ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

The Analysis of Expediency of Daylight Sensors Using by Application of the Combined Strategy of Artificial Lightning Management.

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ABSTRACT

This article suggests the comparison of annual energy consumption based on standard office building by using climatic data of the Moscow region and two strategies of artificial lighting management: in the first case - with daylight sensors, in the second case - without sensors.
Key words: energy and environmental modeling; power efficient buildings and structures; software; energy-dependent systems; energy interrelations.

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INTRODUCTION

Automatic light control is an integral part of the implementation program of energy efficiency technologies. In office buildings people often forget to turn off the light when they leave, or use the light more than they need in the presence of sunlight. Using of daylighting sensors allows to achieve power saving and significantly increase the level of comfort and safety indoors. Sensors are simple in installation, provide automatic switching of any type of illumination and reduce running costs since switching happens only in the right place and time [1,2,3].

METHOD

Using daylighting sensors by control of the light devices power by carrying out assessment and comparison of energy efficiency in modern buildings requires complex calculations of the reached efficiency and expediency. Therefore, the need for development of certain technology of calculations of total annual energy consumption and associable cost of the consumed energy resources is obvious [1-10].

RESULTS AND DISCUSSION

This article suggests the comparison of annual energy consumption based on standard office building by using climatic data of the Moscow region and two strategies of artificial lighting control: in the first case - with daylight sensors, in the second case - without sensors.

Fig.1. 3D model of standard office building

The following assumptions and average values have been used in the calculation:

Climatic data based on the typical 2005 year for the city of Moscow by taking into account hourly values of overcast, solar activity and other used characteristics.

Standard office building with glazing for office rooms equal about 45% has been considered.

By calculation of annual energy, consumption of all building average values for the following categories have been used:

Glazing - 65% light transmittance coefficient
Atrium's roof lantern - 65% light transmittance coefficient
Average specific power of light devices for office rooms equal 12 W/sq.m
Operating time of light devices in office rooms is from 9.00 till 19.00

The minimum level of illumination fixed by sensors such, that shutdown of light devices in office rooms occurs, is equal 420 lx

Energy resources rates:
Electricity - 3,591 rub/kWh
Heating - 1558,47 rub/Gcal

ISSN: 0975-8585

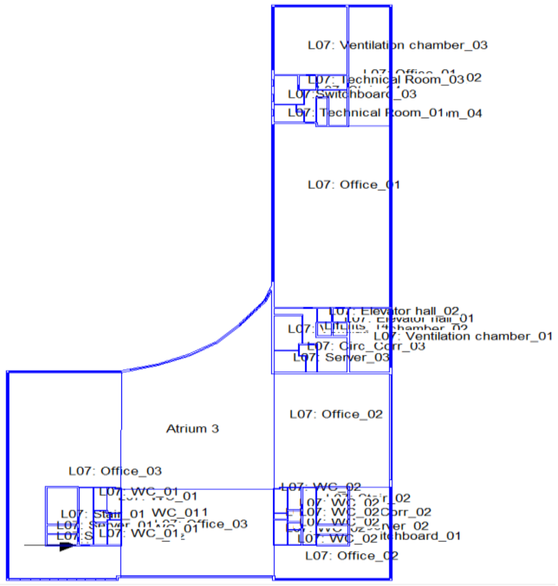

Fig.2. Plan of standard floor in office building

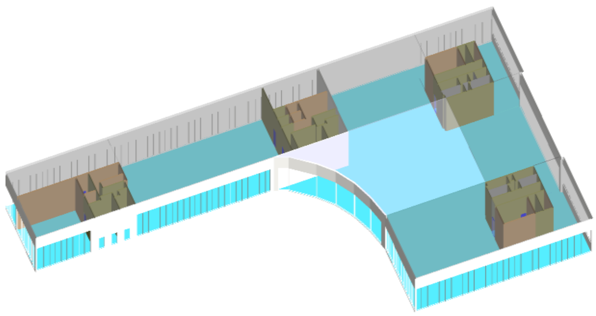

Fig.3. 3D representation of standard floor in office building

Calculation of energy consumption was based on standard floor in office building (office rooms area 2 700 sq.m). In this specific case, the seventh floor has been chosen. Before power modeling of the building by using of the Tas software version 9.3.3 (developer - EDSL company), the analysis of day lighting has been carried out for parameters determination of daylight factor (availability) to all office rooms. Results of this analysis are given below.

Table 1. Results of calculation of daylight factor

Rooms with daylight access	Daylight factor	Maximum	Minimum
Office 1	2,703724	21,25869	0,028059
Corridor	0,064693	0,309541	0,005612
Office 2	4,760827	31,071323	0,367372
Office 3	5,382065	31,467846	0,406353
Technical room	0,270988	1,79682	0,024729
Corridor	0,054172	0,314001	0
Technical room	0,276406	2,332039	0,016684
Technical room	3,10376	13,755683	0,327012
Technical room	3,088386	17,792139	0,138746
Atrium	54,288121	62,272368	19,167242

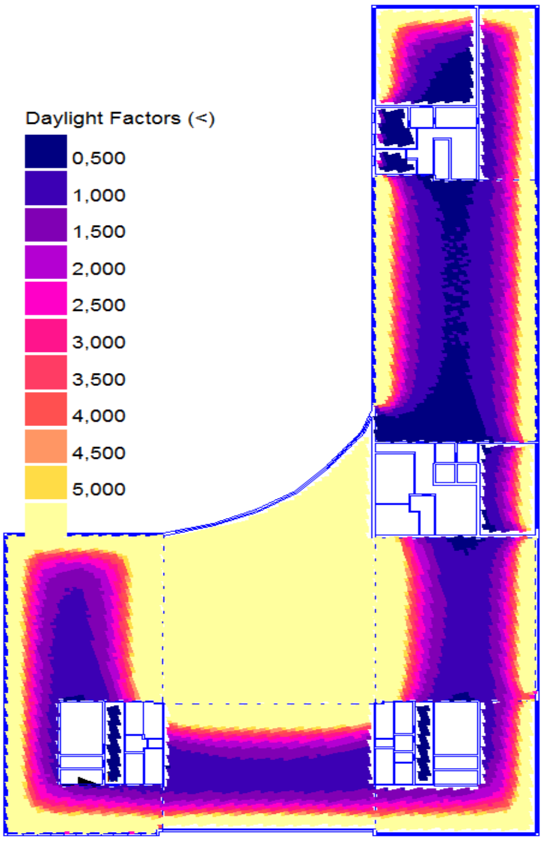

Fig.4. Graphic values of calculation of daylight availability coefficient

As we can see here, light in the building spreads irregularly: there are light rooms with the increased coefficient (atrium), and dark rooms where artificial lighting (corridor) is required most of the time.

The strategy of control of switching off/on the light devices has been simulated by taking into account the received results of daylight factor showed as a percentage based on the above-mentioned hourly parameters of climatic data. Thus at attainment of natural illumination of 500 lx - light devices are switching off, at reduction of natural illumination to 420 lx light devices are switching on. These data correspond to comfortable stay and work indoors.

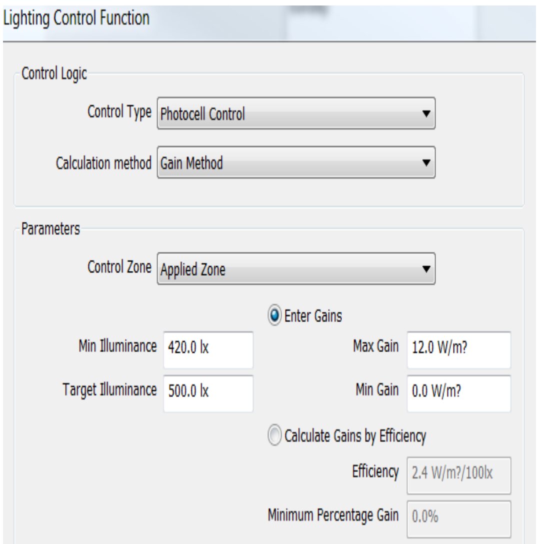

Fig.5. The strategy of artificial lighting management applied in modeling

With the purpose of the comparison of characteristics of building that includes daylight sensors, and building that does not include sensors, in office rooms by using EDSL TAS software two models have been prepared and calculated. The detailed values of energy consumption and cost of the consumed energy resources are given below:

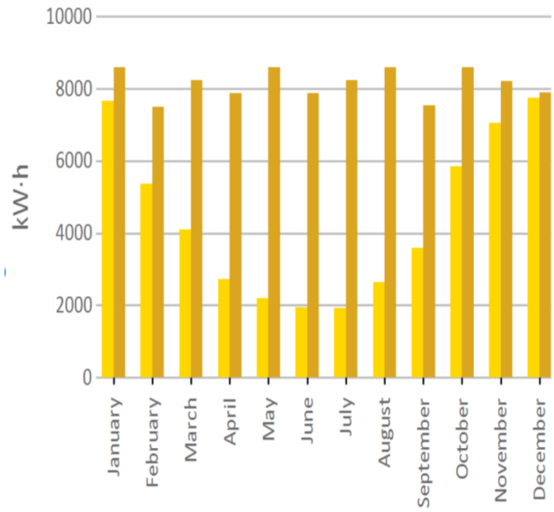

Fig.6. Comparison of energy consumption values of artificial lighting

From the Fig. 6 we see that the greatest saving is reached in the summer when duration of daylight is maximum therefore using of artificial lighting can be reduced.

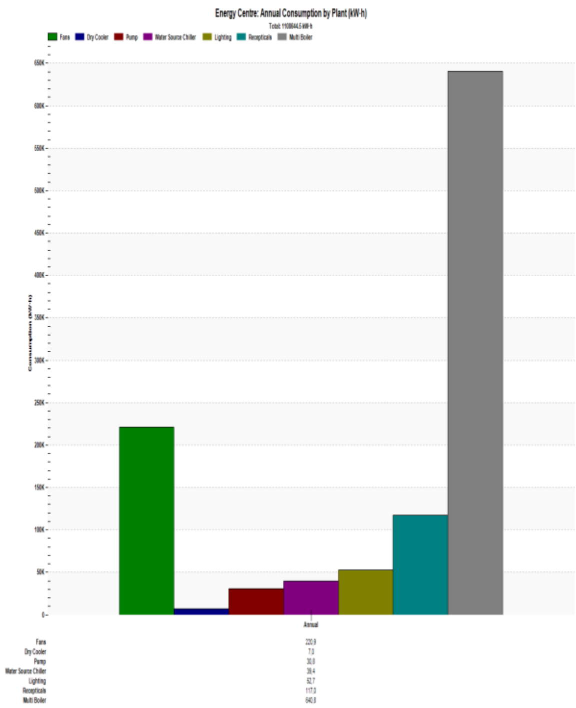

Fig.7. Annual energy consumption by using daylight sensors

ISSN: 0975-8585

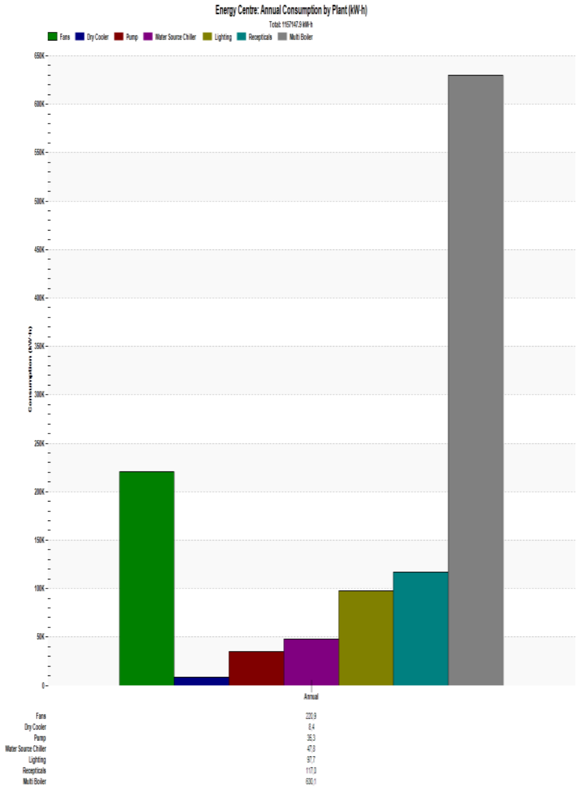

Fig.8. Annual energy consumption without using daylight sensors

Table 2. Comparative values of energy consumption

Annual energy consumption, kWh	Lighting	Heating	Ventilation	Office equipment	Chiller	Dry coolers	Pumps
Using daylight sensors	52738	640781	220890	116967	39420	7049	30798
Without using daylight sensors	97706	630124	220860	116967	47767	8411	35313

ISSN: 0975-8585

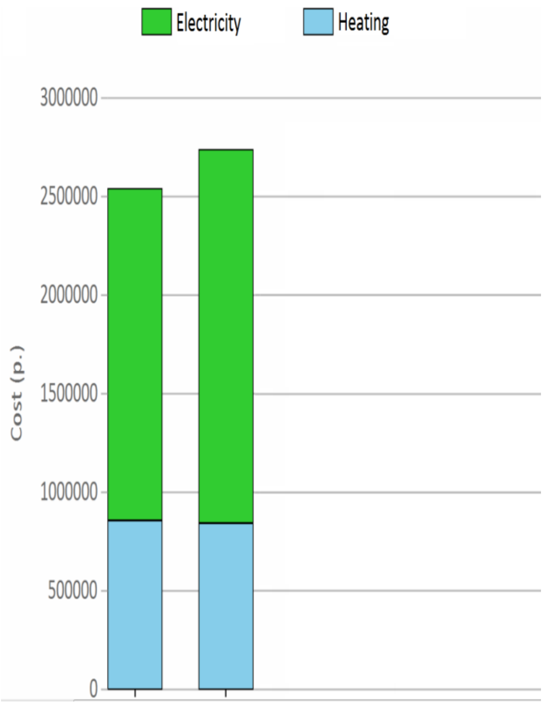

Fig.9. Comparative figures of cost on the example of the standard floor

Table 3. Comparative figures of cost

Energy consumption cost, rub	Using daylight sensors	Without using daylight sensors	Improvement, %
Heating	858647.17	844366.81	-1.69
Electricity	1680095.80	1892541.40	11.23
In total	2538742.97	2736908.21	7.24

The difference between two strategies of artificial lighting control is presented on the figures given above.

On the assumption of the received results the following conclusions can be drawn:

1. Using daylight sensors in offices with open space allows decreasing of energy consumption of artificial lighting by 46%
2. Within all building (based on standard floor) decrease of energy consumption is over 4%
3. Within all building (based on standard floor) reduction in cost of annual energy consumption is over 7%.
4. Based on standard floor (office rooms area 2 700 sq.m) reduction in cost of annual energy consumption due to use daylight sensors is 198,165 rubles.
5. The payback period of sensors amounts about 1.5 years.

CONCLUSION

This method of determination of expediency of application of different technical solutions allows making visual representations of several options by changing initial conditions, and allows getting necessary data in a short time for adjustment of the project.

ACKNOWLEDGEMENTS

This article was performed within the Russian Foundation for Basic Research in the framework of the project "Development of national calculation methods to determine the energy efficiency of buildings and structures with the help of mathematical modeling and the use of complex programs on energy modeling".

REFERENCES

[1] A.A. Volkov, A.V. Sedov, P.D. Chelyshkov, “Theory evaluation of specific consumption of certain types of energy”, Building automation, no. 07-08(42-43), 2010.
[2] O.O. Egorychev, A.A. Volkov, “Automation of engineering systems of buildings, facilities assets and technological cycles in solving the problems of energy saving”, Herald of the Russian Union of builders, no. 1, pp. 23-26, 2010.
[3] A.A. Volkov, “General information models of intelligent building control systems”, Proceedings of the International Conference «Computing in Civil and Building Engineering», 30 June − 2 July 2010 (edited by W. Tizani). UK: Nottingham University Press, paper 43, pp. 85, 2010. ISBN 978-1-907284-60-1.
[4] A.A. Volkov, “Homeostat buildings and structures: Cybernetics objects and processes”, Information model functional systems (Ed. K.V. Sudakov, A.A. Gusakov). M: the Foundation for the New Millennium", 2004.
[5] A.A. Volkov, “Intelligence buildings. Part 1”, Vestnik MGSU, no. 4, pp. 186- 190, 2008.
[6] A.A. Volkov, “Intelligence buildings. Part 2”, Vestnik MGSU, no. 1, pp. 213- 216, 2009.
[7] S.A. Doroshenko, A.V. Doroshenko, “Physical Modeling of Flow around the Underwater Tidal Power”, Procedia Engineering, vol. 91, pp. 194–199, 2014.
[8] V.N. Varapaev, A.V. Doroshenko, “Methodology for the Prediction and the Assessment of Pedestrian Wind Environment around Buildings”, Procedia Engineering, vol. 91, pp. 200–203, 2014.
[9] A. Volkov, “General Information Models of Intelligent Building Control Systems”, In Computing in Civil and Building Engineering, Proceedings of the International Conference, Nottingham, UK, Nottingham University Press, paper 43, pp. 8, 2010.
[10] J.K.W. Wong, H. Li, S.W. Wang, “Intelligent building research: a review,” Autom. Construction, vol. 14, no. 1, pp. 143–159, 2005.