



The Pennsylvania Housing Research Center

PHRC Year in Review

July 2012 – June 2013

Published August 2013

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Table of Contents

I. Introduction	1
Staff changes during 2012-2013 project year	2
II. Training, Education and Outreach Activities	4
A. Workshops and Training.....	5
B. Training, Technical Assistance & Outreach.....	5
III. Publications	16
IV. Research Activities	18
A. Applied Projects	18
B. Support of Standards	26
V. Funding	27
VII. Proposals	29
Appendix A – Views of Recorded Webinars	30

Tables

Table 1. PHRC Training Programs Held July 1, 2012 through June 30, 2013	4
Table 2. PHRC Expenses July 1, 2012 through June 30, 2013	28
Table 3. Summary of Act 157 Funds – July 1, 2012 through June 30, 2013.....	28

Figure

Figure 1. PHRC Organizational Chart.....	3
Figure 2. Distribution of the Number of Programs.....	5
Figure 3. Summary of funding July 1, 2012 through June 30, 2013.....	27

I. Introduction

The purpose of this document is to provide a summary of activities the Pennsylvania Housing Research Center has pursued and products that have been delivered between July 1, 2012 and June 30, 2013. Additionally, the document is intended to provide the reader with an understanding of the major activities of the PHRC and the amount and source of funds the PHRC has received during the reporting period. The organizational chart of PHRC is shown in Figure 1.

Each year, the Pennsylvania Housing Research Center (PHRC) seeks to conduct a series of projects that collectively satisfy the following criteria. Projects should:

- meet the needs of the residential construction industry and the housing consumer in Pennsylvania;
- be consistent with the mission and goals of the PHRC;
- be affordable and feasible, given the resources available and the prevailing constraints on time, expertise and facilities; and
- be a balanced program of projects that address both the long- and the short-term needs of all segments of the industry.

The projects undertaken were developed with input and assistance from the PHRC's Industry Advisory Council (IAC) and the Operations Committee. These bodies consist of manufacturers, suppliers, builders, developers, design professionals, remodelers, and industry associations as well as building code organizations and state agencies. After a thorough discourse at the spring IAC meeting, the members of the IAC voted on projects they felt were the highest priority for the industry.

The result of this input was the "*PHRC Project Plan, July 2012 – June 2013*", which outlined projects that the PHRC would undertake during this time period. The plan included only those projects that were to receive funds provided to the PHRC by the Commonwealth of Pennsylvania. In most cases, we have attempted to use state funding to leverage outside support; in other cases the work is considered important enough to warrant full state support. It should also be recognized that the PHRC undertook an array of additional projects that did not receive any state funds. Those projects are included in this report but are identified as having no support from the Commonwealth of Pennsylvania.

The PHRC receives funds from multiple sources including funds collected under Act 157 of 2006, which established a two dollar fee collected for each building permit to support the activities at the PHRC. To assure that programs funded in whole or part with Act 157 monies meet the needs of the construction industry, Act 157 requires that education, training and other activities provided by the PHRC be approved by its Industry Advisory Council.

Staff changes during 2012-2013 project year

In late March of 2013, the Associate Director, Mike Turns, left the PHRC. Immediately following his departure, Dr. Katie Blansett, the Land Use and Land Development Specialist, served as acting Associate Director to the PHRC to prepare for the spring meetings with the Industry Advisory Council and begin the project planning process for the 2013-2014 project year. Dr. Blansett was later appointed permanently to the position of Associate Director.

The position of Land Use and Land Development Specialist was not filled since Dr. Blansett's expertise in land development and stormwater management is still available to PHRC projects. Instead of filling the vacated positions, two new positions were created: the Housing and Land Development Specialist filled by Chris Hine and the Housing Systems Specialist filled by Brian Wolfgang. Both Mr. Hine and Mr. Wolfgang started with the PHRC on May 20, 2013. See Figure 1 for the updated PHRC Organizational Chart with new positions.

The departure of Mr. Turns and reassignment of Dr. Blansett created a temporary shortage in staff work time. The final deadlines of several projects are being pushed into the 2013-2014 project year because Mr. Turns is no longer working on his projects, and Dr. Blansett's time has been redirected to other administrative duties delaying land development project deadlines. Several of the projects planned for the 2012-2013 year were defined based on the energy expertise of Mr. Turns. Upon his departure, other staff stepped in to complete projects as they were able, but as noted in later sections of this report, one training program and one applied project are not able to be completed. The final builder brief and report for two projects were delayed several weeks due to the staff changes. Although documents were published in July of 2013, technically past the reporting period for this report, they are still included in the 2012-2013 Year in Review because the projects were part of the planning year and completed before the submission of this report.

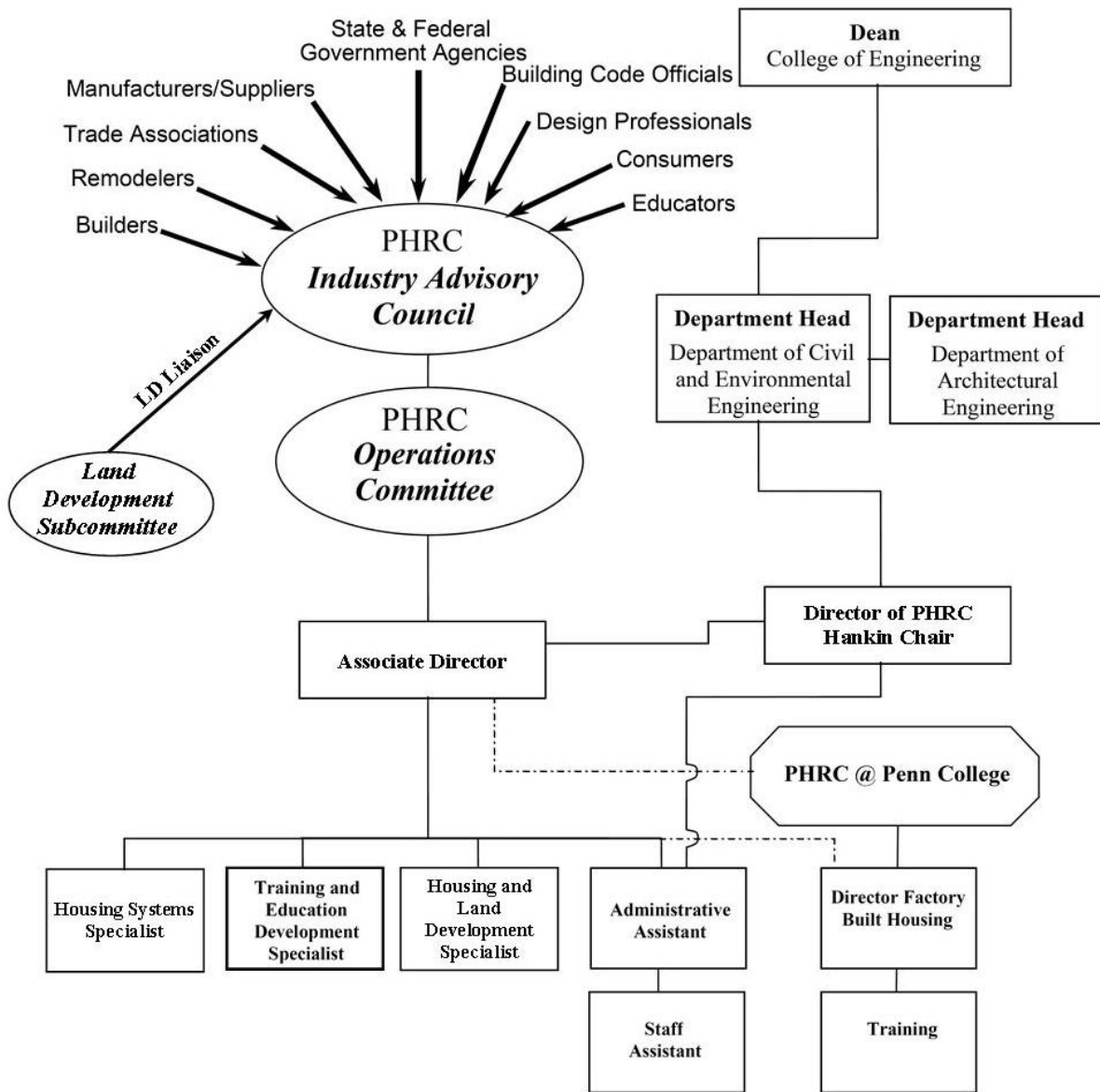


Figure 1. PHRC Organizational Chart

II. Training, Education and Outreach Activities

The PHRC offers a wide array of activities to educate and transfer appropriate technologies to the construction industry. Counting the training and less formal speaker service and presentations at conferences, the PHRC has provided educational services to over 2,446 individuals during this reporting period.

During the 2012-2013 project year, the PHRC delivered 63 technical workshops to 2,139 builders, remodelers, educators, code officials, design professionals, and planners during this reporting period (please see Table 1 for detail).

Table 1. PHRC Training Programs Held July 1, 2012 through June 30, 2013

PHRC Training Programs Delivered			
PROGRAM		Activities for 2012-2013	
		# of Programs	# of Attendees
Advanced Framing	AF1	3	53
Building Science Program	BS1	1	25
International Residential Codes Academy	CO1A	1	11
IRC Building Code Refresher	CO1CR	5	91
IRC Plumbing Academy	CO3A	1	10
IRC Plumbing Code Refresher	CO3CR	4	67
IRC Mechanical Academy	CO4A	1	9
IRC Mechanical Code Refresher	CO4CR	2	44
IRC Energy Code Refresher	CO5CR	1	6
Residential Energy Essentials	CO5R	1	14
Electrical Essentials Academy	EE1A	1	7
IRC Electrical Code Refresher	EE1CR	3	88
Exterior Plaster Finish Systems	EP1	6	190
Building with Exterior Rigid Foam	ERF1	1	8
The 2009 IECC Energy Code Compliance for Commercial Building	IECC-DEP-C	3	100
IECC 2009 Energy Code –Achieving 90% Compliance in Residential	IECC-DEP-R	3	115
Energy Plan Review/Inspections	IECC-PRI	3	67
Two-Family Dwellings & Townhouses Program	MF1	1	16
Speaker Service	SS1	12	471
Webinar	W1	10	747
TOTAL		63	2139

A. Workshops and Training

The distribution of the number of programs over the past 15 years is plotted in Figure 2. The total number of programs delivered during the 2012-2013 period is 63, which is the average number of programs over the prior 10 years (63) and very close to the average for the prior five years (64).

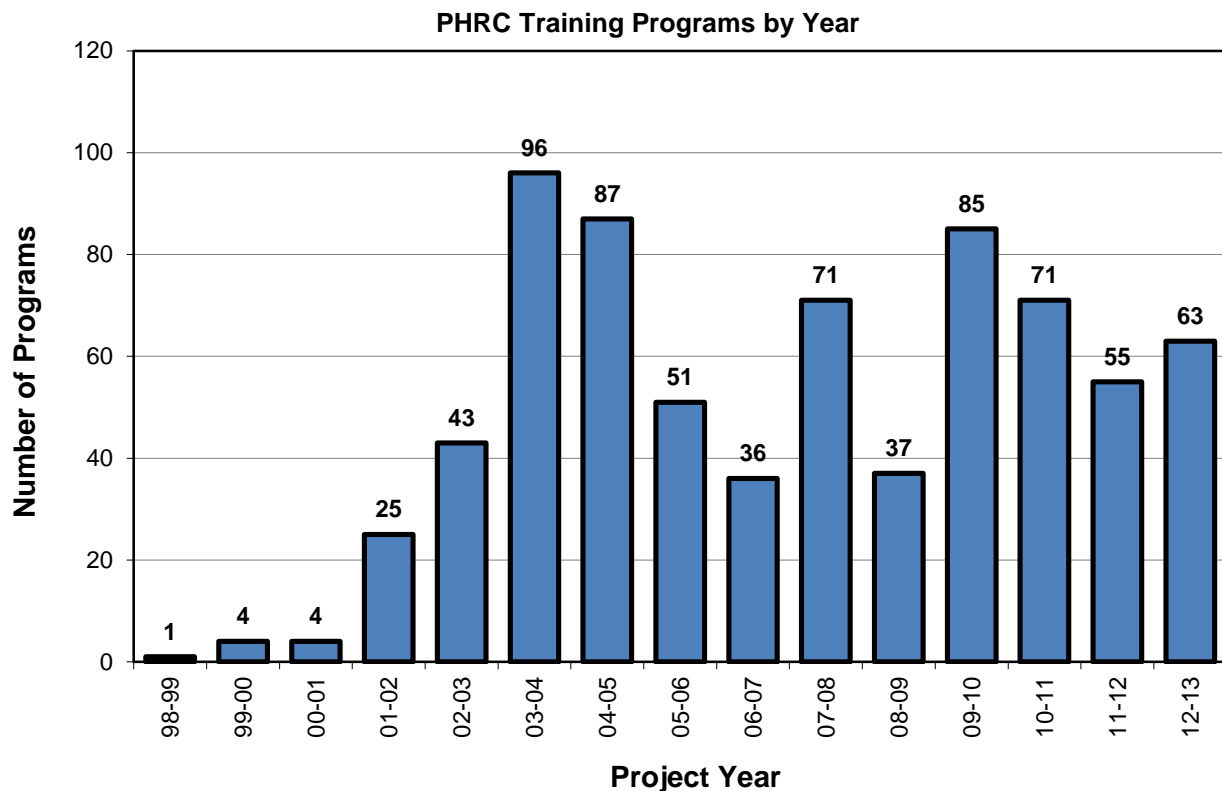


Figure 2. Distribution of the Number of Programs

B. Training, Technical Assistance & Outreach

The PHRC has a mandate to transfer knowledge by providing the necessary training and education to the wide variety of groups that make up the housing industry. The projects that are described below are in response to the recommendations that flow out of the PHRC's Industry Advisory Council and reflect the current needs within the housing industry.

PHRC Training Provided through Industry Partnerships

Description: The PHRC has developed and maintains a wide array of training for all sectors of the construction industry with a focus on residential construction. These programs are intended to address mainly technical issues facing the industry. Additionally the PHRC will customize programs to better meet a need of an industry

partner. Programs are developed to meet the needs of difference audiences, which may include builders, remodelers, trade contractors, design professionals, teachers, building code officials, etc.

Some of these programs are offered with our industry partners, which may include trade associations such as the Pennsylvania Builders Association or their 42 local associations, professional associations, building code associations, as well as the Pennsylvania Construction Codes Academy (PCCA).

General Audience Programs

1. Residential Building—Code Compliance and Quality Construction	1 day
2. Residential Plumbing—Code Compliance and Reliable Installations	1 day
3. Residential Mechanical—Code Compliance and Safe Installations	1 day
4. Residential Electrical—Code Compliance and Safe Installations	1 day
5. Residential Energy—Code Compliance and High Performance Homes	1 day
6. Advanced Framing: Increasing Performance and Reducing Costs	½ day
7. Blueprint Reading for Beginners	1 day
8. Building with Exterior Rigid Foam	½ day
9. Fire-Resistant Construction of Townhouses and Twins	1 day
10. Energy Plan Review/Inspections	1 day
11. Residential Deck Design and Construction	1 day
12. Residential Fire Sprinklers for Townhouses with Three Stories or Less	1 day
13. Solar Electric Installation—An Introduction	1 day
14. Solar Hot Water Installation—An Introduction	1 day
15. Exterior Plaster Finish Systems: Avoiding Moisture-Related Failures	½ day
16. Residential Mechanical Compliance Program	1 day
17. Building Science Program	1 day

Available Only through the Pennsylvania Construction Codes Academy

1. International Residential Code (IRC)-Plumbing Essentials	4 day
2. IRC-Building Essentials	4 day
3. IRC-Mechanical Essentials	4 day
4. IRC-Electrical Essentials	4 day
5. Residential Energy Code Essentials	2 day
6. International Energy Conservation Code Essentials-Commercial	2 day

New Program Development

Description: The PHRC develops new training programs to address issues challenging the residential construction and design industry (builders, designers, remodelers, building code officials, materials suppliers, etc.) During this period the following programs were developed:

1. PHRC Residential Building Scholar Series

In times of very tight competition, builders are frequently looking for ways to differentiate themselves from their competitors. The PHRC offers builders a way

to set themselves apart by recognizing individuals who complete the PHRC contractor educational series. The contractor educational series consists of 5 one-day courses including IRC Building, Plumbing, Mechanical, Electrical and Energy. Contractors have to demonstrate comprehension by passing an exam to be taken at the end of each class. Those individuals who attend four of the five classes and pass the exams within two years will be issued the PHRC Residential Building Scholar designation. This is the first year of the program and no certificates have been offered yet. Twelve (12) different workshops in this series have been delivered and the program will continue into the coming year.

2. Training for the Industrialized (Modular) Housing Industry

With the loss of funding of the Modular Housing Training Institute (MHTI) at Penn College, the PHRC will step in to provide training specifically targeted at the industrialized housing industry. This two-day program is geared toward modular builders and set crews, with content based on input from modular plants. Topics covered will include site preparation, blueprint reading, dimensions and leveling, foundation preparation, worker safety, optimal scheduling, setting a modular home, finishing a modular home, and relevant code requirements. Delays within the contracts office at Penn State greatly delayed the project approval and prevented the sub-contractor from getting started on the project during the 2012-2013 project year. The contract for this project has been extended and the final training program will be complete and ready for delivery in Spring 2014.

3. Subs with Subs – A Quick Guide to Flashing – How & Why

This training program is designed to be a shorter session than traditional PHRC training programs. Builders and remodelers could share lunch with their subcontractors while learning about important flashing details. A large percentage of construction issues result from water leakage, which can usually be blamed on the incorrect installation of flashing. Flashing is designed to prevent water infiltration by effectively protecting seams and joints in the water control area. This program, designed to educate builders, remodelers, and code officials, focuses on the problem areas on a home that require flashing, such as around windows and doors, step flashing at roof/wall intersections, in roof valleys, and around roof deck penetrations in order to properly seal critical seams. The program emphasizes correct installation, which is critical in order to ensure that the home is leak free, thus preventing mold, wood rot and water damage that can result in costly repairs in the future. This program incorporates the use of two window models to better demonstrate the methods presented. One model is a completed window assembly that is used to display proper installation. The second model is incomplete, which allows for a live demonstration of proper installation during the presentation. A pilot of this program was delivered in Johnstown, PA. At least one additional session is scheduled and it will continue to be offered.

4. Spray Foam Quality

Spray foam insulation is becoming more and more common in the residential marketplace. Builders considering specifying spray foam should be aware of several potential foam quality and installation problems and understand how to avoid them. Application errors, off-ratio foam, and improper storage and shipping of spray foam materials can lead to shrinkage and cracking, or even catastrophic fires. This program provides an overview of the benefits of spray foam, along with code requirements and proper storage and application techniques. This information is the key to selecting a subcontractor to get the job done right. A session on spray foam quality was offered at the 2013 Housing Conference and a webinar on the topic was delivered on December 11, 2012. Based on feedback from the webinar and conference presentations, it was determined that there was not additional interest for a ½ day program at this time.

5. Introduction to Building Science

Single-family homes are relatively simple structures, but the interactions between building materials, HVAC and exhaust equipment, appliances, occupants, climate and the movement of air, moisture, and heat can be surprisingly complex. This program begins by explaining the basic physical principles that dictate the magnitude and direction of the flows of air, moisture, and heat. After gaining an understanding of those principles, the participants learn about how construction and occupant decisions affect building performance in terms of comfort, indoor air quality, durability, and energy efficiency. A pilot of a ½-day building science program was delivered in Allentown, PA. There is additional material to warrant a full-day program, which is currently under development. Starting in Oct 2013 both a ½-day and full-day building science program will be offered. Demand for these programs is high and sessions are already scheduled.

6. Tight Construction and Mechanical Ventilation

Modern construction practices and energy code requirements have resulted in homes that are more air tight than in previous decades. With these changes, builders and remodelers should more carefully consider introducing mechanical ventilation, including bathroom exhaust fans, range hoods (vented to the outside), and whole-house ventilation systems. This half-day program was to discuss how to determine ideal rates of mechanical ventilation to provide acceptable indoor air quality and removal of excessive moisture. It was also to cover various options for providing mechanical ventilation.

A webinar on the topic was delivered on November 13th, 2012. The proposal of this training program was based on the expertise of Mike Turns. It was not completed before his departure in March 2013. The completion of this training program will not be pursued at this time.

Annual Pennsylvania Housing and Land Development Conference:

The 21st annual Housing and Land Development Conference was held on February 20th and 21st at the Sands Resort in Bethlehem, PA. Day 1, Wednesday, was the Housing day and Day 2, Thursday, was the Land Development day. This two-day event provides information and updates on issues of interest to the residential construction industry. The conference was intended for all sections of the housing and land development industries including builders, remodelers, code officials, educators, design professionals, developers, engineers, regulators, and modular and HUD-code builders. The Land Development day of the conference served as an annual forum that addresses emerging planning, design, and regulatory issues affecting the land development industry in Pennsylvania. The PHRC also held training sessions related to the housing industry in conjunction with this conference.

Housing (Day 1): This day kicked off with a very charismatic keynote speaker (Gord Cooke) who delivered a message about continual improvement. The conference then broke into three tracks including Building Durability, Plumbing and Mechanical, and Energy/Green Building. Roundtable sessions were presented after lunch. Conference topics included:

- Building Better Homes
- Construction through the Seasons
- Building Envelope and Integration of the Trades
- Spray Foam and Hybrid Insulation Systems
- Mechanical Ventilation for Tight Homes
- Reasons for HVAC Call-Backs
- Water-Efficient Plumbing Systems
- Reducing Costs through Green Building
- ENERGY STAR Homes Version 3.0
- Energy Efficient Mortgages

There were 67 attendees for the Housing day of the conference.

PHRC Leadership Reception: The Leadership Reception was held the evening of February 20th at the Sands Resort with 52 people in attendance.

Land Development (Day 2): This day kicked off with a keynote presentation by Thomas Shepstone who discussed innovative community design techniques. The conference then broke into two tracks: Sustainable Development and Stormwater Management. Specific topics included:

- Innovative Community Development
- Greenmoore Village: A NBGS Green Development Case Study in PA
- Green Development Techniques that Make “Cents”
- PHRC Guidelines for Subdivision and Land Development
- Stormwater Policy update
- Panel Discussion on Role of Authorities in Stormwater Management

- Water Quality Calculations for NPDES Permits

There were 61 attendees for the Land Development day of the conference.

Training Sessions (Day 2): Two training sessions were offered during Day 2 of the conference. These programs included:

- Commercial Energy Code Compliance (47 attendees)
- Fire-Resistant Construction of Townhouses & Twins (16 attendees)

Residential Design and Construction Conference

The Residential Building Design and Construction Conference was organized for the first time in 2013. This conference was held in conjunction with the annual Pennsylvania Housing & Land Development Conference. As a new PHRC program, the annual Residential Building Design and Construction Conference is intended to provide a unique forum for researchers, design professionals, manufacturers, builders, and code officials to keep up-to-date on the latest advancements and discuss their own findings, innovations, and projects related to residential buildings. The two annual conferences are held simultaneously at the same location and provide an opportunity for participants to attend sessions at either event. The Residential Building Design and Construction Conference has parallel tracks consisting of several technical paper sessions with presentations on recent research and innovations related to residential buildings. The Residential Building Design and Construction Conference is focused on various types of residential buildings including single- and multi-family dwellings, mid-rise and high-rise structures, factory-built housing, dormitories, and hotels/motels. Full papers will appear in the conference proceedings.

The Residential Building Design and Construction Conference is different from the PHRC Housing and Land Development Conference in that it is much more research based. Although all professionals in the industry are welcome, the presenters and attendees are primarily in the research field (professor and graduate students from other universities). This conference provides a unique venue for researchers at universities across the country to interact and collaborate. There are no other residential housing conferences in the US geared towards researchers.

Report: The 1st annual Residential Building Design and Construction Conference was held on February 20 and 21, 2013 in Bethlehem, PA. Two keynote speakers were invited for this conference, Sam Rashkin, Chief Architect, Building Technology Program, DOE, and Richard Seifert, Professor Emeritus, University of Alaska, Fairbanks. The conference scheduled 36 presentations in 13 sessions over two days. There was also one session devoted to introducing the book: *Design and Construction of High-Performance Homes: Building Envelopes, Renewable Energies and Integrated Practice*. The authors of the book discussed three major aspects of the book: architectural technologies, system integrated photovoltaic, and energy and integrative design process. Following is the list of papers presented at the conference over the two days.

Day 1:

Keynote: Money-Housing – *Sam Rashkin*

The Need for Building Science Education – *Joseph Laquatra*

Whole Building Design Approach to Achieve High Performance Buildings – *Monjija Belizaire*

Concrete Building Systems: Disaster Resilient Solutions for Safer Communities – *T. Peng, L. Lemay, and B. Cody*

A New Paradigm for Residential Construction in Regions of High Seismicity – *M. Sarkisian, E. Long, D. Shook, and A. Diaz*

Critical Look into ISOMAX (Zero Energy use structures) Construction – *M.T. Sebright and D. Berg*

A Framework for the Process to Identify Dominant Housing Archetypes in a Cold Climate Region: Matching Energy Retrofit Research to Important Archetypes – *T. Mrozowski, S.-K. Kim, and A. Harrell-Seyburn*

Adoption of Innovative Products in the US Housing Industry: Builders' Practices 2000–2010 – *Parisa Nikkhoo, Andrew Sanderford, Andrew McCoy, Theodore Koebbel, Chris Franch, and Hazir Rahmandad*

Deep energy retrofits with retrofit insulated panels – *Ted Clifton*

State of the Art Review of Window Retrofit Options for Energy Saving in Single-family Dwellings – *Tim Ariosto, and Ali Memari*

Zero Net-Energy Ready – *Sam Rashkin*

Prescriptive Details for Wind Resistant Envelope Based on Observations of Newly Built Homes Damaged in 2011 TORNADOS – *Bryan Readling and Edward Keith*

Residential Damage Patterns Following the 2011 Tuscaloosa, AL and Joplin, MO Tornadoes – *David B. Roueche and David O Prevat*

Wind Uplift Capacity of Foam-retrofitted Roof Sheathing Subjected to Water Leaks – *David Roueche, Elexenberger, Kenton McBride, D.O. Prevat, F.J. Masters*

Housing Reconstruction and Community Recovery Following Disasters – No Easy Choices – *Dana Bres and Carlos Martin*

Residential Reconstruction in Haiti, *Mark Taylor*

Haiti Wood-frame Housing Initiative, *Glyn R. Boone and J.D. Kiehl*

Effects of Sheathing and Nail Type on Nail Withdrawal Capacities – *Ashlie Kerr and David Prevat*

Modular Green Roof System in Mid-rise Multifamily Residential Units – *Tuan Vo, David Prevat and Glenn Acomb*

The Unseating of Naturally Aged Asphalt Shingles: An In-situ Survey – *Craig Dixon, David Prevat, Forrest Masters and Kurt Gurley*

High Performance Architectural Technologies – *Franca Trubiano*

System Integrated Photovoltaic (SIPV) – *Jeffrey R.S. Brownson*

Energy and the integrative Design Process – Defining the team of Experts – *Lisa D. Iulo*

Day 2:

Keynote: *30 Years in Dogged Pursuit of the Ultimate Super-insulated Passive Solar Home* – *Richard Seifert*

Information Barriers in Home Energy Retrofit Adoption: Research in Progress – *D. Duah and M. Syal*

Prefabricating Charles Moore: Reinterpreted Saddlebags and Aedicules – *C.A. Debelius, R.C. Everhart and J.A. Russell*

An Introduction to Steel and Concrete Modular Construction – *S. English and B. Brown*

Concrete in Residential Construction – *Pragati Singh and Andrew Scanlon*

Reducing Exposure to Thermal Stress in Cuyahoga County, Ohio Through Residential Weatherization – *Nicholas Rajkovich and Larissa Larsen*

Overheating in Multifamily Residential Buildings – *Jordan Dentz, Kapil Varshney and Hugh Henderson*

Air Distribution Retrofit Strategies for Affordable Housing – *Jordan Dentz, Francis Conlin, Parker Holloway, and David Podorson*

Innovation in Residential Construction Systems in Sweden - *Gregory La Vardera and Scott Hedges*

Chicago Flat Type Planning: Sustainability and the 1902 Tenement House Ordinance – *Richard Gnat*

Introduction to Insulating Concrete Forms – *Dennis Gerdel*

Resisting the Myth of the Monolithic: The influence of Construction Innovation on Single-family House Spatialities in the Work of Gomes and Straub – *Francisco Gomes*

Responsive Housing: Potential and Projected Impact – *A.J. Mills and K.J Tiss*

Investigation for the Removal of Steel Tie Rods in a Historic Segmental Arch Floor – *Jennifer Lan, Michael Lo, David Sharp, and Ramon Gilsanz*

The State of the Art Application of Modular Construction to Multi-story Residential Buildings – *Anthony Jellen and Ali Memari*

Identification of Structural Issues in Design and Construction of Multi-story Modular Buildings – *Issa Jafar Ramaji and Ali Memari*

Sierra Bonita: Innovative use of Long Span Metal Deck Slabs and Shored Construction – *Joseph Mugford, Karl Rubenacker, John Lantry, Ramon Gilsanz*

Lessons Learned from the Process of Retrofitting Existing Housing for Energy Efficiency – *Lisa Iulo and Bruce Quigley*

The proceedings for the 1st Residential Building Design and Construction Conference are available at: <http://www.engr.psu.edu/phrc/Conference/2013RDBCC-PROCEEDINGS.html>. There were a total of 39 attendees at the Residential Building Design and Construction Conference.

Webinars

There is a need for technical programs with a lower cost delivery mechanism than a formal classroom setting. Webinars are an interactive web-based training that can be available live and archived for future viewing. These programs are scheduled on the second Tuesday of most months. The ten programs that were held this year are listed below. PHRC webinars are recorded and available on the PHRC website for on-demand viewing. For a list of all recorded webinars, and the number of times they have been accessed, see Appendix 1.

- Heitzmann, B. *Fire Protection of Floors – Demonstrating Equivalence Under Act 1*. September 11, 2012 (~61 attendees)
- Susanka, S. *Not So Big House Concept*. October 9, 2012 (~79 attendees)
- Turns, M. *Mechanical Ventilation in Tight Homes*. November 13, 2012 (~66 attendees)
- Duncan, R. *Introduction to Spray Polyurethane Foam (SPF)*. December 11, 2012 (~93 attendees)
- Wolfgang, B. *Building Science Primer*. January 8, 2013 (~94 attendees)
- Blansett, K. *The International Storm Water BMP Database for PA*. February 12, 2013 (~112 attendees)
- Heitzmann, B. *Attic and Roof Ventilation – Facts and Fiction*. March 12, 2013 (~75 attendees)

- Prather, D. *HVAC Quality Installation – Code Requirements, Best Practices, and Contractor Selection*. April 9, 2013 (~58 attendees)
- Memari, A. *High-Performance Wall Assemblies*. May 14, 2013 (~68 attendees)
- Turns, M. *Multifamily Design for Energy Star 3.0*. June 11, 2013 (~41 attendees)

Speaker Service and Conference Presentations

As a service to the home building and remodeling industry in Pennsylvania, the PHRC offers a speaker service to local and regional associations. This service is provided at no charge to the local builders associations and other interested groups. The PHRC offers short (20 minute to 2 hour) sessions, often technical, that address some of the issues or problems that builders and remodelers may be facing. Staff and researchers associated with the PHRC also make presentations at professional and academic conferences. Since July, the following presentations have been made by the PHRC:

- Blansett, K. “PHRC’s Subdivision and Land Development Guidelines: A tool for better design in PA.” *PA Society for Professional Engineers 2012 Annual Conference*. Warrendale, PA, September 14, 2012. (~30 attendees)
- Turns, M. “The 2009 IECC – Opportunities for Home Performance Contractors,” *Affordable Comfort Mid-Atlantic Conference*, Pittsburgh, PA, October 2, 2012. (~26 attendees)
- Turns, M. “Insulating with Rigid Foam.” *Remodeling Business Conference and Vendor Showcase*, Jamison, PA, October 25, 2012. (~28 attendees)
- Memari, A. M. “Overview of Recent Research on Seismic Performance Evaluation of Structural Sealant Glazed Curtain Wall Systems,” Presentation at *ASCE AEI Pittsburgh Chapter*, Pittsburgh, PA, November 28, 2012 (10 attendees)
- Memari, A. M. “Overview of Recent Research on Innovative Building envelope and Wall Systems,” Presentation at Saint-Gobain, Marlborough, MA, December 17, 2012. (25 attendees)
- Heitzmann, B., and B. Buddenbohn. “2009 IRC Plumbing – Chapters 30-31,” *PFS Seminar*, Harrisburg, PA, January 11, 2013. (~38 attendees)
- Turns, M. “Compliance with the 2012 IECC,” *PFS Seminar*, Harrisburg, PA, January 11, 2013. (~46 attendees)
- Ariosto, T. and Memari, A. M. “State-of-the-Art Review of Window Retrofit Options for Energy Saving in Single-family Dwellings,” *1st Residential Building Design and Construction Conference*, Bethlehem, PA, February 20-21, 2013. (25 attendees)
- Jellen, A. C. and Memari, A. M. “The State of the Art Application of Modular (Factory Built) Technologies to the Construction of New High-Rise Residential Buildings,” *1st Residential Building Design and Construction Conference*, Bethlehem, PA, February 20-21, 2013. (20 attendees)

- Ramaji, I. J. and Memari, A. M. “Identification of Structural Issues in Design and Construction of High-Rise Modular Buildings,” *1st Residential Building Design and Construction Conference*, Bethlehem, PA, February 20-21, 2013. (20 attendees)
- Blansett, K. “Water Quality Calculations for NPDES Permits,” *Annual PHRC Conference*. Bethlehem, PA, February 21, 2013. (~45 attendees).
- Blansett, K. “PHRC Guidelines for Subdivision and Land Development,” *Annual PHRC Conference*. Bethlehem, PA, February 21, 2013. (~15 attendees).
- Turns, M. “Understanding Energy Code Options in PA,” PBA Board Meeting, Gettysburg, PA, March 1, 2013. (~32 attendees)
- Blansett, K. “A Summary of the International Stormwater BMP Database,” *PSPE PDH Bootcamp East*, King of Prussia, PA, April, 5, 2013. (35 attendees)
- Blansett, K. “PaSTW: Bring Science to Stormwater Implementation,” *PSPE PDH Bootcamp East*, King of Prussia, PA, April, 6, 2013. (~40 attendees)
- Turns, M. “How Tight Is Too Tight,” Mercer County Builders Association, April 15, 2013. (~20 attendees)
- Blansett, K. “Measured Event Water Quality Levels in Urban Karst Watersheds Compared to Reference Values,” *2013 World Environmental & Water Resources Conference*, Cincinnati, OH, May 21, 2013. (~80 attendees)
- Blansett, K. “Runoff Ratios for Five Urban Karst Watersheds Under Different Levels of Imperviousness,” *2013 World Environmental & Water Resources Conference*, Cincinnati, OH, May 21, 2013 (~80 attendees)
- Forry, D. “Energy/Electrical Presentation,” Morgantown, PA, May 28, 2013. (~28 attendees)
- Heitzmann, B. “A Quick Guide to Flashing – How & Why,” Somerset Builders Association, June 11, 2013. (~23 attendees)

Conferences/Meetings Attended:

- Blansett, K. DEP Sewage Advisory Council (SAC). Harrisburg, PA, July 11, 2012.
- Blansett, K. DEP Water Resources Advisory Council (WRAC). Harrisburg, PA, July 12, 2012.
- Blansett, K. Water Environment Research Foundation Stormwater Symposium. Baltimore, MD July 19-20, 2012.
- Turns, M., PENNBOC Conference, Bethlehem, PA, September 13, 2012.
- Blansett, K. Stormwater: Green Solutions beyond Gray Pipes. Harrisburg, PA, September 18-19, 2012.
- Turns, M., KEEA Energy Efficiency Conference, September 24, 2012.
- Turns, M., Heitzmann, B., Affordable Comfort Mid-Atlantic Conference, Pittsburgh, PA, October 1-2, 2012.
- Blansett, K. DEP Sewage Advisory Council (SAC). Harrisburg, PA, February

- 8, 2013
- Blansett, K. DEP Sewage Advisory Council (SAC). Harrisburg, PA, March 6, 2013
 - Blansett, K. Green Building for Building Professionals, Las Vegas, January 19-20, 2013.
 - Heitzmann, B. Residential Advisory Council. Harrisburg, PA, October 18, 2012.
 - Heitzmann, B. Residential Advisory Council. Harrisburg, PA, February 28, 2013.
 - Memari, A. M., Visit the Hankin Group at Eagleview development, Exton, PA, October 26, 2012.
 - Memari, A. M., National Association of Home Builders' International Builders Show, and NAHB Student Chapter Residential Construction Management Project Competition, Las Vegas, NV, January 22-23, 2013.
 - Turns, M., Construction, Codes and Standards Air Tightness/Moisture Working Group, Las Vegas, January 21, 2013.

Web Site

The PHRC maintains a web site (www.engr.psu.edu/phrc) to help disseminate information. Archived webinars, research and technical reports, Builder Briefs, PHRC Standards, as well as other resources, are available on-line.

Pennsylvania Focus Committees:

- Pennsylvania Industrialized Housing Advisory Group (DCED)
- Pennsylvania Builders Association (PBA)—PHRC Committee
- Pennsylvania Builders Association (PBA) – Appraisal Coalition
- PA Stormwater Technical Workgroup – Executive Board Member, Chapter 5 Stormwater Design Committee – Committee Chair, Chapter 4 Land Development Process Committee
- American Society of Civil Engineers – Central PA Chapter
- Pennsylvania Society of Professional Engineers

National and International Focus Committees:

- Memari, A. M., National Consortium of Housing Research Centers Executive Committee meeting and Annual meeting, Las Vegas, NV, January 20-21, 2013.
- Memari, A. M., AEI 2013 Symposium on New Building Enclosure Innovations and Technologies, New York City, NY, February 13, 2013.

III. Publications

The PHRC produces a wide array of publications to provide technical information to the construction industry and to disseminate results of research projects.

Builder Briefs

PHRC Builder Briefs is a series of short technical documents that address specific issues resulting from some research projects or that were topics of interest identified by builders, remodelers, code officials, or design professionals. These documents are intended to be quick to read with much information presented graphically or pictorially. The following Builder Briefs were published during this period:

- Blansett, K. *Summary of the Typical Residential Land Development Process in Pennsylvania*. September 2012.
- Blansett, K. *The International Stormwater BMP Database – Part 1*. February 2013.
- Blansett, K. *The International Stormwater BMP Database – Part 2*. February 2013.
- Turns, M., Wolfgang, B. *Obtaining Proper Ventilation: A Case Study in Residential Exhaust Fan Performance*. July 2013. (Note: Due to the staff changes, the publication of this Builder Brief was delayed by several weeks and it was released in July of 2013. Even though the project actually ended in the 2013-2014 Project Year, it is being reported here because the project was planned for the 2012-2013 year.)

Research Reports

The finding of research are published in PHRC research reports.

- Singh, P. and A. Scanlon. *Concrete in Residential Construction*. May 2013.
- Singh, P. and A. Scanlon. *Sustainability of Residential Concrete*. May 2013.

Research Papers/Proceedings

The publication of research in peer-reviewed journals and conference proceedings not only disseminates the technical information to the public but increases the state, national and international reputation of the PHRC. As such, they are an important component of our mission.

- Aliaari, M. and Memari, A. M., (2012). “Development of a Seismic Design Approach for Infill Walls Equipped with Structural Fuse,” *The Open Civil Engineering Journal*, Vol. 6, pp. 249-263, December 2012, DOI: 10.2174/1874149501206010249.
- Ariosto, T. and Memari, A. M., (2013). “State-of-the-Art Review of Window Retrofit Options for Energy Saving in Single-family Dwellings,” *Proceedings of the 1st Residential Building Design and Construction Conference*,

- Bethlehem, PA, February 20-21, 2013, pp. 221-230.
- Ariosto, T. and Memari, A. M., (2013). "Comparative Study of Energy Efficiency of Glazing Systems for Residential and Commercial Buildings," *Proceedings of 2013 Architectural Engineering Conference*, University Park, PA, April 3-5, 2013, pp. 408-417.
 - Blansett, K. (2013) "Measured Event Water Quality Levels in Urban Karst Watersheds Compared to Reference Values." 2013 Proc., *World Environmental & Water Resources Congress*, ASCE, Cincinnati, OH.
 - Blansett, K. (2013) "Runoff Ratios for Five Urban Karst Watersheds Under Different Levels of Imperviousness." 2013 Proc., *World Environmental & Water Resources Congress*, ASCE, Cincinnati, OH.
 - Jellen, A. C. and Memari, A. M., (2013). "The State of the Art Application of Modular (Factory Built) Technologies to the Construction of New High-Rise Residential Buildings," *Proceedings of the 1st Residential Building Design and Construction Conference*, Bethlehem, PA, February 20-21, 2013, pp. 284-293.
 - Kuczynski, T. C. and Memari, A. M., (2012). "Experimental Evaluation of the Enhanced Panelized Brick Veneer over Steel Stud Wall System for Out-of-plane Loading," *Materials and Structures Journal*, August 2012, pp. 1-18, DOI 10.1617/s11527-012-9930-2.
 - Lepage, A., Shoemaker, J. M., and Memari, A. M., (2012). "Accelerations of Nonstructural Components during Nonlinear Seismic Response of Multistory Structures," *ASCE Journal of Architectural Engineering*, Vol. 18, No. 4, December 2012, pp. 285-297.
 - Liang, J., and Memari, A. M., (2012). "Performance of a Panelized Brick Veneer Wall System under Lateral Loads," *Open Journal of Civil Engineering (OJCE)*, Vol. 2, No. 3, September 2012, pp. 132-146, DOI:10.4236/OJCE 2012.23019.
 - Memari, A. M., Kremer, P. A., and Behr, R. A., (2012). "Seismic Performance of Stick-Built Four-Side Structural Sealant Glazing System and Comparison with Two-Side Structural Sealant Glazing and Dry-Glazed Systems," *Journal of ASTM International (JAI)*, Vol. 1, No. 1, July 2012, pp. 1-22, DOI: 10.1520/ACEM103159.
 - Memari, A. M., (2012). "Comparative Study of Multi-hazard Performance of Different Wall Systems Used in Single-Family Dwelling Construction," *Proceedings of the ASCE 6th Congress on Forensic Engineering – Gateway to a Safer Tomorrow*, San Francisco, CA October 31-November 3, 2012, pp. 1053-1062.
 - Memari, A. M., (2012). "Review of the Performance of Glazing Systems in Earthquakes and Recent Developments to Mitigate Damage," *Proceedings of the ASCE 6th Congress on Forensic Engineering – Gateway to a Safer Tomorrow*, San Francisco, CA October 31-November 3, 2012, pp. 123-132.
 - Ramaji, I. J. and Memari, A. M., (2013). "Identification of Structural Issues in Design and Construction of High-Rise Modular Buildings," *Proceedings of the 1st Residential Building Design and Construction Conference*, Bethlehem, PA, February 20-21, 2013, pp. 294-303.

- Standley, J. A. and Memari, A. M., (2012). “Structural Assessment of a Transparent Sustainable Wall Panel with Load-Bearing Backup-framing for Residential Construction,” *ASCE Journal of Architectural Engineering*, Vol. 18, No. 4, December 2012, pp. 298-314.
- Terentiuk, S. and Memari, A. M., (2012). “Seismic Evaluation of Structural Insulated Panels through Full-scale Racking Load Testing,” *Journal of Architectural Engineering*, Vol. 18, No. 4, December 2012, pp. 261-275.
- Simmons, N. C. and Memari, A. M., (2013). “Finite Element Modeling to Predict Racking Test Results and Performance of Four-sided Structural Sealant Glazing Curtain Wall Systems,” *Proceedings of 2013 Architectural Engineering Conference*, University Park, PA, April 3-5, 2013, pp. 735-744.
- Simmons, N. C. and Memari, A. M., (2013). “Development of Kinematic Equations for Racking Performance Evaluation of Four-sided Structural Sealant Glazing Curtain Wall Systems,” *Proceedings of 2013 Architectural Engineering Conference*, University Park, PA, April 3-5, 2013, pp. 997-1006.
- Simmons, N. C. and Memari, A. M., (2013). “Racking Performance Analysis of Four-sided Structural Sealant Glazing Curtain Wall Systems through Video Capture Technique,” *Proceedings of 2013 Architectural Engineering Conference*, University Park, PA, April 3-5, 2013, pp. 725-734.
- Thiede, J. and Memari, A. M., (2013). “Evaluation of the Performance of Air and Vapor Barriers under Seismic Induced Light-frame Wall Deformations,” *Proceedings of 2013 Architectural Engineering Conference*, University Park, PA, April 3-5, 2013, pp. 837-846.

IV. Research Activities

A. Applied Projects

This group of projects are application-oriented and have a direct need by the residential construction industry as identified by the Industry Advisory Council. This includes the development and support of standards and other longer term initiatives.

Sustainability of Residential Concrete Construction

Concrete is extensively used in residential construction for basements, slabs on grade, above grade construction, driveways, parking areas, and sidewalks. Sustainability is a high priority issue within institutions such as the American Concrete Institute (ACI). Current research topics include replacement of Portland cement with waste products such as fly ash etc., recycling waste products such as glass as for aggregates, and other means to reduce the carbon footprint associated with concrete construction. Use of pervious concrete in residential construction was also investigated.

REPORT: A research report has been published outlining the current state of the art. A Builder Brief has not yet been completed. A Brief providing guidance to home builders and developers on sustainability issues related to concrete construction will be published during the 2013-2014 project year.

- Singh, P. and A. Scanlon. *Sustainability of Residential Concrete*. May 2013.

Concrete Quality in Residential Construction

A great deal of information is available on concrete quality from institutions such as the American Concrete Institute, Portland Cement Association and others. Achieving quality concrete requires attention to all phases of concrete production from proper specifications to finishing and curing. Unfortunately concrete for residential construction is often ordered based only on a specified concrete compressive strength or number of bags of cement per cubic yard. Water content is often not carefully controlled during initial proportioning and additional water is often added on site. These and other factors can lead to a poor quality product requiring remedial action.

REPORT: A research report has been published outlining the issues involved with low quality concrete and identifying actions that can be taken to produce high quality concrete for residential construction. A Builder Brief summarizing the relevance to builders and developers will be completed during the 2013-2014 project year.

- Singh, P. and A. Scanlon. *Concrete in Residential Construction*. May 2013.

Energy Performance Evaluation of Window Retrofit Systems

One of the major challenges facing homeowners is the high capital cost associated with fenestration upgrades. The cost of replacing all the windows in a residential building can be substantial. However, the savings to homeowners resulting from reduced energy use associated with replacing inefficient windows with their expensive higher efficiency counterparts is not expected to be realized in short period. The goal of this study is to develop retrofit strategies along with their ratings of energy performance as alternatives to replacing windows. The project has investigated the performance of several different window retrofit solutions. The result of the study includes a description of each method and comparison of different systems based on criteria such as the expected thermal improvement, comfort, cost, condensation potential, ease of operation, impact on daylighting, privacy and aesthetics. The major retrofit strategies or approaches studied include the following: operable shutters, venetian blinds, interior shutters, interior curtains and draperies, interior roller shades, exterior storm windows, exterior insulated rolling shutters, insulated shutters, exterior window screens, and interior insulated blinds.

REPORT: A paper on the project was presented at the 1st Residential Building Design and Construction (RBDC) conference in February 2013. The draft of the project report of the study has been prepared and is going through the final stages of refinement. The

report is expected to be completed for submittal to the PHRC within three months. A second paper is expected to be presented at the 2nd RBDC conference in February 2014. A journal paper is expected to be prepared based on the results of the study. Finally, a Builder Brief will be developed from the report.

Exhaust Fan Performance in Tight Homes

New homes built to current codes and above code energy efficiency programs have become much tighter than those built previously. The emphasis on air sealing homes has forced builders and designers to consider more deliberate ventilation strategies in order to provide adequate indoor air quality. Methods to provide mechanical ventilation vary in both the IRC and ASHRAE 62.2 standards. This project included a case study of a simple exhaust only ventilation strategy in order to analyze the effectiveness of such strategies. Flow measurements were taken and compared with rated fan flows, as well as compared with installation strategies in order to correlate construction technique with overall system performance.

REPORT: The PHRC completed a builder brief summarizing the results of the exhaust fan case study. A total of 88 exhaust fans in 30 different homes were analyzed. In general, the measured performance of each fan varied greatly with respect to their rated flow. These results could not be statistically related to any specific installation method, as the methods to install each fan and duct system varied significantly. A general set of recommendations for installing exhaust fans and duct systems were assembled, as well as the recommendation for further study of residential mechanical ventilation strategies.

- Turns, M. and B. Wolfgang. Obtaining Proper Ventilation: A Case Study in Residential Exhaust Fan Performance. July 2013.

Architectural Light Therapy System Prototype Development

The goal of the project is to develop a working prototype of a residential living environment outfitted with a novel architectural lighting system designed to promote health by stimulating the human circadian system while maintaining standards for visual quality. The space will be instrumented with measurement devices to verify light exposure performance and will serve as a model for future clinical trials and larger-scale residential installations. This project fosters the research/industry partnership that was a founding goal of the center. The PHRC wishes to encourage the relationship between Penn State faculty and its industry partners in order to stay on the cutting edge of housing-related research. The PHRC has provided seed money to fund the first phase of this project.

REPORT: A six-month extension was granted on this project due to project personnel changes. The Principle Investigator of this project, Dr. Behr, retired and Dr. Houser has assumed full responsibility for this project.

The project is 90% complete and the last remaining task is to complete the end-user interface and controls programming. This is a prototype system. The researchers are

working toward what they hope will be a much simpler “socket level solution.” The long-range goal is for an end-user to simply unscrew a standard light-bulb and replace it with a smart light-bulb that has particular photobiological attributes. Components have been assembled to produce a prototype system, but the components are not compatible in any intuitive way. The next challenges will be to make an architectural light therapy system easy to understand, install, and to use. The final report on the project will be submitted in December 2013.

Determination of Unspecified Snow Loads

The ASCE-7 ground snow load table show a significant portion of Pennsylvania as “CS”, indicating that a case study is required to determine the snow loads in that area. Over 60% of all PA municipalities have at least some of their land area in a CS zone. In such areas the selection of an appropriate snow load is left to the authority having jurisdiction. In most cases such authorities know little about snow loads.

This project will consist of two phases. Phase 1 - Obtain the Army Cold Regions Lab snow database and calculation spreadsheet, and beta test it with AE faculty and/or AE 537 students using PA sites. Phase 2 - Perform a comprehensive analysis of PA snow loads using an MS student to determine the procedure and coordinate with PA structural engineers and builders.

REPORT: Due to limited funding, further exacerbated by the federal sequestration, the Army Cold Regions Lab has not had the resources to release the necessary data. This project has been carried over to the 2013-2014 project year with hopes that the data will be released in the next project cycle.

Builder Energy Case Studies

This project was to spotlight several builders who are using advanced techniques and materials to achieve above-code levels of energy performance. An article or series of articles was to describe the techniques and materials used in several homes, and compare the energy performance of those homes with typical homes, using utility data if possible.

REPORT: This project was defined based on the expertise of Mike Turns. There was not enough work completed on the project for other staff to be able to complete the project. This project will not be continued into the next project year.

A Quick Guide to the Residential Provisions of Pennsylvania’s Uniform Construction Code and Local Amendments

This guide consists of a primer on how the Uniform Construction Code applies, or does not apply, to new construction, renovations, repairs, and alterations to existing residential structures, followed by county-by-county maps of municipalities indicating which municipalities have legal ordinances amending the UCC.

REPORT: This project was originally proposed in the 2012-2013 Project Plan to be “A Remodeler’s Guide to Building Permits in Pennsylvania” but during project development it was determined that the information pertained to a much larger audience than just remodelers. The technical report is complete and was published in July 2013. The Guide summarizes the types of amendments allowed by the UCC, as well as other key issues in the UCC that relate to residential construction. The Guide also includes a Commonwealth map and map of each of the 67 counties in Pennsylvania. The maps indicate absence or presence of pre-1999 or post-2004 municipal amendments. If data about the amendments were available they are included in tables with the maps. The Guide is available on the PHRC website and a webinar on the topic will be delivered on September 11, 2013.

Note: Due to the staff changes the publication of this report was delayed by several weeks and it was published in July of 2013. Even though the project actually ended in the 2013-2014 Project Year, it is being reported here because the project was planned for the 2012-2013 year.

Update to the Pennsylvania Standards for Residential Site Development

The Pennsylvania Standards for Residential Site Design were finalized in April 2007. This set of consensus standards allows for up-to-date design innovations, and provides the flexibility needed for sustainable land development. Since the document was released it has not been as widely accepted by municipalities as was hoped. During the 2011-2012 fiscal year, the PHRC undertook a project entitled “An Update and Revamp of the Pennsylvania Standards for Residential Site Design.” This initiative solicited local government input on the Standards utilizing PSATS committees along with other local government resources. It was expected that an addendum to the Standards would be issued to address updates in reference materials and provide additional design options.

Through the input process it was determined that an addendum would not be sufficient to address the problems preventing the document from being readily used. A larger project to restructure and update the document will be completed for the 2012-2013 fiscal year. The document will be renamed the “Subdivision and Land Development Guidelines for Pennsylvania” and the chapters will be broken into individual booklets. Updated policy, regulations, and guidance will be incorporated. Typographical and formatting errors will be corrected. The Site Design Considerations Chapter (Ch 1) will be completely rewritten to better address the needs of design professionals and the input from planners. The Stormwater Conveyance and Management Facilities (Ch 5) and Streets (Ch 2) booklets will also receive more intensive revisions of content due to updated regulations and references. Appropriate regulatory organizations will be consulted to ensure that the revised document meets their requirements.

REPORT: This project will result in a new series of booklets, the Subdivision and Land Development Guidelines for Pennsylvania. Due to staff changes, Dr. Blansett’s time was diverted away from project work and she was not able to entirely complete the project. The original document has been separated into individual booklets. The

individual booklets have all been reformatted and many editorial corrections have been made. The research needed to update Streets (Booklet 2) has been completed. The edits to Book 1 and Book 5 still need to be completed. The final deadline for this competition of this project has been extended into the 2013-2014 project year.

As the final edits are made to each booklet, webinars will be developed and delivered. The final booklets will be available in PDF format on the PHRC website. Presentations will be made to land development design professionals, and local government groups. The Guidelines were presented at the 2012 Pennsylvania Society of Professional Engineers Conference September 2012 in Warrendale, PA and the PHRC Land Development Conference in February 2013 in Bethlehem, PA. A presentation on the Guidelines will be delivered at the Villanova Stormwater Symposium in Oct 2013.

Stormwater BMP Effectiveness in Real Residential Developments

Description: This project involves the installation of flow monitoring and water sample collection equipment in residential developments to collect long-term data on the characteristics of stormwater runoff from these sites and the effectiveness of Best Management Practices (BMPs) in a typical residential development. Nitrogen (N), phosphorus (P) and sediment (TSS) are the water quality parameters of interest for this study. N, P, and TSS must be considered in the design of stormwater BMPs and water quality controls for NPDES permits. These parameters are also the targets of the EPA TMDL (Total Maximum Daily Load), or pollutant diet, for the Chesapeake Bay. Flow data along with the constituent concentrations can be used to determine the total load (g) and event mean concentration (EMC, mg/L), or a flow weighted average, which is a parameter commonly used to model water quality. Data will be collected from different types of events (for example, spring rains versus summer thunderstorms versus winter rain on snow) over several years.

This is a multi-year project that involves the selection of an appropriate site, installation of equipment, continued maintenance of equipment, and the collection of both flow and water quality data during multiple precipitation events over several years. This entire project cannot be completed during the 2012-2013 project year, but will continue into the next several years. The duration of the project is dependent on annual climate conditions and the continued interest and funding in the research.

The long-term goals of this project are to:

- Define the pollutant load from residential developments,
- Define the effectiveness of different BMPs and treatment trains (BMPs in series), and
- Compare development to undeveloped areas and the modeling assumption of considering 20% of existing area to be meadow in good condition.

Over time as the project expands different types of development can be compared.

REPORT: This is a long term project. In the short-term (during the 2012-2013 project year), much of the planning of the project took place. The project site was to be

selected, equipment purchased and installed, and preliminary data was to be collected to test the experimental set up during the spring rainy season. Several potential sites have been determined and the final site location decision with equipment installation was to occur in the spring of 2013. With Dr. Blansett taking over the responsibilities of Associate Director of the PHRC in the spring, the equipment installation has been delayed. The project will continue into the 2013-2014 project year with pilot data collected in the next project cycle.

In later phases of the project, flow and water quality data will be collected and analyzed from multiple events throughout different seasons. The effectiveness of the stormwater BMPs instrumented will be evaluated based on the influent and effluent pollutant concentrations. These data will be submitted to the WERF BMP database. The median event mean concentration (EMC) for the land use category of residential housing will be calculated and compared to typical reference values.

The long-term outcomes of this project would include peer-reviewed journal publications and technical conference presentations of the study findings and a public summary report of the data. Webinars and other presentations can be developed to disseminate the findings.

Summarize ASCE BMP Database as Applicable to Pennsylvania

The Water Environmental Research Foundation (WERF) and the American Society of Civil Engineers (ASCE) Environmental Water Resources Institute (EWRI) maintain the International Stormwater BMP Database, which is a repository of pollutant removal data from over 400 BMP studies. This database is cumbersome to use, and it is difficult to determine what data or BMPs apply in PA. This project sorted through the data and developed an easy-to-access summary report of the data that is applicable in PA.

REPORT: There are only three BMP sites in PA in the BMP database. One of these is a green roof that collects flow data only and another is a manufactured device in an industrial location. The research BMPs at Villanova University are the only entries in the Database directly related to residential applications in PA. Some general statements about types of BMPs that are good at removing particular pollutants have been determined based on the larger data set, but there isn't a large enough data set to make definitive statements that are Pennsylvania specific. The project was expanded to a categorical summary analysis of stormwater BMPs from across the county.

As the project expanded, two Builder Briefs were written as opposed to the single brief proposed for the project. The first in the series is a less-technical overview of the Database with general summary recommendations about different BMPs for different situations. The second brief in the series contains more tables of data and is intended for an audience of stormwater design professionals. The analysis for this brief included a calculation of pollutant percent removal for nitrogen, phosphorus, and sediment. Some BMPs were found to actually increase the mean effluent pollutant concentration. The Brief includes design considerations and recommendations to avoid increasing pollutant concentration.

A webinar based on the findings of the analysis was delivered on February 12, 2013. The Builder Briefs for this project are:

- Blansett, K. The International Stormwater BMP Database, Part 1: Summary of Database. February 2013.
- Blansett, K. The International Stormwater BMP Database, Part 2: Data Summary for the Design of Residential BMPs. February 2013.

Land Development Process Flow Chart and Comparison of Permit & Approval Process in Pennsylvania to Other States

Permitting and approval agencies don't always know the whole process of developing a piece of land, and are not always aware of the other permits or approvals that are needed to complete a project. Acquiring all of the necessary permits and approvals for a land development project in Pennsylvania often takes a year to 18 months, or longer. The goal of this project was to develop a flow chart that integrates the federal and state requirements and provides a template for the local requirements. The flowchart also includes a typical timeline for the various steps based on agency review periods which will allow for easy comparison of the process in Pennsylvania to other states.

REPORT: A Builder Brief including the land development process and a brief narrative describing the process has been completed. The Builder Brief is available on the PHRC website and will be integrated into the revised version of the *Subdivision and Land Development Guidelines for Pennsylvania*. A proposal for a workshop on the land development process has been submitted for the PSATS 2014 Conference.

- Blansett, K. *Summary of the Typical Residential Land Development Process in Pennsylvania*. September 2012

Market Value of Home Energy Efficiency

Advocates of increasingly stringent energy codes and above-code programs like Energy Star Homes purport various benefits to homeowners like lower energy bills and increased comfort. But are these benefits recognized in the sales price of a home, and if so, by how much? Much of the research is between 10 and 30 years old making it difficult to draw conclusions about today's market. This project would compare the sale prices of homes with various energy efficiencies while controlling for confounding variables.

REPORT: This project was contingent upon data availability and the ability of the PHRC to partner with financial experts. It was not completed during this project cycle.

B. Support of Standards

The PHRC has developed three standards to respond to industry demand. These include Pennsylvania's Alternative Residential Energy Provisions, Pennsylvania Standards for Residential Site Development Standards and Foundation Systems for Relocated Manufactured Housing. Each of these standards requires training and timely technical assistance for local governments, builders/developers, design professionals, contractors, etc. All of these standards are available electronically for free and hard copies are available for a fee.

- Pennsylvania's Alternative Residential Energy Provisions - 2009: Education will be provided by telephone and email support by the PHRC
- Pennsylvania Standards for Residential Site Development Standards: The PHRC will provide technical assistance through telephone and email support
- Foundation Systems for Relocated Manufactured Housing: The PHRC will provide technical assistance through telephone and email support
- Deck lateral load guidelines: The PHRC will provide speaker service engagement, as well as technical support to builders and code officials

V. Funding

The PHRC receives funding from diverse sources including contracts, grants, membership fees, fees for services as well as funds collected under Act 157 of 2006. Additional contributions were made by the Pennsylvania State University through a variety of sources including the Hankin Endowment and in-kind support.

During this reporting period total project costs were \$820,863.74 (Figure 3). The Act 157 Construction Training Account accounted for 47% of these funds. We had no other grants and contracts. Other projects not part of Act 157 matching funds accounted for 9% of the budget. Income from fees and services accounted for 44%.

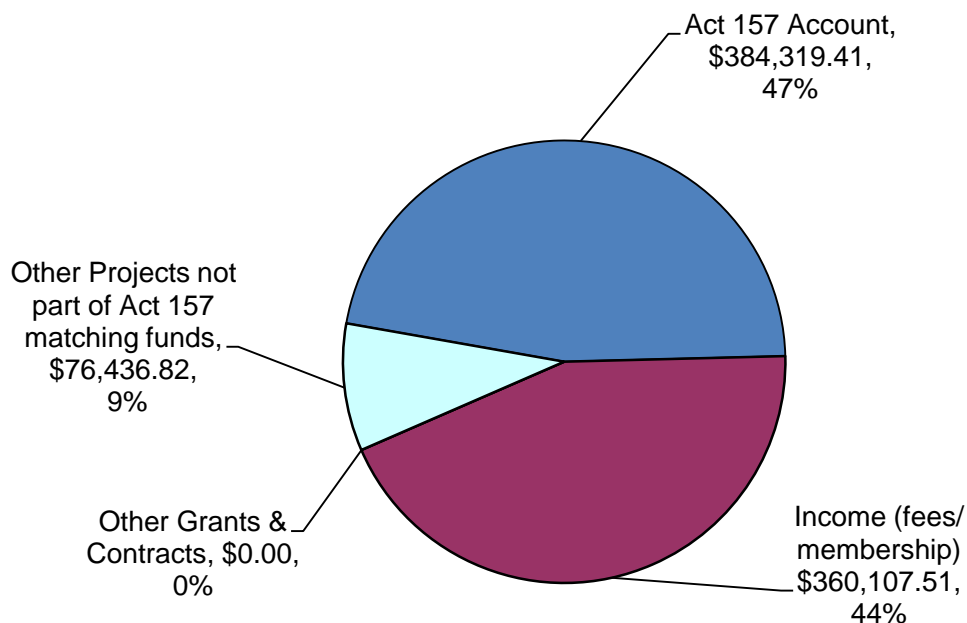


Figure 3. Summary of funding July 1, 2012 through June 30, 2013

The funds collected under Act 157 of 2006 stem from a \$2 fee collected for each building permit to support the activities at the PHRC. This legislation took effect in January 2007. As of July 1, 2012, the beginning of this reporting period, the PHRC received one payment of \$81,902.74 in August 2012, \$129,981.46 in November 2012, \$101,658.89 in February 2013, and \$129,882.95 in May from the Department of Community and Economic Development.

Any remaining funds, and disbursements received during this period, will be used for activities in the next fiscal year.

The Act 157 Account incurred expenses of \$384,319.41 during this reporting period. This is a little less than anticipated in the Project Plan in large part due to the changes in staff, which

created a vacant position for several months and pushed projects into the 2013-2014 year. Those funds will be used in the 2013-2014 year to finish the planned projects.

The *PHRC Project Plan July 2013 – June 2014* was developed with the remaining funds in the Act 157 Account as of June 30, 2013. This plan has anticipated expenditures of \$542,096.

Table 2. PHRC Expenses July 1, 2012 through June 30, 2013

Category	Act 157 Account	Leveraged Funding	Total Expenses
Total Salaries	\$223,486.45	\$186,918.10	\$410,404.55
Fringe Benefits	\$74,390.00	\$44,588.22	\$118,978.22
Supplies and Materials	\$911.46	\$9,062.73	\$9,974.19
Communications Services		\$6,372.74	\$6,372.74
Travel	\$31,890.37	\$87,780.57	\$119,670.94
Publications	\$287.00	\$922.02	\$1,209.02
Maintenance		\$600.00	\$600.00
Consulting & Prof Svc	\$52,705.10	\$2,177.36	\$54,882.46
Copies and Photographic Services	\$110.16	\$29,496.73	\$29,606.89
Scholarships			
Tuition and Fees		\$45,180.00	\$45,180.00
Equipment		\$10,022.66	\$10,022.66
Purchased Services		\$4,629.67	\$4,629.67
Miscellaneous	\$538.87	\$8,793.53	\$9,332.40
Indirect Costs (Overhead)			
Total	\$384,319.41	\$436,544.33	\$820,863.74

Table 3. Summary of Act 157 Funds – July 1, 2012 through June 30, 2013

		Expenses	Deposits	Balance
Fiscal Year 2012-2013	Starting Balance FY 2012-13			\$571,666.29
	Projected Expenditures FY 2012-13	\$521,074.00		\$50,592.29
	August 2012		\$81,902.74	\$132,495.03
	November 2012		\$129,981.46	\$262,476.49
	February 2013		\$101,658.89	\$364,135.38
	May 2013		\$129,882.95	\$494,018.33
	August 2013 (anticipated) \$120k		\$120,000.00	\$614,018.33
	Projected Expenditures FY 2013-14	\$542,096.00		\$71,922.33

VII. Proposals

The PHRC continuously seeks to leverage funding from the Commonwealth with funds from other sources. The following is a list of major grant proposals submitted to the government during the 2012-2013 project year and the proposal status. Several other smaller proposals were also submitted and some are under review/negotiation but those not are reported here.

- U.S. National Science Foundation (NSF), “Structural and Building Science Evaluation of a Transparent Wall System for Light-Frame Construction” – submitted February 2013, (\$481,000) [to be resubmitted]
- U.S. Department of Housing and Urban Development (HUD) Healthy Homes Technical Studies Program, “Determination of Optimum Humidity Level to Reduce Allergy/Asthma Triggers, Optimize Mucocutaneous Membrane Health in Elderly Population, and Engineering Guidelines to Prevent Home Allergy Hazards” – submitted March 2013 (\$750,000) [under review]
- U.S. Department of Energy, “Development of Innovative Energy efficient Glazing Systems”, Submitted May 2013, (\$747,000) [not funded]

Appendix A – Views of Recorded Webinars

Live Event Date	Title	Times Accessed
June 11, 2013	Multifamily Design for Energy Star 3.0	2
May 14, 2013	High-Performance Wall Assemblies	48
April 9, 2013	HVAC Quality Installation — Code Requirements, Best Practices, and Contractor Selection	7
March 12, 2013	Attic and Roof Ventilation — Facts and Fiction	42
February 12, 2013	The International Storm water BMP database for PA	0
January 8, 2013	Building Science Primer	25
December 11, 2012	An Introduction to Spray Polyurethane Foam (SPF)	21
November 13, 2012	Mechanical Ventilation in Tight Homes	60
September 11, 2012	Fire Protection of Floors — Demonstrating Equivalence Under Act 1	164
May 8, 2012	Makeup Air for Exhaust Systems in Tight Houses	154
April 10, 2012	How to properly insulate a slab	340
March 13, 2012	Radiant barriers: Do they make sense in Pennsylvania?	0
January 10, 2012	Individual Lot Preparation: Considerations for Residential Construction	219
December 13, 2011	Building with exterior rigid foam	177
November 8, 2011	Exterior Plaster Finish Systems: avoiding moisture-related failures	202
November 4, 2011	Key Changes in the 2012 IRC... and an Overview of the UCC adoption process	381
October 11, 2011	Solar energy economics in Pennsylvania	172
September 13, 2011	Spray foam - thermal barriers, ignition barriers and specific approval	115
August 9, 2011	Act 1 Requirements for Fire Protection of Lightweight Floor Systems – Things to consider	191
May 17, 2011	Act 1 of 2011: New Uniform Construction Code Exemptions and Code Adoption	382
May 10, 2011	Bringing the ducts inside: unvented attics, conditioned basements and crawl spaces, and avoiding exterior walls	121
April 12, 2011	Chapter 102 Erosion and Sediment Control and Stormwater Management Regulations: Changes you need to know.	150

March 8, 2011	Performing inspections using the IECC insulation and air sealing checklist	137
January 11, 2011	Wall Bracing Overview (2009 IRC)	229
December 14, 2010	Understanding Barriers - vapor, air, water resistive, etc.	148
November 9, 2010	The 2012 International Energy Conservation Code: A Sneak Peak	110
October 12, 2010	Basement Wall Insulation Strategies	176
September 14, 2010	Building Permit Fees in PA - overview of Center for Rural PA study	67
July 22, 2010	Special Webinar - Coordination of the 2009 IRC Energy Requirements with Industrialized Housing Installation	488
May 11, 2010	An Introduction to Advanced Framing: Reducing Costs while Improving Building Performance	331
April 13, 2010	Zero Energy Houses in PA - A technical review	723
March 4, 2010	Performing air tightness testing - a primer for code officials and builders	148
January 12, 2010	Changes in IRC 2009 wall bracing	679
December 15, 2009	Building habitable attics and five floor buildings under the IRC	107
November 5, 2009	Building a durable no step entrance	67
October 20, 2009	Emerging regulation of commercial modular construction	32
September 8, 2009	Verification Required! New Duct Leakage Testing Requirements in the 2009 IRC	143
August 11, 2009	Factory Built Structures, Part 2, Industrialized/Modular Housing	50
July 14, 2009	Factory Built Structures, Part 1, Manufactured Housing	194
June 4, 2009	Special WEBINAR - Municipal Rights & Responsibilities Under the Home Improvement Consumer Protection Act	217
May 12, 2009	Tax Credits, Rebates and Grants for the Residential Construction Industry	89
April 14, 2009	Sneak Peek: Critical Changes in the 2009 IRC	315
March 31, 2009	Residential Sprinkler Systems - an Introduction to NFPA 13-D	514
March 10, 2009	Alternatives to Traditional Foundations: Shallow Frost-Protected Foundations	157
January 13, 2009	Intro to Residential Solar Technologies: Resources and Solutions	182
December 9, 2008	Foundation Systems for Relocated Manufactured Housing	153

November 12, 2008	Inspecting Attached Decks: Ledger Board Flashing Details	290
October 30, 2008	Act 106: UCC Review & Advisory Council (Recorded without audience)	941
October 14, 2008	Ducts II - Inspecting Residential Duct Systems: Obtaining Adequate Air Flow	200
October 8, 2008	Special edition: Federal Manufactured Housing Installation Program	14
September 9, 2008	Ducts I - Inspecting Residential Duct Systems: Making the Connections	412
August 12, 2008	Intro to Residential Green Building	394
TOTAL VIEWS		10,311