Research on deep-energy retrofits yields promising cost savings, human well-being outcomes

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Through the interactive exhibit designed by Krietemeyer and Wilson, visitors can explore the impacts of deep-energy retrofits across residential communities in the Syracuse area. The exhibit was developed in collaboration with interactive artists NOIRFLUX and students in the School of Architecture. The display uses 3D depth-sensing technologies, tracking and gesture-directed software and projection mapping onto a 3D-printed model of the City of Syracuse to display the environmental, health and economic benefits that retrofits offer. Credit: Syracuse University

Modifying and upgrading building enclosures and mechanical systems in older, multi-family apartment buildings can achieve net-zero energy-use efficiencies and help inhabitants lower energy costs, breathe better air and live more comfortably—changes that have wide application for state and national climate-change efforts, a multidisciplinary team of faculty and student researchers has demonstrated.

Their three-year research project, Net-Zero Energy Retrofit Living Lab, offers new insights, recommendations and data supporting the practice of "retrofitting" older buildings. The team has demonstrated how updating interior and exterior building systems for increased energy efficiency and improved air quality can achieve "net-zero" energy use—where the energy a building harnesses is equal to or greater than the energy the building consumes.

Retrofitting is an integral part of energy-use and carbon footprint reductions as well as lowering demolition waste and the building sector's overall carbon impact, says Nina Wilson, assistant professor at the School of Architecture and the project's principal investigator.

"We expect to see wide application of our findings as the state and nation move forward in their efforts to fight climate change. Given the energy and carbon impact exerted by many thousands of retrofit-ready buildings just in New York state, it is important to keep delivering physical demonstration projects and data that enable the industry to better model and predict performance outcomes of retrofit approaches," Wilson says.

New York State has set ambitious, nation-leading goals to combat climate change, committing $6.8 billion for projects to cut on-site energy consumption by 185 trillion BTUs by 2025, reach 70% renewably sourced electricity by 2030 and achieve a zero-emission electric grid by 2040.

Two-building approach

Two identical residential apartment buildings built in 1972 on Winding Ridge Road on the University's South Campus were used for the study. One was chosen for retrofitting and the other served as a "control" to provide near-identical, non-retrofitted building data throughout the project.

Research began in 2021 with a building assessment to diagnose conditions like poor insulation, building envelope leakage and a lack of active ventilation and cooling systems. At the same time, sensor data, digital modeling, cost criteria and performance goals drove the design process. Construction of the retrofit was completed in the summer of 2022, followed by a year of post-occupancy energy and environmental data collection. That analysis compared the retrofitted building's energy use to the non-retrofitted building to gauge the impact of the adjustments.

More systems, less energy

The retrofit plan was initially modified due to cost issues during COVID-19, but because indoor thermal comfort and improved air quality remained as priorities, high-efficiency heat pumps and heat recovery ventilation systems were installed.

So far, Wilson says, the construction modifications have exceeded expectations, producing up to 80% reduction in energy use for heating and cooling, even with the addition of fresh air and cooling systems in place of the original electric baseboard heating. Data also shows significant improvements in indoor air quality through reductions in volatile organic compounds (VOCs), chemicals commonly found in indoor environments that can have long-lasting health effects.

Using holistic and interdisciplinary approaches have been important, given the research team's expectation that this type of work will continue for decades, Wilson says. "We pushed beyond the simple energy-use reduction goal to include occupant well-being and environmental quality considerations. That we were able to do that and still meet the energy target was an outcome that provided valuable lessons."

Interdisciplinary, academic-industrial alliance

Faculty, staff and students from three University schools and colleges, the Syracuse Center of Excellence and the Office of Campus Planning, Design and Construction, plus industry experts and community business partners, participated in the project.

Bing Dong, associate professor at the College of Engineering and Computer Science and a co-principal investigator, designed and managed building data-collection systems to measure indoor air quality, energy efficiency of the spaces and various ways occupant behavior (such as opening windows) affected energy use and indoor comfort levels. He used behavior models, building energy simulation and machine learning approaches in taking those measurements.

Bess Krietemeyer, School of Architecture associate professor and project co-principal investigator, led the design of an interactive, 3D exhibit showing how the Syracuse community would benefit from the energy savings and improved environmental quality, health and well-being advantages that deep-energy retrofits can provide.

The exhibit demonstrates how retrofitting can improve thermal comfort for occupants while realizing cost savings on monthly energy bills and provide fresher air to breathe inside and out. Through interactive, dynamic features, the exhibit also locates residential buildings of all types—from multifamily to single-family homes—to show where and how retrofits can support the health and vibrancy of all Syracuse neighborhoods.

School of Information Studies faculty members Jason Dedrick and Jeff Hemsley, also co-principal investigators, created a website that broadcasts live project data and summarizes research methods, plus an app that streams energy performance data directly to building occupants' personal devices.

Students have been involved in hands-on learning opportunities during all project phases. They have evaluated data, created modeling, analyzed innovative technologies and materials, reviewed life cycle analysis tools that measure carbon impact, assessed energy-saving technologies and documented all aspects of the work.

Website, MOST Exhibit

The website illustrates all phases of the project's three-year path, from the start of building identification in 2021 through data collection, design origination and development and construction phases.

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The display uses 3D depth-sensing technologies, tracking and gesture-directed software and projection mapping onto a 3D-printed model of the City of Syracuse to display the environmental, health and economic benefits that retrofits offer. It will be on display at the Museum of Science and Technology in Syracuse through the end of January.

Provided by Syracuse University

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