Breaking New Ground in Energy Efficiency

Reducing the energy consumption of the nation's buildings is essential for achieving a sustainable clean energy future and will be an enormous challenge. Buildings account for 40% of the nation's carbon emissions and the consumption of 41% of our primary energy, 74% of our electricity, and 34% of our natural gas (56% counting natural gas used to generate electricity consumed in buildings). The importance of buildings is amplified because some decentralized renewable energy technologies are most economical when using buildings as their deployment platforms—for example, generating power with building-integrated photovoltaic cells, lighting and heating water with direct sunlight, and space conditioning and water heating with energy from the ground.

The Building Technologies Research and Integration Center (BTRIC), in the Energy and Transportation Science Division of Oak Ridge National Laboratory (ORNL), focuses on research and development of new building technologies, whole-building and community integration, improved energy management in homes and buildings during their operational phase, and market transformations from concept to commercialization in all of these areas.

The US Department of Energy (DOE) programs supported by BTRIC are primarily within the Office of Energy Efficiency and Renewable Energy (EERE) and include the

- Building Technologies Office,
- Federal Energy Management Program,
- Weatherization and Intergovernmental Programs Office, and
- Sustainability Performance Office.

BTRIC also supports other DOE-EERE offices, other DOE programs, other federal agencies, state agencies, and the private sector through Cooperative Research and Development Agreements (CRADAs) and DOE's Work for Others (WFO) program and as a DOE-designated National User Facility.

ORNL's work in pursuit of energy and environmental sustainability of the built environment is broad-based, accelerating translation of science to applications and addressing residential and commercial buildings that are new or existing. BTRIC's core capabilities are organized into four Centers of Excellence:

- Building Envelope
- Building Equipment
- System/Building Integration
- Building Technologies Deployment

Building Envelope

The envelope (the fabric separating indoor and outdoor environments) is the main determinant of the amount of energy required to heat, cool, and ventilate a building and can significantly influence lighting energy needs in areas accessible to sunlight. The Building Envelope Center of Excellence is devoted to developing affordable envelope technologies that improve the energy efficiency, moisture durability, and environmental sustainability of residential and commercial buildings. The research addresses new and emerging materials, components (sheathings, membranes, and coatings), systems (walls, roofs, attics, and foundations), and the fundamentals of heat, air, and moisture transfer. In addition to advancing performance, durability, and affordability of traditional envelope solutions (high-R, airtight), increasingly the group is focusing on multifunctional solutions. Here the envelope serves as a filter, selectively accepting or rejecting solar radiation and outdoor air, depending on the need for heating, cooling, ventilation, and lighting at that time, and using the heat capacity of the building structure to minimize peak energy demands and overheating from solar gain.

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INNOVATIONS IN BUILDINGS

Building Equipment

The equipment in a building consumes energy to provide amenities to its occupants, such as heating, cooling, fresh ventilation air, humidity control, hot water, refrigeration, and other conveniences to improve health and productivity. The Building Equipment Center of Excellence is devoted to developing affordable equipment technologies that improve the energy efficiency and environmental sustainability of residential and commercial buildings. The research addresses materials, working fluids, cycles (vapor compression, absorption/adsorption/desiccant, magnetocaloric/electrocaloric), components (packaged rooftop units, heat pumps, water heaters), and systems (supermarket refrigeration; ground-source space conditioning and water heating; combined cooling heating and power; multi-zone heating, ventilation, and air conditioning HVAC)). The group is currently focused on a portfolio of activities that includes developing integrated styles of equipment that provide the same amenities as baseline equipment while consuming half the energy, helping chemical companies and equipment manufacturers transition to low global warming potential working fluids while simultaneously improving the efficiencies of the end-use devices, and achieving large efficiency improvements at the individual component level. Equipment energy savings come from a variety of sources: applying advanced hardware-based cycle models, recycling heat between end uses, and incorporating emerging materials and technologies.

System/Building Integration

Whether embarking on new construction or retrofitting established buildings, industry stakeholders often face challenges when integrating components into systems and whole buildings. This is especially true when incorporating technologies that are brand new to the market. The purpose of BTRIC's System/Building Integration Center of Excellence is to provide the means for our industry partners to verify their new products or prototypes in low-risk, realistic field-test environments and make any necessary modifications before market launch. Partners can choose to characterize their technology in vacant, simulated occupancy research houses in nearby subdivisions or in light commercial buildings on ORNL's flexible research platforms (FRPs), or through computer modeling, visualization, and analytics. In ORNL's research homes and buildings, the combination of natural exposure to weather and simulated occupant effect on energy use provides realistic loads and operating conditions for the technologies being evaluated, and the collected data contribute to validation of the technology and models thereof.

These same assets are also essential for development of wireless communications, sensors, controls, and fault detection and diagnostics.

Building Technologies Deployment

To ensure that emerging and underused technologies are successfully deployed to the fullest extent, the Building Technologies Deployment Center of Excellence works to move technologies into residential and commercial settings and optimize the energy performance of homes and buildings through applications research, technical assistance, and technology deployment strategies. The team's comprehensive knowledge of buildings and energy use spans multi-building sites, whole buildings, systems, components, and multi-level interactions. The team helps federal and private-sector customers conserve energy through cost-effective energy management best practice tools and strategies such as planning, metering, benchmarking, auditing, retro- or continuous commissioning, implementing energy retrofit projects, and alternatively financing those projects when direct funding is not available.

BTRIC National User Facility

Private-sector laboratories are not available to conduct many of the tests and experiments possible using the experimental capabilities of BTRIC, which has been designated as a National User Facility. ORNL facilities, tools, and expertise can be accessed by executing a user agreement. CRADA, WFO, or user agreements can be proprietary or nonproprietary. Generally, the user provides the specimens (materials, walls, or roofs) for evaluation, and ORNL staff operate the apparatus, take the data, and document the results.

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