SIMULATION OF A MULTI-FAMILY BUILDING IN MADRID, SPAIN

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ABSTRACT

In this paper we present a case study about the application of dynamic simulation to asses the energy performance of a building in the context of a Leadership in Energy and Environmental Design (LEED) Certification. The project is a multifamily building of 74 dwellings located in Madrid – Spain.

INTRODUCTION

Energy certification processes are nowadays a common practice in many states of the European Union as a consequence of the implementation of Directive 2002/91 on Energy Performance of Buildings. In Spain it is compulsory since the Real Decreto (RD) 47/2007 establishing the basic procedure for the Energy Efficiency Certification of new construction buildings was set forth.

Although the labels that attest the qualification of the buildings should follow a common pattern throughout the European Union, and therefore they should be an international qualification, the procedure applied in each state varies according to the local regulations in force. These regulations are usually determined by the specific characteristics of the building sector of each state member, including, particularly, the level of technological competence of the various trades involved.

Besides the mandatory Energy Certifications other voluntary certifications such LEED and Cradle to Cradle are becoming widespread in the international context and Spain altogether.

For these Certifications, in addition to the building energy efficiency, other dimensions quantifying sustainability such as the water and materials cycles, indoor environmental quality, use of renewable energy as well as the construction process, including material disposal, and the building operations are taken into account.

SPANISH VS. LEED CERTIFICATIONS

LEED is a certification process that gives the tools to measure the impact on buildings performance of five key areas of human and environmental health: sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality. The process expands to three phases of the building lifecycle: design, construction and operations.

According to LEED and Ashrae 90.1-2004 energy performance of the building must be assesed in order to get the project certified. Two ways are provided to evaluate the performance: the presciptive compliance path and the whole building simulation rating method. With the second approach more credits can be scored and also very useful information about the behavior of the buildind and its systems is delivered.

Software programs like EnergyPlus, DOE-2 and Blast are suitable; the list is not limiting, and any software package meeting the required specifications can be used.

For the Spanish certification a computer simulation software of reference was developed. This software, used to determine the level of building energy efficiency, follows the general benefits options and is called CALENER (Código Técnico, 2006). The calculation engine used is DOE-2.

Although the possibility of using alternative software is being considered, the candidates are required to meet the specifications given in RD 47/2007 and must be officially approved, no alternative software has been accredited to date.

In both certification procedures computer dynamic simulation software must have the ability to model 8.760 hours per year and hourly variation in: occupancy, lighting power, miscellaneous equipment power, thermostat set points, and HVAC systems operation, defined separately for each day of the week and holidays. It must take into account thermal mass effect, a minimum of 10 thermal zones, part-load performance curves for mechanical equipment, capacity and efficiency correction curves for mechanical heating and cooling equipment, air-side economizers with integrated control as well as building design characteristics specified.

There is an important difference between these two certifications concerning standard building performance.

In the Spanish procedure the building's performance is compared to the so called *reference building*, it must have the same shape, thermal zones and envelope definitions as the design building but meeting the minimum prescriptive requirements of the CTE - Technical Building Code. The consumption's results will be given by its computer simulation and directly compared to the results obtained for the proposed building.

In the LEED procedure, the *baseline building* fenestration area must be equal to the fenestration area of the designed building up to 40 % of overall exterior wall. If the designed fenestration area is greater than 40 % of total façade area, the exceeding glass area is counted as an opaque surface. Fenestration area shall be distributed around the building in a uniform manner. Windows should be distributed in horizontal bands on each exterior wall.

The computer simulation must be generated by the original orientation and again after rotating the entire building 90, 180 and 270 degrees. The total energy baseline building's consumption will be the average of the 4 computer simulation results.

In the LEED rating well designed and oriented buildings, such the project of reference, get a premium over spanish certification.

It is understood that for voluntary certifications such LEED there are no regional conditionings for implementation. Obviously, any certified project has to respect the enforcement of the local building codes and regulations.

PROTOCOL FOR IMPLEMENTATION OF A LEED CERTIFICATION.

The development of a LEED certification requires the establishment of a protocol for linking all the agents involved in the process: owner, designers, builders and certification agents. We have summarised the referred phases in the protocol table showed below.

The content refers essentially to the chapters of Energy and Atmosphere, Interior Environmental Quality and Innovation and Design Process for the LEED certification design.

This protocol defines the needs for dynamic simulation during the different phases of the certification process.

Table 1
LEED CERTIFICATION PROTOCOL
FOR NEW CONSTRUCTION- DESIGN PHASE

ENERGY & ATMOSPHERE
INDOOR ENVIRONMENTAL QUALITY
INNOVATION & DESIGN PROCESS
DESIGN PHASE

LEED Specification compliance	
1.A. Prerequisites	Basic
1.B. Prescriptions	Basic
Project Design validation	Basic
Baseline Building computer simulation	Basic
Prospective score	Basic
Efficiency Proposals	
4.A. Bioclimatic Efficiency	Advanced
4.B. Energy Systems Efficiency	Advanced
Proposal's Validations	Advanced
Detail Design Project Validation	Basic
Detail Design Project simulation	Basic
Project Score	Basic
Bidding and Contracting Process Phase validations	
9.A. Elements	Basic
9.B. Equipment	Basic
9.C. Systems	Basic
Final building simulation	Basic
Submittal Templates for Design Certification	Basic
CONSTRUCTION PHASE	
Commissioning	
Additional simulation if required	Basic
Submittal Templates for Construction Certification	Basic

Basic
Advanced

Whereas the basic option will be enough to ensure plain certification, the advanced options are appropriate in cases where it is intended to achieve a qualified level: silver, gold or platinum.

The identification of concepts for architectonic and energy sustainability arouse from an initial feasibility analysis with the building owner and the design team.

These concepts include:

-Construction: Insulation, glazing, sun protection, etc.

-Electromechanical systems: cogeneration, solar thermal, solar cooling, photovoltaic, geothermal.
- Advanced ventilation systems.

The concepts feasible to integrate in the project were analyzed to evaluate their potential LEED score. The results and proposals were submitted to the building owner and his design team to be selected and ultimately incorporated into the final design. The energy improvements were analyzed by comparing the consumption results between the baseline building and the proposed building.

Dynamic simulation is essential for energy certification in any context and also quite useful during the building envelope and systems design process in order to maximize thermal and energy performance.

APPLICATION TO A MULTIFAMILY BUILDING IN MADRID

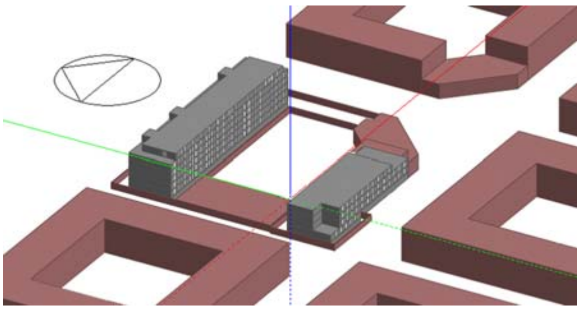

Figure 1 Building Case Study

The building is located in the neighbourhood "Ensanche Barajas" of Madrid.

The building being certified consists of two parallel blocks of dwellings with East-West alignment. The north block is a 6 floors building and the south a 4 floors one. They amount to 74 flats overall. The master plan also includes a shopping area and a parking area in the basement.

Input data definition

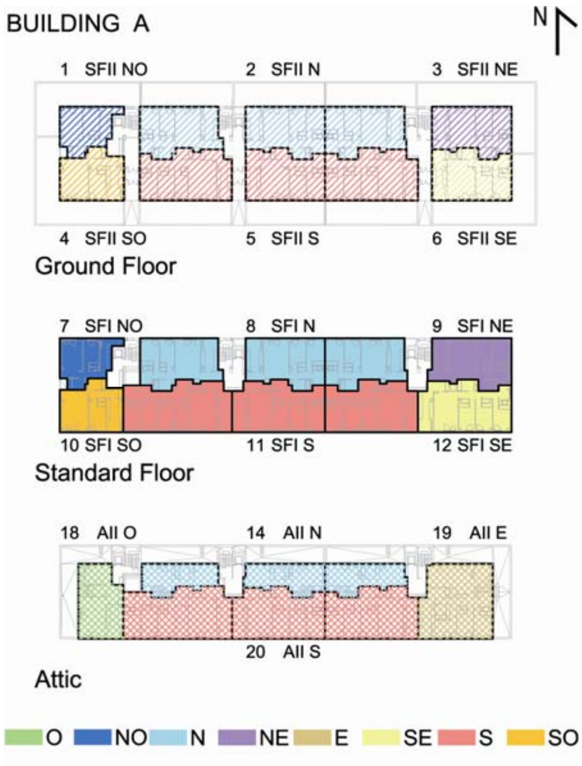

Figure 2 Building Flat Typologies

The computer simulation is based in flat typologies defined by the space conditioned areas of each block, according to orientation and position in the master plan. The resulting typologies are identified for each plant.

The baseline building model definition was simulated according to the CTE-HE-1 for the climate Zone D3 and to the standard Ashrae 90.1-2004 international climate zone 4, using the meteorological data of the Barajas airport in Madrid.

Construction characteristics such as surface's materials, insulation and infiltration, openings, glazing, doors and solar protection were simulated according to regulation's minimum requirements. The characteristics and material's specifications were taken from the databases of the CTE-Lider.

Parameters on activity like internal charges, set point temperatures and ventilation rates were established after the "Document of acceptance's conditions of Alternative Procedures": Alternative programs Lider and CALENER. (Instituto para la Diversificación y el Ahorro Energético IDAE, February 2007).

The HVAC system to supply the heating and cooling demands of the baseline building is taken as a conventional system based on a collective natural gas boiler for space heating and hot water service and individual heat pumps for space cooling. The performance data have been taken from the computer simulation software used.

The proposed building incorporates solar thermal collectors for hot water service.

Programming

In order to obtain simulation results, a transposition of mandatory local regulations concerning ventilation, activity, internal loads and comfort set points has been done. Several simulations were done using different user profiles (UP) but finally CTE UP were used.

Results Presentation

Total energy consumption estimates for the baseline building and the designed building must be compared in order to calculate gains and savings. Total energy is the sum of regulated energy and process energy. Regulated energy is the sum of energy consumption from the building and its associated services. Process energy is the energy required exclusively to perform the activity for which the building is designed for. If not evaluated in detail, process energy is considered as a default value and set equal to 25 % of baseline building's total energy consumption. This is the case for this multifamily development where final household appliances installed are not known at present design phase.

Besides totalizing energy demand and consumption on a year around basis, output from the dynamic simulation gives comprehensive information about passive behaviour of the building, detailed thermal fluxes and indoor comfort conditions in different time scales: monthly, weekly, hourly or subhourly. This information is suitable to analyse and quantify all parameters and variables needed to perform building energy efficiency assessments.

Graphical samples of this information are given in next paragraphs.

Results from the designed building

In the Figure 3, weekly data on three items are shown for a summer design week of a standard flat and in the Figure 4, for the winter design week.

-Indoor temperatures: radiant, convective and operative

-Thermal fluxes through all kind of walls : glass and opaque.

-Ventilation rates.

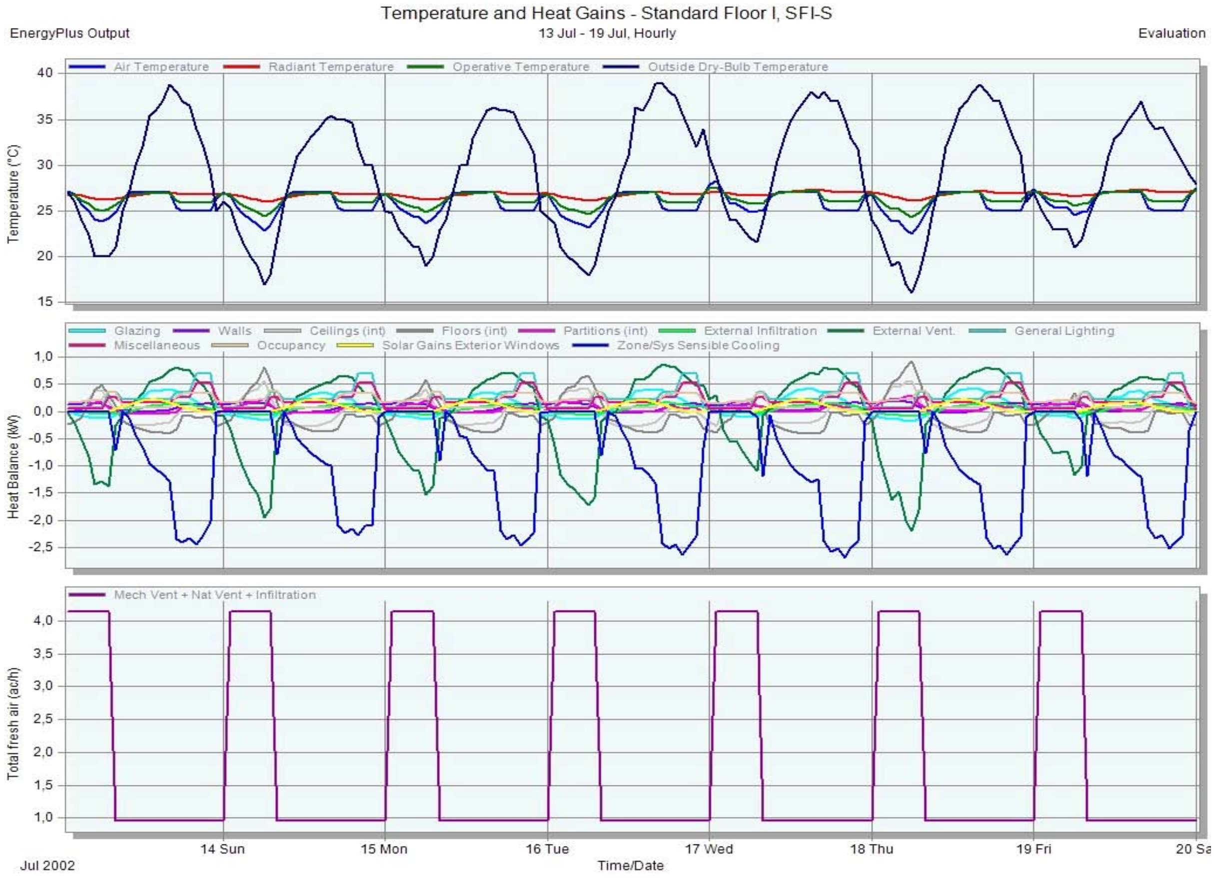

Figure 3 Summer Design Week

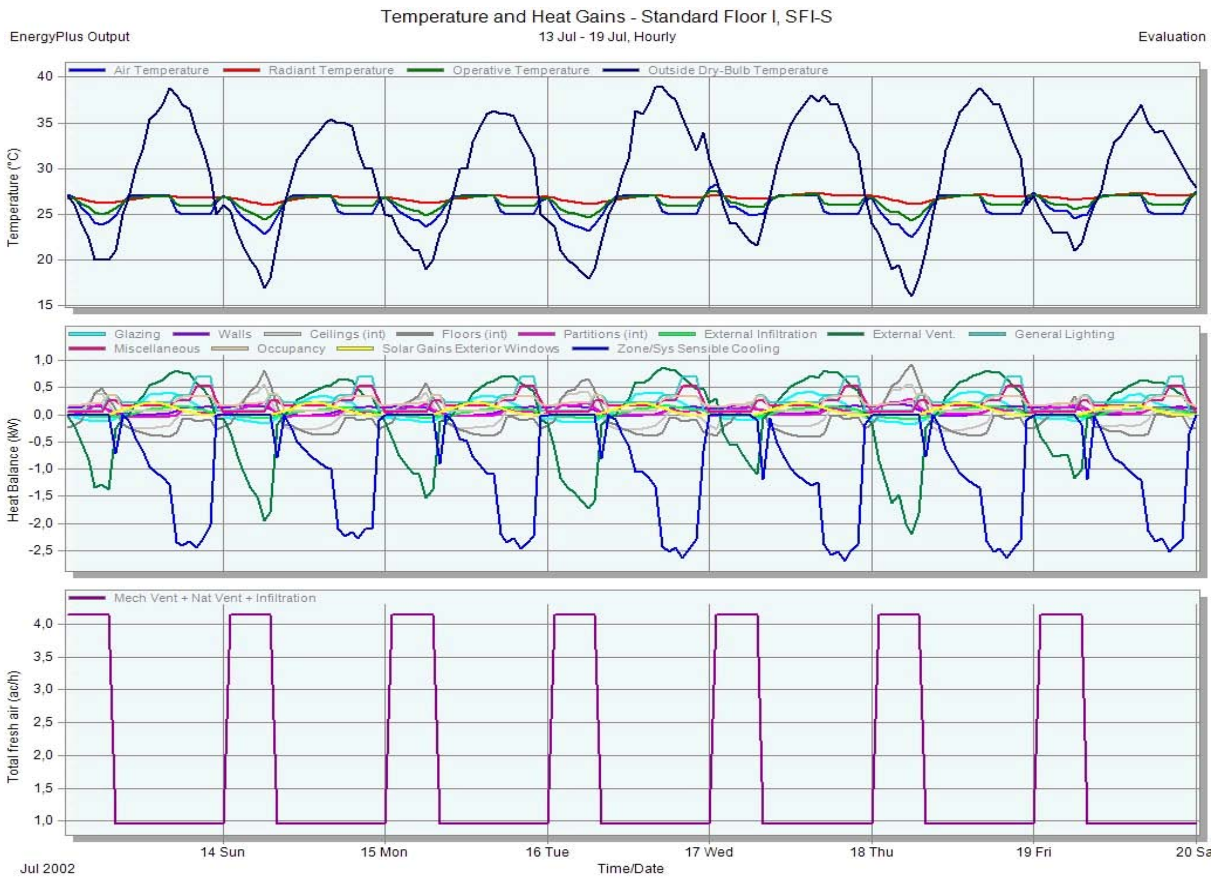

Figure 4 Winter Design Week

Total energy balance of the designed building

All energy consumptions delivered by the dynamic simulation package are aggregated following the LEED breakdown and summarised following the Ashrae's diagram for energy end use.

Table 2 shows a Bisbel VPL (Vivienda de Promoción Libre) - Proposed's Energy Balance based on Process Energy Default Cost.

The same format is used to present the end use energy diagram for the baseline building.

COMPARISON OF RESULTS

Total energy consumptions for both buildings must be compared. A minimum 14 % improvement of the designed building upon de baseline building is mandatory and allows to score 2 points for LEED ranking table.

Table COMPARISON

BASED ON PROCESS ENERGY DEFAULT COST

Energy	Baseline	Proposed	Difference		Points
	Kwh/ Year	Kwh/ year	Kwh/ year	%	LEED
Regulated Energy	732997	587459	145538		
Process Energy	244332	244332	0		
Total Energy	977329	831791	145538	15	**2**

A total of 10 points can be scored under the Optimized energy performance credit provided energy savings up to 42 % are accredited.

More points can be scored under the credits listed in the LEED rating system covering all the sustainability issues discussed in chapter 2.

CONCLUSIONS

Dynamic simulation is a requirement for mandatory energy certifications in the European Union countries. Voluntary energy certifications are based on dynamic simulation tools as well.

Besides the certification use, dynamic simulation is a powerful tool for designing purposes: either to optimize bioclimatic performance or energy systems efficiency.

In this project of multifamily housing, once the feasibility of LEED certification has been established, we are set to go through the improvement and optimising phase to achieve a higher LEED label.

REFERENCIES

Directiva 2002/91/EC del Parlamento Europeo de 16 de diciembre de 2002 sobre las prestaciones energéticas de los edificios.

Procedimiento Básico para la Certificación de Eficiencia Energética de los Edificios de nueva construcción. R.D. 47/2007 de 19 de enero.

LEED R – for New Construction & Major Renovations. Version 2.2, October 2005. US Green Building Council. LEED r is a registered trade mark of the U.S. Green Building Council.

Cradle to Cradle, 2002. Remaking the way we make things. William Mac Donough and Michael Braungart. EcoIntelligentGrowth – Barcelona- Spain.

Informative Appendix G Performance Rating Method - Ashrae 90.1.2004.

CALENER, 2006. Developed by the Thermotechnical Group of the Association for Research and Industrial Cooperation of Andalusia, AICIA, in collaboration with the Eduardo Torroja Institute of Building Sciences, IETCC, promoted by the Ministry of Industry, Tourism and Trade through the IDAE and the General Architecture and Housing Policy of the Ministry of Housing.

Real Decreto 314/2006 de 17 de marzo. Código Técnico de la Edificación DB-HE / Ahorro de Energía.

Table 2
BISBEL VPL - PROPOSED'S ENERGY BALANCE BASED ON PROCESS ENERGY DEFAULT COST

TOTAL		**LEED BREAKDOWN**	**CLIENT**			**TOTAL KWH/YEAR**					
%	Kwh/year		Building A	Building B	Stores						
70,6	**587459**	**Regulated Energy**	426766	160.693							
		SWH	121348	43217							164565
		HVAC	197705	79011							
		Exhausts	39277	13568						52845	
		Air Handlers	2373	820						3193	
		COOLING	48755	18721					67476		
		HEATING	107300	45902				153202			
		LIGHTING	107713	38465			146178				
		Indoor	107713	38465							
		Outdoor									
		Parking									
29,4	**244332**	**Process Energy**	**177279**	**67053**		244332					
		Computers									
		Terminals									
		Tech Rooms									
		Miscellaneous									
		General Services	177279	67053							
	831791	**Total**	**831791**			244332	146178	153202	67476	56038	164565
100,0			100,0			29,4	17,6	18,4	8,1	6,7	19,8
						PLUG	**LTG**	**HTG**	**CLG**	**FAN**	**SWH**

Purchased Energy : Electrical Utility & Natural Gas
Natural Gas : HTG + SWH
Electrical Utility : PLUG + LTG + CLG * FAN

ANNUAL ENERGY END USE - ASHRAE DIAGRAM