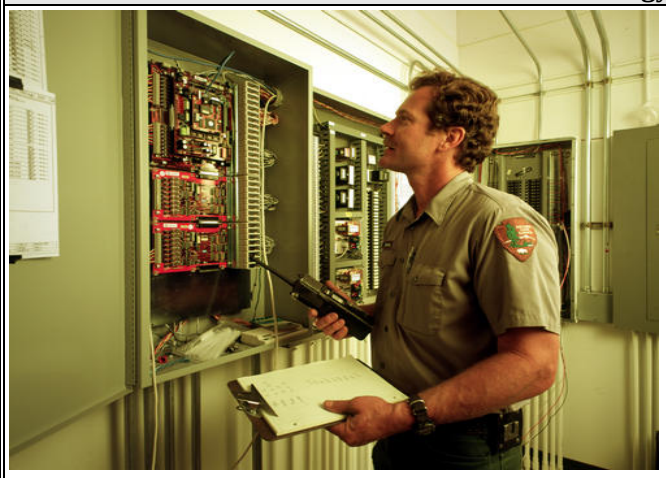
1.2.3 WHOLE BUILDING INTEGRATION

Technology Description



Energy-management system field tests at the Zion National Park Visitor Center (top) and the Bighorn Home Improvement Center complex in Silverthorne, Colorado (bottom), DOE High Performance Buildings Program.

Whole building integration uses data from design (together with sensed data) to automatically configure controls and commission (i.e., start-up and check out) and operate buildings. Control systems use advanced, robust techniques and are based on smaller, less expensive, and much more abundant sensors. These data ensure optimal building performance by enabling control of building systems in an integrated manner and continuously recommissioning them using automated tools that detect and diagnose performance anomalies and degradation. Whole building integration systems optimize operation across building systems, inform and implement energy purchasing, guide maintenance activities, document and report building performance, and optimally coordinate on-site energy generation with building energy demand and the electric power grid, while ensuring that occupant needs for comfort, health, and safety were met at the lowest possible cost.

System Concepts

- The system consists of design tools, automated diagnostics, interoperable control-system components, abundant wireless sensors and controls, and highly integrated operation of energy-using and producing systems.
- These components would work together to collect data, configure controls, monitor operations, optimize control, and correct out-of-range conditions that contribute to poor building performance.
- Whole building integration would ensure that essential information, especially the design intent and construction implementation data, would be preserved and shared across many applications throughout the lifetime of the building.
- Equipment and system performance records would be stored as part of a networked building performance knowledge base, which would grow over time and provide feedback to designers, equipment manufacturers, and building operators and owners.
- Optimally integrate on-site power production with building energy needs and the electric-power grid by applying intelligent control to building cooling, heating, and power.

Representative Technologies

- DOE is developing computer-based building commissioning and operation tools to improve the energy efficiency of “existing” buildings. It is also investing in the next generation of building simulation programs that could be integrated into design tools.
- DOE, in collaboration with industry, also is developing and testing technologies for combined cooling, heating, and power; and wireless sensor and control systems for buildings.

Technology Status/Applications

- Savings from improved operation and maintenance procedures could save more than 30% of the annual energy costs of existing commercial buildings, even in many of those buildings thought to be working properly by their owners/operators. These technologies would have very short paybacks because they would ensure that technologies were performing as promised, for a fraction of the cost of the installed technology.
- Savings for new buildings could exceed 70% using integration of building systems and, with combined cooling, heating and power, buildings could become net electricity producers and distributed suppliers to the electric power grid.

Current Research, Development, and Demonstration

RD&D Goals

- Developing fully and seamlessly integrated building design tools that support all aspects of design and provide rapid analysis of problems.
- Development of automatic operation of buildings systems that require little operator attention.
- Utilizing highly efficient combined cooling, heating, and power systems that use waste heat from small-scale, on-site, electricity generation to provide heating and cooling for the buildings, as well as exporting excess electricity to the grid.

RD&D Challenges

- Design tools: enhanced analytical capabilities, integration with the design environment, automated design and analysis capability, design databases, visualization, and high-level monitoring and reporting tools.
- Automated diagnostics: diagnosticians, plug-and-play capabilities, automated real-time purchasing, advanced data visualization, automated identification, and correction of the causes of operation problems.
- System interoperability and controls: integrated control networks; plug-and-play control components; adaptive, optimized, self-generating control algorithms; automatic configuration and commissioning of controls; and advanced control techniques.
- Sensors: wireless data acquisition, detection of materials properties, micro-scale sensors, microelectronic sensors, multiple-sensor arrays, protocols for using new sensors, new sensing technologies, order of magnitude lower-cost sensor systems, and ubiquitous use of sensors.
- Visualization: use of supercomputers, networked personal computer to provide distributed super-computer-level performance, advanced computational methods, and virtual reality systems to permit real-time visualization of designs and design changes, including lighting, thermal flows, and air quality.
- Buildings Combined Cooling, Heating, and Power: Technologies for reusing waste energy to provide net-electricity producing buildings.
- Early priorities include enhancing design-tool integration; developing automated diagnosticians; implementing remote data collection and visualization; developing combined cooling, heating, and power; and developing low-cost, wireless sensor, and control technology.
- Advanced building simulation tools to permit better design, construction, commissioning, and operation.

RD&D Activities

- DOE is funding work with the California Energy Commission, California Institute for Energy Efficiency, Honeywell, Johnson Controls, Siemens, Electric Power Research Institute, Southern California Edison, and Pacific Gas and Electric Company. International efforts include an effort funded by the European Union to develop adaptive control techniques for improving the thermal environment for JOULE IIICSEC.

Recent Progress

- Energy 10: models passive solar systems in buildings.
- DOE 2: international standard for whole building energy performance simulation has thousands of users worldwide.
- DOE released Energy Plus, the new standard for building energy simulation and successor to DOE-2.
- The International Alliance for Interoperability is setting international standards for interoperability of computer tools and components for buildings.

- DOE-BESTEST: basis for ANSI/ASHRAE Standard 140, *Method of Test for the Evaluation of Building Energy Simulation Programs.*

Commercialization and Deployment Activities

- Design tools for energy efficiency are used by fewer than 2% of the professionals involved in the design, construction, and operation of commercial buildings in the United States. A larger fraction of commercial buildings have central building-control systems. Few diagnostic tools are available commercially beyond those used for air balancing or integrated into equipment (e.g., Trane Intellipack System) and the recently announced air-conditioning diagnostic hand-held service tool by Honeywell (i.e., Honeywell HVAC Service Assistant). The Department of Energy – in concert with the California Energy Commission – is testing a number of automated diagnostic tools and techniques with commercial building owners, operators, and service providers in an effort to promote commercial use. About 12 software vendors develop, support, and maintain energy design tools; most are small businesses. Another 15 to 20 building automation and control vendors exist in the marketplace – the major players include Johnson Controls, Honeywell, and Siemens.
- Deployment involves four major aspects: seamless integration into existing building design and operation practices and platforms, lowering the cost of intelligent-building and enabling technologies, transforming markets to rapidly introduce new energy-efficient technologies, and a focus on conveying benefits that are desired in the marketplace (not only energy efficiency).

Market Context

- These technologies would apply to all buildings, but especially to existing commercial buildings and all new buildings. In addition, new technologies would be integrated into the building design and operation processes.