

## “BEHBUDIY IZDOSHLARI” ILMIY VA IJODIY ISHLAR TANLOVI

must address the challenges of language change to promote linguistic diversity and multilingual competence.

### REFERENCES:

1. Crystal, D. (2003). English as a Global Language. Cambridge University Press.
2. Eble, C. (2012). Slang and Sociability: In-group Language Among College Students. University of North Carolina Press.
3. Tagg, C. (2015). Exploring Digital Communication: Language in Action. Routledge.
4. Androutsopoulos, J. (2006). "Multilingualism, diaspora, and the Internet: Codes and identities on German-based diaspora websites." Journal of Sociolinguistics, 10(4), 520–547.
5. Pennycook, A. (2007). Global Englishes and Transcultural Flows. Routledge.
6. Kachru, B. B. (1992). The Other Tongue: English Across Cultures. University of Illinois Press.
7. McArthur, T. (1998). The English Languages. Cambridge University Press.
8. Danet, B., & Herring, S. C. (2007). The Multilingual Internet: Language, Culture, and Communication Online. Oxford University Press.
9. Bhatia, T. K., & Ritchie, W. C. (2013). The Handbook of Bilingualism and Multilingualism. Wiley-Blackwell.
10. Mesthrie, R., & Bhatt, R. M. (2008)

### USE OF HEAT ACCUMULATORS IN GREENHOUSE TYPE PASSIVE SOLAR HEATING SYSTEMS

**Muzafarova Sevinch Muhammadovna**

*Bukhara State University*

**Abstract.** *In the research work, a mathematical model of heat processes in the passive solar heating system of the Sunspace type was developed, and on this basis, the annual indicators of the considered system were determined. As the results obtained show, heat losses through the southern wall of an ordinary residential building during the heating season are 16-17 kW·hr/(m<sup>2</sup>·year). The heat input through the southern wall in the heating season is about 125-130 kW·hr/(m<sup>2</sup>·year), and the accumulated energy is 107-114 kW·hr/(m<sup>2</sup>·year), in the presence of a heat accumulator.*

**Key words:** *solar energy; heat accumulators; passive solar heating systems; heat conduction; convection; radiation; heat balance.*

## “BEHBUDIY IZDOSHLARI” ILMIY VA IJODIY ISHLAR TANLOVI

**Introduction.** According to the International Energy Agency, residential energy consumption in Uzbekistan in 2020 amounted to 35.92% of the total final energy consumption of the Republic[1]. In developed countries this figure is 20-25%. As the dynamics of energy consumption in Uzbekistan shows, the situation is gradually improving year after year, for example in 2011, about 40% of total energy was consumed in the residential sector.

Today in the Republic, 40% of the electricity produced is used for heating and lighting, that is, the annual specific energy consumption for heating and lighting is 400 kW·hour, and in developed countries 170 kW·hour. As studies have shown, the annual specific energy consumption of rural residential buildings (a typical four-room residential building) for heating alone is 218 kW·hour/m<sup>2</sup> (for the first level of thermal protection)[2].

The amount of energy consumed by the construction sector in economic sectors is up to 40% of the total energy consumption, of which 50% is used to provide comfort in rooms [3]. The energy efficiency of individual residential buildings is very low, which in turn leads to a lot of energy loss and damage to the environment [4]. Active and passive solar heating systems are widely used together with a number of methods to improve energy efficiency in buildings [5].

Passive solar heating systems are characterized by low cost, ease of use and long-term use[6]. Passive solar heating systems are mainly divided into three types: direct gain, heat storage wall and Sunspace [7]. Sunspace is one of the basic types of passive solar heating systems, and has been actively used in recent years in scientific research on improving the energy efficiency of buildings. Studies on the use of Sunspace passive solar heating systems in many climates around the world have yielded positive results [3,8,17–22,9–16].

**Mathematical model.** To develop a mathematical model, we used the mathematical model given in [23] and the equations of heat balances of differential type are written [24]. In writing the heat balance equations for each element of the living room [25] literature is used.

Heat balance equation for a heat accumulator

$$c_{ha}m_{ha} \frac{dT_{ha}}{dt} = h_{ha\_ra}F_{ha}(T_{ra} - T_{ha}) + U_bF_{ha}(T_e - T_{ha}) + (\tau\alpha)_{eff\_ha}F_{ha}I_T \quad (1)$$

where  $c_{ha}$ ,  $m_{ha}$ ,  $T_{ha}$ - specific heat capacity, mass and temperature of the heat accumulator, respectively;  $h_{ha\_ra}$ - coefficient of heat transfer from the heat accumulator to the room air;  $U_b$ - coefficient of heat transfer from the heat accumulator to the external environment through the base of the building;  $F_{ha}$ - the heat exchange surface of the heat accumulator;  $T_{ra}$ - room air temperature;  $T_e$ - soil temperature of a certain thickness;  $(\tau\alpha)_{eff\_ha}$ - effective light absorption coefficient of the heat accumulator;  $I_T$ - solar radiation;  $t$ - time.

Heat balance equation for transparent layer

$$c_gm_g \frac{dT_g}{dt} = h_{g\_ra}F_g(T_{ra} - T_g) + h_{g\_a}F_g(T_a - T_g) + (\tau\alpha)_{eff\_g}F_gI_T \quad (2)$$

where,  $c_g$ ,  $m_g$ ,  $T_g$  - respectively, specific heat capacity, mass and temperature of the transparent layer;  $h_{g\_ra}$ - coefficient of heat transfer from the transparent layer to the room air;

## “BEHBUDIY IZDOSHLARI” ILMIY VA IJODIY ISHLAR TANLOVI

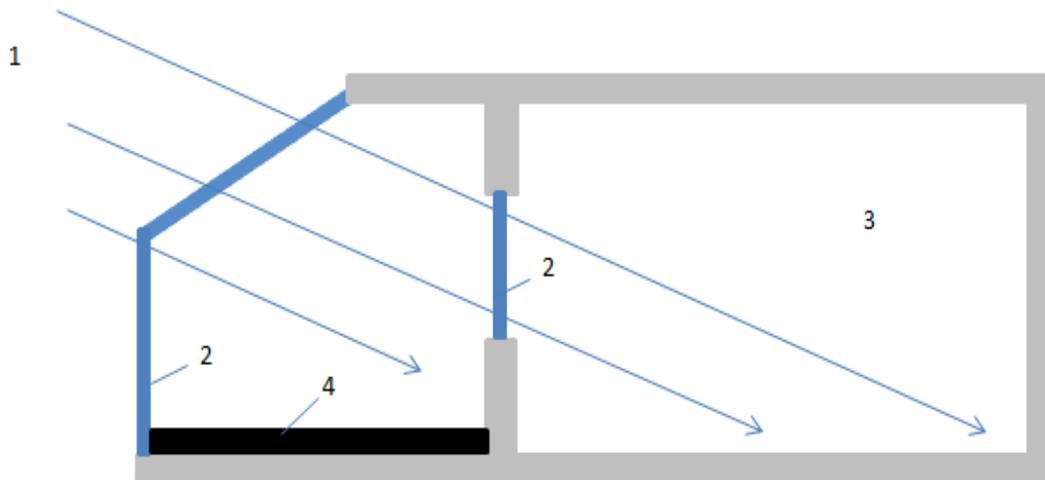
$F_g$ - transparent layer surface;  $h_{g-a}$ - coefficient of heat transfer from the transparent layer to the environment;  $(\tau\alpha)_{eff-g}$ - effective light absorption coefficient of the transparent layer.

Heat balance equation for indoor air

$$c_{ra}m_{ra}\frac{dT_{ra}}{dt} = h_{ha-ra}F_{ha}(T_{ha} - T_{ra}) + h_{g-ra}F_g(T_g - T_{ra}) + h_{sw-ra}F_{sw}(T_{sw} - T_{ra}) \quad (3)$$

where,  $c_{ra}$ ,  $m_{ra}$ - specific heat capacity and mass of room air, respectively;  $h_{sw-ra}$ - heat exchange coefficient between the room air and the south wall;  $F_{sw}$ ,  $T_{sw}$ - south wall surface and temperature, respectively.

The system of equations (1)-(3) together with the system of equations written for the building is solved by Gauss-Seidel iteration method using finite volume method. Calculations were performed in Python and MathCAD programming language and packages. Appropriate mathematical expressions for the heat transfer coefficients were obtained from [5]. As a boundary condition, the values of ambient temperature, solar radiation and wind speed for the Bukhara region were taken from[26].



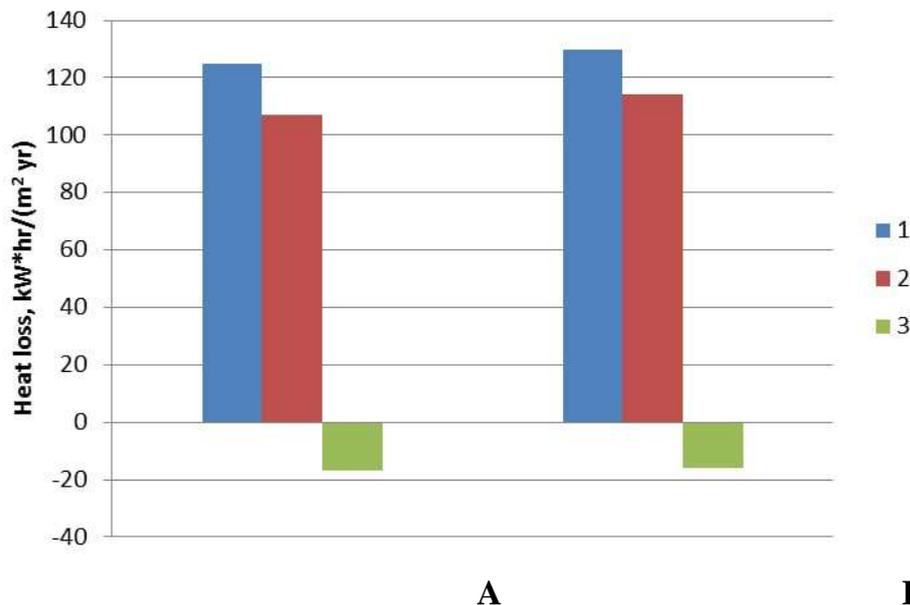
**Fig.1.** Schematic diagram of a passive solar heating system of the Solarium type (Greenhouse): 1-sun rays; 2-transparent barriers; 3-indoor air; 4- heat accumulator.

**Results and discussions.** Relevant experimental studies were carried out for latitude  $39.1^\circ$ . Placing heat accumulators on the front of a passive solar heating system of the greenhouse type makes it possible to accumulate daytime excess heat, and the use of a thermal protective coating at night prevents a sharp drop in air temperature inside the greenhouse.

Based on the developed mathematical model, calculations were made to determine heat flows through the southern wall of a residential building with a passive solar heating system such as a

## “BEHBUDIY IZDOSHLARI” ILMIY VA IJODIY ISHLAR TANLOVI

greenhouse. As the results obtained show, heat losses through the southern wall of an ordinary residential building during the heating season are 16-17 kW·hr/(m<sup>2</sup>·year). The heat input through the southern wall in the heating season is about 125-130 kW·hr/(m<sup>2</sup>·year), and the accumulated energy is 107-114 kW·hr/(m<sup>2</sup>·year), in the presence of a heat accumulator. With an increase in the mass of the heat accumulator in the greenhouse part of a passive solar heating system, heat losses are reduced and heat input and the amount of accumulated heat increase. At the same time, thermal insulation of the outer part of the translucent fence at night and cloudy times plays an important role, reducing heat losses through the translucent fence.



**Fig.2.** Heat balance through 1 m<sup>2</sup> of area of the southern wall of a passive solar heating system of the “Sunspace (greenhouse)” type: A - without heat accumulator; B-with heat accumulator; 1-incoming heat flows; 2- storage energy; 3- heat losses.

**Conclusions.** The main result of the presented research work is the mathematical model for the passive solar heating system of the Sunspace type, its validation and annual indicators. The mathematical model developed for the non-stationary process allows determining the hourly, monthly and annual heat indicators of the passive solar heating system of the Sunspace type based on the boundary conditions. The author determined and compared the heat input from passive solar heating systems of the Sunspace type with and without a heat accumulator. As the results obtained show, heat losses through the southern wall of an ordinary residential building during the heating season are 16-17 kW·hr/(m<sup>2</sup>·year). The heat input through the southern wall in the heating season is about 125-130 kW·hr/(m<sup>2</sup>·year), and the accumulated energy is 107-114 kW·hr/(m<sup>2</sup>·year), in the presence of a heat accumulator.

- [1] International Energy Agency Statistics, (n.d.). <https://www.iea.org/statistics> (accessed September 22, 2021).
- [2] Analysis of Results of Energy Monitoring over the Heating Season of 2014-2015 after Application of Energy-Efficient Measures and Renewable Energy in a Pilot Four-Room Rural House, Tashkent, 2015.  
[https://www.uz.undp.org/content/uzbekistan/en/home/library/environment\\_energy/analysis-of-results-of-energy-monitoring-over-the-heating-season.html](https://www.uz.undp.org/content/uzbekistan/en/home/library/environment_energy/analysis-of-results-of-energy-monitoring-over-the-heating-season.html).
- [3] L. Ma, D. Luo, H. Hu, Q. Li, R. Yang, S. Zhang, D. Li, Energy performance of a rural residential building with PCM-silica aerogel sunspace in severe cold regions, *Energy Build.* 280 (2023) 112719. <https://doi.org/10.1016/j.enbuild.2022.112719>.
- [4] L. Zhang, Z. Dong, F. Liu, H. Li, X. Zhang, K. Wang, C. Chen, C. Tian, Passive solar sunspace in a Tibetan buddhist house in Gannan cold areas: Sensitivity analysis, *J. Build. Eng.* 67 (2023) 105960. <https://doi.org/10.1016/j.jobee.2023.105960>.
- [5] J.A. Duffie, W.A. Beckman, *Solar Engineering of Thermal Processes: Fourth Edition*, 2013. <https://doi.org/10.1002/9781118671603>.
- [6] R.R. Avezov, A.Y. Orlov, *Solar heating and hot water systems (Solnechnie sistemi otopleniya i goryachego vodosnabzheniya , in Russian)*, “FAN,” Tashkent, 1988.
- [7] S. Kalogirou, *Solar energy engineering : processes and systems*, 1st ed., Elsevier, 2009.
- [8] W. Wang, M. Yuan, Y.Z. Li, C. Li, Numerical investigation on the impact of an on-top sunspace passive heating approach for typical rural buildings in northern China, *Sol. Energy* 186 (2019) 300–310. <https://doi.org/10.1016/j.solener.2019.05.013>.
- [9] A. Vukadinović, J. Radosavljević, A. Đorđević, M. Protić, N. Petrović, Multi-objective optimization of energy performance for a detached residential building with a sunspace using the NSGA-II genetic algorithm, *Sol. Energy* 224 (2021) 1426–1444. <https://doi.org/10.1016/j.solener.2021.06.082>.
- [10] A. Vukadinović, J. Radosavljević, A. Đorđević, Energy performance impact of using phase-change materials in thermal storage walls of detached residential buildings with a sunspace, *Sol. Energy* 206 (2020) 228–244. <https://doi.org/10.1016/j.solener.2020.06.008>.
- [11] G. Ulpiani, D. Giuliani, A. Romagnoli, C. di Perna, Experimental monitoring of a sunspace applied to a NZEB mock-up: Assessing and comparing the energy benefits of different configurations, *Energy Build.* 152 (2017) 194–215. <https://doi.org/10.1016/j.enbuild.2017.04.034>.
- [12] M.J. Suárez López, S.S. Castro, A.N. Manso, E.B. Marigorta, Heat collection in an attached sunspace, *Renew. Energy* 145 (2020) 2144–2150. <https://doi.org/10.1016/j.renene.2019.07.137>.
- [13] M. Shan, T. Yu, X. Yang, Assessment of an integrated active solar and air-source heat pump water heating system operated within a passive house in a cold climate zone, *Renew. Energy* 87 (2016) 1059–1066. <https://doi.org/10.1016/j.renene.2015.09.024>.
- [14] A. Sánchez-Ostiz, A. Monge-Barrio, S. Domingo-Irigoyen, P. González-Martínez, Design and experimental study of an industrialized sunspace with solar heat storage, *Energy Build.* 80 (2014) 231–246. <https://doi.org/10.1016/j.enbuild.2014.05.031>.

## **“BEHBUDIY IZDOSHLARI” ILMIY VA IJODIY ISHLAR TANLOVI**

- [15] M. Owrak, M. Aminy, M.T. Jamal-Abad, M. Dehghan, Experiments and simulations on the thermal performance of a sunspace attached to a room including heat-storing porous bed and water tanks, *Build. Environ.* 92 (2015) 142–151. <https://doi.org/10.1016/j.buildenv.2015.04.022>.
- [16] L. Ma, X. Zhang, D. Li, M. Arıcı, Ç. Yıldız, Q. Li, S. Zhang, W. Jiang, Influence of sunspace on energy consumption of rural residential buildings, *Sol. Energy* 211 (2020) 336–344. <https://doi.org/10.1016/j.solener.2020.09.043>.
- [17] S. Lu, H. Tong, B. Pang, Study on the coupling heating system of floor radiation and sunspace based on energy storage technology, *Energy Build.* 159 (2018) 441–453. <https://doi.org/10.1016/j.enbuild.2017.11.027>.
- [18] Z. Liu, D. Wu, B.J. He, Q. Wang, H. Yu, W. Ma, G. Jin, Evaluating potentials of passive solar heating renovation for the energy poverty alleviation of plateau areas in developing countries: A case study in rural Qinghai-Tibet Plateau, China, *Sol. Energy* 187 (2019) 95–107. <https://doi.org/10.1016/j.solener.2019.05.049>.
- [19] Q. Li, H. Hu, L. Ma, Z. Wang, M. Arıcı, D. Li, D. Luo, J. Jia, W. Jiang, H. Qi, Evaluation of energy-saving retrofits for sunspace of rural residential buildings based on orthogonal experiment and entropy weight method, *Energy Sustain. Dev.* 70 (2022) 569–580. <https://doi.org/10.1016/j.esd.2022.09.007>.
- [20] G. Allesina, C. Ferrari, A. Muscio, S. Pedrazzi, Easy to implement ventilated sunspace for energy retrofit of condominium buildings with balconies, *Renew. Energy* 141 (2019) 541–548. <https://doi.org/10.1016/j.renene.2019.04.037>.
- [21] G. Chiesa, M. Simonetti, G. Ballada, Potential of attached sunspaces in winter season comparing different technological choices in Central and Southern Europe, *Energy Build.* 138 (2017) 377–395. <https://doi.org/10.1016/j.enbuild.2016.12.067>.
- [22] J. Gainza-Barrencua, M. Odriozola-Maritorena, R. Hernandez\_Minguillon, I. Gomez-Arriaran, Energy savings using sunspaces to preheat ventilation intake air: Experimental and simulation study, *J. Build. Eng.* 40 (2021). <https://doi.org/10.1016/j.jobee.2021.102343>.
- [23] N.R. Avezova, K.A. Samiev, A.R. Khaetov, I.M. Nazarov, Z.Z. Ergashev, M.O. Samiev, S.I. Suleimanov, Modeling of the unsteady temperature conditions of solar greenhouses with a short-term water heat accumulator and its experimental testing, *Appl. Sol. Energy (English Transl. Geliotekhnika)* 46 (2010). <https://doi.org/10.3103/S0003701X10010020>.
- [24] Y.A. Çengel, A.J. Ghajar, *Heat and Mass Transfer: Fundamentals & Applications*, McGraw-Hill Education, New York, 2015.
- [25] K.A. Samiev, Simulation of thermal regime of room, heated by passive insolation solar heating systems with three-layer ventilated translucent barriers, *Appl. Sol. Energy (English Transl. Geliotekhnika)* 45 (2009). <https://doi.org/10.3103/S0003701X09040197>.
- [26] <https://power.larc.nasa.gov/data-access-viewer/>, (n.d.).

### **OQDARYO TUMANI AHOLI SONINING O’SISHI VA MEXANIK HARAKATI.**

**Ruxshona G’ulom qizi Sultonmurodova**

*Sharof Rashidov nomidagi Samarqand davlat universiteti*

*301-guruh talabasi*

*Email: [ruxshonasultonmurodova5@gmail.com](mailto:ruxshonasultonmurodova5@gmail.com)*