The GENHEPI Concept: a New Methodology for Low Energy Consumption Building Renovation Demonstration Program

L. Sarrade, A. Manificat, D. Corgier

INES RDI, CEA, Savoie Technolac, BP 332, 50 avenue du Lac Léman
73377 Le Bourget du Lac, FRANCE

ABSTRACT

French buildings highly contribute to the total national energy consumption. In order to inflect the increasing tendency, significant efforts have been encouraged by public institutions.

Accordingly, the GENHEPI concept, hereunder described, aims at methodically investigate retrofit operations to ensure an effective renovation of existing buildings. Its first phase consists in preparing and elaborating projects development by a global energy approach. Modelling and sensitivity studies of various technical solutions permit this analysis. Then, an incremental improvement of performances is allowed by monitoring and interpretation of data obtained on each project. A multi competent team is gathered around the projects: researchers, architects, engineering offices, firms, banks and public institutions. Working together stimulates creativity which proves reliable on the currently carried out actions.

The main objectives are focused on a reduced consumption of primary energy and a considerable decrease of greenhouse gas emissions, while keeping in mind the economic optimization. On the first demonstration operations, the objectives amount to a total value of 50 kWh/m²/an of primary energy for heating and cooling supply, and aim at a reduction factor of 4 on the CO_2 emissions.

The case study of the first GENHEPI building makes it possible to illustrate the concept. Development of the analysis and various simulations resulting from TRNSYS 16 model are exposed and discussed in this document. Results underline the necessity of a detailed work on the building envelope. Beside, intelligent regulation of the multi source energy system is an important criterion for energy savings.

KEYWORDS

Building, Renovation, Energy, Heat pump, Modelling, Sensitivity studies

GENHEPI METHODOLOGY

Concept

Three phases typically structure a restoration project: the planning phase, the conception phase and the realisation phase. Engineering offices usually work with architects during the conception phase. Due to both a lack of time and means, the studies are often based on former experiences. Architects and engineering offices actually use ratios to define the new energetic system or the additional insulation needs. These methods result in non optimised operations and are far from being energy efficient approaches. Indeed, not only the specificity of the each building is not considered enough but the fact that monitoring project and experiences feedback are quite never carried out allows errors to be reiterated.

GENHEPI concept aims at answering these problems by integrating two additional phases in the classical process. The first one consists in analysing acurately the project by modelling and sensitivity studies of various technical solutions adapted to a global approach. It occurs upstream of the conception phase and gives good orientations to the project. The second one intervenes downstream the realisation phase and consists in collecting and analysing data given by the building monitoring.

The work undertaken in this methodology is financed both by public institutions and research programs in which the cases study are subjected as demonstration projects. In order to have a global vision of the renovation operation, a multi competent team is gathered. Technical point of view can be given by researchers, engineering offices, architects and firms; financial point of view by bank and public institutions; and social point of view by users themselves. This kind of partnership obviously stimulates the creativity because of its diversity. Beside it allows a better communication and then knowledge in interactions between housing actors.

Objectives

Different steps of objectives can be identified. The first one appears in the choice of the building typology to inscribe in GENHEPI methodology. The most important criterion is the potential reproducibility of the operation. Indeed, a large diffusion of the concept won't be achieved if judicious building typologies are not selected. The first target is the tertiary sector and more particularly office buildings. Existing similarities between many of them explain this focus. Later, the project will be opened to other typologies like social housing or more specific infrastructures like gymnasium, hotels…

Two main criteria direct the technical choices: the primary energy consumption and the greenhouse impact of heating, cooling and preparing hot water. Sensitivity studies are carried out to reach high performance. Typically, for the demonstration operation hereunder described the objectives amount to a total value of 50 kWh/m²/an of primary energy for heating and cooling supply, and aim at a reduction factor of 4 on the CO_2 emissions.

CASE STUDY

Building presentation and problems

The first case study is the ALLP head office (Association Lyonnaise de Logistique Post-hospitalière). The construction is located in Lyon, France and dates back to 1974. See Figure 1 for a picture the building.

Figure 1: ALLP building picture

The building energetic performances are tainted by a hold internal insulation, simple glazing and many cold bridges. A new gas boiler of 350 kW has been installed in 2004.

One of the main problems underlined by the building owner is summer comfort. Indeed, workers complain about too high temperatures in offices which penalize productivity by increasing absenteeism. In June 2005, 34 °C were measured in a southern exposed office of the first floor. These conditions are not acceptable and thus explain the desire to cool the building.

Passive solutions

Efforts were carried out to analyse passive solutions impact on summer conditions. The objectives were both to satisfy users' demand improving comfort and to avoid a cooling system. Modelling and simulation of the building allowed an estimation of hard summer conditions in critical offices. The graph in Figure 2 highlights the temperatures evolution during the third June week in every building zone. The temperatures can reach more than 40°C in the second floor zone and about 35°C in the first floor. Results from the TRNSYS model are approved by the 34°C measured in June 2005. Then the work consists in iterative simulations with successive passive solutions integration in an economical logic. The third June week was kept for the following simulation since it is one of the hottest in Lyon and it represents a period which only few workers choose for their vacations. The building can also be simulated in standard conditions of occupancy.

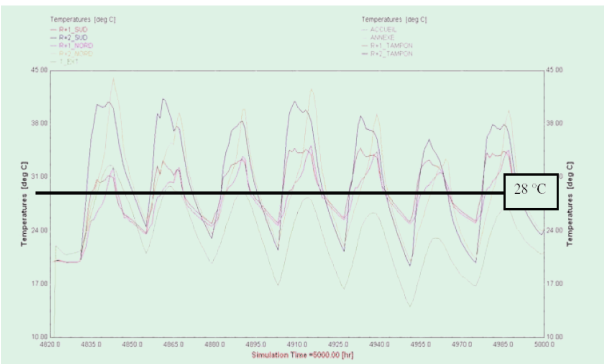

Figure 2: Zones temperatures evolution in June

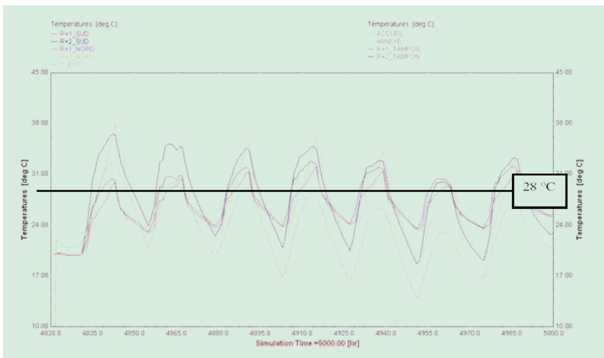

Figure 3: Zones temperatures evolution with external shading devices

The first passive solution added in the model was external shading devices. The results of this modification are shown in Figure 3. The hypothesis that the external shading device could intercept 60% of solar radiation directed to the window was taken. This modification involved an important reduction of zone temperatures but not enough to reach acceptable comfort conditions. On top of that, it is quite difficult to predict how workers will use the shading devices. The real results depend actually on users' behaviour and that's why simulation results have to be taken carefully.
Next step consisted in the integration of an efficient lighting and high night ventilation (about 3 volumes per hour). It came significant lower temperatures which can be seen on the graph Figure 4. The curbs underline a decrease of the night temperature level. However, due to a lack of inertia in the building, it remained impossible to keep low temperatures in zones all day long.

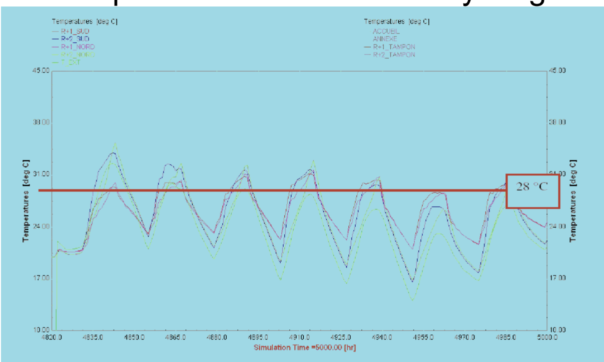

Figure 4: Zones temperatures evolution with high night ventilation

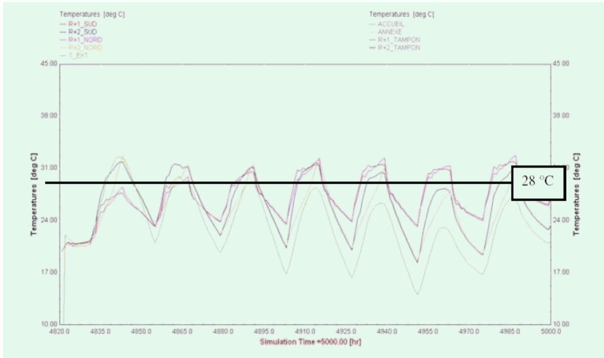

Figure 5: Zones temperatures evolution with double glazing with reflective layer

Last solution which deserved to be analysed was the change of windows. Indeed, simple glazing is efficient neither for winter nor for summer conditions. Double glazing with reflective layer was also integrated in the model. Figure 5 illustrates the new evolution of zone temperatures. Integration of double glazing with reflective layer smoothed the peaks. This phenomenon can be explained by the insulation capacity added with double glazing.

Despite all the efforts to integrate passive solutions, the summer working conditions remained uncomfortable. A cooling system installation seemed also necessary. However, we found it useful to consider the problem with a global approach. Instead of installing an air conditioning system, a reversible solution could appear adapted. Then not only must have the summer period been taken into account but the winter one too. Energetic consumption and greenhouse gas emission were also calculated yearly. These criteria interfered with the building envelope technical choices.

Global approach

One of the GENHEPI concept objectives is to decrease energy consumption while increasing comfort. The ALLP project is also clearly in GENHEPI spirit. The global approach consists in parametric analysis carried out to identify the optimum technical choices. Our first work was focused on the envelope and aimed at observing the influence of several technologies on global consumption and CO_2 emissions.

TABLE 1

Characterisation of glazing types used in the model

	Description	Design	Coeff U	T - sol	T - vis
SV	Simple glazing	2,5	5,74	0,85	0,901
DV	Double glazing	2,5 / 12,7 / 2,5	2,95	0,727	0,817
DV Le	Double glazing low emission	3 / 12,7 / 2,5	1,76	0,544	0,769
DV Le Ar	Double glazing low emission with Argon	3 / 12,7 / 2,5	1,43	0,544	0,769
DV couche	Double glazing with reflective layer	4,6 / 12 / 2,2	1,58	0,319	0,604

Table 1 describes one of the parameters whose influence has been observed. Main thermal characteristics of glazing type are design, thermal loss coefficient (Coeff U W/m².K), global solar transmission factor (T–sol) and visible solar transmission factor (T–vis). Figure 6 and 7 give tendency of respectively annual primary energy consumption and CO_2 emissions depending on the glazing choice.

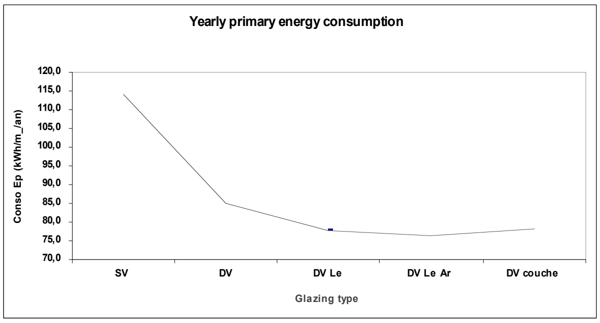

Figure 6: Glazing influence on annual primary energy consumption

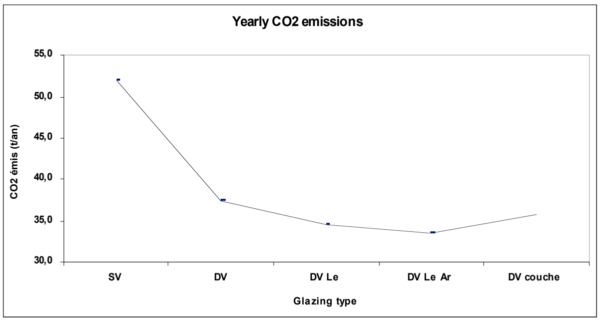

Figure 7: Glazing influence on annual CO_2 emissions

For both energy consumption and CO_2 emissions, a minimum appeared with double glazing low emission filled with Argon. Double glazing with reflective layer would have been chosen if only summer comfort had been considered. In this case study, limitation of solar gains by windows actually increases heat demand and affects global assessment. Such analyses have been carried out for other parameters like night ventilation rate or insulation thickness. Once best technical choices were done, simulate building performance remained lower than GENHEPI objectives. A work on the energetic system must complete the work on building envelope.

Energetic system

An air conditioner system generates important consumption but is necessary to sustain comfort in offices. A reversible heat pump coupled to the existing gas boiler could answer the comfort problem decreasing heat consumption. This energetic system has been simulated for the ALLP building. Figure 8 displays the performances of three systems. An air conditioner (AC), an air/water heat pump (HP A/W) and a water/water heat pump (HP W/W) were compared. The latter was considered because of local ground water presence. Two kinds of regulations were studied for A/W heat pump. The first one aims to minimize CO_2 emissions and the second one, the primary energy consumption. To minimize CO_2, the heat pump has to work continuously since, in France, an average electric kWh contains less CO_2 than a gas kWh, whereas, to minimize primary energy consumption, the heat pump has to be switched off as soon as its performance coefficient becomes lower than 2,58 (factor which link electric and primary energy in France).

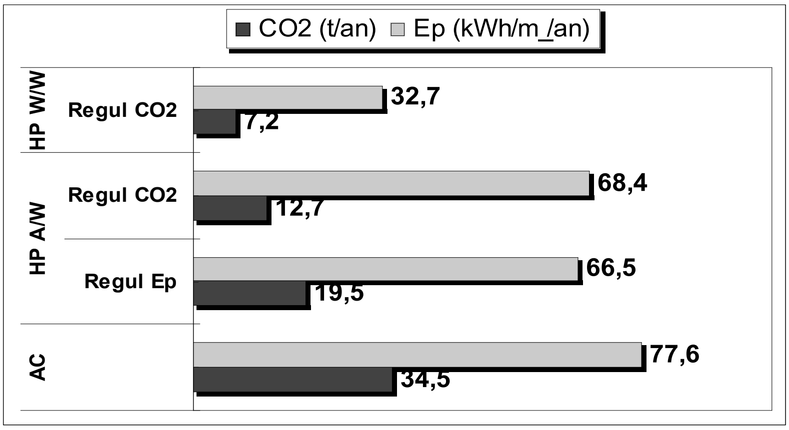

Figure 8: Energetic system performances

The highest performance system was obviously the W/W heat pump. However, an A/W heat pump was chosen due to a better reproduction potential of the renovation operation. The minimisation of CO_2 emissions was selected but the possibility to change the kind of regulation was kept.

CONCLUSION

GENHEPI approach for this realisation allowed important energy savings. Instead of installing an air conditioning system, a global work was carried out both on the envelope and the energetic system. The result of this is that simulation studies foresee that a factor 2 will be reached on primary energy consumption and a factor 4 on CO_2 emissions. The famous factor 4 on CO_2 seems then available even in renovation operations. The common typology of the ALLP building leaves to think that such an operation can be easily reproduced. The monitoring phase will begin at the end of 2006 and we hope it will confirm results from simulation.

References

[1] Sarrade L, Manificat A and Corgier D (2006) Rapport d’activité GENHEPI. CEA – INES RDI - Fr

[2] Sarrade L (2005) Optimisation des systèmes thermiques intégrant une pompe à chaleur et mise en application dans le projet de rénovation d’un bâtiment tertiaire. CEA – Institut ENSAM de Corse - Fr

[3] Chabot B (2004) La méthode TEC d’analyse économique – Présentation générale. ADEME – Fr

[4] Chabot B (2004) La méthode TEC d’analyse économique – Application aux choix d’investissements économes et efficaces. ADEME - Fr