

**Establishing A Long-Term Research Agenda on Design, Construction  
and Technology: A Framing Paper for PD&R Research Conference**

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**White Paper for Green and Energy Efficient New Construction  
And Renovation of Existing Housing Research Teams**

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## **Introduction and Purpose**

A central mission for HUD is to build and provide access to sustainable and inclusive neighborhoods of opportunity for all. In previous years, the Office of Policy Development and Research (PD&R) has relied on external advisors and, more recently, an internal process when establishing top research priorities. Now, PD&R is inviting external stakeholders and researchers to assist in assembling a roadmap for a long-term research agenda that focuses on creating sustainable and inclusive communities. In an effort to highlight recent research and future endeavors for HUD, this framing paper is meant to set the stage for discussion that will take place on May 16th, 2012.

As follows, we highlight key HUD assets that are available to help build on our knowledge base in the research areas of Green and Energy Efficient New Construction, and Renovation of Existing Housing through Design, Construction and Technology research. As you review the work, we ask that you think about PD&R's comparative advantage given these assets and where there may be opportunities to engage with external partners. Second, we focus on areas where we believe research, and research gaps, exist. Following a brief discussion under each category, we then propose discussion questions that will set the stage for the upcoming meeting. Our aim is to distill research questions that complement HUD's strengths and provide the best position for answering these questions as it moves forward (see also Appendix B items).

## **I. Assets for Design, Construction and Technology Research at HUD**

In developing a research platform on green and energy efficient construction HUD has taken several steps. The EPA-HUD-DOT Partnership for Sustainable Communities will celebrate its 3rd anniversary in June 2012. Since the partnership launch, the agencies have invested more than \$2.5 billion across 200 communities in 48 states to help meet housing and transportation goals while simultaneously protecting the environment, promoting equitable development, and addressing the challenges of climate change.

Within HUD, the *Office of Sustainable Housing and Communities' Sustainable Communities Initiative* (OSHC) has sought to integrate transportation and housing planning and decisions in a way that maximizes choices for residents and businesses, lowers transportation costs and drives more sustainable development patterns. This investment reflects HUD's strong belief that housing is best developed "in context" of communities and regions, as proximity to transit, jobs, and retail amenities influence the long term success of both the housing and its occupants. To further this departmental objective, both OSHC and PD&R have sponsored a

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number of research efforts directed at sustainable development with an emphasis on creating more inclusive and diverse communities that also comply with fair housing laws.

Moving forward, PD&R is aiming to capitalize upon key elements of the Sustainable Communities Initiative and also on many years of research dedicated to defining a national housing research agenda, and specifically housing technology. Work over the last decade has aimed to improve the design and construction of housing and the examination of cutting edge building technology issues. Among research aimed to establish a national housing agenda on the design and construction of housing, many notable titles and investigators exist (too many for listing here). Best Practices and other findings from this work can be accessed on the HUD USER website “Publication Archive” ([www.huduser.org/portal/](http://www.huduser.org/portal/)). Based on this vast set of research, HUD is in a unique position to build off of its knowledge platform as a basis for moving forward. Ten years of dedicated funding towards the issues of housing technology have established a market in which HUD can be significantly useful in the services it provides to the housing industry, the community and other federal funding agencies.

Regarding tangible outputs, much recent work was created as technical guides or outreach through guidebooks, handbooks, and guidelines. While these items have been used a great deal by both public and private partners, there might exist a need for updating these texts towards the impacts of new technology and possible changes in the older specifications. Further, HUD is uniquely positioned to warehouse information on building technology. While discussed later in more detail, such a platform could be accessible online and house a substantial part of the cumulative knowledge generated by all stakeholders in the generation and use of the residential built environment.

Regarding research outputs, HUD’s mission for research activities performed under the Sustainable Communities Research Grant Program requires original work that results in substantive contributions to the existing scholarship. To the degree possible, future research should also yield methodological advances for evaluating public policy in Design, Construction and Technology for affordable housing.

Building its “platform” of knowledge, either in tangible or research outputs, would further reinforce HUD’s central role in working across agencies, at the federal level, with industry and through academia to support the needs of affordable housing.

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## **II. Research Developments that Affect Green and Resource Efficient Design, Construction and Technology**

### *Part 1. Research developments in Green and Resource Efficient Design, Construction and Technology*

A 2004 HUD-NSF workshop (Mullens et al. 2004), which contributed heavily to HUD's research agenda over the last decade, highlighted "crosscutting impacts" and recommended research topics on: 1) structural design and materials (including enhanced quality), 2) building enclosures, energy and indoor air quality (shell and in-fill), 3) housing technology, community and the economy (diffusion, commercialization and adoption), 4) Supply Chain coordination and 5) systems interactions (off-site and on-site) and "whole house" approach. While previous goals focused broadly and specifically on various aspects of housing technology, little was known about the impact of green-building and its diverse, and unique, products, practices and systems.

A substantial amount of innovative housing technology research was conducted under the HUD-NSF alliance, a voluntary partnership between leaders of the homebuilding, product manufacturing, insurance, and financial industries. The program established goals of identifying and reducing barriers to innovation; disseminating information to speed the development and adoption of advanced building technologies; advancing housing technology research; and fostering the development of new technology. As part of this work, many non-profit organizations also contributed to the knowledge base of building technology research (i.e. Newport Partners, LLC; NAHB RC; Steven Winter Associates, Inc.) for affordable housing.

In September 2010, PD&R and Virginia Tech convened a symposium in Washington, D.C. with the goal of providing guidance to PD&R on the state and direction of research related to Green and Resource Efficient Design and Construction. The symposium revealed also that there is not a consensus on the definition and state of affordable, green housing research.

Lacking clarity on the knowledge base, especially in the context of the new Inter-Agency partnerships, the symposium suggested conducting meta-reviews in the key thematic areas identified in the symposium: 1) residential energy consumption; 2) capitalization, finance, and subsidy; 3) commercialization and diffusion; and 4) government and agency efficacy. Further, participants determined that priority should be given to developing the first two reviews (energy consumption and capitalization) as these are interdependent and helped frame the reviews of commercialization and efficacy.

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Recent research studying *Green and energy efficient new construction* has tended to focus on several themes including: adoption of green building and energy efficient systems across geographies, the theory and practice of green property investing and development and the influence of public health in shaping housing policy. Further, current research opportunities exist to identify and establish goals of green construction towards *the renovation of existing housing*, including higher energy performance, financing and regulations and, like new construction, the influence on public health. Research towards both new construction and the renovation of existing structures in green construction are discussed in more depth in the coming sections.

### *Green and energy efficient new construction*

As the building industry (and building stock) represents one of the largest enterprises and is one of the largest users of resources, materials and energy in the country, research related to Building Technology has focused on a broad array of topics such as: building and construction materials; materials in systems; energy efficiency technologies and services; worker safety; public health and occupant safety; and building information systems. The ultimate goal of much research is to create higher performance facilities (both commercial and residential) through the incorporation of technology. The drive towards higher performance acknowledges the potential for improvement in the complex systems incorporated into and surrounding the industry, the benefits of energy efficiency, evidence of price and rent premiums associated with green buildings, and regulatory interventions supporting higher performance facilities.

There is significant university, government and private research addressing energy efficiency and innovations in energy technologies, as well as research addressing individual building systems and products (e.g. insulation, windows, HVAC systems, foundations, engineered wood products), and some research on industrialized production systems. Less work has been done on integrated analysis of the entire system (i.e. whole house) and very little is known about the post-occupancy interaction of persons and buildings.

Non-profit and governmental organizations working to deliver *Green and energy efficient new construction (and renovation)* have tended to focus on production and service practices rather than on research and knowledge creation. Although substantial investments have been made in production and renovation of housing by these sectors, particularly to promote low-income access and affordability, research on the physical systems or on the interaction between the occupant and the physical system has been tangential to production and service delivery. As a

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result, the contributions to knowledge creation are limited to best-practice examples, poorly documented performance research, and advocacy claims.

Research knowledge on the residential building system is as fragmented as the residential construction industry. Research is conducted in relatively isolated silos of academic departments, industry subsectors, nonprofit organizations, consulting firms, and federal departments. There is no depository, catalogue, index or search engine that would facilitate a comprehensive review of the current state of knowledge on any major component of the residential system, much less the integration of systems or the post-occupancy human-building interactions affecting performance and value.

Potential research questions:

- ✓ What is the relationship of higher efficiency to affordability and health? How should the future of affordable housing attempt to incorporate technology that could provide efficient and healthy solutions?
- ✓ How might consumers benefit from green technology in the residential housing market of the future? Is there room to benefit within the Single Family Home Market? In the multi-family sector?
- ✓ How will the non-profit side of energy efficiency move forward? Weatherization? ESCO?
- ✓ What incentives could improve the market for energy efficient technologies? Utility regulation?
- ✓ How does research on human factors move forward (post-occupancy operation; perceived value; maintenance)?

### *The renovation of existing housing*

Affordable housing, especially that built prior to the 1980s, can present serious environmental problems as a result of age and deferred maintenance. Residents experience a range of symptoms and illnesses due to Indoor Air Quality (IAQ), which have been reported considerably higher than the national average. Technologies designed and built to combat these issues in affordable houses can further introduce a new set of issues, such as mold and pests, if not properly considered and installed. Technology also presents opportunity to counteract environmental problems through energy efficiency in the renovation of existing housing stock. In recent years, the Federal Government and local housing authorities have attempted to tackle both health and efficiency in homes through technology. The U.S. Department of Energy's (DOE) Weatherization Assistance Program (WAP) invested \$5 Billion in the existing housing

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stock during the American Recovery and Reinvestment Act (ARRA) period, using technology to reduce energy costs and ensure health and safety. According to the website:

“Weatherization crews use computerized energy audits and advanced diagnostic equipment, such as the blower door, manometer, or infrared camera, to determine the most cost-effective measures appropriate for each home. Typical measures include installing insulation in walls, floors, and attics; reducing air infiltration and pressure imbalances; sealing and repairing ducts; and, tuning and repairing heating and cooling units.”

Outside of government-led programs, both academic and practitioner-led research points towards significant opportunities to renovate existing housing units to reduce operations costs and energy consumption, thereby improving affordability. Deutsche Bank America’s Foundation collaborated in 2011 on an investigation of the potential for energy efficiency retrofits in New York City’s public housing stock and determined that substantial opportunities for energy and operational savings existed for renovations to existing housing units. Other examples, such as 2010’s Home Improvements Revitalize the Economy (HIRE) Act, backed by the National Association of the Remodeling Industry (NARI), provided tax deductions and credits to middle and low-income families who improved homes using qualified home furnishings and building products, including a 150% bonus for items that met environmental standards.

A recent consortium (reported by Kats, Menkin and Dommu, 2011) of energy and financial industry researchers and practitioners argued, “the potential for cost effective energy efficiency (EE) investments in the US is on the order of \$200 billion a year. But after decades of public and private support, current energy efficiency financing is only one-tenth its potential – about \$15 to \$20 billion per year”. The consortium suggested that the opportunity was significant and attractive because of its, relatively low cost, potential to reduce carbon dioxide emissions, reduce building operating costs, and boost the value and desirability of occupied assets.

Beyond the markets of NYC, significant opportunities exist in the realm of financing for energy efficient technologies in the renovation of housing. According to the National Housing Trust and other researchers, activity across the country confirms that these opportunities exist and firms and public housing authorities have invested, or are planning to invest, in building renovations and preservations that use energy efficient technologies. This thread of research and investment seems to be catalyzed by (in part) the notion that the Federal government, via DOE and HUD, spends approximately \$5 billion in fuel subsidies and utility payments for low-income housing on a yearly basis. Outside of energy, the conservation of another resource,

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water, seems to be on the horizon for tackling through the public housing sector.

Potential research questions:

- ✓ Where should the primary focus of HUD research lie in the renovation of existing housing? Green and resource efficient design and construction techniques? Financing? Building Operations? How could this research be realized?
- ✓ What drives investment in green renovation, particularly for affordable housing, segmenting for owner and renter occupied housing? What are the obstacles?
- ✓ How will the non-profit side of retrofit move forward? Weatherization? ESCO?
- ✓ How do property conditions and ownership characteristics (age, quality, etc of housing stock) impact energy savings of efficiency interventions and thus the effectiveness of incentives designed to promote energy-efficiency?

### *Part 2. HUD's response to the Needs of Green and Resource Efficient Design, Construction and Technology*

To advance research in the area of green and resource efficient new design, construction and technology and to link work to affordability, HUD funded, as part of its *Sustainable Communities Research Grant Program*, a recent project on the commercialization, diffusion and adoption of energy efficient technologies in new construction. This project was in response to the emerging trends related to higher performance buildings and building systems, green building and energy efficient technologies in residential firms.

While not in response to a specific research question, one area where HUD could perform a significantly useful service to the housing industry and community is by funding or creating a building technology information database similar to PubMed, the NIH sponsored database. PubMed is a database used to access the MEDLINE database that houses a substantial part of the cumulative knowledge generated by the life and biomedical science research communities. Such an effort was previously attempted for innovative products, based on user input, with toolbase.org. HUD could expand this service through allowing users to search (for free) a single database cataloguing and referencing recent efforts, research and publications on green and resource efficient design, construction and technology. Applied to the housing and construction sectors, such a service would be invaluable to practitioners, advocates, regulators and researchers as they could quickly and easily identify the state of the housing literature (e.g., energy efficiency public policy interventions) and project how their own expertise might be parlayed into creating additions to the knowledge base.



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## III. Next Steps

At the May 16th meeting, there will be a “breakout” session in which HUD staff will lead a discussion on the issues addressed in this paper. The breakout convening will provide an opportunity for invited experts to weigh in on what HUD’s research priorities should be in this area, to identify major gaps in the research, and to help us develop a long-range research agenda, given the resources and assets available to PD&R.

### APPENDIX A – Additional Research Questions

Regarding *green and resource efficient new construction and the Renovation of Existing Housing*, additional research questions that could be pursued in this space are:

- ✓ What drives investment in green design, particularly for affordable housing, segmenting for owner and renter occupied housing?
- ✓ How do property conditions and ownership characteristics (age, quality, etc of housing stock) impact energy savings of efficiency interventions and thus the effectiveness of incentives designed to promote energy-efficiency?
- ✓ To what extent does the current subsidy structure provide incentives or disincentives for green consumption behavior?

### APPENDIX B

#### 1. Additional PD&R Assets

##### Data and Resources

- ✓ *American Housing Survey*:
- ✓ The Division of Research Utilization’s *Sustainable Communities Clearinghouse* and the *Regulatory Barriers Clearinghouse*.

##### Existing Research and Evaluations

###### *Energy Efficiency*

Accelerating Adoption of Vacuum Insulation Technology in Home Construction, Renovation, and Remodeling, December 2002

Energy Code and Related Thermal Performance Issues Associated With Steel Framing in Homes, April 1997

Energy Conservation in Housing for the Homeless: A Guide for Providers, January 1993

Energy Desk Book, April 2000

Energy Performance Contracting for Public and Indian Housing, February 1992

Environmental Assessment Guide for Public Housing, October 1996

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Manufactured Homes: Saving Money by Saving Energy, *August 2005*  
Model Energy Code Thermal Envelope Compliance Guide for 1 and 2 Family Dwellings  
An Owners Guide to Energy Efficiency in Single Family Rental Housing  
Technology Roadmap: Energy Efficiency in Existing Homes, June 2002  
Technology Roadmap: Energy Efficiency in Existing Homes—Volume Two: Strategies Defined, October 2003  
Technology Roadmap: Energy Efficiency in Existing Homes - Volume Three: Prioritized Action Plan, May 2004  
Progress Report: Implementing HUD's Energy Strategy, December 2008  
Promoting Energy Efficiency at HUD in a Time of Change, August 2006

### *Renovation of Existing Housing*

Accelerating Adoption of Vacuum Insulation Technology in Home Construction, Renovation, and Remodeling, December 2002  
Barriers to Rehabilitation of Affordable Housing: Volume 1 Findings and Analysis and Volume 2 Case Studies, May 2000  
Best Practices for Effecting the Rehabilitation of Affordable Housing, Volume 1: Framework and Findings, September 2006  
Best Practices for Effecting the Rehabilitation of Affordable Housing, Volume 2: Technical Analyses and Case Studies, September 2006  
A Guide to Deconstruction: An Overview of Deconstruction With a Focus on Community Development Opportunities, February 2000  
Guideline on Fire Ratings of Archaic Materials and Assemblies, February 2000  
HUD Rehabilitation Energy Guidelines for One-to-Four Family Dwellings, November 1996  
HUD Rehabilitation Energy Guidelines for Multi-Family Dwellings, September 1996  
Innovative Rehabilitation Provisions: A Demonstration of the Nationally Applicable Recommended Rehabilitation Provisions, March 1999  
Innovative Rehabilitation Technologies: State of the Art Overview, February 1996  
Making Rental Housing Energy Efficient: Guide to Performing Energy Retrofit During Multifamily Property Rehabilitation, October 1990  
National Survey of Rehabilitation Enforcement Practices, June 1998  
Nationally Applicable Recommended Rehabilitation Provisions, May 1997  
Rehabilitation Data Needs: A Building Industry Forum, July 2002  
The Rehab Guide Volume 1: Foundations, June 1997  
The Rehab Guide Volume 2: Exterior Walls, August 1999  
The Rehab Guide Volume 3: Roofs, March 1999  
The Rehab Guide Volume 4: Windows and Doors, May 1999  
The Rehab Guide Volume 5: Partitions, Ceilings, Floors, and Stairs, November 1999  
The Rehab Guide Volume 6: Kitchens and Baths, September 1999  
The Rehab Guide Volume 7: Electrical/Electronics, April 2000

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The Rehab Guide Volume 8: HVAC/Plumbing, August 1999

The Rehab Guide Volume 9: Site Work, August 2000

Residential Rehabilitation Inspection Guide, February 2000

Residential Remodeling and Universal Design, May 1996

Smart Codes in Your Community: A Guide to Building Rehabilitation Codes, August 2001

The Status of Regulations for Housing Rehabilitation, February 1996

### *Archives- for Historical Reference Only*

Assessment of the 1995 MEC for Adoption, April 1997

MEC Check Manual Model Energy Code Compliance Guide 1992, Version 2.0, June 1995

### *HUD and Federal Initiatives*

- ✓ *Affirmatively Furthering Fair Housing (AFFH).*
- ✓ *Sustainable Communities Initiative.*
- ✓ *The HUD-DOT-EPA Partnership for Sustainable Communities.*
- ✓ *Strong Cities Strong Communities.*