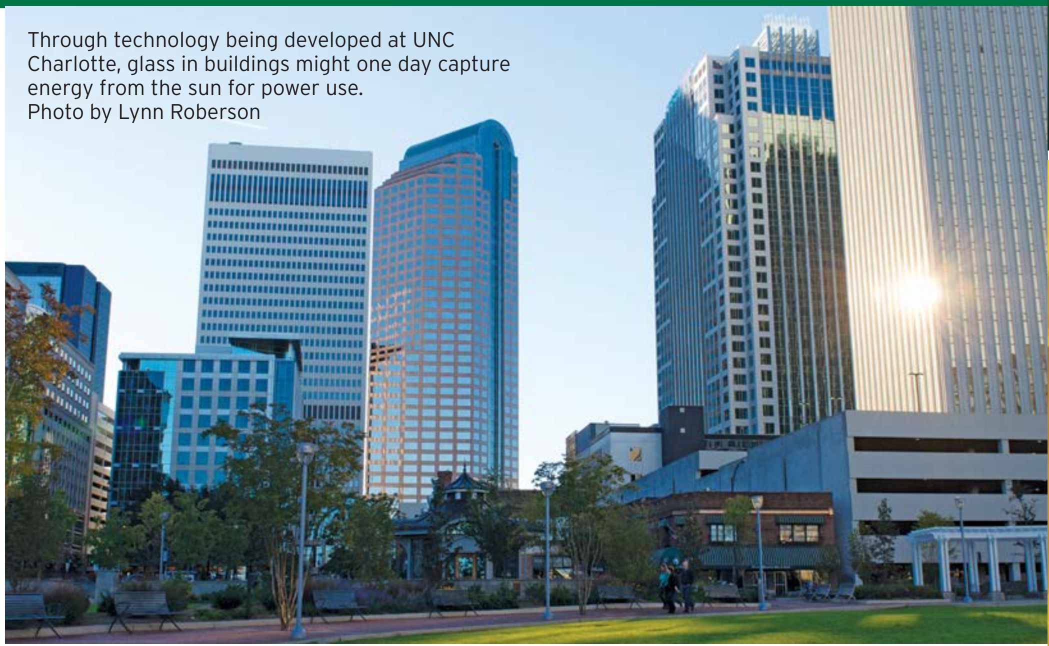
Window to the Future

University team creates material that could revolutionize energy efficiency in buildings

By Meg Whalen and Lynn Roberson



Through technology being developed at UNC Charlotte, glass in buildings might one day capture energy from the sun for power use. Photo by Lynn Roberson

Suppose we could enjoy the windows in our homes and other buildings while experiencing two highly attractive environmental benefits — less heat produced by sunlight pouring through the glass and the capturing of that energy to power the structure.

This compelling idea has moved closer to reality through the work of a UNC Charlotte team of students, led by faculty from architecture and nanoscale science. They have developed a solar-responsive design material that transforms one of the most popular features in most structures — windows — into environmentally responsive surfaces, with potential to revolutionize the use of glass in buildings.

"We believe the nanotechnology we are developing could totally change the way buildings integrate light- and heat-responsive solar materials that channel excess solar energy away and convert it into useful electrical power," said Michael Walter, assistant professor with the nanoscale science doctoral program and the Department of Chemistry.

The students competed for $75,000 in the People, Prosperity and Planet Student Design Competition for Sustainability held by the Environmental Protection Agency (EPA) in Alexandria, Va. April 10-13. UNC Charlotte won honorable mention among the 40 entries, only five of which received second-round grants. To develop the project, UNC Charlotte had received $15,000 in EPA funding and awards from the University's Energy Production and Infrastructure Center, the Department of Chemistry and the School of Architecture.

"THE MOST OBVIOUS IMPACT THIS WORK CAN HAVE, IF IMPLEMENTED, IS TO DRIVE DOWN OUR CO2 EMISSIONS AND FOSSIL-FUEL USAGE."

MEET THE TEAM

The team competing for the prize comprised Dan Cohen and Keming Ren, doctoral degree students in nanoscale science; Maryam Ahmadi Oloonabadi and Amir Hosseinzadeh Zarrabi, master's degree students in architecture; Jennifer Kassel, a bachelor's degree student in physics; and Victoria Pike, a bachelor's degree student in architecture. Mona Azarbayjani, assistant professor in the School of Architecture, joins Walter in guiding the work.

The design draws inspiration from sunlight-responsive mechanisms found in nature and from applied principles in chemistry and materials science. The unique material reacts to the intensity of sunlight striking the window. Excess solar energy converts to electricity instead of heating the interior of a building. This material can be incorporated as an ultra-thin layer on a glass surface in a building's exterior, such as skylights, facades, windows, or on curtain walls, or in vehicles.

Micro-sized, wire-shaped solar cells are embedded in the thin film of clear, heat-responsive plastic material. The plastic absorbs the heat the sunlight produces and reacts by expanding, which causes the nearly invisible wires to bend, and in turn, slightly tint the window. This allows the solar cells to absorb more visible light, increasing the efficiency of the window as a solar panel, which can help meet the building's energy needs. Once the window cools, the plastic and the wires return to their original positions.

Maryam Ahmadi Oloonabadi puts together a wire-array model to demonstrate the technology. Photo by Amir Hosseinzadeh Zarrabi

At the People, Prosperity and Planet Student Design Competition, Victoria Pike (from left), Maryam Ahmadi Oloonabadi, Jennifer Kassel and Keming Ren explain their nanoscale technology. Photo by of Michael Walter

Jennifer Kassel works in the clean room preparing materials. Photo by Lynn Roberson

"I THINK IT HAS AMAZING POTENTIAL TO PUSH THE BORDERS OF NOVEL APPROACHES TO MORE EFFICIENT GENERATION OF ENERGY."

"The most obvious impact this work can have, if implemented, is to drive down our CO2 emissions and fossil-fuel usage," Kassel said. "In the science world, it will open up new avenues of research characterizing such a system and finding ways to optimize it. More subtly, I think it has amazing potential to push the borders of novel approaches to more efficient generation of energy."

The team works as a strong unit, Azarbayjani said. "This project fosters the collaboration among students from different disciplines, including nanoscale science, chemistry, physics and architecture," she said. "This problem-based and active learning model reinforced and advanced the kinds of nontraditional education known to deepen learning and build professional development skills."

GAINING NEW PERSPECTIVES

Team members gained new perspectives and insights from each other, students said.

"Working with the other disciplines is very vital for architecture, as it is an interdisciplinary complex," Ahmadi Oloonabadi said. "It kind of made us think about a major problem of our buildings with a tiny lens. It is always great not to look at the problems from the same angle over and over."

This is not the first time an interdisciplinary team of UNC Charlotte students has conducted research and design in solar energy and sustainability practices for a national competition. Led by Azarbayjani, more than 40 students competed in the 2013 Solar Decathlon, sponsored by the U.S. Department of Energy.

"One of the core objectives of the Solar Decathlon was to turn ideas into research," Azarbayjani recalled. "Throughout the competition, we wanted to embrace all aspects of sustainability and the built environment. That's where the idea of a responsive building envelope was born. This idea then served as a vehicle for our exploration in the P3 competition."

Bringing together researchers from architecture and physical sciences made sense, Walter said.

"In chemistry and nanoscience, we are always trying to push the limits of what our materials can do, and yet at the same time we need to understand the 'why' of our efforts," he noted. "The rapid growth of solar energy materials in the last 10 to 15 years meant that pieces of the solution to this design challenge existed. By bringing together architecture faculty and students with nanoscience faculty and students, we have begun to work out how to put those pieces together."

Meg Freeman Whalen and Lynn Roberson are directors of communications for the College of Arts + Architecture and the College of Liberal Arts & Sciences, respectively.