

## Design of Green Building

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### Abstract

The National Center for Environmental Research (NCER) funds extramural research for the Environmental Protection Agency. Our goal was to provide future research recommendations concerning green building and more specifically water infrastructure. Categorizing NCER's past projects and research, interviewing with principal investigators, and meeting with employees of various EPA offices have allowed us to identify existing research gaps. NCER's future solicitations should consider water reuse, green roofs, and improving cooling towers. NCER should also focus on ways to improve social acceptance of green building, thus advancing implementation of green technologies, devices, and practices.

### Introduction

Pollution is increasing worldwide. Water supplies face a daily onslaught of hazardous wastes. The atmosphere is a dumping ground for greenhouse gasses. Around the world the demand for more energy is on the rise, while the primary source for energy, fossil fuels, is quickly being consumed. Buildings are responsible for a large portion of energy and raw material consumption. In the United States, buildings consume 12% of the potable water, 30% of the materials, 70% of the electricity produced as well as account for 20% of the greenhouse gasses released and 45% of the waste sent to landfills (US EPA, 2004).

However, recent events and discoveries have brought about a change. People are becoming more aware of the costs of energy, both its monetary value and its environmental implications. Government agencies are pushing newly developed green technologies, including recycling, reuse, and efficiency to address these growing concerns. Green building, a recent trend to address the negative effects of buildings, consists of the use of environmentally friendly materials, pollution prevention through recycling, and an increase in energy efficiency.

The Environmental Protection Agency (EPA) has great influence on environmental regulations and policies in the US. To address current issues effectively the EPA needs to focus on areas of research that may have the biggest environmental impact. Over the past decade, one of the federal government's foci has been to continually improve the growing field of green

building technologies. Since 1995 the number of green projects sponsored by EPA's National Center for

Environmental Research (NCER) has risen to 95, with a total funding of over \$7 million. However, this number is relatively small compared with other areas of NCER research. The EPA currently has no designated budget or research solicitations in place for green building research. Therefore, past green building related research was based exclusively upon individual interests and agendas. Outside the EPA, other government agencies, including the Department of Energy and the National

Science Foundation, and organizations such as the U.S. Green Building Council have sponsored research on technologies that are related to green building. Even with these advances in technologies, green building market penetration and social acceptance remain low.

Although it has been generally known that green building is more environmentally friendly than traditional building, there are still some unknown aspects. For example, there is little to no information available regarding any potential negative impacts of green building such as fire hazard or its overall impacts on different infrastructures such as water infrastructure. As a result the EPA is planning to conduct more research regarding green building technologies but it has not yet identified its foci. Being that the EPA does not have a green building research strategy, previous research performed within the EPA has been scattered

among different offices. These research projects, especially those dealing with stormwater management and water recycling, often are not wholly integrated with green building. Ultimately, these gaps in information are potential challenges to the future development of green building technologies.

The purpose of our project is to provide the EPA with recommendations for future research areas regarding green building technologies, specifically those relating to water and wastewater infrastructure. Our first objective was to identify all the current and past research NCER has done on green building technology. Next we identified past research on green building by other offices within the EPA and by other organizations. We then analyzed the garnered research and identified the gaps in research with a focus on water infrastructure but also considered other green building aspects including energy and materials. We also considered the EPA's budgetary and regulatory constraints to carry out research in order to provide appropriate recommendations. The results of fulfilling these objectives were a categorized list and analyzed statistics on NCER and other's green building research and recommendations for future foci in green building technologies and water infrastructure.

## 1 Green Building

Green building is a "high-performance property that considers and reduces its impact on the environment and human health" (Yudelson,

## Green Building Research Trends

The past research funded by NCER concerning green building and related technologies began in 1995 with the reorganization of the Office of Research and Development (ORD). To understand funding trends over time our list of 95 projects had to be organized by the year funded and the program that received the funding. Once again we analyzed the data both by the number of projects and the size of the awards.

2008, p. 13). It is designed to be one part of the answer to the global issue of energy consumption and waste production by reducing energy and water use as well as green house gas emissions. This can be achieved through every stage of building from siting, design, material selection to the actual construction and operation of green building. Green building requires increased planning and organization as the selection of materials and operation systems may affect the building schedule and require further knowledge and equipment on the part of the contractors. A sustainable green building must account for resources and local climate factors and include low-impact materials as well as energy and water efficient systems. The construction of green buildings reduces on-site waste by recycling and conserves natural resources by using alternative materials. Green building achieves better operating performance with better insulation, design, and energy efficiency. Green building efficient Heating, Ventilation, and Air Conditioning (HVAC) systems provide better air and a healthier environment for the people who live in one of these buildings.

In order to easily provide green information and guidance for people to go green, a common rating system to measure and compare the performance of green building is necessary. The main rating system that was developed in the US and is currently used widely is the LEED rating system

Before we provide analysis of these research trends, it is important to note how the data were interpreted. Many of the projects funded by NCER are sponsored for 2 to 3 years, particularly in the SBIR and CNS programs. We wanted to know the value of how much yearly funding is awarded by NCER towards green building research. Therefore Figure 4-3, which shows the funding trends of each program over time, was developed by dividing a project's total funding by the number of years the project was carried out. To eliminate confusion for Figure 4-4, which shows the number of projects

sponsored per year, each project is counted only in the year it was first funded. For example, if a two year project was awarded \$100,000 in the year 2000 our chart would show that the project was done in 2000, but the funding was distributed as \$50,000 in both 2000 and 2001

As shown by Figure 4-3, the general funding trend for green building research appears to be increasing over time. However, after 2007 there are two consecutive years of decreasing funding. This is attributed to proposals still being considered for funding and projects that have not yet been entered into the database.

The CNS program has funded a large

After the year 2004 the SBIR program experiences a decreasing trend in amount of funding. This was a result of the gradual NCER budget cuts since 2004. Since SBIR program represents 2.5% of the total NCER funding, the decreasing funding of SBIR would signal the overall decreasing of NCER fund. The SBIR program currently contains one-half the funding resources it once had. Even with the budget cuts, in 2004 the number of green building SBIR projects doubled that of the previous year. This

#### **Regulations**

In terms of regulations that aid the EPA and its offices in determining the best research topics, the Clean Water Act Section 104 allows NCER to make grants to institutions and colleges for research regarding the causes, effects, extent, prevention, reduction and elimination of water pollution (refer to

which will help reduce the amount of wastewater discharged into the environment and stormwater management research which will help reduce the amount of polluted water runoff discharged into water sources.

The Safe Drinking Water Act Section 1442 (Appendix E) also authorizes the EPA to make grants for research on water quality especially in matters of causes, diagnosis, treatment, control, prevention of physical and mental diseases, and other impairments of man resulting directly or indirectly to water quality. Under this Act, NCER can fund various research initiatives on the health risks involved in using recycled water for potable uses. Research into

amount of grants since 2005 and peaked in 2007 in terms of dollars (Figure 4-3). The purpose of the CNS program was to become the cornerstone of

NCER's shift towards sustainability research. It requires significantly more capital to perform the large-scale regionally focused sustainability projects that CNS targets. The program is a significant progress contributing to green building research. Although all CNS projects have different topics, their approach method of solving the problem in the large scale had partially fixed the gaps of scalability that has been overlooked in the past.

is because 2004 was the first year that SBIR issued a solicitation for green building research. Since 2004 green building has remained on the yearly SBIR solicitation. In terms of dollars granted, green building research under the SBIR program has decreased after its initial year of specific green building solicitation. This is also true with the number of projects funded since 2004, shown in Figure 4-4. However, considering the small number of SBIR green building projects it is difficult to make a conclusive statement

Appendix G for more detail). Any research related to green building's impacts on water infrastructure systems such as water reuse and stormwater management can be allowed by the Clean Water Act. For example, under this act, NCER is allowed to fund research on water reuse

the various pharmaceuticals in recycled water could also be authorized under this act.