RESIDENTIAL SIM-FAST: SOFTWARE FOR RAPID TECHNICAL APPRAISALS

Francis Déqué, Laurent Catusse and Sophie Castanet
Electricité de France / Division Recherche et Développement
Département Applications de l'Electricité dans les Bâtiments
Centre des Renardières, Route de Sens-Ecuelles, F 77818 Moret sur Loing France

ABSTRACT

This article presents the SIM-FAST software : it is a tool which allows to evaluate the energy consumption and the financial cost of French buildings in the Residential sector. Thanks to the limited number of parameters which must be entered to describe the building, it provides rapid appraisals in less than one hour. It provides global results in terms of both energy consumption and financial cost as well as time-based change of temperatures and flux. It operates under Windows 95 with 12 MB RAM.

INTRODUCTION

The main orientations of future software were presented in Prague during the last IBPSA congress [1]. These orientations arose from of the suggestions made during the two conferences organised by the DOE (Department of Energy) and the DOD (Department of Defence) in 1995 and 1996 [2].
SIM-FAST which is a simulation program in the Residential sector, does follow these orientations. It is characterised by:

- Simplified data entry, limited to less than 20 data items.
- An easy to use interface based on the use of the latest object oriented techniques.
- Integrated technical appraisal based on the use of model reduction techniques.
- Interoperability enhanced by dynamic links between SIM-FAST, Word and Excel.

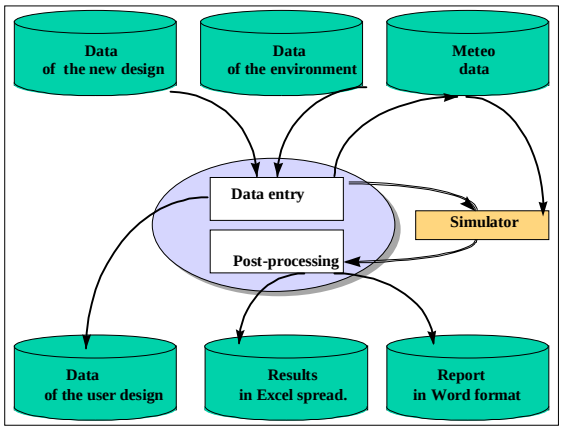

Figure 1

SIM-FAST's purpose is to calculate energy consumptions within the framework of new heating and air conditioning proposals made by Electricité de France. It is designed to produce rapid technical appraisals in less than 24 hours. It runs on a PC under Windows 95 and requires at least 12 MB RAM.
It has a modular architecture providing complete separation between processing, data and the user interface (UI), available in French version. This architecture is displayed on Figure 1.

USER INTERFACE: LESS THAN 20 DATA ITEMS TO BE ENTERED

SIM-FAST's main feature is to simulate the energy response behaviour of buildings through the entry of a minimum number of data items.
For homes in the residential sector, the user describes the building with the following simple data (see Fig 2):
- housing type (detached house, flat),
- construction type (over platform, over crawl space, etc.),
- heat loss of building (GV),
- living space,
- window area by direction,
- window type (French window, window, etc...).

For heating and air conditioning systems, the user determines the type of emitter (Convector, electrically heated floor, etc.), the installed power, and the regulation scenario for intermittence.
Electrical appliances (lighting, domestic hot water, household appliances, cooking) are entered simply in relation to a standard level (100 Watt/m2/day). **In all, no more than 20 data items need to be entered**.

USER INTERFACE: THE POWER OF OBJECT-ORIENTED PROGRAMMING.

The aim of the user interface is to combine simplicity with high performance. For simplicity purposes, a single principle is used in SIMFAST: a multi-function selection button associated with a graphic.

icon. This so-called dynamic icon changes appearance according to the chosen selection.

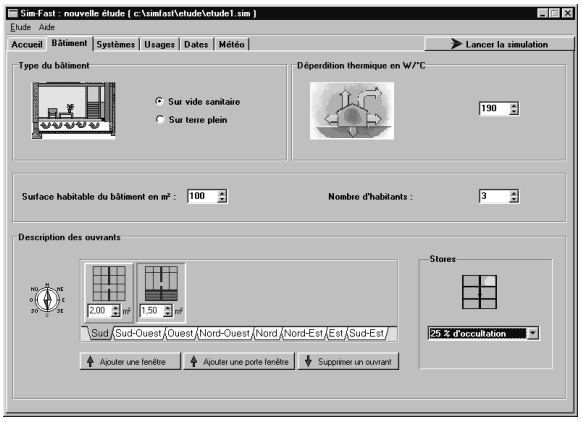

Figure 2 : Data entry parameters for the building

Example: Selecting the emitter in the list makes a heated floor or electrical convector icon appear (see Fig. 3).

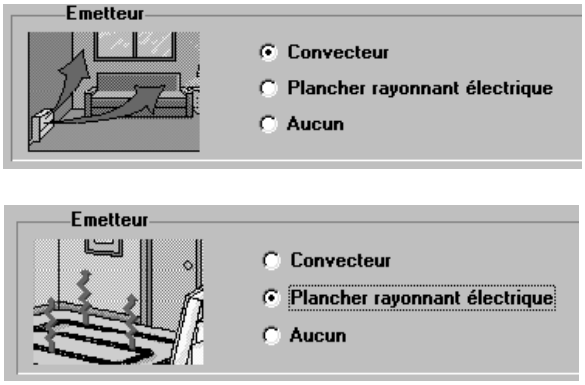

Figure 3 : Dynamic icons in SIM-FAST

The performance of object-oriented programming environments now provides this simplicity for the use of graphic objects. SIM-FAST is based on DelphiTM [3], an object-oriented visual programming environment.
The main functionalities of this environment are:
- an integrated development environment,
- a reusable component library,
- tools for the use of databases.

EDF/DRD TECHNICAL APPRAISAL INTEGRATED INTO SIM-FAST.

SIM-FAST is based on the integration of two different technical appraisals:

- the first is derived from model reduction techniques,
- the second is based on the physical knowledge of the phenomena studied (Buildings, heating/air conditioning systems) capitalised by parametric studies performed in CLIM 2000 [4].

The building model resulting from reduction techniques.

The simulator is based on a reduced building model. This 2nd order model is the result of reduction techniques. Reduction is the technique involved in the transition between a physical model, obtained from CLIM 2000, and a simplified model, which can be ported onto any data processing environment. Moore's reduction[5] is the technique which is used to build the generic building model in SIM-FAST. This is a truncating technique which eliminates part of the model so that only the dominant components of the model are conserved. This truncation is based on a base change which enhances the links between model inputs and the observed outputs. Only the strongest links are conserved in the reduced model. For a building model, the effect of outside temperature, solar flux and heating power on the inside temperature of rooms is thus fully represented in the reduced model [6]. However, the parameters of this reduced model lose their physical meanings. The following phases associate the geometric and thermal parameters (heat losses, wall area, etc.) with the parameters of the reduced model.

Technical appraisal to design generic models.

The models included in SIM-FAST are derived from the expertise acquired from more than a hundred building configurations representative of the French base. The building model steady state is calculated by analytical relations. The time constants, representing the dynamic part of the model, are established from correlations made by parametric studies in CLIM2000. This is also the case for the heating and air conditioning systems.
In order to determine the energy consumption, the following choices have thus been made:

- a reduced 2nd order building model,
- a 1st order heating system model with a gain, used to define the efficiency of the system,
- for thermodynamic systems (heat pumps, air conditioning systems), the technical specifications of thermal machines are incorporated in the form of polynomials (second order interpolation according to the outside temperature and damp inside temperature).

STRONG INTEROPERABILITY BETWEEN SIM-FAST, WORD AND EXCEL.

SIMFAST communicates with Word to generate a report for each study and with Excel to save the set

of simulation results. This transfer of dynamic information is made possible by object-oriented design techniques and in particular by the concept of distributed objects.
This concept of distributed objects involves assembling objects to form the desired application. To settle such an architecture, it was necessary to arrange for objects to be able to communicate between each other, to achieve better interoperability.
Several software publishers have produced a number of technologies allowing objects to communicate with each other.
MicroSoft has developed technique known as COM and its distributed version DCOM to allow applications (Word, Excel, Power Point, etc.) to communicate with each other.
This technique has been adopted in SIM-FAST for the generation of Word and Excel reports. More specifically, we use the "OLE automation" (Object Link and Embedding) technique which is a specific implementation of the COM/DCOM model.
The "OLE automation" technique allows an "Automation controller" customer application to control an "Automation server" server application. The commands are formulated by the customer and conveyed by MiddleWare and then sent to the server to be executed (see Fig. 4).

```
{=======================================
=======================================}
Function writereport (const Nom : TFileName) :
Boolean;
{=======================================
=======================================}
...
 sNomDoc := ChangeFileExt (Nom, '.doc');
 Word := CreateOLEObject('word.basic');
 Word.fileopen(sRepertoireData + '\' + sFichierDoc);
 Word.Filetape(sNomDoc);

  {=== writing the name of the study ===}
  Word.Edit('NOMETUDE');
  Word.Insert(sNomEtude);
....
```

Figure 4 : Name of the SIMFAST study written in the Word file.

The result is a Word report, automatically generated from SIM-FAST and containing the set of characteristics of the study (see Fig. 5).

SIM-FAST: ACCURATE, VALIDATED RESULTS.

Two levels of results are available in SIM-FAST:
- Results tables, available under Word (see Fig. 5), presenting the operating cost as a function of the charging basis. A comfort index indicates the proportion of time during which the set Temperature is reached.

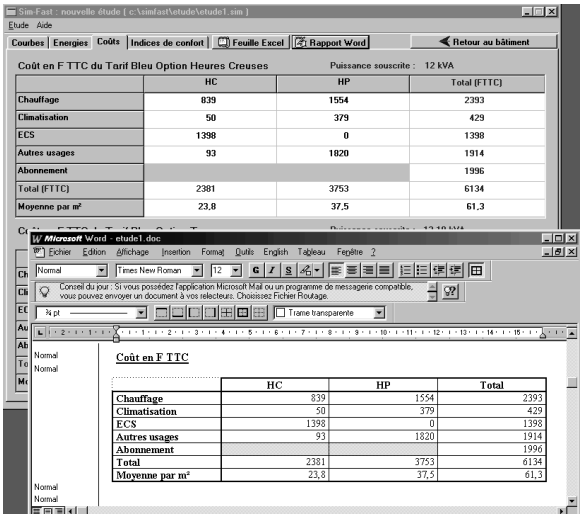

Figure 5 : Results table under SIM-FAST and Word

- Temperature and flux graphs (see Fig. 6) show how the main variables (outside and inside temperatures, heating power, etc.) vary on an hourly basis.

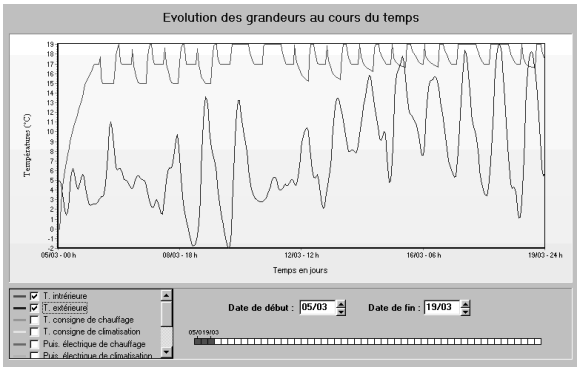

Figure 6 : Temperature graphs

SIM-FAST is validated through comparison with both CLIM 2000 physical models and experimental measurements. The physical models, based on an area and described by more than 500 parameters, act as a reference. The simulations were carried out over a period from October 1 to May 21 with a convector type heating system. For an "Off-peak period" rate, **the difference in the energy bill is less than 2.5%** between SIM-FAST and the physical models. Figure 7 displays these results.

"MI2" represents a single-story detached house built on an underfloor space (110 m^2). Only this physical model was used as a reference model during the development of the reduced model in SIM-FAST. The following models are used to validate the SIMFAST model by comparison with CLIM 2000.

"MI2_GV-10%" is an "MI2" solution with a reference GV at -10%.
"MI3" represents a 2-story detached house with a half-buried garage (138 m^2).
And finally, **Achères, which is, first of all, a real home of 95 m^2** over a platform with two common walls. **The Measurement / Detailed model difference is 5%. The difference between the detailed model and SIM-FAST is 2.2%.**

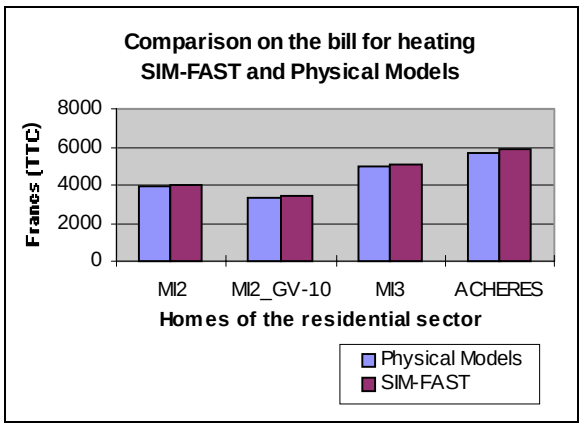

Figure 7: Bar chart recapitulating the SIM-FAST performance

In addition, the air temperature dynamics of homes and the powers drawn (see Fig. 8) are correctly represented in SIM-FAST.

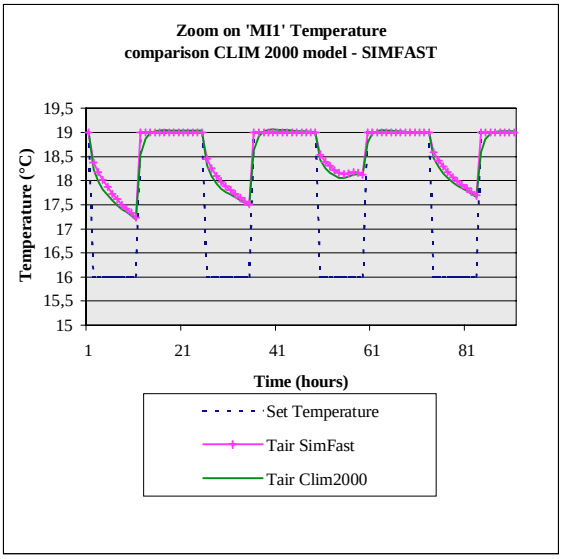

Figure 8: Temperature variations in "MI1" Comparison between SIM-FAST and the CLIM 2000 model.

CONCLUSIONS

SIM-FAST makes it possible, through simulation, to evaluate various types of emitters and also various structural solutions for energy consumption calculations. Through the limited number of parameters to be entered, it provides a tool for rapid technical appraisals in less than 1 hours. SIM-FAST does not, however, replace CLIM 2000 physical models for calculations involving ventilation, humidity, comfort, etc. It rounds out EDF's research and development division's range of software. It is positioned downstream of codes such as CLIM 2000, used to finely model the thermal response phenomena in buildings, or CA-SIS [7], which is a building simulation tool with a graphic interface (CAD)

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