Summary

In the current context of ongoing search for improvement of energy performance, the management of buildings' energy performance has become a very important stake. Openergy aims to revolutionize the energy monitoring of buildings thanks to dynamic thermal simulation. The calibration of the simulation consists in adjusting different input parameters in order to have results close to reality. This convergence is generally guided by an expert of the field, but it aims to become automatic, in order to ease the use of the simulation. This method could even be adapted for energy mutualisation between different buildings.

Context

Openergy is a start-up created in November 2012 specialized in energy efficiency of buildings. Currently, Openergy offers a support to the clients throughout the whole value chain of energy data. It is also developing an innovative platform for building monitoring, that combines data-mining and energy simulation. Thus, Openergy is able to offer to its clients quantitative and relevant results concerning their building efficiency.

The approach is not only oriented "data", it also relies on physical simulation. A building cannot be understood without the physical part. Thanks to the simulation, Openergy acquires a detailed knowledge of the thermal characteristics of the building, which misses with the only data analysis.

Nowadays the simulation starts to be used more commonly during the design phase with the emergence of BIM (Building Information Modeling) which are digital mock-ups and allow a better coordination between the different players (building, heating, electricity…). But this mock-up becomes useless once the building is built-up. Openergy's vision consists in accompanying during the design phase but then adapt and reuse the mock-up for the operating phase. Anyway, important groups will move towards this will of extending the lifetime of the mock-up for the operation. Openergy will then have a technical significant lead in this field, and will be able to save development time to big companies.

Simulation and calibration

The methods used by Openergy succeed in explaining the consumption of a building by simulating digitally buildings and their behaviour. We can then compare the performance of a building to the initially aimed performance during its design, or after its renovation, that is the best possible performance. For instance, simulation can answer questions such as: "Given my building, what should be my consumption? How much will

I earn if I lower the set-point temperature by 2°C during a month? If I change the windows?” because the complete building can be simulated.

The operator in charge of energy performance of a building has an objective of total consumption (monthly or yearly) which has been determined during the design phase, or during the renovation of its building. In most cases, buildings are worse than expected during the first phase. The process suggested by Openergy can explain precisely the observed gaps.

The study follows three major steps: the preparation phase in which real data are processed, the calibration phase in which data and simulation are compared, and the recommendation phase.

The first step consists in analysing the data. The client provides four types of data with time steps which depends of the client’s installations (lighting consumption, electric equipment consumption, heating/cooling consumption, and temperature measures). Data processing is an essential phase of the process because it is a prerequisite to the accuracy of the simulation outputs. Thanks to algorithms developed by Openergy, we can guarantee the quality of data. We detect automatically aberrant data and lacks of data, but generally other details have to be fixed manually. If the time of error is not too long, it is possible to interpolate. Otherwise we will consider that the data are not exploitable for this period.

The first approach consists in validating the model before going to the next step of calibration. In order to obtain a digital mock-up faithful to the building, we need the most possible information. This step depends on the good reliability of the data provided by the client. In the best cases, we dispose of the technical data (equipment, systems, construction information…). When the client is enable to provide these documents, we realise an audit to know the characteristics of the building. Once these information collected, the digital mock-up can start.

The conception of the 3D-model uses the software DesignBuilder, which is based on the calculation engine EnergyPlus. DesignBuilder provides modelling tools in an easy-to-use interface. This enables the whole design team to use the same software to develop comfortable and energy-efficient building designs from concept through completion. In DesignBuilder, we can reproduce the building faithfully thanks to plans and information concerning the structure of the building (composition of walls, roofs, floors, windows…). EnergyPlus is a whole building energy simulation program used to model both energy consumption (for heating, cooling, ventilation, lighting, and plug and process loads) and water use in buildings.

Then, we have to add the occupants which turn the light on, the heat on, and use electric equipment. It is this step which needs more approximations compared to reality. We use standard schedules, which in reality are not strictly respected. In the case of recently built up buildings, a first simulation of its performance should have already been realised. Thus we can use the same hypothesis. Otherwise, we create ourselves the base model.

Once the model is done, we need to adjust the parameters more precisely, such as occupation, electric equipment, or lighting schedules. The main difficulty of energy simulation resides in the important number of parameters. Among these, an important part is not directly measurable. For instance, the occupation rate, the losses, the internal mass… The calibration aims to estimate these parameters in real conditions. So we change the parameters and launch simulations, and by iterations, we try to make the results of the simulation converge towards the real measured data. When the results of the simulation coincide with the reality, we can affirm that the values of the parameters are representatives of the building. If these parameters can explain the behaviour of the building during the period in which we have the data, we are able to simulate its behaviour any time of the year.

Now that we know all parameters related to our building, it becomes possible to detect overconsumptions, compared to the base model. Simulation is necessary because the only data analysis which consists in comparing real consumption curves with model consumption curves does not take into account thermal effects. These thermal effects are generally internal heat sources. A computer which stays turned on creates an overconsumption but constitutes also a heat input. This input will allow the heating system to consume less in winter, or to force the cooling system to overconsume in summer. This could not be detected without simulation.

Openergy created a method which allows to compare electric consumptions to the base model, by taking into account thermal effects. Once the model is calibrated, if we apply real consumptions item by item we find the total consumption of the building. In output, we can evaluate the consumption related to each item and its impact on the global consumption. It becomes also possible to make a simulation of the building's behaviour at any time of the year.

Audit of a building

For this case study, a building of dwellings was chosen in the 15th district of Paris: Convention-Lourmel. The study relies strongly on the concept of "simulation calibration". The idea is to update the building model used in the design phase so that the updated simulation matches well the actual behaviour of the building. Doing so, one is able to identify the possible discrepancies between the target model and the actual building. The final goal is to be able to use this updated simulation to improve the building operations.

Convention-Lourmel has an area of 10 347 m^2 and is heated by the Urban District Heating (CPCU). It was constructed in the 1930's. After modelling the building in DesignBuilder, and entering all construction parameters, the heat transfer coefficient through the walls is calculated by EnergyPlus. For this building, a value of 1,26 W/m^2.K is found. The smaller the value of the U_{bat} is, the better the building is isolated. In this case, the value is quite good for a building of this year of construction.

When the systems of heating and all other consumptions have been entered as inputs (electric equipments, lightings, schedules…), the heat consumption can be calculated. Below is presented the results obtained for Convention-Lourmel

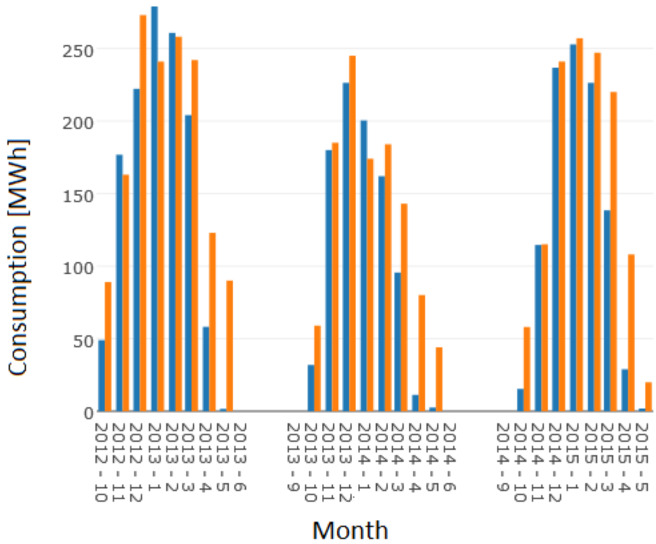

Figure 1 - Comparison of the monthly consumptions measured (in orange) and estimated (in blue)

We see on the figure that there is a small difference for the coldest months. Nevertheless, we note an important gap between the measured and the estimated consumptions during the mid-season. This shows that the heating consumptions could be optimized, in particular by adapting the regulation in mid-season.

Then we can calculate energy savings if we made some actions to the buildings. Measures such as insulating the walls and the roof, or lowering the set-point temperatures are considered. The used climatic conditions correspond to a typical year in Paris. The calculations are made for hourly steps, which allows to take into account very precisely the thermal phenomena (solar gain, ventilation…). These measures can allow important energy savings. For instance, insulating the walls would permit to save 23% of the consumed energy.

DataCity

In order to become smarter, today's cities are going to have to develop new services in a range of sectors: better use of energy, responsible travel, intelligent urbanization and housing, sustainable environment. The City of Paris, along with several partner organizations, is opening a unique field of experimentation to anyone who can propose a project with the aim of taking up these challenges: DataCity.

To participate to this event, Openergy applied in the category "Consolidating energy flows to design "positive energy islands" and decreasing the size of our carbon footprint". In most big French cities, reflecting the situation in Paris, any construction of new dwellings is quite limited. One of the main opportunities we have identified involves the development of energy exchanges between buildings and facilities. What we're talking about here is a change of scale, going from positive energy buildings to positive energy islands, which means multiplying opportunities and enhancing the impact.

One of the aims of the challenge is to model energy flows in order to detect potential exchange opportunities. The main exchange opportunity involves complementary buildings for which the use and requirements balance out. One of the first steps to take would thus be to identify suitable fields and to calculate potential aggregated margins (in terms of financial savings, energy savings, infrastructures…). Different types of exchanges could be considered such as exchanges between buildings, on a neighbourhood or "island scale" or exchanges within buildings.

For the experimentation, three buildings were selected: an office, dwellings and a nursery. These buildings should have complementary schedules, which is very important for mutualisation. Even though these buildings were not neighbours in real life, the study was made as if they were adjacent.

Different scenarios have been imagined in order to save energy. The first one would be to share the production means. Indeed, instead of having three boilers, three transformers… there could be just one, which would reduce the prices of installation and maintenance. The second one would be to use untapped overpower of the offices' building. Since they have installation which could produce heat that are not used, the buildings around could use it. Finally, the last scenario would be to recycle the unavoidable energy of offices for the pre-warming of hot domestic water of dwellings. In a large majority of offices, there are server rooms which need to be cooled. But to cool a room, there is a production of heat which is not used for now. This has no cost, because this production of heat is done anyway. So it will be "free energy" for other buildings. This last scenario seems to be the easiest to implement, because it does not create a situation of dependency from one building to another.

Thus, Openergy is aiming to revolutionize the energy monitoring of buildings by offering a digital platform which integrate data analysis combined with dynamic thermal simulation. If the data analysis has already been automatized, the simulation should as well, progressively in order to be integrated to the platform. The audit of a building shows that the simulation can be used in order to evaluate the possible energy savings. Indeed, the calculation of the simulation gives the heat needed to respect the comfort of the inhabitants, if there are overconsumptions, it can easily be detected and fixed. For instance, it is common that buildings are overheated during mid-season months. A regulation of the temperature could allow important energy savings.

Conclusion

Thus, Openergy is aiming to revolutionize the energy monitoring of buildings by offering a digital platform which integrate data analysis combined with dynamic thermal simulation. If the data analysis has already been automatized, the simulation should be as well in order to be able to deal with bigger projects, such as the study of a military base of 150 buildings.