



HOMES :

Homes and buildings for
Optimized Management
of Energy and Services -
*Collaborative and innovation
programme -*

september 2011

HOMES

Delivering active energy
efficiency solutions
accessible for every
building



HOMES

(Homes and buildings for Optimized Management of Energy and Services)



The HOMES collaborative innovation programme is designed to create solutions for achieving optimal energy performance in all buildings. The four-year (2008-2012) programme is supported by the French Agency for Innovation (OSEO) and led by Schneider Electric. Its thirteen members are manufacturers and researchers with synergistic expertise in building management: CEA, CIAT, CSTB, Delta Dore, EDF, Idea, Philips Lighting, Radiall, Schneider Electric, Somfy, STMicroelectronics, Watteco and Wieland Electric. Together, they are designing solutions to optimize energy use, diversify energy sources, sustain energy performance and facilitate the deployment of energy management systems in new and existing commercial and residential buildings in Europe.

Objective of HOMES:

To equip each building with solutions to achieve the optimal energy performance.

13 Partners

CEA, CIAT, CSTB, Delta Dore, EDF, INPG, Philips Lighting, Radiall, Schneider Electric, Somfy, STMicroelectronics, Watteco, Wieland Electric.

7 Cooperators

FFIE, Manaslu, Electen, Le Confort Electrique, Michel Chiffre Sarl, Perrin Electric, Realiss.

120 researchers



Buildings: quick & accessible energy gains

> 40%

energy consumption in Europe can be attributed to commercial and residential buildings

Existing buildings in Europe:

- > 250 million housing units
- > 30 million non-residential buildings
- > 30,000 million m²

> 300 kWh/m²/year

is the average consumption of European buildings

Breakdown:

- 50% heating
- 15% lighting
- 10% cooling and air-conditioning
- 5% domestic hot water
- 20% for other consumption (excluding industrial processes).

Buildings, a tremendous source of energy savings

In Europe, buildings account for nearly 40% of total energy consumption. Electricity consumption represents a major part of this and leads to more than 40% of CO₂ emissions in the residential sector and up to 65% in the tertiary sector.

The increasing number of household appliances, computers and game consoles, the development of equipment such as air-conditioning and controlled ventilation, computerisation and all the new communication technologies are contributing to greater electricity consumption in comparison with other forms of energy. Electricity is therefore a priority target in terms of energy efficiency.

There are two complementary strategies to significantly reduce the energy consumption of buildings:

- > Building new high-performance buildings
 - buildings are built to last
 - technologies and know-how are available
- > Improving existing buildings
 - the average age of existing buildings is high
 - the renewal rate is very low

A favourable normative and regulatory framework

> EU-level goals for 2020:

- a 20% increase in building energy efficiency
- a 20% increase in the share of renewable energy sources in the end consumption of energy .

> National regulations driven by the Energy Performance of Buildings

Directive (EPBD): a global energy efficiency plan (Energy Efficiency Plan 2011) is focused on the process of renovating buildings in the public and private sectors and improving the energy performance of electrical components and devices used in these buildings. It proposes the following in particular:

- the introduction of energy efficiency criteria into the area of public expenditure
- the implementation of mandatory actions for energy distributors to allow their customers to reduce their energy consumption

> Energy certifications and labels focused on the reduction of energy consumption and associated with regulations:

- in France: BBC-Effinergie, HPE Labels (High Energy Performance), and shortly HPE RT2012
- in Switzerland: Minergie, Minergie standard, Minergie-P, Minergie-ECO certifications
- in Germany: Passivhaus certification
- in the United Kingdom: Eco-homes
- in the United States: Energy Star

> Environmental initiatives which, going beyond energy performance, aim to reduce the environmental impact of the building by addressing, for example transportation, issues:

- In France: High Environmental Quality (HQE) environmental initiative
- In Germany: DGNB environmental initiative
- In the United Kingdom: Code for Sustainable Homes, and Building Research Establishment Environmental Assessment Method (BREEAM)
- At the international level: CASBEE method (Japan); GBL (China); Leadership in Energy and Environmental Design (LEED) Certification (USA)

The motivations of building industry players

The normative framework, the wide media coverage given to the protection of our planet and the tax incentives offered by several countries (carbon tax, subsidies, feed-in tariffs for renewable energies, power plant's selling price of megawatts) have given rise to energy efficiency needs that can be classified under 4 categories:

> Needs of owners:

- increase the ecological value of the building by reducing its environmental footprint
- identify the most efficient improvements for their buildings

> Needs of site managers:

- identify wastage and potential energy gains
- identify how to improve site comfort and productivity
- understand the deviation between the measured or observed reality and conventional calculations

> Needs of maintenance technicians in charge of the site's technical equipment:

- adapt the operation of the machines to the building's flexibility of use (change of occupants, tenants, use, purpose, etc.)
- detect and analyse operational drifts

> Needs of occupants:

- have ideal environmental conditions for their activity (lighting and thermal comfort, air quality, etc.)
- have the option of adjusting their environment in a simple way, while being eco-responsible

> 600 interviews

were conducted in 15 European countries under the HOMES programme among occupants and players in the real estate and construction sectors in order to establish a comprehensive overview of the concerns and needs of each category of players.

Development of professions

Players in the construction sector form a mosaic of knowledge structured by the building trades and the value-added chain. We can see a strong trend towards the decompartmentalisation of professions and the emergence of new skills.

In fact, energy-related skills are being developed to deal with the energy issue, which requires a cross-disciplinary and systemic approach.



Towards energy performance contracts

New business models have developed around these three skills. For example: the emergence of energy performance contracts that vertically combine these three skills (design, execution, operation) to propose contracts with guaranteed results.

> **Energy engineering**, which first appeared in the area of project management assistance and then at prime contractor level, has become a crucial profession: as specialists of energy management in all its forms, energy engineers complement the designs of the architect, who focuses on the building's structural aspects.

The future energy performance of buildings, based on the three pillars below, is played out between the skills of the architect and those of the energy engineer:

- the quality of the construction,
- the quality and controllability of technical systems,
- the quality of use (which encompasses its controllability and its interactions with users).

The interaction between the architect's digital tools (BIM) and the engineer's simulation tools becomes a prerequisite for integrated engineering.

> **System integration**: optimised control & instrumentation and efficient monitoring call for the integration of technical applications that had been standalone until now. With the cross-over of technical work packages, they must now become a separate supply package: integrators implement it and provide assistance during the first operational year of the building. Thanks to all the data processed, they become an instrument for commissioning the buildings (for example: measurement of air infiltrations).

> > **Energy services** that include the following tasks:

- monitoring or remote monitoring of effective energy performance
- identification of participation in the capacity market
- analysis of consumption trends
- proposals for corrective actions or improvement operations
- certification or labelling during operation.
- ...

Moreover, the concept of a site energy manager made its appearance in the standards (e.g. EN 16001) or in practice.

The HOMES strategy: active energy efficiency

Active energy efficiency is focused on people and how they use the building, equipment and energies:

- > Reduce energy demand while maintaining comfort by taking into account real occupancy and free gains such as solar heat through windows
- > Optimise delivered energy through new strategies for optimised equipment control, the management of local renewable energies while respecting network constraints
- > Maintain performance during the building's life cycle thanks to energy measurement and consumption monitoring
- > Reduce energy consumption by involving people and changing behaviours

Potential gains

With infinite resources (without taking economic feasibility into account), and based on the analysis of the operation of European buildings, the potential savings offered by active energy efficiency (automatic control and monitoring) **would be more than 50%**.

We find the same order of magnitude with the other two solution families, namely:

- intrinsic improvement of technical equipment (LED lighting, heat pump, low emissivity radiator, etc.)
- passive solutions such as the improvement of the building envelope (insulation, tightness, transparency, topology)

These three families do not offer the same level of efficiency for all buildings.

Active energy efficiency solutions are all the more effective in buildings:

- with high intermittent occupancy (schools, offices, auditoriums)
- of medium size (2,500 m²)
- with partitions (hotels, individual offices, schools)

The need for equipment controllability is greater when the building's thermal inertia decreases and when its insulation and air-tightness increase.



To assess the energy efficiency and comfort performances of future HOMES solutions, the programme has set up considerable experimentation resources:

- 2 virtual buildings
- 8 test platforms
- 5 pilot sites



HOMES levers

> Combine energy and comfort

Reduce energy demand in each zone

- > By adapting the setpoints to the occupants' activity and actual occupancy
- > By using free gains
- > By optimising the complete system using multi-application control

Optimise energy supply

- > Improve the performances of heat, cold and air production, distribution and emission systems
- > Manage energy sources with priority to renewable energies while respecting network constraints (Smart Grids)

Involve people: monitor consumption, provide advice for improvement

- > Occupants
- > Owners
- > Maintenance technicians
- > Energy managers

At zone level

Have a controller for each zone

Set to energy idle mode when occupants are absent

Adjust lighting levels to the available natural light

Adjust emission set points to needs

Make energy consumptions visible



At the building level

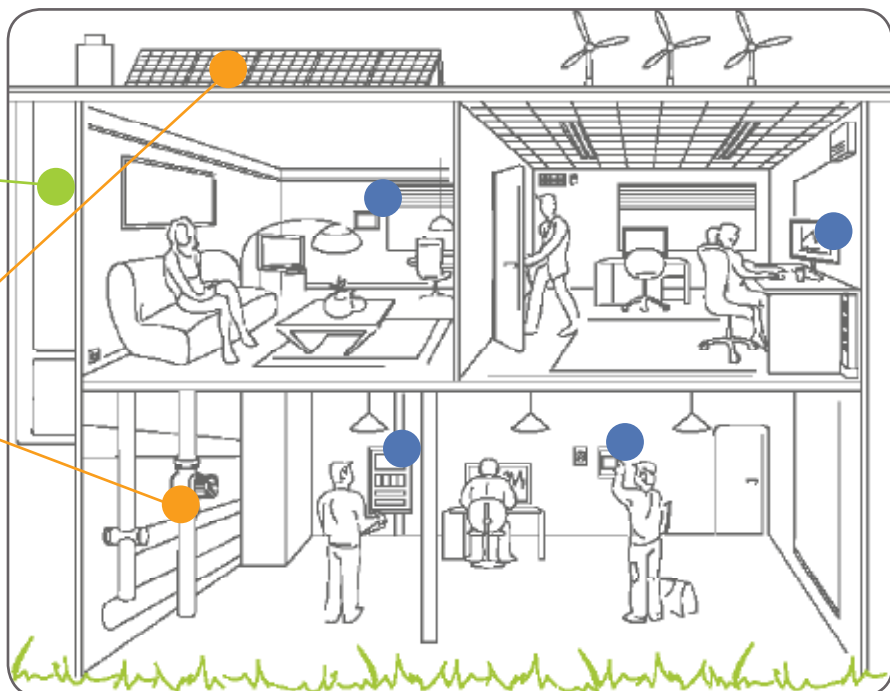
Make use of free cooling

Use and manage local renewable energy production

Improve the efficiency of heat pumps and fluid distribution systems

Contribute to peak shaving

Give consumption control tools



Optimal conditions for achieving significant gains

Active control is more efficient when:

> **The conditions of use, flexibility of use as well as interactions between buildings and users (occupants, managers, maintenance technicians) are defined at the programme level (project management or project management assistance).**

If monitoring is specified in the project manager's requirements, it will naturally appear during the design and execution phase. It is possible to add it subsequently for existing buildings, but it is more difficult than when it is specified in new buildings.

> **The building's technical equipment (heating, ventilation, electricity, air-conditioning, etc.) can be controlled with sufficient accuracy.**

For example: There is no possible gain if the ventilation system renews the air for the entire surface area of the building or if there is only one thermal zone in a dwelling.

> **If active control is identified as a distinct work package in the construction project,** a multi-application approach to technical equipment becomes possible.

The functions of this package are specified by energy engineering. It is implemented by a system integrator capable of providing the yearlong monitoring required to optimise the operation of the building after acceptance.

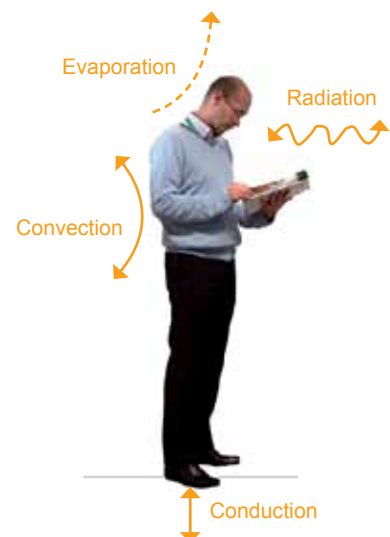
Enhanced feeling of comfort

The HOMES programme adapts the equipment regulation strategies to combine comfort and energy efficiency.

The comfort actually perceived by the occupant depends on several parameters, whether thermal, visual or acoustic comfort or air quality. Using new multi-physical sensors in particular, HOMES takes into account the parameters necessary for assessing the perception of comfort.

> **Example of thermal comfort related to the balance between the various interactions of the body with its immediate environment.**

This balance depends in particular on physical activity, clothing and parameters such as air temperature, radiant temperature, air speed or humidity.



Energy gains thanks to HOMES solutions

> Result of the simulation of solutions on pilot sites

5 pilot sites



Savoie Technolac office building



Montbonnot primary school



3-star hotel in Nice



Collective residential building at Vaux-sur-Seine



1-star hotel in Carcassonne

5 representative examples

- > Equipment: 2 heat pumps, 2 gas boilers, one fully electric
- > Sectors: offices, hotels, educational and residential
- > Size: between 500 m² and 3,000 m²
- > Age: new or existing, refurbished or not
- > Climate: differentiated

The experiments carried out

1. Measurement of the building's effective performance
2. Simulation of the five pilot sites (with the measurement data gathered)
3. Simulation testing of the active control functions defined by the HOMES programme
4. Estimation of gains provided by these functions
5. Recommendations to achieve these gains (in progress)
6. Evaluation of gains provided by monitoring (forthcoming)

Estimation of gains provided by the HOMES control functions for the Montbonnot site (simulation results)



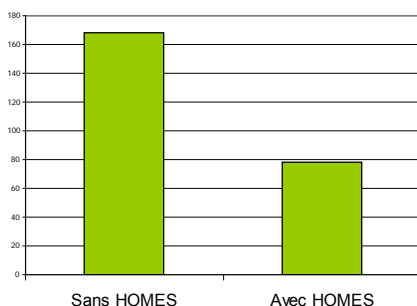
Ecole primaire de Montbonnot

Control strategy:

- > reduce energy demand in each room based on effective presence while optimising comfort.
- > optimise energy supply (production / distribution) to cater to these needs.

56%

of energy consumption saved using active control solutions



Simulated solutions:

- > A ventilation system
- > A zone controller in each room to control radiators, lighting, shutters and ventilation based on occupancy
- > A boiler, heating network and ventilation system controller

Enhanced comfort

- > Improved air quality
- > Minimisation of heat losses and temperature variations caused by the opening of windows

Main energy gains

- > by room: in the dining room
- > by application : heating and ventilation losses

Building design & renovation, what HOMES proposes

1. Measure the building's effective performance to set up an improvement plan

Measure actual energy consumptions:

- > Measure and understand the deviations between the promises of conventional calculations and reality
- > Take into account all the consumption items and in particular movable, activity and process equipment

Measure the building's conditions of use:

- > Understand the services provided by the energies consumed
- > Take into account the occupants and their activity, the occupancy time
- > Measure the actual impact of external weather conditions
- > Measure the elements necessary for IPMVP methodology (International Performance Measurement and Verification Protocol)

The types of measurements to carry out

Actual energy consumption:

> Energy consumption:

- In the main rooms
- For the main items: heating, electric sockets, lighting, ventilation, office automation, etc.

> Energy flow at the production output to identify distribution losses

(difference between production and consumption)

- wires: electrical energy
- pipes: thermal energy (or mechanical energy for compressed air)
- ducts: thermal energy or loss

Building's conditions of use:

> Ambient conditions

- Thermal comfort: temperature and humidity
- Visual comfort: luminosity
- Air quality: CO₂ and humidity

> Exogenous variables influencing energy consumption

- occupancy
- other uses of electricity
- external weather conditions: temperature, light intensity and wind (to weight heating, lighting and ventilation consumption)
- the measurement of supplied energy meters provides a continuous link with the bill and the identification of production equipment efficiency loss



The measurement of the effective performance of buildings is a prerequisite for any improvement initiative.



Prototypes HOMES

Wireless battery-less comfort sensor

- Measurement of comfort parameters (humidity, temperature, luminosity and soon CO₂).
- Self-powered: Using a solar cell, it communicates measurement data wirelessly based on the ZigBee protocol.
- Very low consumption (5 μ watts): guarantees that it operates even when sunlight is very limited (two months of operation in an unlit room).





HOMES control strategy:

- Reduce energy demand in each room based on actual room occupancy while optimising comfort.
- Optimise energy supply (production/distribution) to cater to these needs.

2. Implementation of multi-application control solutions in each zone

Control by zone (and ideally by room) is the most effective solution to reduce a building's energy demand.

This also makes it possible to adjust to the occupants' uses and provide excellent flexibility to buildings (in case of change of occupants, tenants, use of a room, installation of partitions, purpose, etc.).

HOMES has defined 150 control functions intended for multi-application zone controllers

> designed to reduce the energy consumption of equipment and systems

"Zone" functions: to reduce energy demand in each room.

For each zone, they control local equipment based on data gathered by local sensors to provide the expected service

"Equipment" and "production or distribution equipment" functions: to optimise energy supply in each vector to cater to these needs.

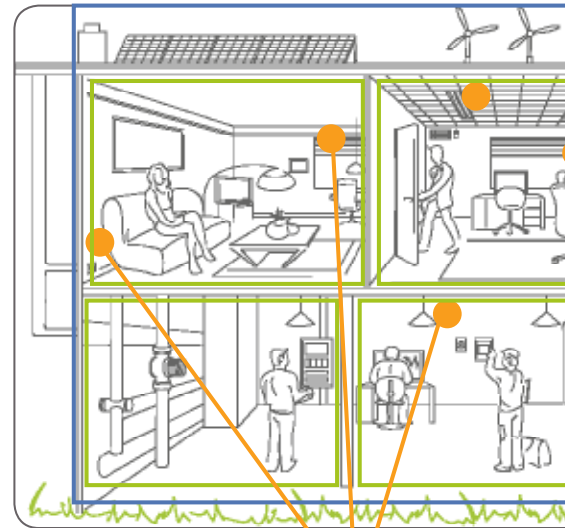
They control and optimise the production or distribution equipment by adjusting the operating modes at any moment based on requirement and consumption information fed by the zone control functions. They make it possible to supply energy to the distribution terminals and optimise the manner in which the energy is transported, based on the principle of "just necessary".

"Energy" functions: to control energy sources that feed energy vectors by giving priority to free gains and renewable energies.

They optimise the building's overall consumption balance:

- > based on tariffs
- > based on their environmental impact (minimising CO₂ emissions and kWh)

They control the building's storage and release capacities to contribute to peak shaving, or to participate in the capacity market (service functions in relation with the outside of the building, in smart cities or smart grids).



"Equipment" functions

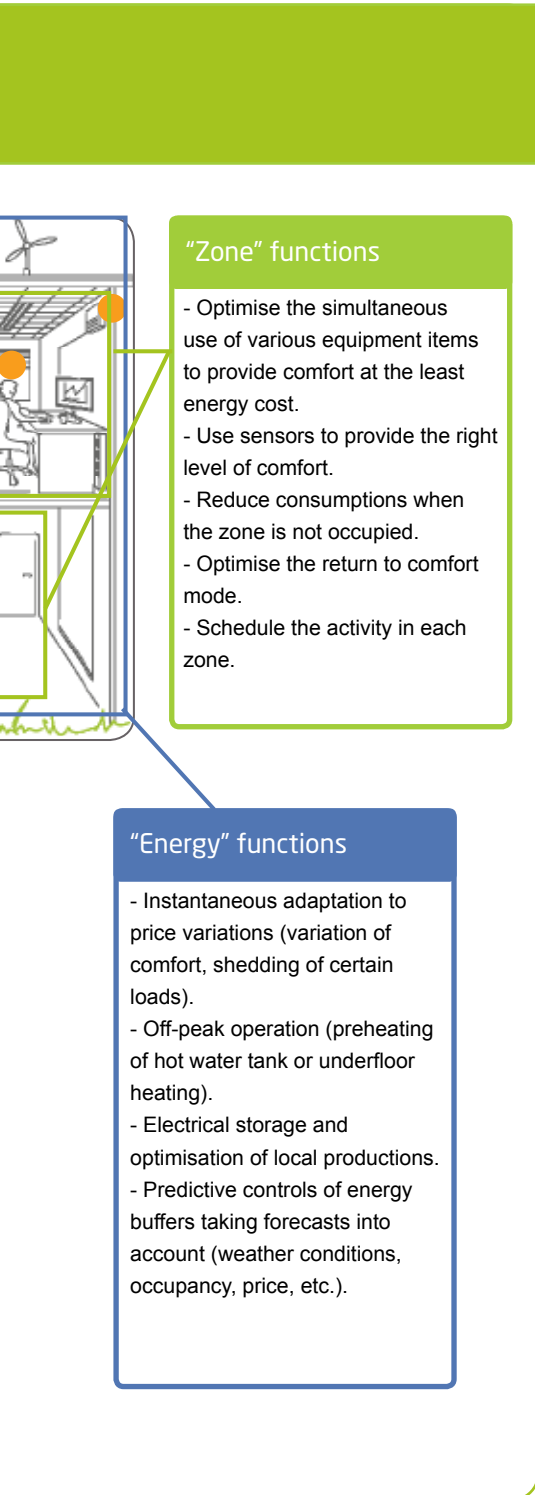
- Optimise production based on the requirement (optimising distribution network water temperatures).
- Over-ventilate when this can contribute to thermal comfort.
- Choice of the production source.
- Management of "building closures", for example when there is no one inside.
- Adaptive comfort (adjustment of temperature setpoints to external temperature).

Towards smart controllers

> thanks to embedded control functions

> which communicate:

- wirelessly, via communication standards such as ZigBee
- via existing wires (power line carrier)
- using gateways to interface with technologies deployed already widely and to connect to the existing system.



"Zone" functions

- Optimise the simultaneous use of various equipment items to provide comfort at the least energy cost.
- Use sensors to provide the right level of comfort.
- Reduce consumptions when the zone is not occupied.
- Optimise the return to comfort mode.
- Schedule the activity in each zone.

"Energy" functions

- Instantaneous adaptation to price variations (variation of comfort, shedding of certain loads).
- Off-peak operation (preheating of hot water tank or underfloor heating).
- Electrical storage and optimisation of local productions.
- Predictive controls of energy buffers taking forecasts into account (weather conditions, occupancy, price, etc.).



HOMES prototypes

Multi-application zone controller: Roombox

- offers a decentralised multi-application control-command architecture.
- powers, protects and controls lighting, shutters and blinds, and heating, ventilation and air-conditioning (HVAC) at the same time.
- performs four key functions: electrical distribution, consumption measurement, control of each electrical circuit, individual protection of electrical circuits.
- reduces the use of cables by 30 to 60 % and halves the office installation and reconfiguration time.



High-energy efficient HVAC emission controller

- controls the water supply and ventilation motor speed at any instant based on the needs (based on real-time information from fan coil unit sensors).
- improves comfort, by adapting the ventilation to precise needs while minimising noise during variations in ventilation levels.
- provides detailed information on the equipment's thermal and electrical consumption: dashboards and energy balances.





Find the best compromise between fully-manual and fully-automatic:

- > fully-manual buildings are energy-intensive
- > fully-automated buildings are a source of anxiety as the slightest deviation or failure can cause

3. Design Human-Building Interface solutions

HOMES is experimenting with Human-Building Interface solutions for everyone involved: occupants, managers, maintenance managers, owners.

The design of HOMES Human-Building Interfaces relies on the following principles:

The building is not only smart, it is obedient

- The occupants determine the conditions of perceived comfort in their environment when they enter a room, using a simple control. In return, they receive information indicating the energy consequences of their actions. The zone controller optimises the building's consumption consistent with this choice. As soon as the occupants leave the room, the zone controller chooses the environmental instructions to place the room in an energy idle state.
- The occupants do not have to decide on non-perceived environmental parameters: the zone controller optimises them automatically.
- The changes in parameters related to machine and network operations are not visible to the occupant.



Make energy data more easily accessible and understandable depending on the motivations: productivity, professional necessity, self-learning, curiosity or teaching



A display for each player

To reduce energy demand, the Human-Building Interfaces provide each player with information that allows them to carry out actions aimed at energy efficiency.

- > for occupants: display of the consequences of their choices
- > for managers and maintenance technicians: support for site operation and operation parameterisation (uses, occupancy)
- > for owners: support in improving the environmental value of the site and choosing improvement works.

These solutions are currently being tested on real sites (5 pilot buildings).

4. Develop design tools for professional channels

HOMES develops new design tools for professional channels to avoid data re-entry and save time, prevent data loss and improve the understanding of all those involved.

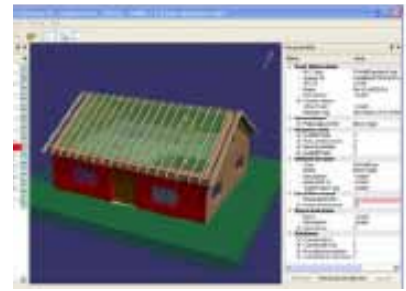
Integration of the energy dimension in BIM (Building Information Modelling)

The digital model created by HOMES implements the open IFC standard (Industry Foundation Classes). This standard is drawn from the Building Smart consortium and constitutes a building description model that goes beyond the geometry of the framework: materials, physical characteristics, and position of equipment. Every object in the building has a semantic description. Furthermore, this standard covers structural as well as finishing work and generic equipment. Designed as an extensible "framework model", the IFC makes it possible to create new objects if necessary.

The integration of simulators in business tools

HOMES activities are focused on the integration of a simulator which brings the energy dimension into each stage of building design and construction:

- to provide architects a preliminary energy assessment based on the building's sketches
- to allow energy engineers to take into account occupancy scenarios and occupant comfort conditions right from the design stage and to establish a dialogue with the thermal and electrical engineering offices
- to monitor and analyse its performances and identify avenues for improvement throughout the building's life cycle.



A first software prototype to view IFC files (3D views and objects) has been developed.



HOMES prototype

Simplified parameterisation

The complexity of implementing control systems from the large number of parameters that must be set in order to adapt to the diversity of buildings. Thanks to new sensors and expert functions embedded in the controllers, most of these parameters (about a quarter) can be calculated automatically: this drastically reduces the integration and setup time.

Some examples:

- > Calculation of the air infiltration rate in each room
- > Elimination of temperature setting when occupants are absent
- > Reduction of system parameters of each zone controller



www.homesprogramme.com

Delivering active energy efficiency solutions accessible for every building

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- Collaborative and innovation programme -

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