Intelligent Buildings – Technology for the 21st Century

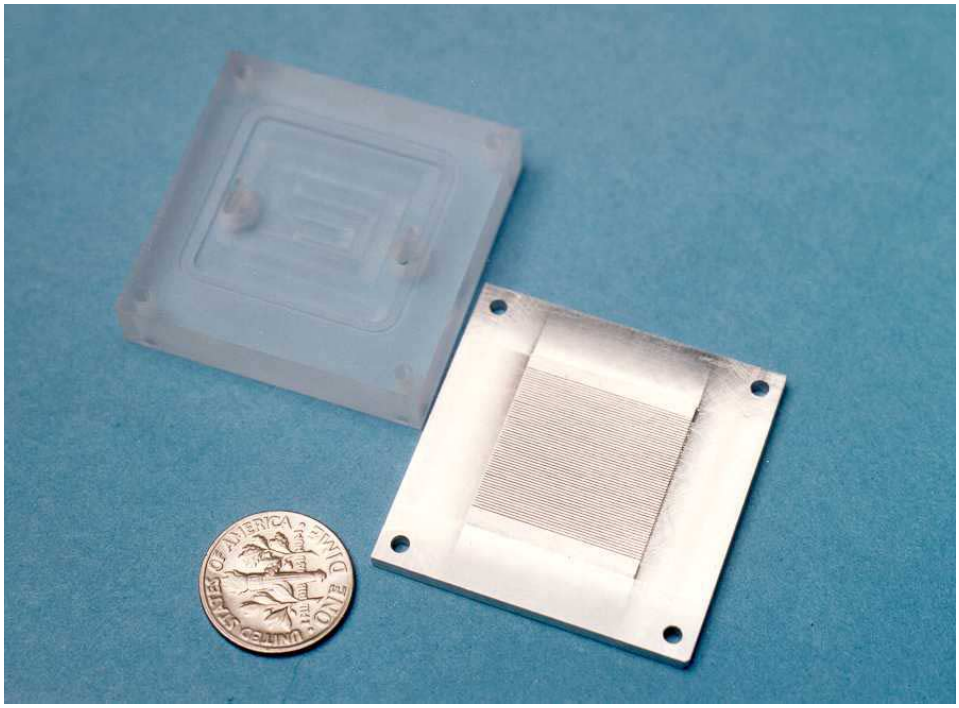
The global architecture, engineering, and construction industry is the world's largest industry, estimated at $3.2 trillion annually. Buildings account for one-third of all U.S. energy, use. However, at least 20% of the energy used for heating and cooling these buildings is wasted. R&D spending by the building industry has traditionally been low and technological advancement slow. Poor building operation leads to wasted energy, poor indoor conditions, increased occupant illness, and reduced productivity; these impacts continue over the life of the building—usually decades.

Increased health care costs and productivity losses due to poor office environments cost U.S. businesses more than $438 billion per year.

Ever wonder why you're freezing in a hotel conference room? You can't read anything under 12 point type because your office lighting is so bad? You're wearing a sweater and running a space heater in your office all summer while the guy across the hall has a portable fan going?

Building heating and cooling systems are far from simple. Most buildings have only the minimum sensors needed for control and their control systems provide no guidance on what might be wrong. As a result, when operating changes are made they often treat the symptoms of problems but not the cause, resulting in fixes that are rarely long lasting. In most buildings at least 20% of the energy used for heating and cooling is wasted. Increased health care costs and productivity losses due to poor office environments cost U.S. businesses more than $438 billion per year. The U.S. Department of Energy (DOE) estimates that utility costs of more than $45 billion are incurred annually to operate these "broken" systems.

The Pacific Northwest National Laboratory (PNNL) is leading research and development to make buildings operate smarter, use less energy, cost less to build and operate, while providing better comfort and climate control for the people that use them. Through its Intelligent Buildings for the 21st Century initiative, PNNL is developing key technologies for intelligent building systems. Relying on advanced networks of sensors, intelligent buildings will provide much more than today's rudimentary control. They will optimize operation across building systems, inform and implement energy purchasing, guide maintenance, and report building performance, while ensuring that occupant needs for comfort, health, and safety are met at the lowest possible cost.



Micro-scale devices, like this heat exchanger developed at Pacific Northwest National Laboratory, show promise for significantly improving the way we heat and cool buildings.

A vision of the future for intelligent buildings includes

- more effective ventilation systems to improve indoor air quality and reduce "sick building syndrome"
- advanced space-conditioning equipment that uses microtechnology and operates efficiently and effectively
- schools and office buildings built of modular parts so rooms can be reconfigured, daily if need be, and additions can easily be made when space demands increase
- even buildings that "know" each occupant and his or her heating and cooling preferences and lighting needs and can accommodate those preferences from room to room.

Reducing energy and operating costs, improving health and safety, and increasing comfort (and productivity) are some of the major benefits of the intelligent buildings initiative.

Through work for DOE's Office of Building Technology, State and Community Programs, the private sector, and key internal investments, PNNL is developing breakthrough technology that will help make today's technology vision tomorrow's technology fact. Laboratory research efforts include

- automated diagnostics for building systems
- automated building commissioning tools and technology
- low-cost, highly reliable, sensor systems
- novel volumetric flow sensors
- micro-scale energy conversion technology
- flexible, reconfigurable structures and systems.

Through this research and development, PNNL is leading the way to intelligent buildings for the 21st Century.

A Tale of Two Buildings

When the Pacific Northwest National Laboratory needed to add office space to its Richland, Washington, campus it decided to conduct an experiment in energy efficiency. Two 100,000 ft^2 office buildings were constructed side by side in 1994. The two buildings were nearly identical except that Building A was designed to be 20% more energy efficient than Building B. The buildings were monitored over 5 years of operation and the results surprised everyone. Building A, the so-called more efficient building, used 35% more energy than Building B! Why? To resolve occupant complaints, the building operators had overridden the supply temperature reset controls, disabling setbacks. Also pressure sensors had failed, affecting ventilation. In some sections of the building, simultaneous heating and cooling was occurring all winter long! Corrections have since been made, resolving most of the problems and demonstrating the importance of proper operation, even in "energy efficient" buildings.

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