ABSTRACT:

This dissertation investigates the application of advanced machine learning (ML) and optimization methods to enhance the efficiency and cost-effectiveness of heating, ventilation, and air conditioning (HVAC) systems in smart homes. The research is structured into three main chapters, each addressing different aspects of energy management through innovative technologies and strategies.

The first part focuses on improving electrical energy demand forecasting using long short-term memory (LSTM) models. It examines the impact of various model parameters on forecasting accuracy, finding that certain configurations can significantly enhance model performance measured as model accuracy. The research identifies optimal model settings, including layer numbers and batch sizes, which provide better model performance, which in turn will contribute to more effective energy management. In the second part, a novel approach to demand side management (DSM) at the district level is presented. This approach employs cloud-based technologies and deep learning models to optimize HVAC energy usage, demonstrating potential energy cost reductions of up to 36% and peak load reductions up to 9.97%. The strategy involves scheduling HVAC operations within user-defined comfort levels, facilitated by smart home devices and a dedicated communication network with energy providers. The third part introduces a Q-Learning optimization algorithm that incorporates input convex LSTM (ICLSTM) models within a predictive control framework. This method optimizes HVAC system operations, achieving a balance between reducing electricity costs and maintaining user comfort. The algorithm shows an 87% success rate in maintaining desired temperature setpoints, leading to significant energy savings.

Overall, this dissertation provides valuable insights into the potential of ML and optimization techniques to revolutionize energy management in residential settings. By combining detailed theoretical analysis with practical simulations, it demonstrates how these technologies can be used to make HVAC systems more efficient and cost-effective, paving the way for smarter and more sustainable energy solutions.