U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

EMPOWER Wall: Smart Wall

The Department of Energy's Federal Energy Management Program (FEMP) is collaborating with Oak Ridge National Laboratory (ORNL), the Advanced Manufacturing Office (AMO), and the Building Technologies Office (BTO) to demonstrate a first-of-its-kind smart wall that combines advanced manufacturing, building innovations and power electronics.

The wall is designed to showcase the power of possibilities to function as a cooling system for a room and helps to reduce energy use, decrease peak time energy demand, lower energy bills, utilize renewable energy, and maintain occupant comfort. EMPOWER wall's functionality and design can be customized to fit the parameters of the customer and adapted for installation in any building.

EMPOWER wall realizes the power of possibilities, showcasing FEMP's ability to work with national labs to deliver tangible energy efficient solutions.

ORNL researchers with SkyBAAM, an additive manufacturing system used to 3D print the EMPOWER wall. *Photo credit: Oak Ridge National Laboratory, US Dept. of Energy.*

Additive Manufacturing

The 5 ft. by 8 ft. EMPOWER wall is 3D printed with a unique infrastructure scale additive manufacturing system called SkyBAAM that uses concrete. This new system is low cost, large-scale, field deployable, cable driven and reconfigurable to adapt to any construction site.

ORNL has collaborated with industry partner Quikrete to produce a special mix of concrete material compatible with SkyBAAM. An extruder uniformly dispenses the pre-mixed concrete and carefully deposits it in pre-programmed layers. SkyBAAM is cable-driven by four base stations and suspended from a single crane, eliminating the need for a gantry system commonly found in large-scale additive manufacturing systems. SkyBAAM is designed to be able to be set up at a construction site within hours with minimal site preparation. EMPOWER wall's façade is 3D printed with the BAAM® system (Big Area Additive Manufacturing) and made out of low-cost injection molding plastics. The pelletized plastics allow the wall's façade to be custom designed with a decorative pattern.

Thermal Storage and Active Insulation

The EMPOWER wall contains thermal storage and active insulation systems. The thermal storage system is made of a chiller that connects to the wall. Pipes embedded in the wall carry chilled water throughout the wall during low peak demand hours, cooling the interior temperature of the wall.

Active insulation surrounding the thermal storage can vary its thermal conductivity on demand; therefore, it transfers the coolness stored in the interior of the wall to the occupied space when needed. In the winter, the temperature of the wall is raised above the indoor space and heat is released. The on-demand capabilities of the active insulation reduce electricity costs by lowering the use of the HVAC

Reducing HVAC Use

A building's HVAC system is typically responsible for more than 20 percent of energy used in buildings. The EMPOWER wall's thermal storage and active insulation systems are designed to show the power of possibilities to reduce the building's need to use HVAC by operating as a thermal battery.

Charged

- During low electricity demand times or when renewable energy such as solar is abundant
- Summer – lowers wall temperature below that of the indoor space
- Winter – raises wall temperature above indoor space

Discharged

- During peak demand time to reduce HVAC operation
- Summer – wall absorbs heat from the interior space
- Winter – wall releases heat to the interior space

system during peak demand hours or when costs are high. This ability to tailor the HVAC's operation provides flexibility.

Advanced Controls

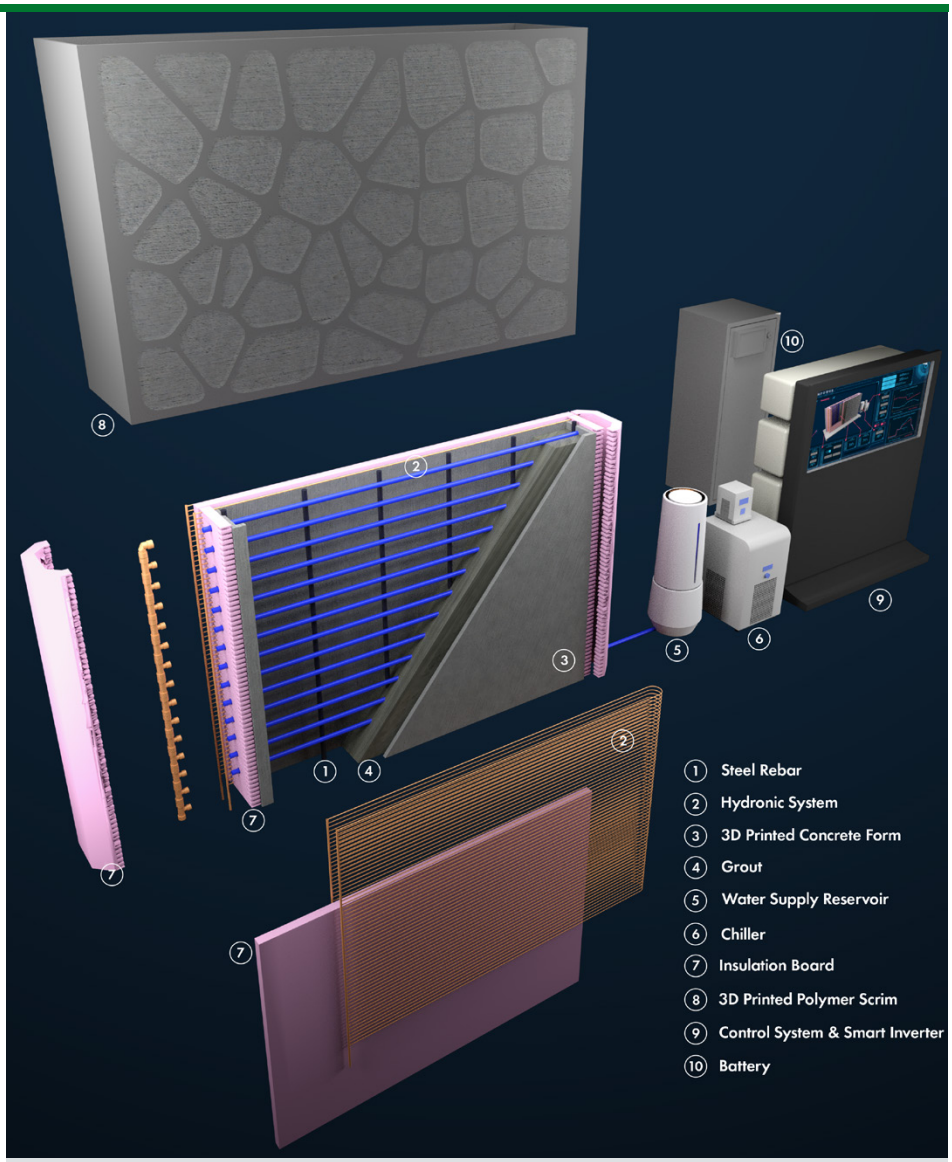
EMPOWER wall uses a control method, called Model Predictive Control or MPC, that optimizes the operation of the active insulation and thermal storage system based on the prediction of future conditions. These conditions can include weather or the occupant's behavior and the corresponding HVAC system's behavior.

As a first step of MPC, a simplified computer model is designed to represent the building and system behavior realistically. The model can predict the building's energy use and thermal comfort in various scenarios of weather conditions, occupant behavior and building/system operation schedule. Based on the prediction of the simplified model, MPC determines the optimal charging/discharge rate and timing (when and how fast to charge and discharge) and works with embedded sensors within the wall to send a signal to the existing HVAC system to turn on or off. In concert with the active insulation, this control method minimizes energy consumption and energy cost during peak demand times without compromising thermal comfort. Optimal control points for the system are updated continuously.

Smart Inverter

A smart inverter, which is a power electronic device, powers the chiller connected to the wall and the pumps that transfer the cool temperature stored in the concrete to the wall's surface. This inverter is connected to a battery that also stores energy from the building's main power grid during low electricity demand times and allows the energy to be available when needed during peak demand times.

The inverter enables the wall to also use renewable energy systems such as solar, fuel cells, and wind turbines. These systems require inverters to power loads and connect to the main grid. The inverter introduces resiliency to the EMPOWER wall system. By combining its battery energy storage with a renewable source, the inverter can power the wall without dependency on the main electrical grid.



Conceptual, exploded view of EMPOWER wall componentes.
Creative Services, Oak Ridge National Laboratory.

Field Validation

FEMP has collaborated with ORNL to produce EMPOWER walls for field validation of the system. EMPOWER wall field validations are planned in FY2021 where the wall will function as an interior office wall.

ORNL researchers will test EMPOWER wall's controls, insulation and thermal storage systems, gathering data on energy efficiency, costs, resilience and overall performance in reducing electricity demand without compromising the occupant's comfort. Updates on the EMPOWER wall field validations will be presented by FEMP and ORNL during the August 2021 Energy Exchange. ■

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FEMP Federal Energy Management Program

For more information, visit:
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