

Cyber-Enabled Efficient Energy Management of Structures (CEEMS)

Tyrone Vincent , Robert Braun , Dinesh Mehta, Kevin Moore, Marcelo Simoes, William Hoff,
Alexandra Newman
Colorado School of Mines

Siddharth Suryanarayanan
Colorado State University

This project focuses on modern buildings as a natural expression of a cyber-physical system, with many features that are typical to such systems. Modern buildings exhibit a tight integration of sensing, computation, and actuation within multiple physical domains. For example, larger buildings usually contain a sensor network, with a variety of sensors that measure power flow, temperature, relative humidity, carbon monoxide and carbon dioxide. They control the operation of the chiller and heating systems, and may have actuators to control airflow into and through the building, or building access. A physical network describes the thermal dynamics the building itself, along with the surrounding environment. Finally, an energy management and control system takes in sensor measurements and determines the actuator response, which can be a hierarchical or distributed implementation.

Improving the energy efficiency of building structures and complexes represents a significant opportunity for lowering national energy consumption and emissions. While sophisticated control systems for buildings exist, such as for heating, ventilation, and air conditioning (HVAC), there is great opportunity to achieve highly efficient management of energy in structures with the development of cyber resources. For example, the potential for dynamic control of temperature set-points (i.e. pre-cooling) to achieve energy savings has been known for some time. Yet to achieve the full potential savings, significant knowledge is required, including thermal behavior of the building, accurate weather predictions, accurate predictions of building use, knowledge of energy markets, and equipment efficiency characteristics. In addition, in the near future, it is likely that many buildings will have local sources of energy production (solar, fuel cells, or gas turbines) or energy storage (hydrogen production, active thermal storage, hybrid cars in parking lots) that make the decision problem even more complex.

Our fundamental view of a building (and by extension, the type of cyber-physical system we are interested in) is a series of overlapping, interacting networks, and our project is organized into five thrust areas that examine these networks with different tools and at different scales. These areas are

- 1) Simulation and optimization, with the objective of developing methods for simulation and design of highly integrated, dynamic, building energy systems.
- 2) Cyber enabled building energy management systems, with the objective of demonstrating cyber-enabled dispatch of energy in a building using multi-agent systems
- 3) Activity recognition, with the objective of developing new methods to represent and recognize activities of groups of people from low-level sensor network data.
- 4) Identification of interconnected dynamic systems, with the objective of exploiting structure in system identification of interconnected dynamic systems.
- 5) Decision and control for interconnected dynamic systems, with the objective of developing or adapting analysis and design tools for interconnected dynamic systems typified by buildings.