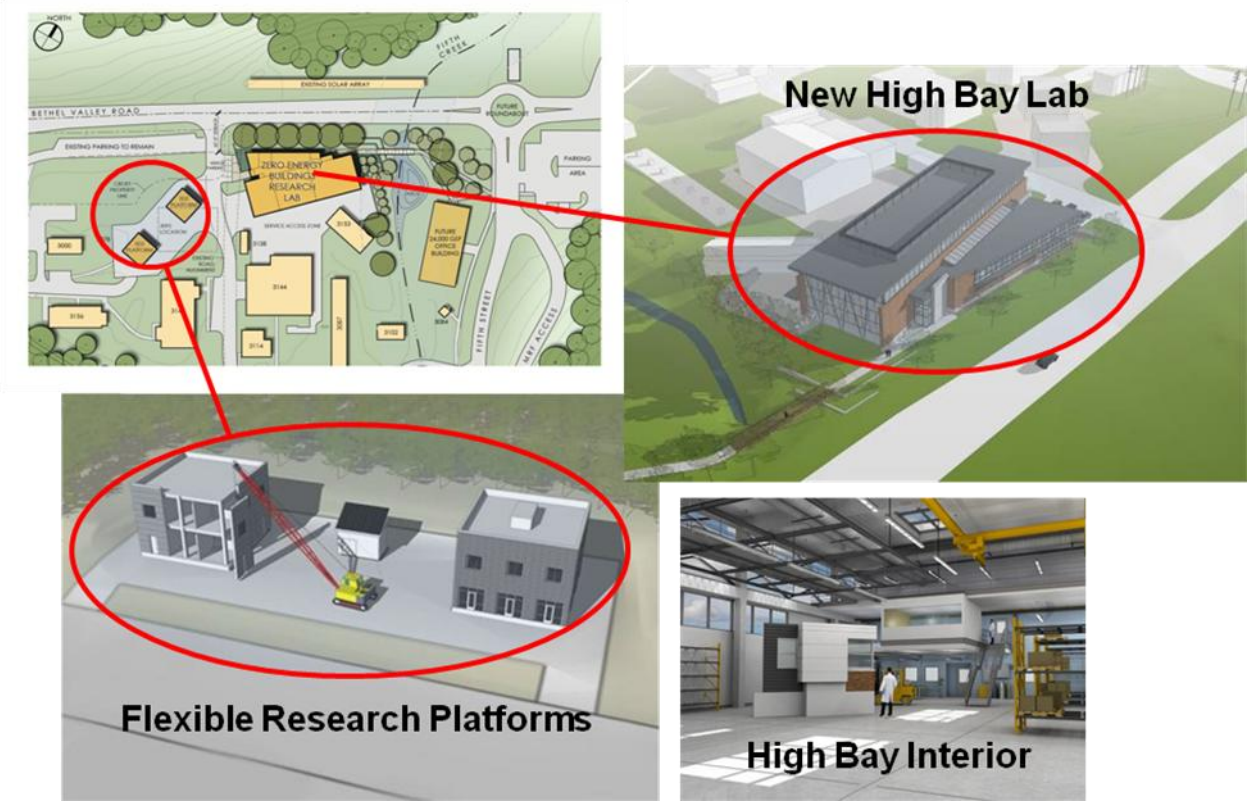
2009-03-15

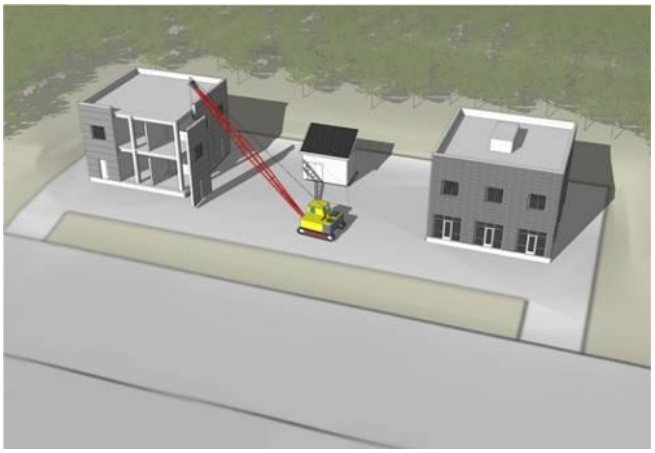
ORNL Building Technologies Research & Integration Center (BTRIC) New Laboratory Facilities per Lab Call #09-002 Award (20% De-Scope Needed)

<u>New BTRIC Facilities Located Near Existing BTRIC Facilities on ORNL Main Campus</u>



ORNL's current facilities and equipment have enabled large gains in component-level energy efficiency in residential and commercial buildings, new or retrofit. In addition, thanks to a partnership/alliance strategy, they have enabled additional gains in single-family residential energy efficiency due to improved systems/building-level integration, both for design and construction of new houses and for packaging of comprehensive retrofits to existing homes. However, the successful residential approach (partnering with builders on new construction and retrofits) is not feasible for commercial buildings. The land, bricks, and mortar investment is too great. In addition, there is tremendous functional diversity in the space utilization in commercial buildings, which limits the R&D value that can be gained from holding any one building off the market for an extended research period (as has been done with research houses). The signature feature of this proposal is the two new, unique commercial-building flexible field research platforms. Over time, these platforms will be used to accomplish the necessary integration research and generate solutions supported by sufficient rigor that the next steps will be feasible in actual commercial buildings.

Flexible Research Platforms



The proposal included construction of two 3,200 ft^2 two-story (40’ x 40’ x 2) commercial-building flexible field research platforms. Over time, the research platforms will enable systems/building-level technology development and integration that would otherwise require use of many new separate commercial buildings at far greater cost.

These two free-standing platforms will be placed in an open area; one will have a concrete skeleton and the second will have a steel skeleton, representing the structural approaches in the majority of low-rise commercial buildings constructed and in use today. They will be positioned for unobstructed solar access throughout the day, with walls facing in the ordinal directions. Each platform will be provided with (1) an active foundation thermal management system, (2) structural supports with fixtures to accommodate simple attachment of prototype external walls and roofs in many configurations, (3) an interior stair and second floor, (4) a complete and flexible data acquisition system and process control for simulating occupancy, and (5) an initial “test building” applied to the skeleton typical of today’s building practice.

The initial test buildings will be used to commission the data acquisition and process control and provide the benchmark for future prototype buildings tested on the platforms. The platforms will provide the opportunity to test two entirely different commercial-building integrated system configurations each year. Aside from the fixed 40' × 40' two-story structural footprint, essentially everything about the buildings can be changed. Prototypical changes can include the envelope (walls, roof, windows, doors), heating and cooling system, ventilation system, zoning strategy, and many different internal functions (e.g., food display case aisle, fast food kitchen, etc.). Miscellaneous energy loads and their schedules, controls and embedded intelligence, building-integrated renewable energy and/or distributed energy or CHP systems, customer-side-of-meter plug-in hybrid electric vehicle (PHEV) or EV docking, and approaches to integration of the building to the grid can also be modified.

New BTRIC High Bay

The new 12,000 ft^2 high bay laboratory building will include four major sections:

The **Advanced Construction Technology Evaluation Laboratory (ACTEL)** provides a user facility for the development, demonstration, and evaluation of advanced construction technologies. The facility addresses both emerging building-information-modeling-driven automated construction processes and associated novel materials. It produces entire building sections for multi-attribute performance characterization and will use novel automated construction techniques to generate new architectural solutions (shapes, forms, thermal mass, and geometries) that will enable greater use of natural ventilation and lighting and better management and passive use of incident solar energy and other self-delivering renewable resources such as rainwater and ground-energy sources and sinks. Features include a 3,000 ft^2 dedicated high bay area and a computer-controlled gantry system that can carry material delivery and deposition heads and has sufficient positioning degrees of freedom to allow construction of full size building-scale experimental components with complex geometries.

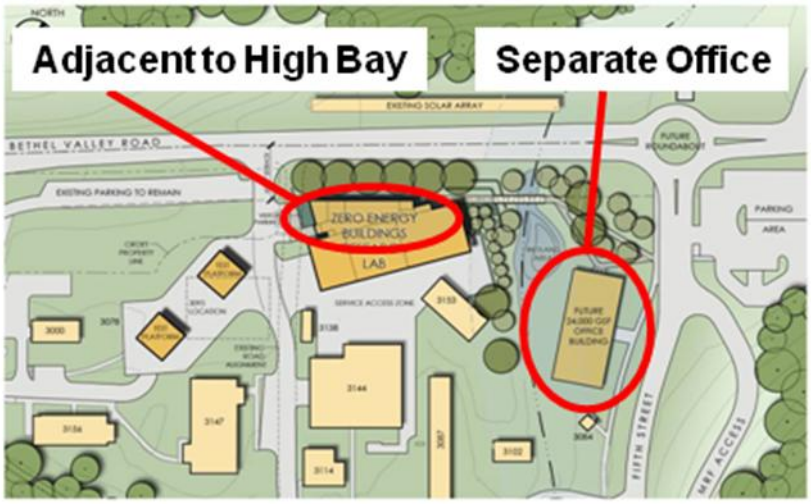
The **HVAC Refrigeration and Equipment Laboratory (HVACRE)**, is a 1,000 ft^2 dedicated high bay HVACRE staging and set-up area, which will increase the utilization rate of new and existing BTRIC facilities by providing a space for readying experimental equipment for installation in the environmental chambers or research platforms. This space will include workshops for equipment brazing, welding, instrumentation, etc. and areas for pre-testing of controls, embedded intelligence systems and compatibilities with the electrical distribution system architecture to be used in upcoming “test buildings” on the research platforms.

The **Multifunctional Envelope Laboratory (MFEL)** is 4,000 ft^2 and will be used to investigate envelope systems that serve multiple functions passively (e.g., natural self-cooling) or actively by including power generation, light control, and active thermal control and storage and that may be controlled by intelligent building systems. Most importantly, this laboratory and the field research facilities will be used to determine whether prototype designs can pass the test of

providing durable shelter from the elements. The goal is to develop and validate multifunctional envelope solutions that have the potential to offer persistent failsafe energy and demand savings with little or no maintenance over the operating life of new buildings and to explore the potential of retrofit into existing buildings. MFEL will also house apparatus to collect moisture penetration data on envelope assemblies. Since moisture durability is becoming an issue as buildings become more airtight and highly insulated, a design criteria standard is being developed, and data from MFEL will provide the science basis. MFEL features include areas for fabrication of envelope specimens for water penetration tests and multifunctional envelope tests, apparatus for measurement of water penetration rates into building envelopes, and equipment for bench-scale experiments to validate models of individual attributes of passive and active multifunctional envelopes.

The **Buildings-to-Grid Integration Laboratory (B2GIL)** is a 4,000 ft^2 space with a 12 × 25 ft^2 control room that provides the facilities necessary to optimize power systems on the building owner side of the electric meter in the context of the whole building. Customer-side power systems, in addition to the traditional electrical distribution architecture within the building, may also include customer-owned renewable or distributed power generation (photovoltaic, DG/CHP, wind), two-way (charge/discharge) docking of PHEVs and EVs, and associated batteries, inverters, converters, and other power electronics. The Government-owned and ORNL-operated campus electric distribution system provides a unique opportunity to experimentally investigate approaches to buildings–renewable power–PHEV/EV–grid integration, including ancillary services (reactive power compensation, local voltage and power factor regulation, spinning reserve, demand response). This also enables performance characterization of standard AC, hybrid AC/DC or DC electrical distribution architectures for commercial buildings.
Features include provisions for rapid electrical connection of indoor and outdoor test power equipment and controls, an adjacent 4,000 ft^2 dedicated patio area to haul in large and heavy equipment, and a staging area for ready testing all power systems before their installation at the research platforms.

<u>Low Bay Labs and Offices</u>



The original proposal was to renovate 9,450 ft^2 of space in the east end of Building 1005 to accommodate four major low

bay spaces. As a cost saving measure, current thinking is to provide a portion of this space as new construction adjacent to the high bay, with a separately funded stand-alone office building nearby. Below are the original descriptions:

The **Intelligent Buildings Laboratory (IBL)**, at 1,200 ft^2, provides the glue between the myriad active components and systems of a building to optimize functional integration. IBL users will operate as a "skunk works" to identify simple, affordable solutions to wringing as much energy efficiency as possible from integration, optimization, coordination, diagnostics systems, and methodologies. IBL is designed to address the key challenge areas of control and optimization of miscellaneous energy loads, fully utilizing the capabilities of information technology systems or building automation and/or energy management control systems, developing standards and protocols for a cyber-secure networked building infrastructure, and documenting best practice solutions for typical systems and configurations. Other features include modeling and analysis workstations; dedicated 802.11g wireless infrastructure; electronics development and test equipment and work benches to support custom sensor and control device modification, development, and testing and signature analysis tools; test racks with power supplies, cable trays, and test instrumentation; and independent sensor network devices and infrastructure (i.e., wireless sensor and controller test bed environment—temperature, flow, humidity, vibration, occupancy, photocell sensors, electrical, etc.).

The **Hygrothermal Materials Properties Laboratory (HMPL)** area in Building 1005 will accommodate the transfer of HMPL experimental apparatus from the existing location in the basement of ESRA (i.e., 3153) so ESRA can be fully utilized for its intended purpose, which is side-by-side natural exposure testing of sloped roofs, low-slope roofs, walls, and foundations. The HMPL is the only facility in the U.S. currently generating hygrothermal properties for construction materials. The primary devices within HMPL include three equilibration chambers operated under controlled temperature and relative humidity to measure the water vapor permeance, sorption, and desorption isotherms of building materials (ASTM C1498); pressure plate apparatuses to measure the suction isotherm of building materials; and apparatus for measuring liquid diffusivity, heat-flow meters (ASTM C518), and permeability apparatus.

The **Data/Network Center (DNC)**, 1,000 ft^2, will enable effective integration of research efforts at ORNL with industry, university, and other research partners. Features include a raised floor system for cooling/wireways, gigabyte-per-second-network infrastructure that would interface all of the BTRIC laboratories, 10 rack-mountable project servers and supporting RAID data storage units, one Crestron unit, one state-of-the-art backup/archival unit for data storage and retention, and two workstation areas.

The **Office and Conference Room Space**, at 4,250 ft^2, provides 30 offices, fully furnished and outfitted with equipment, and a conference room furnished to seat 16 around the table and 16 more around the perimeter, for staff and users to support operations of the high bay laboratory and the field research platforms.

Upgrades to Existing Buildings-Related R&D Equipment

Various process control, data acquisition system, and refrigeration plant capacity upgrades will be implemented at the existing BTRIC laboratory facilities shown above, as described in the proposal. When completed, internet-based data acquisition, communications, and data processing infrastructure will overlay all of ORNL's new, renovated, and existing BTRIC facilities including the new Data/Network Center. This will accommodate effective collaboration between ORNL research staff and their university and industry partners.