



Boulder

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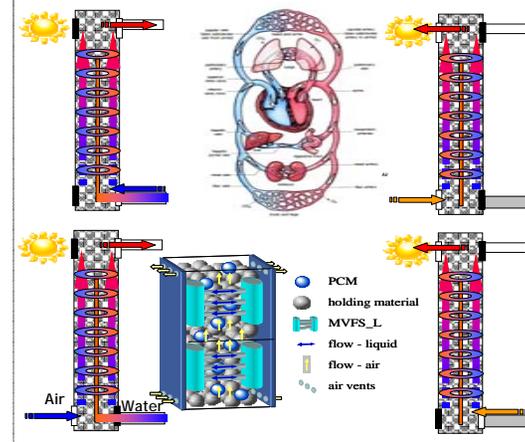
EFRI-SEED: LIVING WALL MATERIALS AND SYSTEMS FOR AUTOMATIC BUILDING THERMO-REGULATION (EFRI-1038305)

Goal: Apply biomimetic design principles to develop an intelligent and integrated **LIVING** building wall system with smart materials and innovative structures, to radically reduce heating/cooling/lighting energy of buildings.

Living Wall: Two sets of optimized **micro-vascular networks** and distributed **phase change medium** (PCM) are embedded into an innovative **polymer-based wall unit** to allow autonomous movement of air and liquid and charge/ discharge of PCM to dynamically regulate the thermal behaviors of building envelope and entire dwelling.

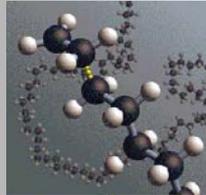
System-scale Overview: ZNEB Zero Net Energy Buildings:

The Living Wall System is developed as an integral part of an Interstitial Wall system for commercial as well as residential building solutions. The Living Wall reacts to the building's external environment and climatic opportunities, driven by solar exposure and air temperature/wind. The multiple wall system consists of an exterior layer of high tech materials consisting of smart glazing with multiple high tech coatings. This outer curtain wall acts like a greenhouse trapping solar energy inside a thermal chimney. The rising heat developed within the interstitial wall creates not only excess heat, but also ventilating negative pressure, collected into the building's central heat collection system and regulated by BAS, Building Automated Systems.



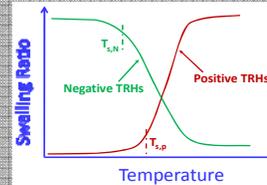
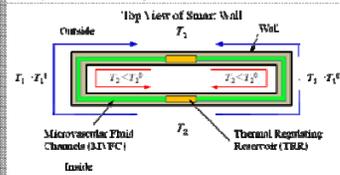
micro-scale

Micro-scale materials (polymer)

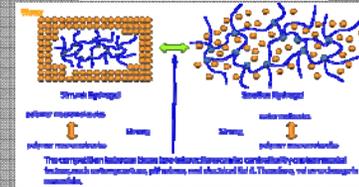


Autonomously regulate water via pairs of thermally responsive hydrogels

Temperature change induced water circulation

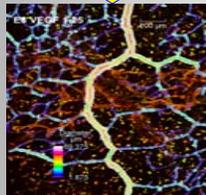


Molecular mechanism of hydrogels

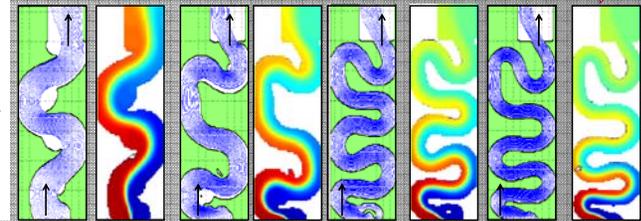


meso-scale

Micro-vascular fluid channels & networks

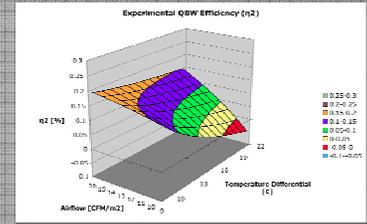
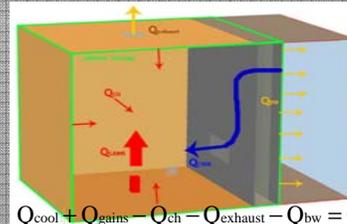
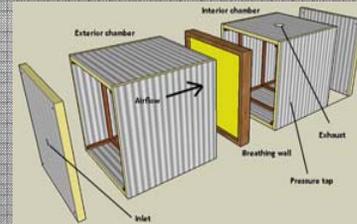
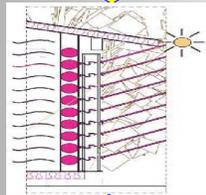


Micro-vascular network design: A formal topology optimization approach is being developed for the optimal convective heat transport. The figure to the right shows channel geometries optimizing the mixing of fluids with different temperatures for various pressure drop levels (increase from left to right) as generated by the hydrogels.



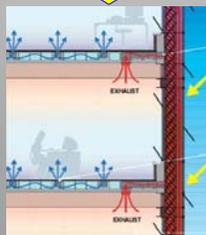
macro-scale

Macro-scale individual wall units



system-scale

System-scale whole building systems



System-scale: Living Wall:

The Living Skin as the inner interstitial wall is a multi layered heat and light exchanging wall panel that rapidly transmits excess heat via the hydrogel into a central PCM and capillary matrix layer. This heat is drawn off to the BAS controlled central system for use elsewhere in the building. The inner layer of the Living Wall creates an insulation layer to prevent excess heat from overheating perimeter spaces. The entire Living Wall System remains translucent while producing ultra efficient and rapid heat exchange. The entire system runs in reverse "seeding" the upper half of a non-solar cool wall with excess heat, facilitating the thermal uplift of the interstitial air column via an expanded temperature gradient, providing ventilating air movement. We believe the entire system will provide enough heat, cooling, ventilation and light for a completely passive ZNEB, Zero Net Energy Building.

