Integration of Engineering Education with Research through Demonstration Projects of Zero-Energy Buildings

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INTRODUCTION

We present here a history of demonstration projects of net-zero-energy buildings and related building energy efficiency projects. It is essential to understand that buildings currently account for 40 percent of U.S. energy use and a similar percentage of carbon dioxide emissions, more than the transportation or industrial sectors. Emissions associated with buildings and appliances are projected to grow faster than those from any other sector. On top of this, population growth further adds to the pressure of ensuring adequate supplies of energy. Significant efforts in finding ways to reduce building energy consumption have been undertaken along many fronts. US Department of Energy leads development of various innovative building technologies, while US National Institute of Standards and Technology focuses on enabling technology through new measurement science to address the building operation practice issues. Universities across US have been engaged in various aspects of building energy efficiency research and education in response to the urgent needs to provide both technical solutions to the society and education to the future engineers and scientists. At Florida International University and University of North Texas, faculty, students and administrators work together to create an innovative educational environment that integrates research and degree programs with demonstration projects in zero energy buildings.

PROJECTS

For example, **FIU's Engawa solar house,** a 800 sq. ft solar powered residential building (Fig. 1), a multi-disciplinary projects involving more than 100 undergraduate and graduate students and 7 faculty members from Mechanical and Materials Engineering, Construction Management, Architecture, Civil, Electrical, Computer Science and Creative Writing. The project won three awards including the first place in energy balance category in Washington DC as part of 2005 Solar Decathlon competition.

From 2006 to 2008, we worked with a consortium of industrial partners to build a 3,200 sq. ft grid-tie net-zero-energy demonstration building (**American House**, Fig. 1) as part of Beijing Olympic project. It represents US's green building technology in a ten-country demonstration project sponsored by Chinese government. Five students and 5 faculty members from various disciplines contributed to the projects. The project was visited by US Secretary of Energy, Dr. Steve Chu and then Secretary of Commerce Mr. Garry Locke, 2009.

Figure 1 Solar Decathlon House in DC (2005, left), and American House in Beijing (2008)

Another project is **the campus energy audit for FIU's Health Science Building**. Through field sensors and wireless network data collection, energy consumption patterns of the 87,000 sq. ft building were analyzed and the results were presented to the university administration as part of campus energy efficiency improvement initiative. Through the project, three graduate students were involved. It was found that nearly 65% of energy consumption was due to the use of lab equipment, a significantly different use pattern compared to an office building. We also conducted an **investigation of effect of skylights on energy saving potential for residential and commercial buildings** – a power utility incentive project. The FIU Engawa house was restored on campus after the competition as a research lab. The effect of with or without skylights

was studied by metering the house for AC and lighting energy consumption. Energy simulation software EnergyPlus was used to simulate the annual energy consumption and validated with the field data. It was found that for a residential house in a hot and humid climate, the annual energy consumption due to installation of the skylights for the test case is actually higher, contradicting to the manufacturer's claim.

Zero Energy (ZOE) research Lab at University of North Texas (currently under design and to be constructed, Fig. 3) is a permanent state-of-the-art 1,000 square feet residential-like flexible space/envelope/structure with a main utility core, a bathroom with a shower, a small kitchen with refrigerator, open flexible living/work space, and an attached or detached garage. The project will be located at UNT's Discovery Park (see image below).

This UNT Zero Energy Research Lab will be a testing ground for present and future sustainable technology, a research and teaching center, and a fund raising focal point for UNT. It is an integral part of UNT's **Renewable Energy and Conservation Research Cluster**. The facility will be used to test the following technological and building systems: Windows & screens, wall assemblies, roof; solar photovoltaic [on roof and free standing "trees"]; solar hot water panels; energy star appliances; overhangs; skylights [operable & non-operable]; geothermal heat pump;wind turbine; radiant heated floor slab; insulation (structural insulated panels) at walls and potentially roof; rainwater harvesting; solar chimney; passive solar heating & cooling; occupant energy consumption behavior; smart building energy monitoring and control system; validation of building simulation models.

Providing abundant, cheap, renewable energy for homes, businesses and other end users is a global, conservation imperative that requires innovative research strategies across disciplines. Next generation renewable energy and energy conservation solutions are needed to address complex scientific, technological, environmental, and societal problems. The Renewable Energy and Conservation (REAC) research cluster combines expertise in materials science, mechanical and energy engineering, electrical engineering, engineering technology and other physical and social science fields to conduct research in three thrust areas: Distributed Renewable Power Generation, Smart Grid Transmission, and Building Energy Conservation. A focus in these niche areas capitalizes on existing UNT strengths and primes the cluster to strategically expand its base of expertise and funding.

From device development to system modeling and validation, REAC serves as a research pipeline for diverse energy and conservation projects, including affordable photovoltaic systems and wider utilization of wind power; cost effective, high energy efficient building products; and key grid-tie solutions for wide penetration of distributed renewable energy. The goal of the REAC cluster is to form key research teams in a few critical areas that will impact the regional, national and international renewable energy research landscape and spur rapid technology transformation. UNT has a considerable investment in growing research across the university, and the resources available to REAC scientists and engineers are no exception. Access to cutting-edge micro/nano fabrication instruments, clean rooms, a zero energy house as a living lab, research laboratories and distinguished faculty give REAC researchers a distinct advantage in advancing research. By leveraging existing resources and adding critical new talent to its foundation within a multi-disciplinary framework, REAC aims to distinguish itself as a leader in sustainable energy research.

SUMMARY

All the above examples have created or will create unique multi-disciplinary education opportunities for students. At FIU a 5-course undergraduate certificate program , called "sustainable Construction" was created because of those demonstration projects. At UNT, a proposal for a Ph.D. program in Mechanical and Energy Engineering was submitted to the State of Texas and a graduate certificate in renewable energy is in planning stage. Through those demonstration projects, students gained hands-on, multi-disciplinary team work experience on top of their systematic acquisition of scientific knowledge.

Figure 2 Energy Audit for FIU's Health Science Building

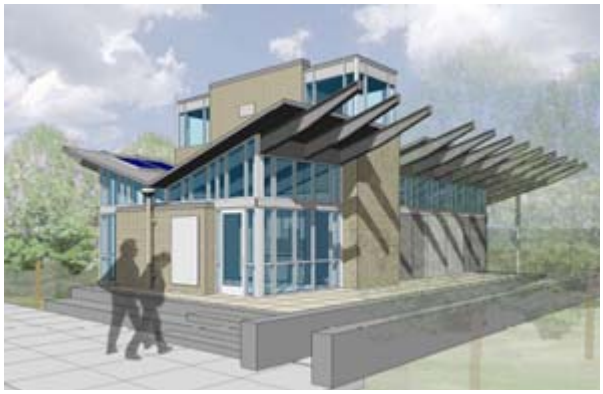

Figure 3 Zero Energy (ZOE) research Lab at University of North Texas