



The Pennsylvania Housing Research Center

PHRC Year in Review

July 2013 – June 2014

Published August 2014

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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, 2013 and June 30, 2014.

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 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 (IAC).

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 2013 – June 2014*", 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. When appropriate, the PHRC attempts to use state funding to leverage outside support. It should also be noted that the PHRC undertook an array of additional projects that did not receive any state funds. Some of these projects are included in this report but are identified as having no support from the Act 157 funds.

Staff changes during 2013-2014 project year

On February 28th, 2014, Rhonda Decker, the Administrative Support Coordinator for the PHRC, retired from Penn State. The position was posted in May 2014 and filled by Sarah Klinetob Lowe, who started on July 14th, 2014. Please refer to Figure I for the PHRC organizational chart and current staff.

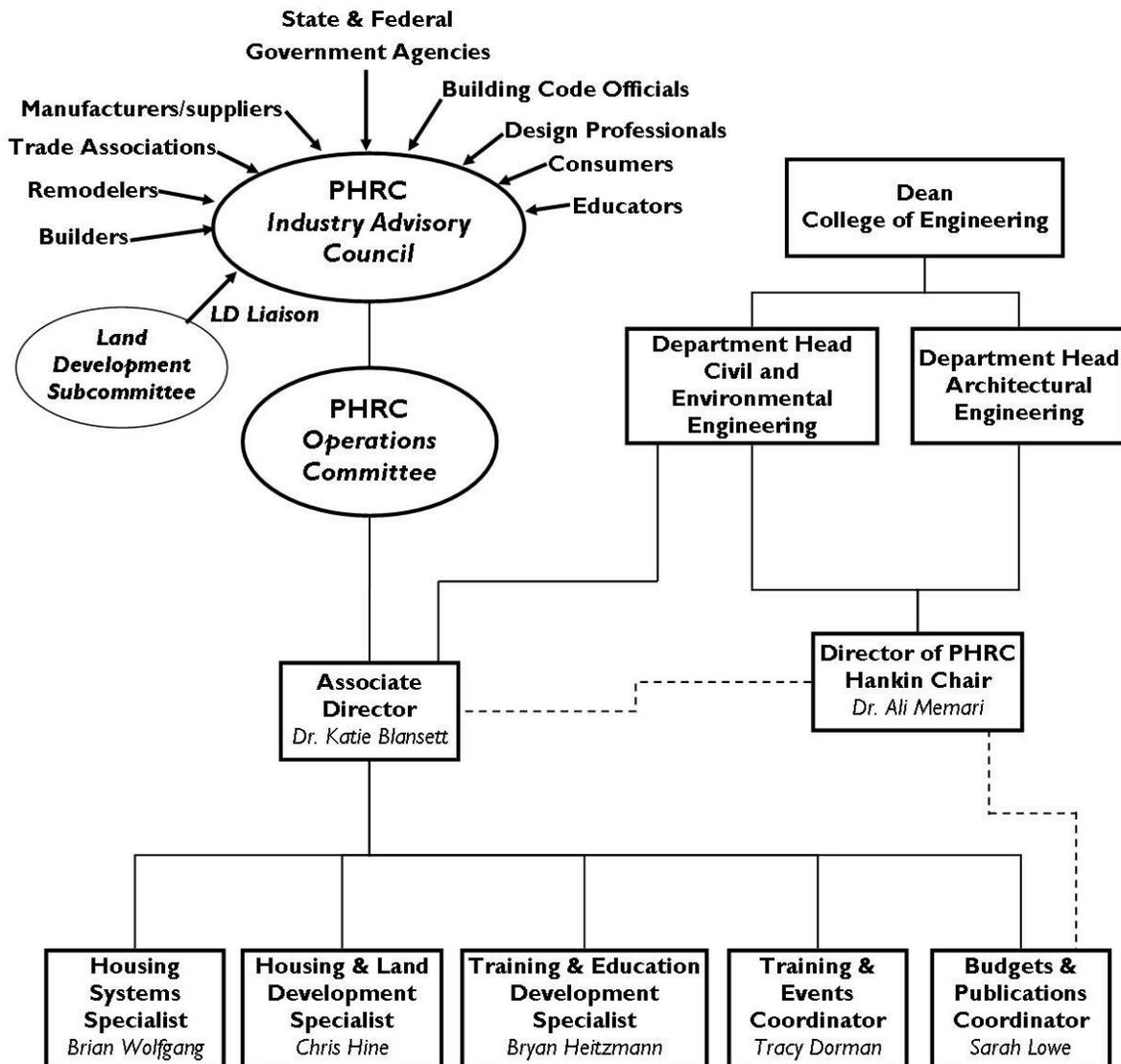


Figure I. PHRC Organizational Chart

PART I - Education, 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. To meet this mandate the PHRC offers a wide array of activities to educate and transfer appropriate technologies to the industry. These activities can include the development and delivery of educational programming using a variety of media, the hosting of conferences/symposia, and the publication of reports, as well as serving as a general resource to the industry in answering questions.

Counting the workshops, webinars, speaker services, and conferences, the PHRC has provided 66 educational services to over 2,377 individuals during this reporting period (Table I).

Table I. Summary of all PHRC Educational Programs for the 2013-2014 Project Year

PROGRAM	Activities for 2013-2014	
	# of Events	# of Attendees
Workshops	27	562
Webinars	9	546
Speaker Service	26	1,000
PHRC Conferences/PCCA Symposium	4	269
TOTAL	66	2,377

The distribution of the number of educational services over the past 15 years is plotted in Figure 2. The total number of programs delivered during the 2013-2014 period is 66, which is more than the average number of programs offered each year since the PHRC started receiving the Act 157 funds (63).

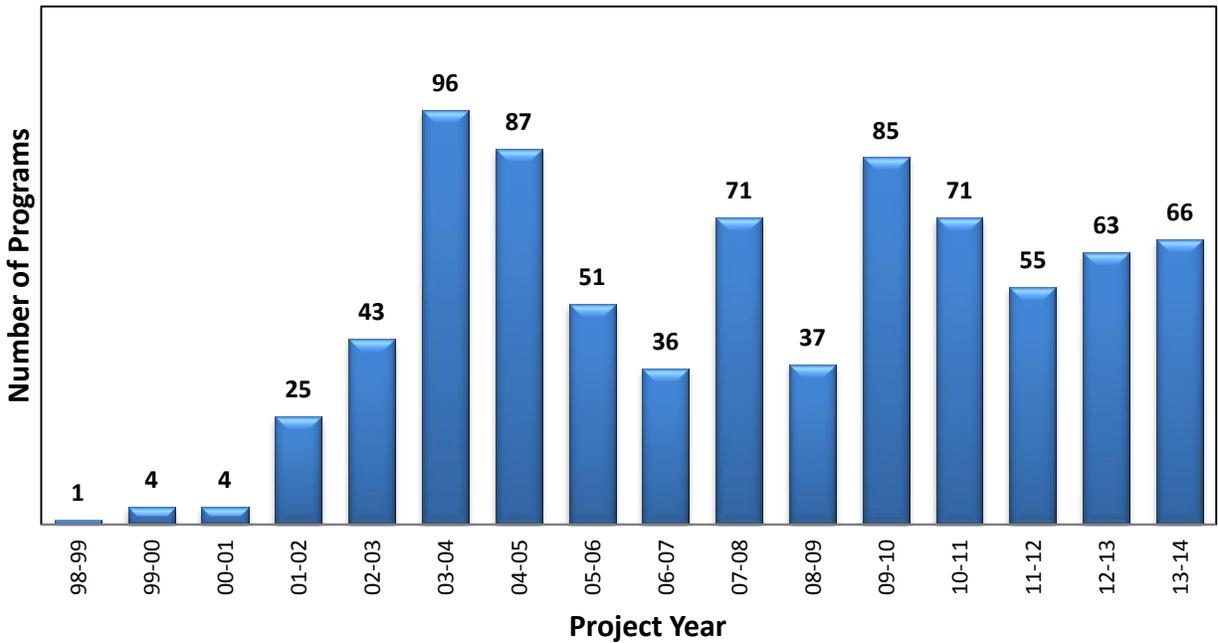


Figure 2. PHRC Educational Programs by Year.

The five general categories of the PHRC's work in this area include:

- A. Workshop Delivery
- B. New Workshop Development
- C. Webinar Development and Delivery
- D. General Technical Assistance, Technology Transfer, & Outreach Activities
- E. Builder Briefs

The following sections labeled A through E of the report will provide further details on the PHRC's accomplishments in each of these categories.

A. Workshop Delivery

The PHRC has developed and maintains a wide array of workshops for all sectors of the construction industry with a focus on residential construction. These programs are intended to address technical issues facing the industry. Additionally, the PHRC will customize programs to better meet the needs of an industry partner. Workshops are geared to an audience that may include builders, remodelers, trade contractors, design professionals, teachers, and building code officials.

The following is a full list of in-person training programs available for delivery by the PHRC.

(1) Residential Building Scholars (RBS)/Residential Code Scholar (RCS)/Code Refresher programs are intended for those wishing to attain the RBS designation or for code officials looking for a short review of the key code issues in a 1-day version, as opposed to the multi-day academy version. These programs are also well-suited for anyone interested in an introduction to building codes, an update from 2006 to 2009 IRC provisions, or information to make inspections go more smoothly. For the 2013-2014 plan, the program was expanded to include the Residential Code Scholar certificate for code officials who complete four out of the five programs and pass exams at the end of each program.

- | | |
|-----------------------------|-------|
| a. IRC Building | 1 day |
| b. IRC Plumbing | 1 day |
| c. IRC Mechanical | 1 day |
| d. IRC Electrical | 1 day |
| e. Residential Energy Codes | 1 day |

(2) Focused Topics programs are designed to immerse the student more deeply into a particular aspect of construction. These programs are ideal for meeting continuing education requirements for RBS designees and certified code officials.

- | | |
|---|----------|
| a. Advanced Framing – Increasing Performance & Reducing Costs | ½ day |
| b. Beginner’s Blueprint Reading | 1 day |
| c. Building with Exterior Rigid Foam | ½ day |
| d. Exterior Plaster Finish Systems | ½ day |
| e. International Residential Code Inspections | 2 day |
| f. Photovoltaic Installation and Inspection | 1 day |
| g. Residential Deck Design and Construction | 1 day |
| h. Residential Fire Sprinklers | 1, 2 day |
| i. Residential Mechanical Compliance Program | 1 day |
| j. Solar Hot Water Installation and Inspection | 1 day |
| k. Special Issues with Two-Family Dwellings and Townhouses | 1 day |
| l. Stucco & Adhered Masonry Veneer | ½, 1 day |
| m. Energy Plan Review and Inspection | 1 day |
| n. Basement Essentials 101 | ½ day |
| o. High-Performance, Code Compliant HVAC Systems | varies |

- p. Building Science ½, 1 day
 q. Residential Plan Review and Inspection 1 day

(3) Academy Programs are typically offered twice per year through the Pennsylvania Construction Codes Academy (PCCA). These programs are geared toward beginning code officials seeking to pass their certification exams, or anyone interested in a comprehensive overview of residential building codes.

- a. International Residential Code – Building Essentials 4 day
 b. International Residential Code – Plumbing Essentials 4 day
 c. International Residential Code – Mechanical Essentials 4 day
 d. International Residential Code – Electrical Essentials 4 day
 e. Residential Energy Code Essentials 2 day

Report: During the 2013-2014 project year, the PHRC delivered 27 workshops to 562 builders, remodelers, educators, code officials, design professionals, and planners during this reporting period (please see Table 2 for detail).

Table 2. PHRC Workshops Held July 1, 2013 through June 30, 2014

PROGRAM	In-person/ Online	# of Programs	# of Attendees
Achieving Compliance with the International Energy Conservation Code in Residential Occupancies	Online	1	49*
Blueprint Reading Training Program	In-Person	1	11
Building Science	In-Person	3	61
Commercial Plan Review/Inspections	In-Person	3	82
Electrical Essentials Academy	In-Person	1	31
IECC Commercial Energy Training Program	In-Person	1	19
IRC Building Code Refresher – 1 day	In-Person	2	37
IRC Building Code Academy – 4 days	In-Person	1	21
IRC Plumbing Code Refresher – 1 day	In-Person	2	41
IRC Plumbing Code Academy – 4 days	In-Person	1	15
IRC Mechanical Academy – 4 days	In-Person	1	14
IRC Energy Academy – 2 days	In-Person	1	10
IRC Electrical Code Refresher – 1 day	In-Person	3	63
Residential Energy Plan Review/Inspections	In-Person	3	57
Residential Fire Sprinklers/Multifamily	In-Person	3	51
Total Programs Held		27	562

* Note: Attendees for online courses indicate the number of people who have completed the program as of date of report. A total of 121 are enrolled in the online program.

Online Training Programs

With tight budgets and near record-high gasoline prices, the need for web-based training is greater than ever. The 2013-2014 reporting period was the first year for introducing Self-Paced Online Training Programs. The online program “Achieving Compliance with the International Energy Conservation Code in Residential Occupancies” was launched in July 2013. It is a self-paced program that allows participants to watch program videos on their own schedule. There are quiz questions for each of the 26 modules, and participants must get the questions correct to move on to the next module. A total of 121 people have enrolled in the program, and so far, 49 people have completed all modules of the program. The feedback from the program is very positive.

B. New Workshop Development

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

I. Basement Essentials 101

Description: Basements in residential construction today are different than in the past, and in many cases they are constructed with the intentions of becoming living space. Incorporating basements into the overall building enclosure can be a difficult task. This PHRC program will address both the code requirements and recommended practices for basement construction, including structural design, moisture and heat management, ventilation design, containment of pollutants, and finish options.

Manager/PI: Wolfgang

Report: The Basement Essentials 101 course was identified as a course that would be best delivered in a web-based interface. In response the course has been developed in a series of modules, each covering a different topic associated with basements. Each of these modules discusses design theory, code regulation, material and system standards, and construction details which demonstrate compliant assemblies. The PHRC is currently reviewing its online content delivery system. Once this system has been updated and available to receive updated content, the Basement Essentials 101 modules will transition to the web-based interface.

2. High-Performance, Code Compliant HVAC Systems: ACCA Training for HVAC Contractors

Designing and installing HVAC systems has turned from being “rules of thumb” into a very scientific calculation based on location, size and construction materials of the structure, fenestration, air leakage, orientation, and equipment efficiency. The Air Conditioning Contractors of America (ACCA) is a non-profit association of HVAC

contractors that write standards for the design, maintenance, installation, testing, and performance of indoor environment systems. ACCA provides training and education programs to the HVAC industry, but much of their programming is available at their headquarters in Arlington, Virginia. Through this project the PHRC trainers will bring ACCA training to the HVAC contractors in Pennsylvania.

Manager/PI: Hine

Report: Chris attended a 4 day EPIC training program through ACCA in July. The program provided an extensive amount of information that we can use to develop training programs geared toward the proper design and installation of residential HVAC equipment. The PHRC is also planning to team with IBACOS for final program input and edits later this year.

3. Educating the Next Generation of Tradespeople

Description: Educating the “next generation” residential trade contractors is essential for the future of residential construction. The construction of a residential structure has as much to do with science as it does with knowledge for construction practices. Today’s industry leaders can support secondary schools in laying a good foundation for this information. The PHRC will pursue multiple avenues to reach out and include the next generation of tradespeople in programs. Outreach activities will include trying to increase participation of vocational students and instructors in the PHRC conference, PCCA symposia, and PHRC webinars. This project involves longer-term relationship building between the PHRC and the vocational school instructors that will benefit both organizations well beyond the current project cycle.

Manager/PI: Blansett

Report: The ultimate goal is to increase the detailed knowledge of future industry tradespeople through this general outreach and draw them to future training sessions such as the PHRC Annual Conference and PCCA Symposium. This project involves longer-term relationship building between the PHRC and the vocational school instructors that will benefit both organizations well beyond the current project cycle.

The PHRC has been developing a relationship with the Pennsylvania Association of Career and Technical Administrators (PACTA) and is also investigating other educational opportunities to involve the next generation with PCCA and DCED. Some of the outreach activities to the next generation include speaking engagements with the Central Pennsylvania Institute of Science and Technology (CPI), Penn College, Penn State Civil Engineering classes, Penn State Architectural Engineering classes; serving as a carpentry judge for a regional trade school skills competition; and chaperoning multiple tours for Penn State students and State College High school students.

4. Introduction to Building Science

Description: The study of building envelopes and building science is a rapidly evolving segment of the residential construction industry that continues to play an important role

in home performance, code development, and overall best practices. The PHRC has previously developed a half-day workshop consisting of an introduction to these concepts. This course is to be expanded into workshops of varying levels of detail in order to reach a more diverse audience.

Manager/PI: Wolfgang

Report: The full-day building science workshop has been delivered successfully three times, with positive feedback from each offering. This workshop will continue to be adapted as new technology and construction techniques emerge. This workshop has been used to develop materials for multiple speaking engagements and webinars. Also, portions of the full day workshop have been used in the development of the Basement Essentials program.

5. The Land Development Process

Deliverables: The land development process is a long and complicated process. Many of the entities involved in the process do not know what other steps are involved in getting a project from conceptual idea to construction. The PHRC published a Land Development Brief, *Summary of the Typical Residential Land Development Process in Pennsylvania*, in 2012 to help educate those involved with the process about the many steps. This current project will expand upon that Brief to provide municipal officials, code officials, and sewage enforcement officers (SEOs) with an overview of the land development process through a focused training program. Content in the workshop will focus on the land development flow chart included in the Brief. The program will highlight the various approvals needed and where additional information on steps in the process can be found.

Manager/PI: Blansett

Report: The development of a workshop is complete. It was delivered at the PBA Fall Board meetings, the PHRC Housing and Land Development Conference, the Annual PA State Association of Township Supervisors (PSATS) Conference, and to the Bradford County Planning Commission. It will continue to be offered when requested or as proposals are submitted for conference presentations as appropriate.

6. Stormwater 101

Description: Professionals in the land development field have been dealing with the issues of stormwater management for years. Recent regulatory and policy changes have now made stormwater management an issue for some single-family homebuilders. Regulatory and permit updates and increased public awareness of flooding and water quality are bringing the issues of stormwater management to others professions, such as municipal officials and code officials who may not be well versed in the topic.

Manager/PI: Blansett

Report: A workshop was developed to educate municipal officials, code officials, builders, and other non-stormwater professionals on the basic issues of stormwater, the

management of runoff, and the new rules that affect a larger percentage of the development community. It was delivered at the Pennsylvania Manufactured Housing Association (PMHA) Community Symposium, the PHRC Housing and Land Development Conference, and the Annual PA State Association of Township Supervisors (PSATS) Conference. A webinar on the topic was delivered on April 8th, 2014. The workshop will continue to be offered when requested or as proposals are submitted for conference presentations as appropriate.

7. Residential Plan Review and Inspection

Description: The existing PHRC workshop on Energy Plan Review and Inspection has been very successful in terms of the number of people attending and the feedback from participants. Based on the success of this workshop, a similar workshop will be developed focusing on the components of a residential plan review and inspection. The course will consist of an overview of relevant code requirements and a hands-on guided plan review, followed by one or two small group plan reviews that will be discussed later as a whole group.

Manager/PI: Heitzmann

Report: This new 1-day new workshop has been completed as of June 30, 2014. The workshop has been added to the PHRC's current list of training workshops and will be delivered at locations around the state as requested.

C. Webinar Development and Delivery

In today's economic climate, there is a need for technical programs without the added cost of hotel stays and transportation. To meet this need the PHRC has continued its successful monthly webinar series. Webinars are delivered live, and are also archived for on-demand viewing. One certification maintenance credit is offered for each webinar for PA code officials. As appropriate, AIA Learning Units (LUs) for architects and professional development hour (PDHs) for engineers have been offered.

Manager/PI: Heitzmann, Hine

Report: The PHRC delivered nine webinars during this reporting period to a total of 546 people. Due to the PA Housing and Land Development Conference, no webinar was held in February.

Webinar Series		
Month	Title/Topic	Number of Attendees
August	Act 54- Development Permit Extension Act of 2013	153
September	Quick Guide to UCC Amendments	49
October	Energy Efficient Lighting and Appliances	24
November	OSHA Compliance Tips	50
December	Soil Considerations for Builders	50
January	NAHB Green Building Standard Update (Home Innovation)	28
February	No webinar – PA Housing and Land Development Conference	--
March	Renovation Requirements in Floodplains	74
April	Stormwater 101	66
May	Aging-in-Place	52
	Total Attendees	546

D. General Technical Assistance, Technology Transfer, & Outreach Activities

This reporting item is a continuation or expansion of activities to transfer information and publications to builders, remodelers, design professionals, building code officials and others involved in the residential construction industry.

Manager/PI: Blansett

Report: The PHRC worked with the PBA and other industry and trade organizations on the following activities:

1. The Annual Pennsylvania Housing and Land Development Conference
2. 2nd Residential Building Design and Construction Conference

3. PCCA Symposium
4. Speaker Service and conference presentations
5. General outreach activities

I. The Annual Pennsylvania Housing and Land Development Conference

This two-day event provides information and updates on issues of interest to the residential construction industry. The intended audience is builders, remodelers, code officials, design professionals, home performance contractors and others. Day 1 of the conference focuses on issues related to the housing structures and their systems, while Day 2 focuses on Land Development. Training programs are also offered on Day 2 of the conference.

Report: The 22nd annual Housing and Land Development Conference was held on February 19th and 20th, 2014 at the Penn Stater Conference Center and Hotel in State College, PA.

Housing (Day 1): The day started off with some less than impressive weather and a more than impressive keynote speaker, Brad Oberg (principle and CTO at IBACOS) who delivered a message on “Building America, High Performance and Technology that Works.” The conference then broke out into three separate tracks that were geared towards different audiences/professions within the industry.

- Design & Innovation Track
 - “The Passive House” by Michael Whartnaby & Laura Nettleton
 - “Innovations in Swedish Factory-Built Housing” by Greg La Vardera
 - “Urban Renewal” by Elizabeth Baldwin, PE & George Altmeier, PE
- Construction Track
 - “Stormwater 101” by Katie Blansett, PhD, PE
 - “Super-Efficient Remodel” by Michael Merck
 - “Wood Design for Builders” by Brennan Glantz, PE
- Building Code Track
 - “Installation and Habitability Guidelines for Relocated Manufactured Housing” by Mark Conte
 - “Visit-ability, Aging in Place & Accessibility” by Amy Martino, AIA
 - “UCC Q&A Panel Discussion” by Bob Buddenbohn, Matt Light & Frank Thompson

Right after the end of the last technical session of day, attendees had the opportunity to attend a tour of the PHRC Laboratory facilities. Approximately 25 people took advantage of this opportunity.

New to the conference this year were exhibitor tables set up in the break area. This was a trial addition to the PHRC conference so they were offered for free and only to PBA, local trade schools, and student groups. The organizations that participated

included the Pennsylvania College of Technology and the Penn State NAHB Student Chapter.

There were 84 attendees for the Housing Day of the conference.

PHRC Mix and Mingle Reception: Instead of the traditional Leadership Dinner, the Wednesday evening social event for this year's conference was the Mix and Mingle Reception, which was held at the Hintz Alumni Center on the campus of the Penn State University with approximately 60 people in attendance. Attendees of the Housing and Land Development Conference as well as the Residential Building Design and Construction Conference were invited to the Reception. It provided a great opportunity for people from both conferences to socialize and network.

Land Development (Day 2): The second day kicked off with a highly energetic keynote presentation from Elliot Eisenberg, PhD during which he discussed the "Economic Impact of Government Regulation." The conference then broke out into 2 tracks.

- Land Development Process Track
 - "Land Development Process" by Katie Blansett, PhD, PE
 - "Online Resources of Conducting Due Diligence" by Bob Fisher, PE
 - "Critical Issues in Traffic Planning & Engineering" by Casey Moore, PE & Francis Hanney
 - "More Efficient Project Management" by Thomas Skibinski, PE
- Stormwater Management Track
 - "Soil Mixes for Stormwater Management" by Andrea Welker, PhD, PE
 - "Stormwater Offset Policy & DEP's Expectations for Long-term Obligation" by Jennifer Orr
 - "DEP's Evaluation Process for New BMPs" by Darl Rosenquest, PE, PG
 - "Calculations of Evapotranspiration" by Mark Bowen, PE

There were 73 attendees for the Land Development day of the conference

Training (Day 2): Two training classes were also offered in conjunction with the conference.

- Building Science
- Residential Energy Plan Review & Inspection

2. 2nd Residential Building Design and Construction Conference

The RBDC Conference was held in conjunction with the Annual Pennsylvania Housing & Land Development Conference. The Residential Building Design and Construction Conference is intended to provide a forum for researchers and design professionals to discuss their latest findings, innovations and projects related to residential buildings. The

RBDC invites papers and presentations on various types of residential construction including single- and multi-family dwellings, mid-rise and high-rise structures, factory-built housing, dormitories, and hotels/motels.

Report: The 2nd RBDC Conference was held on February 19-20, 2014 at the Penn State Conference Center Hotel in State College, PA. Two Keynote Speakers were invited for the conference, Tim McDonald, President, Onion Flats LLC, and Dr. David Crowe, Chief Economist, National Association of Home Builders. The conference also had two invited speakers, David Crump, Director of Legal Research, National Association of Home Builders, and Erik Churchill, Project Manager, SHoP Construction. The conference included presentations by university professors, researchers, graduate students, architects, consulting engineers, product manufacturers, and product related associations/councils. The following is a list of papers presented at the conference over the two days:

- **87 Dikeman Street** – *Alexis Lenza*
- **Adoption Patterns of Energy Efficient Housing Technologies 2000-2010: Builders as Innovators?** – *Andrew R. Sanderford, Andrew P. McCoy, Matthew J. Keefe, and Dong Zhao*
- **An Effort to Refine Regional Energy Assessment Methods in Support of Energy Auditors to Increase Assessment Accuracy and Consumer Confidence** – *Oluwateniola Ladipo, Georg Reichard, Andrew McCoy, and Annie Pearce*
- **Changes to the 2012 Wood Frame Construction Manual** – *John Showalter, Bradford Douglas, Philip Line, Peter Mazikins, Loren Ross, and Lori Koch*
- **Cost Effective Ways to Construct EnergyStar Homes** – *Rick Gazica*
- **Disentanglement and Flexibility: Keys to Sustainable Modularity** – *Stephen Kendall*
- **Integrated BIM Platform for Multi-Story Modular Building Industry**– *Issa J. Ramaji, Ali M. Memari, and Ryan Solnosky*
- **Evaluation of Venetian Blind Attributes for Energy Efficiency** – *Tim Ariosto and Ali M. Memari*
- **Home Building Impact** – *David Crowe*
- **Lifecycle Assessment of Residential Buildings** – *Tien Peng and Lionel Lemay*
- **Meeting Residential Energy Requirements with Wood Frame Construction** – *Loren Ross and John Showalter*
- **New Methods of Delivery: Prefabrication Strategies in Residential Construction** – *Erik Churchill*
- **Observations from Model Scale Thermal Tests on Heat Exchanger Pile** – *Omid Ghasemi-Fare, Cory Kramer, and Prasenjit Basu*
- **Performance Optimization and Development of a Home Modular Delivery System** – *Lisa D. Iulo*
- **Policies to Enhance Resilient Communities** – *Tien Peng and Lionel Lemay*
- **Pump-Up the Volume – Passive House, Mass Production and Multi-Family – Can HOUSING save the planet?** – *Tim McDonald*
- **Prescriptive Residential Deck Design** - *Loren Ross and John Showalter*
- **Residential Vertical Expansion of Existing Commercial Buildings Using Modular Construction Methods** – *Anthony C. Jellen and Ali M. Memari*
- **Resuspension and Transport of Allergen-Carrier Particles in Residential HVAC** – *Dong Hwa Kang, Dong Hee Choi, Paul Kremer, and James Freihaut*
- **Review of Different Components of Solar Decathlon House Projects** - *Ehsan Kamel and Ali Memari*
- **Structural BIM Processes for Modular Multi-Story Buildings in Design and Construction** – *Ryan L. Solnosky, Ali M. Memari, and Issa J. Ramaji*

- **Structural Systems and Design Considerations for Low-Rise Senior Living and Multifamily Residential Buildings** - Jason Dreher and Mark Erdman
- **Sunlight Reflected from Double-Paneled Low-e Windows, and Damage to Vinyl Siding and Other Materials** – David Crump, Jr. Esq.
- **Superstorm Sandy Storm Surge and Structural Damage Correlation - A Case Study of Long Beach, NY** – Nicole Leo Braxtan, KerryAnne Donohue-Couch, and Kerrienne Westphal
- **The Effect of Building Envelope Impact Protection Schemes on Community Resilience** – J. Michael Grayson and Weichi Pang
- **Twelve Simple Steps to Net-Zero Energy Design** – Ted Clifton
- **Value-Based Evaluation of the Residential Energy Assessment Process** - Fuju Wu, David Riley, Kelly Sprehn, Tabitha Sprau Coulter, and Michael Whelton

The papers or presentations for the 1st Residential Building Design and Construction Conference can be found in the proceedings of the conference at the following link: <http://goo.gl/xmVWr03>

3. PCCA Symposium

The PHRC worked with the PCCA to plan and deliver the 5th Annual PCCA Symposium East and West. The PHRC assisted in developing the agenda for both Symposia, secured speakers, and also delivered two sessions at each Symposia. The programs drew from the content of the 2014 PHRC Pennsylvania Housing and Land Development Conference and consisted of two tracks addressed technical issues being faced by building code officials. The East Symposium was held in Feasterville/Treose, and the West Symposium was held in Monroeville.

4. Speaker Engagements

The PHRC participates in talks, seminars, and conferences directed at the housing and land development industries. This may include trade and professional association functions and regional meetings, local association meetings, or state or national conferences. Over the 2013-2014 reporting period, the PHRC delivered 26 speaker services, reaching 1,000 people. Speaker service and conference presentations included:

- Ariosto, T. M. and Memari, A. M., (2014). "Evaluation of Venetian Blind Attributes for Energy Efficiency," *Proceedings of the 2nd Residential Building Design and Construction Conference*, Penn State University, University Park, PA, February 19-20, 2014, pp. 64-81.
- Blansett, K. "A karst case study: Flow and water quality analysis of 5 urban watersheds," *Villanova Urban Stormwater partnership Symposium*, Villanova, PA, October 18, 2013. (75 attendees).
- Blansett, K. "Panel – Pennsylvania's Next SCM Manual," *Villanova Urban Stormwater Partnership Symposium*, Villanova, PA, October 18, 2013. (75 attendees).
- Blansett, K. "Land Development Process in PA," *Bradford County Planning Commission*, Bradford, PA, June 19, 2014. (20 attendees).

- Blansett, K. "Land Development Process in PA," *PBA November Board meeting*, Hershey, PA, November 8, 2013. (32 attendees).
- Blansett, K. "Land Development Process in PA," *PSATS Conference*, Hershey, PA, April 14, 2014. (26 attendees).
- Blansett, K. "The PHRC's Guidelines for Residential Development in PA: A Tool for Better Site Design," *Penn State Extension's Land Planning Webinar Series*, State College, PA, May 21, 2014 (36 attendees).
- Blansett, K. "Stormwater 101," *PSATS Conference*, Hershey, PA, May 21, 2014. (66 attendees).
- Blansett, K. "Stormwater and Land Lease Communities – Understanding Stormwater Regulations and How they can Impact your Community," *PA Manufactured Housing Assn (PMHA) Community Symposium*, Carlisle, PA, November 13, 2013. (55 attendees).
- Blansett, K. and Heitzmann, B. "Act 54 Permit Extension." July 17, 2013. (~22 attendees)
- Heitzmann, B. "90% Energy Compliance – Visual Inspection & Checklist Webinar," *PA Construction Codes Academy*, State College, PA, March 13, 2014. (79 attendees).
- Heitzmann, B. "Air Barriers," *The Pennsylvania State University*, University Park, PA, April 24, 2014. (15 attendees).
- Heitzmann, B. "Exterior Water Management." *Bucks/Montgomery Builders Association*. September 11, 2013. (~17 attendees)
- Heitzmann, B. "Exterior Water Management for Builders," *Central PA Institute of Science & Technology (CPI)*, Pleasant Gap, PA, November 18, 2013. (26 attendees in morning session and 35 attendees in afternoon session).
- Heitzmann, B. "Exterior Water Management for Builders," *PCCA Symposium – East*, Feasterville/Treose, PA, March 5, 2014. (36 attendees).
- Heitzmann, B. "Exterior Water Management for Builders," *PCCA Symposium – West*, Monroeville, PA, March 20, 2014. (35 attendees).
- Heitzmann, B. "Providing Code Compliant Air Barriers," *Indiana County Tech Center*, Indiana, PA, April 17, 2014. (First offering - 35 attendees).
- Heitzmann, B. "Providing Code Compliant Air Barriers," *Indiana County Tech Center*, Indiana, PA, April 17, 2014. (Second offering - 32 attendees).
- Hine, C. "PHRC Site and Land Development Guidelines," *Villanova Urban Stormwater partnership Symposium*, Villanova, PA, October 18, 2013. (50 attendees).
- Hine, C. "Providing Code Compliant Air Barriers," *PCCA Symposium – East*, Feasterville/Treose, PA, March 5, 2014. (35 attendees).
- Hine, C. "Providing Code Compliant Air Barriers," *Juniata Builders Association*, Downtown OIP, Lewistown, PA, May 14, 2014. (10 attendees).
- Hine, C. "Providing Code Compliant Air Barriers," *PCCA Symposium – West*, Monroeville, PA, March 20, 2014. (35 attendees).
- Jellen, A. C. and Memari, A. M., (2014). "Residential Vertical Expansion of Existing Commercial Buildings Using Modular Construction Methods,"

- Proceedings of the 2nd Residential Building Design and Construction Conference*, Penn State University, University Park, PA, February 19-20, 2014, pp. 216-229.
- Kamel, E. and Memari A. M., (2014). “Review of Different Components of Solar Decathlon House Projects,” *Proceedings of the 2nd Residential Building Design and Construction Conference*, Penn State University, University Park, PA, February 19-20, 2014, pp. 335-354.
 - Ramaji, I. J., Memari, A. M., and Solnosky, R. L., (2014). “Evaluation of Software for Application in Multi-story Modular Building Construction,” *Proceedings of the 2nd Residential Building Design and Construction Conference*, Penn State University, University Park, PA, February 19-20, 2014, pp. 230-244.
 - Solnosky, R. L., Memari, A. M., and Ramaji, I. J., (2014). “Structural BIM Processes for Modular Multi-story Buildings in Design and Construction,” *Proceedings of the 2nd Residential Building Design and Construction Conference*, Penn State University, University Park, PA, February 19-20, 2014, pp. 201-215.
 - Wolfgang B. “90% Air Barrier Code Compliance: It’s All About Continuity,” *PCCA Webinar*, State College, PA, June 12, 2014. (72 attendees).
 - Wolfgang, B. “90% Energy Compliance – Slab Insulation Webinar,” *PA Construction Codes Academy*, State College, PA, February 13, 2014. (69 attendees).
 - Wolfgang, B. “How Tight is Too Tight?” *Mifflin/Juniata Builders Association*, Port Royal, PA, November 12, 2013. (12 attendees).

5. General Outreach Activities

The general outreach activities of the PHRC include activities to let builders know about the PHRC and the services and publications it provides. These activities may include PHRC mailings, promotional pamphlets, articles in research or trade journals, answering phone and email questions, and the maintaining PHRC’s website, as well as various relevant technical meetings attended by PHRC staff.

Webpage Update

Over the past year the PHRC has been working to revise and update our webpage. This project did not use Act 157 monies, but it is being reported here, because the updated version of the webpage will provide easier access to PHRC publications, information about the many different research projects of the Center, and a user-friendly training calendar. The revised webpage will make the work and people of the PHRC more accessible to our audience. The new webpage includes a new address at www.phrc.psu.edu.

Publications

The following list includes the scholarly publications published during the reporting period.

- Memari, A. and Solnosky, R. (2014). “In-Plane Shear Performance of Wood-Framed Drywall Sheathing Wall Systems under Cyclic Racking Loading” *Open Journal of Civil Engineering*, Vol. 4, No. 1, pp. 54-70, March 19, 2014, DOI: 10.4236/ojce.2014.41006.
- Memari, A. M., Iulo, L. D., Solnosky, R. L., and Stultz, C. R., (2014). “Building Integrated Photovoltaic Systems for Single Family Dwellings: Innovation Concepts,” *Open Civil Engineering Journal*, Vol. 4, pp. 102-119, DOI:10.4236/ojce.2014.42010.
- Terentiuk, S. and Memari, A. M., (2014). “Seismic Evaluation of Structural Insulated Panels in Comparison with Woodframe Panels,” *Buildings*, Vol. 4, pp. 394-417, doi:10.3390/buildings4030394.
- Maneetes, H. and Memari, A. M., (2014). “Introduction of an Innovative Cladding Panel System for Multi-Story Buildings,” *Buildings*, Vol. 4, pp. 418-436, doi: 10.3390/buildings4030418.
- Vu, B., Unal, M., Warn, G. P., and Memari, A. M., (2013). “A Distributed Flexibility and Damping Strategy to Control Vertical Accelerations in Base-isolated Buildings,” *Journal of Structural Control and Health Monitoring*, DOI: 10.1002/stc.1580, 2013, pp. 1-19.
- Memari, A. M., (2013). Editor, *Curtain Wall Systems – A Primer*, Consisting of 12 Chapters, American Society of Civil Engineers (ASCE), ISBN 978-0-7844-1270-1 (paper); ISBN 978-0-7844-7768-7, 217 p.
- Memari, A. M. and Wolfgang, B. M., (2014). Editors, *Proceedings of the 2nd Residential Building Design and Construction Conference*, State College, PA, February 19-20, 2014, The Pennsylvania Housing Research Center, Penn State University, University Park, PA, ISBN 978-1-62307-003-8, 401 p.
- Ariosto, T. M. and Memari, A. M., (2013). “Evaluation of the Energy Performance of Glazing Systems and Fenestration Retrofit Solutions,” PHRC Research Series Report No. 111, The Pennsylvania Housing Research Center, Penn State University, University Park, PA, December 2013, ISBN 978-1-62307-002-1, 145 p.

Conferences/Meetings Attended

The following is a list of the housing industry-related conferences and meetings attended by the PHRC personnel.

- Blansett, K. and B. Wolfgang. Greenbuild. Philadelphia, PA, November 20-22, 2013.
- Blansett, K. “In my Backyard: An Innovative look at the Advances of Onsite Decentralized Wastewater Treatment.” Invited workshop participant. Washington, D.C., December 17-18, 2013.
- Heitzmann, B. NAHB Business Management for Building Professionals,

- Blansett, K. B. Heitzmann, C. Hine, B. Wolfgang. NAHB Train the Trainer, Washington, D.C.
- Hine, C. and Wolfgang, B. National Association of Home Builders' International Builders Show and NAHB Student Chapter Residential Construction Management Project Competition. Las Vegas, NV February 2-6, 2014.
- Memari, A. M., National Association of Home Builders' International Builders Show, and NAHB Student Chapter Residential Construction Management Project Competition, Las Vegas, NV, February 2-6, 2014.
- Memari, A. M., Housing and Urban Development (HUD), Discuss Potential Research Proposals, October 31, 2013.
- Memari, A. M., Department of Energy, Building Technology Program, Emerging Technologies and Building America Workshop, Washington, DC, October 31, 2013.
- Memari, A. M., DuPont Building Innovations, Richmond, VA, 7/25/14. Wolfgang, B. HERS Rater Training, Green Training USA, Silver Spring, MD, October 21-23, 2013.
- Wolfgang, B. NAHB Basics of Building, Las Vegas, NV, February 3, 2014.
- Wolfgang, B. NAHB Green Building for Building Professionals, Las Vegas, NV, February 1-2, 2014.

Service in Professional Societies

The PHRC staff and faculty are involved in a variety of organizations at both the state and national level.

Pennsylvania Committees and Organizations

- Blansett, K. PA Stormwater Technical Workgroup – Executive Committee
- Blansett, K. Pennsylvania Society of Professional Engineers – Central Region Vice-President
- Memari, A.M., and K. Blansett. American Society of Civil Engineers

National and International Committees and Organizations

- Memari, A. M., National Consortium of Housing Research Centers Executive Committee meeting, Washington, DC, July 23-25, 2013.
- Memari, A. M., National Consortium of Housing Research Centers Executive Committee meeting and Annual meeting, Las Vegas, NV, February 2-4, 2014.
- Memari, A. M., ASCE Architectural Engineering Institute Board of Governors meeting and Technical Region Board of Governors (TRBG), 1/31-2/1/2014, Phoenix AZ
- Memari, A. M., ASCE Architectural Engineering Institute Board of Governors meeting, 3/28-29/2014, Philadelphia, PA
- Memari, A. M., ASCE Journal of Architectural Engineering Editorial Board meeting, 3/31/2014, Reston, VA.

Annual Newsletter

Over the past few years the annual newsletter has been sent to PHRC members in January to keep them up-to-date on recent PHRC activities and to promote the PA Housing and Land Development and RBDCC conferences. This year the newsletter schedule is shifted to be more aligned with the project reporting and planning. The 2014 newsletter is expected to be mailed in mid- to late-October and will include project reports from the 2013-2014 project year and highlights of projects to come in the 2014-2015 year.

E. Builder Briefs

Description: The PHRC continues its series of short technical documents that address specific issues that have been identified by builders or remodelers. These documents are intended to be quick to read with a lot of the information presented graphically or pictorially.

Manager/PI: Blansett

Report: Three Builder Briefs have been completed during this reporting period:

- Turns, M. and B. Wolfgang. Obtaining Proper Ventilation: A Case Study in Residential Exhaust Fan Performance. July 2013.
- Fortney, M., E. Burnett, B. Wolfgang. *Site Design Considerations for Manufactured Housing, 2nd Ed.*, PHRC, University Park, PA. April 2014.
- Fortney, M., E. Burnett, B. Wolfgang. *Soil Freeze Depth Guide for Manufactured Housing in PA, 2nd Ed.*, PHRC, University Park, PA. April 2014.

An easy-to-reference, laminated guide to OSHA fall projection regulations was also published.

PART 2 - Applied Research

A very important function of the PHRC is to undertake or stimulate research and development on materials, products, procedures, and processes related to the housing industry. These efforts may have a longer-term or a more fundamental focus than other projects. The projects that are listed below foster partnerships and draw on the expertise and strengths of the persons, groups and facilities available the Pennsylvania State University.

I. Learning from the Experience of Solar Decathlon

Description: The Solar Decathlon program is a very successful Department of Energy (DOE) sponsored competition that challenges colleges to design, construct and operate solar powered homes for energy efficiency, cost-effectiveness and various other criteria such as renewable energy, clean energy, and advanced building technologies. The program started in 2002 and has so far been held during 2002, 2005, 2007, 2009, and 2011. Teams from universities in the U.S. and other countries participate at the competition. Although the competition will result in one team winning first place, each team uses different features from which much can be learned. In particular, if the target audience will be the builders and developers, there are many useful features that this audience may benefit from for different applications. The goal of this project is to develop a collection of learning materials from the significant investment and effort that has so far gone into the Solar Decathlon program. In particular, the detailed designs of all of the past solar decathlon homes will be reviewed to identify special features that were used for each home. These features will then be categorized and tabulated with their attributes. Then the features and their impact considering various performance criteria will be compared taking into account the analyses results generated by each team in their projects.

Manager/PI: Memari

Report: The project is near completion with major aspects of the study carried out. The literature review of the past Solar Decathlon projects has been completed. Major load-bearing and non-load bearing components of competition projects have been reviewed and categorized. For example, the percentage use of various type of roofs, wall systems, windows, insulation, and framing type have been determined by reviewing the details of all competition houses. Criteria such as market appeal, affordability, comfort zone performance and energy balance have been considered in comparative evaluation of the Solar Decathlon projects. A paper based on the work done has been presented at the 2nd Residential Building Design and Construction Conference (2nd RBDDC, February 19-20, 2014). A second paper further documenting the progress on the project has been submitted to the Architectural Engineering Conference 2015, and will be presented in Milwaukee, Wisconsin, March 24-27, 2015. Project is approaching the final stages of completion, 90% done, and a final report is under preparation.

2. Resuspension and Transport of Allergen Carrier Particles in Residential HVAC Systems

Description: HVAC systems play an important role in transporting allergen carrier particles that trigger asthma episodes in residential indoor environments. Unfiltered particles deposited on interior duct surfaces resuspend and transport when disturbed under mechanical vibration and varying air flow conditions in the system. However, experimental data is needed to characterize the behaviors of individual allergen-carrier particles in response to HVAC system disturbances and to inform modeling work that will lead to better design and performance guidance for builders seeking to improve indoor air quality in residential settings. A combination of experimental work in residential settings and in a more controlled laboratory resuspension chamber setup is proposed to characterize the resuspension of allergen-carrier particles deposited in residential HVAC ductwork and to obtain resuspension rate data for individual allergen-carrier particles in various HVAC system environments. The results of this research investigation are expected to provide a better understanding of the behavior of allergen sources in residential homes that would benefit the Pennsylvania housing industry and its residents.

Manager/PI: Dr. James Freihaut (Penn State Department of Architectural Engineering)

Report: This project has helped meet the need for more experimental data to characterize the behaviors of individual allergen-carrier particles in response to HVAC system disturbances, and to inform modeling work that will lead to better design and performance guidance for builders seeking to improve indoor air quality in residential settings. A combination of experimental work in residential settings and in a more controlled laboratory resuspension chamber setup has been conducted in this research investigation to characterize the resuspension of allergen-carrier particles deposited in residential HVAC ductwork, and to obtain resuspension rate data for individual allergen-carrier particles in various HVAC system environments. This project is nearing completion, and a final report is expected at the end of September.

Three residential settings were selected for the study: the Morningstar solar home on the Penn State University Park campus, a single family home in State College, and a condominium in Arlington, Virginia. A custom vibration and particle measurement software tool was developed to acquire vibration spectra, particle measurements, air flow, relative humidity, and temperature measurements at the sites using specialty accelerometers, particle counters, and sensing and data acquisition equipment. The software tool was used to establish the range of vibration, particulate matter, air conditions, and computed resuspension rate data for the ducted mechanical systems in the residences included in the study. Bulk samples of particulate matter were collected in the residences to evaluate dust loading in the residences, for follow-up analyses of particulate matter comprising the dust samples, and to conduct laboratory resuspension experiments with the collected dusts. The software tool developed will continue to be used for future data collection efforts in residential and commercial settings. Follow up visits to the Morningstar home and the condo have been scheduled for early September to seed the ductwork in these homes with specific particles and conduct in-field

resuspension experiments. Resuspension data from these field experiments will be compared with laboratory resuspension data collected under similar conditions as described below.

A methodology for reproducing the measured disturbance data in the residences was developed for the laboratory resuspension chamber facility in the Architectural Engineering Department at Penn State. Modifications to the facilities' control software were made for scaled playback of the acquired vibration patterns from the residences with the facilities' electromagnetic shaker. A custom-constructed glovebox enclosure system and humidity control system were designed and fabricated to serve the resuspension facility. An additional round of laboratory resuspension experiments using the modified resuspension facility programmed to simulate the range of acquired vibration disturbances, humidity, dust loading, reservoir type and air disturbances in the subject residences and beyond (e.g., extreme humidity variations) are underway. The custom humidity control system serving the resuspension facility was made adaptable to the full-scale exposure environmental chambers in the AE department, and the apparatus was made portable enough to allow deployment in the field for generating extreme humidity variations in small residences such as the Morningstar home and condominiums with sufficient air-tightness. The enhancements made to these facilities through this project are expected to contribute to significant future experimental studies across a range of topics related to particulate matter in indoor and outdoor air. A College of Engineering Research Experience for Undergraduates award was made to one of the students working on this project, Evan Hummer, a senior in Mechanical Engineering at Penn State. Evan's project will extend this resuspension work toward the development of inactivation methodologies for reducing allergen content in household dust. He will work on this REU project during the upcoming academic year. Any positive results from Evan's work will be considered as potential intervention measures for investigation in a larger study related to mitigation of allergy-asthma/irritation side effects of home occupants.

A paper detailing some of our project work was presented at the February 2014 PA Housing and Land Development Conference. A draft manuscript for submission to the *Aerosol Science and Technology* journal detailing humidity effects on the resuspension parameters of indoor particles has been prepared and is awaiting final data from the aforementioned laboratory resuspension experiments. A CFD model of the Morningstar home was developed to predict particle concentrations in that indoor environment, and to investigate the impact of in-duct particle resuspension and transport on occupant exposure. More rigorous modeling for assessing occupant exposure to allergen carrier particles is being planned to account for the performance characteristics of HVAC system components, varied particle reservoir surfaces, and particle resuspension behavior in residential settings attributable to varied disturbances related to HVAC system operation and human activities, e.g., walking. The results of these research activities are expected to influence HVAC component and system designs, which in turn will aid in the development of improved methods of mitigating dust-borne allergens for Pennsylvania builders and homeowners.

3. Performance Optimization and Development of a Home Modular Delivery System

Description: The objective of this research is to expand affordable home energy performance by developing an optimized modular delivery system, a Kit-of-Parts (KoP), applicable for infill development of new homes and for retrofitting existing homes. This innovative system of components will result in homes that surpass Energy-Star performance for energy-efficiency, have improved indoor air quality, and provide realistic options for aging-in-place. Most notably it will provide a way to deliver high quality, well-designed, small affordable housing projects on a broad scale.

Manager/PI: Prof. Lisa Iulo (Penn State Department of Architecture)

Report: With the generous support of PHRC a team of Penn State researchers undertook the design of a home modular delivery system. The objective of this research was to expand affordable home energy performance by developing an optimized modular delivery system, a Kit-of-Parts (KoP), applicable for infill development of new homes and for retrofitting existing homes. The innovative system of components will result in homes that surpass ENERGY STAR performance for energy-efficiency and provide realistic options for aging-in-place. Most notably it informs a method to deliver high quality, well-designed, small affordable housing projects on a broad scale.

The project team investigated precedents for the project, identifying successful strategies for further investigation. Repetitive building components that contribute to a home's energy performance were identified and designed using design criteria that included (but was not limited to) energy performance, accessibility and flexibility for aging-in-place, comfort and indoor environmental quality, and modular construction methods. Repetitive and replicable individual components, core elements, and housing typologies were developed.

During the first phase of proof-of-concept the modular KoP homes were applied to an actual development site identified by our partner organization, the Union County Housing Authority. Based on a LIHTC analysis for the site, a master plan with a variety of housing unit types was designed for an underutilized (formerly industrial) site in the heart of Lewisburg, PA. This master plan along with architectural drawings for the KoP housing was used to seek input from building professionals, developers, and other specialists. Concurrently, a series of existing building conditions representative of those found in small towns throughout Pennsylvania were identified. Schematic designs for the retrofit and adaptation of these structures for single-floor living (aging-in-place), conversion to multifamily, and the addition of ancillary dwellings were developed using the KoP.

Consistent with the RFP Program Requirements, a peer-reviewed paper was written and presented at PHRC's annual Residential Building Design and Construction Conference in February 2014. Project funding has primarily supported student researchers, including an architectural graduate student for the 2013-2014 academic year, two undergraduate research assistants on wage-payroll, and sponsorship of twelve (12) Energy Engineering students working on two College of Engineering Learning Factory capstone teams.

The team is grateful to PHRC and the Industry Advising Council for the generous support of this project. 2013-2014 seed funding from PHRC has been successfully leveraged, with the Hamer Center for Community Design supporting continuing work on the KoP concept during the 2014-2015 academic year.

4. Stormwater BMP Effectiveness in Real Residential Developments

Description: 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. The duration of the project is dependent on annual climate conditions and the continued interest and funding in the research.

The 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. 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.

The long-term goals of this project are to define the pollutant load from residential developments, and define the effectiveness of different BMPs and treatment trains (BMPs in series).

Manager/PI: K. Blansett

Report: This project has been moved to the category of contingency projects. In September of 2013 a bill was proposed in the Pennsylvania Senate (SB 1023) that would reduce PHRC funding. As of August 2014, this piece of legislation is still active in the PA House Labor and Industry Committee. The large equipment purchase needed to move forward with the project was placed on hold because of the need to reassess the budget. The feasibility of the project will be reassessed when the status of funding is more definite.

5. Prototype of an Architectural Light Therapy System to Promote Successful Aging in Place

Description: 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.

Manager/PI: Dr. Kevin Houser (Department of Architectural Engineering)

Report: Full physical realization of the *Architectural Light Therapy System* has been achieved, which comprises a customizable 5-channel (i.e., red, green, blue, cool white, warm white) color changing architectural lighting system and a custom lighting control interface.

The lighting hardware includes thirty-seven individual color-changing lighting fixtures from Philips Lighting. Five are employed for accent lighting. The other 32 were grouped and enclosed in five custom-built luminaires created with aluminum housings and acrylic diffusing panels.

Lighting control is achieved via a touch-panel controller from Pharos Architectural Controls. A custom interface was designed with the following defining goals:

1. To be user-friendly
2. To provide high customizability in an intuitive manner
3. To present the user with simple architectural presets—typical of a residential system—that can be edited via the interface
4. To offer a simple interface for an intelligent system that is photobiologically enhanced

In addition to the lighting, the space is furnished as a typical residential living room (e.g., couch and chair, coffee and end tables, bookshelf/TV stand).

Photometric measurements were performed at a position in the room corresponding to where an occupant would sit on the couch and look forward. These measurements are representative of the luminous conditions in the space as experienced by an occupant. Separate measurements were taken for each of the five channels at a sufficient number of dimming levels to permit reconstruction of all possible combinations via simulation. A tool was developed in Microsoft Excel to analyze and quantify the photometric and photobiological conditions that can be delivered by the lighting system.

A manuscript is under development. It will document the design and construction of the prototype system and its photometric and photobiological potential.

PART 3 - Applied Projects

These groups of projects are application oriented and have a direct need by the residential construction industry. This includes the development and support of standards, and longer term initiatives.

I. Moisture Management in Homes

Description: Moisture damage to home incurs unwanted repair costs to homeowners and potential health hazards if left untreated. Although there is a considerable amount of information about waterproofing and use of vapor barriers and flashings, water damage to basement walls due to rain on basement windows (without proper and reliable well cover protection), water damage to above grade walls due to window failure/malfunction, water damage to floors and ceiling drywall due to overflow of bathroom toilet or tub are common occurrences. In this study, sources of water damage will be identified and, where needed, new concepts such as basement window solutions or bathroom waterproofing ideas will be developed. In particular, the existing monitoring and sensor technologies will be reviewed and potential applications for homes to detect intruding moisture and alarming the homeowner of potential problems will be explored.

Manager/PI: Memari

Report: The project has made very good progress and is nearly 70% complete. Extensive literature review has been carried out, which has helped identify all types of moisture-related damage, causes, and some corrective/preventive measures. A case study has been reviewed that consists of major commonly experienced moisture related problems in a typical PA home. A design has been developed to prevent rain-related moisture to enter basement windows that open to window wells. Moisture detection and sensor technologies have been identified for use in homes, and a comprehensive review of available technologies is underway. Such technologies are developed to detect leaks from failure of appliances that use water, and if they appear near windows, in basements, or under plumbing, and alert the homeowner for quick response. The project is continuing and is expected to be complete before the end of the year.

2. Details that Work

Description: New construction practices create a need for new and innovative details for contractors and sub-contractors to ensure proper installation. These necessary details encompass a wide range of scenarios starting from the footing level through shingles. This project will review critical details, which include controlling bulk water through proper flashing, moisture control, proper insulation, and controlling air infiltration, particularly at problem areas like penetrations. These details will help ensure code compliance as well as increase the durability and sustainability of the structure.

Manager/PI: Hine

Report: Several details related to flashing for water management have been completed. The completed details are available for download in PDF form from the PHRC website. Details that Work will become an ongoing project with new categories of details added each year.

3. Support of the UCC RAC

Description: The International Code Council's (ICC) code development process will finish in October of 2013, and the 2015 I-codes will be published during 2014. Pennsylvania's Uniform Construction Code (UCC) Review and Advisory Council (RAC) will most likely begin their task of reviewing new code provisions and voting for or against their adoption in PA in 2014. Once the results of the final ICC hearings are published, the PHRC will begin to review the documentation and summarize new code provisions and highlight the ones deemed to be most significant. The PHRC will continue to support the RAC through comprehensive analysis of proposed code changes, as well as serving as a general technical resource upon request.

Manager/PI: Wolfgang, Blansett

Report: The PHRC has continued to attend RAC meetings, as well as monitor legislation associated with changes to RAC procedures (particularly SB 1023). The PHRC will continue to be available as a technical resource as deemed necessary by RAC leadership.

The PHRC will develop a summary of new code provisions, as well as provide education to the RAC and the public regarding proposed code updates.

4. Update of Manufactured Housing Briefs

Description: The manufactured housing industry provides installation manuals with every house it produces. Those manuals provide instructions for the onsite completion of the home, including acceptable foundation design and construction practices. Two previously published PHRC Technical Briefs (TB0101 and TB0201) were developed to provide supplementary guidance to the manufactured housing industry regarding various site design considerations relevant to PA. The PHRC will review current manufactured housing industry practices and technology in order to update the previously published briefs to current state of the art.

Manager/PI: Wolfgang

Report: The PHRC has developed a new Builder Brief format and layout. This updated template was used to publish updated versions of the Soil Freeze Guide and Site Design Considerations briefs related to manufactured housing. The update was requested by DCED and the updated content took into consideration feedback from DCED. Updated briefs are published on the PHRC website and are available in print per request.

5. Location and Land Areas for Buffers on High Quality and Exceptional Value Streams

Description: Recent and proposed regulation and policy updates are relying heavily on stream buffers as a major tool in protecting water quality, particularly in High Quality (HQ) and Exceptional Value (EV) watersheds. Some areas of the Commonwealth have a much higher density of HQ and EV streams than other areas. In addition to affecting many traditional land development projects, the new regulations and policies can affect single-lot home builders. Single-lot builders have not traditionally needed to be concerned with knowing in which watershed they are building, obtaining stormwater permits, or designating and planting stream buffers. This project will use GIS data to map the location of HQ and EV streams in Pennsylvania to assist in determining if a location is within an HQ or EV watershed. The location and amount of area needed for a 150 foot stream buffer will also be determined for all HQ and EV streams.

Manager/PI: Blansett

Report: A technical report entitled “Summary of Stream Buffer Requirement and Geographic Distribution of Buffers for Exceptional Value and High Quality Streams in Pennsylvania” was published in August 2014. This report includes a short summary of the regulations and policies that require a stream buffer, as well as tables that highlight the length of EV/HQ stream miles and area of land in an EV/HQ stream buffer in each county. The report also includes county by county maps of the EV/HQ designated streams in the Commonwealth. The report is available for download from the PHRC website.

6. OSHA Residential Construction Compliance Recommendations

Description: Various levels of government oversight have taken a more predominant role in the current residential construction industry with differing levels of compliance on the part of builders and contractors across the state. The PHRC will investigate the most effective means of communicating OSHA compliance strategies to builders and contractors. Based on the results of this research, the PHRC will use various forms of media to delivery this material both online and in-person to increase awareness of OSHA regulations and compliance procedures.

Manager/PI: Hine

Report: A webinar highlighting the OSHA fall protection regulations was given on November 12, 2013 and a one page graphic laminated handout was created for distribution to field workers. This graphic shows major fall protection areas and how to comply with OSHA’s requirements. The fall protection handout has been distributed at several PHRC events including the Annual Conference and the Spring PBA Board meetings. A PDF version of the handout is available on the PHRC website.

7. Support of Standards

Description: 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, and contractors. All of these standards are available electronically for free and hard copies are available for a fee.

Manager/PI: Blansett, Wolfgang

Report: The PHRC frequently fields phone calls from building code officials and builders regarding the PHRC standards that are available on the internet. Also, these standards, specifically the *PA Alternative Residential Energy Provisions*, were included in other training programs such as Introduction to Building Science and various building science related speaker services. K. Blansett was a guest speaker on the *Subdivision and Land Development Guidelines for Pennsylvania* in May as part of the Penn State Ag Extension Land Use webinar series.

PART 4 - Proposals & Contracts

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 2013-2014 project year. Several other smaller proposals were also submitted and some are under review/negotiation but those not are reported here.

The following research proposals were submitted during this reporting period.

- Department of Housing and Urban Development (HUD), “Innovative Technological Guidelines for HUD’s Physical Building Inspections Program: Fresh Expert Advice to Improve the Quality of Public Housing Facilities” – submitted October 2013
- National Science Foundation (NSF), “A Lifecycle Structural BIM Platform for Modular Construction” – submitted October 2013 (\$473,003)
- National Science Foundation (NSF), “PT-SIPs for Tornado-Resistant Low-Rise Construction” – submitted February 2014 (\$509,688)
- Grace Woodward Grant for Collaborative Research in Engineering and Medicine, Penn State College of Engineering and Hershey College of Medicine, “Development of Approaches to Minimize the Effect of the Home Environment on Allergy-Asthma/Irritation Side Effects in Elders” – submitted April 2014 (\$50,000)

PART 5 - Act 157 Funds

Table 3 summarizes the total funds received and utilized for Project Year 2013-2014. As authorized by Act 157 of 2006, these funds were collected through a \$4 fee on every building permit issued in the Commonwealth, and are dispersed through the Department of Community and Economic Development. PHRC receives 50% of the collected permit fees minus a 7.5% administrative fee. Funds for the 2013-2014 Project Year are based upon funds received from July 2012-June 2013.

Table 3. Summary of Act 157 Funds received during the 2012-2013 fiscal year used for the 2013-2014 PHRC Project year.

Collection Period	Amount Received
Q3: July 2012 - September 2012	\$129,981.46
Q4 October 2012 - December 2012	\$101,658.89
Q1: January 2013 - March 2013	\$129,882.95
Q2: April 2013 - June 2013	\$69,504.50
Total	\$431,027.80