Abstract

The building sector, responsible for 36% of global energy consumption, is strategic to reach the carbon neutrality since it presents significant opportunities for energy optimization, in particular during building operation. This thesis explores the deployment and scaling of Artificial Intelligence-based Decision Support Systems (DSS) to enhance energy management in buildings. Focusing on Energy Management and Information Systems (EMIS), the research addresses the challenges of integrating advanced machine learning techniques for meter- and system-level anomaly detection at different scales across dynamic, heterogeneous data environments which is the state of the art of the building sector nowadays. The key methodologies proposed include unsupervised machine learning algorithms, context-aware data processing, portable semantic modeling, and automated diagnostic systems tailored to evolving building configurations. To address challenges related to interoperability and portability during the implementation and deployment of applications, a portable application framework is introduced. This framework is validated through comprehensive analyses spanning development, implementation, deployment, and continuous commissioning in real-world case studies. The results highlight its adaptability and robustness, demonstrating its capacity to optimize energy use across diverse operational contexts. By addressing practical constraints — such as data heterogeneity, interoperability, and scalability — the research bridges the gap between academic innovation and industry adoption. Results indicate significant potential for reducing the implementation gap of advanced energy management methodologies fostering its adoption throughout the building sector, contributing to the growing body of knowledge on AI-driven decision support systems, proposing solutions that are not only innovative but also practical, portable, and scalable for real-world applications.