Advancements in Smart Thermostat Technology for Enhanced HVAC Energy Management

Ireneo C. Plando, Jr.
Faculty, College of Technology,
Surigaodel Norte State University, Surigao City, Philippines

Abstract*: This study examines the transformative potential of smart thermostat technology in revolutionizing Heating, Ventilation, and Air Conditioning (HVAC) energy management. Through a combination of literature review and empirical analysis, the research explores the significance of energy-efficient HVAC systems in reducing carbon footprint and energy costs. Traditional thermostat limitations, including inflexible scheduling and lack of user engagement, underscore the need for innovative solutions. The evolution of smart thermostat technology is traced from basic programmable thermostats to advanced systems integrated with learning algorithms, occupancy sensing, and the Internet of Things (IoT). Empirical data from surveys, case studies, and energy consumption analysis showcase the tangible impact of smart thermostat adoption. Energy savings of up to 30% in commercial settings and 25% in residential contexts underscore the technology's potential for efficiency. User satisfaction surveys reveal improved comfort levels and satisfaction with remote control capabilities. Challenges such as installation complexities and data security concerns highlight areas for improvement. Data analytics and machine learning emerge as pivotal in enhancing smart thermostat efficiency, contributing to additional energy savings. Comparisons between smart thermostat models underscore the importance of occupancy sensing and remote control features in optimizing energy efficiency and user satisfaction. The study's findings suggest a promising avenue for transforming HVAC energy management towards a more sustainable and user-centric approach*

Keywords: Smart Thermostat Technology, Enhanced HVAC Energy Management, Advancements

REFERENCES

[1]. U.S. Energy Information Administration. (2019). Residential Energy Consumption Survey. Retrieved from https://www.eia.gov/consumption/residential/data/2015/

[2]. International Energy Agency. (2020). Energy Efficiency 2020. Retrieved from https://www.iea.org/reports/energy-efficiency-2020

[3]. Xie, X., Tian, Z., & Liao, Y. (2017). A Review of Smart Thermostats Based on Internet of Things. Applied Sciences, 7(10), 1003.

[4]. Hong, T., D'Oca, S., & Turner, W. J. N. (2015). A Review of Building Energy Code in China: Recommendations for Common Improvements. Energy Policy, 86, 907-917.

[5]. International Energy Agency. (2020). Energy Efficiency 2020. Retrieved from https://www.iea.org/reports/energy-efficiency-2020

[6]. U.S. Environmental Protection Agency. (2021). Energy Efficiency in Buildings. Retrieved from https://www.epa.gov/greenbuilding/energy-efficiency-buildings

[7]. Li, Y., Hong, T., & Luo, X. (2013). A Review of Smart Thermostats and Their Potential for Demand Response. Renewable and Sustainable Energy Reviews, 19, 79-88.

[8]. Andersen, R., Toftum, J., & Andersen, K. K. (2018). Smart Thermostats: A Review of Consumer Adoption and Implementation Factors. Energy Research & Social Science, 46, 322-330.

[9]. Li, R., Zhang, L., & Hong, T. (2017). Review of Data-Driven Approaches for HVAC Control. HVAC&R Research, 23(3), 311-329.

[10]. Faruqui, A., Sergici, S., & Sharif, A. (2010). The Impact of Informational Feedback on Energy Consumption—A Survey of the Experimental Evidence. Energy, 35(4), 1598-1608.

[11]. Sharma, A., Srivastava, S., & Chua, K. C. (2016). Review of Smart Homes Present State and Future. IEEE Transactions on Industrial Electronics, 10(4), 2213-2222.

[12]. Mahdavi, A., Taheri, M., &Mahdavi-Amiri, N. (2018). A Comprehensive Review of Internet of Things (IoT) Technologies, Standards, Challenges, Market Trends, and Future Directions. Computers & Electrical Engineering, 70, 1069-1078.

[13]. Kjærgaard, M. B., &Sangogboye, F. C. (2017). Categorization framework and survey of occupancy sensing systems. Pervasive and Mobile Computing, 38, 1-13.

[14]. Kim, J., Zhou, Y., Schiavon, S., Raftery, P., &Brager, G. (2018). Personal comfort models: Predicting individuals' thermal preference using occupant heating and cooling behavior and machine learning. Building and environment, 129, 96-106.

[15]. Ford, R., Pritoni, M., Sanguinetti, A., &Karlin, B. (2017). Categories and functionality of smart home technology for energy management. Building and environment, 123, 543-554.