

PORTFOLIO

SCHOLARSHIP OF RESEARCH &
CREATIVE ACCOMPLISHMENTS

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Application for Tenure and Promotion

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INTRODUCTION

NARRATIVE STATEMENT

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It is widely acknowledged that, in this resource-constrained world, a paradigm shift needs to occur in the way that we approach the design of our built environment. In order to transform established patterns an architect must be visionary, understanding technical advances and bringing artistic energy to the practical aspects of design. My education in architecture and urban design provides me with the background to address these issues at multiple scales, from comprehensive planning to building detail. Simultaneously, responsible design must consider real constraints and foster social equality through affordable solutions. Central to this vision is multidisciplinary collaboration and teamwork; I highly value the benefits that this cooperation provides, and strive to seed this value in others. The research selected for inclusion in this portfolio demonstrates these two themes: Part 1 presents four residential projects and related publications that demonstrate my dedication to establishing contextually appropriate solutions for housing and communities that are viable and affordable in the long and short term. Part 2 shows a few recent examples of new courses and programs that I have dedicated significant effort to in the interest of fostering meaningful, progressive collaboration.

Part 1: Publications & Projects, Selected Work 2006-2011

My research and creative work pushes the bounds of conventional models to investigate much needed affordable and sustainable strategies. To achieve this goal consideration at multiple scales - including urban, community, building and detail - is necessary. This work, organized chronologically from most recent, demonstrates this intention.

A recent article, *Design Strategies for Community-Scale Renewable Energy Solutions* (Iulo, Haksar, Blumsack, 2011), reports on the first phase of research that has grown out of a realization that effective solutions must be looked at as collective and inter-related systems. This research considers strategies, policies and financial models for renewable energy production and distribution that will financially benefit local communities. Leveraged by a unique collaboration with a co-investigator whose background is in energy engineering and economics and the generous support of a grant from the Penn State College of Arts and Architecture, the intention of this research is to develop interactive best-practices guidelines through high-dimensional visualization information that integrates built physical form with economic, regulatory and policy-relevant implementation factors.

Union County Housing Authority's Energy Efficient Housing Program (EEHP) expands the common mission of most housing authorities to thread short and long-term affordability into their housing model by accounting for the ongoing cost of energy during construction and in the expenses carried by future homeowners. As Sustainable Design Specialist on this project, working with Office for Planning and Architecture (OPA) and energy expert Peter Vargo, I organized public participation and design charrettes and worked closely with the team to design the retrofit of two existing homes (currently under construction) and the award winning *EEHP Duplex housing* project presented herein. These homes comply with or greatly exceed ENERGY STAR standards and, to meet the needs of the "Prime Time" (age 55+) income eligible homebuyers accommodate aging in place. Modular construction significantly reduced the up-front project costs of the new duplex housing. Based on my work on the EEHP Duplex and other projects that implemented modular construction, I was invited to reflect on the benefits of this construction in facilitating energy-efficient building as a guest author for a forthcoming book entitled *High Performance Homes, Their Design and Construction: New Materials, Renewable Energies and Integrated Practice* (edited by Franca Trubiano, London: Routledge).

Another example of my work exploring the energy conscious renovation and retrofit of existing buildings and community-centered design, is reflected in the paper "*Low Energy Architecture / Low Energy Living: Strategies for Passive Design at the Urban and Building Scales*" (2009). This project and the related publication articulates a necessary nesting of scales that addresses revitalization of our existing towns and housing stock in a sustainable, energy-efficient manner.

Perhaps my proudest accomplishment to date has been my involvement with the University-wide Solar Decathlon teams. As a Faculty Advisor/Principle Investigator to the 2007 Penn State Solar Decathlon team I co-advised students on the design of the project, coordinated these efforts with the larger interdisciplinary team (more than 900 Penn State students, faculty and staff participated), supervised student team leaders, contributed original research, and participated in the design and construction of the MorningStar homes-*MorningStar Pennsylvania*, Penn State's entry to the 2007 NREL Solar Decathlon, and *MorningStar Montana*, the affordable prototype home for the Northern Cheyenne Indian Reservation in Lame Deer, Montana. Reflection on the 2007 Solar Decathlon provided insight for me to counsel the 2009 *Natural Fusion Solar Decathlon* team on research and design as an "Architecture Advisor". This effort resulted in model homes for residential scale application of energy-efficient construction methods and cutting-edge solar design; additionally they served as a case study for the integration of sustainability into architectural education. I have disseminated research and reflections related to the Solar Decathlon beyond the initial success of the project. Publications include a peer-reviewed article "*The MorningStar: A Hybrid Concept for Community Building and Renewable Energy*" (Iulo, Riley, 2009).

Most of the projects fall under the category of what I have termed "transparent" approaches to green affordable housing. Transparent refers to improvements in the building methods, materials and quality of living in the spaces created that are conscientious of finite resources and environmental impact, but generally fit into the accepted norm for housing. Providing model projects that are not viewed as significantly different or experimental is important when designing affordable housing. Principles behind this transparent approach are embodied in the AIA Merit Award for Excellence in Design winning project *Petersburg Commons*. This project has been recognized as the Commonwealth of Pennsylvania's first affordable "green" housing. Petersburg Commons is further described, and compared to another project with more aggressive green strategies, in the paper "*Affordable Housing – Transparent vs. Transformative Approaches*" (Iulo, Quigley, 2007).

Part 2: Fostering Collaboration

My dedication and leadership in promoting collaboration, especially between disciplines, has been widely recognized across campus and professionally. Several projects where I served as Sustainable Design Specialist, facilitating research on sustainable design, leading collaborative interdisciplinary projects, and contributing significantly to the design of the projects have been recognized with prestigious juried professional awards. In recognition of my accomplishments in interdisciplinary research at the Pennsylvania State University, I recently (January 2011) received a significant award from Penn State Institutes of Energy and the Environment (PSIEE). I have been invited to speak at several symposia and conferences on topics related to interdisciplinary education.

As a founding member of the Penn State Department of Architecture's Committee for Environmentally Conscious Architecture (CECA) I am studying methods for integrating the teaching of environmentally conscious design in the architecture curriculum. In October of 2009 I co-organized a symposium, *Environmentally Conscious Design – Educating Future Architects*, to explore precedent programs and implementation strategies for "greening" the curriculum at Penn State. Initial findings from this symposium are reported on in the related paper "*Innovation in Education: Implementing Environmentally Conscious Design in the Architecture Curricula*" (Iulo, Poerschke, 2010).

In teaching I endeavor to cultivate an attitude where adaptive, collaborative learning is a lifelong approach. This commitment has lead me to dedicate significant time to the development of new coursework. The cross-listed, co-instructed course *Collaborative Seminar on Sustainable Design: Sustainable Design Strategies and*

Solutions (Arch 497: Integrative Energy and Environmental Design) is the first of its kind in the H. Campbell and Eleanor R. Stuckeman School of Architecture and Landscape Architecture at Penn State. It grew out of grass-roots demand from students and I first taught it as an independent study in 2009. Since then I have been developing the course and instructing it each spring semester. Periodic surveys and semester-end reviews indicate that this class has been well received by the participants, mostly architecture, landscape architecture and architectural engineering majors.

Relationships forged with the Department of Architectural Engineering (AE) and the College of Earth and Mineral Sciences (EMS) through the 2007 & 2009 Solar Decathlons have resulted in several collaborative research projects to investigate sustainable technologies and material integration in residential construction. I am working with the 2009 Solar Decathlon project team leader Jeffrey Brownson and another colleague from the Department of Material Sciences, R. Allen Kimel, to look at opportunities for multidisciplinary projects beyond the limited focus of the NREL competition. These efforts include developing the “*Living with Sustainable Energy in a Global Society*,” class. Participants in this interactive course and immersive study abroad experience included students in eight different disciplines from the colleges of Arts and Architecture, Engineering, and Earth and Mineral Sciences (including Human Geography). Since 2009 we have adapted this class to serve as the capstone requirement for a new Bachelor of Arts in Energy, Business and Policy and it was recently adopted as a permanent course listing at Penn State. We are continuing to actively seek funding for projects and hands-on educational experiences that will benefit the University and surrounding communities, both locally and abroad. Some of these opportunities include engaging students in previous research and creative work. For example a student team is performing ongoing monitoring of energy use at the EEHP Duplex and eventually the two retrofit projects. This five-year project will yield information valuable to improving the design for future homes built by the Union County Housing Authority and in providing information about the benefits of energy-efficient housing to the homeowners and the general population (through a dedicated project website and Facebook networking page). Last semester a group of undergraduate students collaborated on a study and report of the Life Cycle Assessment (LCA) of the building envelope products and materials selected for the retrofit of the existing homes. Of course the integrated nature of the Solar Decathlon itself- bringing together multiple research endeavors, diverse disciplines and specific lessons – lead to significant educational opportunity in its own right. In pursuing these projects I co-developed several related courses, open to students from different disciplines, in sustainable building strategies, residential design and construction, and construction management.

The final article selected for inclusion in this portfolio directly relates my interests in improving residential construction and encouraging collaboration in reaching mutually beneficial end goals. *Energy and the Integrative Design Process – Defining the Team of Experts*, another chapter for the book *High Performance Homes, Their Design and Construction: New Materials, Renewable Energies and Integrated Practice* (edited by Franca Trubiano, London: Routledge, forthcoming), compiles information about emerging energy professions, their expertise, and the benefits that integrative team involvement provides in reaching high performance building objectives. This chapter will provide valuable information to professionals and the interested public alike.

Broadly disseminating my research and related creative work to diverse audiences allows me to meaningfully contribute to the emerging field of environmentally conscious design and planning for energy-efficiency and renewable energy. My research and creative accomplishments are proving to be important models for affordable housing. For the sake of brevity and continuity, the work included in this portfolio is representative of the two related themes that are consistent in all of my work. My Curriculum Vitae (CV), included in this document, provides a more complete picture of my accomplishments to date and my balanced commitment to all areas of academic scholarship – teaching and learning, research and creative accomplishments, and service to the Pennsylvania State University, society and building professions.

CURRICULUM VITAE

EDUCATION AND CREDENTIALS

City College of New York School of Architecture and Environmental Studies
Master of Urban Planning, 2002, 4.00/4.00 GPA

New York Institute of Technology School of Architecture and Design
Bachelor of Architecture, 1995, cum laude

Professional Credentials

LEED™ Accredited Professional, nationally recognized (2006)

Licensed Professional Planner, State of New Jersey (2003)

Registered Architect, Pennsylvania (2010), New Jersey ('02), New York ('01)

National Council of Architectural Registration Boards (NCARB) Certified

SCHOLARSHIP OF TEACHING AND LEARNING

Academic Appointments

The Pennsylvania State University, Assistant Professor, 2006-present

Member of the Graduate Faculty, 2008-present

Instructor, 2003-2006

Graduate student advisor, 2008-present

Fifth-year design studio thesis advisor, 2010-2011

Fourth-year urban design studio, 2007-2010; coordinator 2007-2010

Graduate Design Studio, Fall 2007; Spring 2009

Architectural Design and Research for AE majors, 2004-2006, 2008;

Spring Semester coordinator 2004-2006

Second-year design studio, 2003-2007

Visual Communications I & II, 2003-2005; coordinator 2003-2005

New course development:

Collaborative Seminar in Integrative Energy & Environmental Design,
2009-2011

Solar Home Design and Integration, Spring 2008

Design-Build Solar / Green Solar Construction, Spring & Fall 2007

Prefabrication and Preassembly, Spring 2007

neXt House - Small, Affordable, Sustainable, Spring 2006

University-wide new course development:

Living with Sustainable Energy in a Global Society, 2009-2010. Interdisciplinary course investigating the technology, science, planning and policy necessary for realizing a reduced-carbon future. 3-part course included a summer trip abroad (see below). Course adopted as capstone for new BA in Energy and Sustainability Policy degree program.

Educational trips abroad coordinated & instructed:

CAUSE: *Living with Sustainable Energy in a Global Society* (see course description above) immersive travel abroad experience. 15-day travel to Germany and Paris in May 2009 to visit research institutions, projects, and case-study applications of renewable energy generating technology.

Courses developed and instructed in support of outreach-based programs:

Penn State Architecture / Landscape Architecture Summer Camp,
2004-present

New York Institute of Technology, Adjunct Professor, 2000- 2003

First-year design fundamentals studio

Second-year architectural design studio

Courses & Presentations dedicated to Teaching Excellence

The Penn State Course in College Teaching Schreyer Institute for Teaching Excellence 8-week seminar, Spring 2009, participant.

Teaching Sustainability Across the Curriculum presentation and panel discussion on *“Disciplinary Approaches to Environmental Inquiry,”* Schreyer Institute for Teaching Excellence, April 2009, invited presenter.

Graduate Student Advising – Primary Advisor

Emily Denhoed, Master of Architecture, “Urban Co_Evolution: The Architectural Linkages Between people and Ecology,” completed Spring 2009

Graduate Student Advising – Committee Member

Neeraj Chatterji, Master of Architecture, “Investigation of the Energy Footprint of Multi-layered Façade Systems,” 2011-present

Kristen Segasser, Master of Architecture, “Aging in Place in Suburbia: A Concept for Multiple Generations,” 2011-present

Jian Gong, Master of Architecture, “Developing a Zero Carbon Community at Shanghai World Expo Park,” 2010-present

Ashley L. Wisse, Graduate thesis in Architectural Engineering, “Process-Based Policy Development for Sustainable Implementation on Pennsylvania State University Renewal Projects,” completed Summer 2010

Suhas Bambardekar, Master of Architecture, “An Investigation into the Methods to Facilitate Understanding of the Use of Energy Simulation Programs by Architects in the Early Design Stage,” completed Spring 2010

Kaustav Gupta, Master of Architecture, “Towards Sustainable Design – The Excluded Issues: LEED Rating System in India,” completed Fall 2009

Gina Marie DeLeon, Master of Architecture, “Hurricane Katrina Aftermath and Post Disaster Construction: Towards a Self-Generative Society,” completed Spring 2008

Teaching Honors

2009 Architecture Faculty Marshall, Penn State College of Arts and Architecture Undergraduate Graduation Ceremony, May 2009

SCHOLARSHIP OF RESEARCH AND CREATIVE ACCOMPLISHMENTS

Publications

Iulo, Lisa D. “Energy and the Integrative Design Process – Defining the Team of Experts.” In *High Performance Homes, Their Design and Construction: New Materials, Renewable Energies and Integrated Practice*, ed. Franca Trubiano, (London: Routledge, forthcoming), Part 3.

Iulo, Lisa D. “Modular Building – Three Scales / Three Strategies.” In *High Performance Homes, Their Design and Construction: New Materials, Renewable Energies and Integrated Practice*, ed. Franca Trubiano (London: Routledge, forthcoming), Part 4.

Lulo, Lisa D., Haksar, R.R., and Blumsack, S. "Design Strategies for Community-Scale Renewable Energy Solutions," Proceedings of the 27th International Conference on Passive and Low Energy Architecture, Louvain-la-Neuve, Belgium, July 13-15, 2011 (forthcoming): 6 pages.

Lulo, Lisa D. and the Committee for Environmentally Conscious Architecture, *Environmentally Conscious Design: Educating Future Architects: Whitepaper*, The Pennsylvania State University Department of Architecture (2011): 30 pages.

Staub, Alexandra and Lulo, L.D. "User-Participation and the Design Charrette: A Systematic Approach to Furthering Design Process," Proceedings of 2011 Architectural Research Centers Consortium (ARCC) conference, *Considering Research: Reflecting upon current themes in Architectural Research* (2011): 305-313.

Lulo, Lisa D. "Landscape and Architecture: An Integrated Network – Humanized Landscape for Downtown Brooklyn." *Design Research 1*, no. 1 (2011): 55-60.

Lulo, Lisa D., Blumsack, S., Brownson, J.R.S., and Kimel, R.A. "Potential and Implementation Strategies for Renewable Energy in the Planned World," *Interdisciplinary Themes Journal 2.1* (2010): 16 pages.

Lulo, Lisa D., and Poerschke, U. "Innovation in Education: Implementing Environmentally Conscious Design in Architecture Curricula," Proceedings of the 6th International Conference on Innovation in *Architecture, Engineering and Construction (AEC)*, ed. C.J. Anumba and others, Loughborough University, UK (2010): 487-496.

Brownson, Jeffrey, R.S., and Lulo, L.D., "Upsetting the Balance Beam: System Integrative Photovoltaics as purposeful manipulation of energy demand and microclimate in the built environment," Proceedings of the American Solar Energy Society (ASES) annual conference (2010): 7 pages.

Lulo, Lisa D. and Brownson, J.R.S., "SEED/ CATALYST: Collaborative and Cross-Disciplinary Education in the Penn State Solar Decathlons," Proceedings of the American Solar Energy Society (ASES) annual conference (2010): 6 pages.

Lulo, Lisa D., and Bertomen, M. C., "Green Foundations: A framework for responsible design," Proceedings of the 24th National Conference on the Beginning Design Student (2009): 10 pages.

Lulo, Lisa D., "Low Energy Architecture / Low Energy Living: Strategies for Passive Design at the Urban and Building Scales," Proceedings of the 26th International Conference on Passive and Low Energy Architecture, *Architecture, Energy and the Occupant's Perspective*, ed. Claude Demers and Andre Potvin (2009): 33-38.

Lulo, Lisa D. and Riley, D., "The MorningStar: A Hybrid Concept for Community Building and Renewable Energy," Proceedings of the American Solar Energy Society (ASES) annual conference (2009): 8 pages.

Denhoed, Emily R. and Lulo, L.D., "The Value of Collaborative Design: Urban Revitalization Through Community Invited Events," Proceedings of the 97th Association of Collegiate Schools of Architecture (ACSA) Annual Meeting, *The Value of Design: Design is at the core of what we teach and practice*, ed. Phoebe Crisman and Mark Gillem (2009): 700-708.

Lulo, Lisa D., "Hybrid Prefabrication: prototypes for green residential construction," Proceedings of the 2008 ACSA Northeast Fall Conference, *Without a Hitch- New Directions in Prefabricated Architecture*, ed. Peggi Clouston, Ray Kinoshita Mann, and Stephen Schreiber (2009): 260-268.

Lulo, Lisa D., "Confronting the Hitch: Prefab in the Classroom, respecting roles, ideas and each other," Proceedings of the 2008 ACSA Northeast Fall Conference, *Without a Hitch- New Directions in Prefabricated Architecture*, ed. Peggi Clouston, Ray Kinoshita Mann, and Stephen Schreiber (2009): 270-275.

Memari, Ali M., Grossenbacher, S.V., and Lulo, L.D., "In-plane and Out-of-plane Load Testing and Evaluation of Sustainable Masonry Walls," Proceedings of the Architectural Engineering Institute of the American Society of Civil Engineers (AEI), *Building Integration Solutions* (2008): 10 pages.

Memari, Ali M., Grossenbacher, S.V., and Lulo, L.D., "Structural Testing of High Thermal Mass Walls Used in Sustainable Designs," Proceedings of the Structures Congress, *Sustainability for Structural Engineers: Strategies, Paradigms and measurement*, ASCE Press (2008): 9 Pages.

Lulo, Lisa D., "Leading by Doing at the 2007 Solar Decathlon", AIA Middle Pennsylvania newsletter (January-February 2008): p. 1, feature story.

Avalon, Nelsa, Lulo, L.D., and Riley, D., "Real-World Education," *Design-Build DATELINE* special topics issue: Sustainability and Design-Build, Volume 14, Number 10, October 2007, 34-40.

Lulo, Lisa D., Quigley, B.L., "Affordable Housing – Transparent vs. Transformative Approaches," Proceedings of the American Solar Energy Society annual conference (2007): 8 pages.

Lulo, Lisa D., LaCoe, J., "EX TEMPORE 'Out of Time'," Proceedings of the 2005 ACSA SW Regional Conference- *IMPROVISATION*, ed. Geoff W. Gjertson (2006): 123-130.

Bertomen, Michele C., Cohen, E., Lulo, L.D., "Casa del Sol/FUTURE CITY; An Ecology that Sustains," Proceedings of the ACSA International Conference, *Contribution and Confusion: Architecture and the Influence of Other Fields of Inquiry* (2003): 42-51.

Creative Accomplishments – original works of architecture & design (selected)

Union County Housing Authority Energy Efficient Housing Program

Sustainable Design Specialist and designer with Office for Planning and Architecture (OPA), Harrisburg, PA.

Energy-efficient retrofit of an existing residence, Lewisburg, PA, 2011

Energy-efficient retrofit of an existing residence, Mifflinburg, PA, 2011

Model affordable duplex housing, Lewisburg, PA, 2010

Village Acres Farm, Mifflintown, PA, under construction

Development of passive solar and renewable energy design strategies for New Food Center Building and Village Acres Master Plan; assisting with fundraising and outreach.

Hyde/Sheridan Residence, Carlisle, PA, 2009

Sustainable Design Specialist and designer with OPA for the retrofit of an 1841 row house for energy-efficiency and passive solar design.

Bedford Mews, Carlisle, PA, ongoing

Designer with OPA for a 20-unit green community.

Schematic Design, ongoing

Planning and zoning amendment drawings, 2008

Petersburg Commons, Duncannon, PA, 2006

Project Designer with OPA for "Pennsylvania's first Affordable Green Housing".

Lisa D. Iulo, Architect, Principal, Jersey City, NJ, 2002-2003

Hollander Residence, addition to a historic townhouse, not realized.

Southern Gateway Innovative Urban Infrastructure Project, Harrisburg, PA,

Project Architect/ Design consultant to OPA; contributed to project

research, design, and public participation leadership, August 2001- 2003

Brooklyn Architects Collective (BAC), Designer, Brooklyn, NY, 1999-2002

Loft conversion / renovation, 45 Beekman Street, New York, NY, 2001

"World Trade" group exhibition- Roebling Hall Gallery, Brooklyn, NY, 1999

Hell's Kitchen South urban design strategies, invited designer, 1999

The Hillier Group Newark Regional Office, Designer, Newark, NJ, 1998-1999

Urban Renewal Study for the City of Newark, NJ, 1999

Creative Accomplishments – Competitions & Exhibitions

THE GREEN HOUSE Design Charrette, sponsored by the Ideas Institute, 2008 (with Greg Olsen, Landscape Architect / Patina Care). Jury recognized for design excellence; One of 12 projects selected for exhibition at the American Association of Homes and Services for the Aging conference, Philadelphia, PA, October 10-15, 2008.

Natural Fusion solar home exhibited on the National Mall for the 2009 U.S. Department of Energy National Renewable Energy Laboratory (NREL) international Solar Decathlon competition, Washington, DC, October 9-25, 2009.

MorningStar Pennsylvania solar home exhibited on the National Mall for the 2007 NREL international Solar Decathlon competition, Washington, DC, October 11-20, 2007.

"Campus Camping: An Architectural Viewpoint" (with Jodi LaCoe) poster exhibition at the 2006 Outreach Scholarship Conference, *Engagement Through The Disciplines*, Columbus, OH, October 8-10, 2006.

"Three Recent Competitions: Woven Landscapes", New Faculty Exhibition, The Pennsylvania State University Department of Architecture, Spring 2004

Density - Reinventing the Urban Village, international development ideas competition sponsored by the Boston Society of Architects (BSA), 2003.

“LEEP- Study for Ecological Planning & Responsible Building,” competition submission selected for The HOME House Project National Tour traveling exhibition (one of 50 out of 440 entries), Spring 2003-2007. Venues for exhibition included (selected): Southeastern Center for Contemporary Art (SECCA), Winston Salem, NC; Contemporary Arts Center (CAC), Cincinnati, OH; Baltimore’s Center for Visual Art and Culture; El Paso Museum of Art; Fredrick R. Weisman Art Museum, University of Minnesota; Plains Art Museum, Fargo, ND; Cleveland Institute of Art; New York School of Interior Design.

HOME/House Project, sponsored by SECCA & Habitat for Humanity, 2003. Jury recognized. Project team acknowledged in book The HOME House Project: The Future of Affordable Housing edited by David J. Brown (MIT Press, March 2005).

Dead Malls open ideas competition sponsored by L.A. Forum for Architecture and Urban Design (w/ Bruce Quigley), 2002.

“Local Community, Global Marketplace” Sunset Park, Brooklyn, strategies for SWBIDC, 2000. Ideas competition for community development and marketplace in the Sunset Park neighborhood of Brooklyn, NY. Project exhibited at opening reception, July 2000.

Martin Luther King Jr. Memorial Competition. Two-part international competition to design a memorial adjacent to the Tidal Basin in Washington DC (with BAC). Initial design selected from over 800 entries; Design team invited by the competition organizers for Phase 2 project refinement, 1999.

“Ekistics: Urban Design Strategies for Hell’s Kitchen South”, original design work (with BAC) exhibited at Storefront for Art and Architecture, New York, NY, November 18-December 23, 1999.

Published Creative Work

Petersburg Commons project profile, Enterprise Foundation Green Communities High Performance Building Database. www.greencommunitiesonline.org/projects/profiles.

Hell’s Kitchen South; Developing Strategies, Design Trust for Public Space with Hell’s Kitchen Neighborhood Association, by Michael Conard and David Smiley (Faith & Hassler, Stockholm, Sweden, 2002): 112, 113, 139-141, 152-153, co-designer of published project.

“Urban design studio explores design for Ground Zero enclosure,” *Architectural Record*, December 2001. Design project published.

“Figure/Fabric: Process/Production”, *Journal of Architectural Education*, volume 54, number 4, May 2001. Contributed to layout; design work published.

Martin Luther King Jr. Memorial, *Competitions*, Winter 2000/2001. Award winning international conference submission published, co-designer with BAC.

Martin Luther King Jr. Memorial, *Oculus Magazine*, November 2000.

Urban Design Strategies for Hell’s Kitchen South, *Oculus Magazine*, October 1999.

Urban Design Strategies for Hell’s Kitchen South, *Metropolis Magazine* February/March 2000.

Lectures and Presentations

“User-Participation and the Design Charrette: A Systematic Approach to Furthering Design Process,” presented (w/ Alexandra Staub) at the 2011 ARCC conference, *Considering Research: Reflecting upon current themes in Architectural Research*, Detroit, MI, April 21, 2011.

“Potential and Implementation Strategies for Renewable Energy in the Planned World,” presented at *The Planned World: Urban, Rural, Wild* international conference, Vancouver, BC, Canada, August 05, 2010.

“Collaborative Effort, An Educational Experience,” presented at *The Planned World: Urban, Rural, Wild* international conference, Vancouver, BC, Canada, August 05, 2010.

Breaking Boundaries / Making Connections: Collaboration in the Arts, Humanities, and Design, College of Arts and Architecture Symposium on collaboration and interdisciplinarity, panel discussion on “Facing the Barriers and Understanding Our Disciplinary Diversity: Bridging Disciplinary Methodologies,” November 12, 2010. Invited panelist.

“Innovation in Education: Implementing Environmentally Conscious Design in Architecture Curricula,” presented (w/ Ute Poerschke) at the *6th International Conference on Innovation in Architecture, Engineering and Construction (AEC)*, the Pennsylvania State University, June 9, 2010.

“SEED/ CATALYST: Collaborative and Cross-Disciplinary Education in the Penn State Solar Decathlons,” presented at the *American Solar Energy Society (ASES) national conference*, Phoenix, AZ, May 17-22, 2010.

“Living with Sustainable Energy in a Global Society – Speaking a Common Language,” presented at the Society of Building Science Educators annual retreat, June 24-27, 2009, Quebec City, Canada.

“Low Energy Architecture / Low Energy Living: Strategies for Passive Design at the Urban and Building Scales,” presented at the 2009 Passive Low Energy Architecture (PLEA) Conference, City, Canada, June 21-24, 2009.

“The MorningStar: A Hybrid Concept for Community Building and Renewable Energy,” presented at the 2009 American Solar Energy Society annual conference, Buffalo, NY, May 12-16, 2009.

“Confronting the Hitch: Prefabrication hits the classroom,” presented at the American Collegiate Schools of Architecture (ACSA) Northeast Regional Conference, University of Massachusetts, Amherst, MA, September 25-27, 2009.

“What is a Green Building: Focus on Green Homes,” Green Building Initiative seminar hosted by Sunrise Homes, Boalsburg, PA, July 12, 2008. Invited presenter.

“Green Foundations: A framework for responsible design,” presented (w/ Michele Bertomen) at the 24th National Conference on the Beginning Design Student, *We Have Never Been Pre-Disciplinary* Conference, panel on Sustainability and Beginnings, Georgia Institute of Technology, Atlanta, GA, March 13-16, 2008.

“Eco-literacy and Architectural Education,” presented at the Penn State Department of Architecture *Under Construction* faculty discussion series, February 22, 2008. Invited speaker.

“Affordable Green Housing Development, Design and Construction strategies,” presented at New York Institute of Technology, School of Architecture and Design, February 14, 2008. Invited lecturer.

“Affordable Housing: Transparent vs. Transformative Approaches,” presented at the Architectural Research Consortium: *Cross Currents in Architecture and Urbanism Cross-Disciplinary Conference*, Housing and the Poor panel session, The Pennsylvania State University, University Park, PA, January 31, 2008.

“Inside the Solar Decathlon,” presented (w/ Scott Wing) at the Penn State Department of Architecture Insights panel discussion, Fall 2006.

“Petersburg Commons: Case Study for affordable green housing and model for sustainable development,” presented at the Pennsylvania Planning Association 2006 Annual Meeting “change...plan....change”: “Green Building / Green Planning Mobile Tour Workshop,” Harrisburg, PA, October 2006. Invited presenter.

“Applied Lessons & Lessons Learned: An Example,” presented at the Enterprise Foundation Green Communities Initiative Training Seminar, Philadelphia PA, June 2006. Invited keynote speaker with Bruce L. Quigley, OPA Harrisburg.

“Portfolio Preparation,” instructional lecture presented at the AIA Pennsylvania 2004 Statewide Conference & Leadership Meeting in Hershey, PA, November 2004. Invited speaker.

“Crazy Quilt: Case Studies in Building Materials Reuse,” presented at the 2004 Deconstruction and Building Materials Reuse Conference in Oakland, CA, September 2004.

“Trend-setting Community Development: Petersburg Commons Project,” presented (w/ Bruce Quigley) at the Community Development Forum, Community Action Association of Pennsylvania, Philadelphia, PA, June 2004.

Synaesthesia “Hearing Colors,” introductory workshop at the Synaesthesia symposium, The Pennsylvania State University Department of Architecture, Fall 2003. Invited speaker and workshop coordinator.

Conference Session Moderator

“Living with Sustainable Energy in a Global Society,” organized and moderated a 90-minute Educational Workshop at the GreenBuild International Conference and Expo, Phoenix Arizona, November 2009. One of 120 out of over 1300 submissions accepted for presentation.

“Energy Simulation in the Design Studio” session moderator (w/ Ute Poerschke) at the 2010 American Collegiate Schools of Architecture (ACSA) Annual Conference, New Orleans, LA, March 4-7, 2010.

“Building Integration: Solar and Energy Efficiencies,” Invited facilitator and session moderator at the Solar Energy Conference, Awareness, Challenges, and Opportunities, The Penn Stater Conference Center Hotel, State College, PA, May 6-7, 2009,

“Renewables & Alternative Energy” Invited moderator for a 90-minute session on LEED Buildings at the 2008 Northeast Renewable Energy Conference, Penn Stater Conference Center, State College, PA, August 26-28, 2008,

Design Workshops, Charrettes and Symposia

Environmentally Conscious Design – Educating Future Architects symposium on teaching sustainability in architectural design education, University Park, PA, October 23-25; co-organized symposium with the Committee for Environmentally Conscious Architecture (Ute Poerschke, Loukas Kalisperis, Christine Gorby, Malcolm Woolen, Denson Groenendaal, and Charlie Cox).

Union County Housing Authority Energy Efficient Housing Program design charrette, Bucknell University, Lewisburg, PA, June 18, 2009; coordinated day-long workshop with design team and advisory board to establish project objectives and criteria; authored charrette report.

Village Acres planning and green building charrette, Village Acres Farm, Mifflintown, PA, November 01, 2008; coordinated design workshop to address issues of long and short-term planning and project parameters for a new passive solar building for Community Sustained Agriculture (CSA) activities; authored charrette report.

Hyde / Sheridan Residence renovation and retrofit Design Charrette, Carlisle, PA, July 2, 2008; coordinated project objectives decision-making workshop; authored charrette report.

Bedford Mews project workshop, Carlisle, PA, February 14, 2006; facilitated workshop and authored charrette report.

Petersburg Commons “kick-off” charrette, Duncannon, PA, June 4, 2004; organized charrette and authored design manual and final charrette report.

Invited Design Studio Critic

Morgan State University, School of Architecture and Planning graduate program in architecture, Fall 2010

University of Pennsylvania, PennDesign graduate program in architecture, Spring 2007

Kent State University, School of Architecture 3rd year reviews, Fall 2007

New York Institute of Technology, School of Architecture and Design architectural thesis juror, Spring 2006

Columbia University Graduate School of Architecture, Planning and Preservation urban design seminar project critic, Spring 2006

Harrisburg Area Community College, Architecture Transfer Program second year reviews, Invited annually 2003-present

City College of New York, The School of Architecture and Environmental Studies invited participant for History of the City panel discussion, Spring 2004.

Technical Institute of Berlin, Germany, 4th year architecture student projects, February 1999

Funded Projects & Grants

Pending:

Water Quality Issues Related to Green Building Design: East Coast, proposal submitted to the Water Research Foundation (WRF), June 10, 2011, \$19,500, Principal Investigator and sub-contractor to research team at Colorado State University.

- Current: *Identification of key “players” and their roles in an Integrative Process for Achieving High-Performance Homes,”* research funded by the President’s Fund for Research to engage undergraduates in faculty research programs, The Pennsylvania State University, \$500, Principal Investigator
- Spatial Guidelines for Community-scale Renewable Energy,* research funded by the College of Arts and Architecture 2009-2010 Competition for Faculty Research Grants, \$9,000, Principal Investigator.
- Funds to Support Lectures of Interest in Architecture, Landscape Architecture and Architectural Engineering,* funded by the Raymond A. Bowers Program for Excellence in Design and Construction of the Built Environment, \$15,500, Principal-Investigator.
- Completed: *“Environmentally Conscious Design – Educating Future Architects,”* support for organizing a symposium, October 23-25, 2009, on the topic of teaching sustainability in architectural design, funded by four Penn State sources, \$20,364, Co-Investigator.
- Preparing Pennsylvania for an Elder-Friendly Future,* research and related coursework funded by the Raymond A. Bowers Program for Excellence in Design and Construction of the Built Environment, 2008-2009, \$10,500, Co-Investigator.
- Study of Building Integrated Photovoltaic Systems for Single Family Dwellings – Efficiency and Innovative Design,* research funded by the Raymond A. Bowers Program for Excellence in Design and Construction of the Built Environment, 2008-2009, \$6,000, Co-Investigator.
- 2009 Solar Decathlon,* funded by the U.S. Department of Energy National Renewable Energy Laboratory (NREL), 2008-2009, \$100,000, Co-Investigator.
- Comprehensive Comparison of “Green” Guidelines applicable to Affordable Housing in Central Pennsylvania,* Funded by the President’s Fund for Research, 2007, \$500, Principal Investigator.
- 2007 Solar Decathlon,* funded by the U.S. Department of Energy National Renewable Energy Laboratory (NREL), 2006-2007, \$100,000, Co-Principal Investigator.
- Structural and Building Technology Evaluation of Some Mass Walls Suitable for Sustainable Design of Residential Construction,* research funded by the Raymond A. Bowers Program for Excellence in Design and Construction of the Built Environment, Interdisciplinary Project Support 2006-2007, \$8,000, Co-Investigator.

Grants for Teaching

- Current: *Innovative Collaborative Seminar on Sustainable Design Strategies and Solutions,* course development funded by The Stuckeman Collaborative Design Research Fund, Spring 2011, \$10,900, Co-Investigator.
- Curricular Initiative: Enhancement to Sustainable Design Education,* 2010 Incentives and Innovations Fund, College of Arts and Architecture, \$20,000, Co-Investigator.

Completed: *A Cleaner Greener Living Neighborhood for Baltimore's Greenmount West Community*, urban design studio and community design workshop funded by the Hamer Center for Community Design, Spring 2010, \$3,000, Co-Investigator.

A Comprehensive Landscape for the PSU MorningStar Home, course funded by the Raymond A. Bowers Program for Excellence in Design and Construction of the Built Environment, Category II matching fund support for 2007-2008, \$20,000, Co-Investigator.

Planting Seeds: Freshman Seminar in Sustainability for Architecture, Landscape Architecture, and Architectural Engineering, funding to develop an inter-disciplinary course module in sustainability provided by the Raymond A. Bowers Program for Excellence in Design and Construction of the Built Environment, 2005, \$19,429, Co-Investigator.

Honors & Awards

Award of Recognition for "contributions to interdisciplinary collaboration at Penn State," *presented by Penn State Institutes of Energy and the Environment*, 2011

Green Building Award Overall Winner (projects \$5 million and under category), Union County Energy Efficient Housing Program Duplex, *presented by the Green Building Association of Central Pennsylvania (GBACPA)*, April 2011

U.S. Department of Energy 2009 Solar Decathlon, Natural Fusion, *served as project advisor to the 2009 Penn State Solar Decathlon team:*

Third Place (tie, out of 20): Lighting Design, October 2009

Third Place (out of 20): Engineering, October 2009

NAHRO Award of Excellence winner (one of 23 projects recognized across the nation). Petersburg Commons, *presented by the National Association of Housing and Redevelopment Officials (NAHRO)*, December 2008.

U.S. Department of Energy National Renewable Energy Laboratory (NREL) 2007 Solar Decathlon, MorningStar Pennsylvania, *served as Faculty Advisor / Investigator:*

Innovation in Design award *presented by GBACPA*, April 2008

First Place (tie, out of 20): Hot Water, October 2007

Third Place (out of 20): Communications, October 2007

Third Place (out of 20): Market Viability, October 2007

Fourth Place (out of 20): Overall

BP Solar Performance Award, October 2007

PV News Editor's Choice Award, November 2007

Design Excellence Award in the "Energy and Atmosphere" category, Petersburg Commons, *presented by GBACPA*, April 2007

Merit Award for Excellence in Design, Petersburg Commons, *presented by the American Institute of Architects (AIA) of Central Pennsylvania*, November 2006

2006 Non-Profit Innovation Award for Operations and Technologies, Petersburg Commons, *presented by the Central Penn Business Journal*, 2006.

Certificate of Achievement and the Bellamy Award for Housing (organization's top honor), Petersburg Commons, *presented by The Pennsylvania Association of Housing and Redevelopment Authorities (PAHRA)*, 2006

Rural Development Award in recognition of energy-efficient affordable housing for Petersburg Commons, *presented by the US Department of Agriculture (USDA)*, June 2005

Second runner-up, Martin Luther King Jr. Memorial International Design Competition, project selected from over 800 submissions, (Designer with Brooklyn Architects Collective), 1999

Evidence of Impact in Society of Research and Creative Accomplishments – Citations & Media Coverage

Union County Housing Authority Energy Efficient Housing Program (EEHP)

In Your Neighborhood with Jennifer Wakeman, DVD, documentary video on Union County Energy Efficient Housing Program (EEHP) Duplex, (Community Cable Network (CCN), 2011). Aired on CATV Channel 8 for four weeks 3 times / week in April 2011.

Deinlein, Joseph. "Grant to help retrofit two homes in Union County." *The Daily Item*, February 10, 2011. http://dailyitem.com/0100_news/x1227160959/Grant-to-help-retrofit-two-homes-in-Union-County

Bartlett, Sara. WKOK radio, news coverage on EEHP Duplex, April 14 & 15, 2010

Diehl, Jim. WGRC Radio, August 31, 2010. Overview of EEHP Duplex.

WNEP Web Staff. "Green Senior Housing." WNEP.com, August 20, 2010. Article on EEHP Duplex. <http://unioncounty.wnep.com/content/green-senior-housing>.

Diehl, Jim. "Matter at Hand," WGRC Radio, October 13, 2010

Hamill, Jim. "Power to Save - Green Senior Housing: New housing for seniors will soon be available in Union County and it will be energy efficient." WNEP special news report, August 12, 2010.

Steele, John. "Energy Efficient duplex breaks ground in Union County." *Keystone Edge*, July 22, 2010.

Bartlett, Sara. WKOK radio, news coverage on EEHP Duplex groundbreaking, July 15, 2010.

Eyewitness News. "Energy-Efficient Duplex Coming to Union County." *PAHomepage.com*, *WBRE* and *WYOU*, April 8, 2010.

NREL Solar Decathlon

Media attention for the US Department of Energy NREL international Solar Decathlon event on the National Mall in Washington, DC exceeded 800 million media bytes produced by major television, newspaper, and radio outlets. During the week that the "Solar Village" was open to the public in 2007 and 2009 the Penn State *Natural Fusion* and *MorningStar* homes were toured by over 200,000 people. The Penn State projects were featured in television publications, local and national news articles, several radio stations, and magazine publications.

Coverage specific to the 2007 Penn State Solar Decathlon (selected):

Joy, Rachael. "It's Not Easy Being Green," *HGTV / Fine Living* Current TV. http://current.com/items/88825317_solar_decathlon_07. This feature story on the 2007 Penn State Solar Decathlon and the MorningStar Home, Aired Spring / Summer 2008 on Direct TV channel 366, Dish Network channel 196, Comcast cable channel 107, AT&T channel 189, Time Warner cable channel 189.

U.S. Department of Energy Solar Decathlon website, "Embracing the Possibilities," story highlighting significant elements of the Penn State MorningStar home. url: http://www.solardecathlon.org/2007/team_penn.html.

PV News, "The Solar Decathlon," November 20, 2007.

Penn State Outreach. GreenEnergy TV, podcast "Penn State Solar Decathlon," April 4, 2007, <http://www.brightcove.tv/title.jsp?title=716057688&channel=291706308>.

Pennsylvania Business Central. "International Journalists Tour Penn State & Region," article highlights the Penn State MorningStar home, October 2008.

Flashenberg, Amy. "Penn State solar home team wins fourth place," *Daily Collegian*, October 22, 2007.

"It's Not Easy Building Green," *Philadelphia Sunday Inquirer*, September 23, 2007.

Penn State "State of the University Address" video webcast, University President Graham Spanier highlights the PSU Team, September 07, 2007.

"The Penn Stater Cheers on Team", *PSU Alumni Magazine*, September 01, 2007.

The Philadelphia Sunday Inquirer, feature story with pictures on the first page of the Real Estate section, August, 19, 2007.

"Dream House," *Audubon Magazine*, July 2007 issue.

Penn State Outreach Video Webcast "PSU Solar Decathlon, Part 1" story on the Penn State team including interview, October 2006.

Pennsylvania Department of Environmental Protection. "Outreach Center to Focus on 'Green' Education," *Daily UPDATE*, March 2006.

U.S. Department of Energy "Energy Department announces 2007 Solar Decathlon Teams, Each of the 20 Schools to Receive \$100,000 in Funding". National press release, January 10, 2006.

Petersburg Commons "Green Affordable Housing"

PA Environmental Digest. "Sustainable Fund Finances 'First Green' Affordable Housing Development," *PA Environmental Digest*, June 23, 2006.

"Housing project will be 'green'," *The Carlisle Sentinel*, Monday, August 9, 2004, sec. A1.

Penn State Architecture / Landscape Architecture Summer Camp

“High School Students participate in Architecture and Landscape Architecture Summer Camp,” *NewsWire*, July 14, 2009.

“Still Life: Summer camps aren’t just for sports-minded,” *Penn State Live*, August 2008.

Plattner, Lauren. “Many children come to PSU for summer camp,” *The Daily Collegian*, May 02, 2003.

Teaching

Marynak, Flora. “Students travel to Europe to observe sustainable energy approaches,” *PennState Live*, July 7, 2009.

Fishlock, Diana. “Building New Worlds: Architecture Students Gain Real-Life Experience Through the Harrisburg Urban Studio Program,” *Central Penn Business Journal Construction and Real Estate Report*, 2005.

Olenchek, Christina., “Building A Vision: Architectural students design urban projects” *The Patriot-News*, March 3, 2005, sec. B2.

SCHOLARSHIP OF SERVICE to the UNIVERSITY, SOCIETY and the PROFESSION

Service to the University, College and Department

University: Faculty Senate, 2010-present; Intra-University Relations Committee

University: University-wide Sustainability Council (ad-hoc), 2009-present

University: BA in Energy and Sustainability Policy (formerly Energy, Business and Policy) Advisory Board.

College: Graduate Council Committee on Fellowships and Awards, 2010-2011

College: Annual Undergraduate Exhibition Judge, Spring 2011

School: SALA Task Force Vision Committee sub-group, 2008-2009

School: Hamer Center Advisory Board, 2008-present

Department: Scholarships & Awards Committee, Chair, 2009-present

Department: Committee for Environmentally Conscious Architecture (ad-hoc), founding member, 2008-present

Department: ACSA Councilor, 2007-present

Department: Architecture Lecture Committee, 2006-present; Chair 2006-2009

Department: Head Search Committee, 2010-2011

Department: Curriculum Committee, 2008-2010

Department: Coordinators Committee, 2007-2010

Department: Faculty Search Committee, 2006-2007

Department: Second-Year Portfolio Review Committee, 2003-2006

Contributions to University programs to Enhance Equal Opportunity and Diversity

Penn State Architecture /Landscape Architecture Summer Camp, curriculum development and coordination program for high school students; the camp encourages participation by a diverse student body with the mission of outreach to under-represented students.

Cincinnati Freedom Summer 2004: On-the-Ground Charrette for Social Justice, organized a trip for 12 second-year architecture students to participate in a weekend of design activities and installations related to social justice in Over-the-Rhine, Cincinnati, OH, September 2004.

Service to the Community and the Profession

Book proposal reviewer for John Wiley & Sons, Inc, 2011

Reviewer for 2nd Erasing Boundaries Symposium, *Educating at the Boundaries: Community Matters*, 2011

Students for Environmentally Enlightened Design (SEED) Award of Distinction Advisory Board Member, 2010-present

SEDA-Council of Governments Energy Resource Center (ERC) Advisory Board Committee, 2009-present

U.S. Department of Energy (DOE) Zero Energy Commercial Buildings Consortium (CBC) Advisory Committee Member, 2009-present.

Green Building Association of Central Pennsylvania (GBACPA) North Central Branch, Board of Directors and Founding Member, 2008-present

NCARB Intern Development Program (IDP) Mentor, 2008-present

Residential Green Construction Advocate for the U.S. Green Building Council (USGBC), 2007-present

Green Building Association of Central Pennsylvania (GBACPA) 2006-present; Educational Committee Member and Chair, Green Home subcommittee, 2011

Competition juror for GBACPA Annual Green Building Awards Program, 2009 & 2010

The Bridge at Mifflintown/ Mifflin, founding member, community organization advocating comprehensive, long-term planning, 2005-2007

Rt. 35 Bridge Replacement Project Community Action Committee, Community advisor to FHWA/ PENN-DOT, 2005-2007

Reviewer for the Association of Collegiate Schools of Architecture (ACSA) 95th National Conference, 2006

Harrisburg Urban Studio Curriculum Coordination Committee, 2005-2006

Harrisburg Area Community College Advisory Committee, 2003-2004

Service Honors

College nominee for the Penn State Award for Faculty Outreach, 2009

RESEARCH & CREATIVE WORK

PART 1: PUBLICATIONS & PROJECTS

PART 2: FOSTERING COLLABORATION

LISA DOMENICA IULO
Sample Work

Publications and Projects

SELECTED WORK 2006-2011

- | | |
|--------------------|--|
| Publication | Design Strategies for Community-Scale Renewable Energy Solutions
<i>Lisa D. Iulo, Rohan R. Haksar, Seth A. Blumsack</i> |
| Project | Energy Efficient Housing Program Duplex, 2010
<i>Sustainable Design Specialist / Designer, OPA</i> |
| Publication | Modular Building - Three Scales / Three Strategies
<i>Lisa D. Iulo</i> |
| Project | Natural Fusion, 2009
<i>Advisor to the 2009 PSU Solar Decathlon Team</i> |
| <i>Publication</i> | Low Energy Architecture / Low Energy Living: Strategies for Passive Design at the Urban and Building Scales
<i>Lisa D. Iulo</i> |
| <i>Publication</i> | The MorningStar, A Hybrid Concept for Community Building and Renewable Energy
<i>Lisa D. Iulo, David Riley</i> |
| Project | MorningStar PA, 2007 & MorningStar MT, 2007
<i>Co-Investigator to the 2007 PSU Solar Decathlon Team</i> |
| <i>Publication</i> | Affordable Housing - Transparent vs. Transformative Approaches
<i>Lisa D. Iulo, Bruce L. Quigley</i> |
| Project | Petersburg Commons, 2006
<i>Project Designer, OPA</i> |



Iulo, L.D., Haksar, R.R. and Blumsack, S.,
“Design Strategies for Community-Scale Renewable Energy Solutions.” Proceedings of the 27th International Conference on Passive and Low Energy Architecture, Louvain-la-Neuve, Belgium, July 13-15, 2011 (forthcoming).

Design Strategies for Community-Scale Renewable Energy Solutions

Lisa D. IULO¹, Rohan R. HAKSAR² and Seth BLUMSACK³

¹ Department of Architecture, The Pennsylvania State University, University Park, PA, USA

² Department of Architecture, The Pennsylvania State University, University Park, PA, USA

³ Department of Energy and Mineral Engineering, The Pennsylvania State University, University Park, PA, USA

ABSTRACT: The strategies, policies, and financial models for community-scale renewable energy production and distribution exist and in some cases are immediately achievable. A gap in information seems to be that the spatial and regulatory implications for implementation of community-scale renewable energy are widely unknown to the architects and developers responsible for planning these projects. This problem is two-fold: 1) even if a community is interested in pursuing a renewable energy project, very little information exists on how to achieve the goals; more detrimental is the fact that 2) most people are unaware of the possibilities for locally owned / used, community-based renewable energy production and distribution, or fearful of exploring this option due to misconceptions. This focused study explores precedents for renewable energy production and distribution in architecture and community design, specifically projects that demonstrate efficient renewable energy strategies at the community scale, in the interest of demonstrating proven methods for implementation.

Keywords: community-scale renewable energy

DESIGN STRATEGIES for COMMUNITY-SCALE RENEWABLE ENERGY SOLUTIONS

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ABSTRACT

The strategies, policies, and financial models for community-scale renewable energy production and distribution exist and in some cases are immediately achievable. A gap in information seems to be that the spatial and regulatory implications for implementation of community-scale renewable energy are widely unknown to the architects and developers responsible for planning these projects. This problem is two-fold: 1) even if a community is interested in pursuing a renewable energy project, very little information exists on how to achieve the goals; more detrimental is the fact that 2) most people are unaware of the possibilities for locally owned / used, community-based renewable energy production and distribution, or fearful of exploring this option due to misconceptions. This focused study explores precedents for renewable energy production and distribution in architecture and community design, specifically projects that demonstrate efficient renewable energy strategies at the community scale, in the interest of demonstrating proven methods for implementation.

Keywords: community-scale renewable energy

1. INTRODUCTION

The energy demands associated with buildings are a major contribution to greenhouse gases and other harmful emissions. The technologies and strategies for achieving goals associated with transitioning to a low-environmental-impact renewable energy future exist, and although they will continue to improve with time, the precedents are sufficiently advanced at the present to allow for major penetrations of renewable energy into mainstream design and societal infrastructures [1]. Community-scale generation and distribution of renewable energy - specifically solar, wind, and non-fossil fuel based combined heat and power plants (CHP) - are clean, efficient, and reliable approaches to generating energy. In addition to reduced environmental impact, potential benefits of community-based small-scale distributed generation include increased security/reliability as well as economic opportunities (in many states and throughout the EU this includes the opportunity to sell surplus power to the utility-owned power grid) and the potential for improved services and economic savings for customers [2]. Most important to our work, community-scale energy projects allow communities to make energy decisions consistent with mutually shared preferences and goals.

Existing literature, including Karl Mallon (ed.), *Renewable Energy Policy and Politics: A handbook for decision-making* (London: Earthscan, 2006), Greg Pahl, *The Citizen-Powered Energy Handbook: Community Solutions to a Global Crisis* (Vermont: Chelsea Green

Table 1: The graph below shows initiators of community-scale renewable energy projects most often identified in the case study projects. Local “Sustainable Initiative,” including policy, was the most significant motivating factor (fifth column from left); “Citizen movement” (often in opposition to other energy projects, most notably nuclear), “High Fuel Costs” and “Financial Stimuli” (first three columns from left) were other frequently cited initiators. A couple of projects (2 each) employed renewable energy in response to “Outdated Energy Systems” and the necessity for improved “Energy Security”.

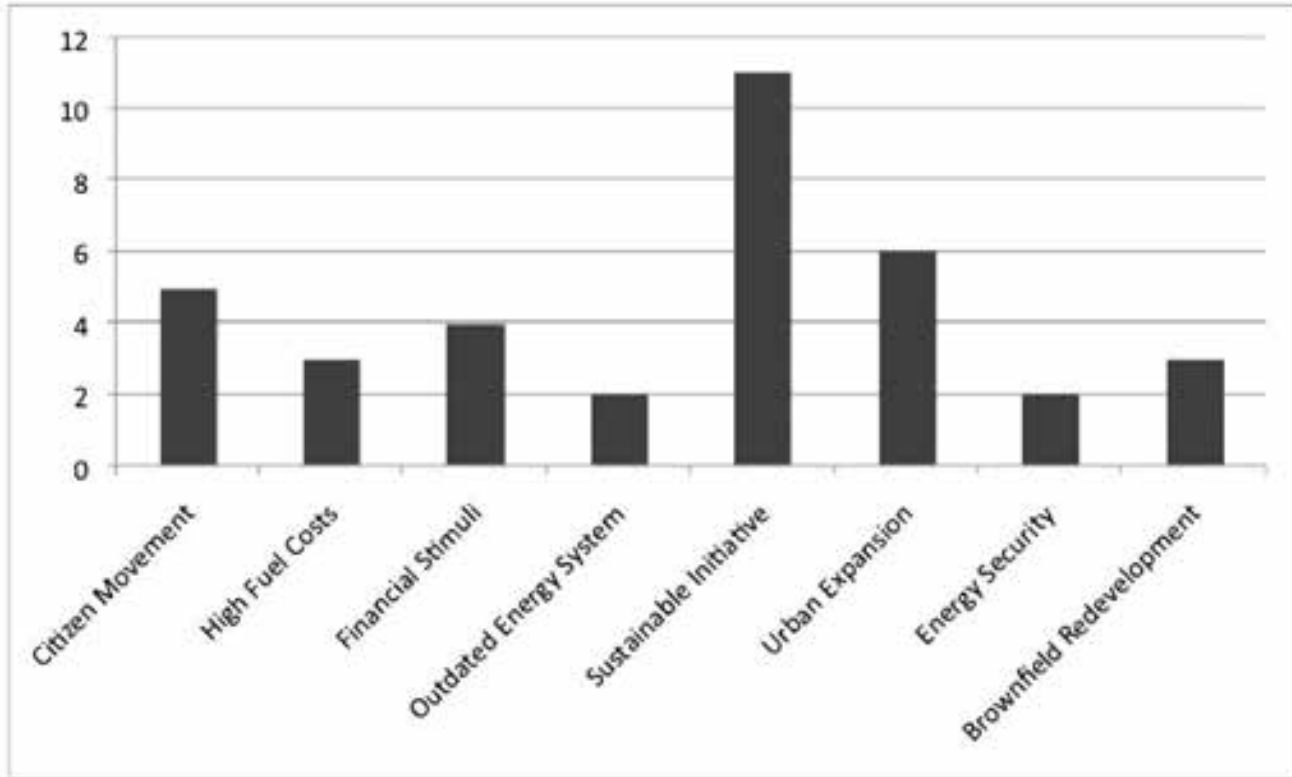
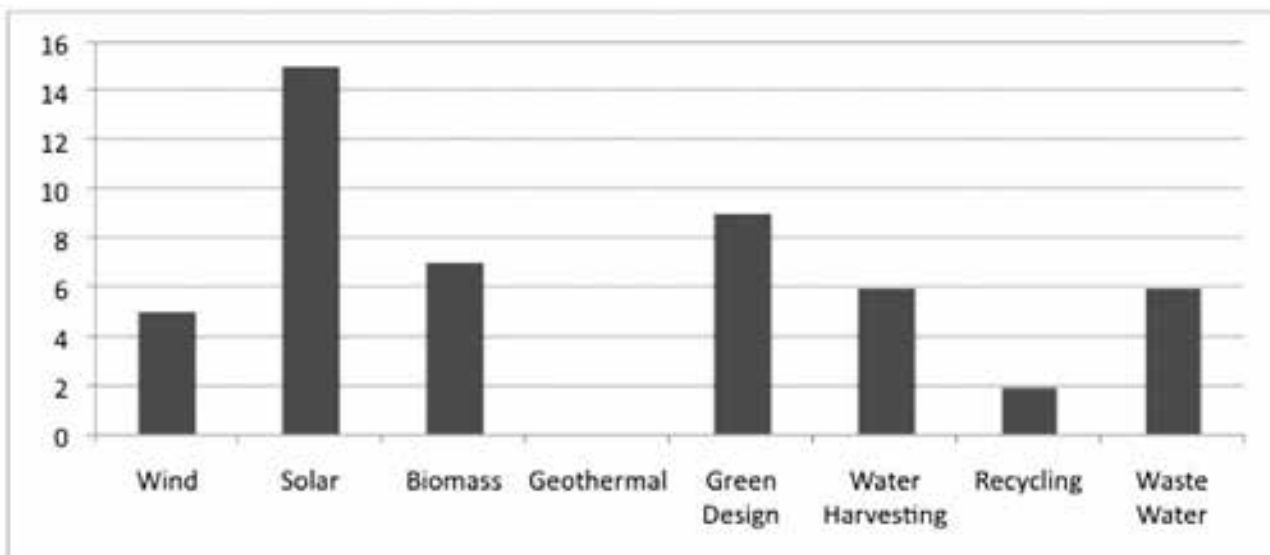


Table 2: The bar graph below indicates types of renewable energy and other sustainable design strategies most commonly employed in the projects including (from left) wind, solar, biomass, geothermal, “Green Design” measures including reducing energy demand, and strategies for the use / reuse of resources.



Publishing Company, 2007) and Barry G. Rabe, *Statehouse and Greenhouse: The Emerging Politics of American Climate Change Policy* (Washington, D.C.: Brookings Institution Press, 2004), and several articles (including reports by the Pew Center on Global Climate Change), provides background for community-scale renewable energy projects. *Urban Infrastructure In Transition: Networks, Buildings, Plans* edited by Simon Guy et al (London: Earthscan, 2001) considers 'sustainable' infrastructure, including green building design, and particularly the reactions of various stakeholders to case study projects. One book, *Photovoltaics in the Urban Environment: Lessons Learnt from Large-Scale Projects* (London: Earthscan, 2009), presents successfully implemented strategies for community-scale renewable energy projects related to solar. Although collectively this literature presents some examples and speaks to specific technologies and policies for realizing community-scale renewable energy solutions, it largely does not comprehensively present spatial information of value to the professional responsible for the design of a community-scale project that will include production and distribution of renewable energy.

This study, currently in its beginning stages, explores strategies relevant to the integrative design of groups of buildings and renewable energy systems. Specifically this research considers planning and implementation strategies for renewable energy production and distribution in existing and new mixed-use and residential communities. The focus of the study is on models that directly benefit a community. Projects where energy assets are located within the community and serve that community, rather than a development model where renewable energy assets are built on community property by a private energy company and connect directly to regional utility transmission networks. The development model is already well studied and documented; we feel that there is opportunity for wider applicability of the community-scale model.

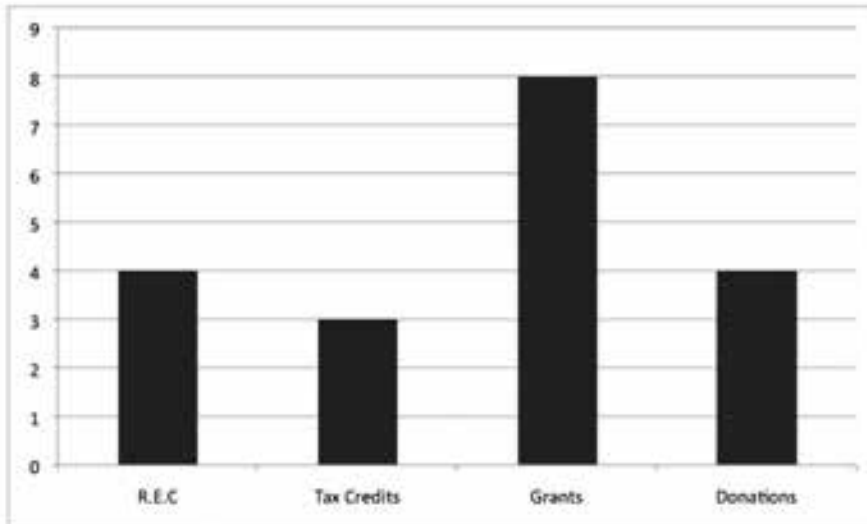
2. BACKGROUND

Twenty (20) case-study projects of existing and planned sustainable communities that implement renewable energy strategies in Europe and the United States were analyzed. These case studies were used to identify commonalities and trends with the intention of eventually informing spatial guidelines for community

scale renewable energy solutions. The case studies were analyzed across a broad range of parameters including renewable energy solutions applied, cost, incentives and ownership models. The projects studied are located in Europe and the United States, most between the latitudes of 19°N and 48°N, with the exception of the proposed Low2No project in Helsinki, Finland (60°N). The average area of the communities studied was 710 hectares (approximately 2.75 square miles) and include multiple buildings, typically mixed-use, with 50 or more residential units. Some smaller communities were studied, typically representing rural or suburban communities. Some of the larger communities, for example the Kronsberg district of Hannover, Germany, tended to account for future urban expansion. The motivation for the implementation of renewable energy in the communities studied were generally in response to rising fuel costs and/or the need for a local financial stimuli, sustainable initiatives taken by local citizens or government (especially in the EU). A few projects in the US were the initiative of an individual project developer. See Table 1.

The most favored form of renewable energy used in the projects studied was solar followed by biomass gasification. Many of the projects also implement additional strategies including ground-source geothermal and other sustainable planning strategies. Table 2 indicates types of renewable energy and other sustainable design strategies most commonly included in the projects studied. It goes without saying that reducing energy demand through passive low-energy design and energy-efficiency measures must come before considering renewable energy production. Overall project costs varied greatly depending on the scale of the project, the renewable technologies used, and how they were implemented; also a few revitalization projects were considered. Our best attempt was made to determine overall cost (construction + renewable energy) standardized by size. The average cost of the communities studied was approximately US\$132,49 million / square mile. Incentives available are a major factor in the formation and success of a project. As indicated in Table 3 below, incentives range from government-based grants, Renewable Energy Credits and tax credits to donations from companies. As expected, a distinct trend is that government funding is more prevalent in the European case studies than in the United States.

Table 3: The bar graph below shows incentives for the implementation of community-scale renewable energy projects include government-based grants, Renewable Energy Credits, other tax credits and donations.



Utility-owned renewable energy projects and Co-ops are the favored ownership / management models used by most sustainable communities. This is mainly because a firm owns or manages the renewable energy systems reducing up-front costs for the customers while providing reliability and quality. The customer-generated model allows the community to control the energy resources and the potential for profit. Management in this case is obviously more complex and requires additional study. In some of the case-study projects individual customers could invest in a share of the community energy system or retain control of photovoltaic arrays on their rooftop.

2. TYPOLOGIES

Four typologies for retaining control of renewable energy resources are identified below and illustrated using simplified line diagrams to indicate energy use and distribution. In all cases the icon of the sun represents any renewable energy source. They are divided into two categories: Direct and Distributed Energy Resources.

3.1 Direct: Individually owned and used

For the most part, renewable energy systems in the built environment have been limited to single building applications, small-scale applications where energy is used directly. This configuration is generally referred to as “distributed generation” or “behind the meter generation” and encompasses not only renewable

installations such as rooftop PhotoVoltaics (PVs), but also emergency power supplies such as backup generators fuelled by diesel oil or propane.

1. *Non grid-tied / self-sufficient:* A non grid-tied settlement generates and uses renewable energy to meet its own energy demand. Such a settlement, or individual residences within, generally use passive sustainable design features and are appropriately insulated to reduce energy demand. Renewable energy features may include PVs and/or wind turbines. Some incentives, including tax credits or low interest rate energy loans may be applicable. The 2002, 2005, and 2007 NREL Solar Decathlon Competitions simulated a non grid-tied community since the individual homes were collectively configured into a “Solar Village,” but each home was electrified by its own Building Integrated PhotoVoltaic (BIPV) system and excess energy was stored on-site for use when power was not being generated (fig. 1). For the most part non grid-tied systems should not be considered where reliable utility access exists.

2. *Grid-tied / non-interconnected:* A variation of the self-sufficient model is where renewable energy generates all or some of the electricity necessary to power an individual home or building. The balance of energy is provided through a connection with the utility grid. This configuration results in reduced energy bills, since not all electricity is purchased from the utility, serving as an incentive for building owners (fig. 2).

3. *Grid-tied / Interconnected:* In an interconnected scenario communication between the utility grid and the building works in two directions; balance of energy is provided through interconnection and excess energy generated is fed back into the utility grid (fig. 3). Prior to considering a grid-tied project in the United States, interconnection regulations and protocols must be investigated since many states are non-permissive or otherwise restrict tying into the utility grid. Feed-in tariffs (EU) or Net-metering is an accounting system for grid-tied renewable energy projects. These projects are provided with credits for surplus electricity that is supplied to the utility grid. Selling excess electricity to the utility offers cost savings compared to purchasing grid electricity from a utility and is a promising way to reduce the costs of installing community energy projects. Net metering regulations also vary widely in the US; although the 2005 US Energy Policy Act encouraged individual states to adopt net metering regulations, not all have done so. Those states that do allow net metering vary widely in the sell-back price as well as the procedures required to register with the utility as a net-metered customer. For the 2009 Solar Decathlon competition homes were grid-tied and extra points in the “Energy Balance” competition were awarded to teams that provided excess energy to the grid.

3.2 Distributed Energy Resources (DER) Configuration:

For renewable energy to have a more significant impact in realizing carbon-neutral goals installation at the community (neighborhood) scale must be considered in a distributed energy resources (DER) configuration. DER provide benefits of a centralized system, generating and distributing power, but have distinct characteristics that are locally beneficial: 1) DER are smaller in size than typical power plants; 2) they are located near customers and serve individual or small groups of customers; and 3) they are generally modular and scaleable, utilizing off-the-shelf technology that can be scaled up as demand increases [3].

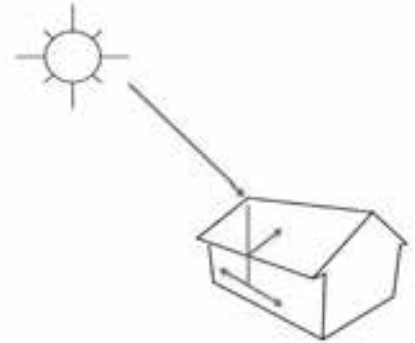


Figure 1: Diagram of a stand-alone renewable energy system.

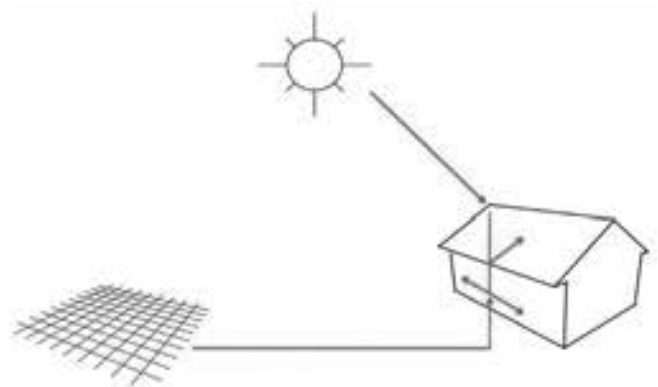


Figure 2: Diagram of a grid-tied, non-interconnected renewable energy system.

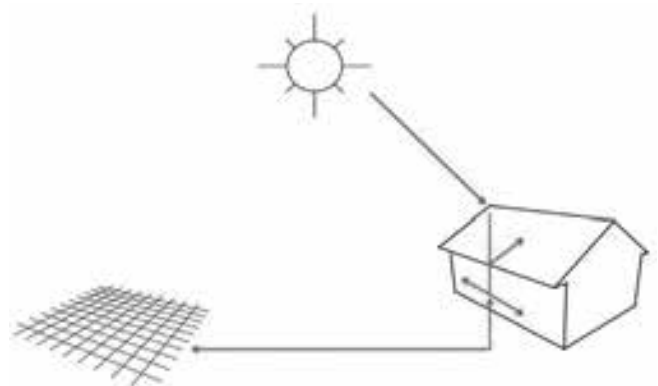


Figure 3: Diagram of an interconnected renewable energy relationship where energy is generated from renewable sources on site and supplemented by the utility grid. Through interconnection, excess energy generated is fed back into the utility grid.

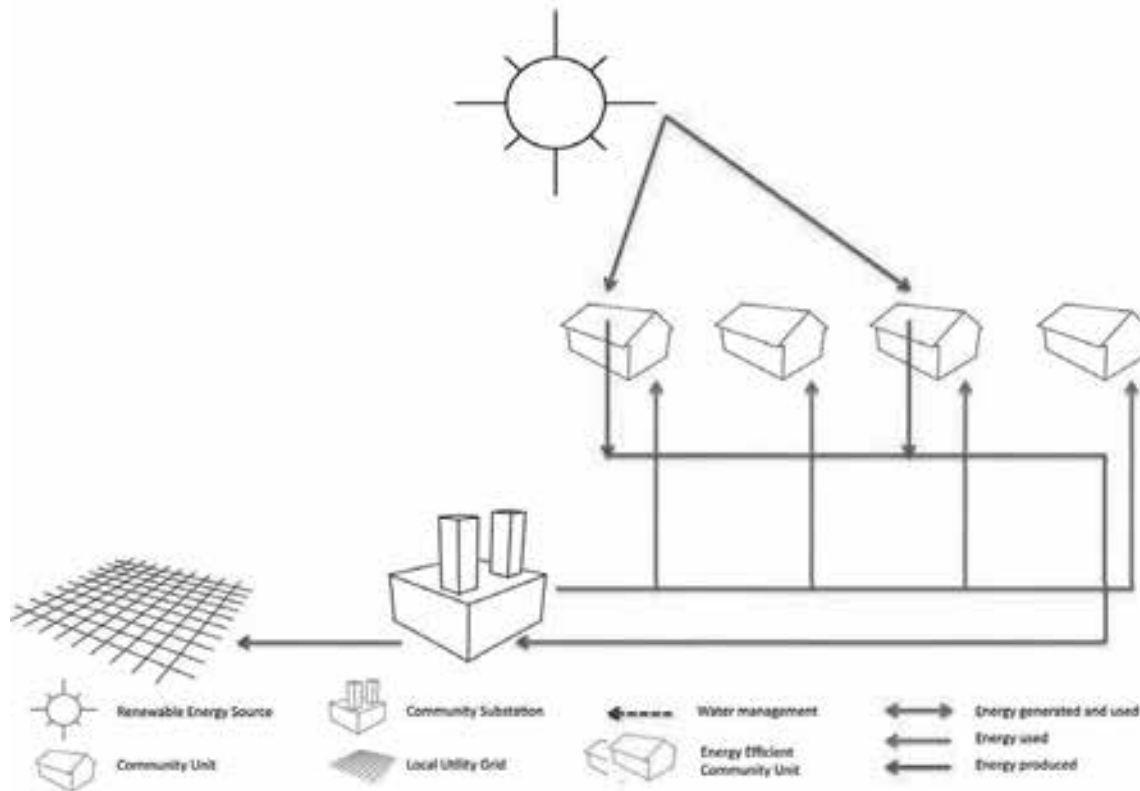


Figure 4: Diagram of a micro-grid configuration where all or some energy needed for the community is produced by renewable sources and the community is connected by a localized grid that interconnects with the utility grid at a single point.

4. *Micro-grid connected community*: This type of community consists of energy-efficient buildings where all or some energy is produced by renewable energy (fig. 4). The community is connected by a localized grid and interconnects with the utility grid at a single point. Potential for increased ownership and control of the project are advantages of a micro-grid for a community-based energy project. Incentives for such a model are in the form of government grants that help offset the costs of establishing the micro grid. Tax credits may apply to individual buildings and serve as an incentive for people to buy into the community. A benefit of the micro-grid configuration is that renewable energy may be used in a community even where all buildings are not ideally oriented. A major barrier to the deployment of micro-grids in the US is the fact that no state has a legal definition of a micro-grid. As a result, even where micro-grids have the right to exist their legal status could vary based on the interpretation of the utility regulators or the politicians who appoint them.

A successful variant of the micro-grid model is being implemented in the state of Maine, USA. The Fox Islands community-owned wind project provides electricity to the island residents and sells surplus power directly to the New England transmission operator through the wholesale market, rather than to an electric distribution utility. The Fox Islands project was able to side-step interconnection negotiations with the electric utility because of its relatively large size (4.5 MW) for a community-scale energy project. The island community has begun experimenting with the use of distributed thermal storage to “store” surplus wind power for heating and hot water, thus reducing the need of the island residents to import fuel oil or propane from the mainland [4] [5].

Deployment of micro-grids require significant expertise and capital investment beyond the source of the power supply, since inherent in the micro-grid is the existence of a local electricity distribution network. In the case of Smethport, Pennsylvania, a biomass CHP system that will provide electricity and district heating to the

existing town is being considered in the context of an expensive infrastructure replacement project. Inspired by a similar initiative in the town of Gussing, Austria, Smethport is planning to construct a biomass reactor fuelled by low-grade timber (low-value wood that would otherwise be discarded as waste). The economics of the project are appealing, and local technical expertise exists since the municipality owns some of the electric distribution assets within the community. The project will also help the town meet its environmental and economic development goals, since providing fuel for the biomass plant will help support the town's timber workers [6].

4. LESSONS LEARNED

Through analyzing the various case studies across Europe and the United States certain common lessons were learned that, while not absolute, might be useful in establishing guidelines for the design of renewable energy-based sustainable communities [7]:

4.1 Integrative Design

One of the main factors required for a successful community is the need for an integrated design approach. This requires project stakeholders and agents to be involved in the design process, especially in setting and agreeing upon clear project goals and objectives at the outset. Coordination to attain these goals must take place throughout design and construction. Additionally, experience plays a significant role in the realization of complex community-scale energy projects. For example, in the case of the Nieuw Sloten PV houses (The Netherlands, Amsterdam) where leaking occurred in some of the PV roofs due to the complexity of the field conditions and lack of experience by the installer in both PV installation and in roofing [8]. Another example is the 'City of the Sun' (Stad van de Zon) also in the Netherlands. Although "from a purely technical point of view, there were no problems in the design and realization of the project," barriers in the process included "lack of knowledge of PV by the urban designers" and some of the architects considering "PV as a design limitation rather than a challenge." As a result, PVs were not always a priority and in some cases designs were produced that "were unsuitable for PV" due to inappropriate orientation, structure and shading [9].

New communities are already learning from these cases and trying to involve all the concerned parties from the very start. This is evident in the approach taken by ARUP for the design and development of the Low2No project in Helsinki. They followed a methodology of :

- Setting objectives at the very outset
- Integrating processes like economics and environment to identify synergies and benefits early on;
- Involving the client at the core of the development process through workshops and meetings; and;
- Carrying out testing and inspection of systems to have a level of accountability. [10]

4.2 Community Participation

Community Participation is an extension of the integrative design approach and involves getting the community involved in setting goals and aspirations for the project. Such participation was evident in the Sustainable Model City District Vauban (Freiburg, Germany) where an NGO called Forum Vauban was formed to foster participation between the planners and community. This was particularly helpful in bringing citizens to the table and brainstorming creative ideas that helped overcome the obstacles the planners were facing with regard to traffic [11].

4.3 Changes in Policy

Lack of government support, both for project funding and as incentive for investments in training and education, has lead directly to lack of competency in the implementation of renewable energy, significantly in North America, but also in Europe where existing incentives are constantly threatened by changing politics. These trends affect project cost, relating directly to funding sources, and potentially the success of a community-scale renewable energy project.

4.4 Multiple Funding Sources

It is evident from the case studies that the cost for renewable based sustainable communities is quite high and that despite incentives it is hard to raise project funds from a single source. Multiple sources to raise the necessary finances can be a mix of equity and debt. The projects at Rieselfeld, Germany and Fox Islands, Maine, USA, are examples of multiple and varied sources of funding being used. The Rieselfeld financial model was based on government incentives

and tax credits along with the main funding from the City through a trust account covered by the KE LEG GmbH. Riesefeld saw state support for residential construction discontinued and tax advantages for investors cut. However, in this case the financial model was tweaked to allow small investors as well as private and industrial groups to buy into the community. This helped to eventually develop the community and has kept demand strong even today [12]. In the case of Fox Islands, it was a combination of PTC/ITC funding and RUS debt financing at a fixed rate of 4% for 20 years that made the project viable [13].

4.5 Post-Occupancy Maintenance

Loss in energy efficiency due to a lack of post occupancy maintenance was another problem recognized in some of the case studies examined, adversely affecting overall energy performance. Post occupancy maintenance problems were foreseen in the proposed Port of Barrow redevelopment project (Barrow, UK) where community-member's feared that energy saving and PV features would be eliminated by the developer to cut costs or not maintained by the homeowners over time. Although these are difficult problems to address, innovative measures were considered to counter these problems including implementing planning restrictions to prevent energy-saving fixtures from being removed and establishing procedures for educating homeowners about long-term benefits of maintaining energy-related features including PV [14].

5. CONCLUSIONS / NEXT STEPS

For successful implementation of community-scale renewable energy projects, zoning regulations that are consistent with energy development goals need to be devised. Zoning regulations and property rights must be designed especially carefully if the desired system is distributed in nature (such as a community with multiple rooftop solar installations). Since a building with a rooftop photovoltaic installation may be affected by nearby tall buildings or trees, "solar shadow" regulations that provide some property rights related to rooftop solar have been adopted by a couple of states [15]. Homeowner covenants can also be designed with energy goals in mind. For example several of the projects studied separated rooftop ownership from control to ensure that community managers had access to install and maintain renewable energy systems.

The preliminary research results included in this paper will be used by this team to develop *spatial guidelines* that will reveal principal modes of interaction between buildings and energy systems by summarizing findings related to physical form in a series of schematic diagrams. Building orientation and relationships relative to different renewable energy implementation strategies will naturally be important to our spatial representation approach, but other decision-making dimensions, including regulatory considerations (i.e. innovative zoning strategies, ownership/management models and property rights and homeowner-association covenants), will also be researched and incorporated. The resulting guideline will present high-dimensional visualization information that integrates built physical form with economic, regulatory, and policy-relevant implementation factors.

6. ACKNOWLEDGEMENTS

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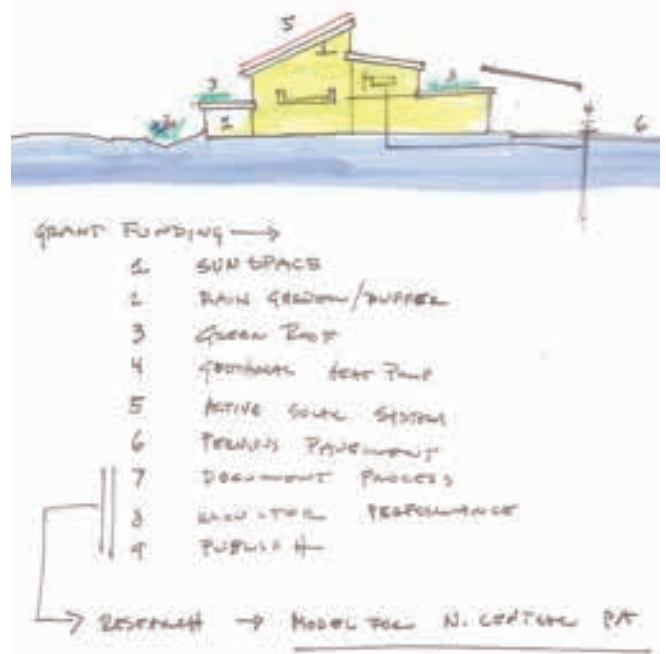
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Union County Energy Efficient Housing Program Duplex

Lewisburg, Pennsylvania

Sustainable Design Specialist / Designer: Lisa D. Iulo
Architect: Office for Planning and Architecture (OPA)
Energy Expert: Peter Vargo, Nu-Tech Energy Solutions
Manufacturer: Vision Homes LLC, Bloomsburg, PA
Certification: DOE/EPA EnergyStar, NAHB Silver

Union County Housing Authority's Energy Efficient Housing Project (EEHP) model duplex addresses short and long-term affordability by accounting for the ongoing cost of energy during construction and in the long-term expenses carried by the "Prime-Time" (age 55+) homeowners. Design emphasis was on energy efficiency and energy cost savings as a first priority; sustainable development as a second priority; and minimizing construction costs while maximizing opportunities for utilizing locally produced materials selected for long-time durability as a third priority.



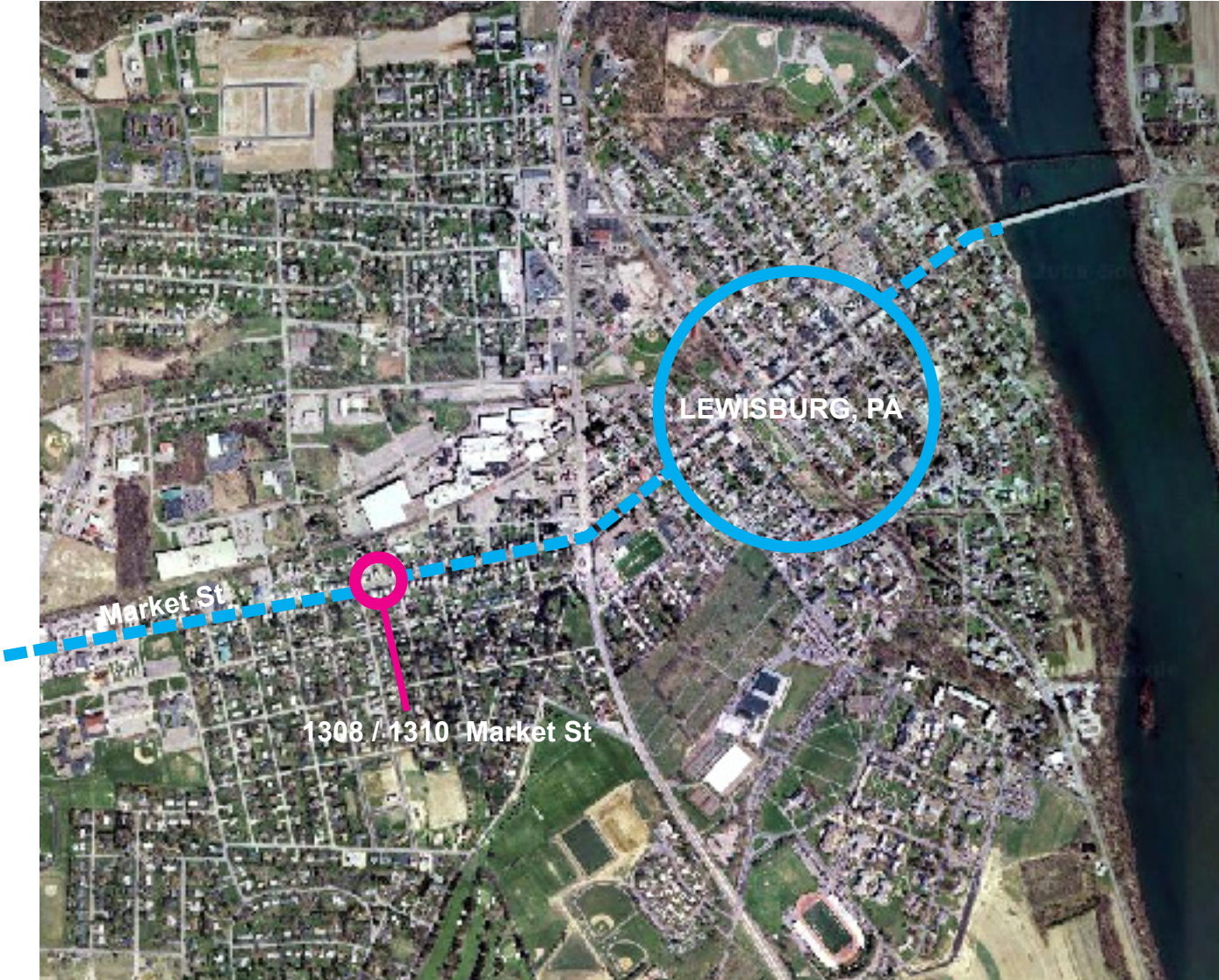
WINNER: OVERALL EXCELLENCE,
GBACPA Green Building Awards Program, 2011





The EEHP Duplex sits on a previously developed 50-foot wide by 150-foot long infill site (the original duplex home was destroyed by fire prior to acquisition of the land). It is located in existing town fabric that is contiguous with Lewisburg's and is within walking distance of the mixed-use downtown, parks, and the Susquehanna River. This project reinforces community and improves surrounding property values, enhancing overall quality of life for the home residents and their neighbors.

The massing and design of the duplex fits into the context of the adjacent residences. Though contextual, the sun-collecting roof, rain garden and recycled content siding announce the home's "green" status. A sun-shading trellis and ADA accessible patio/entry evokes the front porches common along this main street and extends the home's living space.



"Walkable" community: map showing proximity of site to the center of Lewisburg, Pennsylvania



Photo of Market Street, Lewistown, PA



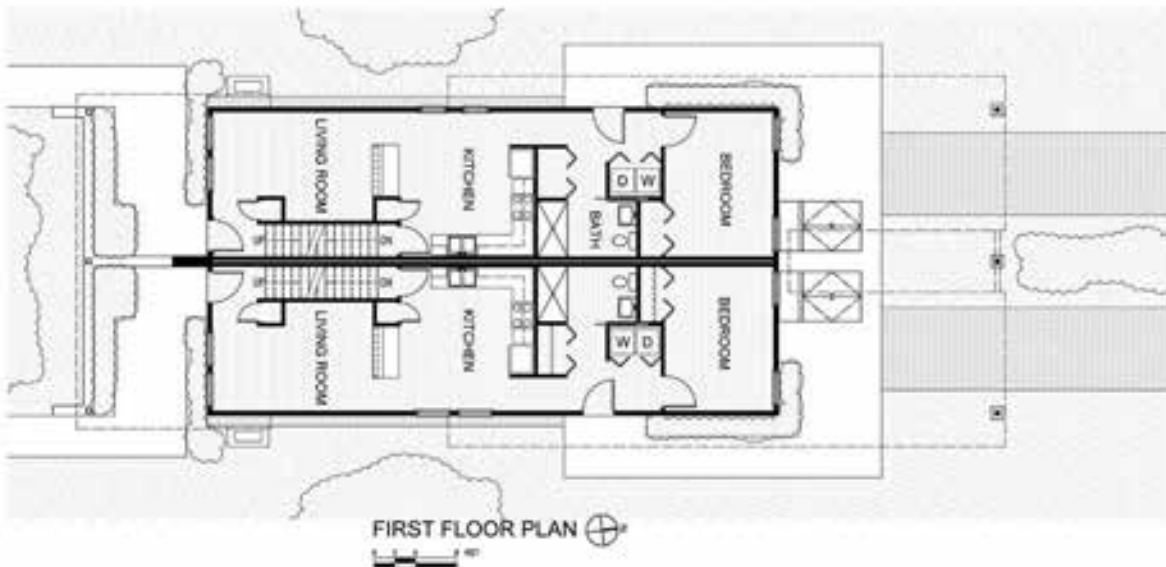
Original home on the project site; destroyed by fire



Panaramas of Market Street, before (upper image) and post-duplex (lower image)



Each home is 1,100 square feet and designed to provide for single-storey living. The ground floor includes a living room, kitchen/dining room, full bathroom, laundry facilities and a bedroom. There is a semi-finished partial second floor “bonus room” that can be fit out by the homeowner as needed for a bedroom suite, home office, or space for a caretaker.





For this project modular construction was ideal; both cost effective (more than 30% lower than bids for conventional construction) and because the on-site construction time overall was significantly reduced, minimizing impact on the site and the neighbors. The duplex was constructed in a home manufacturing plant in four modules over the course of two weeks and assembled on the site in a day.



Outreach and education were an important goal of this project. To encourage input and collaboration while maintaining an efficient schedule and cost-effective building, an integrated design approach was applied to this project. Prior to contracting with the design team, a project advisory board, representing expertise and experience relevant to the project, was assembled. This advisory board participated in an initial project charrette to establish project goals and priorities. The project has been showcased with multiple tours throughout construction and progress can be tracked through Facebook and on a dedicated project website. Penn State students have been engaged in on-going research related to this project, tracking energy performance and studying material LCA. This project and the related retrofit of two existing homes (currently under construction) have received significant media attention.



(left) Public tour of the duplex at the manufacturing plant; (below) Penn State research team at the duplex



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Fall Project Spotlight: The Union County Housing Authority's Energy Efficiency Vision

The Union County Housing Authority will soon be celebrating the opening of the Union County Energy Efficient Housing Project. This small, but exciting project packs a tremendous number of features into a small footprint. The two semi-attached units were built as infill housing for income eligible applicants aged 55 and older. These highly efficient modular homes feature siding that is 95% recycled steel produced in Schuylkill County, countertops made from recycled paper, and wood floors from locally-grown trees. The health of the indoor environment was not taken for granted – paints and finishes are low in volatile organic compounds, and air exchangers supply fresh air to keep mold at bay. The houses even incorporate sustainable features to mitigate storm water runoff, such as rain gardens to channel water into the ground to be filtered and returned to the aquifer.

The homes are constructed to appeal to the largest segment of Union County's population – "Prime Time" or active seniors in search of affordable houses where they can age in place. The homes will sell for \$100,000 each, and will be extremely low maintenance. The homes are 45% more efficient than an Energy Star home and 60% more efficient than a home built to the

International Energy Conservation Code. While not handicapped accessible, they are handicapped adaptable, so that accessible features can be added as the need arises.

By adding these features, UCHA was responding to a number of challenges in the market that many small, rural housing authorities also face. First, according to UCHA Executive Director Jere Engle, seniors, regardless of income level, were calling the agency looking for appropriate housing. Many wanted to downsize, and were interested in accessible features that would allow them to age in place. Also, as seniors look to retirement, affordability and low maintenance become increasingly attractive. The development serves as a model for housing authorities hoping to create a product that meets the needs of a changing market.

In order to share the energy lessons it learned, the UCHA created a website (www.unioncountyhousingauthority.org) and a Facebook page (Affordable Energy Efficient Housing). Realizing the dearth of information from practitioners may be a barrier for some agencies contemplating starting their own projects, the UCHA is preparing a technical paper for presentation in academic and professional associations.



Union County's Energy Efficient Duplex
Check for updates on this and future projects on Facebook (Affordable Energy Efficient Housing), and online at www.unioncountyhousingauthority.org

Another important aspect of the project is UCHA's collaboration with the Pennsylvania State University. The university will track energy consumption and compile the research. UCHA installed energy monitoring equipment in each house so that the university can conduct its energy consumption research over the next five years. The UCHA plans to continue its partnership with the university for its next phase of their current project, the rehabilitation of two existing homes. The homes will be retrofitted

with energy efficient features, and will be monitored as well.

The UCHA has gotten positive attention for this innovative project from multiple sources. The local cable network is putting the finishing touches on a documentary on the Energy Efficient Housing Project, which will soon be aired. Local media has also spread the news. More celebration is sure to come when the ribbon-cutting ceremony is held on September 29, 2010.

EEHP Duplex was recognized by HUD as a "Spotlight" project in their Energy e-Bulletin. A number of other media venues carried stories about the project including a news program special edition on energy efficiency.



Iulo, Lisa D. "Modular Building - Three Scales / Three Strategies." In *High Performance Homes, Their Design, Renewable Energies and Integrated Practice*, edited by Franca Trubiano. London: Routledge, forthcoming.

MODULAR BUILDING – THREE SCALES / THREE STRATEGIES

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ABSTRACT: Modular building is a productive vehicle for achieving high-performance residential designs. The following chapter discusses a range of design and construction practices in modular building where performance parameters are associated with energy, constructability and more generally - sustainability. By way of three different projects, this chapter identifies strategies for the modular building of homes and/or their parts. The first confines the limits of the module to the production of an easily configurable 'utility core', the second focuses on opportunistic alterations to the module's envelope made possible by the "inside-out" construction sequencing used in modular housing manufacturing, and the third engages the energy saving potential of building modular housing at the scale of the building and community.

Keywords: high performance homes, modular construction

MODULAR BUILDING – THREE SCALES /THREE STRATEGIES

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ABSTRACT

Modular building is a productive vehicle for achieving high-performance residential designs. The following chapter discusses a range of design and construction practices in modular building where performance parameters are associated with energy, constructability and more generally - sustainability. By way of three different projects, this chapter identifies strategies for the modular building of homes and/or their parts. The first confines the limits of the module to the production of an easily configurable ‘utility core’, the second focuses on opportunistic alterations to the module’s envelope made possible by the “inside-out” construction sequencing used in modular housing manufacturing, and the third engages the energy saving potential of building modular housing at the scale of the building and community.

1. INTRODUCTION - INDUSTRIALIZED HOUSING & MODULAR CONSTRUCTION

To meet housing demands due to population increase and inefficiencies in existing housing stock in the aftermath of World War II research and development of new production methods were promoted, including prefabrication. As early as 1923 architects Le Corbusier and Walter Gropius recognized the significance of off-site prefabricated building to meet ‘mass demand’ for housing.¹ An enormous growth in new housing starts in the U.S. was spurred by The Veteran Emergency Housing Act (VEHA, 1946) which called for the building of “850,000 prefabricated houses in less than two years,” transforming the industrialized home industry.² Taliesin Associated Architect Vernon D. Swaback defined the industry as follows:

“Mobile Homes, Modular and Prefabricated Houses are all different degrees and expressions of industrialized housing techniques. A mobile home has permanently attached wheels; a modular house is delivered on a chassis and demounted at the site; and prefabrication generally refers to factory manufactured components assembled in essentially on-site construction.”³

He predicted modular design would gain ground over mobile housing, recognizing that “heavier modules... built to conventional housing specification as well as criteria for over-the-road transportation...involve more skilled labor” and would therefore, result in a more highly designed and resolved homes.⁴ Despite the fact that today modular homes account for only seven percent of the U.S. housing market (mostly single family homes and low-rise apartment buildings), Swaback’s predictions were not completely unfounded.⁵ A decade later architect and educator Edward Dean also celebrated the advantages of manufactured housing systems, specifically their capacity for innovation related to high performance homes. He outlined six design characteristics which could align “*the accomplishments of the specialized designs of solar architecture while solving the related, and perhaps more fundamental, problems of affordability and quality*”.⁶ These characteristics included minimizing the initial costs of construction with economies of scale and labor, using the best available materials and building products, insisting on the highest level of quality control, eliminating the need for heating and cooling by passive means, achieving indoor air quality, and ensuring the home’s integration with the site and its appropriate planning for user needs.⁷

Although Dean doubted these changes could be realized in 20 years, recent projects demonstrate that progress has indeed been made. Architect Michelle Kaufmann, as one example, is celebrated for bringing modern prefabrication techniques to sustainably designed modular housing, with some of the principles outlined above illustrated in her 2009 publication *Prefab Green*.⁸ The three residential projects described here below further illustrate the potential for realizing high-performance, net zero-energy, homes by adopting innovative strategies for modular construction.

2. MODULAR BUILDING - THREE SCALES / THREE STRATEGIES

The first of three strategies described involves the design of a modular 'utility core' that centralizes all of the home's mechanical, electrical and plumbing systems. The *MorningStar* home was designed using this independent pod deployable on any site and easily integrated with existing or new construction. This highly energy efficient module rationalizes the home's building systems, facilitates their shipment, and provides opportunities for introducing renewable energy, essential to achieving zero-energy performance. The second strategy, adopted in the project *Natural Fusion* was designed to contain all living spaces in a single module, taking advantage of the 'inside-out construction' method used in home manufacturing plants. This method facilitated the introduction of innovative materials within the building's envelope and ensured higher levels of quality control; conditions necessary for the realization of a high-performance home. And lastly, the prototype home built for the Union County Housing Authority's Energy Efficient Housing Program (*EEHP*) introduced a 'whole-house' approach to high performance by employing off-the-shelf technologies and modular construction methods to deliver a cost-effective product, which evidenced that vast energy savings could be had when a high performance model is employed at the scale of a community. Collectively, these three approaches address market-based parameters that promote truly deployable strategies for achieving high-performance homes.

3. MORNINGSTAR - THE PREFABRICATED 'UTILITY CORE'

MorningStar is a hybrid high-performance residence, both prefabricated and site-built. It combines the efficiencies and cost-saving potential of modular building with the adaptability and environmental benefits of site built construction.⁹ While the former ensured efficiency of systems and economies of scale and labor, the latter allowed for optimizing solar orientation using passive design strategies, taking advantage of local materials and resources, and incorporating local vernacular construction methods and available untrained labor in realizing homes that reduce costs, generate jobs, and promote a healthy living environment.

Two versions of *MorningStar* were designed and built for different sites and climatic conditions. The first, *MorningStar Pennsylvania (MorningStar PA)*, was built as an 800 s.f. (74 m²) net zero-energy home located in central Pennsylvania (USA) and the second, *MorningStar Montana (MorningStar MT)*, was an approximately 1,000 s.f. (93 m²) two-bedroom affordable home for the Northern Cheyenne Indian Reservation in southeastern Montana, USA (see Fig.1 and 2). Both met stringent standards for livability, energy efficiency, and indoor environmental quality, and both were fitted with renewable energy technologies appropriate to climate and client.

3.1 Modular Construction: Utility Core

The modular component of *MorningStar PA* and *MT* was the 'utility core'; a pre-manufactured self-contained pod housing the home's building systems. All mechanical equipment, electrical services, plumbing fixtures, water supply, drain, waste and vent (DWV) piping, telephone, coax cables and Balance of Systems (BoS) for photovoltaic arrays and solar thermal panels were centralized into the highly insulated envelope of this module. Its compact design served to minimize line-losses and improve overall efficiency. It acted as a compact energy management system, organizing the functions of kitchen, bathroom, laundry and mechanical room. Once manufactured, the utility core was deployed to the site where a single point of connection tied the prefabricated utility core to the rest of the home. All ductwork and temperature sensitive systems were located within the conditioned utility core, allowing

these systems to function efficiently even if the core was connected to a less energy-efficient building envelope. Contrary to the portion of the house built on-site, this specialized module was built using skilled labor in a controlled manufacturing environment.

The utility core dimensions were based on maximum flexibility for laying out all building systems within the limitations prescribed by transportation of the core on a 2-axel trailer. Three separate variations were developed by functionally reconfiguring the interior layout of partition walls, fixtures and equipment; one providing all of the services needed for a small home, the second providing a kitchen, bathroom and mechanical space for a living space addition, and another accommodating a plumbing / utility closet and two full bathrooms to service a bedroom addition. These variations were created to offer greater choice and to ensure the utility core was adaptable to either an existing home or new construction. More than one core can be used depending on the needs of the client. And in all cases, the utility core can be mass customized, facilitated by the use of stock elements and standardized connections and details



Fig. 1: MorningStar PA as exhibited at the Solar Decathlon on the National Mall in Washington D.C. in October of 2007. (Courtesy of the 2007 Penn State Solar Decathlon Team and the Center for Sustainability at Penn State)

3.2 On-Site / Off-Site Hybrid

In a 2008 keynote address delivered at the Association of Collegiate Schools of Architecture conference, *Without a Hitch: New Directions in Prefabricated Architecture*, Stephen Kieran, principal of KieranTimberlake, spoke poetically of construction as a process that employs the principles of both “knitting and quilting;” ‘knitting’, referring to the complex integration of systems more easily coordinated and installed in a controlled manufacturing environment; ‘quilting’, as the stitching together of components that takes place on-site.¹⁰ In *MorningStar’s* prefabricated utility core, all mechanical, electrical and plumbing components were ‘knitted’, that is installed, inspected, and preliminarily commissioned in the controlled environment of the workshop or home manufacturing plant. The result of which was enhanced systems performance, easier coordination of installation schedules and the careful integration of waste heat recovery from vents and plumbing drains. While living spaces were ‘quilted’ on-site by an untrained volunteer workforce (see figure 3). The *MorningStar* demonstration homes combined the efficiencies of mass-production with the benefits of site-specific construction and in so doing maximized their potential for achieving high performance metrics.



Fig. 2: American Indian Housing Initiative’s MorningStar MT. (Courtesy of the 2007 Penn State Solar Decathlon Team and the Center for Sustainability at Penn State)



Fig.3: Time-lapse construction sequence of MorningStar MT. The Utility Core was prefabricated, transported to the site, and set on a prepared foundation. The home's living space was site-constructed by volunteer labor using straw-bale construction for exterior walls and structurally insulated panels for the roof. A solar-electric array and evacuated-tube solar thermal panels were installed on the south-facing roof, providing heat, hot water and power to the home. (Courtesy of the 2007 Penn State Solar Decathlon Team and the Penn State Center for Sustainability American Indian Housing Initiative)

4. NATURAL FUSION - INNOVATING AT THE BUILDING'S ENVELOPE

In 1947 Theodore Larson, U.S. Housing Authority architect / project planner and technical consultant to the Military Affairs Kilgore Subcommittee on War Mobilization, recognized the significant impact which aircraft and other war-related industries were having on housing production, writing that “*unlike the earlier house prefabricators whose units have differed little from the conventional house in design and construction, these newcomers are experimenting with new materials, new designs, and wholly new systems of house fabrication*”.¹¹ One result of which was the development of new methods for modular building. *Natural Fusion* (see fig. 4) employed modular construction techniques to make the most of the efficiencies of standardization.¹² More specifically, the home capitalized on the exterior wall fabrication technique used by modular homebuilders to integrate advanced materials and institute increased levels of quality control to optimize the building envelope, both important for achieving high-performance results.

The design team leveraged unique collaborative partnerships with Pennsylvania industries to implement the construction of a healthy, adaptable, and net zero-energy solar-powered home available to a general consumer. Three variations of the home were designed as a result of marketing studies. The base module was a 748 s.f. (69.5 m²) complete one-bedroom home; with variations two and three being two different versions of a two-bedroom home (see Fig. 5).

4.1 Optimizing the Envelope: Building Inside – Out with Innovative Materials

Natural Fusion was designed according to manufactured home standards established by the US Department of Housing and Urban Development (HUD), which prescribe code restrictions for durability and strength, fire resistance, transportability, energy efficiency, HVAC, plumbing and electrical systems performance. Ultimately, to ensure the construction of a highly insulated and well-sealed building envelope, the *Natural Fusion* team partnered with a reputable Pennsylvania modular home manufacturer with significant experience constructing to ENERGY STAR certification standards to build the home.¹³

Aside from an exposed timber-frame post and beam structure, fairly typical modular construction framing techniques were used (see fig. 6). The floor was framed first, using floor trusses instead of conventional floor joists. The open web of the trusses made it easier to run piping, wiring and ductwork below the floor of the home from the centralized mechanical space. The walls and roof of the home were framed using wood studs spaced 24 inches on center, reducing the amount of framing lumber required and maximizing space for insulation.¹⁴ The walls were assembled horizontally where drywall was applied to the interior surface prior to the walls being tilted into place.



Fig. 4: Natural Fusion home. (©Geoff Rushton Photography, Courtesy Penn State Public Information)



Fig. 5: Plans of Natural Fusion "Get Ready to Own (gr2o)". Prospective owners could purchase a home using an interactive website choosing from three configurations; base module (top left), two-bedroom versions (middle and bottom plan). (Courtesy of the 2009 Penn State Solar Decathlon Team)



Fig. 6: Natural Fusion home (interior). (©Jim Tetro Photography, Courtesy DOE)

Important innovations were made in constructing the building's envelope that contributed to the high performance of the home while minimizing mass and weight for efficient transportation. Under the flooring, a unique refillable water bladder added thermal mass for passive heating. This bladder was left empty for transportation purposes and was filled on-site. Other innovations took advantage of the 'inside – out' wall fabrication typical of modular building practices; that is, walls constructed from the interior drywall to the exterior cladding. This process afforded a number of opportunities for significantly increasing the performance of the home. One example was the phase-change material, sheets of thin bubble-wrap like membrane containing cellular pockets filled with soy-based chemicals that changed phase from solid to liquid, installed on the interior surface of walls and ceiling directly behind the drywall. As a light-weight alternative to thermal mass, this highly engineered material absorbed heat when the interior temperature of the home increased and solidified – releasing stored heat – when the space cooled; this contributed to the home's high performance by regulating interior temperature while reducing heating and cooling demands.

4.2 Optimizing the Envelope: Better Quality Control

The wall fabrication methods used in modular home manufacturing also facilitated the proper execution of construction details essential for enhanced energy performance.—Modular building expert and author Andrew Gianino asserts that modular manufacturers can be more successful at sealing a house than convention building practices and attributes this to “the luxury of building from the inside out.”¹⁵ For *Natural Fusion* this technique was very conducive to achieving the proper installation and sealing of interior air barriers given that the drywall was installed prior to the outside sheathing of the walls and roof. Careful insulation installation and double-checking for settling and gaps allowed for an almost perfect seal of the building's envelope. The factory setting also aided more careful assembly oversight and inspections to identify and more easily correct any problems. Additional benefits of building in the controlled manufacturing environment were that construction waste was reduced since material re-use and recycling was easier to implement and oversee. And since most of the construction took place inside, porous and organic materials were protected from water damage, reducing the risk of mold.



Fig. 7: *Rendering of semi-detached EEHP duplex.*
(Courtesy of Office for Planning and Architecture)

Today's builders of manufactured homes must compete for shares of the industry; constructing more energy-efficient and sustainable homes is one way of achieving this goal. Enhancing employee training and pursuing certification of homes through EPA Energy Star and other third-party rating systems helps to set manufacturers apart. As this example demonstrates, *Natural Fusion* is a modular home that takes advantage of assembly line techniques, while achieving a greater standard of high performance by integrating advanced materials and effective details against air infiltration.

5. EEHP HOUSING – MODULAR HOMES AT THE SCALE OF A COMMUNITY

The final case study is the first project of the Union County Housing Authority's (UCHA) Energy Efficient Housing Program (EEHP). Located in Lewisburg (Pennsylvania, USA), the home was intended as a model for highly energy-efficient modest houses deployed on underutilized sites throughout the area's small towns. A 'whole-house' modular approach is employed to leverage the benefits of multi-modular home construction facilitated through an intensive *integrative design process* to enable adaptability and mass customization for scattered sites in existing communities. This approach is intended to address a need for quality housing for an aging population and the revitalization of existing walk-able (and thus inherently sustainable) communities. In order to control cost and ensure a replicable model, readily available systems and technologies are used.



Fig. 8: EEHP modules on the assembly line in the modular home manufacturing plant. (Photograph by author)



Fig. 9: Modules of the EEHP duplex being set on site. (Photograph by author)

The semi-detached duplex prototype was designed for a narrow infill lot (see Fig.7). Each home is 1000 square feet (93 m²) and programmed for universally accessible single floor living.¹⁶ A semi-finished room on the second floor added flexibility to the program; utilities on the second floor were installed for future use. Approximately 90% of the EEHP duplex was completed in a manufacturing plant near the building site. Comprised of four building modules, the duplex integrated construction strategies that contributed to a 'complete' thermal envelope. Like in *Natural Fusion*, the modular approach significantly eliminated air infiltration through careful detailing and sealing of gaps. The modules were trucked to the site and craned into place. No on-site framing was required since construction of the building shell, electrical and plumbing systems, installation of appliances and finishes were all closely supervised and completed in the manufacturing plant. Some commissioning and third-party inspections for Energy Star and 'green' home certification also took place in the factory prior to delivery.

The homes' materials were highly durable, renewable, recycled and recyclable, and whenever possible, locally manufactured. A highly energy-efficient building envelope minimized the need for space heating and elaborate conditioning systems; a single compact mini-split heating and cooling unit was used to condition the entire home. A programmable heat recovery ventilation (HRV) system, and a hybrid hot water heat pump, were selected for long-term energy savings and improved indoor air quality. All lighting, appliances and fixtures

were Energy Star rated or otherwise highly energy or water efficient. As a result of integrative design and engineering, the semi-detached homes are 44% more efficient than Energy Star Homes and 56% more energy efficient than a home built to the International Energy Conservation Code (IECC) minimum standards. Additionally, the primary roof of the duplex faces south and was appropriately sloped for solar installation that would bring the homes to net zero-energy performance. Each home was fitted with a conduit from roof to basement mechanical area for the future installation of this solar installation. Energy monitoring systems were installed to provide live feedback to the occupants and data that can be remotely accessed for continuous optimization of the homes that will inform further development of the model.

5.1 The Complete Thermal Envelope

The exterior walls of the EEHP pilot homes were constructed using a unique panelized system where, unlike most Structurally Insulated Panels (SIPs), the studs were offset to eliminate thermal bridging. As a result, continuous insulation allowed for a wall that was only 5-1/2" thick to achieve a very high thermal resistance value.¹⁷ The panelized wall system was also advantageous in reducing overall building materials since no sheathing was required; interior drywall and exterior siding were attached directly to the metal studs of the panels. To achieve the 'complete' building envelope desired for efficient energy performance, special attention was paid to the potentially thermally

weak conditions where the individual modules were connected. Most significantly this included where the upper and lower modules were connected at the perimeter band joists. Gaps were eliminated by applying rigid board insulation along the joints. Other critical areas were the connection between modules on the same floor and those between the upper storey modules and the attic. These joints were difficult to insulate in the factory, therefore, insulation was completed after the modules were set using expanding spray-foam and blown cellulose insulation.

The modular nature of this home was ideal, for the spatially confined infill site upon which it was located. With neighbors but a few steps away, very little space was available for building on-site. Because the scope of on-site construction was significantly reduced, the site disturbance was minimal and the homes were erected in one day. Importantly, building costs for modular construction proved to be over 30% less than conventional construction bids for this project.

5.2 A Community Approach

The open and flexible floor plan of the EEHP semi-detached duplex allowed for its adaptability to the site and for meeting the residents' future needs. The modular whole-building approach to energy-efficiency was an ideal solution for this infill site and an ideal model for other development on infill sites in urban areas, revitalizing core community fabric. Additionally, through rigorous preliminary design and an amplified integrative design process, a "kit-of-parts" of optimized modules can be developed that would have positive implications for the efficient use of materials and the elimination of waste. Likewise, short-term cost savings can be achieved though an economy of scale facilitated by repetition, while long-term energy-savings are realized by the residents. Such an adaptable approach allows for significant variation in appearance from home to home and implementation of the model to realize communities of highly energy-efficient modular homes..

6. CONCLUSION

The merits of modular building are widely recognized in the field of green construction. The controlled factory environment with its use of manufacturing techniques is effective in realizing high-performance utility cores, building envelopes, entire buildings and communities. Modular construction is considerably safer than a construction site, its techniques improve on-site efficiency, decreases construction time, and has the potential to help to address issues of health-and-safety.¹⁸ Modular manufacturing addresses questions of project delivery, allowing complex or difficult to install systems to be completed by a trained labor force. Additional benefits include increased product precision, standardization of components, improved productivity, shorter assembly and on-site construction time, minimized waste, increased recycling and improved quality control. Directly related to high-performance design, modular building methods can be highly attentive to reducing air infiltration, to increasing the insulation value of building skins and to construction details that improve energy-efficiency.

In the United States, modular homes are the fastest growing segment of the residential building market. In theory, their manufacturers have an opportunity to become leaders in the industry by providing competitively priced low-energy, high-performance homes. As seen in the projects described here above, careful design of their construction details and methods is necessary for achieving innovation and excellence in high-performance modular homes.

ACKNOWLEDGMENTS

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MorningStar, 2007 Penn State Solar Decathlon Team: www.solar.psu.edu
Natural Fusion, 2009 Penn State Solar Decathlon Team: www.naturalfusion.org –
EEHP team: www.unioncountyhousingauthority.org/EEHP.

Special thanks to Bruce Quigley (Office for Planning and architecture) and Peter Vargo (Nu-Tech Energy Solutions) for their reflections on the benefits of modular construction relative to high-performance homes.

ENDNOTES

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9. For more information see, Lisa D. Iulo and David Riley, "The MorningStar: A Hybrid Concept for Community Building and Renewable Energy" (paper presented at the 38th American Solar Energy Society (ASES) Annual conference, Buffalo/Niagara, NY, 11-16 May 2009).
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11. C. Theodore Larson, "Toward a Science of Housing," *The Scientific Monthly*, Vol. 65, No. 4 (October 1947), 297.
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13. ENERGY STAR is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy. <http://www.energystar.gov/>
14. This framing strategy is known as 'Optimal Value Engineering'. For more information see U.S. Department of Energy Building America, *Best Practices: Optimal Value Engineering* (Washington, D.C.: IBACOS, Inc., 2003).
15. Andrew Gianino, *The Modular Home* (North Adams, MA: Storey Publishing, 2005), 14-15.
16. Entrances to the EEHP Duplex were ADA Accessible; the living spaces of the home were built to *Visitability* standards. *Visitability* is a universal design strategy that allows for accessibility to residences by all people including those with physical disabilities.
17. The manufacturer documents an effective r-Value of 33. "Thermasteel Eliminates Thermal Bridging," document downloadable on the product website, <http://www.thermasteelcorp.com/>.
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"Redesign, Rebuild, Reside = Reinventing the Conventional Ideas of the Home".

Sponsored by the U.S. Department of Energy and the National Renewable Energy Laboratory (NREL), the Solar Decathlon is an inter-collegiate competition to design, build, exhibit and operate a small, beautifully designed solar home. 20 teams, including Penn State, participated in the 2009 Solar Decathlon competition.

Dubbed *Natural Fusion*, the conceptual design for the home encourages interaction between inhabitants and their surrounding environments. *Natural Fusion* features an open, adaptable living area with an operable south façade that expands the living space to the outdoors. Warm, natural, recycled, and eco-friendly materials, selected using rigorous Life Cycle Assessment (LCA), define the character of the home. *Natural Fusion* incorporates environmentally conscious and energy efficient materials and technologies, from reclaimed wood flooring and zero VOC paint to phase change materials and water storage for thermal mass.



Natural Fusion Solar Home

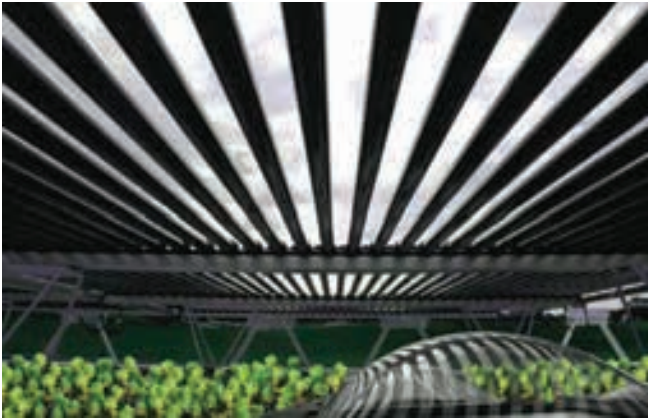
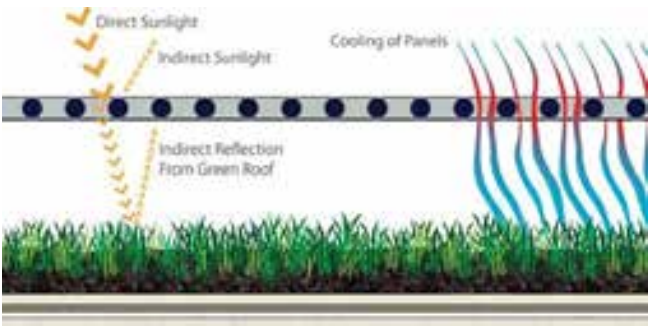
2009 NREL Solar Decathlon

Lisa D. Iulo, PSU Team Architecture Advisor









GRIPV roof improves the efficiency of the solar panels



This solar-electric shading canopy tracks the sun



All of Natural Fusion's building systems are centralized in a common mechanical space called the "Nexus"

Natural Fusion's design accommodates ambitious goals for applied research. The educational and research opportunities provided by this Solar Decathlon project were strengthened and elaborated on through partnerships with Pennsylvania-based industries.

Innovative research applications developed for Natural Fusion include a solar canopy that provides passive solar shading of the south façade and incorporates solar panels that track the sun to provide power to the home and a Green Roof Integrated Photovoltaic (GRIPV) array on the roof. The greenwall improves indoor environmental quality and reiterates the *Natural Fusion* concept by creating continuity between the interior and exterior of the home.



WINNER: 3rd place (tie, out of 20) - **Lighting Design**
3rd place (out of 20) - **Engineering**
2009 NREL Solar Decathlon competition

“The collaboration with a ‘real-world’ modular builder and ENERGY STAR partner definitely improves the marketability of this project. The jury found this home to appeal not only to environmental & socially conscious, but also to cost-conscious homeowners.”

Market Viability jury comment

“...the team’s overall project struck an appropriate compromise between innovation and reliability, with energy systems that are suitable for the team’s target market climate.”

Engineering Jury comment

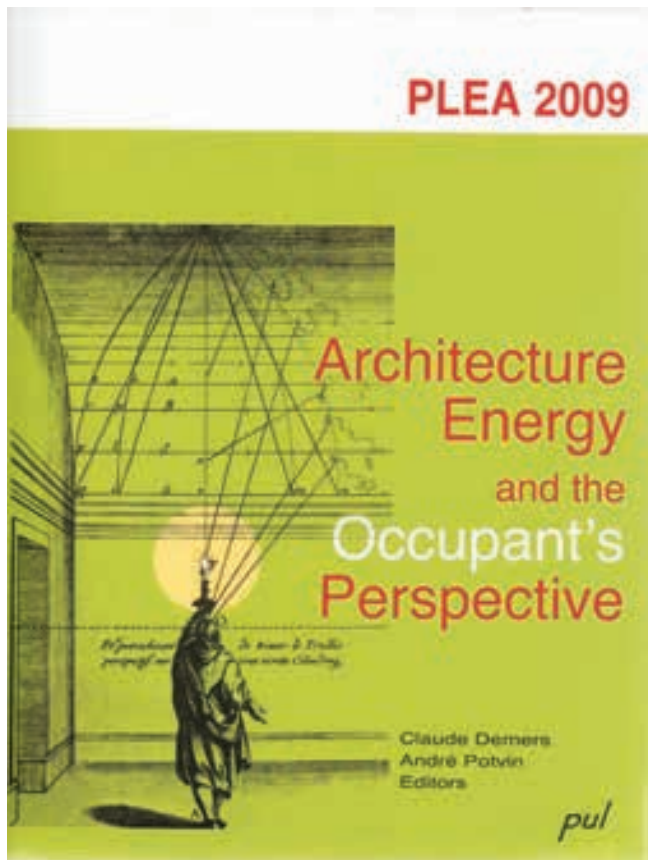




Natural Fusion on the National Mall in Washington DC in October 2009 during the Solar Decathlon



Natural Fusion on its permanent site, at the Bayer Material Science campus in Pittsburgh, PA, serves as a conference center and materials research facility



Iulo, L.D., "Low Energy Architecture / Low Energy Living: Strategies for Passive Design at the Urban and Building Scales." In Proceedings of the 26th International Conference on Passive and Low Energy Architecture: Architecture, Energy and the Occupant's Perspective, edited by Claude Demers and Andre Potvin (2009).

LOW ENERGY ARCHITECTURE / LOW ENERGY LIVING: Strategies for Passive Design at the Urban and Building Scales

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ABSTRACT: Low energy architecture must be addressed in the context of low energy living; it must be addressed at the scale of urban/town fabric as well as that of individual buildings. Although limited guidelines addressing energy efficient rehabilitation of existing homes and town fabric exist, none of the resources address these issues from the point of view that can have the most impact, the occupant's. This paper presents a replicable process for low-energy architecture and living that takes into account occupant patterns as a design factor in passive design at the urban and building scales.

Keywords: low-energy, renovation, retrofit, planning, passive design, occupant

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1. INTRODUCTION

This paper addresses low energy architecture through occupant interaction and the understanding of occupant patterns at the urban and building scales. Specifically, the paper addresses 1) the use and reuse of existing infrastructure; 2) establishment or expansion of walkable uses on a community scale with the intention of reducing car trips 3) the adaptation of existing homes to contemporary use, in the interest of proposing strategies for energy-efficient, passive low energy renovation and retrofit of existing, sometimes historic, buildings in existing town centers. These opportunities are illustrated through the presentation of a case study for the renovation and retrofit of a semi-attached, historic row house in Carlisle, Pennsylvania. The analysis of the existing town fabric and infrastructure will illustrate the benefits of the historic development patterns of the downtown area as an inherently sustainable community. Design strategies for the use, reuse and expansion of existing infrastructure and community fabric will be discussed. Finally, an 1841 row home will be presented as an evolving model for passive low-energy design to include the reuse of existing spaces to meet the live/work needs of the occupants and the modification of the existing building envelope and systems to achieve a higher-performing, more energy efficient, and environmentally responsible building. The intension of this study and precedent is to illustrate a flexible, occupant-driven process that can be adapted

to fit other homes within existing towns.

2. BACKGROUND

2.1 Low Energy Living

On the fringes of the Northeast Corridor traditional towns are undervalued. They may provide regional and civic identity for residents of surrounding areas but rarely are they the commercial, institutional or residential centers that they once were. The formerly healthy mixed-use town centers are now under-used and considered to be less desirable than surrounding suburbs or rural areas. When businesses and institutions moved to remote (car based) venues, towns had less market appeal. Their fabric, in many cases, doesn't adequately support autos (at least not one car for every adult) and their (often very well made) buildings are not easily and efficiently adapted to contemporary uses. The reinvigoration of such towns represents not just an excellent opportunity for low-energy living but a satisfying alternative to the homogenous development that has often emerged nearby. Such transformation will likely require active support from myriad sources but it is clear that considered, contentious and evolving resident action is requisite. The transformation must be a reawakening of community.

2.2 Low Energy Architecture

In 2000, single-family attached houses (row houses and townhouses) comprised 5.6 percent of the total U.S. housing inventory, 2% less than their highest inventory in 1940 [1]. Although this market is a small percentage of the overall single-family housing market, it is the majority of the housing type in existing town centers and therefore energy-efficient renovation of these structures, to reinforce community, is essential. Despite the United State's reputation as a "rootless" society, fewer than 12 percent of Americans moved since 2007, the lowest rate since the Census Bureau began tracking this information in 1940 [2]. However the vast majority of the nation's existing housing stock is constructed to standards far below current energy codes. Although some guidelines exist to inform the retrofit [3] or renovation [4] of existing homes to green and energy efficient standards, these guidelines do not generally take owner occupant patterns into account beyond material performance/preference and thermal comfort. Recognizing and designing with occupant patterns in mind provides the opportunity "to position users' behavior as a key 'active' determinant of energy performance in passive design"[5], not only through adaptive opportunities, but also as a strategy for low-energy design and community building. Strategies for passive low energy design should be considered at multiple scales within the context of the neighborhood



Fig. 1: *St. Jerome in His Study*, ANTONELLO da Messina, about 1475. © The National Gallery, London fabric and the building.

3. SCALES OF INTERVENTION

The layers of St. Jerome in his Study (Antonello, about 1475) illustrate the multiple scales of consideration necessary for a low energy approach (refer to Fig. 1). The inserted workspace provides privacy, functions for its specific use, and controls the space around it. This work "pod" organizes the space around it into zones, implying different uses and connections with the surroundings. The enclosing building envelope monitors thermal performance, daylight and natural ventilation. The occupant remains connected to the outdoors with visual connections to the sky and the ground. Ultimately the building shell nests within the context, the peacock symbolizing a garden oasis and the windows framing the urban environment – neighbors and adjacent buildings. The occupant, central to the image, controls his work while simultaneously interacting with the environment.



Fig. 2: Photomontage of Carlisle Square. Photos by A. Hyde

3.1 Case Study

251 South Pitt Street is being renovated for an adult couple with no children at home. It is important to the occupants that their residence meets the basic tenets of responsible low-energy community living. Further, both desired a degree of character and authenticity. They concluded that their basic goals could best be met by efficiently occupying an existing house in a walk-able neighborhood.

The home is located in Carlisle, Pennsylvania (40°12' 9" N 77°11' 42" W). Big by Pennsylvania standards, the town is the county seat of Cumberland County. Carlisle has character; the old courthouse even has marks from artillery shells fired by confederate soldiers around the time of the battle of Gettysburg. Carlisle benefits from multiple amenities within easy walking distance, including stores, community resources, two universities and a law school, governmental and judicial buildings, diverse employment opportunities, parks and recreational facilities, and productive agricultural land (refer to Fig. 2).

Likewise, the house has integrity. Built in 1841, it is solid brick with satisfying proportions and high quality detailing and materials that would be difficult and expensive to replicate today (refer to Fig. 3). At 2,786 square feet the home is too large for the occupants needs, and not well insulated, but the traditional layout supports the separation of space by use, time of day, or comfort requirements. The orientation also provides opportunity for passive solar improvements (refer to



Fig. 3: 251 South Pitt Street, Carlisle Pennsylvania.

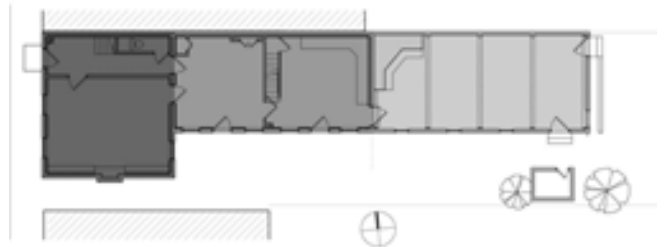


Fig. 4: Plan of 251 South Pitt Street illustrating existing conditions and building orientation.

Fig. 4).

3.2 Implementation Scale 1: Use and Reuse of Existing Infrastructure and the Expansion of Walk-able Uses

The occupants are fully committed to town living. They primarily walk or bike, keeping one (hybrid) car for limited-use. Further, they are dedicated to improving community through their actions, serving on a board that recently brought a permanent farmers market to downtown and supporting local food-production through home gardening and subscribing to community supported agriculture (CSA). The couple collocated their office and residence. The positive impact is obvious - no commute, efficient use of the extra space, one mortgage, one utility bill - and the day and night activity of the live/work mix of uses benefits the community by providing "eyes on the street" and expanding walk-able amenities.

3.3 Implementation Scale 2: Building Envelope

Any renovation or retrofit project should begin with a home energy audit that will provide existing energy performance information as well as specific strategies for energy conservation. Recommendations for water efficiency, financing opportunities for energy-efficient upgrades, and quick efficiency improvements that can be easily achieved by the owner may also be outlined in the home audit report. Based on the audit information appropriate retrofit measures can be identified to reduce air infiltration and improve energy-efficiency of the existing home. Since 251 South Pitt Street was newly purchased, retrofit of the project - improving the performance of the existing thermal envelope - could be substantially completed prior to move-in. The audit confirmed moderate to severe air leakage at the attic and attic junctures (wall tops, electrical boxes, recessed lights), basement band joist, and attic stairwell. An overall goal of a 30% reduction in air infiltration for the original house was established as a realizable (although significantly lower than recommended) target for the home.

Recommendations were made to inspect the exterior brick walls and seal any leaks, to add insulation to the basement, attic and crawl space, to insulate the floors between levels, and to replace the drafty front door and sidelights. Existing fenestration patterns, overhangs, and opportunities for shading, were analyzed and improved as needed. In order to maintain the character of the original brick structure, alternative methods for improving energy performance were explored for insulating the walls by isolating the different uses through implementing zones and “pods”.

3.4 Implementation Scale 3: Zones

Four zones were identified according to function and time of use (day/night; work/home; public/private). Offices on the first floor would be active during weekday business hours, while the downstairs kitchen/pantry, second floor sitting room and sleeping suite were to be used during winter evenings and overnight. Thermal separation between zones allow for more specialized control of temperature and comfort according to which spaces are in use and what types of activities are happening in each zone (refer to Fig. 5).

The rear addition (constructed in the 1980’s), a separate zone both mechanically and spatially, was identified as an opportunity for idealized passive solar strategies for lighting and climate control. The space will serve as

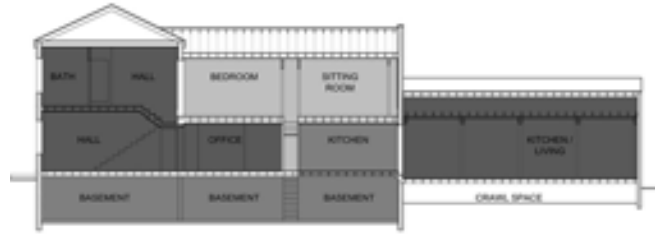


Fig. 5: Schematic diagram of proposed Zones.

the primary living and dining area for flexible morning, evening, and weekend use. A major goal of this project was to achieve overall efficiency without separating the occupants from the outdoors. The renovations to the back addition play a large role in connecting the interior with the rear garden (to the east) and an outdoor room defined by a trellis (to the south). The trellis shades the windows from solar gain in the summer, supporting seasonal foliage and a row of deciduous fruit trees in the rear garden. The upgrade of a large existing fireplace and the addition of mass, by replacing part of the floor with a concrete slab and reconstructing the south wall with a partial-height Trombe wall, will allow the space to be primarily passively heated. Eliminating the dropped ceiling to follow the north to south slope of the existing roof allows for operable clerestory windows high in the lot-line wall of the north façade. These additional windows (in combination with doors and operable windows to the south) improve ventilation in the space and eliminate the need for mechanical cooling (refer to Fig. 6). Reversible ceiling fans augment circulation throughout the year, improving occupant comfort.

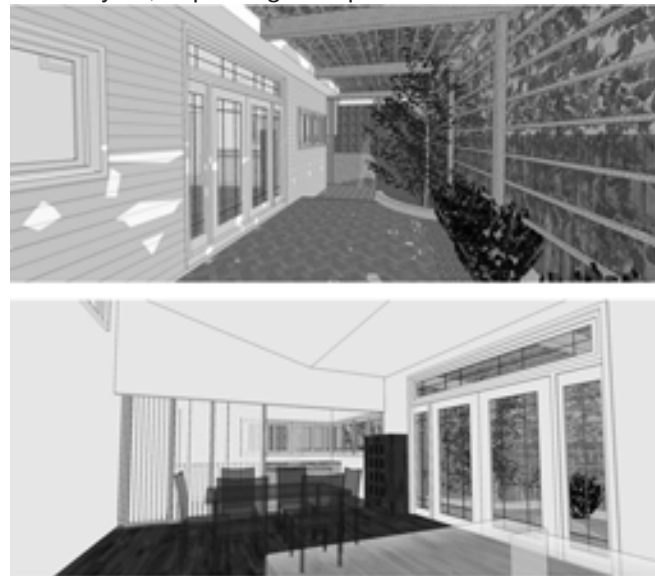


Fig. 6: Rear Addition renderings. © OPA, Harrisburg.

3.5 Implementation Scale 4: Pods and Mini-systems

“What is needed are many more small rooms – some need not be larger than alcoves – to conform to the range and variety of [leisure] activities in the modern home [6].”

After the building envelope has been retrofitted and the zones implemented through minor renovation, thermally isolated “pods” can be added to further separate zones, by use, within the existing structure. In addition to allowing more specialized control over the temperature in each zone, separating the house into “pods” will keep heat from accumulating on the second floor. Mini-systems, optimized according to occupant use patterns, will augment the existing mechanical systems and provide time-of-use comfort. Systems include dehumidification and clean burning efficient stoves that provide both comfort and character (refer to Fig. 7).

A mini-split air source heat pump could supplement the existing hot-water heating by zone or within “pods”. Because of the great opportunity for solar gain along the south wall and roof of the back addition, this space can function independently, providing a solar hot water boost to the whole-house boiler in the future. Controlled connections between zones and pods provide opportunity for natural ventilation and nighttime “flushing” (refer to Fig. 8).

4. STRATEGIES FOR AN OCCUPANT INFORMED LOW ENERGY APPROACH

The strategies developed for 251 S. Pitt Street can be replicated to achieve passive low-energy living at the urban and building scale. The occupants’ decision to purchase an existing home in an established town was a major factor in low energy living. Using existing urban infrastructure and living within walking distance of the town square and neighborhood resources eliminated the need for a car. Re-allocating the unused front parlor and dining room as commercial office space further reduced car trips and expanded walk-able uses within the community. The reuse of the home’s infrastructure and management of space minimizes costs for mechanical heating, cooling and ventilating, allowing the home to function passively for most of the year. The overall space assessment and adaptation of existing spaces updated the structure for contemporary patterns, identified opportunities for maximum efficiency, and minimized high-energy consumption heating and cooling systems for small scale individual



Fig. 7: Efficient stove supplementing hot water heating system in “Pod”.

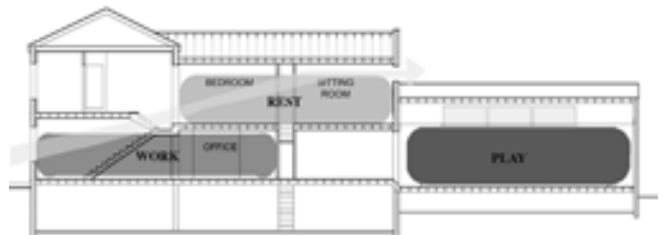


Fig. 8: Schematic “Pod” diagram with opportunities for natural ventilation highlighted.

systems to meet localized, time-of-use demands.

This project demonstrates that energy-efficient, passive low energy living begins with location. Existing town fabric must be cherished and re-established. Approaches for retrofitting of existing homes for maximum energy-efficiency must be balanced with use assessment and identification of existing assets to maintain town fabric and historic character where applicable. This balance is achievable, especially when strategies for managing living spaces or interior “pod” configurations are considered. Most importantly, project coordination and management must be considered, focusing on a long-term plan to achieve maximum efficiency. The plan must recognize and set goals, but must also be flexible enough to transform with changing occupant needs and technology overtime.

Isolating the strategies applied to 251 South Pitt Street may serve as guiding parameters for low

energy architecture and low energy living:

- Minimize waste, and reuse or retain existing infrastructure and materials where possible.
- Expand and support local businesses, amenities, and food sources to reduce car trips.
- Study the performance of the existing thermal envelope and identify problem areas. Seal leaks and evaluate window and door performance. Add insulation where possible.
- Evaluate the inherent mass of a building and explore possibilities of using it to store thermal energy. Where little mass exists, consider adding it.
- Identify zones of intensive use by working with occupants to establish how they use space. Establish zones and “pods” of space customized according to time, duration and type of activity.
- Take a two-tier approach to heating and cooling to increase overall performance and meet localized, time-of-use demands.
- Achieve cooling in the summertime by using a minimum of conditioning (by zone) and daily flushing through natural ventilation, concentrating on movement and dehumidification of air to improve the comfort irrespective of the desired temperature which varies from person to person.
- Evaluate the feasibility of adding solar thermal assistance to systems. Consider solar-electric strategies only after optimizing overall efficiency and energy performance.

A long-term goal of the project is to provide a model for occupant informed renovation and retrofit of an existing home. Records of monthly and yearly energy savings will be maintained and compared to prove the value of such a model to other homeowners. Documentation of results will also help to evolve and improve the process over time.

5. CONCLUSION

The strategies and methods presented provide a needed model for customizing existing housing stock to maximize performance and minimize energy costs through working with the occupant to customize the home and use patterns. It suggests a continuously evolving process for renovation and retrofit of existing homes, but most importantly it provides an alternative to abandoning the resources and advantages of

our existing town fabric. This paper suggests a continuously evolving process for renovation and retrofit of existing homes that will allow homeowners to find sustainable ways to reduce their energy bills, while greatly increasing the quality of their communities and living space. The purpose is not to provide a product, but instead to offer occupants a holistic vision specific to each home and a flexible process that will allow them to attain their goals.

ACKNOWLEDGMENTS

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The MorningStar: A Hybrid Concept for Community Building and Renewable Energy

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ABSTRACT: This paper presents a concept for community building and renewable energy that was developed and tested by the 2007 Penn State Solar Decathlon Team. This concept, the MorningStar, demonstrates a practical hybrid prefabricated / site-built design that is easily adapted to multiple contexts. The hybrid energy system serves to demonstrate regional solutions in which integrated energy efficient and renewable energy strategies can be customized and affordably integrated into new or retrofit building projects. The team tested the hybrid concept through a design-build process that resulted in two prototype homes, an 800 square foot (sf) zero-energy home designed for the 2007 National Renewable Energy Laboratory (NREL) Solar Decathlon competition and a 1015 sf two-bedroom affordable prototype home that demonstrates the market potential of the hybrid concept. Both homes serve to advance and promote energy-efficient construction and the use of residential-scaled solar energy systems.

Keywords: community building, hybrid residences, renewable energy

THE MORNINGSTAR: A HYBRID CONCEPT FOR COMMUNITY BUILDING AND RENEWABLE ENERGY

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ABSTRACT

This paper presents a concept for community building and renewable energy that was developed and tested by the 2007 Penn State Solar Decathlon Team. This concept, the MorningStar, demonstrates a practical hybrid prefabricated / site-built design that is easily adapted to multiple contexts. The hybrid energy system serves to demonstrate regional solutions in which integrated energy efficient and renewable energy strategies can be customized and affordably integrated into new or retrofit building projects. The team tested the hybrid concept through a design-build process that resulted in two prototype homes, an 800 square foot (sf) zero-energy home designed for the 2007 National Renewable Energy Laboratory (NREL) Solar Decathlon competition and a 1015 sf two-bedroom affordable prototype home that demonstrates the market potential of the hybrid concept. Both homes serve to advance and promote energy-efficient construction and the use of residential-scaled solar energy systems.

1. INTRODUCTION

Few things empower people more than home ownership, except perhaps security from power outages and independence from fossil fuels. The Morningstar presents opportunities for both. A team of students and faculty advisors, representing

multiple disciplines from across the Pennsylvania State University, developed and tested a hybrid model for green residential construction.¹ The hybrid model is adaptable to specific sites and climates and demonstrates an advanced alternative energy system that integrates home and vehicle to provide electricity. The MorningStar solar home is a prefabricated/ site-built system for home building that combines the economic advantages of prefabrication with the merits of on-site construction. The team tested the hybrid concept through a design-build process that resulted in two prototype homes, an 800 square foot (sf) zero-energy home designed for the 2007 National Renewable Energy Laboratory (NREL) Solar Decathlon competition and a 1015 sf two-bedroom affordable prototype home that demonstrates the market potential of the hybrid concept.² Both homes serve to advance and promote energy-efficient construction and the use of residential-scaled solar energy systems. The marketable prototype is a residence for visiting faculty to the Northern Cheyenne reservation and a model for future homes that will be built through a design-build collaboration between the Center for Sustainability at Penn State and the Northern Cheyenne Housing Authority.³ The zero-energy home will serve as a Hybrid Renewable Energy Systems (HyRES) laboratory that showcases multiple, interconnected, and integrated alternative energy systems and will be used for teaching, research, and outreach programming.

2. BODY OF PAPER

MorningStar is intended to serve as the first solar home in a community. Inspired by a continuing partnership with the Northern Cheyenne Indian Tribe – the Morning Star People– to create affordable housing, the concept improves previous initiatives directed towards community development by introducing an architecture that leads to new sustainable ways of living. The design goal is to demonstrate a practical and flexible structure that is easily adapted to multiple contexts. In addition, the MorningStar Home serves as a model to explore and demonstrate regional solutions in which energy efficient systems, including solar electric, can be customized and affordably integrated into new or retrofit building projects.

2.1 Background of Concept and Design for a Hybrid Prefab/Site Built Solar Home

To develop an architecture that is adaptable, the conceptual model simplifies the MorningStar home into three basic components: a “*Technical Core*” that houses the mechanical aspects of the design, a “*Living Space*” that integrates working, sleeping and eating functions, and a transitional “*Breezeway*” that acts as a buffer zone between the supporting technical functions and the supported communal functions of the home. The three components are arranged as a series of layers oriented along the north-south axis for educational and solar optimization purposes – the Living Space to

the south, the Breezeway as the central corridor, and the Technical Core to the northern side of the home. The overall placement of the building is dictated by the orientation of the sun, in a practical expression of sustainable living (Figure 1).

The Technical Core is designed as a standardized module that can be easily prefabricated, mass-produced, transported and integrated into a custom configuration. It houses the active systems, using energy generated from the sun to fuel the home. Containing the technical functions of the house (including the air, water, and energy distribution), the Technical Core is designed to allow equipment to be easily maintained, added, removed, or replaced in a “plug and play” fashion. With a tight envelope and high thermal resistance values of the walls and roof, the technical core reduces the need for energy by organizing the plumbing and ductwork to minimize line losses and to create opportunities for synergies between systems such as the capturing and re-use of heat. The Technical Core, as a display case for sustainable technologies, provides visual cues and hands-on information about renewable energy production systems.

MorningStar’s Living Space can be customized around the technical core to work with site conditions and meet occupant needs or accommodate additional bedrooms or bathrooms depending on family size. The Living Space’s enclosure is a panelized assembly, using



Fig. 1: Diagram of three basic components of the MorningStar home

regional methods and materials. Unlike the Technical Core, the Living Space would not be prefabricated but assembled by volunteers and local laborers to promote community and economic development in the region of deployment. The Living Space benefits from the south-facing façade that absorbs and filters light to generate or dissipate heat. The Breezeway takes the middle ground, defining a path along which the home is able to expand to accommodate extra bedrooms or bathrooms and introducing methods of efficient human flow and effective distribution of active systems. This zone incorporates passive and active solar systems, natural ventilation, and daylighting strategies that can be configured for the specific geographic region. The Breezeway is also a feature of visual interest and connection to the environment, depending on the application and preference of the homeowner. Specific to the MorningStar home, the Breezeway is oriented East / West with a point of reference towards the Morning star (Venus) and the rising sun, connecting the home to the traditions of the Northern Cheyenne Tribe. The division of the home into three functional zones allows for customization of the home and for the occupant to understand sustainable design and its complimentary motives.

2.2 Customization: One Vision, Infinite Possibilities

MorningStar can be customized as a locally relevant and user-responsive design by identifying and responding to local characteristics of the community during design. These characteristics include cultural values, climatic aspects, material availability, landscape and site variables, construction methods, economic factors and other issues related to the final configuration of the home. Based on the priority given to each characteristic, various aspects of the model are ‘personalized’ and become tangible in the home (Figure 2). By applying this process, the design of the MorningStar solar home can serve as an educational model for the community, acting as a testing ground for feasible technologies and as a demonstration tool for local and sustainable practices that will enable wider deployment of these concepts in a particular region, community, or development.

The MorningStar concept manifests a vision for 21st century homebuilding that encompasses communities of all cultures, climates, and incomes. It represents new ways of thinking about construction, energy, beauty,

and the environment. To test the conceptual model, two versions of the MorningStar home were pursued, in regions with different climates and cultural values, to demonstrate the broad spectrum of possibilities associated with the design. MorningStar Pennsylvania, built for the 2007 Solar Decathlon, represents a high-tech version of the home, while MorningStar Montana represents a more simple and affordable – yet equally attractive – version of the adaptable design concept.

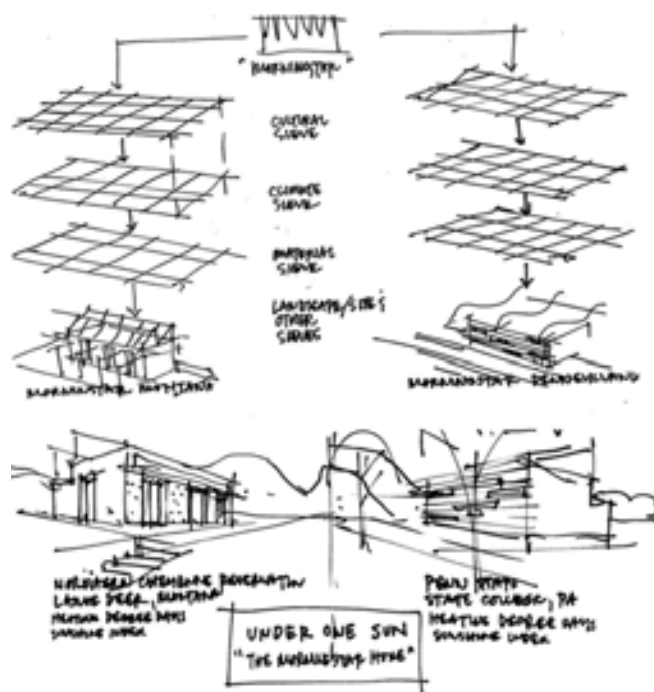


Fig. 2: Conceptual “sieve” diagram illustrating the characteristics used to customize the MorningStar Home. Illustration by Scott Wing, courtesy of the artist

2.3 MorningStar PA

MorningStar Pennsylvania (MorningStar PA) was designed for the central Pennsylvania climate with the competition and transportation requirements held paramount (Figure 3). Transportability, constructability, and deconstructability played a major role in the customization of MorningStar PA. To minimize transportation and speed construction and disassembly in Washington D.C. for the Solar Decathlon competition, MorningStar PA was designed and built in two prefabricated modules. A hinged roof and forklift compatible components



Fig. 3: Photograph of MorningStar PA

further streamlined construction and eliminated the need for a crane. Student and volunteer-friendly components reduced the need for skilled labor and encouraged participation. The home was intended as a teaching tool, with didactic features displaying and demonstrating available sustainable technologies and new strategies for sustainable living, as a net-zero plus home. The prototype was designed to respond to two different performance modes adjustable to the *Competition Mode* on the National Mall and the long-term *Operational Mode* at its permanent site at the Center for Sustainability on the Penn State University Park campus.

A trade-off in the design, specific to the Pennsylvania prototype, was to favor high mass for passive solar collection over lightness for transportation, therefore significant structure was required. The two modules were constructed on steel chassis, serving as the floor structure. A recycled steel structural frame at the perimeter of the home and along the breezeway is intentionally exposed to represent Pennsylvania's steel industry. The size of the modules were mostly defined by transportation and competition regulations and by the panelized Structurally Insulated Panel (SIP) wall and roof construction (supplied by Murus, a Pennsylvania based manufacturer). The marriage line of the two modules is along the south edge of the breezeway, and an umbilical chase at the breezeway floor allows electricity and hot water for the radiant floor heating system to be distributed to the Living Space module.

The Technical Core module, "a compact energy management system," includes the kitchen, bathroom, laundry niche, and mechanical space program elements required by the competition, and all primary wiring,



Fig. 4: Interior of MorningStar PA showing the "Milk Bottle Wall", "Moveable Wall," and sliding partitions

ductwork, and plumbing "plug-ins" for the home; It was designed to be mass-produced and shipped based on economies of scale. To facilitate use as an education tool and research laboratory, flexibility of the mechanical space accommodates ongoing and future research projects related to sustainable practices. The Technical Core module is clad in brilliant blue Trespa paneling, detailed as a pressure-equalizing rain screen, to identify it as the prefabricated component of the home.

The *Breezeway* component was constructed integrally with the Technical Core module for transportation. This central element peaks at just under the 18-foot height limit imposed by the competition and provides views to the sky and the green roof on the Technical Core. Diffuse daylighting, for the two modules, is provided through north-facing clearstory windows. When conditions outside are appropriate, motorized operable windows facilitate natural ventilation through the spaces. Two evacuated tube panels, visible through a skylights centered on the breezeway, provide high-temperature hot water.

The *Living Space* was preassembled and married to the Technical Core on site. The open floor plan of the Living Space is flexible and adaptable to different resident needs. Glazed doors and windows are aligned for passive ventilation and to visually expand the interior space. An interior "Movable Wall" storage unit separates the bedroom and living/dining area; it can be slid to provide more space in individual areas when needed. In addition to various green technologies incorporated into the home, many of its building materials were recycled, reclaimed, and /or locally harvested or manufactured, further contributing

to the sustainability of the home. For example, the Living Space demonstrates materials that are regionally appropriate and significant to the permanent site location, including reclaimed Pennsylvania Black Slate cladding. The finished floor is 1" thick locally quarried bluestone to distribute heat from the radiant floor heating tubes and to provide some mass for solar heat collection in the winter. Built-in furniture, designed and crafted by Penn State students and staff, highlight sustainably harvested Pennsylvania hardwoods.

The layered southern façade of the living space, a significant design feature, is an occupant-operated passive-solar control that teaches about the absorption and reflection of sunlight and the possibility of solar collection. On the façade "Exterior Sliding Panels" (EPSs), composed of locally manufactured recycled steel and white oak harvested from a fallen tree, allow residents to regulate light penetration and solar heat gain. The folding shelves are adjustable to provide privacy and can be moved for functional and aesthetic manipulation of the elevation. On the interior a "Milk Bottle Wall", symbolic of Pennsylvania's dairy industry, diffuses light and, as an ongoing research project, can be filled with fluids or materials to test thermal-mass storage potential (Figure 4). As an energy collector, MorningStar PA makes use of multiple solar technologies. For electrical energy production, two high-efficiency AC solar arrays are mounted on the south-facing sloped roof; a 5.7 kW fixed array over the Living Space and a 2.3 kW adjustable array along the Breezeway. For efficiency, AC power was directed from the inverter directly to AC loads only storing excess power. For the Competition Mode this excess energy was stored in large-capacity batteries, on the permanent site, in Operational Mode the home will be grid-tied. A modern version of the exterior slate cladding, Solarslate (manufactured by Atlantis Solar) arrays on the east and west facades provide DC power to dedicated LED lighting devices, eliminating the need for inverters. Digitally controlled LED lights, sandwiched between polycarbonate sheets in the north-facing clerestory, will be linked to streaming weather data. The changing colored lights correspond to weather predictions to alert the occupants and passers-by of the next day's weather forecast and related energy production. To provide for innovation opportunities and research initiatives, the MEP systems interface with a Direct Digital Control (DDC). A unique "Energy Dashboard" monitors consumption and provides real-time response and predicted data

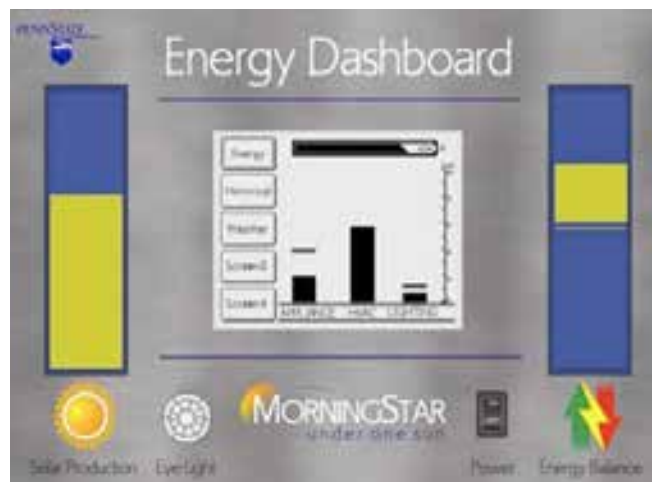


Fig. 5: Mock-up of "Energy Dashboard"

related to the energy use and production (Figure 5). The system allows occupants to understand the effect that their behavior has on the home's energy balance and helps them develop energy-responsible behavior patterns. This feedback is subsequently used to optimize performance based on the various occupant use strategies and to examine the performance of the home in a manner that will inform future versions of the prototype. For research and educational purposes, the control system will document performance changes based on the insertion and replacement of solar technologies in the home.

The Penn State Solar Decathlon team pursued passive-solar design strategies, advanced high-performance engineering, and information feedback systems for the MorningStar PA solar home. The approach was to reduce energy loads via conservation and efficiency, effectively capture and use solar energy, and reclaim waste energy. It is a living laboratory and an outreach tool for energy-efficient design, cutting-edge technology, and common sense features that visitors can use in their own homes.

2.4 MorningStar MT

Unique situations call for unique solutions. Plains Indians, such as the Northern Cheyenne, live in distinct cultural and economic contexts that distinguish them from most other American communities. On the Northern Cheyenne Reservation, in southeastern Montana, unemployment is three times the national rate and poverty is four times higher. Twice the percentage of people live in mobile homes and fewer own their own homes. Almost half of the population relies on bottled, tank, or LP gas, the most expensive form of home heating fuel, while only 9.9 percent of the total U.S. population relies on this type of fuel. The Cheyenne nation also has great assets. The tribe boasts numerous

artists and tradesmen among its members, and youth make up a higher percentage of the population than in the United States in general, giving the tribe energy and strength. However, on-reservation jobs must be created to capture and empower this talent, and daily living expenses need to be reduced to free up income for investment in the tribe's infrastructure and future.

With these constraints and opportunities in mind, MorningStar Montana (MorningStar MT) was adapted from the hybrid concept to build upon principles established by the continuing nine-year design-build partnership between Penn State and the Northern Cheyenne people, and to design a home that reduces costs, generates jobs, and promotes a healthy environment. (Figure 6.) The MorningStar concept combines the efficiencies of modular housing with the cost-saving benefits of self-help housing and enhances them with the energy savings of green technology. By applying the MorningStar home to the reservation context the Penn State MorningStar team intends to improve affordable housing through energy efficient systems, placing an emphasis on the adaptation of solar technologies, the potential to mass-produce technical core units, and the utilization of unskilled labor during construction. MorningStar MT serves as a visiting faculty residence at Chief Dull Knife College (CDKC) on the Northern Cheyenne Indian Reservation, in Lama Deer Montana. The prototype home is larger than MorningStar PA, providing an additional bedroom to accommodate a small family and office space for the faculty member.



Fig. 6: Photograph of MorningStar MT

The goals set by the team for adapting the Hybrid Concept for the marketable prototype were:

- **Livability:** Maintain an open, central floor plan to allow comfortable movement between different spaces of the home and easy adaptation by frequently changing residents, while engaging the occupants in seasonal adjustments.
- **Buildability:** Combine the economies of manufactured housing with panelized components and details that engage volunteers and students in a community-build construction process.
- **Flexibility:** Promote regional, site specific, and personal adaptability. The prefabricated core joins a site-built living space made of regionally appropriate 'materials of opportunity' addressing site specific constraints and the need for frequent interior reconfiguration.
- **Economic Viability:** Establish the feasibility of solar energy in low-income communities and help assess Energy Efficiency Measures (EEMs) with actual costs rather than assumptions.

The MorningStar Team, community volunteers, students, alumni, and faculty constructed MorningStar MT in June and July of 2007 during a three-week "blitz-build." The site and foundation were prepared prior to the Team's arrival. The Technical Core was manufactured by engineering students and faculty members in ten days on the University Campus and transported to the prepared construction site. Because research and development of the building systems was not a prioritized goal for MorningStar MT the mechanical room was significantly smaller, reducing the overall size of the Technical Core module for transportation with a standard trailer. Future prefabrication of the Technical Core will be constructed on the reservation in cooperation with the Northern Cheyenne Housing Authority in an effort to provide stable employment to skilled labor in healthier and safer working conditions, eventually mass-producing the modules to reduce costs and continually improve quality.⁴

Students and volunteers poured a concrete slab for the living space after installing tubing for the radiant floor heating. The site-built Living Space employs panelized systems and strawbale construction for easier and faster construction to promote volunteer and community participation with a goal of providing jobs for unskilled labor.

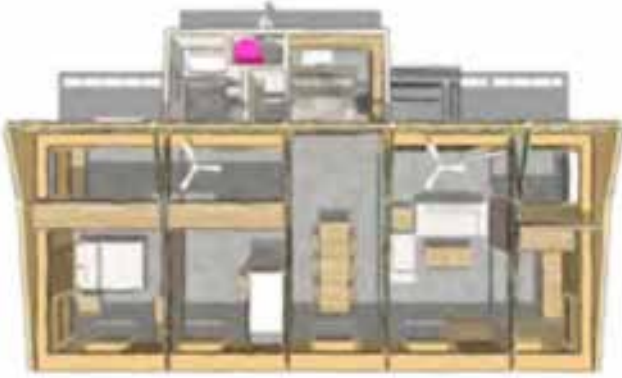


Fig. 7: Plan of MorningStar MT

Panelized interior walls can be regionally pre-manufactured using local resources, reducing construction time and allowing for some reconfiguration of spaces by the residents. The exterior walls of MorningStar MT are constructed using densely packed strawbales, providing a load-bearing and well insulated wall. To establish an even tighter envelope, MorningStar MT's door and window openings and structural sills were framed out in SIPs to minimize thermal bridging. In keeping with Cheyenne tradition, MorningStar MT's entry door faces east, greeting the

Morning Star and the rising sun. The open portion of the Living Space, living/dining and office area, face southeast providing for some passive gain in the winter and celebrating the movement of the sun across the front of the home. The Breezeway is oriented from east to west maintaining long views through the home into the surrounding landscape and providing for cross-ventilation. Ceiling fans and north-facing operable clerestory windows further promote natural ventilation and daylighting, minimizing the need for overhead electric lighting and mechanical ventilation for much of the year. Like MorningStar PA, the dining room table is centered on the home and oriented from north to south aligning with centered windows that reiterate the cardinal orientation of the home. The kitchen of the Technical Core is also centered on the home maintaining traditional community/ family gathering around meals. The Breezeway roof of MorningStar MT is oriented and angled to optimize solar gain for the photovoltaic array mounted to the roof. Unlike the energy-production goal of MorningStar PA, to provide enough solar energy for the home with excess to sell back to the grid, the smaller array on MorningStar MT supplements the energy needs of the home, making overall energy costs more affordable and providing alternative power to remote rural customers. (Refer to figures 7 & 8.)



Fig.8: Time-lapse photomontage of the construction of MorningStar MT

The cost of the prototype home was \$133,968 or \$132 per square foot (\$106,125.00 or \$105 / sf without solar technologies), without sweat equity the cost would have been \$157,240. The most significant cost savings of MorningStar MT comes from the energy-saving features. The combination SIP / strawbale envelope, whose R-value is 29 for walls and 35 for the SIP roof saves approximately \$615 annually, while the solar panels save an additional \$445 per year. In a climate where temperatures range from highs of 110 degrees in the summer to lows of -30 degrees in the winter, these features are key to making homes affordable. By producing more than one house to decrease cost of materials due to economies of scale, increasing the square footage to decrease the cost per square foot, reducing the cost of solar systems and increasing solar incentives, the home could be affordable for more tribal residents. In a collaborative effort between the University and the Northern Cheyenne Housing Authority, plans are in progress to implement a new housing program on the Northern Cheyenne Indian Reservation that will allow for the local construction of technical cores and the development of a community-built housing program to pursue the construction of more homes using the MorningStar concept. The prototype is now open to the Cheyenne community to assess initial reactions about the appeal and marketability of the home. The partnership adapts and deploys sustainable housing methods to address the housing challenges facing the Northern Cheyenne and other Native American tribes and remote rural communities in the U.S.

3. HYBRID RENEWABLE ENERGY SYSTEMS(HyRES)

People from both sides of the debate argue the pros and cons of hydrogen and batteries as energy carriers and storage solutions for solar power. In the future, solar powered homes will still be grid-connected and will have the ability to sell energy back to the grid. However because of peak pricing of electricity, there will be some solutions that will offer advantages over others regarding when to store the solar generated electricity, when to use the stored energy, or when to sell it back to the grid. Innovative storage solutions are appearing in smart battery packs and integrated circuit chips. This hybrid alternative power system combines alternative energy generation with cutting-edge storage.

3.1 Competition Mode

For the 2007 Solar Decathlon competition, the MorningStar home had to be completely independent of the grid and all energy for the home and for driving an electric vehicle had to come from the sun. During the Competition Mode, the MorningStar home integrated two strategies for energy collection, conversion and storage. Energy was generated from the sun by a primary AC system that included dual solar arrays, a 5.7 kW fixed array and a 2.3kW adjustable array, both located on the south-facing roof the living space. Excess energy from the AC arrays was stored in two large super-capacity batteries. A secondary DC system of BIPV cladding slates on the east and west facades powered LED lighting devices directly (without the use of an inverter). Building upon the University's hydrogen fueling station and hydrogen vehicle research laboratory, a Hybrid Car-Home Energy System was demonstrated, using a toy fuel cell car, during the Solar Decathlon competition at the National Mall.

3.2 Operational Mode

At the Center for Sustainability, MorningStar PA's permanent site, the solar home will become a research and outreach facility, the Hybrid Renewable Energy Systems Laboratory (HyRES). The integration of wind, solar, geothermal, hydrogen, and grid-tied energy will be advanced and continually refined (Figure 9). Net metering will be used to balance energy use, and surplus power used to make hydrogen for a fuel cell vehicle. In rare cases when the sun, wind, and grid power are unavailable, the MorningStar solar home will be powered through a vehicle possessing a fuel cell power system that will be integrated with the home through the car-home interface kiosk. Relationships with industry, established during the design and construction of the MorningStar homes, are helping to develop the installation of an operable hydrogen electrolyzer system that can interact with and interface between the house and vehicle. Advanced energy storage solutions will be investigated, including iCel systems for advanced battery backup. Another key research facet includes investigating how the home interacts with the grid, selling excess power and developing the possibility of a future, distributed energy web.

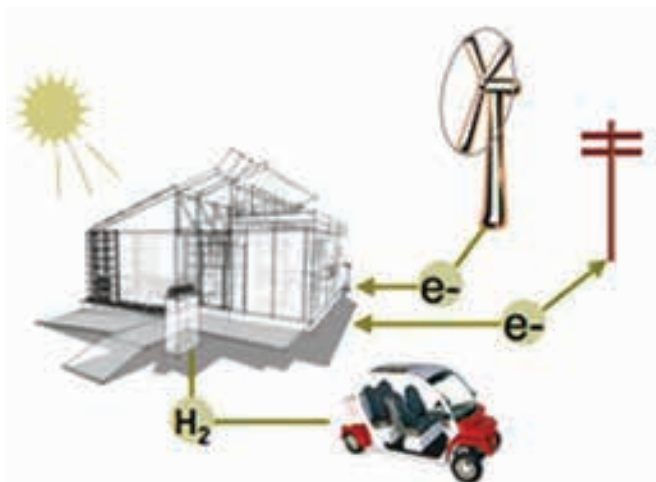


Fig. 9: Diagram of hybrid energy interface system in Operational Mode. Power features for the hybrid energy systems include:

- 8.5 kW roof mounted PV array
- 60 SF Solar Thermal panels
- Whisper 500 Wind Turbine
- Hydrogen Electrolizer
- Net metered Grid Connection

4. CONCLUSION

The MorningStar hybrid concept emPOWERS communities to build responsible and affordable solar homes and provides research, inspiration and incentive for applying solar and other renewable energy solutions into single-family homes. The hybrid prefab / site built construction strategy supports an inclusive construction process that employs both scarce skilled labor for the construction of the Technical Core and provides jobs for unskilled labor and takes advantage of local resources in the site-specific assembly of the Living Space. The home showcases multiple strategies for energy-efficient design and renewable energy use, while home-energy interface systems inform residents and visitors about the systems and performance. The HyRES laboratory will provide ongoing research of renewable systems and provide the outreach necessary to reinforce to students, homeowners, and policy makers that we all HAVE THE POWER to realize the potential of renewable energy and make it a reality in our communities.⁵

ACKNOWLEDGMENTS

MorningStar PA, Penn State's entry to the 2007 Solar Decathlon, placed fourth overall (out of 20 noteworthy colleges and universities) in the international competition. The team placed 3rd overall in the "Marketability" competition recognized, in part, for the adaptability of the hybrid prefabricated / site-built system and for the realization of MorningStar MT, the marketable prototype home.

Recognition and respect to the 2007 Penn State Solar Decathlon Team, especially Student Team Leaders Andreas Phelps, Sally Gimbert and Claudia Torres Ariaga; Faculty advisor Scott Wing; and all of the Penn State students, faculty and staff that dedicated themselves to the MorningStar project.

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The MorningStar home demonstrates a conceptual design strategy for a hybrid prefabricated/site-built system for green residential construction that can be widely adapted and deployed. The 2007 Penn State Solar Decathlon team tested the hybrid concept through a design-build process that resulted in two prototype homes, an 800 square foot zero-energy+ home designed for the 2007 National Renewable Energy Laboratory (NREL) Solar Decathlon competition (MorningStar Pennsylvania) and a 1000 square foot two-bedroom affordable prototype home that demonstrates the market potential of the hybrid concept (MorningStar Montana). Inspired by the respect for the sun of the Cheyenne Indian Nation, known as the Morning Star People, both homes serve to advance and promote the hybrid prefab strategy and the use of residential-scaled solar energy systems, didactic passive solar design, and energy-efficient construction.



MorningStar Solar Home

2007 NREL Solar Decathlon

Lisa D. Iulo, Faculty Advisor / co-Investigator



MorningStar Pennsylvania

Washington, D.C. + University Park, PA



WINNER: 4th place (out of 20) - **Overall**
1st place (tie, out of 20) - **Hot Water**
3rd place (out of 20) - **Marketability**

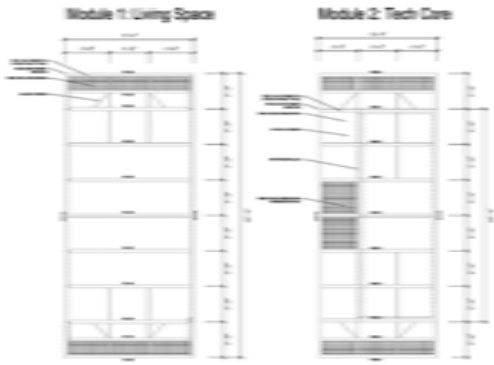
Innovation in Design, GBACPA Green Building Awards Program, 2008

BP Solar Performance Award, October 2007

PV News Editor's Choice Award, October 2007







MorningStar Pennsylvania (MorningStar PA) was designed for the central Pennsylvania climate with the competition constraints held paramount. Transportability, constructability, and deconstructability played a major role in the customization of the home. To minimize transportation and speed construction and disassembly in Washington DC for the Solar Decathlon, MorningStar PA was designed and built in two prefabricated modules. A hinged roof and forklift compatible components further streamlined construction and eliminated the need for a crane. Student and volunteer-friendly components reduced the need for skilled labor and encouraged participation.

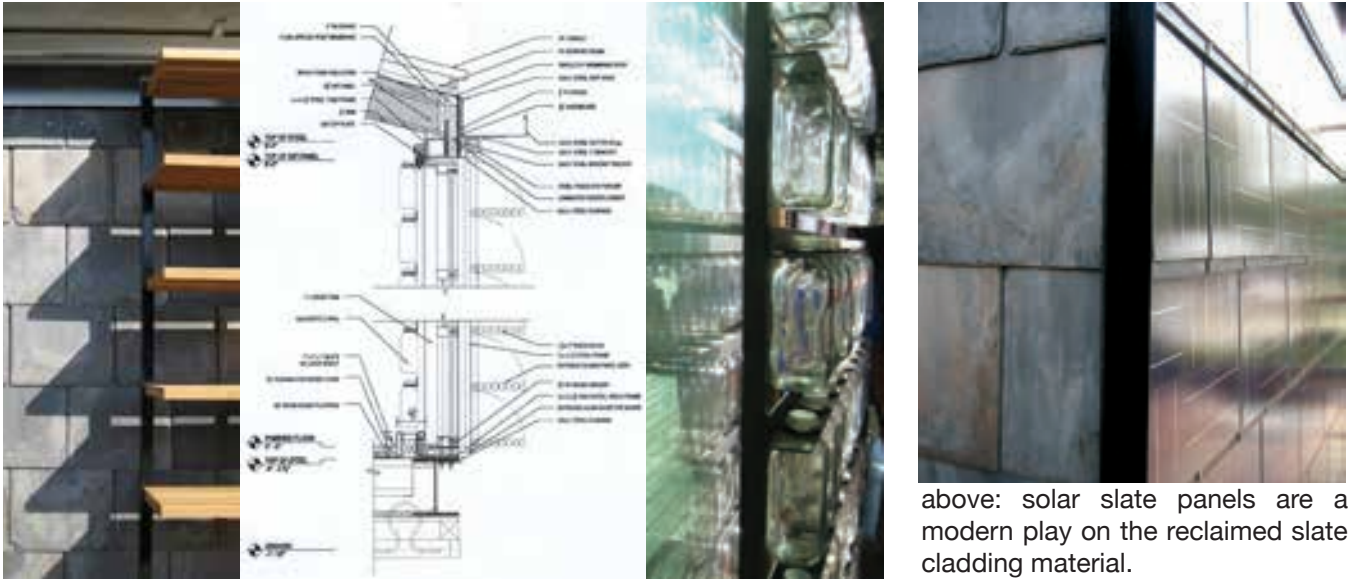






MorningStar PA celebrates materials indigenous to and symbolic of Pennsylvania, including bluestone flooring, reclaimed slate, recycled steel, and custom furniture designed to showcase local hardwoods.

The layered south facade (facing page) allows occupants to control natural light and ventilation in the home and to customize the facade.



above: solar slate panels are a modern play on the reclaimed slate cladding material.



ESP (exterior sliding panels) were constructed from an oak tree that was sustainably harvested on the PSU University Park Campus. The ESP can be configured as shelves and used in the summer to block direct sunlight from heating the interior of the home; in the winter the shelves are folded down and slid away from the windows to allow sunlight to heat the Pennsylvania Blue Stone floor on the interior of the home. The Sliding milk-bottle wall (seen through the window on the interior) filters sunlight and provides thermal radiation for extra heat in the winter; the milkbottles are filled with different liquids to test thermal storage capacity as an ongoing research project.



MorningStar PA's extensive landscape demonstrates alternatives to conventional lawns: prairie and meadow grasses, a rain garden, a native species habitat garden, a compact vegetable garden, and a modular green roof.

The PSU Team marches in the Victory Parade before the 2007 Solar Decathlon Awards Ceremony on Friday, October 19. PSU completed the competition standing 4th place overall in the international competition.



=

MorningStar Montana

Northern Cheyenne Indian Reservation,
Lame Deer, MT

As if the construction of the MorningStar, Pennsylvania competition home was not enough, the Penn State team also built an affordable version of the design to demonstrate its market potential. This home, built on the Northern Cheyenne Reservation in Montana, illustrates how solar energy can be a part of an energy-efficient and affordable home in low-income communities. The design for MorningStar Montana adapted from the hybrid concept developed for the competition home. The “Technical Core” was constructed by the student team at Penn State and transported site in Montana, students and volunteers constructed the living space on site using load-bearing strawbale exterior wall construction during a three-week “blitz-build” construction process.

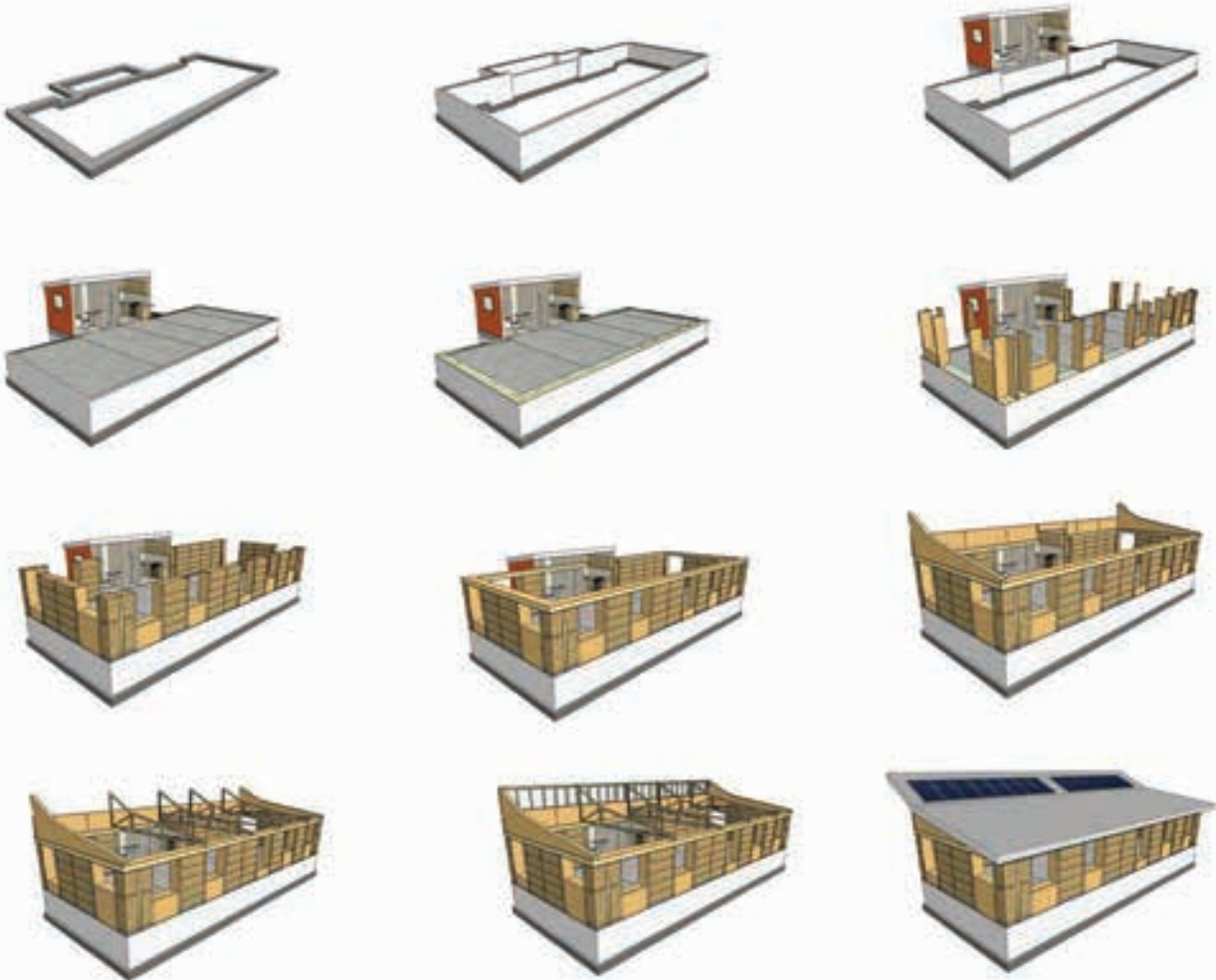


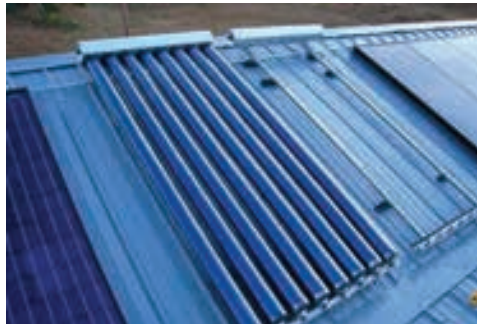
MorningStar Montana serves as a lab and residence for visiting faculty to Chief Dull Knife College. The home is a model for future solar homes that will be built through Penn State’s American Indian Housing Initiative, an ongoing design-build collaborative project between Penn State, Chief Dull Knife College, and the Northern Cheyenne Housing Authority.





MorninStar MT's "Technical Core" module was manufactured on the Penn State campus and transported to the site. Once positioned, the Living Space of the home was constructed using volunteer labor.







Iulo, L.D., and Quigley, B. L.,
“Affordable Housing - Transparent vs. Transformative Approaches.” Proceedings of the American Solar Energy Society National Solar Conference (2007).

Affordable Housing - Transparent vs. Transformative Approaches

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ABSTRACT: This paper compares two approaches to green affordable housing. “Transparent” refers to green housing that is perceptually little different than its un-green counterparts but meets the requirements and standards of green building. A transformative approach is one in which the housing is markedly different from its non-green contemporaries. Petersburg Commons represents a “transparent” approach; the process and product are incrementally improved over the conventional approach. Houses are “green” by standard, but they do not look overtly different nor are there dramatic changes in the way residents are required to interact with their home or community. Bedford Mews is more aggressive in its “green” stance; the form and character of the development is different from that of adjoining neighborhoods, and residents are expected to interact differently within their house, their development, their neighborhood and their region; it is intended for people who want to transform the way we use natural resources.

Keywords: affordable housing, “green” approaches

AFFORDABLE GREEN HOUSING: TRANSPARENT vs. TRANSFORMATIVE APPROACHES

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ABSTRACT

This paper compares two approaches to green affordable housing. “Transparent” refers to green housing that is perceptually little different than its non-green counterparts but meets the requirements and standards of green building. A transformative approach is one in which the housing is markedly different from its non-green contemporaries.

Petersburg Commons represents a “transparent” approach; the process and product are incrementally improved over the conventional approach. Houses are “green” by standard, but they do not look overtly different nor are there dramatic changes in the way residents are required to interact with their home or community. Bedford Mews is more aggressive in its “green” stance; the form and character of the development is different from that of adjoining neighborhoods, and residents are expected to interact differently within their house, their development, their neighborhood and their region; it is intended for people who want to transform the way we use natural resources.

1. INTRODUCTION

Both Petersburg Commons and Bedford Mews are intended as models for responsible development that can be replicated. These projects seek to improve the status quo in various ways. In the case of Petersburg Commons, the developer and design team made a deliberate decision to work within the established and prevailing patterns of development. For Bedford Mews, the developer and design team made an equally deliberate decision to break with established patterns.

The transparent logic is that we are (at least for now) going to build new houses and they are going to generally follow prevailing (non-green) development patterns. Projects like Petersburg Commons demonstrate that there is little reason or excuse for not building such projects in a more environmentally responsible manner since energy cost savings can overcome somewhat higher initial prices and lenders often allow higher mortgage amounts and smaller down payments for energy-efficient dwellings. Petersburg Commons was conceived and built during a long period of time in which the housing market in the region was very strong. Developers had little incentive to consider “greening” their product. They were selling houses as fast as they could build them. Today, in a slower housing market, developers are urgently searching for ways to differentiate their product. The transformative logic is that there is a growing market for explicitly green projects; growing environmental awareness and changing demographics are bringing about a new and (as yet) underserved market. And the number of potential homebuyers who not only want to reap the benefits of lower energy costs but also want to reduce their “ecological footprint” through active engagement is growing.

The transparent approach focuses primarily on the house. Reducing energy (or maximizing value for energy) used in making the house and reducing home operating costs in the context of good, well loved and maintained houses are sine qua non. The transformative approach includes a similar focus while opening itself to any and all opportunities for increased sustainability now and in the future; it looks to establish an active and

endless effort and to understand and act to balance individual needs with those of the community and the planet. The implication of the switch from transparent to transformative is far-reaching. By its nature, the transformative approach cannot be fully defined, though the general goals are clear. It places emphasis on planning as well as social and community issues; development of each house is part of a strategy to solve the complex environmental problem by addressing it comprehensively.

2. BODY OF PAPER

2.1 Transparent Approach: Petersburg Commons

Completed in January of 2006, Petersburg Commons is the Commonwealth's first actively *green* affordable housing project. The project consists of fourteen attached homes in two adjacent buildings. The townhouses achieve high quality space both inside and out with energy use at more than 50% less than similar houses built to meet code and were completed at a cost of approximately 6% more than conventional construction. The project was funded to provide affordable housing options to residents in Perry County. All of the homes were sold within a year and occupied by first-time homebuyer households with incomes between 40% and 80% of the area median income.

A Request-for-Proposal (RFP), developed by the housing corporation with aggressive requirements in the interest of creating a green project, initiated the design process. The RFP process required development teams (design/build collaborations) to submit concept plans and methods that were judged by an independent volunteer panel of design, construction and environmental experts. Wagman Construction (York, PA) and Office for Planning and Architecture (Harrisburg, PA) were selected with a conceptual model that combined achievable goals for energy efficient, passive solar and ventilation strategies and an ambitious approach to the design of the site. The approach outlined a goal to achieve ambitious performance in a home that would not seem foreign or experimental to the low-income first-time homebuyers targeted. A project charrette was conducted to establish core values for the project and the design team worked closely with the Developer and a buyer's representative to achieve a marketable prototype project. Although the townhouses were designed with LEED certification requirements in mind, the design team and developer decided early in the

design process not to pursue LEED certification for the project (LEED for Homes was not yet available). An architect experienced in green building independently evaluated the project on behalf of one of the funding agencies. The buildings and individual homes achieved Energy Star labeling and the project was partially funded through Enterprise Foundation and their "*Green Communities*" guideline criteria were achieved.



Fig. 1: Conceptual sketch of Petersburg Commons

The project design priority was to provide buildings that perform optimally for both the users and the community-at-large. Among the many aspects of "performance" are initial cost, aesthetics, and operations cost. The buildings work within the rational expectations of cultural norms and do not demand additional attention or inconvenience to achieve greater performance. Ultimately, the site design and ownership of Petersburg Commons is fairly similar to the adjacent market-rate housing: the town homes and yard spaces are individually owned and maintained providing the sense of independent ownership that was deemed important to the first time homebuyers. This individual ownership precluded the opportunity for more aggressive "transformative" methods, for example - shared systems such as a combined geothermal heat pump system rather than individual air-to-air heat pumps. One incremental difference is in the organization of the building lots. An initial goal of the design team was to take advantage of the entire site as living space, overcoming the ambiguous nature of yard space accepted in most multifamily developments, and providing zones for private dwelling and communal interaction (fig. 1).

2.2 Site and Development Plan

The 1.03-acre site represents the third phase of a subdivision of market rate townhouses (39 units were built in phase I and II by another developer). Water, sewer, electric, cable and stormwater management infrastructure, and all road surfaces were in place prior to site acquisition (fig.2). Petersburg commons is contiguous with the town of Duncannon. The small town's center, with restaurants, a convenience store and a Laundromat, is within walking distance, as are the Appalachian Trail and the Susquehanna River. Sidewalks were extended throughout the development to encourage walking and a nature trail that originates at the development and meanders through the adjacent woods and wetland area further encourages exercise and engagement with the environment. The existing land development plan defined the footprint area of all future development, and a decision was made to respect this land development plan in the interest of providing a model for design decisions that can be more widely replicated.



Fig. 2: Petersburg Commons subdivision plan

Petersburg Commons fits into the existing subdivision. Massing, setbacks, and parking are similar to that of the first two (non-green & market rate) phases. Most stormwater is managed on site through the use of pervious pavement, rain gardens and water infiltration pipes, and low maintenance landscaping. The use of planters for infiltration of storm water from the roof (via a trellis on the south side of the houses) helps to define outdoor rooms. While the location of the water infiltration pipe at the backyard more subtly defines a rear outdoor room. Additional unseen measures used to reduce environmental impact include the use of a

frost-protected shallow foundation system (FPSF), the re-use of on site boulders for landscaping, and aggressive sediment control and topsoil protection during construction.

2.3 Unit Design



Fig. 3: Petersburg Commons looking Northeast

Petersburg Common's offers two basic home models, all designed to *Visitability* standards; the four (4) end units are two-bedroom flats designed to be ADA adaptable and intended for older homeowners; the (10) two-story homes have three bedrooms. The existing subdivision plan limited opportunities for passive solar gain through orientation. Though an angled window in the west end units faces due South, providing for direct gain during the winter months and is a gesture towards the sun (fig. 3). The design team thought it important to improve the prototypical townhouse model. To that end the entire lot was identified as living space. The floor plan (inspired by Frank Lloyd Wright's usonian houses) is open and flexible with visual connections to outdoor rooms at both the front and back. Recycling and storage stations further define these outdoor rooms. A shaded cupola introduces daylight to the center of the narrow townhouses and serves to vent warm air in the summer. In all units, the living spaces are designed to be as open as possible for flexible furniture layouts and room use by the homeowners. The small homes (1,050 sf and 1,230 sf respectively) are extended seasonally through the aforementioned outdoor rooms; windows and glazed doors and even the cupola are aligned to provide expanded views (fig. 4).

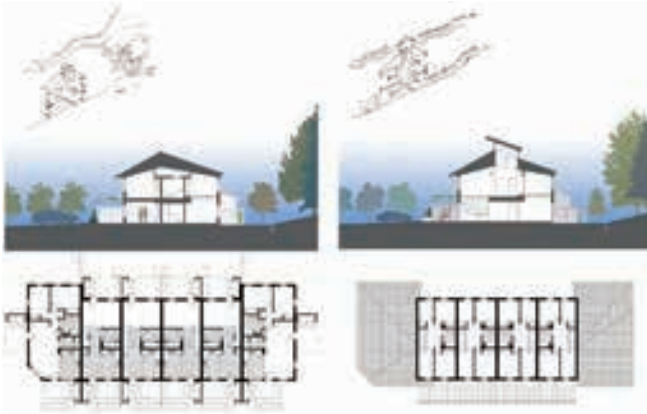


Fig. 4: Petersburg Commons plans, sections and interior concept sketches (above); Photo of interior (below)



2.4 Specific Technologies and Materials

Energy efficiency was a primary focus of the project from the beginning. Although several other wall construction methods were considered, super-insulated (2x8) wood framing using Optimum Value Engineering (OVE) was selected based on budget and the skills of available local contractors. The resulting wall cavities were filled with wet-blown cellulose insulation providing a wall R-value of 28. Dry-blown cellulose was employed in the attic spaces providing a roof value exceeding R-40. The entire thermal shell was intensively air sealed prior to insulation. These efforts paid off in achieving Home Energy Rating System (HERS) scores ranging between 87.4 and 88.3 for all units (HERS requires a minimum rating score of 80).¹ Appliances and all HVAC equipment were selected for high energy performance and Energy-Star certification, if applicable. The entire electric fixture package is Energy Star labeled and would meet

¹ The HERS index has changed since the publication of this paper. This project would receive a HERS score of apprx. 60 according to the new standards.

LEED for Homes (LEED-H) certification criteria. Ceiling fans were installed in all bedrooms and living rooms, and the cupola received a remote-operated reversible ceiling fan to augment the passive cooling aspects of the cupola. Light fixtures are equipped with compact fluorescent bulbs and occupancy sensors control the powder room fan/light combination fixtures. Exterior light fixtures are wired through light sensors. Water conservation measures within the home include faucet fixtures equipped with flow restrictors and low volume water closets. Piping and ductwork is located within the thermal envelope of the structure thereby minimizing the potential for moisture condensation and heat loss. The MEP contractor was actively involved with the design to ensure that HVAC units were appropriately sized and to establish a design that minimizes air delivery and return ductwork (and the energy loss associated with long duct runs). These units are conditioned by 14 SEER air-to-air heat pumps.

Material selection was instrumental in achieving project goals. The RFP charged the design team with achieving a 5% level of materials manufactured with post-consumer recycled content. This goal was achieved through the selection of locally obtainable products including concrete and concrete products with fly-ash content, engineered wood structural members and sheet-goods, metal roofing and siding with high recycled content, locally manufactured cellulose insulation with 85% recycled content, and green-certified finishes with recycled content. The design team was also charged with achieving a level of 50% of wood products being FSC certified. This goal was intentionally under-achieved, opting instead to use lumber from sustainably managed forests closer to the project site. The integrated process continued through construction when, despite a very modest budget, a rigorous Construction Administration scope added value to the project by facilitating the use of green “Materials of Opportunity.” Some of these materials included locally manufactured, recycled-content metal siding used for the roof and rear facades (in lieu of asphalt shingles and vinyl siding); The front and sides of the buildings are sided with locally harvested bug-killed hemlock. The use of this material is certified by Smartwood Rediscovered as a category-B neutral salvaged material, and the selection and hanging technique is regionally appropriate. Shallow frost-protected foundations (which were necessitated in part by the late discovery of subgrade stone) ultimately lead to both a better insulated thermal envelope than traditional slab-on-grade and a reduction in the materials and energy required for construction.

2.5 Status of Project and Potential as a Model

As a model for green affordable housing the project is successful. The market has embraced the houses and buyer feedback is overwhelmingly positive. The developer tracked energy costs for five of Petersburg Commons' homes over a twelve-month period from January to December 2006 and found the total energy costs to average \$61.45 per month (including heating and air conditioning). The developer reports that energy costs for similar non-green projects of the same size typically range from \$140-\$180 per month.

Easily replicable aspects of this design, including improved thermal efficiency, natural day-lighting, HVAC efficiency, Energy Star labeling, etc., can be applied to both affordable and market rate housing throughout Pennsylvania and beyond.

Rural housing is an on-going challenge that has no apparent easy answer. It is in this context that the Commonwealth's first affordable green housing project at Petersburg Commons was built; it is clear, in retrospect, that the difficult part of a project should not be making it green. The developer compared the project with another similar but non-green project it was developing simultaneously and determined that the initial "cost of green" was about six percent higher than the conventional project. Through somewhat progressive financing such higher upfront costs are more than made-up for by the lower operating costs.

3. BODY OF PAPER – PART 2

Bedford Mews is currently under design. The site, building configuration, building systems and ownership structure are transformed so as to achieve a more substantially green result. The project includes 20 mixed-income units designed to LEED for Homes (LEED-H) standards and to be overtly environmentally responsible. Importantly, a collective ownership structure allows the building systems and site infrastructure design to be significantly transformed - even from other green development. The resulting economy of scale allows the developer, who will maintain an interest in the project, to provide a highly efficient project that puts both its environmental and social priorities at the fore.

3.1 Project Vision

The developer for Bedford Mews, Executive Director of the Green Building Association of Central Pennsylvania, purchased an option on the property with the intention of re-thinking conventional development and providing a model for ecologically responsible living through infill development in Pennsylvania small towns.

A pre-purchase charrette, organized by the potential developer (a civil engineer) and OPA, brought together real estate advisors, design and construction experts, and representatives of Alliance for Aquatic Resource Monitoring (ALLARM), in the interest of determining whether development of the site was feasible and to determine a development strategy that would include intensive storm water management, constructed wetlands, and stream restoration. Other goals established at the pre-purchase charrette, included providing multiple unit types that would encourage community diversity (especially "first and last time buyers," rental apartments, and designated affordable housing), decreased parking and designated shared parking for hybrid or electric vehicles, and collective systems including geothermal systems and shared solar voltaic and solar thermal arrays. The design challenge was to maximize the number of units while developing a minimal footprint that would allow for restoration of the majority of the lot.

A central goal of the project is to integrate this newly built environment with a restored stream and riparian zone, and to employ storm water and flood management features to reestablish natural cycles. Condominiums or cooperatives are the proposed ownership models. While individual units will be privately owned, collective ownership and management of common space and infrastructure will allow for greater efficiency in construction, performance, operations and maintenance. Collective infrastructure will include a central plant, bioretention cell, geothermal system, designated solar collection areas, recycling/waste station, loading station, gathering space and a business center (for live/work residents), shared cars and bicycles, and Community Sponsored Agriculture (CSA) support. Perhaps most importantly, Bedford Mews will enhance and reinforce an existing walkable neighborhood. Due to the proximity to Carlisle's existing urban fabric it is likely that some of Bedford Mews residents will not own an automobile (fig. 5).



Fig. 5: Pedestrian and bicycle travel distances from site



Fig. 6: Site plan of Bedford Mews, Carlisle PA

3.2 Site and Development Plan

Bedford Mews' site is located within comfortable walking distance of stores, community resources, K-12 schools, two universities and a law school, governmental and judicial buildings, and diverse employment opportunities. Although adjacent neighborhoods are urban in density and mixed-use in occupancy, the immediate area's character and density is suburban in nature. The proposed density of Bedford Mews is greater, with 20 homes on 1.3 acres organized around a central courtyard (mews). The courtyard helps to mend and extend the urban fabric and density of Carlisle. The houses front on the courtyard and provide individual garden spaces at the rear (fig. 6).

The landscape design for the proposed South Bedford Housing is conceived as a series of overlain and fully integrated systems whose ecological performance will ensure the landscape's sustainability and long-term health. These systems are a series of layers that build on each other, each with their own function, that combine to form an environment that will be not only ecologically functional but also visually and spatially compelling. One primary project goal is for the ecological functions to be revealed to residents and visitors in a way that engages them with the processes at work on the site. Education about sustainable design and its importance to the daily lives of those residents and visitors will bring understanding, support, and long-term project success. The potential for future on-site roof water harvesting, storage, and re-use will be built into the landscape design.

The pedestrian and vehicular circulation system will provide access while avoiding conflicts between the two. Automobile drivers will sense that they are entering a pedestrian zone by the paving pattern of the parking court. The stepped planted terraces and plinth will integrate a pedestrian path that will connect the housing complex to downtown, eventually to the Letort Creek, and to the public park space and regional trail system across South Bedford Street. A pedestrian bridge will link downtown Carlisle and the residential complex. This bridge and path system will provide a variety of walking and jogging experiences as well as vantage points from which to view the landscape.

A bioretention cell, located in the center of the parking court, will capture pollutant-laden runoff from paved vehicle parking areas, cleansing it in a planting soil and sand bed through primary removal pathways of sedimentation, filtration, adsorption, infiltration, and microbial action as well as two secondary pathways of plant resistance and uptake. Runoff will pass through a native grass pre-treatment strip on the sloping sides of a shallow basin where water ponding can occur for no longer than 72 hours. This allows the runoff to infiltrate through planting soil and sand layers below the surface before being conveyed in its newly cleansed state into the ground water or into the riparian open space alongside Mully Grub Run at the northern-most edge of the site.

Building orientation and form is intended to maximize passive solar effects and minimize home energy needs (lighting, heating and cooling). The roof terraces and open floor plans will optimize natural ventilation within the units. The south face of the north buildings' roof forms a large and continuous solar collector for incorporation of both solar thermal and photovoltaic systems. All units are accessed directly from the court, reinforcing the sense of individual ownership. The vertical circulation, located as a central module within the individual units, is oriented and designed to act as a passive solar collection space and is vented accordingly at the roof. This sunspace is separated from the dwelling spaces with doors, allowing the occupant to control desirable heat gain or improve natural ventilation in the living spaces through the chimney effect in the stairwell.



Fig. 7: Bedford Mews 2nd floor plan and elevations with continuous solar collectors on roof.



Fig. 8: Bedford Mews 3rd floor plan; roof terraces and flex spaces allow for future expansion of the individual homes.

3.3 Unit Design

Flexibility and diversity of the unit types were primary objectives in the design of the Bedford Mews. This goal was intended to attract diverse buyers and to allow for flexibility over time. Several unit types are designed on a module system, from studio apartments to three-bedroom homes. As envisioned, the project includes six two-story, two bedroom 1,400 square foot units; three-story units with one to three bedrooms at 1,800 square feet; four flats at 1,000 square feet, that are intentionally stacked to allow for the possible expansion of the units into single two-story, four bedroom homes; and 2 studio apartments that are 450 square feet and are configured as separate dwelling units or easily re-configured to be combined with the upper two-story dwelling to create a "Mother/Daughter" home (fig 7). The modular design optimizes flexibility within the units, and provides for future expansion within the building envelope -- live / work flex spaces can be converted into an additional bedroom for a guest or parent, or outdoor roof decks can be enclosed to use as an additional bedroom (fig. 8 and 9). Parking garages are provided for 16 of the 20 dwellings, 6 additional shared spots are located in the center of the court, with priority parking going to car share vehicles. The developer is exploring options to provide car-share vehicles with electric "refueling" stations located at the central parking. The majority of the homes will be sold at market-rate, with 20% of the units reserved for buyers at or below 80% of the area medium income. A homeowners association with cooperative ownership structure, under the direction of the project developer, will maintain the infrastructure.



Fig. 9: Section of Bedford Mews through bioretention cell and systems tunnel

3.4 Specific Technologies and Materials

The design module used in configuring the buildings and dwelling units provide an economy of means during construction by allowing for less material waste and pre-manufactured component installation. The buildings exterior structural walls, Insulated Concrete Form (ICF) construction, were selected for durability and energy-efficiency. The “skin” materials, on the south-facing facades, allow for direct solar gain and summer shading. All finish materials will be considered with the concept of “cradle-to-cradle” in mind; Recycled, recyclable and reusable materials and details will be considered and local materials and manufacturers will be prioritized (fig.10).

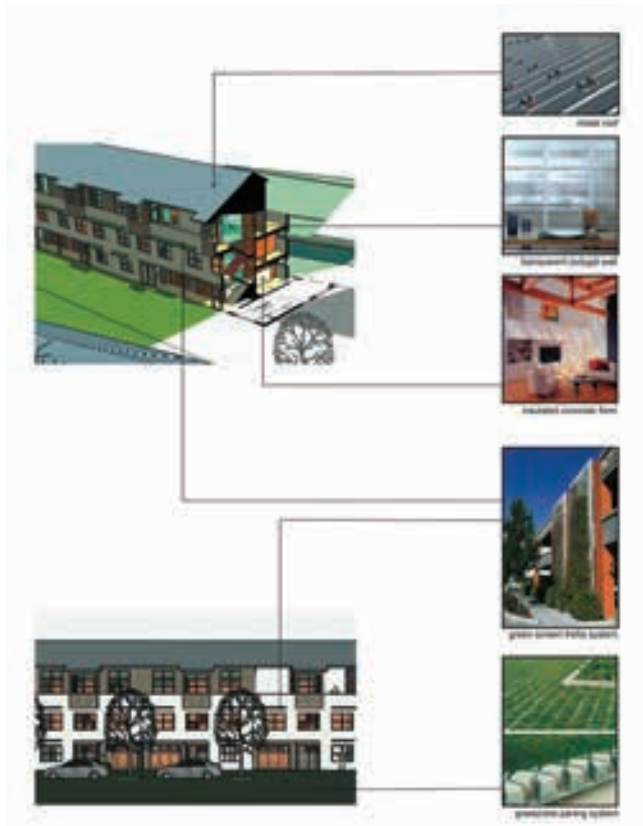


Fig. 10: Bedford Mews materials study

It is a goal of the project to move beyond simply reducing energy consumption through energy-efficient construction, and to provide holistic integrated planning for micro-energy production, allowing for the potential of self-sufficient energy production for the development. Shared building systems, including collective solar-thermal collectors and a micro-generator will reduce energy requirements for the subdivision and protect the residents in the event that the grid goes down. A future photovoltaic system will be grid-tied. Phone, data, cable, water, and HVAC is distributed and accessed through a continuous, connected tunnel. This tunnel allows for easy maintenance of building systems and the possibility for integrating emerging technologies and systems into the buildings (fig. 9). The energy goal is to reduce the requirements for this development to far exceed energy requirements for homes built conventionally (code compliant). Green guidelines, including LEED for Homes, Energy Star® & Green Communities™ Criteria, are being considered for both benchmarking and certification. The proposed on-site active energy systems are categorized into three areas: sub-surface heat-exchange occurring within a geothermal/bioretention cell under the courtyard; solar exposure to the roofs and south-facing facades of the buildings; and gas-powered turbines. System controls and equipment will be located in a Collective Systems Building at the southeast corner of the site, this structure will also include the development office, an enclosed bicycle storage facility, and a garbage / recycling center and loading dock.

3.5 Status of Project and Potential as a Model

The Bedford Mews project should receive land development approval in late 2007 with final design and the start of construction occurring in 2008. Bedford Mews shows promise as an ownership model and as a model for process rather than as a specific physical model. Through the use of collective systems Bedford Mews is predicted to be able to increase energy performance **and** environmental awareness dramatically. Further, it seeks to establish a two-way relationship with the utility grid and greater passive sustainability when the development is cut off from the grid or other utilities. The project looks to establish stronger ties between its residents, their community (and its economy), with nature, and with the world.

4. CONCLUSION

Petersburg Commons demonstrates one way to “green” a prevailing development type. The project demonstrates that there is no reason not to do this in every instance. It uses less energy in construction, provides incrementally better living space, and it uses significantly less energy than its non-green counterparts. Primarily because it uses so much less energy these improvements are virtually free. In short, this level of green should be the minimum acceptable. What Petersburg commons doesn’t do is look beyond it’s own boundaries. It has and will continue to use less energy than most development of its ilk, however because of its transparent nature sustainability is not at the fore. Petersburg Commons’ residents are generally required to rely on autos for travel to work, school, and entertainment. They are inextricably tied to the electrical grid with little capacity for passive sustainability or redundancy.

Bedford Mews explores how development can begin to challenge inherently wasteful patterns. It is consciously placed in the context of the global fight for sustainability. It seeks to establish a two-way relationship with the utility grid and greater passive sustainability when the development is cut off from the grid or other utilities. Through the promise of collective systems Bedford Mews should increase energy performance for its buildings substantially (over that of Petersburg Commons). It will seek to do more through reducing car trips and incorporating alternative energy production. Though integration into the local community (walkable neighborhood) and global community it can continue to reduce its energy use per capita dramatically. Thanks to this collective approach, the only incremental increase should be in construction! This model will encourage dramatic changes in patterns and environmental awareness.

5. ACKNOWLEDGMENTS

Petersburg Commons:
Jack Berger, Perry Green Building Housing Authority
and Cumberland County Housing Authority.
Michele Bertomen, Architect

Bedford Mews: David Sheridan, Sustainable
Community Development and Aquacura
Timothy Baird, Landscape Architect.

Petersburg Commons

Duncannon, Pennsylvania

Lisa D. Iulo: Project Designer for OPA

Petersburg Commons (Phase III; 39 units were built in phases I & II by another developer) is recognized as Central Pennsylvania's first green affordable housing project. Its fourteen townhouses include ten two-story, three bedroom homes of 1,230 square feet each, and four single-story two bedroom homes that are each 1,025 square feet. The townhomes were sold to first-time homebuyers with household incomes at or below 80% of the regions median income. Petersburg Commons was completed in May 2006 at a building-only construction cost of \$92/ square foot.

The project intention was to provide efficient, affordable dwellings that benefit occupants, neighbors and the community and to provide houses that allow residents to take pleasure in the everyday acts of dwelling. The townhomes are designed to minimally impact pools of resources known to be finite. Performance criteria included consideration for initial cost, operating cost and aesthetics; to create homes that are beautiful, well-loved and therefore well-taken care of for long-term project sustainability.



AWARDS (selected):

DESIGN EXCELLENCE, ENERGY & ATMOSPHERE

GBACPA Green Building Awards Program, 2007

MERIT AWARD for EXCELLENCE in DESIGN

AIA of Central Pennsylvania, 2006

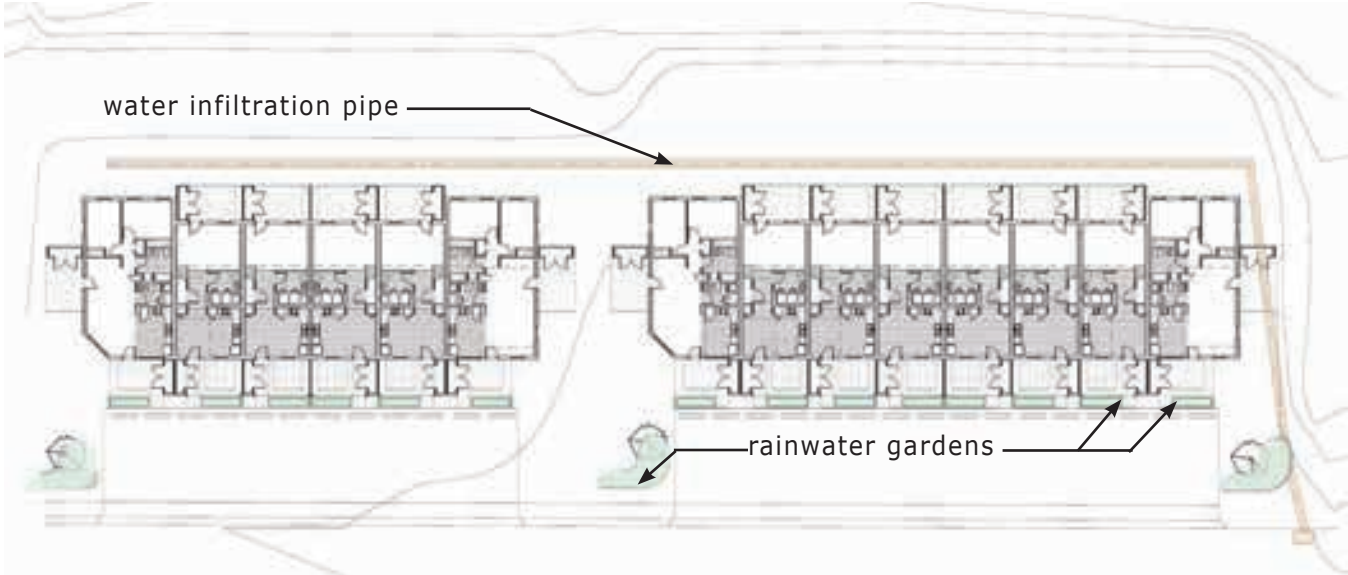
BELLAMY AWARD for HOUSING

PAHRA, 2006



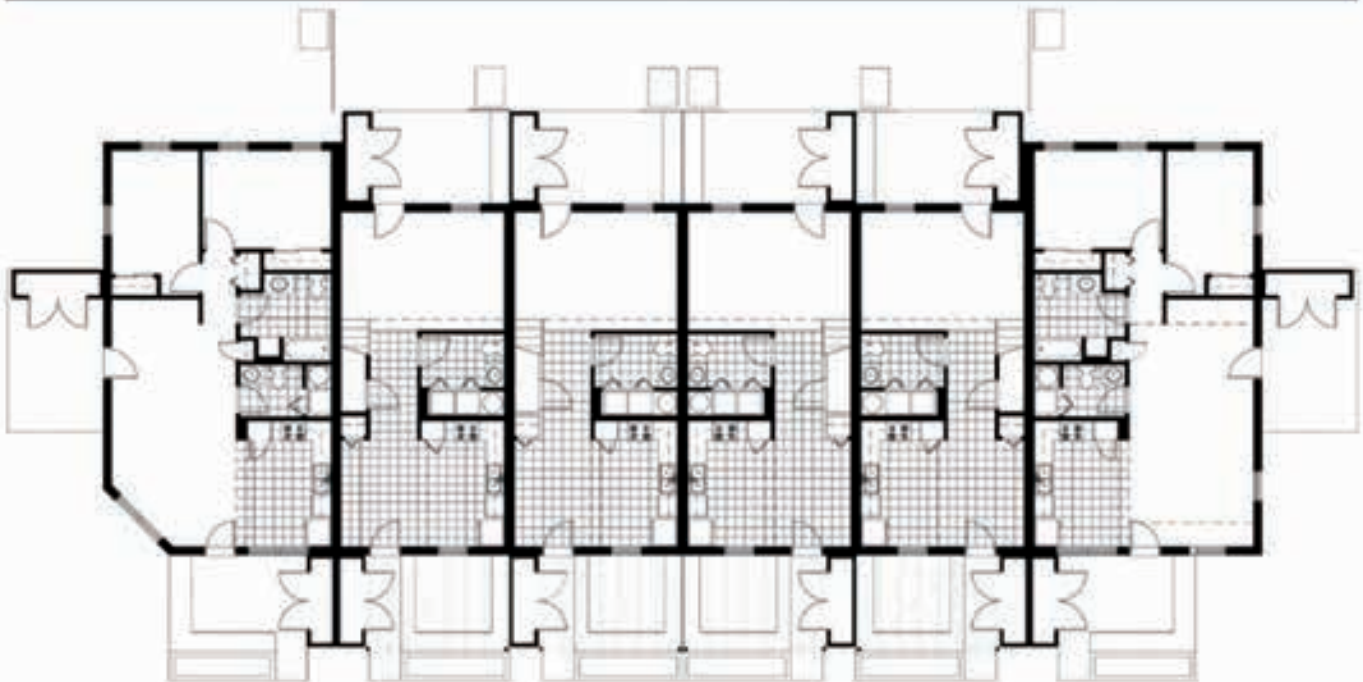
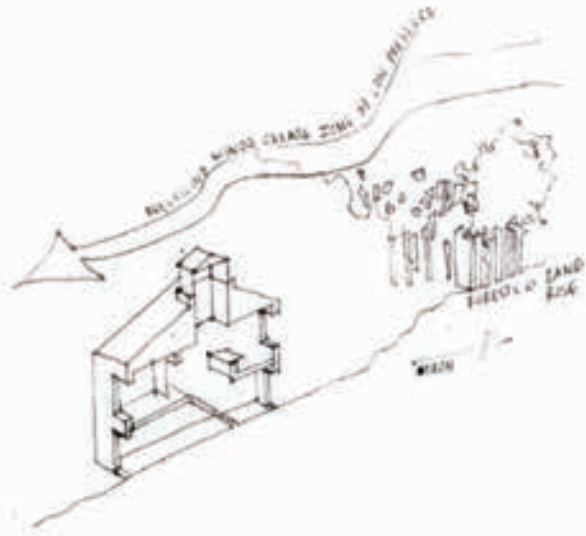
Working with the pre-existing plot plan, the design seeks to overcome the ambiguous nature typical of yard spaces in suburban townhouse development by designing the entire site as living space; features such as a conveniently located recycling station and trellis encourage “greener” living practices and connection to the outdoors.



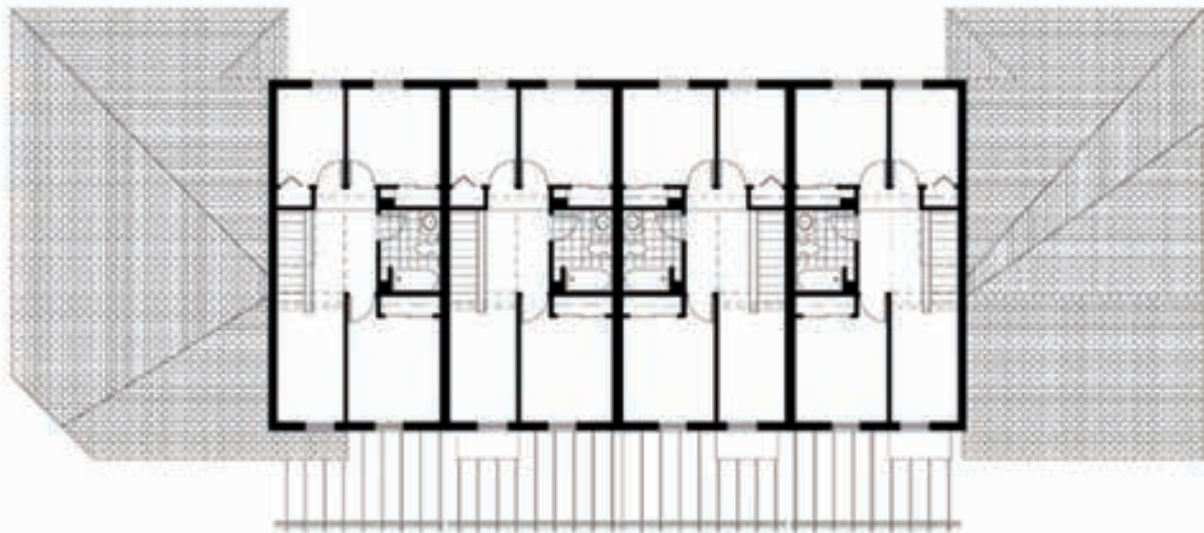
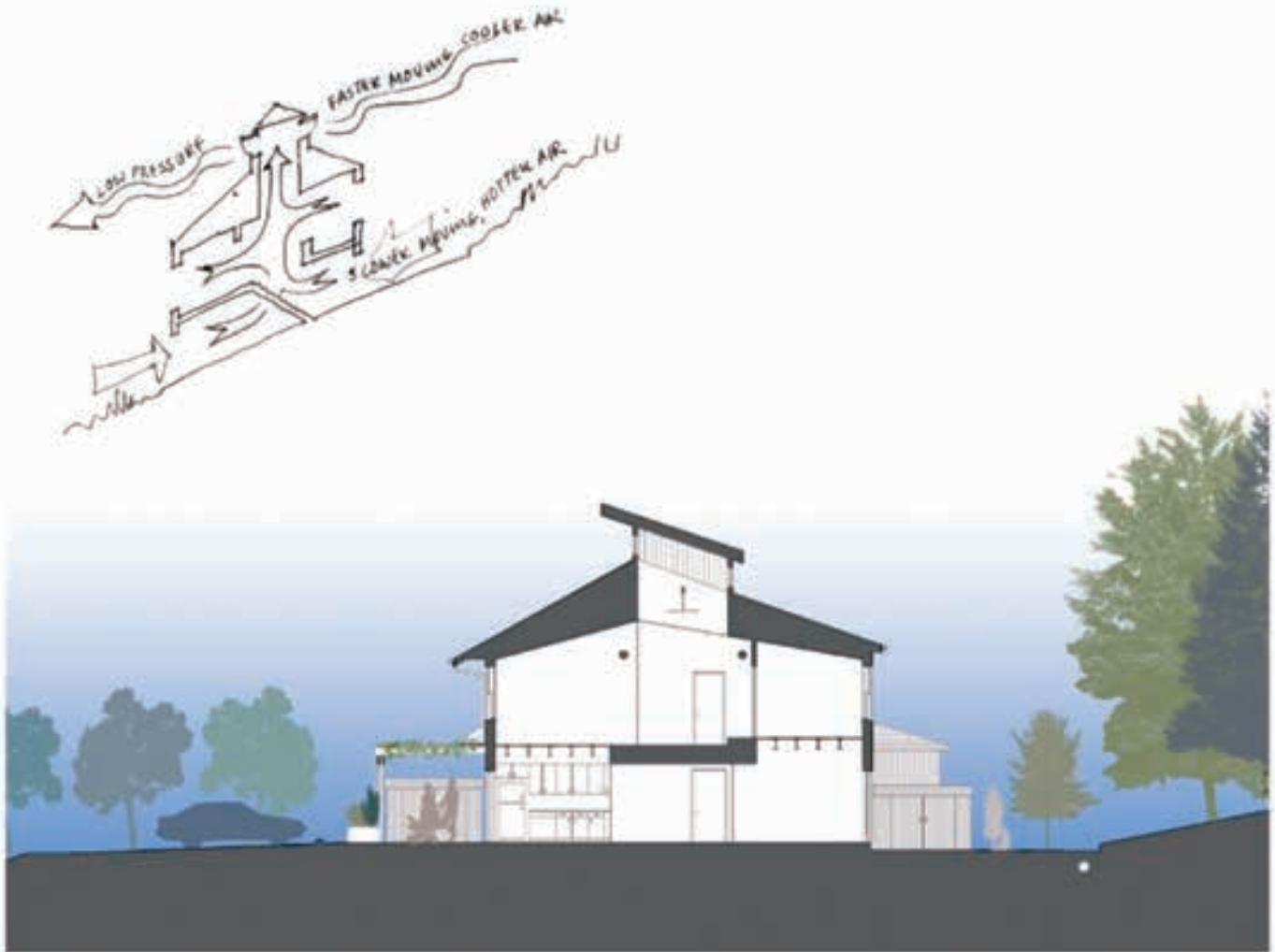


Despite existing stormwater infrastructure, all storm water is managed on site through the use of pervious pavement, rain gardens, water infiltration pipes and low maintenance landscaping.





Building 1. first floor plan



Building 1. second floor plan



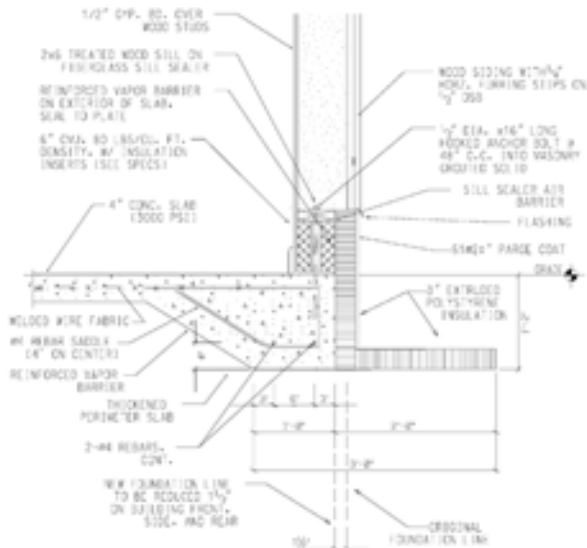
High energy efficiency is achieved within the context of high quality living space. Super insulation is combined with a cupola that provides light and ventilation to the core of the attached homes. Other innovations for daylight and natural ventilation include recessed windows in the end units. The cupola and recessed window solutions are also relevant solutions for infill housing in urban contexts. The angled window in the west end units face due south.







The goal of using local, sustainable materials is most successfully achieved through the use of locally harvested “bug-kill” hemlock siding, a material with local historical and contemporary precedent. This siding is certified by the Forest Stewardship Council as “salvaged.” Other innovative materials and design strategies include the use of polycarbonate glazing in the cupola; the use of ENERGY STAR metal roofing and recycled metal siding on the rear facades.



The shallow frost-protected foundations (SFPF) used significantly less material than conventional foundations and were a cost-effective solution for the site.



FOSTERING COLLABORATION

- Symposium Environmentally Conscious Design - Educating
Future Architects
*Co-organized with the Committee for Environmentally
Conscious Architecture (CECA)*
- Course Collaborative Seminar on Sustainable Design
New course development
- Course “Living with Sustainable Energy in a Global Society”
New inter-college course development
- Programs Penn State 2007 & 2009 Solar Decathlon
Courses, lectures and workshops coordinated
- Publication* Energy and the Integrative Design Process - Defining
the Team of Experts
Lisa D. Iulo

CECA SYMPOSIUM

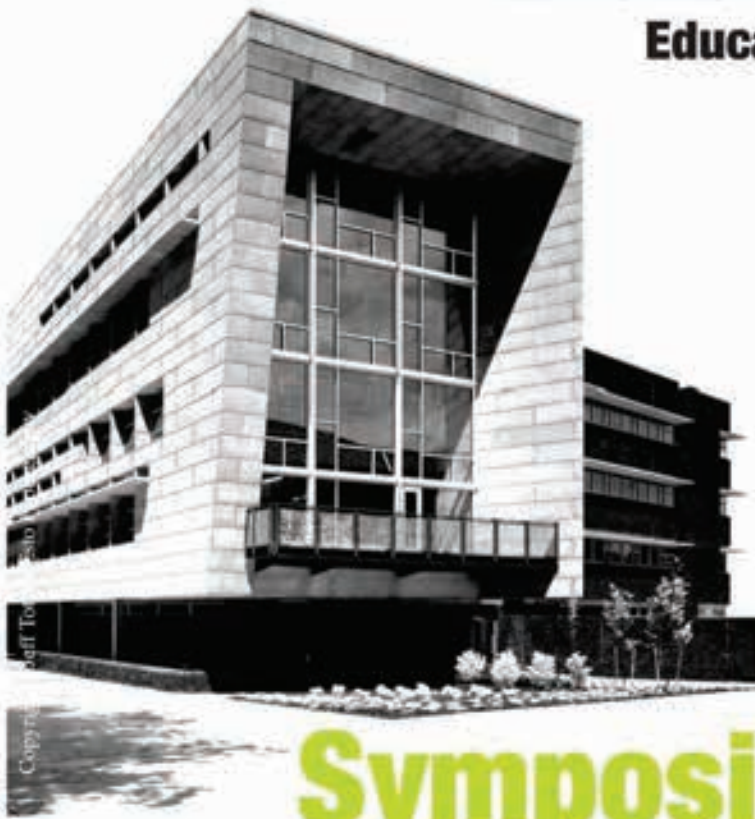
Co-organizer

Environmentally Conscious Design - Educating Future Architects

In response to consensus about climate change and the necessity to critically consider architectural curricula in order to define environmentally conscious design as a major priority, the Committee for Environmentally Conscious Architecture held a symposium in October of 2009. This event brought together experts in teaching environmentally conscious architecture to discuss exemplary curriculum scenarios. The goal of the symposium was to further define the role that environmentally conscious design should play in the undergraduate and graduate curricula, research agendas and outreach efforts at Penn State. An outcome of the symposium was an evaluative *white paper*. This *document* will be used to inform the future direction of environmentally conscious design education in architecture, to serve as the basis of future collaboration with other departments, and to provide a platform for individual and joint research efforts.

2009 OCTOBER 23-24

Environmentally Conscious Design Educating Future Architects



Symposium

PENNSTATE





Symposium invited speakers and panelists (from left) Brook Muller, Donald Watson, Margot McDonald, Warren Byrd, Mary Guzowski, Steven Moore, and Vivian Loftness.

Environmentally Conscious Design | Educating Future Architects

2009 OCTOBER 23-24



THURSDAY 22

6:00 p.m. **Bracken Lecture:**
Warren T. Byrd
110 Business Building

FRIDAY 23

4:00 p.m. **Keynote Lecture + Reception:**
Vivian Loftness
Palmer Lipcon Auditorium
Palmer Museum of Art

SATURDAY 24

8:30 a.m. Breakfast with attendees
102-103 Stuckeman Family Building

9:00 a.m. **Welcoming + introduction**
101 Stuckeman Family Building

9:15 a.m. **3 Speakers present their visions on teaching sustainability**

10:00 a.m. Break

10:30 a.m. **4 Speakers present their visions on teaching sustainability**

11:15 a.m. **Discussion round table with speakers and audience**

12:00 p.m. Lunch

102-103 Stuckeman Family Building
2:00 p.m. **Breakout sessions - Group discussions**
3rd floor Stuckeman Family Building

7:00 p.m. **Invited Dinner**
Nittany Lion Inn
Penn State Room



SUNDAY 25

9:00 a.m.-12:30 p.m. **Conclusions + summary**
Willow Room, Days Inn State College





The 6th International Conference on Innovation in Architecture, Engineering and Construction (AEC)

Iulo, L.D. and Poerschke, U., Committee for Environmentally Conscious Architecture, "Innovation in Education: Implementing Environmentally Conscious Design in Architecture Curricula." Proceedings of the 6th International Conference on Innovation in Architecture, Engineering and Construction (AEC), edited by C.J. Amumba and others, Loughborough University, UK (2010).

Innovation in Education: Implementing Environmentally Conscious Design in Architecture Curricula

Lisa D. IULO¹ and Ute Poerschke²

Representing: The Committee for Environmentally Conscious Architecture (CECA)

¹ Department of Architecture, The Pennsylvania State University, University Park, PA, USA

² Department of Architecture, The Pennsylvania State University, University Park, PA, USA

ABSTRACT: *In response to a new consensus about climate change and new accreditation criteria for sustainability and carbon-neutral design issued by the National Architectural Accrediting Board (NAAB), the sole agency authorized to accredit professional degree programs in architecture in the United States, an increasing number of architecture departments are revising and innovating their curricula in order to define environmentally conscious design as a major priority. Recognizing the importance of this discourse, the Pennsylvania State University Department of Architecture hosted a symposium to discuss exemplary and innovating curriculum scenarios for teaching environmentally conscious architecture. The symposium, entitled Environmentally Conscious Design – Educating Future Architects, was held at the Penn State University Park Campus on October 23-25, 2009. Organized by the Department's Committee for Environmentally Conscious Architecture (CECA), the symposium brought together experts in teaching environmentally conscious design from nine different universities. Emphasis for discussion was placed on the redefinition and innovation of curriculum content concerning aesthetic, ethical and technical sustainability in architecture and urban design, and the definition of the appropriate structures and mechanisms to ensure the implementation of this knowledge and approach.*

This paper reflects how a sample of academic institutions recognize the imperative to respond to the discourse of sustainability that is becoming prevalent in architectural practice, in order to stay at the forefront of architectural education. It collects faculty, student, and administrative perspectives, approaches for exemplary curriculum scenarios, and structures for teaching environmentally conscious architecture.

Keywords: architectural education, design Integration, environmentally conscious design, interdisciplinarity, sustainability

INNOVATION IN EDUCATION: IMPLEMENTING ENVIRONMENTALLY CONSCIOUS DESIGN IN ARCHITECTURE CURRICULA

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Committee for Environmentally Conscious Architecture CECA

Iulo, L.D. and Poerschke, U., Committee for Environmentally Conscious Architecture, "Innovation in Education: Implementing Environmentally Conscious Design in Architecture Curricula." Proceedings of the 6th International Conference on Innovation in Architecture, Engineering and Construction (AEC), edited by C.J. Amumba and others, Loughborough University, UK (2010).

ABSTRACT

In response to a new consensus about climate change and new accreditation criteria for sustainability and carbon-neutral design issued by the National Architectural Accrediting Board (NAAB), the sole agency authorized to accredit professional degree programs in architecture in the United States, an increasing number of architecture departments are revising and innovating their curricula in order to define environmentally conscious design as a major priority. Recognizing the importance of this discourse, the Pennsylvania State University Department of Architecture hosted a symposium to discuss exemplary and innovating curriculum scenarios for teaching environmentally conscious architecture. The symposium, entitled *Environmentally Conscious Design – Educating Future Architects*, was held at the Penn State University Park Campus on October 23-25, 2009. Organized by the Department's Committee for Environmentally Conscious Architecture (CECA), the symposium brought together experts in teaching environmentally conscious design from nine different universities. Emphasis for discussion was placed on the redefinition and innovation of curriculum content concerning aesthetic, ethical and technical sustainability in architecture and urban design, and the definition of the appropriate structures and mechanisms to ensure the implementation of this knowledge and approach.

This paper reflects how a sample of academic institutions recognize the imperative to respond to the discourse of sustainability that is becoming prevalent in architectural practice, in order to stay at the forefront of architectural education. It collects faculty, student, and administrative perspectives, approaches for exemplary curriculum scenarios, and structures for teaching environmentally conscious architecture.

1. INTRODUCTION

A paradigm shift is being realized in the way that we practice and teach architecture. The global energy situation, for example the vanishing resources of fossil fuels and the ecological problems that fossil fuels cause, has become a major concern in architecture. Since 40% of all energy is used to produce, run, and dispose of buildings¹, the architectural professions have realized the need to drastically change not only technical systems but all components within a building toward a higher level of efficiency and environmental responsibility. Moreover, they have become aware of the fact that future buildings must be able to react to the changing climate. The limitations of modernist icons, compartmentalization of knowledge, and the mentality of the master designer, must be reconsidered and replaced by a cooperative mentality that recognizes the necessity for relationship-building and reinforces systems thinking. No matter what priority is being addressed - resource limitations,

global climate change, social responsibility, or simply maintaining a competitive edge in a difficult market – environmentally conscious design is crucial. The 2010 imperative for architectural education mandates an immediate change in pedagogical approach with *ecological literacy* becoming a “central tenet of design education.”² To reach this goal it is necessary to rethink teaching methodologies in curricula and define appropriate structures and mechanisms to ensure the implementation of knowledge and approach. Addressing these needs, the Penn State Department of Architecture’s Committee for Environmentally Conscious Architecture (CECA)³ organized a symposium to bring experts in teaching environmentally conscious architecture from eight different Universities together to discuss exemplary curriculum scenarios. The intension of the symposium was to better understand the current thinking on teaching of environmentally conscious architecture, to emphasize the redefinition and innovation of curricular content concerning aesthetic, ethical and technical sustainability in architecture and urban design, and to consider future directions for environmentally conscious design in the undergraduate and graduate curricula exemplarily at Penn State by recognizing the opportunities inherent in the department’s structure within a school of architecture and landscape architecture.

2. BACKGROUND

Many faculty members within the Department of Architecture at Penn State approach sustainability in architecture as a critical part of their research agenda and their teaching.⁴ Additionally students in the School of Architecture and Landscape Architecture (SALA) have successfully competed in the NREL Solar Decathlon competitions in 2007 and 2009.⁵ These interests, along with the LEED Gold rated Stuckeman Family Building that houses SALA, involvement in the American Indian Housing Initiative (AIHI)⁶, and other endeavors, provide the department with excellent opportunities for building up a strong portfolio concerning environmentally conscious architecture and urban design. CECA was established in 2008 with the objective of embracing these efforts and institutionalizing sustainable thinking as part of the departmental mission and focus, including the engagement of undergraduate and graduate students in faculty research projects. CECA’s mission is to support the department in moving from the many individual faculty driven endeavors toward a coordinated effort. CECA’s position is to regard sustainability as a set of principles that have a place

in design, theory and specialty areas - principles that form a continuous thread through all aspects of the curriculum.

CECA also serves as a primary liaison between the department and the University at large, fostering cooperation and dialog related to sustainability and environmentally conscious design. There are many institutions at Penn State with which the Department of Architecture is collaborating. The Department of Architecture is part of the School of Architecture and Landscape Architecture, which includes the Hamer Center for Community Design, the Stuckeman Center for Design Computing, and the Center for Watershed Stewardship. The School resides in the College of Arts and Architecture. Two strong collaborators related to sustainability at Penn State are the Center for Sustainability (CfS) and the Penn State Institutes of Energy and the Environment (PSIEE).⁶

3. SYMPOSIUM ON INNOVATING ARCHITECTURAL EDUCATION

Guests invited to present and participate in the Symposium were selected based on their long-standing roles and experience as teachers and administrators of programs with noteworthy reputations in *environmentally conscious design*. A thorough search of the available literature, resources available on the different institutions’ web sites and educational awards, constituted the different criteria that were used in selecting the prominent individuals who were invited. Participants were:

Warren T. Byrd, Merrill D Peterson Professor of Landscape Architecture at the University of Virginia;

Mary Guzowski, Associate Professor of Architecture at the University of Minnesota;

Margot McDonald, Professor of Architecture at California Polytechnic State University, San Luis Obispo;

Steven Moore, Bartlett Cocke Regents Professor in Architecture at the University of Texas at Austin;

Brook Muller, Associate Professor of Architecture at the University of Oregon;

Donald Watson, FAIA, Earthrise Design, Former Dean and Professor Emeritus at Rensselaer Polytechnic Institute; and

Vivian Loftness, Professor of Architecture at Carnegie Mellon University.

Three key questions were posed to invited guests and investigated through presentations, breakout discussion sessions, and workgroups during the symposium:

- How can we enable students to develop an inclusive understanding of natural systems, ecological literacy, environmental responsibility, energy-efficient design, and interpretations and implications of sustainability in order to be informed and adaptable professionals?
- How can we achieve in-depth environmentally conscious design knowledge by introducing relevant concepts in design studios, seminars, and lecture courses, and establishing interrelationships between these courses and throughout the curriculum?
- How can we address the nature of environmentally conscious architecture as complex, interrelated, multi-dimensional, multi-scale, and the necessity to approach it with interdisciplinary knowledge from natural sciences, humanities, social sciences, and the arts?

Prior to the Symposium each invited participant was asked to develop a position paper that represented his or her ideals on teaching *Environmentally Conscious Architecture*. The request for position papers included the questions outlined above, but also encouraged authors to emphasize their own view concerning how environmentally conscious architecture should be integrated and taught in an undergraduate and graduate curriculum. All seven invited guests submitted their position paper prior to the symposium and also presented their views in a public forum during the symposium.

4. SUMMARY OF POSITION PAPERS

Key themes and ideas that were identified and reiterated in different ways by all of the guest presenters generally fit into two broad and interrelated categories, *Structural Networks* and *Functional Relationships*.⁷

4.1 Structural Networks

The teaching of environmentally conscious design begins with the awareness that all things are connected, endeavoring to realize education that is “context-full [full of the messiness of real life] rather than context-free [free of confounding variables that lurk outside of studio]” (Moore). Students should be encouraged to have an inclusive understanding of natural systems,

“environmental forces, rhythms and moods of place, and other bioregional factors that shape and inform ecological thinking” (Guzowski). According to Margot McDonald this understanding can “best be achieved when the learning environment provides the ability and the opportunity to experience an interwoven and direct relationship with sustainability in a real world setting”. A foundational quality of this relationship is that students learn to engage the needs of others – whether for nature or society – as they are confronted with ambiguity and complexity as well as the possibility of making a tangible difference in the world around them.”

Specific suggestions for implementing this knowledge into curricula were also frequently reiterated by the different speakers. Both history and theory were deemed important by the respondents, “including the social science of environment and equity” (Loftness). The importance of “balance” and “attending” to both poetics and quantitative aspects, including simulation and guidelines, was elaborated upon in the position papers and discussed at length during the symposium (Guzowski and Muller respectively). Vivian Loftness stressed the importance of a curriculum that recognizes the significance of building technology and building science, both as independent course streams, in “depth through sequenced courses”, and by linking lecture and studio classes (Loftness & McDonald).

Most of the positions presented addressed relationships across diverse scales and issues, including recognition of the importance of context relevant to place and social ethics. As stated by Brook Muller, “We shall conceive an individual work of architecture as a nexus of life, providing systems embedded within complementary systems of greater magnitude.”

4.2 Functional Relationships

As important as the understanding of connections (networks) is, the realization that one cannot know all there is to know, and respectful collaboration – both with other disciplines and within a community – is equally necessary. Participants stressed the importance of applied learning, both in the studio and in the field (both out of doors in general and working on community design projects and other “real-world experiences”). There was some debate among the participants regarding the role of specialization. Generally it was agreed that some specialization was necessary in the professional fields of architecture and landscape architecture, but that the need is for specialists who

are either trained or can function as generalists (Byrd, McDonald). Margot McDonald relates this to the “need [in the curriculum] to facilitate deep learning of subject matter relevant to the built and natural environment alongside teaching the techniques of effective teaming, communication and collaborative problem solving.” It was generally agreed that environmentally conscious design education required respect for expertise and the sharing of disciplinary knowledge, overcoming stereotypes to “value all viewpoints and skill-sets” (McDonald). Respectful collaboration must be both taught and applied in the curriculum, providing opportunities for students to participate in collaborative design studios and related classes (McDonald, Muller). This opportunity for shared learning must also extend beyond the bounds of academe into communities – an opportunity to both better understand the patterns of the environmental context and the “dynamic ecosocio-technological processes that are always dependent on context” (Moore). Applying learning to real-life projects and problem sets, and learning lessons offered by community members through interaction, foster environmental and ethical sensibilities in students.

As articulated by Donald Watson, universities and schools of architecture and environmental design fill a unique role as incubators for projects, test beds, and demonstration living labs. They have the opportunity to disseminate best practices paradigms through research and publication and to foster relationships through design centers. Many of the symposium participants pointed out the importance of reaching across the university and beyond, to “develop a ‘roadmap’ of environmentally oriented curricular offerings, so strategic linkages can be identified and cultivated.” (Muller). “Breadth of expertise” and broadness of engagement (with people and context) are necessary in the practice of environmentally conscious design (quote from Loftness). Reaching this goal, according to Vivian Loftness, must begin with an “inventory of *all* faculty with accomplishments in sustainability / ecology” and lead to a “faculty and student manifesto / commitment to carbon and equity” and by extension, environmentally conscious design.

4. SUMMARY OF SYMPOSIUM DISCUSSIONS

Primary ideas discussed during the symposium centered on the concept that architecture requires an

understanding of living systems and basic science. Buildings must be conceived and understood as part of larger systems, including understanding local and regional environmental contexts, the complex network of material and constructional systems and their impact on the cultural, social and economic contexts.

Symposium participants stressed that architectural education should instill complexity and diversity of the cultural, natural, and societal environment and should acquaint students with the principal theories, materials, and construction techniques used to create environmentally conscious buildings or retrofit existing buildings to be more sustainable. Discussions stressed that environmentally conscious content should be envisioned as a continuous theme that connects all curriculum year levels. The symposium reiterated that architectural design should address not only 2D and 3D visual expressions and spatial & structural relationships, but also the many aspects of time, like diurnal or seasonal changes, functional alterations, material ageing, or building lifecycle, treating buildings as living mechanisms rather than *just* aesthetic or functional objects.

It was stated that environmentally conscious design processes encompass systems knowledge and interactions between many disciplines during all phases of the design process. To achieve the environmentally conscious design goals of building functionality and appeal for the occupants while reducing the environmental footprint, matters of complexity and integration of all building components should be emphasized steadily.

5. THREE ‘I’s TOWARDS INNOVATION OF ARCHITECTURAL EDUCATION: A FRAMEWORK

On the basis of the position papers, the symposium identified a framework of three themes that can help architectural programs clarify, define and implement mechanisms to renew their structures, curricula and facilities in order to innovate architectural education: *Identity, Integration, and Interdisciplinarity*. These three ‘I’s will be discussed in the following with Penn State’s Department of Architecture serving as an example to which this framework is applied.

5.1 Identity

As a first step for developing strategies of sustainability implementation, it is important to clarify the importance environmentally conscious architecture should play in a particular program and the curricula. The positions might vary widely, from sustainability defining an overarching “umbrella” identity under which all efforts within a department fall, to being a major priority within a curriculum, or as an underlying concept. The symposium participants agreed that environmentally conscious design should be seen as a thread through the curriculum rather than a brand. Going further, it can be asked if the school, department or program should emphasize only one or a few particular areas of sustainability, for example community design, materials research, or theory and history, and thus strengthening a very specific sustainability identity. Answering these questions will form the basis for other questions that will inform curricular structure such as: What relationship between undergraduate and graduate programs could enhance the teaching of sustainability? or: How important are laboratories for building up a strong agenda?

Penn State’s Department of Architecture, for example, has a spirited discussion about identity as related to sustainability. The undergraduate architecture program is already widely recognized as a rigorous professional program that trains independent thinkers and problem solvers. While it has a wide spread agenda, several key areas are associated with the program and serve as an important basis for a curriculum unique to Penn State:

- Craft and the Art of Making
- Community and Social Responsibility
- Digital Design
- Sustainability

All of these areas are supported by particular institutions and facilities - a well equipped model shop, the Hamer Center for Community Design, the Stuckeman Center for Design Computing, and the LEED Gold rated Stuckeman Family Building, CECA and an evolving sustainability-focused student group. Depending on the further clarification of the importance of environmentally conscious design for the program’s identity, currently faculty and student driven voluntary groups might change to institutionalized efforts.

5.2 Integration

Integration, as understood in this context, deals with ways of implementing environmentally conscious design into curricula. Questions that can reveal potential ways of integration are for example: What is the right setting for teaching environmentally conscious design? Is it the studio, a seminar, a lecture course, or a mix of two or three of these settings? How do we teach ethical, aesthetic, and technical aspects of environmentally conscious design in studio? Is studio integration or a seminar the best structure for teaching technical systems within a sustainability emphasized architecture curriculum? How, and in which courses, can social, historical and theoretical questions of sustainability be best addressed?

Relating the question of integration of environmentally conscious teaching content to Penn State, there is no doubt that the existing curriculum does address environmentally conscious design. The first and second year studios, for example, have explored the potential of material and material reclamation for many years, the third year studio has introduced daylighting and passive ventilation as a requirement in their projects, and the fourth and fifth year studios have consistently emphasized sustainable planning and design principles. Technical systems classes address energy and environmentally effective design, and the number of elective or supporting courses focused on green architecture, LEED, and the Solar Decathlon are steadily increasing. Although this is successful in many ways, it was discussed that environmentally conscious content should be formalized as a continuous thread that better coordinates all year levels, building on itself from year to year, going from the global condition to specific design investigation. Proposals included:

- Encouraging environmentally conscious emphasis within existing studio and theory courses;
- Assisting in coordination between existing studio and theory courses;
- Formalizing processes for bundling studio with technical courses and using studio assignments in architectural engineering and systems classes; and
- Realizing supporting courses at appropriate year levels, including e-learning.

5.3 Interdisciplinarity

One sentiment kept reoccurring throughout the symposium discussions, 'Practice requires collaboration of disciplines. Why is education different?' On the basis of respect and acknowledgement of discipline-specific expertise and different modes of thinking, questions that can reveal ideas for interdisciplinarity are, among others: How can the assets in other departments be combined to strengthen environmental learning? Where have architecture and landscape programs combined assets to strengthen environmental learning? How pivotal is the closer cooperation between architectural engineering and architecture programs in order to strengthen environmental learning?

Relating the question of interdisciplinarity to Penn State's situation, it was concluded that there are already many successful efforts of collaboration between the Departments of Architecture, Landscape Architecture, and Architectural Engineering. The Raymond A. Bowers Program for Excellence in Design and Construction of the Built Environment, for example, supports new teaching projects collectively undertaken by faculty from the three departments. On the basis of the discussion outcomes related to identity and integration, priority might be given to projects addressing sustainability.

In addition, the connection to other professional fields within and outside of the University, including arts and humanities, industrial engineering, psychology, business, material sciences, and many others, has slowly increased. The coordinated intersection of parallel sustainability efforts and the faculty, students, or staff behind these efforts, has been identified as a major task not only in the Department of Architecture, but University wide. Penn State offers nearly 600 courses on energy and environmental topics; 16 undergraduate majors in energy and environmental studies; 37 minors; and 6 graduate programs. While most of these efforts would open up new interdisciplinary opportunities, the challenge is how to increase connectivity and collaboration among the potential partners.

It was also observed that many collaborative efforts are faculty initiated and taught as a teaching overload. Also here, institutionalizing interdisciplinary collaboration leads back to the question of identity. Suggestions for strengthening relationships and fostering more integrated learning include:

- Investigating opportunities for interdisciplinary studio experiences between architecture and landscape architecture students at different year levels;
- Seeking opportunities for interdisciplinary collaboration including industry partnerships and relationships (professional engagement), program opportunities (minors and certificate programs), and research opportunities;
- Providing incentives for interdisciplinary collaboration.
- Allowing for freedom within the curriculum to take advantage of classes in other disciplines and interdisciplinary project opportunities.

Structuring the questions related to implementing environmentally conscious design in architectural education through the framework of the three 'I's' appeared to be a fruitful process. However, further investigation must clarify the framework, for example by more closely connecting them to the categories of structural networks and functional relationships.

ACKNOWLEDGEMENTS

The Committee for Environmentally Conscious Architecture (CECA), including Charlie Cox, Instructor of Architecture; Christine L. Gorby, Associate Professor of Architecture; Denson Groenendaal, Instructor of Architecture; Lisa D. Iulo, Assistant Professor of Architecture; Loukas N. Kalisperis, Professor of Architecture; Ute Poerschke, Associate Professor of Architecture; and Malcolm S. Woollen, Assistant Professor of Architecture, not only organized the symposium, but is reflecting on it with this paper being the first outcome. Thank you to Moses Ling, Department of Architectural Engineering and Tim Baird, Department of Landscape Architecture for their input and support in organizing this symposium. The symposium was generously supported by the Schreyer Institute for Teaching Excellence, the College of Arts and Architecture Incentives and Innovations Fund, the Raymond A. Bowers Program for Excellence in Design and Construction, and the H. Campbell and Eleanor R. Stuckeman School of Architecture and Landscape Architecture.

REFERENCES

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- 2 Mazria, E. (2003) "The 2010 Imperative," *Architecture 2030*. http://www.architecture2030.org/2010_imperative/index.html. [last accessed January 2010]
- 3 *The Committee for Environmentally Conscious Architecture (CECA) includes Charlie Cox, Instructor of Architecture; Christine L. Gorby, Associate Professor of Architecture; Denson Groenendaal, Instructor of Architecture; Lisa D. Iulo, Assistant Professor of Architecture; Loukas N. Kalisperis, Professor of Architecture; Ute Poerschke, Associate Professor of Architecture; and Malcolm S. Woollen, Assistant Professor of Architecture.*
- 4 www.arch.psu.edu/aboutus/priorities_sustainability.shtml [last accessed January 2010]
- 5 www.solardecathlon.org [last accessed January 2010]
- 6 <http://www.engr.psu.edu/greenbuild/index.asp> [last accessed January 2010]
- 7 *The quotes in this section were taken from the position papers submitted by the external participants in the symposium.*
- 8 <http://www.psie.psu.edu/> and <http://www.cfs.psu.edu/> [last accessed January 2010]

ARCH 497C / LARCH 424

Elective Seminar (3 cr.)

COLLABORATIVE SEMINAR on
Sustainable Design Strategies & Solutions

This collaborative seminar introduces green building and construction strategies. Focus is on energy, environmental and ecological design as it applies to site planning / neighborhood development, building design and construction strategies, and the green building design process. Providing a detailed overview of specific strategies and approaches to green building planning, design and construction, this course also covers the theory, history, and past, current and potential future practices in environmentally conscious and ecological design. Developed with the generous support of the H.Campbell and Eleanor Stuckeman School of Architecture and Landscape Architecture, this collaborative seminar fosters collaboration between architecture, landscape architecture and architectural engineering students.

Collaborative Seminar on Sustainable Design

This course will provide students with an introduction to **environmentally conscious design** concepts / **green design principles** and will guide students in developing the vocabulary and skills to become productive contributors and **leaders on sustainable design project teams** through lectures, discussion groups, field trips, educational seminars and collaborative projects.

Wednesdays 9:05 AM-12:05 PM

101 Stuckeman Family Building

Instructors:

Lisa D. Iulo, Asst. Prof. of Architecture

Neil Korostoff, Assoc. Prof. of Landscape Architecture

**ARCH 497C /
LARCH 424**

"The field trips were very useful! The windfarm was a valuable experience, and the compost/stormwater trip was surprisingly illuminating. Even the construction site visit was a great opportunity to see sustainable elements in the making." 5th yr. B.LA student



Course Goals:

The goal of this *Collaborative Seminar on Sustainable Design Strategies and Solutions* is to provide students with skills promoting collaborative thinking and valuing team-oriented professionalism.

- Review green building and sustainable design thinking including different points of view.
- Communicate material on green building strategies and green guideline criteria to others through presentations and design implementation.
- Identify green building concepts and meaningfully contribute to group discussions about green building theories and approaches.
- Gain a detailed understanding of a site, energy or environmental design strategy through research and the development of a collaborative project.



"I have always had an interest in a more sustainable forms of development and now feel better prepared to tackle these issues. I now feel that collaboration is a key aspect of sustainable construction." 3rd yr. B.Arch





EMSC 470W / ARCH 497D
 Collaborative CAUSE Project (6 cr.)

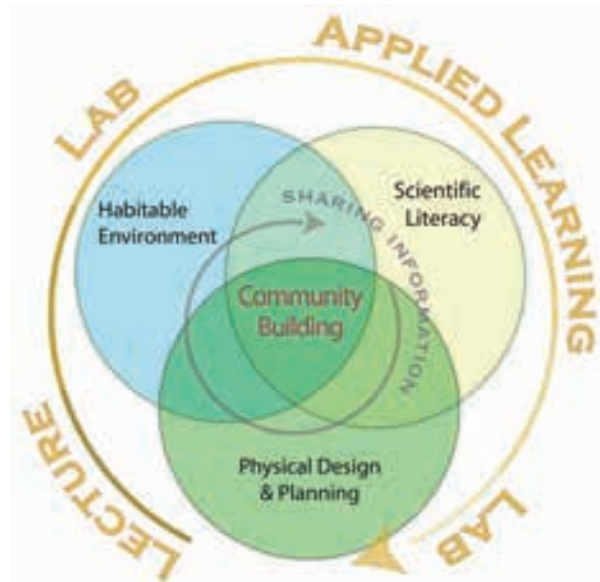
***Living with Sustainable Energy in a
 Global Society***

This course sequence and summer travel program brought together two Colleges and multiple departments at the Pennsylvania State University to interact in sharing information and building positive feedback interactions necessary to affect a reduced-carbon future of our built environment. A multidisciplinary group of students collaborated to develop common scientific literacy and skills in research and design necessary to inform future leaders in transitioning the built environment to a sustainable energy future. The principles, technologies, and impact of renewable energy systems were investigated at multiple scales—from materials, to systems, to buildings, to planning—in the interest of understanding interrelationships and broader policy and planning thinking necessary for achieving a sustainable habitable environment.

Course Sequence:

The class met over two semesters with an immersive study abroad experience during the summer between.

1. Spring 2009—Collaborative Lecture/Lab: (3 cr.) Weekly lectures covered material related to the science, technologies, and context of energy solutions while the students worked together to explore relevant science/engineering and design strategies.
2. Summer 2009: A two-week trip abroad to visit research institutions, built precedents, and case-study applications of renewable energy.
3. Fall 2009—Application and Public Literacy (3 cr.): Synthesis semester to investigate public policy and develop communicate skills necessary to raise public awareness.



Course Goals:

- Facilitate multidisciplinary group collaboration to develop a common literacy of energy usage, technology, and skills in research and design;
- Form future leaders in transitioning the built environment to a sustainable energy future;
- Foster community responsibility through individual actions and information exchange;
- Encourage collaboration and public coordination in physical design and planning;
- Equip students for global citizenship, facilitating literacy of energy use and technologies;
- Establish applied learning opportunities focused on the habitable environment



Throughout the course, each student maintained a blog to reach out to others.

Living with Sustainable Energy in a Global Society



ITINERARY

ITINERARY AT A GLANCE

MAY 19	FRANKFURT
MAY 20	FREIBURG
MAY 21	DARMSTADT
MAY 21, 22, 23	MUNICH
MAY 24	DESSAU
MAY 24,25,26	BERLIN
MAY 27	WOLFSBURG
MAY 28,29,30,31	PARIS

“CAUSE opened our eyes to the developments of other peoples and their impact in economic, social, and technological arenas.”

2nd yr. Enery, Business and Finance (EBF) major



Group during the summer immersive experience in Europe.



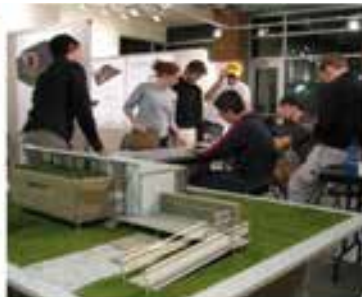
Public presentations and meetings with policy-makers allowed students to “bring their knowledge home”.

“EDUCATIONAL FOOTPRINT” 2007 & 2009 Solar Decathlon



The Department of Energy National Renewable Energy Laboratory (NREL) Solar Decathlon expanded well beyond a typical research project to engage an “educational footprint” that benefited over 1,000 students, faculty and staff at the Pennsylvania State University (900 people participated in Penn State’s 2007 entry alone). Bringing together traditionally separate disciplines, members of the Penn State Solar Decathlon team represented the Colleges of Engineering, Earth and Mineral Sciences, Arts and Architecture, Education, Agricultural Studies, Health and Human Development, Communications, and Business. This interdisciplinary collaboration put Design-Build to the test in an academic setting, while preparing the students to work with people from a variety of backgrounds from day-one of a project. Curriculum integration that fostered collaborative, multi-disciplinary / multi-organizational efforts was an important role as Advisor / co-Investigator to the Penn State Solar Decathlon teams. Several new course related to design-build, project management, prefabrication and green design were developed related to this effort. Others were engaged through the organization of public lectures, open design competitions, and design charrettes and project integration workshops.





In 2006-2009 1000 students, faculty, and staff at the Pennsylvania State University were engaged in the Solar Decathlon through new cross-disciplinary courses, public lectures, design competitions, workshops and charrettes.

Iulo, Lisa D. "Energy and the Integrative Design Process - Defining the Team of Experts." in *High Performance Homes, Their Design, Renewable Energies and Integrated Practice*, ed. Franca Trubiano. London: Routledge, forthcoming.

Energy and the Integrative Design Process – Defining the Team of Experts

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ABSTRACT: A new set of building industry experts contribute to the highly integrated nature associated with the design and construction of high-performance, net zero-energy homes. This chapter identifies the range of energy professionals who may be needed alongside the architect and the engineer, during the early phase of design, to ensure the attainment of performance goals. The building performance specialist, the renewable energy expert and/or installer, the home energy rater, and the homebuilder or manufacturer all contribute particular skills, principles, values and benchmarks for measuring performance excellence. Their role in the process, their contributions to the home's overall performance, and best practices for achieving an integrative design process specific to high-performance, net zero-energy homes are discussed in this chapter.

Keywords: high performance homes, integrative design process, project team

ENERGY AND THE INTEGRATIVE DESIGN PROCESS – DEFINING THE TEAM OF EXPERTS

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ABSTRACT

A new set of building industry experts contribute to the highly integrated nature associated with the design and construction of high-performance, net zero-energy homes. This chapter identifies the range of energy professionals who may be needed alongside the architect and the engineer, during the early phase of design, to ensure the attainment of performance goals. The building performance specialist, the renewable energy expert and/or installer, the home energy rater, and the homebuilder or manufacturer all contribute particular skills, principles, values and benchmarks for measuring performance excellence. Their role in the process, their contributions to the home’s overall performance, and best practices for achieving an integrative design process specific to high-performance, net zero-energy homes are discussed in this chapter.

1. DEFINING INTEGRATIVE DESIGN

Integrated design provides a conceptual and practical framework for increased communication and collaboration between owners, architects, engineers, contractors, specialty suppliers and a wide range of technical specialists during the construction of high-performance projects. It is a method of great promise given expected efficiencies and the higher chances it affords for meeting project goals, budgets and schedules. The Integrated Design Process is widely accepted in North America and Europe for building

projects large and small.¹ In the United States, the American Institute of Architects (AIA), in affiliation with the AIA California Council, has developed a tool for promoting its adoption. Integrated Project Delivery provides a legal structure and ‘contract mechanism’ supporting the Integrated Design Process.² The AIA publication, *Integrated Project Delivery: A Guide*, offers insight into possible approaches and implications of engaging in contractual arrangements in which design and construction teams “include members well beyond the basic triad of owner, architect, and contractor”.³ Moreover, a number of guidelines and certification systems for so-called ‘green’ homes also require the adoption of integrated project planning and delivery methods.⁴

This chapter discusses the Integrated Design Process as a ‘whole-building approach’ to high performance homes that recognizes the importance of establishing an inclusive team for building an integrated building.⁵ The 2003 National Renewable Energy Laboratories (NREL) guide, *A Handbook for Planning and Conducting Charrettes for High-Performance Projects* advocates this whole-building approach as a *design process* that offers “a multidisciplinary strategy that effectively integrates all aspects of site development, building design, construction, and operations and maintenance to minimize a building’s resource consumption and environmental impact while improving the comfort, health, and productivity of building occupants”.⁶ The

Integrated Design Process is an iterative and interactive practice where exact process is customized for each project. It requires a *“flexible method...different each time...with ongoing learning and emergent features”*.⁷ And it is precisely because the process is iterative that leaders in the field, including the 7-group and Bill Reed, have re-coined the practice Integrative Design.⁸ The goal of the Integrative Design Process (IDP) is to design better systems-integrated solutions that are aesthetically, functionally, technically, and economically successful. To achieve this, the Integrative Design Process provides a method for investigating and coordinating the inter-dependent relationships that exist between a building’s various systems. Author and practitioner Jerry Yedelson notes that such a process ideally *“explores...building orientation, massing and material choices as critical issues affecting energy use and indoor air quality, and attempts to influence these decisions before the basic architectural design is fully developed.”*⁹ The process is focused on the sequence of decisions made during the conceptual and early design phase that contribute to the performance of a building. IDP has also defined new models for collaboration between team members specifically engaged in the design and construction of high-performance, net zero-energy homes. The participation of a new set of building industry experts contribute to the highly integrated nature of this construction. To achieve the highest level of integration, the energy performance of the project must complement the architectural solution. This is best accomplished with the participation of energy experts who agree with project goals and aspire to common ends. The building performance specialist, the renewable energy expert and/or installer, the home energy rater, and the homebuilder or manufacturer are valuable to the Integrative Design Process as they contribute important skills, principles, values and benchmarks for achieving performance excellence. Their contributions are herein discussed.

2. ENERGY PERFORMANCE AND INTEGRATIVE DESIGN

Energy must be a key factor at every stage in the design, construction, and use of a high performance home. Demand, consumption and production are inter-related tenets of net zero-energy residential

construction and designing for energy performance is most effective when key energy related parameters are considered even before design begins. A building’s energy demand (i.e. an assessment of its consumption) should be estimated during the concept stage as this information establishes important benchmarks for performance measures that should inform all levels of design. Reducing energy and electricity demand is related to the selection of an appropriate site, the optimization of passive solar strategies, providing increased levels of insulation and the use of integrated building systems.¹⁰ And to attain the measure of performance desired of high performance, net zero-energy homes energy demand must be significantly reduced for on-site renewable energy production to be appropriately considered.

Further, homeowners and residents are crucial for establishing a building’s energy equation since everyday decisions and living patterns significantly impact a home’s performance and as such they should be involved in the Integrative Design Process. Establishing performance benchmarks early in the design process, and actively monitoring the resulting decisions makes the final compliance of the building envelope, building systems and occupant functions easier to assess. For all these reasons, engaging issues directly related to energy performance during the IDP is essential and the professional activities of four energy related experts make significant contributions.

3. ENERGY EXPERTS – TOWARDS AN INTEGRATIVE PROCESS

Increasingly architects and engineers provide specialized services associated with the design of high-performance homes, including in-depth assessments of building systems and performance parameters. However, in the rapidly developing field of net zero-energy architecture, introducing expertise in matters specifically related to energy is essential. The following section discusses the activities of four energy professionals and the roles they play in the Integrative Design Process for high-performance homes.

3.1 Building Performance Specialist

An important contributor to the integrative project team is the Building Performance Specialist (BPS). This individual, also referred to as the Building Performance Consultant (BPC) or the Energy & Environmental Consultant (EEC), emphasizes the fundamentals of building science and promotes an integrated understanding of building components. Building Performance Specialists are trained, professionally and/or academically, in the evaluation, diagnostics and installation of residential building systems as well as in the implementation of best strategies for energy efficiency, building performance analysis, air infiltration, weatherization and indoor air quality.¹¹ They are knowledgeable in high-performance residential construction and, during the design process, serve in an advisory capacity to the architect and engineer.

The Building Performance Specialist generally provides energy modeling and performance simulation services for calculating energy demand and for establishing the home's benchmark performance. In the schematic design phase simulations provide quantifiable feedback useful in determining alternatives to basic design solutions, including those that affect a building's orientation and fenestration patterns. Energy modeling is also used to confirm that sound building science has been adopted throughout, to fine-tune material and technology choices and to verify the appropriateness of construction details and specifications prior to construction.

Evident in the number of titles used to identify this emerging professional, the field is rapidly growing and evolving. Determining the appropriate specialist for a project should be based on matching project goals with the expert's qualifications and professional experience. Proof of expertise relevant to the project might include accreditation by a specialty group such as the Building Performance Institute, Inc. (BPI), or a certification guideline agency such as USGBC/LEED, NAHB, or the Passive House Institute of America.¹²

As an independent participant in the Integrative Design Process, the Building Performance Specialist can positively influence the nature of the assumed relationships between the traditional Architect/Engineer/Contractor team. According to Building Performance Specialist Peter Vargo, the addition of

this professional can improve the integrative design process by encouraging all *“team members to [have a] greater respect for one another's disciplines in achieving the common goal of a high-performance, net zero-energy home”*.¹³ Since the BPS is knowledgeable of both design strategies and verification procedures, he or she can mediate between the priorities of design professionals and those of builders and, if experienced enough, foresee issues that could directly affect the project's energy performance. In this way the BPS assists in fostering a collaborative environment and in facilitating the positive outcomes of an Integrative Design Process, focused on real project goals and based on sound principles of building science.

3.2 Renewable Energy Expert

Renewable energy systems, when used in the design of a high performance, net zero-energy home, must interface with other building components including the envelope, the building's structure, and its mechanical and electrical systems. Significant coordination is necessary to ensure a functional system that does not compromise the building's design or its construction. To this end, Renewable Energy Experts (REE) provide experience and guidance in concerns related to on-site production of home energy. They champion the inclusion of renewable energy systems and ensure their integrity and integration in the final project.¹⁴ The REE provides support and information for a vast number of commercially available systems, advising in the design, selection, optimization, installation and coordination of solar systems (electric and/or thermal), wind turbines, biomass and energy storage devices. They can also identify energy-savings solutions associated with ground or water coupling for heat pumps. Renewable Energy Experts keep informed of governmental rebates and other financial incentives, and assist in identifying all costs and financing options for implementing renewable energy systems.

Options for renewable energy generation should be explored at the beginning of the design process to maximize efficiencies. To achieve a holistic systems-integrated approach, the REE works alongside the architect and the engineer to integrate renewable energy systems on at least three levels during the planning and construction of the building: as related to the building's architectural design, to its mechanical and electrical systems, and with regard to the maintenance

and operation of the energy producing system.¹⁵ Many Renewable Energy Experts provide technical support and are responsible for the coordination of all energy producing components, from schematic design, engineering, construction documentation, through procurement and systems implementation. The Renewable Energy Expert is familiar with all energy generating related system components and qualified to inspect and to ensure proper functioning of this technology. In many cases the REE also serves as the system's installer and when not involved with the installation the REE can serve as liaison between the design team and installer, establishing a construction schedule and coordinating the installation. This is an important activity since a lack of coordination can result in delays, additional field verifications, and increased costs. Absence of the Renewable Energy Expert from the integrative design process may result in the less than optimal placement or installation of photovoltaics (PV) or other sensitive energy-generating technology and in the worst-case building envelope failures.¹⁶

Many of the problems or delays associated with implementing renewable energy technologies originate in unfamiliarity with local regulations and the failure to coordinate with utility companies. According to a report by the U.S. Department of Energy, "*utility interconnection for systems has been a barrier for PV system implementation...the system designer should contact the local utility at the very beginning of the system design process to establish the interconnection framework and the possibility of a contract between the utility and the PV system owner.*"¹⁷ To address this, the Renewable Energy consultant can serve to synchronize needs of the project team and those of related code and utility officials. And lastly, following construction, the Renewable Energy Expert can provide initial system commissioning and training of homeowners and/or systems operators.

Like the Building Performance Specialist, the Renewable Energy Expert is an emergent professional in a quickly developing field. A vast knowledge of energy related issues is required in order to keep abreast of rapidly developing technologies and policies. Typically, the REE is educated in engineering or energy-related sciences having

completed graduate work or advanced training in the field of renewable energies. In the United States the North American Board of Certified Energy Practitioners (NABCEP) offers certification and certificate programs to renewable energy experts.¹⁸ Once again, selecting the appropriate consultant is a matter of coordinating project needs with specific expertise and experience of the Renewable Energy Expert.

3.3 Home Energy Rater

A Home Energy Rater (HER) provides field verification and diagnostic testing associated with the energy performance of a high-performance home. During renovation or retrofit projects Home Energy Raters perform energy auditing services, assessing home energy usage and making recommendations for improving energy efficiency. More specifically, related to both retrofit and new home construction projects, an Energy Rater provides services associated with energy rating certification. In the United States a numerical score is typically used to assess a home's energy performance with scores compared to that of a reference home defined by the International Energy Conservation Code (IECC). According to the Home Energy Rating System (HERS), whose index scoring parameters are established by the Residential Energy Services Network (RESNET), the lower the HERS index the more energy efficient the home. For example, a new home constructed to meet with the minimum requirements of the IECC would receive a score of 100, while a net zero-energy home would score a HERS index of 0. In other words, a one-point decrease in the HERS Index corresponds to a 1% reduction in energy consumption compared to the IECC reference home. Based on a preliminary design for the home, a Home Energy Rater performs an energy analysis using simulation software that results in a pre-construction HERS score. The rater uses this information to identify and recommend improvements in energy efficiency that should be implemented. Finally, and perhaps most importantly, the Energy Rater conducts onsite inspections during construction to verify the home's performance. Typically, these inspections include a blower door test of the building envelope to verify levels of air infiltration, as well as testing of the ductwork for leaks. These diagnostics are used to generate the final HERS score for the home.¹⁹

3.4 Home Builder or Manufacturer

Training of the Home Energy Rater includes knowledge in the basic principles of building science, background in energy efficient construction including building components and HVAC (heating, ventilation and air conditioning) systems, on-site inspection procedures and quality assurance. Additionally, Energy Raters may be trained in specialized systems such as those affecting the building's envelope and they may have knowledge of energy efficiency mortgages, financial rebates and incentives. Following training, candidates for certification must gain hands-on experience by participating in supervised energy ratings, sometimes including software simulations, and pass associated examinations. No experience or expertise is necessary prior to training and testing for professional accreditation as a Home Energy Rater.

Increased interest in high-performance homes has expanded the home rating industry with more and more companies offering related services. In the United States, two agencies offer training programs and accreditation. A certified 'Home Energy Rater' is someone who has successfully completed training by a Residential Energy Services Network (RESNET) Accredited Rater Training Provider and is certified by a RESNET Accredited Rating Provider.²⁰ While the Building Performance Institute (BPI); an independent not-for profit organization dedicated to developing national standards and accreditation procedures for energy-efficient homes, provides training and accreditation to professionals with a focus on existing home retrofits and weatherization.²¹

Because Home Energy Raters provide verification of building and systems performance, during and directly following construction, their primary involvement in the Integrative Design Process may at times be limited and in some cases third-party verification of energy performance is desired or necessary for home certification precluding the Energy Rater from participating as an integral member of the integrative design team. However, if third-party verification is not required, the Home Energy Rater and the Building Performance Specialist may be one and the same, depending on experience, and a contract for consulting could be inclusive of all services needed throughout the Integrative Design Process, from pre-design through occupancy.²²

Even with an experienced team and a refined design, building envelope performance, indoor air quality and thermal comfort rely on proper detailing, construction and installation. Attention to how well the building is constructed is paramount for an energy-efficient high performance, net zero-energy home. Builders, construction crews (including sub-contractors), and installers must be properly trained and take the initiative to ensure proper performance of the built product. To encourage this level of quality, direct participation on the Integrative Design Team offers the builder an active voice in setting project goals and objectives. Having the homebuilder involved in decision-making from the very beginning of the process can be extremely beneficial. The builder can provide real cost information throughout the design process as well as offer insight into material opportunities, preferred building strategies and established relationships with suppliers that can save money, labor, lead-times, and shipping expenses. The contractor also has direct building experience and can identify potential conflicts related to weather, site conditions or conflicting systems, and facilitate coordination between building trades. For all of these reasons, early 'buy-in' and commitment by homebuilders and manufacturers of modular or prefabricated homes is essential for achieving the goals of high-performance, net zero-energy homes. This engagement in the IDP by the homebuilder or manufacturer may also serve to avoid frustration and increased delays during construction since the builder will be familiar with the process and the necessity for careful construction and additional inspections.²³

Increasingly, builders are favoring the competitive edge that focusing on high-performance construction provides and are seeking opportunities to further their expertise in this field. A number of companies offer inclusive design-build services explicitly related to high-performance homes with specialists on staff that address everything from detailed systems design to construction and performance verification. These builders are attentive to energy performance details, including the "*ability to install products effectively so that they may perform in the manner intended, and the ability to get the knowledge and skills into the hands and minds of the labor and subcontractors – educating those who may impact the installation.*"²⁴ Although professional accreditation in the area of high performance home

construction is generally unnecessary, training is desirable. There are many options for short courses and other training programs for homebuilders and some specifically related to the home manufacturing industry. In the United States, the National Association of Home Builders (NAHB) National Green Building Certification Program, the Passive House Institute US, and independent accrediting agencies like BPI offer training and professional accreditation for builders. The U.S. Department of Energy (DOE) ENERGY STAR program provides additional training and qualifying credentials for increasing the expertise of homebuilders and manufacturers.

The informed participation of the homebuilder or manufacturer is essential for attaining the goals of high performance. This necessitates a shift in normal procedures, since on most residential projects the homebuilder is not selected until after the design is complete. By encouraging an integrative design process, even on the smallest residential project, high performance, net zero-energy objectives become more achievable.

4. THE INTEGRATIVE DESIGN PROCESS FOR HIGH-PERFORMANCE HOMES

It is generally accepted that both the architect and the engineer are essential to the Integrative Design Team. In her article “Integrated Design Process: From analysis/synthesis to conjecture/analysis,” Maureen Trebilcock describes the partnership as requiring, “*architects and engineers to get closer in terms of sharing knowledge and skills. The architect needs to develop knowledge in architectural sciences and skills in simple environmental analysis, while the engineer needs to develop knowledge in architectural matters and skills in design. They share a common language, as well as sharing the character of designer.*”²⁵

Many share Trebilcock’s advocacy of a “common language”. However, generally such blurring of disciplinary expertise is unrealistic. Instead an IDP that sets parameters for common goals and agreement on performance benchmarks provides a platform for respectful collaboration that values the specialized knowledge of the various energy experts and design professionals. Camilla Brunsgaard, Mary-Ann Knudstrup and Per Heiselberg cite a similar viewpoint

from the European Union’s International Energy Agency (IEA) Task 23 document; “*In [the IDP] approach the client takes a more active role than usual, the architect is a team leader instead of sole form-giver and the different engineers, including the energy specialist, takes an active part in the early stages of the process. The process is based on the specialist knowledge of each [expert].*”²⁶

A successful Integrative Design Process depends on the input and critical thinking of an entire team. Setting common project goals and values is the first step. Establishing client/homeowner needs and desires is fundamental as these may include, knowing the owner’s primary energy objectives, how committed he or she is to attaining these objectives, developing a realistic cost scenario to achieve the desired performance goals, and how invested the owner will be in actively maintaining and managing the high-performance or energy producing aspects of the home. All other team members also contribute in defining the project’s goals and throughout the process to provide benchmarks for evaluating the project’s development. Optimum high performance, net zero-energy homes are based on the successful integration of technical, aesthetic and economic objectives related to energy goals. It is the team of energy experts - the Building Performance Specialist (who analyses the energy demands and energy balance of the design), the Renewable Energy professional (who integrates energy producing technologies within the design), the Energy Rater (who measures and certifies the performance of the completed house), and the homebuilder or manufacturer (who ensures that the actual construction meets the energy terms set out by the entire team) – in collaboration with the project architect and engineer who directly contribute to the attainment of these goals.

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ENDNOTES

1. In Canada the *Roadmap for the Integrated Design Process* (BC Green Building Roundtable prepared by Busby Perkins + Will / Stantec Consulting, 2001) promotes the IDP. Internationally, Task 23 of the Solar Heating and Cooling program of the International Energy Agency (IEA-SHC, Task 23) is also focused on IDP, see www.iea-shc.org/task23/
2. For more information on Integrative Project Design and Delivery see, Tristan Roberts, "Integrated Project Delivery: A Platform for Efficient Construction," *Environmental Building News*, November 2008, vol. 17 no. 11, 1.
3. AIA National/ AIA California Council, *Integrated Project Delivery: A Guide*, version 1, (Washington, DC: The American Institute of Architects, 2007), Introduction, <http://www.aia.org/contractdocs/AIAS077630>
4. In the United States certification guidelines including Enterprise Foundation's Green Communities, USGBC LEED for Homes and the National Association of Home Builders (NAHB) National Green Building Program all require some form of an Integrated Design Process (IDP). The United Kingdom's Code for Sustainable Homes (BRE Global, November 2010) does not make direct reference to the design process, but assignment of responsibility for assuring performance falls upon several project contributors, encouraging the adoption of an IDP.
5. Whole Building Design is an IDP approach facilitated by the National Institute of Building Sciences via an online resource, *The Whole Building Design Guide* (www.wbdg.org, accessed 14 January 2010). The U.S. Department of Energy (DOE) Energy Efficiency and Renewable Energy Building Technologies Program, "Builders Challenge," and the DOE National Renewable Energy Laboratory "Building America Program" encourage a related "Whole-House" approach in realizing their vision for "cost-neutral, net zero-energy homes anywhere in the United States," see <http://www1.eere.energy.gov/buildings/challenge/about.html>
6. Lindsey, G., Todd, J.A., Hayter, S.J. , *A Handbook for Planning and Conducting Charrettes for High-Performance Projects, Second Edition* (Washington, DC: National Renewable Energy Laboratory, 2009), p. iii, http://www1.eere.energy.gov/buildings/commercial_initiative/charrette.html
7. Busby Perkins + Will and Santec Consulting, *Roadmap For The Integrated Design Process* (Vancouver: BC Green Building Roundtable, 2007), 7, <http://www.metrovancouver.org/buildsmart/design/pages/integrateddesignprocess.aspx>
8. 7group and Bill Reed, *The Integrative Design Guide To Green Building: Redefining the Practice of Sustainability* (Hoboken, NJ: John Wiley & Sons, Inc., 2009). Their term, "Integrative Design Process" (IDP) is used in this chapter.
9. Jerry Yudelson, *Green Building Through Integrated Design* (New York: McGraw Hill, 2009), 36.
10. The U.S. Department of Energy's (DOE) ENERGY STAR program requires new homes to include energy-saving features that typically result in 20-30% more efficiency than homes built to U.S. residential codes. However, these benchmarks are significantly less than standards set in the European Union. Germany's energy standard is only 70 kWh/m²; Passivhaus ultra-low energy building standards set annual heating and cooling demand to not more than 15 kWh/m². See Passive House Institute, http://www.passive.de/07_eng/index_e.html

11. The Building Performance Institute, Inc. (BPI) provides training and certification to professionals in the U.S. home performance industry. They stress an integrative 'house-as-system' approach in their credentialing programs and certify Building Analyst Professionals and Building Envelope Professionals. Building Performance Specialists may also hold HERS Rater certification provided by RESNET (Residential Energy Services Network). See <http://www.bpi.org/professionals.aspx>.
12. Both the National Association of Home Builders (NAHB) Green Home Building Guidelines and the Passive House Institute standards recommend the hiring of consultants knowledgeable in their respective methodologies and offer professional accreditation to this end. The LEED for Homes certification program provides points for following an integrative design process and including a LEED-Accredited Professional (LEED-AP) on the design team; it also requires third-party verification and oversight of the process by a United States Green Building Council (USGBC) approved regional LEED for Homes Provider.
13. Peter Vargo, Correspondence with author, October 22, 2010.
14. Donna Munro, *Photovoltaics in the Urban Environment: Lessons Learnt from Large-Scale Projects*, ed. Bruno Gaiddon, Henk Kaan, and Donna Munro (London: Earthscan publishing, 2009), 9.
15. U.S. Department of Energy, *Photovoltaics in the Built Environment: A design guide for architects and engineers*, (prepared by Solar Design Associates, Harvard, Massachusetts, and the National Renewable Energy Laboratory, Golden, Colorado, for the U.S. Department of Energy, 1997), 8.
16. The problems identified in this section are summarized from the many case studies and exceptional examples provided in the book: Bruno Gaiddon, Henk Kaan and Donna Munro, ed. *Photovoltaics in the Urban Environment: Lessons Learnt from Large-Scale Projects* (London: Earthscan publishing, 2009).
17. U.S. Department of Energy, *Photovoltaics in the Built Environment: A design guide for architects and engineers*, 1997, 66-67. See also Donna Munro, *Photovoltaics in the Urban Environment: Lessons Learnt from Large-Scale Projects*, ed. Bruno Gaiddon, Henk Kaan, and Donna Munro (London: Earthscan publishing, 2009), 9-10.
18. See the North American Board of Certified Energy Practitioners (NABCEP) website, <http://www.nabecep.org/>
19. Refer to "What Is A Home Energy Rating," <http://www.resnet.us/home-energy-ratings>
20. See RESNET website, "How to Become a Certified Rater," <http://www.resnet.us/rater/certified>
21. See Building Performance Institute's web site, <http://www.bpi.org/> ; and "Prove your worth," http://www.bpi.org/professionals_designations.aspx. Some states have their own requirements for verification of home energy performance. In California, the California Energy Commission has a process for certifying HERS Raters who perform third-party inspections when verification of duct sealing, thermostatic expansion valves (TXVs), refrigerant charge, airflow measurement, and building envelope sealing measures are used to comply with Title 24, Part 6, of the Building Energy Efficiency Standards, see <http://www.energy.ca.gov/HERS/index.html>.
22. Home energy rating systems are widely recognized tools in the mortgage industry and a HERS Index, verified by a RESNET qualified rater, is necessary to qualify for United States federal tax credits associated with energy-efficient homes. RESNET establishes standards for basic services provided by Home Energy Raters and makes arrangements to insure certified RESNET raters against liability.
23. Shaun T. Pardi, phone interview with author, March 21, 2011.
24. Gregory L. Olsen, interview and correspondence with author, February 16, 2011.

25. Maureen Trebilcock, "Integrated Design Process: From analysis/synthesis to conjecture/analysis," Proceedings of the 26th International Conference on Passive and Low Energy Architecture, June 2009, *Architecture, Energy and the Occupants Perspective*, ed. Claude Demers and Andre Potvin (Quebec City: Les Presses de l'Universite Laval, 2009): 559-564, p. 563.

26. Camilla Brunsgaard, Mary-Ann Knudstrup and Per Heiselberg, "The First Comfort Houses in Denmark: Experiences of Different Design Processes," Proceedings of the 26th International Conference on Passive and Low Energy Architecture, 22-24 June 2009, *Architecture, Energy and the Occupants Perspective*, ed. Claude Demers and Andre Potvin (Quebec City: Les Presses de l'Universite Laval, 2009): 585-590; p. 586.

Lisa D. Iulo is an Assistant Professor of Architecture at the Pennsylvania State University and a Registered Architect, Professional Planner, and LEED Accredited Professional (LEED AP) who has focused her work and research on building and planning for a sustainable future. Specifically, Lisa's work has been recognized in research and practice related to residential green building practices and affordable housing, energy efficiency and strategies for the implementation of renewable energy at the building and community scale.

Lisa was co-recipient of two U.S. Department of Energy National Renewable Energy Laboratory (NREL) Solar Decathlon grants to design, build and operate a solar powered home on the National Mall in Washington, DC. As co-faculty advisor (co-PI) to the 2007 *MorningStar* team and an architecture advisor to the 2009 *Natural Fusion* team, she collaborated with hundreds of students, faculty members and industry partners in researching, developing and promoting beautifully designed, highly-efficient, plus zero-energy homes as models for Pennsylvania and throughout the US. MorningStar PA, PSU's submission for the 2007 Solar Decathlon, was recognized 4th place overall (out of 20 teams) in the competition. This highly integrated design-build project also won a BP Solar Performance Award and *PVNews* Editor's Choice Award.

Lisa has been a member of the architecture faculty at the Pennsylvania State University since 2003 where she is committed to introducing ecological planning and green building practices to architectural education. She teaches design studio courses throughout the curriculum, including the 4th year urban design studio, and seminars on LEED and sustainable design. Previously she taught as an adjunct instructor of architecture at New York Institute of Technology and practiced in Jersey City, New Jersey and Brooklyn, New York. She holds a Master of Urban Planning degree from CUNY City College of New York and a Bachelor of Architecture degree from New York Institute of Technology. Her professional and creative work has been recognized both nationally and internationally.

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