Title: **Model Predictive Control for Energy Efficient Cooling and Dehumidification**
Author: **Tea Zakula** (*Building Technology Program, MIT*)

Committee Members:
Professor Leslie Norford (*Chair, MIT*)
Professor Leon Glicksman (*MIT*)
Professor Peter Armstrong (*Masdar Institute of Science and Technology, Abu Dhabi, UAE*)

Abstract:

Energy has become a primary concern in countries worldwide, and is a focus of debates on national safety, climate change, global economy, developing world, and many more. With the lifestyle of western countries slowly adopted by more people in developing countries, the tremendous increase in word's energy consumption in the next few decades seems difficult to avoid. The building sector is of particular interest, since it accounts for a large portion of the total energy market: currently in the U.S. forty percent of the total energy and seventy percent of electricity is consumed by residential and commercial buildings. Within commercial buildings, cooling equipment represents the second largest consumer of electricity.

This research analyzes an advanced cooling system termed low-lift cooling system (LLCS) that comprises thermally activated building surfaces (TABS) with water running through pipes embedded in a building's construction to cool it. The LLCS utilizes model predictive control (MPC), an advanced control algorithm that, based on weather and load predictions, decides on the optimal cooling strategy over next 24 hours for the lowest energy consumption. The objective of this research was to minimize the total electricity consumption for cooling. However, different objectives, such as the total cost of electricity, can be achieved by modifying the objective function. Currently there is no commercially available software that allows the analysis of systems that employ MPC. The first goal of this research was to develop a computer algorithm that can simulate the LLCS performance, but also the performance of other cooling systems that employ MPC. The second goal was to analyze the LLCS performance across different U.S. climates relative to a conventional cooling system and to explore different dehumidification strategies that can be used in combination with the LLCS.

This research significantly advances the knowledge of simulation and performance of the LLCS. The developed MPC computer algorithm enables a systematic study of primary factors influencing dynamic controls and the savings potential for an individual building. The algorithm is highly modular, enabling an easy future expansion, and sufficiently fast and robust for an implementation in a real building. The results of the analysis suggest that the electricity savings using the LLCS are up to 23% relative to the all-air system under MPC and up to 50% relative to the all-air system under a conventional control. The savings were achieved through lower transport energy for fans and pumps and improved equipment efficiency, a result of the TABS technology and the optimal control.