That's a Wrap!

The objective of this challenge is to improve the **building envelope performance** of new or existing residential buildings by reducing energy consumption in a cost-effective and accessible way.

Background

In the heat of summer, does your air conditioner seem to run all the time? In winter, do cold drafts in your house make it impossible to get comfortable? Your house may be energy inefficient due to the performance of the building envelope. The **building envelope**—consisting of the walls, roof, foundation, and windows—separates the interior living conditions from the exterior weather and is the single largest contributor to primary energy use in residential buildings.[1] Nearly 60% of total residential building energy is used to provide occupant comfort by heating, cooling, and ventilating the living space.[2] The performance of the building envelope disproportionally affects communities that lack the resources to improve the quality of the building envelope through remediation techniques.[3]

One of the primary functions of the building envelope is to control the flow of matter and energy—specifically, the flow of moisture, air, and heat between the interior and exterior.[4] Failure to control this flow can cause reductions in energy efficiency, durability issues, decrease in occupant comfort, and reduced indoor air quality, which can lead to mold and cause significant health issues.[5] The flow of moisture (both liquid water and vapor) is typically controlled using water-resistive barriers, ventilation air gaps, and drainage planes. The flow of air is typically controlled using air-resistive barriers and air sealing techniques. The flow of heat is controlled using insulation and solar reflectance. While new building construction can easily benefit from novel technologies and methods, many of these control methods can be difficult, cost-inhibitive, or sometimes even impossible to implement into existing buildings.[6]

More than 50% of existing residential buildings in the United States were built before 1980 when energy conservation codes were first introduced,[7] and they lack modern efficient technologies that effectively control the flow of matter and energy. However, less than 2% of U.S. buildings are **remediated** each year[8] to improve the energy efficiency, primarily because the cost to retrofit commonly exceeds several thousand dollars[9] and often falls entirely on the building owner. In some cases, the building owner may have a high **energy burden** and may not have the resources to improve the quality of the building envelope to lower energy consumption. Energy burden is the percentage of a household's gross annual income spent on energy costs (including electricity, natural gas, and other home-heating fuels).[10] A person is considered energy burdened if they spend 6% or more of their annual income on energy costs.[11] Lower income households are disproportionally impacted by energy burden—households that make $15,000 or less per year spent on average 21% of their income on utilities and may forgo other life necessities in order to address issues with the envelope.[12] To increase energy efficiency and address energy burden, innovative solutions must be developed that provide access to energy-efficient, cost-effective, and accessible building envelopes.

Common remediation strategies to improve the building envelope performance of existing buildings require that occupants leave their homes for days or weeks while the envelope is tested, sealed, or rebuilt. For some individuals and families, temporary relocation is often not a possibility due to limited resources; remediation strategies are often delayed, sometimes indefinitely.

Remediation techniques to improve the quality and performance of the building envelope vary in effectiveness, affordability, and accessibility. To evaluate and remediate air leakage issues, a blower door test is often used to pressurize the building and search for air leaks,[13] which is time consuming and requires specialized equipment. Sealing of air leaks is commonly performed manually using sealant. Innovative solutions are required to improve both the process of finding and sealing air leakage. When an envelope is made more airtight, the susceptibility to moisture damage increases[14]; therefore, remediation efforts should be accompanied by analysis or evaluation to predict if moisture durability will be a concern. Moisture durability prediction tools commonly require expert input or destructive methods. Innovative solutions are needed to make the moisture durability assessment process more affordable, more accessible, and widely available. To improve thermal performance of the envelope, insulation or solar reflectivity is added to the walls, roof, or foundation. Additionally, windows can be replaced with more thermally efficient modern designs. Some insulation remediation strategies exist that allow occupants to stay within their homes while the envelope performance is improved[15]; however, these solutions are often not cost-effective, not applicable to all types of existing construction, or not widely available on the market in the United States. Innovative solutions are needed to generally improve the affordability, accessibility, and quality of building envelope remediation strategies.

The Challenge

This challenge asks student teams to address the high energy burden that some communities face by developing an innovative solution that allows building owners to access high-quality and affordable envelope remediation or construction technologies, strategies, or methods. Students may consider solutions to address air leakage, moisture durability, and/or thermal performance of the envelope for new or existing residential buildings. Students must target solutions that are cost-effective, affordable, quickly implemented, and accessible to the end user.

Suggestions for the student teams include (but are not limited to) developing cost-effective, fast, and accessible solutions or technologies to:

- Detect and seal air leakage through the building envelope.
- Predict, assess, or evaluate the moisture performance or potential moisture damage of the building envelope.
- Add insulation, air barriers, water barriers, and/or weather resistance (cladding) to existing building envelope elements—walls, roof, foundation, etc. Students should target solutions that are directly applicable to housing types that may need the most improvement, such as low-median-income manufactured housing or large multifamily housing.
- Increase the function of the building envelope to limit the flow of air, water, and/or heat for new residential buildings. Students should target solutions that are directly applicable to low-median-income housing such as manufactured housing or large multifamily housing.
- Increase accessibility of specific, deployable envelope retrofit technologies by using existing rebate programs. Students should focus on using existing rebate or incentive programs at the federal, state, county, or city levels to increase the adoption of specific, deployable technologies or remediation strategies.
- Increase accessibility of specific, deployable envelope retrofit technologies, and develop education programs to accelerate deployment.
- Harness ambient energy from the sun, air, or sky to make the building more energy efficient.

Student submissions should:

- Describe the scope and context of the problem based on a current or emergent problem(s) in the United States.
- Identify affected communities, making sure to research stakeholder backgrounds and understand the stakeholders' needs.
- Develop a novel technical solution to address the problem at the building scale; the solution can include technical and/or nontechnical aspects such as policy or economic solutions and may focus on new or existing residential buildings.
- Discuss appropriate and expected impacts (including any unintended consequences) and benefits of the proposed solution; include a cost analysis of the proposed solution.
- Develop a plan that describes how the team envisions bringing its idea from concept to implementation, such as a technology-to-market plan for a commercially viable, market-ready product for real buildings, and/or integration into the planning and design process.

References

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Additional Resources

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