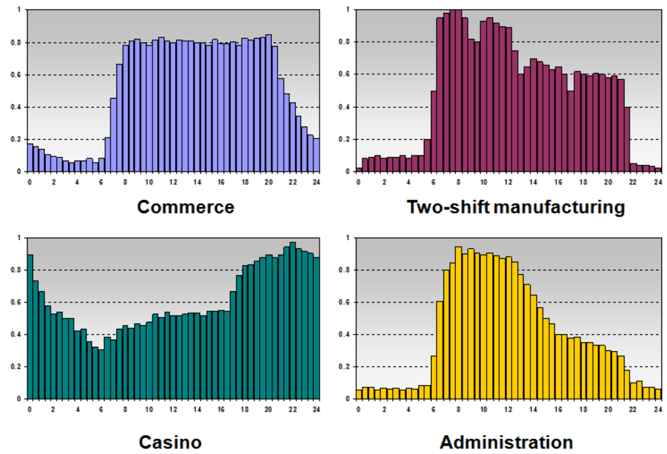
Control for Energy-Efficient Buildings

Globally, the building sector is responsible for 40% of annual energy consumption and up to 30% of all energy-related greenhouse gas emissions; hence the interest in increasing energy efficiency in buildings. Heating, ventilation, and air conditioning (HVAC) is the principal building system of interest, but there are others: lighting, active façade systems, renewable generation sources, and storage.

Real-time control and optimization can help building owners and tenants minimize energy consumption and costs based on inputs from occupants, local utilities, and weather conditions. Challenges for implementation of advanced control solutions include the heterogeneity and complexity of typical building environments. Recent developments in building automation systems are addressing these and other challenges.



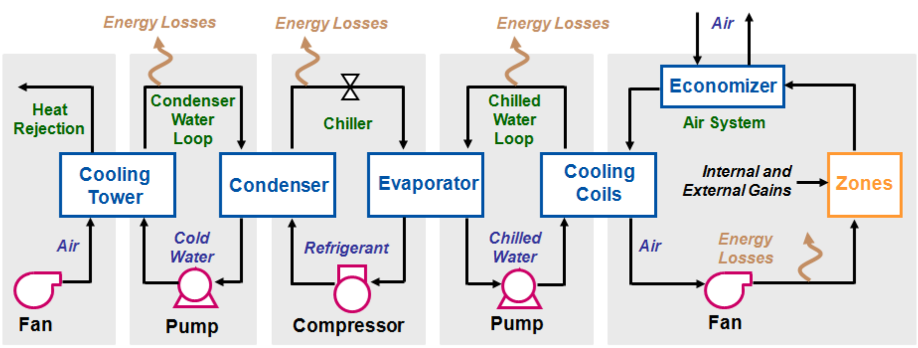
Daily consumption profiles: Every building has a unique consumption pattern

Trends in Building Automation

The cloud and data analytics. Cloud computing enables the retention of more detailed data about the facility as well as integration of automation and other business data. This in turn enables more powerful building analytics, which can better inform facility managers about likely equipment faults, deviations from expected energy use, or underperforming controllers.

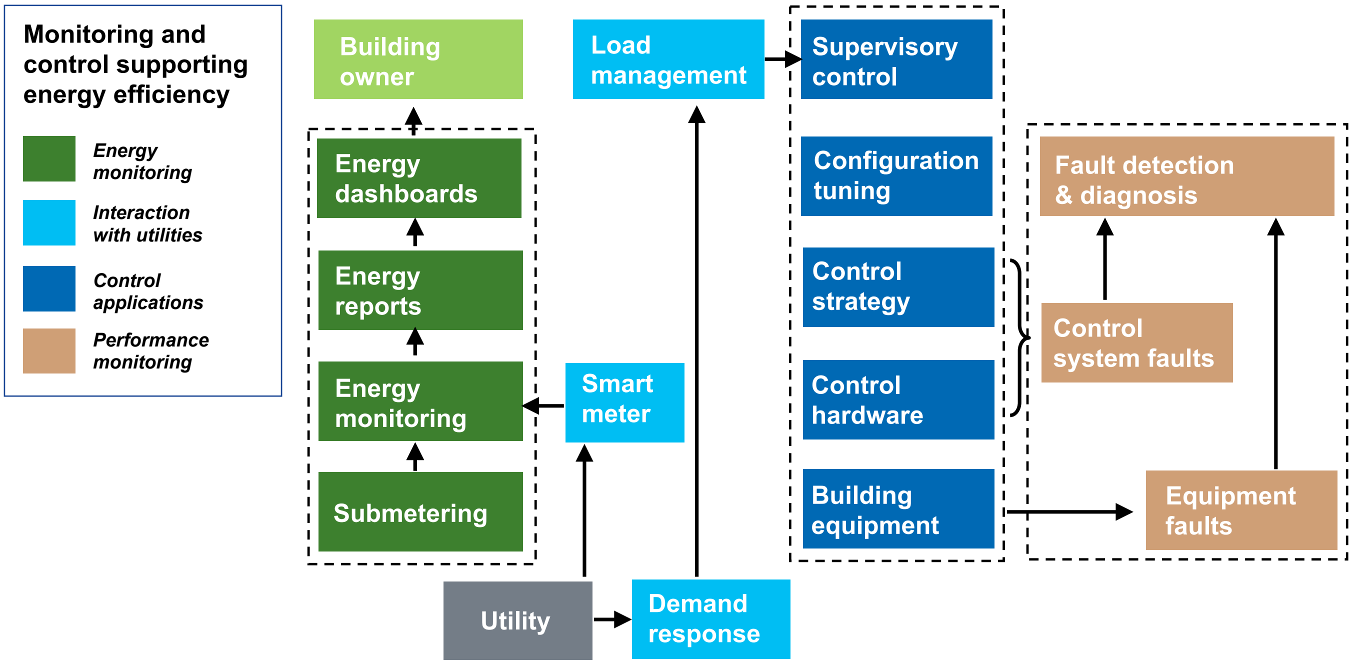
Intelligent devices. Building controllers increasingly embed intelligent software and computational power, which enable delivery of enhanced functionality. Smarter devices can enable automated reconfiguration or parameter tuning in response to changes in the environment. Also, such devices will be able to share information with other devices, automatically synchronize, and support deployment of distributed optimization concepts.

User experience. With social networking tools, occupants can provide instant feedback on their experienced comfort as well as receive explanations of system behaviors. In this way, occupants can be systematically engaged in energy management and building control. In the cloud environment, the social media data can be meshed with other real-time building data to create insights into the building's daily operation and implement improvements and cost-saving measures.



System view of HVAC

Contributor: Petr Stluka, Honeywell, Czech Republic

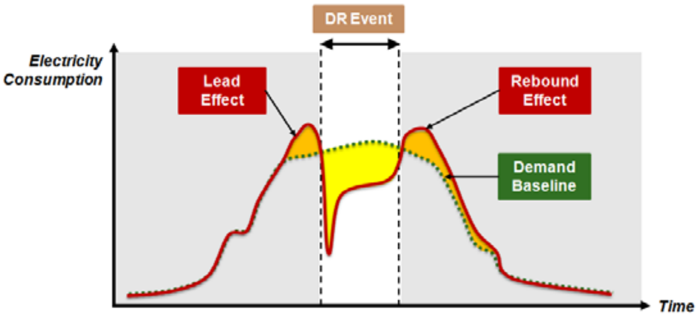


Challenges and Opportunities in Energy-Efficient Buildings

Multivariable HVAC supervisory control. The primary goal of HVAC control is to maintain occupants' thermal comfort and system energy efficiency. This requires adjustments of multiple setpoints—primarily temperatures and flow rates**.** Today these setpoints are either kept constant or manipulated by simple reset rules. An obvious opportunity exists for new robust multivariable supervisory control strategies that will leverage principles of model predictive control (MPC) to dynamically adapt key HVAC setpoints based on weather conditions, occupancy, and actual thermal comfort in zones. The challenge of developing reliable HVAC models for MPC might be addressed by moving the optimization engine to a cloud and coupling it with efficient analytics for identification of suitable models from the HVAC data.

Whole-building optimization. Economic optimization of building energy systems can be formulated to integrate all subsystems, including HVAC, lighting, onsite generation, and storage. The implementation of this approach is complicated by disturbances such as weather conditions and occupant behaviors and potentially also by dynamic pricing of electricity. However, the fundamental issue lies with buildingwide optimization models, which will always be hampered by significant inaccuracy, uncertainty, and lack of measurements. Distributed optimization approaches could be more viable; these would first divide the building into meaningful subsystems and then optimize each subsystem locally but not independently of others.

Building-to-grid integration. Recently, demand response (DR) has been recognized as a promising approach for the electricity market and an essential element of smart grid implementations. By sending changing power-price signals to building automation systems, adjustments of temperature setpoints, cycling of HVAC systems, or other actions can be initiated, and consequently energy use and expenditure can be reduced. A fundamental challenge is to enable the building to participate in demand response without violating thermal comfort. Advanced control strategies are needed that will manage building loads and use the building's thermal mass to implement various preheating strategies and adapt zone temperature trajectories. In addition to dynamic load management, in many cases, the scope of optimization could also encompass local generation and storage devices.



Building-to-grid integration: A DR event, which can result in significant reduction in electricity consumption (the yellow shaded region), can also result in increased consumption (orange) before and after the event. For optimizing demand response, models must be developed that incorporate the lead and rebound effects.

For more information: United Nations Environment Programme, Buildings and Climate Change: A Summary for Decision Makers, 2009, www.unep.org.