METHOD AND TOOLS FOR ASSESSMENT OF ENERGY PERFORMANCE OF BUILDINGS - CASE STUDY

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Keywords: energy efficiency, building automation, commissioning

Abstract

The application of whole "BEPS-Building Energy Performance Simulation“ models is being increasingly used as a method of information management, as well as a project management tool all along the life cycle of energy efficient buildings.

This study enters in the framework of the European project TRIBUTE (2013-2017).

The goal of this project is the reduction of the gap between predicted and measured energy performance of buildings, through the improvement of the prediction capacity of energy modeling and simulation tools.

This improvement will take into account all key parameters that influence the energy performance of buildings, like the behavior of occupants, the key components of buildings (envelope, HVAC systems, control systems) and the aging of materials.

For this purpose, three buildings have been selected, especially a public library in Torino that is the purpose of this paper.

This paper presents, in particularly:

- the synthesis of energy audit of the building realized in order to collect input data indispensable for simulations;
- the simulation tool used and the first results of energy performance simulations;
- the deployment of comfort sensors (temperature, humidity, luminosity) in the building and the protocol used to follow real-time measurements;
- the connection between real-time measurements, and the energy simulation model.

For existing buildings, this involves the use of the best and most faithful modeling in returning data through the development of better technology for on-line identification of key parameters of buildings and automatic scaling in real-time systems than at present BEPS of building-system.

1 Introduction

The use of templates to "BEPS-Building Energy Performance“ is soaring as useful energy information management emanating from the buildings that are monitored. Analyzing and processing this information you can check the operation of the energy system of the building, evaluate performance and diagnose errors and anomalies, intervene where appropriate allowing for a systematic approach to continuous improvement of its energy efficiency. Nowadays, the analyses produced by such simulation models show a remarkable discrepancy compared with the real situation and this limits and conditions the practical application.

As mentioned, with funding from the European project TRIBUTE was commissioned a case study of energy audit, energy dynamics modeling, cost-benefit evaluation of retrofit options, installation of smart metering systems thermal and electric, integrated into existing BEMS systems at a library in the Città di Torino. Energy optimizations are being implemented through remote system via web and monitoring installations (temperature, humidity, light, CO2, occupation of space).

2 Description

The project aims to minimize the gap between the simulated and the real ones, energy performance by improving the predictive ability of existing measuring systems, monitoring and control of energy performances of buildings by developing a "smart energy monitoring and control system" in Italo Calvino's Library in Torino. In addition, the project TRIBUTE plans to extend the use of the instruments of BEPS even during management of buildings (as well as for the design). For existing buildings, this involves using the best and most faithful modeling systems in returning data through the development of better technology to identify key parameters of buildings and online real-time automatic scaling of BEPS systems than in the present state of building-system. In addition, an application is under development by Building Health Management able to compare the measured data with those predicted and detect any deviations and failures. The measurement systems, accounting, monitoring and control of heat and electricity, using open and interoperable protocols, are provided by the partner Schneider Electric (with experimental sensors integration provided by other partners), while dynamic energy simulation is made through the IDA_ICE modeling software.

3 Testing site

In order to validate and prove the replicability of the TRIBUTE, smart metering systems, accounting, monitoring and control of heat and electricity were installed (partly being implemented) in three different buildings, located in three different States with different climatic conditions: the library Italo Calvino in Torino (Italy), a block office in La Rochelle (France) and the Living-lab of IBM Headquarters (Ireland).
The building of Torino, located on the right side of the river Dora in a central area, was built in the nineteenth century and was originally a tannery. In 2003, the city of Turin decided to transfer to it the neighborhood library and designed and implemented a complete renovation. The works were completed in late 2006 and is functioning as a library since 2007.

Fig. 1 - Italo Calvino Library - Lungo Dora Agrigento 94 Torino

The library has approximately 14x16m rectangular base dimension, on three floors and a basement, oriented with the northeast side facing towards the river Dora. The main building is in full load-bearing brickwork, while the side wings have reinforced concrete and masonry bricks for a total of 50 cm thick. The wooden roof is covered with tiles. The frames are made of aluminium with double glazing.

3.1 Time schedule and occupancy

Usual occupancy of the building is:

- N° 3 operators, present during working hours
- N° 100 people average present when reading rooms are opened to public

- 140 people maximum occupancy in the meeting room, which could be used both during working hours and in other period.

Operational time scheduling of the library is:

- Monday 8:00 to 15:00 only operators, 15:00 to 19:45 public
- Tuesday and Wednesday 8:00 to 14:00 only operators, 14:00 to 19:45 public
- Thursday and Friday 8:00 to 14:00 public, 14:00 to 17:00 only operators
- Saturday 8:00 to 14:00 public

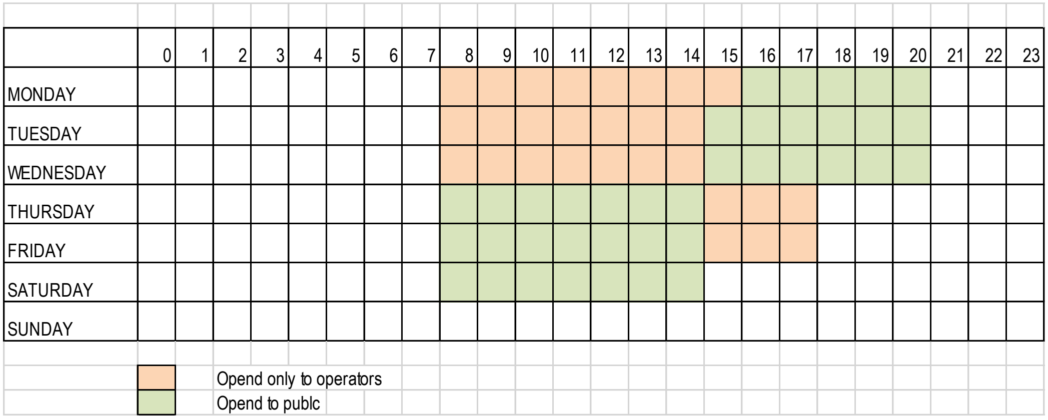

Fig. 2 - Time schedule

4 Energy audit

The energy audit aims at identifying as a building and who is using the energy, what are the fees for the supply of energy, and the identification of improvements to reduce energy consumption. The scope of work undertaken with an energy audit results essentially from the study objectives and available resources. In ns. If you performed the first two levels, as defined by ASHRAE standards, while the third level (third-level audits focus on optimizing plant potential and possibilities of economic investment, based on the analysis, based on data collected and monitoring performed and in progress, providing data or data fields more detailed and more comprehensive engineering analysis).

4.1 Electrical system

There is a single point of low voltage electrical connection, placed in a reception booth outside the building, bargaining power of 250kW, three-phase + neutral 400V. The main electrical panel, as well as the UPS group from 20kVA and the electrical safety circuits are installed in the booth on the second floor. Outside the building there are a generating set 150kVA and refrigeration unit from 411, 6kWt (power 164kWe). The lighting system is made by bodies illuminated with fluorescent lamps and electronic ballasts (partly with adjustable power).

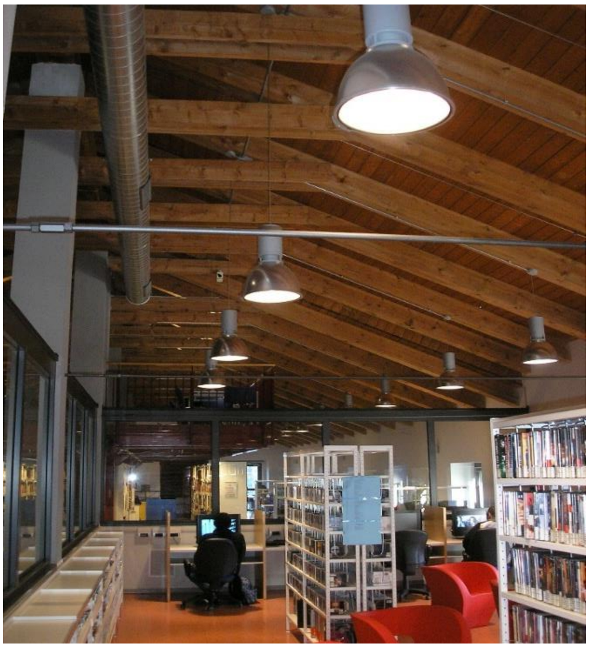

Fig. 3 - The multimedia room

4.2 Air conditioning system

Water heating plant consists of two gas boilers, rated at 274kWt each. The refrigerating unit is the thermal capacity of 411,6kWt. There are different systems in different parts of the building: two-pipe fan-coil and fresh air in the Conference room and reading rooms-two pipe fan-coil in offices, hallways and rooms that are not open to the public-radiators in the restrooms. The fan-coil have on board an electronic temperature sensor, which regulates water valve opening/closing and has three levels of emission regulation air speed. Hot water given the modest consumption, consists of electric boilers installed in individual blocks services.

Fig. 4 - Pumping room

4.3 Annual energy consumption

Water heating plant consists of two Natural gas consumption data is grouped in 6 years, following heating seasons, i.e. from October 2007 to September 2013. Electrical consumption data is splitted in hours, months or years, from January 2009 to December 2012. Only three complete consumption years, precisely from October 2009 to September 2012, are therefore available. We used the 9,883721 kWh/Sm3 calorific value, to transform Standard Cubic Meters of natural gas consumption to kWh of equivalent energy used in the building. To calculate specific energy consumption indexes we divided energy pictures by 2.820 m2 of total Gross Floor Area and 11.632 m3 of Total Gross Volume.

Themal season	Natural Gas Consumption Data from Provider IRIDE				Electricity Consumption Data from Provider IRIDE			Total Consumption		
	Sm3	*kWh/y*	*kWh/m²/y*	*kWh/m³/y*	*kWh/y*	*kWh/m²/y*	*kWh/m³/y*	*kWh*	*kWh/m²/y*	*kWh/m³/y*
ott 07 - sett 08	15.575	153.939	*72*	*13*						
ott-08 - sett 09	16.630	164.366	*77*	*14*						
ott 09 - sett 10	21.223	209.762	*99*	*18*	179.688	*64*	*15*	389.450	*138*	*33*
ott 10 - sett 11	20.011	197.783	*93*	*17*	172.141	*61*	*15*	369.924	*131*	*32*
ott 11 - sett 12	20.305	200.689	*94*	*17*	140.528	*50*	*12*	341.217	*121*	*29*
ott 12 - sett 13	23.815	235.381	*111*	*20*						

Table 1 : Annual Energy Consumption

4.4 Possible improvements

The interventions suggested by the audit mainly concern the implementation of building automation system of the building, with a series of other measures, such as: the replacement mixer high efficiency heat exchanger with UTA, replacing the circulating pumps with variable delivery, installation of dampers on the primary air flow and return pipes, replacement of the fan-coil water regulation system and existing anti-shoplifting system connection (comes with software that counts and records the number people in and out of the library) to the new BEMS.

5 Energy dynamic simulation

The template, with IDA-ICE software was created starting from a basic AutoCad Revit BIM and ASHRAE standards.

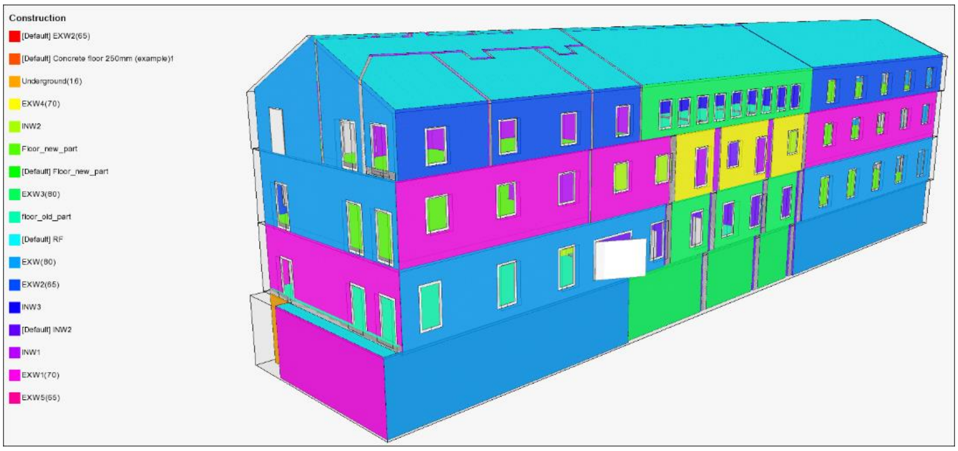

Fig. 5 - Modeling of building components

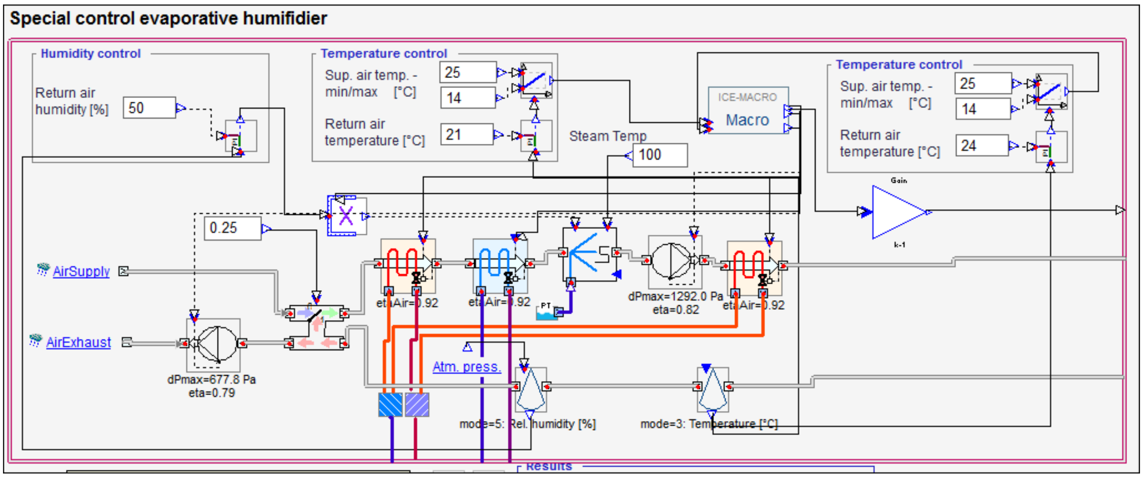

Fig. 6 - Modeling of the ventilation system

At the time it was completed the entire energy model and are experiencing trust with data in our possession and with those who are arriving from measuring and monitoring system installed this spring.

6 Building automation system

Computerized management systems are installed in the library of the various plants. Following the analysis of the protocols used (especially by the HVAC system), it was found that they were not well integrated and were not connected to the web. With the support of the European project's industrial partner Schneider Electric Company, TRIBUTE has designed the new architecture of control and management of energy systems of the building, trying to "catch up" as much as possible of existing systems while aiming at a target "high performance" of comfort and energy efficiency.
The building automation system of this first phase consists in summary:

- an automation server to control I/O modules, device management and monitoring on the fieldbus;
- Ethernet BACnet/IP-easy software;
- Ethernet gateway for existing HVAC system;
- a series of electricity and thermal energy.

In short you will install wireless facilities sensors (temperature, humidity and brightness) in any premises used by the public and will be done experimenting with CO_2 sensors and presence people in some quarters. The goal is to capture data that are coming from both the existing temperature control system by new devices installed, process them critically and verify the correspondence with the energy simulation model created.

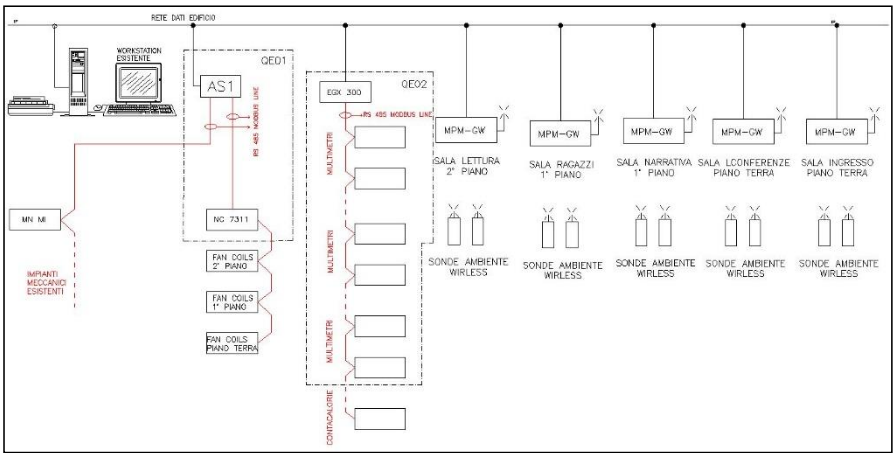

Fig. 7 - New BEMS

7 Conclusion and future developments

The adoption of an Energy Management System of an existing building (or complex of structures) needs to ensure better energy performance and comfort, deep diagnosis of building-system. Also, you should equip themselves with dynamic energy modelling system to analyze the state of fact and, following implementation of an appropriate system of building automation, to check for validity. Next, may be made before intervention, tested before, and after simulator with the feedback that comes from monitoring and measuring system installed. More details about the progress of the results can be found on the website of the project www.tribute TRIBUTE-fp7.eu/.

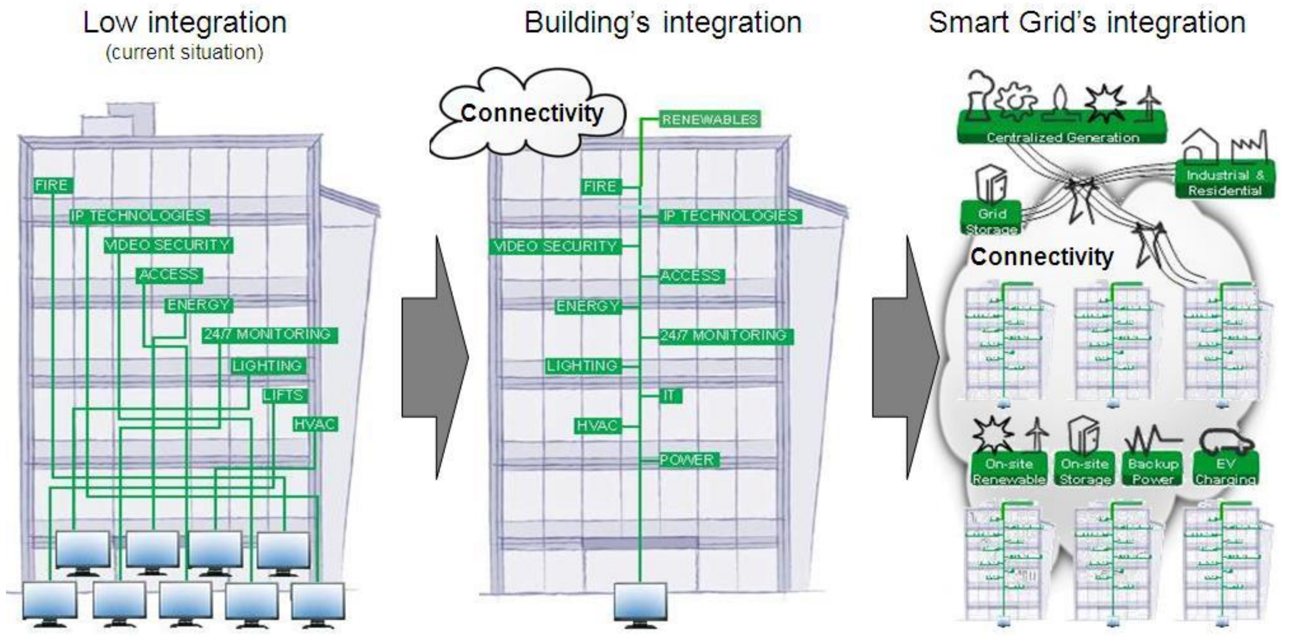

Fig. 8 - Smart Grid's integration

Furthermore, the results and knowledge from this case study, as those of other similar projects, are also intended to bring to a greater integration of smart grid and energy systems in buildings. The creation a replicable model from a case study to urban areas may: to generate an important economic value of the energy performance, to increase the comfort and safety of the occupants and to contribute to the reduction of greenhouse gases.

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