The analysis shows that a high potential is available to decrease the energy consumption of the building, reducing energy performance index from maximum values of 27 kWh/m^2/month down to minimum values of 5 kWh/m^2/month. At the same time, however, the discomfort indexes becomes critical, thus suggesting intermediate values of IPE around 15 kWh/m^2/month, showing an energy saving of about 16% in respect of standard IPE data of the building of 18.2 kWh/m^2/month.

The simulation results show also that when the building was not equipped with a thermostatic valve for the heating elements, the mean temperature was far from the temperature set point, while when the building was supplied with thermostatic valves the overheating was reduced and indoor temperature oscillations where reduced too, thus improving indoor comfort and reducing energy consumption.

In particular the effects of the different regulation settings of mixing valve (α) and thermostatic valve (β) are calculated quantitatively and proven to be extremely different. In the first case (β=0) the thermostatic valves are not used and the internal temperature has some significant fluctuations from the temperature of set point, strongly depending on α values.

Extending the analysis to increasing values of β the building reduce the fluctuations of temperature and reduce also heating energy demand.

Further developments are expected in the definition of proper comfort indexes for the indoor operation, in order to quantify correctly the potential energy savings due to smart regulation for building heating system.

REFERENCES

[1] *Europe's Buildings under the Microscope*. Buildings Performance Institute Europe (BPIE), 2011

[2] M. Isaac, D.P. Van Vuuren (2009) Modelling global residential sector energy demand for heating and air conditioning in the context of climate change. *Energy Policy 37*, pp. 507-521.

[3] *Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012* on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC Text with EEA relevance.

[4] *Final communication on A Framework Strategy for a resilient Energy Union with a Forward-Looking Climate Change Policy.* Energy Union Communication COM, 2015.

[5] *The Energy Performance of Buildings (Recast)*, Council of the European Parliament 2010/31/EU, 19 May 2010.

[6] *Energy Conservation in New Building Design*, ASHRAE Standard 90A-1980. (Atlanta American Society of Heating Refrigerating and Air Conditioning Engineers)

[7] S.A. Klein, EES - Engineering Equation Solver, F-Chart Software, (2015) Version 9.902, info@fchart.com .

[8] H. Boyer, J. P. Chabriat, B. Grondin-Perez, C. Tourrand and J. Brau, "Thermal building simulation and computer generation of nodal models," *Building and Environment*, vol. 31, no. 3, pp. 207–214. DOI: 10.1016/0360-1323(96)00001-7.

[9] G. Hudson and C. P. Underwood, "A simple modeling procedure for Matlab/Simulink," *Proceedings of the IBSPA Building Simulation.* Kyoto, pp. 776–83, 1999.

[10] T. Nielsen, "Simple tool to evaluate energy demand and indoor environment in the early stages of building design," *Solar Energy*, vol. 78, pp. 73-83, 2005.

[11] *Energy Performance of Buildings – Calculation of Energy Use for Space Heating and Cooling*, UNI EN ISO 13790:2008. (CEN, UE).

[12] M. Cucumo, V. Ferraro, D. Kaliakatsos and V. Marinelli, (2013). Simulation of the thermal behaviour of buildings equipped with low-emissivity glazed components. *Int J Heat & Tech*. [Online]. *31(2),* pp. 111-118, 2013. DOI: 10.18280/ijht.310215. Available: http://www.iieta.org/Journals/H%26TECH/ARCHIVE/Volume%2031%20No%202

[13] G. Cannistraro, M. Cannistraro and R. Restivo. (2013). Simulation of the thermal behaviour of buildings equipped with low-emissivity glazed components. *Int J Heat & Tech*. [Online]. *31(2),* pp. 155-158. DOI: 10.18280/ijht.310221. Available: http://www.iieta.org/Journals/H%26TECH/ARCHIVE/Volume%2031%20No%202

NOMENCLATURE

A	area [m^2]
C	thermal capacitance [J K^{-1}]
cp	water specific heat [J kg K^{-1}]
DD	degree days
H	heat transfer coefficient [K W^{-1}]
IB	temperature standard deviation [K]
IPE	energy performance parameter [kWh/m^2]
M	water flow rate [kg s^{-1}]
Q	heat transfer rate [W]
R	thermal resistance [K W^{-1}]
T	temperature [K]
U	transmittance [W m^{-2} K^{-1}]

Greek symbols

α	parameter of mixing valve
β	parameter of thermostatic valve
τ	time [s, h]
σ	Stefan-Boltzmann constant [W m^{-2}K^{-4}]

Subscripts

A	ambient
E	external
d	day
HS	heating system
i	internal
P	wall
RAD	solar radiation
source	internal sources
W	water