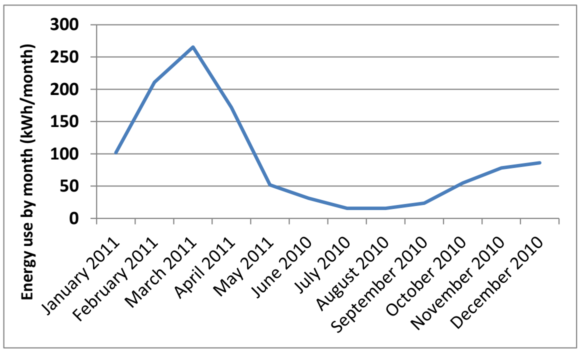

Figure 6 Energy use for ceiling fans in the building from June 2010 to May 2011

With this data, it is possible to check the diversity factor used to calculate the energy use of the ceiling fans (hypothesis: 0.3). If the energy use for ceiling fans is averaged per month (from November to March), it generates a value of approximately 150 kWh/month. Taking into account an average of 17 working days per month and 8 hours of use of ceiling fans per day, with the total load of the ceiling fans in the building being 3.8 kW, and the diversity factor obtained is 0.29. The hypothesis made during design can be made correct.

CONCLUSION

This paper has shown the importance of the user's behaviour to calculate the energy use of a building. The user influences the energy use with their occupancy of the building as well as their use of the equipment for their activitys. In high performance buildings such as NZEBs, the consideration of the user's behaviour becomes paramountl as most of the time the user has a choice to achieve his comfort between a passive way (for example natural ventilation, daylighting…) and an active energy consuming system (heating, air-conditioning, artificial lighting…)

The second part of this paper explained a simple methodology that can be used by design offices to have a quick result for the energy use of a building (without using building simulation). To use this method, several hypothesis have to be made on the installed equipment load, the occupancy of the building and the use of these systems.

With the example of the ENERPOS building that has been fully monitored for more than a year, it was possible to compare the results obtained during design with the measurements. It was attempted to apply the same methodology using the real installed load values and more realistic occupancy scenarios based on the detailed study of the building.

As a conclusion, the methodology is better at predicting the energy usage because the hypotheses are correct, and it is possible to have more accurate results for the energy use. Table 2 gives the energy index of the building with the new hypothesis. The result is 15.6 kWh/m².y while the measured usage is 12 kWh/m².y.

The main problem remains on how to make the right hypothesis during design phase on the equipment installed or on the occupancy scenarios.

As a perspective on the ENERPOS building, measurements that are more precise will be conducted on all the equipment (computers, copy machine, printer…) and the systems. The idea is also to find a way of measuring the occupancy rate of the building whether in the administration or in the classrooms and to measure the impact of it on the energy index of the building.

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REFERENCES

Crawley D., Pless S., Torcellini P. 2009. Getting to net zero. ASHRAE Journal, September 2009

ENERPOS ANR. 2009. Development of new methods for the modelisation and the conception of Net Zero Energy Buildings in hot climates. Final Report. lpbs.univ-reunion.fr/enerpos/

EPBD recast. 2010. Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast), *Official Journal of the European Union*, 18/06/2010.

Garde F., Bastide A., Bentaleb D., Ottenwelter E. 2006. The construction of a zero energy building in Reunion Island. Presentation of a new approach to the design studies. ASME. International Mechanical Engineering Congress and Exposition. November 5-10. Chicago, Illinois, USA.

Garde F., David M., Lenoir A., Ottenwelter E. 2011. Towards net zero energy buildings in hot climates. Part 1 : New tools and methods. 2011 ASHRAE Winter Meeting, Las Vegas, USA.

Hoes P., Hensen J.L.M., Loomans M.G.L.C., de Vries B., Bourgeois D. 2009. User behavior in whole building simulation. Energy and Buildings vol. 41 p. 295–302.

IEA SHC Task 40 - ECBCS Annex 52. 2008. Towards Net Zero Energy Solar Buildings. Available from: http://www.iea-shc.org/task40/. Accessed on 2011/05/20.

Lenoir A., Thellier F., Garde F. 2011a. Towards net zero energy buildings in hot climates. Part 2 : Experimental feedback. 2011 ASHRAE Winter Meeting, Las Vegas, USA.

Lenoir A., Wurtz E., Garde F. 2011b. Zero Energy Buildings in France: Overview and Feedback. Accepted ASHRAE Transactions. Montréal, Canada.

Leysens E. 2010. Retour d'expérience : la tour Elithis est-elle vraiment un "bâtiment à énergie positive" ?. April 20. Accessed on Lemoniteur : http://www.lemoniteur.fr/195-batiment/article/etudes-de-cas/701725-retour-d-experience-la-tour-elithis-est-elle-vraiment-un-batiment-a-energie-positive

Pless S., Lobato C., Drexler J., Torcellini P., Judkoff R. NREL's Research Support Facility: An Operations Update. 2011/03/01.

Saelens D., Parys W., Baetens R. 2011. Energy and comfort performance of thermally activated building systems including occupant behavior. Building and Environment vol. 46 p. 835-848.

Sartori I., Napolitano A., Marszal A.J., Pless S., Torcellini P. and Voss K.. 2010. Criteria for Definition of Net Zero Energy Buildings. 2010 Eurosun Conference, Graz, Austria.

US DOE. 2008. Building Technologies Program, *Planned Program Activities for 2008-2012*, Department Of Energy, US, http://www1.eere.energy.gov/buildings/mypp.html (downloaded 01/07/2010).

Voss K., Sartori I., Napolitano A., Geier S., Gonzalves H., Hall M., Heiselberg P., Widén J., Candanedo J.A., Musall E., Karlsson B., Torcellini P. 2010. Load Matching and Grid Interaction of Net Zero Energy Buildings. 2010 Eurosun Conference, Graz, Austria.

Table 1 Early design: energy consumption for the ENERPOS building

	Installed load	Daily time of use	Diversity factor	Annualy time of use	Working time	Energy ratio
Air-conditioning (offices and computer rooms)	6.9 kW	9.5 h	0.75	399 h	December to March	**2.8 kWh/m^2/an**
Splits systems (technical rooms)	2.5 kW	24.0 h	0.5	8 760 h	All year	**14.7 kWh/m^2/an**
Air treatment unit	2.3 kW	9.5 h	0.75	399 h	December to March	**0.9 kWh/m^2/an**
Fan coil	0.9 kW	8.0 h	0.6	399 h	December to March	**0.9 kWh/m^2/an**
Interior lighting	3.7 kW	4.0 h	0.5	624 h	All year	**1.6 kWh/m^2/an**
Basement car park lighting	0.5 kW	1.0 h	1	365 h	All year	**0.2 kWh/m^2/an**
Front outside lighting	1.1 kW	4.0 h	1	1 460 h	All year	**2.1 kWh/m^2/an**
Patio outside lighting	0.3 kW	1.0 h	1	365 h	All year	**0.1 kWh/m^2/an**
Ceiling fans	4.4 kW	8.0 h	0.3	912 h	November to April	**1.6 kWh/m^2/an**
UPS	5.4 kW	24.0 h	0.16	8 760 h	All year	**17.1 kWh/m^2/an**
Plug loads	8.5 kW	8.0 h	0.2	1 248 h	All year	**2.9 kWh/m^2/an**
Lift	4.5 kW	1.0 h	0.2	156 h	All year	**0.2 kWh/m^2/an**

Energy index	**45 kWh/m^2/an**

Table 2 Building completion: same calculations with the actual installed equipment and more realistic occupancy scenarios

	Installed load	Daily time of use	Diversity factor	Annualy time of use	Working time	Energy ratio
Air-conditioning (offices and computer rooms)	6.9 kW	9.5 h	0.75	67 h	1 week during summer season	**0.5 kWh/m^2.y**
Splits systems (technical rooms)	0.7 kW	24.0 h	0.5	8 760 h	All year	**4.1 kWh/m^2.y**
Air treatment unit	2.3 kW	9.5 h	0.75	67 h	1 week during summer season	**0.2 kWh/m^2.y**
Fan coil	0.9 kW	8.0 h	0.6	399 h	December to March	**0.3 kWh/m^2.y**
Interior lighting	3.3 kW	4.0 h	0.5	686 h	All year	**1.5 kWh/m^2.y**
Basement car park lighting	0.7 kW	1.0 h	1	365 h	All year	**0.3 kWh/m^2.y**
Outside lighting	0.7 kW	3.5 h	1	921 h	All year	**0.8 kWh/m^2.y**
Ceiling fans	3.8 kW	8.0 h	0.3	912 h	November to April	**1.4 kWh/m^2.y**
Plug loads	2.8 kW	8.0 h	0.8	1 888 h	All year	**5.7 kWh/m^2.y**
Lift	0.7 kW	24.0 h	1	8 760 h	All year	**0.8 kWh/m^2.y**

Energy index	**15.6 kWh/m^2.y**