Figure 5, Figure 6 and Figure 7 show the results of the temperatures obtained.

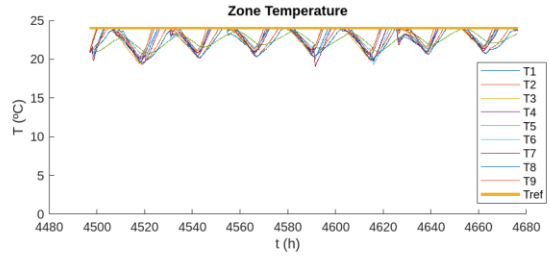

Figure 5. First floor rooms temperatures during summer

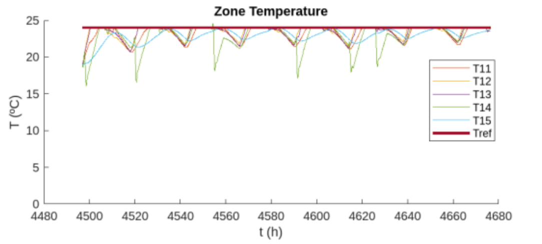

Figure 6. Ground floor rooms temperatures during summer

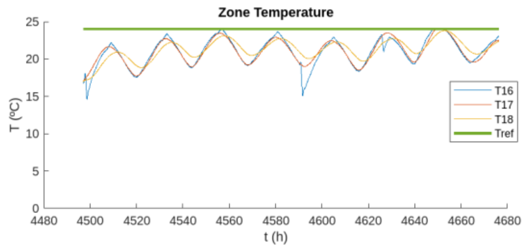

Figure 3. Basement room temperatures during summer

The thermal power generated by the air-conditioning system is shown in Figure 8.

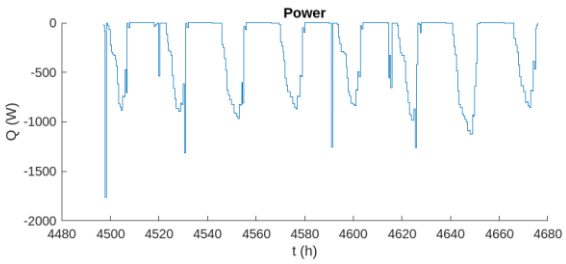

Figure 8. Cooling thermal power for the house.

Thus, the annual electricity consumption for cooling was 3140 kWh, of which 980 kWh came from the grid and 2160 kWh from the photovoltaic system.

6 CONCLUSIONS

After analyzing the different results obtained, we can conclude that the thermal model adequately reflects the thermal evolution of a single-family home and the thermal properties of the materials used in the construction of a single-family house have been considered accordingly to the actual legislation.

Also, the operating parameters of the controller have been determined by predictive model that allow an optimal performance of the controller. For each of the simulated situations, a set of parameter values has been found that always ensures the thermal comfort of the house, in addition to complying with the other optional functionalities of the controller.

The consumption and the associated economic cost of the energy coming from the electrical network have been minimized. Moreover, a reduction in consumption and cost has been achieved in both winter and summer seasons with respect to the base case of single temperature control. In winter, the reduction in consumption and cost was 9.02% and 15.50%, respectively. In summer, a reduction in consumption and cost of 69.23% and 71.38%, respectively, was achieved.

The consumption of electricity from the photovoltaic installation for self-consumption of the single-family home has been maximized. In both winter and summer, the value of electrical energy used by the air conditioning system from the photovoltaic installation has been increased. In winter this increase was 1.89%, while in summer the increase was 11.11%.

The controller has a correct behavior when there are intense disturbances in the thermal loads. It has been demonstrated that with the parameter values obtained in common situations, the controller is able to act adequately in exceptional situations such as heat waves or cold waves, maintaining at all times the thermal comfort in the single-family house.

References

[1] LAGUNA, G., MOR, G., LAZZARI, F., GABALDON, E., ERFANI, A., SAELENS, D., & CIPRIANO, J. (2022). Dynamic horizon selection methodology for model predictive control in buildings. *Energy Reports*, *8*, 10193-10202.

[2] SANTOS-HERRERO, J. M., LOPEZ-GUEDE, J. M., & FLORES, I. (2017). A Short review on the use of renewable energies and model predictive control in buildings. *Journal of Energy Systems*, *1*(3), 112-119.

[3] Chen, W. H., & You, F. (2022). Sustainable building climate control with renewable energy sources using nonlinear model predictive control. *Renewable and Sustainable Energy Reviews*, *168*, 112830.

[4] MERZBACHER, H., SYNDICUS, M., WARTHMANN, A., & VAN TREECK, C. (2022). Exploratory comparison of control algorithms and machine learning as regulators for a personalized climatization system. *Energy and Buildings*, *255*, 111653.

[5] WANG, YANG Y KUCKELKORN, JENS Y LIU, YU. 2017. A state of art review on methodologies for control strategies in low energy buildings in the period from 2006 to 2016. 2017. Energy and Buildings 147:27–40.

[6] AFRAM, ABDUL Y JANABI-SHARIFI, FARROKH. 2017. Supervisory model predictive controller (MPC) for residential HVAC systems: Implementation and experimentation on archetype sustainable house in Toronto. 2017. Energy and Buildings, 154:268-282.

[7] CHING, FRANCIS D.K. 2015. Diccionario visual de arquitectura. 2015. 2a. ed. Barcelona: Gustavo Gili S.L., p. 39. ISBN-13: 978-84-252-2787-5

[8] LÖFBERG, JOHAN. 2004. YALMIP: A Toolbox for Modeling and Optimization in MATLAB [programa informático]. 2004. Versión R20181012. Taipei.

[9] WÄCHTER, ANDREAS Y LAIRD, CARL. 2005. IPOPT: Interior Point Optimizer. 2005. Versión 3.14.0. Pittsburgh.

[10] PRÍVARA S, SIROKÝ J, FERKL L, CIGLER J. Model predictive control of a building heating system: the first experience. Energy Build 2011;43:564–72.

[11] YANG S, WAN MP. Machine-learning-based model predictive control with instantaneous linearization – a case study on an air-conditioning and mechanical ventilation system. Appl Energy 2022;306:118041.

[12] OLDEWURTEL F, ULBIG A, PARISIO A, ANDERSSON G, MORARI M. Reducing peak electricity demand in building climate control using real-time pricing and model predictive control. Ieee Decis Contr; 2010.

[13] DRGONA J, ARROYO J, CUPEIRO FIGUEROA I, BLUM D, ARENDT K, KIM D, ET AL. All you need to know about model predictive control for buildings. Annu Rev Control 2020;50:190–232