Evergreen Affordability

TOOLS FOR BUILDING SUSTAINABLE HOUSING

Produced by the National Center for Appropriate Technology
Affordable Sustainability Technical Assistance for HOME Project

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Tools for Building Sustainable Housing

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National Center for Appropriate Technology

Affordable Sustainability Technical Assistance for HOME Project

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U.S. Department of
Housing and Urban Development

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Introduction

Evergreen Affordability has been produced under the Affordable Sustainability Technical Assistance for HOME (HomeASTA) project of the National Center for Appropriate Technology (NCAT), funded by the U.S. Department of Housing and Urban Development. HomeASTA was created to provide technical assistance to recipients of HOME grants in incorporating sustainable design into affordable housing.

Under the HomeASTA project, NCAT has provided affordable housing developers with online resources for affordable, sustainable building, as well as customized technical assistance, training and access to exemplary case studies. HomeASTA serves the needs of the affordable housing developer by providing step-by-step recommendations on how to make single-family home construction projects more sustainable in the areas of resource and energy use and occupant health. HomeASTA helps developers learn how to capture the significant environmental and social benefits of sustainable design—without compromising their ability to meet project budgets.

Evergreen Affordability is a solutions catalog based on the results of the HomeASTA project that addresses specific questions affordable housing developers may have about implementing sustainable design. *Evergreen Affordability* discusses particular issues such as choosing an architect, selecting building materials, and designing systems for a project, and then describes how actual building projects have arrived at a solution to those challenges. The case study discussions in this document help illustrate the potential and the obstacles involved in applying sustainable, affordable solutions in real-world building projects.

Sustainability often is defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs. A growing number of people are committed to reaching this goal by modifying patterns of development and consumption to reduce demand on natural resource supplies and help preserve environmental quality. Achieving greater sustainability in the field of construction is particularly important, because building construction consumes more energy and resources than any other economic activity. Not only does a home represent the largest financial investment a family is likely to make, but it also represents the most resource- and energy-intensive possession most people will ever own. Making homes more sustainable, then, has a tremendous potential to contribute to the ability of future generations to meet their own needs.

Sustainable housing design is a multifaceted concept, embracing:

- affordability
- marketability
- appropriate design
- resource efficiency
- energy efficiency
- durability
- comfort
- health

Only a holistic approach to design—one that considers and addresses each of these facets—can truly claim to provide a sustainable house.

At the same time, it's important to recognize the constraints that often affect real-world, rather than ideal, projects. *Evergreen Affordability* offers practical tools to use in building sustainable housing, based on experience with actual design and construction projects.

The Pine Street Neighborhood Team

City of Hazleton

For initiating the City's interest in the Pine Street Neighborhood, Hazleton Mayor Louis J. Barletta credits the efforts of city resident Bill Sherman. Nearly 50 years ago, Sherman relentlessly petitioned the Hazleton School Board to demolish the former Pine Street Elementary School and use the land to develop a playground, rather than reserving the plot for commercial development. Sherman's work did not go to waste, as the city has now invested $500,000 in upgrades for the playground, which has served as an anchor for the new Pine Street Neighborhood.

The City of Hazleton and its Office of Community Development have committed significant time, money, and effort to the project, including holding public meetings to gain input from citizens. The New Homes in the Pine Street Neighborhood strengthen the ongoing efforts of the "Alliance to Revitalize Center City Hazleton," a partnership of local government, the Chamber of Commerce and community development corporations committed to a re-energized downtown district. The Alliance has worked to upgrade buildings in the downtown area, bring in new businesses, and customers to the hub of the City. Nearly half of the acquisition costs for Pine Street were defrayed by Hazleton's Community Development Office. The balance of the property was acquired through actual donation of land by the property owners to the City, a factor which further signifies the community support of this undertaking. The City and its Community Development Office have committed additional dollars for infrastructure improvements, demolition, construction and other project related costs needd to bring this project to fruition. Another key role of the City has been to extend the arms of the partnership to encompass other key players that offer expertise and assistance.

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Luzerne County Board of Commissioners

Luzerne County Board of Commissioners serving as partners in the Pine Street Project are:

- Gregory A. Skrepenak, Chairman
- Todd A. Vonderheid
- Stephen A. Urban

Luzerne County

Sandra Russell

Luzerne County, through its Office of Community Development and under the leadership of Ms. Sandra Russell, Director, has helped to ensure that Pine Street Neighborhood will serve as a model to be replicated throughout the Commonwealth of Pennsylvania and beyond. Recognizing the importance of working together with the City of Hazleton and its Community Development Office, Ms. Russell has brought forth valuable community building blocks through her involvement with the Luzerne County Consolidated Plan, Continuum of Care, and most recently, passage of the Affordable Housing Trust Act through the Luzerne County Board of Commissioners.

The Pine Street Neighborhood has received assistance through the Luzerne County Community Development Office with costs related to demolition, and has carried out required relocation activities. Financial assistance has also been provided for infra-structure, construction, and related project costs.

Through the establishment of the Act 137 Housing Trust Fund, along with the County's HOME Program, the County will offer financial assistance to prospective home-buyers. The

County will administer Brownfields for Housing funds to further benefit the Pine Street Neighborhood. The County also successfully applied for a Department of Environmental Protection Environmental Energy Challenge Grant and aided in the application for the Pine Street endeavor.

The commitment of time, energy, and money by the County Commissioners, along with Ms. Russell and her staff, is worthy of special recognition and credit. The Pine Street Neighborhood would not have been successful had it not been for their efforts.

Luzerne County's Solid Waste Management Agency

Luzerne County's Solid Waste Management Agency is researching sources of green materials to be utilized in construction. The Recycling Coordinator will work closely with HDC staff to insure that materials are readily available, thus eliminating construction delays. Not only will the New Homes in the Pine Street Neighborhood serve as a model for reuse of brownfield sites, as well as a model for resource and energy efficiency, but the County is committed to utilizing this project as a model for increased commitment to recycling and a demonstration of the benefits of purchasing recycled materials.

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The Housing Development Corporation of Northeastern Pennsylvania

The Housing Development Corporation of Northeastern Pennsylvania (HDC), a non-profit organization, is the developer for the new homes in the Pine Street Neighborhood. Gene Brady, President, has spearheaded efforts to develop Pine Street Neighborhood. It is their vision that has made the project a model for sustainable and affordable housing. The purpose of the Housing Development Corporation of Northeastern Pennsylvania is to further the goals of affordable housing for all Northeastern Pennsylvania residents by promoting and developing affordable housing.

HDC has extensive experience developing and managing housing and is recognized by the Commonwealth of Pennsylvania, Department of Community and Economic Development as the Community Housing Development Organization (CHDO) for the City of Hazleton as well as the County of Luzerne. HDC has significant experience with homebuyer financing programs and also has a successful track record with the Pennsylvania Housing Finance Agency, and myriad of other housing activities and funding sources. HDC also provides homebuyer counseling, family savings program, budget management, pre-purchase counseling and an assortment of other services key to prospective homebuyers.

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Design Coalition provided architectural schematic and design development services as well as consulting on project implementation for the Pine Street Neighborhood. Design Coalition Inc. is Wisconsin's only full-time non-profit architectural and planning office, and a Community Design Center. Design Coalition states "We don't work for profit; we have always sought ways to serve a greater community good through our professional practice. We work with our clients for a successful project, and for positive change." Design Coalition was founded with the mission of serving and empowering people who are without access to quality design and construction expertise. Today Design Coalition is a small office that still specializes in socially conscious and ecologically responsible design.

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Borton-Lawson Engineering provided construction documents, bidding, and contract administration architectural services as well as landscape design, and geotechnical serivces for Pine Street Neighborhood. Since its founding in 1988, Borton-Lawson Engineering, Inc. has grown into a multi-disciplined professional engineering consulting firm.

The firm's staff includes civil, structural, mechanical, electrical and environmental engineers, as well as professional land surveyors. This team of professionals provides consulting services to industrial, commercial, institutional, governmental and private clients.

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Fannie Mae

Fannie Mae contributed funding to aid in completion of the housing study and market analysis completed by Real Estate Strategies, Inc.

The Federal Home Loan Bank of Pittsburgh is providing funding to aid in construction activities through its Affordable Housing Program.

Janet Flack provided interior design consulting services for the Pine Street Housing.

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NCAT provided technical assistance to the Pine Street Neighborhood in project development and sustainable design assistance. A non-profit corporation, NCAT was founded in 1976 to research, develop, and implement sustainable technologies to assist the economically disadvantaged. NCAT provides innovative information, training, and technical services to public agencies, grassroots organizations, and businesses.

The Center for Resourceful Building Technology (CRBT), a project within NCAT, is dedicated to promoting environmentally responsible practices in construction. Its mission is to serve as both catalyst and facilitator in encouraging sustainable and resource-efficient building technologies.

Affordable Sustainability Technical Assistance (ASTA) is a national technical assistance project funded by the U.S. Department of Housing and Urban Development HOME program. ASTA is designed to provide technical assistance to recipients of HOME grants in incorporating sustainable design into affordable housing.

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Real Estate Strategies, Inc.

Real Estate Strategies, Inc. conducted a housing study which verified the need for projects of this nature in the City of Hazleton. The consultants have remained involved throughout the design process to analyze design and affordability issues that will ensure the marketability of the finished units to Hazleton area residents.

Pennsylvania Housing Finance Agency

The Pennsylvania Housing Finance Agency provided project funds that applied to the acquisition and demolition of existing properties and the design, construction, development, and sale of 25 homes.

Sustainable Energy Fund of Central Eastern Pennsylvania

The Sustainable Energy Fund was created by the Pennsylvania Public Utility Commission in the electric utility restructuring. The Fund provides financing that promotes renewable energy, advanced clean energy technologies, energy conservation, and energy efficiency.

Pennsylvania Department of Community and Economic Development

The Pennsylvania Department of Community and Economic Development provided funds under the Communities of Opportunity Program, including Housing and Redevelopment funds for site restoration and development, and Brownfields funding for affordable housing activities on previously developed sites in core communities.

Hazleton Redevelopment Authority

Hazleton Redevelopment Authority is providing its expertise in the assemblage of the land parcels, demolition, and site clearance. It also is responsible for the civil work on the site and the planning and subdivision of the revitalized sites.

PNCBANK

Every day is an opportunity to do more.

PNC Bank donated real estate and, as a member bank, filed an application for funding from the FHLB of Pittsburgh on behalf of the HDC.

LDF Consultants

LDF Consultants served as liaison and expeditor between all parties and contracts.

LDF Consultants
151 East County Road
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Section 1

Getting Started in Affordable Sustainable Housing

Section 1: Getting Started in Affordable Sustainable Housing

Tech Brief 1
Defining Project Priorities and Adopting Standards

While a development is still in the idea stage, anything is possible. As an idea, it can be the most environmentally responsible, efficient, cutting edge, affordable housing imaginable. As the project progresses, though, reality hits, and the developer has to reconcile conflicting priorities with each other and with the real-world circumstances of the particular project, site and budget.

No single house can be a stellar example of every possible facet of affordable and green construction. In part, this is because some features or materials are only appropriate in certain climates or design styles. Also, different objectives sometimes may be in conflict with one another. For example, both indoor air quality and energy efficiency are worthwhile goals, yet ventilating a house to improve indoor air quality reduces its energy efficiency somewhat. The two goals have to be balanced with one another to arrive at an optimal solution. This kind of compromise means that on any given project, some goals may be unattainable. In addition to having to reconcile diverse goals, most projects face budget constraints that may rule out the choice of some materials or technologies. That doesn't mean that affordable, environmentally responsible construction isn't possible; it simply means that coordinated planning and a unified approach to design are vital to achieving exemplary green construction in an affordable home.

Some of the priorities a project might have include:

- Energy efficiency
- Locally-manufactured or harvested materials
- Recycled materials
- Good indoor air quality
- Durability
- Low maintenance requirements
- Reduced wood use
- Minimal job-site waste
- Affordable purchase price
- Affordable long-term operating cost
- Renewable energy use
- Water efficiency
- Disaster resistance
- Soundproofing
- Accessibility
- High resale value

It's best for the developer and design team to determine and agree upon their top priorities at the outset of the project, so they know where they can afford to compromise and where they want to hold the line. Otherwise, the development's conflicting priorities are all likely to be compromised, resulting in a watered-down project that doesn't truly achieve any of the original goals the developer envisioned. Prioritizing goals helps to streamline the decision-making process during both the design and construction phases of the project.

Sometimes it's difficult to achieve project priorities because they're not well defined. What the developer considers "energy-efficient" may not be the same equipment or air sealing practice that the builder calls "energy-efficient." In order for the project priorities to be carried through the design process and executed in the building as it's constructed on the ground, it may be useful to adopt some clearly-defined standards that everyone recognizes.

These may be standards that are mutually agreed upon by the design team and included in written form in the project specifications. Alternatively, the developer and design team may opt to create a development that meets an objective, independently-set standard. This helps everyone involved in the project understand precisely what the goal is and what steps must be taken to reach it.

One widely-accepted national standard for energy performance is provided by the Energy Star program. In order to achieve an Energy Star rating, houses must meet specific performance requirements that show them to be 30% more efficient than standard construction for the area. Designing and constructing houses that meet Energy Star qualifications is one good way to ensure that an affordable development will be energy–efficient.

In some parts of the country there are green building programs that provide checklists or rating systems for environmental considerations. These may address energy and resource efficiency, job-site waste reduction and water efficiency, as well as other facets of a project. In areas where such programs exist, they provide a convenient means of gauging the "greenness" of a project and providing targets for a project to strive towards. Many designers are looking forward to the day when the U.S. Green Building Council unveils its LEED standard for residential buildings, which will offer a nationwide standard for green homes. Until then, developers in areas without local green building programs may have to borrow the checklists and guidelines of other programs in similar climates to provide a benchmark for their projects.

Several green building programs across the country offer their checklists and evaluation criteria online. Check with state and local home builders associations, energy offices and building departments for green building programs that may be applicable to your project.

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Tech Brief 2
RFP for Design of/Consulting on a Green Building Project

The design and construction of sustainable buildings should be an integrated process, involving a design team that ideally includes the owner/developer, designer, engineers and the builder. Generally, it's easier to build a sustainable building if at least one member of the design team has experience with green building. Since many traditional design firms have limited experience with sustainable design, a consultant who specializes in sustainable building can be a worthwhile addition to the team. Team members with experience in green building will be at least somewhat familiar with the possible strategies for sustainability and potential material options. They can help the project avoid pitfalls and costs associated with extra research and learning curves, because they won't be starting from square one.

However, one team member alone can't make a building sustainable. It is essential that all team members work together in a holistic approach. Because a house is a complex combination of systems, it is vital that all the systems be integrated and balanced to complement one another in achieving maximum efficiency. For example, improving the energy efficiency of a building shell often means that the heating/cooling system doesn't have to be as large—but the mechanical designer needs to be made aware of the opportunity to downsize equipment, the structural designer has to include room for insulation in walls and roof, and the builder has to use proper installation techniques.

Many developers who have successfully completed affordable green building projects have issued requests for qualifications (RFQs) or requests for proposals (RFPs) that specifically seek designers, consultants and builders with experience in sustainable design. In particular, a request might specify that respondents must comply with one or more of the following, as appropriate for the job and the location:

- have designed/constructed/consulted on a LEED-certified building
- have designed/constructed/consulted on an Energy Star building
- have completed LEED training
- submit a copy of job-site waste management plans from previous jobs
- document completion of energy-efficient building and/or energy rating training
- provide evidence of specialized training or continuing education in sustainable building
- furnish performance data from previous projects as built, correlated to predicted performance
- demonstrate proficiency with energy modeling software
- furnish examples of previous projects, with statements highlighting sustainable features
- submit a company philosophy that illustrates commitment to principles of sustainability
- possess relevant licenses, degrees and professional affiliations and memberships.

In addition, the developer might ask that the respondents provide evidence of their expertise in fields that are priorities for the project, such as:

- energy efficiency
- alternative building materials
- water conservation
- native landscaping
- stormwater catchment
- indoor air quality
- deconstruction and salvage

A local firm with genuine enthusiasm for learning about sustainable design may offer the best value for the nonprofit affordable housing developer even if they don’t have a great amount of experience in green building. Community connections, familiarity with the climate and site, willingness to learn more about sustainable building, and the ability to be on site regularly can go a long way toward offsetting a lack of prior green building experience. However, employing alternative building materials or innovative new systems is greatly simplified and usually less costly if the design team has a proven track record using them.

As soon as project priorities are determined, they should be included in all RFPs, RFQs and bid documents throughout the remainder of the project. This helps ensure that the design and construction team share the same expectations for the project.

Section 1: Getting Started in Affordable Sustainable Housing

Tech Brief 3
Interview Questions for Selecting a Green Building Consultant and/or Architect

Selecting an architect and design team is one of the most important steps toward a successful building project. There are two types of firms that should be considered for a sustainable project. The best choice is a firm with a proven track record of sustainable design, with several projects that demonstrate their experience and commitment to sustainable design. The other type of firm that could be considered is less experienced with sustainable design but can convince the selection committee that they are eager and willing to learn about the design patterns and construction techniques associated with this type of project. In some areas of the country there are few, if any, firms experienced with sustainable design and a less-experienced firm may be the only alternative.

The following questions can be modified by each project selection team to include local issues and concerns.

1. How would you describe sustainable design?
2. Would you describe the projects designed by your firm that include sustainable design features, emphasizing housing projects?
3. Would you describe the projects designed by other members of your proposed design team that include sustainable design features?
4. When discussing sustainable design features with your clients, what approach has been most successful in convincing them to include sustainable features?
5. What opportunities do you see to incorporate sustainable design into this project?
6. Do sustainable design features add to the cost of a project?
7. How do you prioritize sustainable design features with other design considerations when cost becomes an issue?
8. Is a member of your firm trained to apply the LEED green building rating system?
9. If so, what role will the LEED-trained designer play in this project?
10. Please discuss the resource-efficient materials that may be applicable to this project.
11. What features should be included in housing design to assure the best indoor air quality possible?
12. Has your firm designed housing projects that have been certified Energy Star compliant?
13. Does your firm regularly perform energy modeling as a tool in design?
14. Is there someone on the proposed design team that uses REMDESIGN or REMRATE energy performance software?
15. What sustainable design goals would you like to see established for the project?
16. How would you measure the success of a sustainable housing design?
17. Are there sustainable design services that are outside the scope of basic services and would require a separate contract?

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Tech Brief 4
Contract Scenarios for Green Building

In the most simple and typical affordable housing project, the owner/developer hires an architect who designs the project. The architect may hire a mechanical, structural or electrical consultant to assist with the design. Depending on the nature of the project, an interior designer and landscape architect may also be involved with the project. After the project is put out for bid, a single general contractor is selected to construct the project. This basic model will work well for many projects, although a number of affordable housing developers are trying other approaches that may include special consultants and material-purchase options. You may find these approaches useful for your projects:

Green Design Consultant
In cases where the local architects have little experience with sustainable design, a sustainable design consultant can be added to the design team. This consultant can work directly for the owner or as a consultant to the project architect. In most cases, the consultant will work as a subcontractor to the primary architect. Firms who have little experience with sustainable design would be well-served by adding a sustainable design consultant to their proposal.

For the Pine Street Neighborhood development in Hazleton, Pennsylvania, an out-of-state architect was hired to perform schematic and design development services and a local architect was hired to perform the construction documents, bidding and administration services. The owner negotiated separate contracts with each firm, with much attention given to defining the specific roles of each firm.

Owner/Developer Material Purchase
In the typical construction contract utilizing a general contractor, the contractor adds 10% to 20% to all project costs for overhead and profit. The materials purchased for construction projects are subject to sales taxes in most states. In Wisconsin and Pennsylvania, though, it is possible to negotiate a contract that allows an entity such as a nonprofit organization or local government to purchase the major materials to avoid paying the sales tax. In Pennsylvania, state law prohibits the non-profit community housing developer from fulfilling this role, so on the Pine Street project the local community development corporation purchased the construction materials.

In this case, the bid package was prepared to clarify the role of the contractor relative to material purchases, scheduling delivery and coordination. The three bidders on the Pine Street project did not mind this approach to material acquisition. Obviously, the bid documents and bid form must be carefully crafted to deal with this non-standard approach to purchasing.

If this approach is considered, state law should be investigated to see if it is possible to avoid the sales tax on material purchases by either non-profit developers or an arm of the local government.

Owner/Developer as General Contractor
It is also possible that the Owner/Developer would act as the general contractor for the entire project. For this approach to be successful, the Owner/Developer would have to employ staff capable of performing the role of general contractor. By taking on this responsibility, the Owner/Developer is betting that they can do the job as well as a general contractor to avoid paying the profit charged by the private firm.

Some funding sources may require that a development project incorporate competitive bidding. The regulations that are associated with each type of funding must be carefully examined for potential conflicts with the Owner/Developer acting as general contractor.

Section 2

Key Design Decisions in an Affordable Sustainable Housing Development

Section 2: Key Design Decisions in an Affordable Sustainable Housing Development

Case Study 1
Introducing Pine Street Neighborhood in Hazleton, Pennsylvania

In 2001, the Housing Development Corporation of Northeast Pennsylvania, a non-profit housing developer, began the Pine Street Neighborhood Revitalization in partnership with the City of Hazleton and Luzerne County. “New Homes in the Pine Street Neighborhood” began developing 24 new homebuyer opportunities geared toward a diverse audience with a range of income levels, as part of an overall revitalization program of the City of Hazleton.

New Homes in the
Pine Street Neighborhood

Affordable, Accessible,
Healthy and Sustainable

The Pine Street Neighborhood utilizes state-of-the-art design techniques to integrate health, accessibility, operational efficiency, low maintenance, functional living space and aesthetic appeal. This affordable, sustainable development is about renewing a sense of community and traditional values, intertwining the charm of a small town environment with the latest design and construction technology.

The Pine Street Neighborhood was able to take advantage of free affordable sustainability technical assistance services offered to HUD HOME grantees by the National Center for Appropriate Technology under a grant from HUD. In addition, the Housing Development Corporation paid for additional green building consulting and design services to help make the project more sustainable and energy-efficient.

Hazleton, Pennsylvania

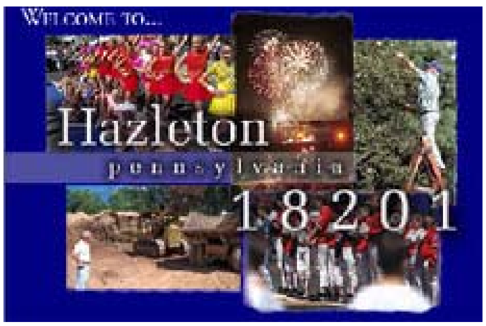
Hazleton was incorporated as a borough in 1856. The borough's population grew steadily until the 1880s when waves of eastern European immigrants poured in to take jobs created by the booming coal industry.

In 1891, Hazleton was chartered as a city. In the early part of the 20th Century, Hazleton was a boomtown, its population increasing from 14,230 in 1900 to 25,452 in 1910. The population would peak at 38,009 in 1940. With the decline of the anthracite coal industry the city's population decreased.

Today, with a population of about 25,000, Hazleton attracts top-notch industries based on its access to major highways, a dedicated work force, a low cost of living, and a high quality of life. This includes a commitment to excellence in the arts, education, recreation and health care.

Hazleton is a city with a wealth of municipal services, a revitalized downtown that is the center of banking and professional services, mass transit and many of the amenities associated with city life, but few of the problems. The crime rate, for example, is eighth lowest in the entire nation. The Hazleton downtown area combines a charming small-town environment, traditional values, and modern conveniences. Together, they form a complete package that makes the Pine Street Neighborhood a great place to live, work and play.

Pine Street Neighborhood



New Homes in the Pine Street Neighborhood are being constructed on a three-block site adjacent to downtown Hazleton, bounded by Fulton Court and Hemlock, Pine and Green streets. This once-lively turn-of-the-twentieth-century industrial, commercial and residential neighborhood has felt the full impact of economic distress with the obsolescence of its industrial buildings and deterioration of its housing stock. Ultimately the three-block area became a site of debris, decaying and abandoned residential and commercial structures, and substandard housing. The economic distress was creeping outward to impact surrounding properties. Returning this brownfield site to active use is a success story waiting to happen.

The Pine Street Neighborhood is an exciting opportunity to view a neighborhood as a cohesive unit, where adults and children can walk to nearby shopping, services, schools, parks, recreation centers and in some cases their own jobs and businesses; where public transportation is readily available; where houses are built close together, with yards. The pedestrian-friendly environment helps facilitate community spirit and emphasize neighborhood safety and security.

The Pine Street Neighborhood encourages "smart growth" by utilizing existing infrastructure and services in an already-developed area rather than contributing to suburban sprawl. New Homes in the Pine Street Neighborhood can make use of existing power, water and road infrastructure. The city saves the significant costs of extending municipal services like fire, police, transit and road maintenance beyond their existing territory. In addition, the site enjoys easy pedestrian access to downtown businesses and mass transit, as well as an adjacent park with playground and sports courts.

While the Pine Street Neighborhood will be a one-of-a-kind asset to Hazleton, it follows a national trend of builders to locate housing close to urban areas, since young families, single professionals and older Americans with grown children recognize the value of living in a diverse and active neighborhood with city amenities. A young family will benefit from the local park that features a playground, basketball court and soccer/hockey court. The park is well lit to allow for evening sports activities.

Sidewalks will be lined with trees and short lampposts. Crosswalks will be handicap accessible and intersections may be designed with materials to alert drivers that children will be in the area. A "walkable" neighborhood like this one builds a sense of community among residents, and helps the city avoid traffic congestion, road maintenance and air quality problems that are associated with suburban sprawl and the increased auto use that accompanies it.

Pine Street Neighborhood will attract many different kinds of residents. Such diversity helps create a vibrant neighborhood and build a sense of community. Additionally, new development on Pine Street complements other Hazleton revitalization programs, like building façade improvement, and meshes with the city's economic development and community vitality goals. Also, new residents in the neighborhood provide an expanded market for the area's retail and service businesses.

The Homes

Pine Street Neighborhood provides 24 new single family housing units that will furnish each owner with about 1,350 square feet of living space in reasonably priced and accessible homes.

The Pine Street Neighborhood homes offer:

- Universal Design
- Healthy Living
- Maintenance-free Lifestyle
- Resource Efficiency for a Healthier Environment
- Energy Efficiency for Reduced Costs and Increased Comfort.

Accessible, adaptable, and universal are terms now used to refer to housing or features in housing intended for use by people with disabilities and others. The term a*ccessible*, as generally used, means that the dwelling meets prescribed requirements for accessible housing as defined by the Americans with Disabilities Act (ADA), building codes, or in agency regulations or standards such as the American National Standards Institute's A117.1 and the Uniform Accessibility Standards (UFAS). Most of the features in "accessible" design are permanently fixed in place and clearly recognizable.

Universal Design for Greater Accessibility

Some people for whom accessible features are not essential, dislike the appearance of such items as knee spaces under sinks and counters and grab bars in bathrooms or reduced base cabinet space. The term *adaptable* refers to a living unit with features that a fixed accessible unit has but allows some items to be omitted or concealed until needed, so the dwelling units can look the same as others and be better matched to individual needs when occupied.

Items that are usable by most people regardless of their level of ability or disability can be considered universally usable. Many accessible and adaptable features are universally usable. For example, round doorknobs are not usable by people with limited use of their hands, but lever handles are usable by almost everyone, including people who have no hands. Some items are made more universally usable by their placement. Making them adjustable makes some features more universally usable. Universal design addresses the scope of accessibility and suggests making all elements and spaces accessible to and usable by all people to the greatest extent possible. By incorporating the characteristics necessary for people with physical limitations into the design of common products and building spaces, we can make them easier and safer for everyone. Designers of the Pine Street Units have incorporated universal design throughout the project.

In the Pine Street Neighborhood housing universal accessibility offers the "home for a lifetime" aspect to home ownership, eliminating the need for households to renovate or relocate if someone in the family has or develops mobility impairments. Not just the interiors of many of the homes, but also the sidewalks, yards and parking will be designed to be fully usable by people with mobility impairments.

This means that all neighbors will be free to visit and join in the life of the community regardless of their physical limitations.

Each of the homes will be created with kitchens, bathrooms and dining rooms on the first-floor levels. "Jog-in walls" in the garages, which enable wheelchair accessibility, the lack of a front step and wider doors are some of the accessible aspects. First floor interiors, garages, sidewalks, yards and parking throughout the entire project are designed for full accessibility to people with mobility impairments. This universal design consists of subtle variations on standard design. Doorways are wider, wall outlets higher, kitchen cabinets lower and bathrooms designed for accessibility. Each dwelling unit is designed to provide wheelchair circulation accessibility of the first floor, from grade and from the garage, including the kitchen, dining and living spaces and at least one bedroom.
One area where these homes will stand out is in using materials that promote good indoor air quality. Choosing the right building materials and ventilation systems will be a high priority. By making healthy building materials and

Healthy Living

practices a priority, the Pine Street Neighborhood's new homes will promote good indoor air quality, contributing to the health of residents.

The Pine Street homes will focus on less-toxic building materials and interior finishes, as well as ventilation systems, to ensure good indoor air quality, an issue strongly supported by the American Lung Association and the Environmental Protection Agency.

When we're talking about affordable housing, we are referring to long-term affordability beyond just the purchase price. We're not only considering energy costs, but durability as well. Durability and low-maintenance will be

Maintenance-free Lifestyle

hallmarks of the Pine Street Neighborhood Homes. That also contributes to time savings and energy efficiency for homeowners. What's more, it will help keep the neighborhood looking good for a long time.
Durable, low-maintenance building products are an environmental benefit, as well as a time

and energy savings to homeowners. Materials that require little maintenance don't add unexpected costs to homeowners' budgets. Eliminating the need for replacement materials is also a resource and energy savings.

Use of fiber cement siding is just one design feature that will result in long life of the building envelope. Meanwhile, installation of a heat recovery ventilator will help assure that there is not long-term damage to the building envelope from penetration of water vapor. The recycled roofing will provide more than double the lifetime than a traditional asphalt shingle roof. The energy-efficient design will assure that costly energy improvements will not be necessary over the life of the home.
New Homes in the Pine Street Neighborhood feature sustainable materials that provide a range of benefits to the neighborhood residents and to the Hazleton community as a whole. For example reused and recycled building materials save the energy and resources that would be

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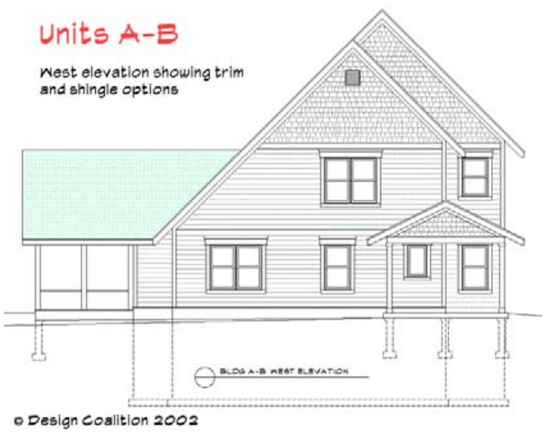

used in obtaining and processing new materials.

Resource Efficiency for a Healthier Environment

Reused and recycled building materials help keep waste out of landfills by turning it to productive new uses. Pennsylvania companies offer some resource-efficient building materials and by using them, the Pine Street Neighborhood contributes to the local and state economy. Opting for regionally produced materials also prevents the expense and pollution that accrues when building products are transported from far away.

Roofing shingles for the Pine Street Neighborhood will be made with recycled tire rubber and recycled plastic. Carpeting will be produced from recycled plastic fiber. Brownstone from the foundation walls of the former Geissler Knitting Mills facility will be used to build retaining walls near the playground.

These new homes feature numerous sustainable materials that are more abundant and cause less environmental impact in their production. Examples of green materials that will be used in construction include fiber cement siding, cellulose insulation, and less-toxic finishes. In addition, the contractor will use a waste management plan to reduce the generation of waste during construction.
The Pine Street Neighborhood Homes will combine energy-efficient materials and systems to offer their owners low operating costs. Energy-efficient construction saves money - usually 30 percent over standard construction. That stretches household budgets, making energy-efficient houses a real boost to providing reasonably priced homes. Some

Energy Efficiency for Reduced Costs and Increased Comfort

mortgage lenders actually offer special energy-efficient mortgages that take into account the reduced household energy costs when they factor loan amounts.
An electrically heated home built in Hazleton to the current state energy standard, the International Energy Efficiency Code, will use

53.2 mmbtu of energy at a current cost of $1,499 per year. By contrast, the Pine Street units will use only 24.7 mmbtu annually, cost $1,119 per year and meet ENERGY STAR.

A natural gas heated housing unit built in Hazleton to the International Energy Efficiency Code would use 88.9 mmbtu of energy at a current cost of $1,130 per year. In comparison the Pine Street units that meet ENERGY STAR will use just 25.6 mmbtu and cost $799 per year. These units would be constructed with a whole-house ventilation system.

Well-built energy-efficient homes help residents stay cool in the summer and warm in the winter. The extra insulation and air sealing that make a home energy efficient also keep it quiet in a busy urban neighborhood. Cross ventilation stemming from the installation of diagonal windows could eliminate the need for air conditioning—which will also help reduce energy expenditures.

The Pine Street Neighborhood includes trees and yards that not only make it an attractive place to live, but also contribute to summer cooling. A well-recognized way to combat the urban heat island effect that makes cities uncomfortably hot in summer is to include green vegetation in landscaping plans. Trees contribute both shade and an evaporative cooling effect. Also green areas help cities manage storm water runoff that can tax water treatment facilities.

The Pine Street homes are oriented to allow for solar electric and solar water heating systems, with building roofs sloped at 45 degrees to accommodate solar installations, and to emulate the steep roof pitches of surrounding neighborhood dwellings.

Section 2: Key Design Decisions in an Affordable Sustainable Housing Development

Case Study 2
Saving Existing Buildings on Site

One of the most resource-efficient development strategies is to rehabilitate an existing building on an already-developed site. This not only preserves the value of the materials in the existing building, but also avoids the consumption of new building materials in the creation of a new building. Unfortunately, it's not always possible to reuse existing buildings. Sometimes there are no buildings on a site. Other times, it may be more costly to renovate a damaged, contaminated or unsuitable existing building than to build new. In this case, it is usually desirable to deconstruct the existing buildings and save as many materials as possible for reuse.

Even in cases where existing buildings or materials can't be saved, it makes sense for an affordable, sustainable development to be built on an already-developed site. This helps avoid urban sprawl, gives the development's future occupants access to services and allows the developer to avoid the costs of infrastructure extension.

Pine Street Neighborhood

The site of the Pine Street Neighborhood project was carefully chosen. This site offers residents easy access to public transit, Hazleton's municipal services and an outstanding park recreation area just across the street. Because redevelopment of this downtown site coincided with the city's urban revitalization goals, the City of Hazleton was willing to pay for infrastructure improvements for the site. This investment by the City helped keep the construction costs for the project in check, in turn keeping the home prices affordable.

The Pine Street site was covered with existing buildings, ranging from old houses in very poor condition to abandoned industrial buildings. The owner/developer did not consider reuse of these structures prior to input from the sustainability specialists about the opportunity presented by one of the existing buildings. Only one of the existing buildings had potential for renovation as multifamily housing. Unfortunately, the funding sources and project schedule did not allow for modifying the project scope at that point in the project. In addition, a multifamily building

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didn't coincide well with the Pine Street Revitalization's program of providing affordable, single-family housing for purchase. Consequently, all existing buildings were cleared from the site before new construction began.

The bricks from the old industrial buildings proved too soft to be cleaned and reused. However, all large timber beams and posts were salvaged and sold by the demolition contractor. In fact, the demand for reused timbers is so high all the timber was sold for reuse in the Philadelphia area before the actual deconstruction on the Pine Street site began. The brownstone used in the foundation in one of the buildings was also salvaged and will be reused in site work at the neighborhood playground and on the adjacent block of the Pine Street project.

Section 2: Key Design Decisions in an Affordable Sustainable Housing Development

Case Study 3
Rigid Insulation in Walls

Installing rigid foam insulation on the exterior walls of a home is an effective way to reduce conductive heat loss through the framing members and enhance the home's thermal performance. Rigid insulation can be installed on the interior or exterior of the wall framing, depending on preference and the climate where the home is being constructed. Either way, installing rigid insulation can provide substantial energy savings over a wood-framed wall with insulation in the wall cavity alone. Some of the advantages and disadvantages of each installation strategy are summarized below. The climatic considerations relating to where in the wall rigid insulation should be installed are discussed in depth on the Building Science Corporation website at http://www.buildingscience.com.

Exterior rigid insulation provides an effective barrier to water penetration into the wall. It minimizes moisture accumulation and the potential for damage to the exterior wall. The exterior insulation also helps to keep the wall cavity warmer and improves its drying potential. Research has shown that walls with exterior insulation have significantly lower moisture levels than walls without it.

Rigid insulation on the exterior of the wall can be applied over the structural sheathing, under the siding. Note that some siding manufactures require that an air space be provided behind the siding when their materials are installed over rigid foam insulation. The required air space can be produced by nailing furring strips to the wall studs through the rigid insulation, and then installing the siding over the furring strips. The resulting air space allows the siding to dry both to the front and back, thus reducing cupping and splitting and extending siding life. The rigid insulation and the air space behind the siding of course add to the thickness of the walls. Window, door, and trim installation will be affected, and special attention is needed for backing in corners and rough openings.

In another possible assembly, rigid insulation is substituted for the structural sheathing. In this case, if the siding chosen is not structural you will need to provide separate bracing for the structural support of the exterior wall. Buildings of two stories or less can employ diagonal bracing of either wood or steel. The Uniform Building Code may be consulted for bracing requirements for residential buildings, as well as applicable local seismic codes.

Rigid insulation installed on the interior of the wall provides the same overall R-value as the exterior installation. Applying the rigid insulation on the interior allows normal framing and cladding of the exterior wall. It also allows the rigid insulation to act as the vapor retarder in the wall assembly, if the insulation has a perm rating of less than one. Taping or caulking the seams of the rigid insulation, as well as sealing it to the ceiling and floor, will form a continuous air barrier.

As with exterior rigid insulation, special attention is needed to provide backing for drywall and nailers around windows, doors, corners and wall intersections. The locations of exterior wall studs need to be marked on the foam as it is installed, for the drywall installers to follow. In addition, electrical boxes and plumbing stubs need to be adjusted due to the extra thickness of the wall due to the interior insulation.

Pine Street Neighborhood

The architectural consultant on the Pine Street Revitalization Project specified an interior application of 1” expanded polystyrene (EPS) rigid insulation on the exterior walls. The extra 1” of EPS increased the total wall R-value by 4.2, in addition to reducing the thermal bridging between exterior wall studs and the interior drywall, which improves the whole-wall thermal performance.

Section 2: Key Design Decisions in an Affordable Sustainable Housing Development

Case Study 4
Comparing Central Air Conditioning and Spot Conditioning

When designing an energy-efficient house, efficient heating and cooling systems are always high on the list of desirable goals. If a house is designed well to maximize the solar gain to its advantage in the winter and to limit solar gain in the summer, and it is properly insulated, then both the heating and cooling requirements are reduced. When systems for an efficient house are properly sized, they might be downsized from the standard system or not needed at all. This is particularly true with cooling systems for moderate or cold climates.

In moderate and cold climates, there are only a few times during the summer when the interior house temperatures might require air conditioning for occupant comfort. In those instances, the cooling requirements might be addressed with a room or spot air conditioner rather than central air conditioning. Spot air conditioning allows rooms that are frequently used—such as the dining and family room—to be cooled as needed when they are occupied, thus eliminating the need for a whole-house system.

Room air conditioners are used only when they are needed. They cost less to purchase, but are usually less efficient than central systems. Most use normal house voltage and can be easily moved to where they are needed.

Central air-conditioning systems are either packaged or split systems. Both circulate cool supply air and warm return air through a ducted system. If a house has a ducted heating system, a split system is the most economical form of air conditioning to install. The split system would use the existing furnace duct work and blower with an evaporator attached and have an exterior unit that houses the condenser and compressor.

On the other hand, packaged central air-conditioning systems are typically used for small commercial applications. They usually have a cabinet mounted either on the roof or on a concrete slab adjacent to the building, with the evaporator, compressor and condenser in it. Supply and return ductwork go through the building envelope to the unit. Most packaged systems also have electric heating coil or natural gas furnaces included. This eliminates the need to install separate systems for heat and cooling.

The Air Conditioning Contractors of America (ACCA) and the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) publish procedures to properly size central cooling systems. Any reputable installer will use one of the above procedures to size a system for your house.

Each type of air conditioner has an efficiency rating as to how many Btu per hour it removes per watt power used. The efficiency rating for room air conditioners is the Energy Efficiency Ratio or EER. The central system efficiency rating is called the Seasonal Energy Efficiency Ratio or SEER. Either efficiency ratio should be displayed on the Energy Guide Label of the unit.

Recent advances in cooling equipment have allowed air-conditioning systems to be 30% to 50% more efficient than comparable models built in the 1970s. Even air conditioners that are 10 years old can now be replaced with new units that are 20% to 40% more efficient. National appliance standards require new room air conditioners be at least an 8.0 EER or greater. Central system air conditioners require a SEER of 9.7 for packaged systems and 10.0 for a split system. Many manufacturers have systems available that approach SEER 17, and most air-conditioning manufacturers are now participating in EPA’s Energy Star Program, offering high-efficiency EER and SEER models that are Energy Star-certified.

Air conditioners can cool a room or house fairly quickly. For maximum energy savings, operate them only when the house is occupied. Programmable thermostats on central systems are a good idea. Keep drapes and blinds on the east, south and west windows closed during the day to reduce unwanted solar gain.

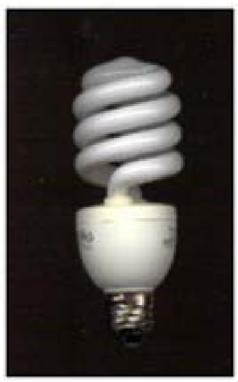
Pine Street Neighborhood

Houses in the Pine Street Neighborhood were designed and oriented to maximize winter solar gains and to limit summer gain. High insulation levels and strategic placement of windows will help limit radiant heat gain to houses. Consequently, the design team and developer decided not to install central air-conditioning systems at Pine Street, since their use would be limited in such efficient homes. With such infrequent use, installing central air conditioning would not be cost effective. Lists of Energy Star-labeled room air conditioners will be supplied to the new homeowners, for individuals who decide to install supplemental spot cooling.

Section 2: Key Design Decisions in an Affordable Sustainable Housing Development

Case Study 5
Compact Fluorescent Light Fixtures

Compact fluorescent lights (CFLs) are far more efficient than standard incandescent light bulbs, using only about a quarter as much energy to produce the same amount of light. Although the bulbs themselves are more expensive to purchase, the CFLs last as much as ten times longer than standard bulbs and operate at higher efficiency, so in the long run, they save the homeowner money.



With the wide range of CFLs available today, it is possible to install a compact fluorescent bulb in almost any fixture to improve its energy performance. Developers can completely outfit their new homes with CFLs before sale. Yet the developer has no assurance that a home's future owner will continue to buy and use CFLs as bulbs burn out over time. With the wide range of CFLs available today, in varying quality and widely varying prices, the homeowner may find selecting CFLs an unwanted burden. If future owners purchase inefficient replacement bulbs, this could compromise the home's future energy performance and operating cost.

In order to ensure that the homeowner continues to use compact fluorescents, the developer may choose to install dedicated CFL fixtures, rather than CFL bulbs in standard fixtures. While the dedicated fixtures help to promote the long-term energy performance of the home, they may be responsible for construction cost increases. Because there are relatively few dedicated CFL fixtures on the market, the choice of styles is limited and prices may be higher than for standard light fixtures.

Furthermore, the developer faces the issue of how many hard-wired light fixtures to provide with the home, and how much lighting to leave to the future owner's discretion. It is often the case that only a few hard-wired light fixtures are included in the home as sold. This limits the owner's ability to influence lighting efficiency.

In one affordable, sustainable development, the developer chose to include hard-wired dedicated compact fluorescent fixtures in the kitchen and bath, while encouraging residents to use CFLs in other household lighting.

Pine Street Neighborhood

At the Pine Street Neighborhood, the design team debated where and how to incorporate CFLs in the homes. They considered specifying some dedicated hard-wired CFL fixtures, but found these specialized fixtures to be considerably more expensive than standard fixtures. The developer finally decided to supply the homes with CFL bulbs installed in the standard hard-wired fixtures in major living spaces.

Section 2: Key Design Decisions in an Affordable Sustainable Housing Development

Case Study 6
Frost-protected Shallow Foundations

Affordable housing developers have their choice of several strategies that can reduce the resource consumption of foundations. These are worth consideration because they reduce environmental impacts, such as carbon dioxide emissions, that stem from the production of cement, and because they often reduce construction costs, as well.

A simple foundation footprint based on even size increments reduces both foundation labor and material costs. Interest can be added to a home's design by using above-grade bump-outs and bays. These are generally less expensive than footprint modifications that increase foundation complexity, cost and resource use.

Replacing a portion of the cement used in concrete with fly ash is a means of reducing the energy and emissions involved in the manufacture of cement. Coal combustion fly ash, a by-product of electricity generation, is a pozzolan that can replace 18%-50% of the cement used in concrete, depending upon the application. Fly ash is ASTM listed (C-618 and C-311) and approved as a mineral admixture for use in mortar, patching, and structural concrete. In some areas ready-mix concrete companies supply fly ash concrete as a matter of course; in other areas the builder will have to request it specially. Fly ash concrete takes longer to reach its full cured strength, but ultimately provides a strong product with a smooth finish, made from recycled material.

Requiring reusable forms for any poured-in-place concrete is a good way to cut the amount of construction waste generated on site. The only job that should be exempt from using reusable forms is one where permanent insulating forms are used for the footing and wall system.

One of the most resource-efficient foundation systems available to builders is the frost-protected shallow foundation (FPSF). Rather than extending foundation footings below the frost line, this system relies on rigid foam insulation at the foundation perimeter to retain heat below the building slab, thus preventing frost heaves although the foundation is as little as 12" deep.

The FPSF system, developed in Scandinavia, has been used by some builders in the United States for decades, and is included in the International Building Code. Both the U.S. Department of Housing and Urban Development and the National Association of Home Builders have researched the frost-protected shallow foundation and published materials on its design and use. The FPSF has been a particular favorite among builders of affordable housing, because it greatly reduces the excavation and backfill costs associated with a conventional foundation, especially in a cold climate where the frost line is deep. This can provide a substantial savings.

Pine Street Neighborhood

The houses at Pine Street are designed with basements, in part because this was the regional standard. The basement provides an out-of-the-way location for the furnace and utility room, and could later be finished to provide additional living space if needed. Frost-protected shallow foundations cannot be used in conjunction with basement construction

Section 2: Key Design Decisions in an Affordable Sustainable Housing Development

Case Study 7
Whole-wall Energy Performance

Over 90% of American residential construction has walls framed with dimensional lumber. It takes careful planning and design to achieve the goals of improved thermal performance, comfort, structural integrity for natural disasters, security, fire safety, durability, or just keeping building costs low. Fortunately, energy-efficient walls can be constructed in many ways and with a variety of materials. However, choosing between materials and the different ways to assemble them can be difficult.

There are many possible choices for insulation types: fiberglass batts, blown-in fiberglass, spray cellulose and foam are a few of the most popular. Wall assemblies can range from standard stick framing assembled on site to several types of pre-assembled panels.

Developers, designers and builders need to weigh the merits of the different wall system options available. One way of evaluating the energy performance of differing wall systems is to compare the R-values they provide. The most accurate way to do this is by comparing each system's "whole-wall R-value." The whole-wall R-value takes into consideration not just an insulated section of wall, but also all of the wall interfaces including the window and door openings, as well as the floor, wall and ceiling intersections. In addition, the whole-wall R-value includes what is called the "framing factor," which accounts for the thermal bridge that each wooden framing member provides through the wall assembly. Systems with fewer framing members, or an exterior layer of insulation, will have less performance loss than assemblies with many framing members. The whole-wall R-value is almost always lower than the stated wall R-value for any assembly, but for some it can be dramatically less.

To make it easier to compare various wall systems or components used in a wall, Oak Ridge National Labs has developed a "Whole Wall Thermal Performance Calculator." It is available to anyone at http://www.ornl.gov/roofs+walls/whole_wall/wallsys.html. The program accepts a simple description of custom building plans and enables the user to compare uniform whole-wall R-values for at least 40 different wall systems.

Calculators like this one help a design team evaluate the effect that different types and levels of insulation can have on a building's energy performance. In addition, the designers can predict how different structural assemblies will affect thermal performance. Calculators show how advanced framing techniques, which combine wider stud spacing with additional wall insulation, not only reduce wood use, but also improve whole-wall R-values.

Pine Street Neighborhood

At the Pine Street Neighborhood, the design team made several recommendations aimed at improving whole-wall R-values. They recommended consideration of structural insulated panels, a wall system with greatly reduced use of framing lumber, minimal thermal bridges and good thermal and sound performance. However, recognizing that the cost of structural insulated panels is often above the budget of an affordable housing project, the design team also suggested some strategies for producing more efficient wood-framed walls

The design team originally specified that the Pine Street homes employ Advanced Framing Techniques. As discussed above, this portfolio of strategies is designed to decrease wood used in framing, while increasing the amount of insulation that can be included in the wall. Some studies have documented cost savings of hundreds of dollars from the application of Advanced Framing Techniques, because less framing lumber is needed. Some of the provisions of Advanced Framing are 2-stud corners, insulated box headers, in-line framing on second stories, single top plates and 24” stud spacing. Although the structural performance of these measures has been well documented by the National Association of Home Builders and others, some builders are reluctant to use Advanced Framing Techniques because they are concerned about keeping walls straight and having adequate nailing opportunities for siding application.

During the prebid meeting, a number of contractors were adamant that the 24” stud spacing with 5/8” gypsum wallboard instead of the standard 1/2" would actually be more costly. For that reason, the design team compromised on a 16” stud spacing for the walls.

The design team also specified cellulose insulation for the Pine Street homes. Not only does cellulose insulation have a high recycled content, usually derived from recycled newsprint, but the spray-applied insulation is very good at reducing air infiltration. The blown-in-cellulose provides a higher, more even density of insulation while eliminating compression and voids around wiring, plumbing pipes and framing members in the exterior walls. The Pine Street homes will have 5 ½” of cellulose insulation within the wall cavity.

In addition to the cellulose insulation, the walls at the Pine Street project have an interior layer of rigid foam insulation. This dramatically reduces thermal bridges through the wall and adds additional R-value. The wall assembly at Pine Street is expected to provide R-24 effective insulation value.

Section 2: Key Design Decisions in an Affordable Sustainable Housing Development

Case Study 8
Comparing Fuel Sources: Natural Gas and Electric

When building a new house, the selection of heating fuel can be an important factor in determining both construction and future operating costs. For an energy-efficient house, heating fuel type is still important, but less so. If the shell is properly insulated and sealed and energy-efficient windows and doors are used, the heating system can be downsized. If a high-efficiency unit is selected, the system can be even smaller, using even less fuel. When a minimal amount of fuel is used, variations in the cost of fuel types become less significant to the homeowner.

Prior to the mid-1970s energy crisis, developers and builders commonly built houses with minimal insulation. They also heated them with whatever fuel was available: heating oil, natural gas, propane or electricity, depending on region and whether the building site had access to a particular fuel. For some locations, fuel choice was quite limited. When energy prices started to rise, owners of inefficient homes saw enormous increases in their energy bills. Some increases were as much as 50% to 100% at that time, and prices have risen steadily since.

In most parts of the country, electricity is more expensive than fossil fuel for heating. Many homeowners have switched to fossil fuel heat. Decisions to switch heating systems and fuels are frequently based on monthly utility bill savings rather than long-term cost effectiveness. During the winter of 2001, the price of natural gas—usually the least expensive heating fuel—more than doubled in some areas. Although prices have again declined, uncertainty about international oil prices will make accurate prediction of future energy prices very difficult. Usually the costs of extending the fossil fuel distribution system (the pipes) along with the cost of a new heating system are more than the average homeowner will recoup in savings during the time they own a home.

In response to the potential loss in market share from customers switching to fossil fuels, many electric utilities seized the opportunity to promote energy conservation by marketing and supporting energy-efficient house construction. In addition, utilities promoted the use of more efficient appliances, heating and cooling systems. By encouraging energy-efficient houses, electric utilities can reduce their loads and serve more residences with their available power and existing facilities.

Developers building today can construct energy-efficient homes that use fewer resources and cost less to operate. However, at some point they must still make the decision about what type of fuel they will use. After energy efficiency is addressed, then each space- and water-heating system variable (initial cost, unit life and life-cycle operating cost) can be evaluated. This will allow the developers and builders to select the best space- and water-heating systems for projects based on efficiency, cost, and environmental effects.

Recent research by the Environmental Protection Agency (EPA) has shown that existing home heating systems contribute more to the introduction of greenhouse gases in the U.S. than automobiles. Older house heating systems are only about 50%– 70% efficient in their burn cycle. So for every $1 of fossil fuel purchased only 50-70 cents of that dollar actually heats the house while the rest is lost up the flue. The 1993 Model Energy Code (MEC) in effect in many states today requires 80% minimum efficiency for new fossil fuel heating system installations. Heating systems with higher efficiency are available. Although their initial cost is more, they offer greater energy savings potential. The current life expectancy for a fossil fuel heating system is 20 to 25 years.

Most power plants use fossil fuels (e.g., coal, natural gas) to generate electricity. Electrical power is also generated by hydro-electric dams and nuclear power plants and, in a few areas, by wind or other renewable energy sources. Reducing the need for new power plants through demand reduction keeps the electric utilities' rates lower and also eliminates additional emission of greenhouse gases.

Pine Street Neighborhood

At the Pine Street Neighborhood, the design team had the option of electric or natural gas heating systems and water heaters. With both fuels readily available and neither showing a significant cost advantage, the developer opted to provide natural gas water heaters and to let the builder choose the heating fuel source. The architectural designs allow for either electric or natural gas heating systems. All designs specify the same insulation levels, energy-efficient windows and doors, air tightness criteria and energy recovery ventilators. Consumers will benefit by having properly-sized space-heating and water-heating systems that operate efficiently. So, no matter what heating fuel is chosen the house will be efficient, comfortable, quiet and have good indoor air quality.

Section 2: Key Design Decisions in an Affordable Sustainable Housing Development

Case Study 9
Choosing a Roofing

Choosing an appropriate roofing material can be one of the greatest challenges of affordable, sustainable housing development. While there are a number of roofing materials with recycled content on the market, these tend to be considerably more expensive than a standard asphalt roofing. Reused or synthetic slate roofing materials offer some environmental benefits, but these premium products are seldom within the budget of affordable housing developments.

A number of composite and fiber-cement roofing materials are available; however, these also tend to be more expensive than asphalt shingles and some may not perform well in freeze/thaw climates. Since the climate of eastern Pennsylvania, where the Pine Street Revitalization is located, is definitely a freeze/thaw area, fiber-cement roofing materials weren't seriously considered for the development.

Metal roofing is the most environmentally preferable choice in many cases, because it has recycled content, is again recyclable, and it is possible to combine rooftop water catchment systems for potable water with metal roofing. The price of metal roofing, however, is usually far above the cost of standard asphalt shingles, which significantly limits its application.

Most affordable housing developments end up using asphalt shingles. The main environmental drawback of these shingles is the inability to recycle them, combined with the relatively short life expectancy of the lower-end products—approximately 15 years. Together, these two factors result in high recurring roof replacement expenses over the lifetime of a building, as well as large contributions to the solid waste stream. In a few communities, asphalt shingles can be recycled into road patch material, which does help to divert them from the waste stream, although it is a relatively low-value recycled product.

Some lines of asphalt shingles do contain recycled material, which may consist of recycled paper and/or recycled industrial slag materials used as aggregate. Recycled content varies with manufacturers, brands and even colors. It may be difficult to obtain verification of recycled content in asphalt roofing shingles.

Pine Street Neighborhood

At the Pine Street development, the design team anticipated using asphalt shingles with recycled content. They reasoned that saving a significant amount of money on roofing would make it possible to use environmentally preferable products elsewhere in the project. However, just as construction was about to begin, the Pine Street Revitalization project was awarded a $162,000 grant to support the purchase of recycled-content shingles. The grant came from a new grant program, the Pennsylvania Environmental and Energy Challenge (PEEC) grants, administered by the Pennsylvania Department of Environmental Protection. With this grant, the Pine Street development was able to choose a composite roofing product with high recycled content, a 50-year warranty and a slate-style appearance that contributed to the design aesthetic. The roofing slates made from recycled rubber and polymers help divert material from the solid waste stream.

Section 2: Key Design Decisions in an Affordable Sustainable Housing Development

Case Study 10
Choosing a Siding

Choosing an exterior cladding can be one of the most difficult design decisions in developing housing. Not only does the exterior finish play a significant role in the appearance of the house, but it can also be an important factor in the longevity of the structure. In an affordable, sustainable development, the challenge is to find an exterior cladding that optimizes cost, durability and environmental impact while providing aesthetic appeal.

Wood and wood-composite sidings are some of the most popular exterior cladding options. They can be cost-effective choices in some situations, and are often selected for their looks. However, most wood-based products are quite vulnerable to moisture, so their longevity may be compromised in wet or humid climates. To help protect them from the effects of weathering, almost all wood-based sidings require comparatively frequent maintenance in the form of paint or stain. This regular maintenance requirement is usually something that affordable housing developers seek to avoid, in order to spare future owners the expense and potential difficulty of frequent repainting.

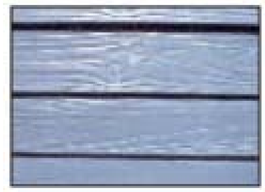
In some areas of the country—notably the Northeast and North Central—vinyl siding, more formally polyvinyl chloride (PVC), has gained an increased residential market share in recent years, due in part to its low maintenance requirements. Because of its integral color, vinyl siding does not need to be painted, although some vinyl siding may “chalk” or fade as it ages. There are many different brands, styles and qualities of vinyl siding available, which differ radically in performance. Most sustainable building developers avoid use of vinyl siding, due to concerns about the environmental impacts of PVC manufacture and disposal.

Another exterior cladding option is fiber-cement siding. Fiber cement is a composite made from silica sand, cement binder and wood fiber reinforcement. The wood fiber is often recovered from industrial processes, though it comprises such a small proportion of the product that the siding as a whole cannot really be considered a recycled product. Fiber cement is a popular siding choice for its durability, embodied in its low coefficient of expansion, low rate of moisture absorption, and fire resistance. In many markets the purchase price of fiber cement siding is comparable to wood siding. Installing fiber cement siding requires that steps be taken to mitigate dust from cutting the material, such as using shears to cut the siding instead of saws. Although builders who haven’t installed the product before may complain that they find the installation procedures burdensome, many builders across the country regularly install fiber cement siding successfully and without undue difficulty.

Fiber-cement siding is usually available pre-primed. Because of its dimensional stability, the material holds paint well. Fiber-cement cladding is available in shingle styles, lap siding styles and in panels.

Pine Street Neighborhood

At the Pine Street Neighborhood, the design team chose fiber-cement siding for the exterior cladding on the homes. According to area builders, fiber-cement siding is rarely used in the Hazleton market, so there was lengthy consideration on whether including it in the Pine Street development would discourage builders from bidding on the project, or raise prices. However, after careful research by the design team, fiber-cement siding stood out as the best cladding option for Pine Street when its performance benefits were weighed against its environmental cost. Furthermore, fiber-cement siding is manufactured within Pennsylvania, offering the efficiency and reduced transportation impact of a comparatively local product. Following consideration of all these factors, the design team decided that the Pine Street project would use fiber-cement siding as its exterior cladding.



Section 2: Key Design Decisions in an Affordable Sustainable Housing Development

Case Study 11
Addressing Indoor Air Quality

In recent years, there has been an increase in scientific research and data suggesting that many homes, schools and office buildings have more polluted indoor air than most large industrial cities' outdoor air. Research also points out that we as a society spend more than 90% of our time indoors, putting our health at greater risk from indoor pollutants than from outdoor air.

People who are exposed to pollutants for longer periods of time can become more susceptible to their effects. People who spend more time indoors, and especially young children, the elderly and persons with chronic respiratory and cardiopulmonary disease, are at highest risk from prolonged exposure to pollutants in indoor air. These pollutants can include carbon monoxide, dust and other particulates, formaldehyde, radon, mold, pesticides and a variety of volatile organic compounds (VOCs), as well as a wide range of chemicals that may be irritants or allergens to particular individuals.

Even though individual pollutant sources may not pose a significant risk, most houses have more than one pollution source, and the cumulative effect causes concern. Informed homeowners can take steps to limit sources of existing pollutants in the home and avoid the introduction of new ones. The U.S. Environmental Protection Agency (EPA), along with the Consumer Product Safety Commission (CPSC), offers a free booklet to help homeowners reduce the levels of indoor air pollution in their homes. It's titled: *The Inside Story: A Guide to Indoor Air Quality*, available online at http://www.epa.gov/iaq/pubs/insidest.html or through the mail from EPA.

The primary cause of indoor air pollution is the release of gases or particles from sources within the house. Pollution sources can be either materials used in constructing and furnishing the home, or a result of occupant activities. Some examples include: combustion sources like gas, propane, kerosene, wood, oil, and tobacco products; building materials and household furnishings, finishes, carpets, and cabinetry; cleaning products; personal care items; hobbies; mold caused by excess moisture; introduction of outside air pollution or contaminants. Emissions of some pollutants are increased by high temperature and humidity levels. Central heating and air-conditioning systems can help spread pollutants throughout a building. Also, inadequate ventilation can contribute to poor indoor air quality by not providing enough fresh air to help dilute pollutants and exhaust stale air to the outdoors. In addition, poor ventilation can support the growth of molds and mildew by leaving moisture trapped inside the house.

Homes that are built to limit the amount of air that can enter them for energy-efficiency reasons can have indoor air quality problems. Yet many existing homes that have been weatherized or remodeled experience indoor air quality problems as well. Many households rely on natural ventilation and infiltration to change the air in the home. This means they rely on cracks and holes in the exterior walls or the opening of doors and windows to let fresh air in. But who leaves doors and windows open in the winter? Mechanical ventilation systems help ensure that houses have adequate air change rates, and promote improved indoor air quality.

Homes that are built with mechanical ventilation systems have the ability to exhaust pollutants and bring in fresh outdoor air on a regular basis. The systems may be as simple as properly sized and ducted bathroom fans or kitchen exhaust hoods programmed for a set amount of time each day. More complex ventilation systems include complete duct coverage and air-to-air heat exchangers that exhaust and supply air to various rooms in the home. These systems allow the homeowner to control the amount of ventilation air supplied and to exhaust pollutants out of the home. Many systems have timers that can be programmed to provide ventilation for a certain number of minutes every hour, throughout the day.

Some building materials and household furnishings emit pollutants primarily when they are first installed. Other products many continue to offgas over time. Activities such as painting or installing products with adhesives can leave high concentrations of pollutants in the air or trapped in carpets and furnishings for extended periods of time. To promote good indoor air quality, it's important to ventilate well, but it's also helpful to choose less-toxic and sealed materials and to specify installation practices that reduce pollution.

Pine Street Neighborhood

Building specifications for Pine Street Neighborhood call for low-VOC waterborne acrylic latex paint for interior walls and ceilings and low-VOC waterborne acrylic urethane finish sealers for interior doors, as well as wood flooring with a factory prefinished low-VOC waterborne finish. Additionally, kitchen cabinetry will be prefinished to seal all particle board surfaces to limit the outgassing of formaldehyde. Alternatively, the builder may opt to use formaldehyde-free particleboard, so that sealant doesn't have to be appliedBy limiting the amount of "volatile organic compounds" (VOC) used in finishing the interior environment, as well as limiting the use of formaldehyde-containing products, the Pine Street design team has eliminated two common continuous emission sources. This will help occupants enjoy better indoor air quality in their new homes.

Homes in the Pine Street Neighborhood will be equipped with mechanical ventilation systems in the form of properly-sized air-to-air heat exchangers that operate on timers. These systems will exhaust warm moist air from the kitchen, bathrooms and laundry room on demand and also regularly supply fresh air to the central living area and bedrooms. In addition, the homes will have kitchen exhaust hoods that are ducted to the exterior, in order to exhaust moisture and combustion by-products from gas ranges that builders may choose to install.

Section 2: Key Design Decisions in an Affordable Sustainable Housing Development

Case Study 12
Deciding Among Trim Options

One of the most resource-efficient trim options is to minimize the use of trim. By using a technique called a “drywall wrap” window and door openings can be attractively finished without the use of additional trim materials. Using the drywall wrap can increase labor costs, though, unless the drywall installers are quite proficient with the technique.

Although trim pieces are generally relatively small, they are generally cut from comparatively large trees, because clear—knot-free—trim is the most desirable. Thus, reducing the amount of clear, solid-wood trim used in a project can have a significant effect on the forest impacts that result from the construction.

One means of reducing the amount of clear wood trim used is to substitute a composite trim, whether that be a paint-grade composite or a wood composite with a finished-wood veneer. Wood composites do contain adhesive, however, and one member of the design team for Pine Street felt strongly that wood composites should be avoided as part of the effort to promote good indoor air quality in the development.

Pine Street Neighborhood

For Pine Street, the design team considered several trim options. The drywall wrap technique was eliminated as an option because the target market was understood to perceive trim as a sign of value in construction. Oak trim was considered for the aesthetic it provided, and the design team researched the production of oak trim to assess the comparative impact of this wood species versus others. Finally, painted pine trim was selected for the project, as a relatively resource-efficient and cost-effective option.

Section 2: Key Design Decisions in an Affordable Sustainable Housing Development

Case Study 13
Optimizing Roof Angle for Solar, Efficiency and Safety

Homes often get their roof design almost by default, not as a matter of conscious choice. The roof design may be a result of the architect's aesthetic sense, or the product of a desire to make a new home blend in with an existing neighborhood. What the developer may not realize, however, is that relatively slight changes in roof configuration and angle can make important differences in both project cost and sustainability potential.

A design with complex rooflines can add significantly to project cost, given the labor time devoted to installing multiple hips and valleys. This also raises potential for roof leakage, if those installations aren't absolutely correct. In addition, the homeowner will eventually pay a higher cost for replacement roofing on a complex roof.

A house roof can be a good location for renewable energy equipment, whether photovoltaic panels to generate electricity for the home, or a solar hot water system that supplies heated water for the household. Even if the development budget doesn't allow for the installation of solar systems now, orienting and angling the roof for their placement at a later date is a minor investment that leaves the opportunity for renewable energy wide open for future homeowners. The optimal roof design is one that provides a flat, unshaded roof surface oriented within 20 degrees of true South, and that offers an angle of 45 degrees.

While 45 degrees is a good angle for solar collection, it is not necessarily the best angle for an affordable home. Most roofers charge more for installing an especially steep roof, because of the extra fall protection that is required. Also, a steep pitch may require a larger amount of comparatively costly roofing material, without necessarily offering any more usable living space. On the other hand, nearly flat roofs have drawbacks, as well. Not only can they be prone to poor drainage and snow load buildup, but many roofing materials are not designed to be installed on low-pitch roofs, so the choice of available affordable roofing materials may be limited.

The design team and developer are challenged with adopting a roof design that is not only aesthetically appropriate, but also offers solar collection potential without increasing roof installation costs.

Pine Street Neighborhood

At the Pine Street site, it was impossible for all roofs to face within 20 degrees of South, since the small site and comparatively high density of housing restricted the orientation of homes on the site. However, the architect was careful to design the site plan so that each home had some solar potential. In order to preserve that solar access, restrictions were placed on future construction that would shade another homeowner's roof. The Pine Street homes will contain the plumbing for rooftop solar water heaters, a relatively low-cost investment at time of construction.

The Pine Street Neighborhood will be constructed in several phases. The first phase of four houses will be equipped with one-kilowatt solar electric systems. These systems are expected to provide 20% to 30% of a typical natural gas-heated unit's electric needs. The systems are funded by utility universal system benefits funds available to low-income homeowners, the Low Income Renewable Energy Program and the Sustainable Energy Fund. All Pine Street units are solar ready and will readily accept solar hot water and solar electric systems in the future. Future homeowners will have the option of installing solar hot water or photovoltaics, as they desire, because the design team made the effort to incorporate proper orientation and workable roof angles in the original design.

Section 2: Key Design Decisions in an Affordable Sustainable Housing Development

Case Study 14
Participating in the ENERGY STAR Program

ENERGY STAR is a national certification for energy-efficient homes, commercial buildings, appliances and equipment. Homes built to ENERGY STAR standards typically use 30% less energy than comparable homes built to comply with the 1993 Model Energy Code.

The developer of the Pine Street Neighborhood was eager for the homes to be energy efficient. The design team suggested that the development be designed to meet ENERGY STAR standards. This would both establish an energy-efficiency goal and provide a means for evaluating the buildings' energy efficiency against independent standards. Computer simulation was done for each house design in the Pine Street development, to model energy consumption and prove that the houses qualified for the ENERGY STAR rating.

Pine Street Neighborhood

Two of the design features that helped the Pine Street homes achieve the ENERGY STAR standard were a very efficient building envelope teamed with efficient systems. In particular, the homes feature higher-than-usual levels of insulation in the basements, exterior walls and attics:

- **2x6 walls with R-22 cellulose insulation and expanded polystyrene rigid insulation board**
  The blown-in-cellulose provides a higher, more even density of insulation while eliminating compression and voids around wiring, plumbing pipes and framing members in the exterior walls. In addition, the added inch of expanded polystyrene rigid board on the interior of the wall reduces the thermal bridging between exterior wall studs and the interior drywall.

- **R-52 blown-in cellulose insulation in the attic**
  Cellulose insulation in the attic will provide a long-lasting, even and stable thermal barrier during Pennsylvania winters for years to come. Cellulose does not settle as much as other types of insulation and its density makes it less susceptible to wind washing (loss of insulating value due to convective air currents swirling around the insulation) adjacent to attic vents.

- **Basement walls insulated with R-10 rigid insulation board**
  Each home's basement will be thermally insulated on the exterior during construction. This substantially reduces heat loss from the concrete foundation to the surrounding ground. The result will be warmer, more comfortable basements that can be finished later for additional living space if the occupants desire.

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- **R-10 insulated steel entry doors**
  Highly-insulated exterior doors will provide superior thermal performance and durability.

- **Energy-efficient "low-E argon" windows**
  Windows are the biggest source of heat loss and uncomfortable drafts in conventional houses. By installing energy-efficient ENERGY STAR windows with low-emissivity coatings and argon gas fill, Pine Street homeowners will be more comfortable and able to enjoy added daylighting without worrying about high energy bills.

- **Advance air-leakage control**
  Homes will be carefully constructed using measures to eliminate energy-wasting drafts and damaging moisture penetration in the exterior walls. Proven energy-efficient construction techniques, including insulating wall penetrations, sills and wall joints, will be employed to limit the intrusion of cold outside air through gaps in the building envelope. This helps ensure comfort and low energy bills well into the future. What's more, the extra insulation and air sealing that make a home energy-efficient also help keep a home quiet, even in a busy urban neighborhood.

  In addition to extensive insulation in the envelope, the Pine Street homes also feature efficient systems that also contribute to improved energy performance:

- **Heat Recovery Ventilation Systems (HRVs)**
  HRVs will be installed in Pine Street homes to exhaust stale moist air from the bathrooms and kitchens and provide fresh dry air to the central living area and bedrooms. The active ventilation systems will allow the occupants to have substantially better indoor air quality than conventional homes without paying higher energy bills.

- **Energy-efficient heating systems that are smaller and properly sized**
  With higher levels of insulation and tight building envelopes, the heating and coong requirements of the Pine Street homes are reduced. This means that the heating units can be downsized and a central cooling system can be eliminated altogether. Properly sizing heating systems for the expected load allows them to have more efficient performance and a longer life.

- **Options for energy efficient lighting and appliances**
  Homeowners at Pine Street will be encouraged to select energy-efficient lights and fixtures along with ENERGY STAR appliances for their new homes. Choosing efficient lights and appliances will provide the homeowners with operating energy savings for years to come.

  Meeting the nationally-recognized ENERGY STAR standards will allow the developer to market the homes at Pine Street using the ENERGY STAR logo. This should help build customer confidence in the energy performance of these homes, both for their initial purchase and in subsequent resales.

Section 2: Key Design Decisions in an Affordable Sustainable Housing Development

Case Study 15
Conducting Energy Modeling

Energy modeling is a proven way for the designer/architect/engineer to forecast the energy performance of proposed designs or to determine what energy improvements will be most cost effective in retrofits. There are many computer software programs for energy modeling available. Most comply with ASHRAE Standard 140-2001, which requires that energy modeling software be tested for accuracy and capability of handling any given building energy modeling problem.

Pine Street Neighborhood

The homes in the Pine Street Neighborhood were designed to meet or exceed the Environmental Protection Agency's (EPA) "ENERGY STAR Home" efficiency standards. Computer simulation was done on each house design to evaluate the most cost-effective material and design choices for energy-efficient construction, and to model energy consumption so that the homes qualified for ENERGY STAR.

In the initial building design phase, many different combinations of insulation types and levels were considered to come up with R-values and U-values to meet ENERGY STAR and give the most energy savings possible while not breaking the budget. REM/Design 10.0, an energy modeling program, was used to optimize the thermal characteristics of the building shell and project associated energy savings. REM/Design allows the operator to input local utility rates for individual building projects. Energy rates for electricity, natural gas, and propane are entered and used to predict typical yearly energy use for each combination of insulation and other building components and systems.

To conduct the Pine Street energy modeling, the design team gathered utility rates and costs on installing various insulations and differing levels of R-value in Hazleton. With the utility rates and installed insulation costs, each incremental increase in thermal performance could be evaluated for cost-effectiveness.

Building parameters taken from the floor plans, including exterior building envelope, window and door areas, square footage of the floors, walls, ceiling and basement areas, and interior volume, were entered into REM/Design 10.0. Computer evaluations were done for incremental increases in R-value. Pennsylvania is in the process of adopting the International Energy Efficiency Code (IEEC) as its energy code, and with this in mind, simulations started with thermal performance set to meet the minimum requirements of the IEEC.

A total of 90 simulation runs were completed to evaluate the potential changes in R-value per component alteration and per heating fuel choice. First, runs were performed for both electric and natural gas heat. In addition, increasing mechanical heating system efficiency from code minimum to high efficiency was evaluated for both fuel types.

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An Excel spreadsheet was developed to track the effect of increases in R-value for exterior walls and ceilings, as well as increases in U-values for windows and doors. Incremental steps were compared against each other for their increase in efficiency and added cost per square foot. This allowed for ease of comparison of each variable.

The yearly energy savings projected by REM/Design 10.0 were then added to the spreadsheet and the increases in cost were divided by the yearly savings to show a realistic payback period on the added cost for each incremental step. These payback periods helped the developer and design team compare different energy efficiency strategies and design which ones were realistic and affordable for the Pine Street Revitalization.

While the energy modeling provided valuable information on the performance of various combinations of insulation, the consulting architect stayed with his initial thermal specifications, which called for R-20 cellulose insulation in wall cavities, teamed with an inch of rigid foam insulation on wall interiors that added approximately R-4. Roof insulation was specified at R-52, blown-in cellulose.

The design team also performed energy modeling to compare the yearly utility costs for gas and electric heat for the houses at Pine Street, for both IEEC base homes and ENERGY STAR homes.

Energy Performance Simulation Results

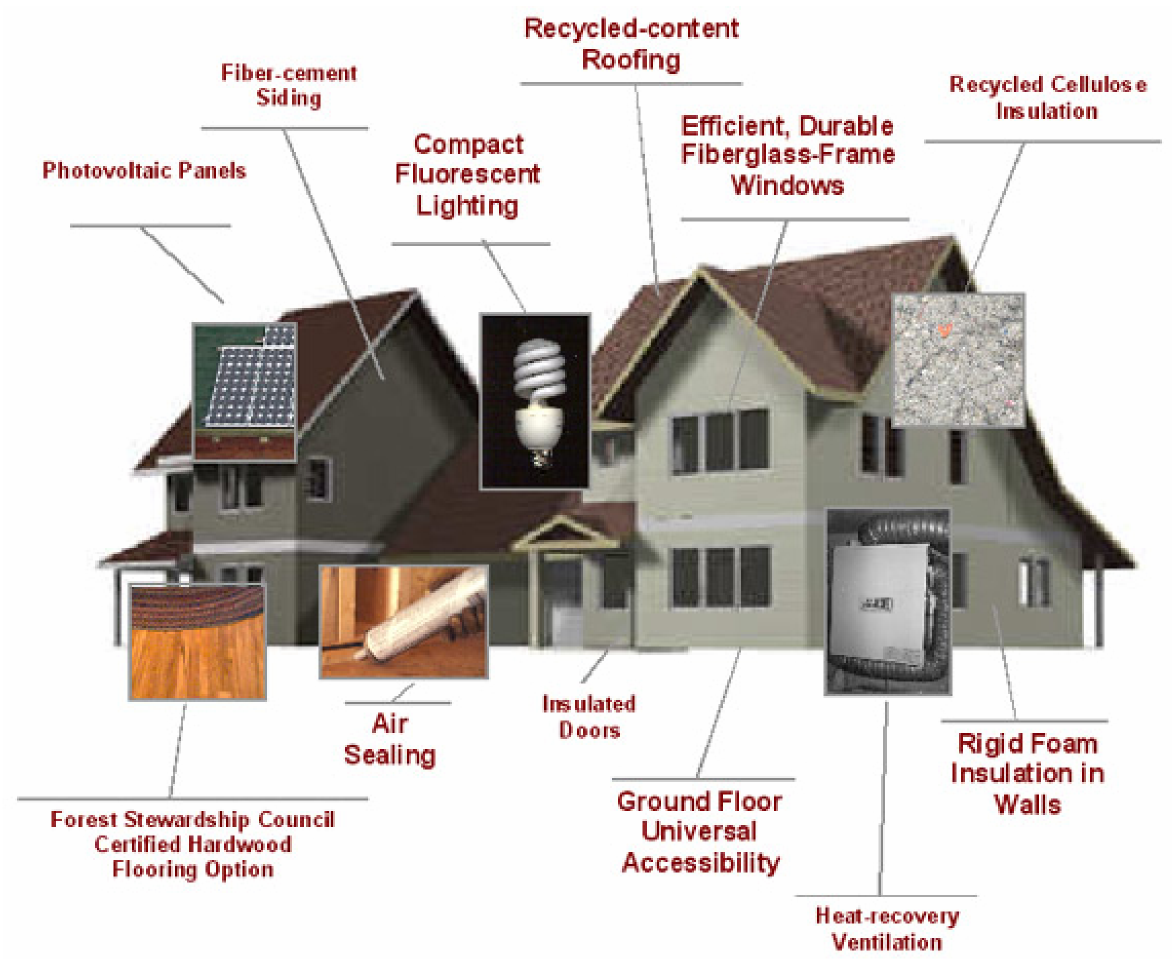
Building Component Analysis

	Current State Energy Code			Energy Star			
		Energy Loss	% loss		Energy Loss		% loss
Energy Features		MMBtu/yr			MMBtu/yr		
Attic Insulation	R-38	6	6%	**R-52**	3.7	10%	
Rim/Band Joists	R-11	2.7	3%	**R-24**	1.4	4%	
Above Grade Walls	R-11	21.7	23%	**R-24**	10.3	29%	
Foundation Walls	R-10	9.1	10%	**R-8**	10.2	28%	
Doors	R-2	3.1	3%	**R-10**	0.9	3%	
Windows	.39 UA	6.2	6%	**.32 UA**	4.2	12%	
Basement Slab	R-0	2.8	3%	**R-0**	2.8	8%	
Infiltration	.67ACH	37.8	40%	**.2 NACH**		11.3	31%
Infiltration Measure	Blwr Dr			**BlwrDr**			
Gas Forced Air Furnace	80% EF			**92.1% EF**			
Water Heater	.56 EF			**.61 EF**			
Ducts	UNSLD	23.9	25%	**Sealed**		5.4	15%
Mechanical Ventilation	EX Only	2.8	3%	**AAHX**	0.5	1%	
Internal Gains		-20.5	-21%			-14.7	-41%
Total MMBtu/yr		95.6				36.0	

Annual Energy Cost Analysis

Yearly Energy Costs	*Base*	*Energy Star*
Service Charges	$138	$138
Lights & Appliances	$369	$369
Water Heating	$141	$129
Space Heating	$528	$205
Total Annual Energy	$1,176	$841

Resource- and Energy-Efficient Features
of the
Pine Street Neighborhood Homes



Section 3

A Palette of Real-World Solutions for Affordable Sustainable Housing

Section 3: A Palette of Real-World Solutions for Affordable Sustainable Housing

Design Note 1
Using Salvaged Materials

Reusing salvaged building materials is one of the most resource-efficient strategies available to designers and developers. Reuse not only preserves the energy and resources invested in existing materials, but also alleviates the demand on remaining raw resources. This conserves resources, saves manufacturing and transport energy, and prevents waste.

Sometimes it's possible to reuse an entire building. Many success stories document cases where warehouses or other old industrial or commercial buildings have been converted to housing. This type of reuse is not always inexpensive, and may be a particular challenge for the developer as unforeseen problems with the existing building arise. Often the structural condition of the building and the extent of renovation needed to meet current codes don't become fully apparent until construction has actually begun. When structurally and economically feasible, whole-building renovations can provide distinctive, resource-efficient homes that help preserve community heritage.

For example, in instances where it's not possible to reuse a whole building, the developer may still have the option of reusing salvaged materials. Using salvaged materials in a new building project can produce financial and aesthetic rewards, though it also presents the design and construction team with some special challenges. For example, simply locating used materials can require extra time on the part of the design team. Coordinating procurement, storage and delivery of used materials are all important, but time-consuming, tasks. Because historic materials don't necessarily conform to today's standard building material dimensions, some design revision and field modifications may be required to accommodate particular products. Also, in multiple-unit construction projects, it may be difficult to secure enough salvaged materials to make all units match. Finally, it's important for the designer and developer to make sure that salvaged materials will meet applicable codes for structure, seismic performance, access and other provisions, and to make sure that salvaged materials aren't introducing hazards like lead paint or asbestos fiber into a new building.

For the developer who is willing to invest time and effort in obtaining and reusing salvaged materials, the rewards can be great. Some older materials are of a quality and craftsmanship not often seen today. They can lend an air of distinction to a home, a thoughtful detail that can be especially valuable in affordable housing. A number of affordable housing developers have successfully incorporated a wide range of salvaged materials in homes they have built.

One developer, Memphis Heritage, Inc., salvaged entire buildings when they led the renovation of ten shotgun and seven double-shotgun houses dating from the late 1920s and earlier. The renovation of these extremely dilapidated buildings helped preserve a vernacular style of housing that became popular in New Orleans around 1895 and spread throughout the South, but which is now vanishing. Rather than building new homes, the Delmar-Lema village project completely renovated 24 historic units of 600 square feet each to provide affordable housing.

Meanwhile GreenHOME, an all-volunteer nonprofit organization dedicated to demonstrating and promoting affordable, sustainable design, construction and landscapes in the Washington, D.C., area, has used a number of salvaged materials in their new-home construction projects. Some of the materials that GreenHOME has salvaged and reused include heart pine flooring, wall studs, an antique brick foundation façade, walnut cabinets and a cast-iron bathtub.

In Missoula, Montana, affordable housing developer homeWORD has been able to reuse salvaged wood from existing dilapidated structures on building sites to construct privacy fences and as interior trim. In addition to including a renovated house within a new affordable housing development, homeWORD has also reused an existing commercial building, turning a historic hotel into affordable housing and retail space.

In addition to the examples above, some other materials that are good candidates for salvage and reuse include interior doors, glass block, brick, flooring, code-compliant fixtures and efficient windows. Even single-pane windows can be reused in applications that aren't thermally important, like transoms to light interior closets and room dividers. For developers willing to take the time and effort, the aesthetic, energy and resource benefits of materials reuse can be tremendous.

Section 3: A Palette of Real-World Solutions for Affordable Sustainable Housing

Design Note 2
Alternative Wall Systems

More than 90% of the homes built in the United States each year are wood framed. While dimensional lumber framing is the system that most designers and builders know best, some affordable housing developers are daring to push the envelope and build homes using alternative wall systems, such as structural insulated panels (SIPs) and straw-bale building.

Although SIPs, with a foam core sandwiched by sheathing, are typically thought of as an expensive type of construction, a PATH demonstration project documented their use in an affordable housing development. Carl Franklin Homes, a Texas builder, constructs affordable homes that feature structural insulated panel roofs and walls, as well as geothermal heating and cooling, tankless on-demand water heaters, and pigmented concrete floors. These features are included in homes priced around $85,000, which is far below the local average.

Several affordable housing developers have chosen to demonstrate a completely different construction technique, using stacked straw bales as wall structure and insulation. The thick bale walls offer good insulation, providing high R-value. Straw-bale construction has gained popularity in recent years, in part because the materials are comparatively cheap and can be installed using some unskilled labor. Some affordable housing developers have been able to assemble straw-bale walls quickly using large work parties of volunteers.

While they may offer an attractive building technology for some, straw-bale homes often present challenges for developers, as well. Thick straw walls aren't well suited to the small lots of dense developments. Finding affordable interior and exterior finishes may be difficult, and accommodating trade contractors (i.e., electrical and cabinetry) with an unfamiliar wall system can lead to delays and added costs. In addition, unconventional straw-bale homes may be difficult for future owners and occupants to finance and insure, unless the developer assembles a purchase package for the buyer that covers these unusual homes.

Although straw-bale construction certainly isn't the answer for every affordable housing developer or every lot, it has helped some developers produce exemplary affordable and sustainable houses with walls built from local, rapidly-renewable resources. Habitat for Humanity International affiliates and other affordable housing developers have constructed straw-bale homes in numerous locales, including: Spokane, Washington; Missoula, Montana; Minneapolis, Minnesota; and Pueblo, Colorado, as well as other communities scattered throughout the country.

3.2.2

At least one nonprofit housing developer has adopted straw-bale building wholeheartedly. Tierra Madre, an affordable housing developer working with low-income families in Sunland Park, New Mexico, is working with its residents to build a sustainable community with 47 straw-bale homes, community center, play area ,and alternative economic enterprise.

Depending on the number of houses in a development, and the efficiency of their design, other alternative wall systems may become cost-effective for affordable housing. Developers may want to consider various types of wall panels, as well as insulating concrete forms, as potential construction systems that offer enhanced energy efficiency and a shortened construction schedule.

Section 3: A Palette of Real-World Solutions for Affordable Sustainable Housing

Design Note 3
Panel-Style Cladding Omits Sheathing

Sometimes it is possible to reduce the cost of housing construction by eliminating redundant materials. For example, in designs where an exterior cladding that comes in 4'x 8' sheets is used, it may be possible to eliminate wall sheathing, rather than have the two panels adjacent to one another and performing the same function. Siding panels that consist of a finish on a panel of plywood substrate can assume the functional role of both sheathing and cladding. Similarly, stiff fiber-cement panels may also provide adequate shear strength, allowing sheathing to be eliminated.

The ability of panel cladding to stand in for sheathing depends on the strength characteristics of the particular cladding product, local code requirements, whether the building has multiple stories, and particular conditions to which the building may be subject. Even if it's only feasible to eliminate sheathing in certain areas of the building, this can still furnish both a material and labor savings for a building project.

When a development in Missoula, Montana, was designed and built with fiber cement panel cladding, the designer was able to eliminate supplemental sheathing from some of the walls in the 12-unit construction project. The fiber cement siding alone provided adequate strength and racking resistance.

Note that some builders may be reluctant to omit sheathing from the wall assembly because they are concerned about a perceived lack of wall stiffness. This can be adequately disproven using manufacturer material on siding characteristics and performance. Eliminating sheathing on only some wall areas requires careful attention to detail, since it changes the dimensions of the wall and may require furring or adjustment of window and door openings and trim. When the builder is aware of the plan to omit sheathing and can plan for the process from the beginning of construction, it shouldn't pose added difficulties, and should actually help shorten construction time.

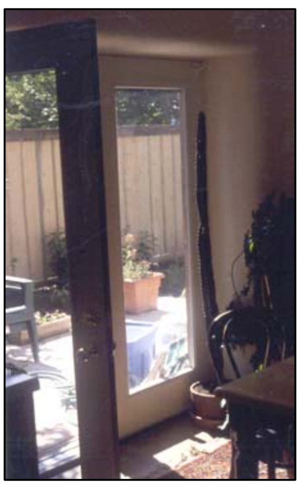
It may be of interest to note that at least one metal panel roofing manufacturer makes a stiff panel with integral purlins that allows the elimination of roof sheathing. Here again, a panel product can offer substantial labor and material cost savings, provided the available roofing style meshes with the project's requirements.

Eliminating unnecessary duplication of structural systems is a great way to make a project more resource-efficient, as well as more cost-efficient.

Section 3: A Palette of Real-World Solutions for Affordable Sustainable Housing

Design Note 4
Stained Concrete Flooring

When a component can be effectively eliminated from construction, that action typically provides both a cost and resource savings. Having structural materials double as finishes allows some expensive finish materials to be eliminated from a project. Using structural materials as finish doesn't have to compromise either appearance or performance. Instead, it can offer advantages in both areas. One good illustration of using structure as finish is staining a concrete slab so that it functions as a decorative finished floor. Omitting finish flooring saves not only the money and material of the flooring alone, but also the underlayments and adhesives that are usually part of flooring installations.



Several companies offer products that can be applied either directly to the concrete slab itself or in a thin layer on top of the slab to create a finished flooring. For slab-on-grade construction or frost-protected shallow foundations, these finished concrete floors create a real potential for cost and material savings. Depending on the product chosen, the completed floor may look very little like a concrete slab. Alternatives range from integral concrete colorants to acid stains that etch the concrete surface, to thin layers of colorant that can be used to create custom art works on the floor. In addition, concrete templates allow the floor to be scored in patterns like tile or flagstone as it is poured, mimicking much more costly types of hard-surface flooring.

Not only does a stained concrete floor cost less, but it is incredibly durable, easy to maintain, and helps promote good indoor air quality. Hard surface flooring doesn't trap indoor air pollutants and dust the way carpet can. It is particularly suited for areas exposed to extreme wear or moisture, such as entryways, utility rooms, kitchens and baths. Where needed, the hard floor can be cushioned with mats or area rugs to reduce fatigue from standing on concrete. Although some people have reservations about the potential for a concrete floor to be cold, in many climates it can be quite comfortable. A concrete floor can be thermally comfortable in virtually any climate when it is teamed with in-floor radiant heat and a frost-protected shallow foundation.

Finished concrete flooring has been used in many types and styles of housing, ranging from high-end custom homes to owner-built houses to affordable developments. It has also been used successfully in stores, restaurants, and institutional buildings. Though some concrete finishing products must be installed by a licensed applicator, others can readily be incorporated by a concrete subcontractor or the builder.

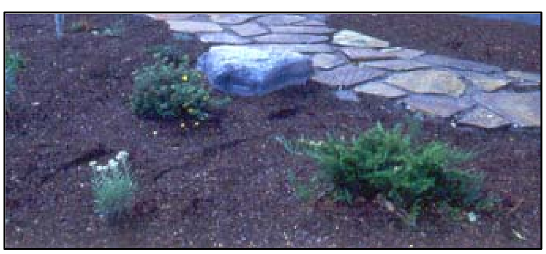
Stained concrete finish flooring has been employed by a number of affordable housing developers from Texas to Montana, saving construction expenses and resources on several sustainable building projects.

Section 3: A Palette of Real-World Solutions for Affordable Sustainable Housing

Design Note 5
Water Catchment and Low-water Use Landscaping

As locations throughout the United States seem to alternately combat drought and flooding, more and more attention is turning to the way that communities and households manage and use water. In some areas of the country, development is being limited by inability to ensure adequate water supply to households. In other areas, the scale of development and the materials used in landscaping and construction are being restricted in attempts to control stormwater runoff. Affordable housing developers aren't the only ones affected by water use policies, but they may have to give special attention to the cost implications of water regulations.

Fortunately, many of the measures designed to save water and extend the resource also result in cost savings for home owners and occupants. For example, water-efficient fixtures and appliances not only reduce water bills, but can also lower energy costs for water heating and pumping, and reduce water treatment needs. Similarly, low-water-use native landscaping not only saves on water, but generally doesn't require as many other supplements (fertilizer, maintenance, etc.) as exotic landscaping.



Many affordable housing developments have been able to reduce landscape maintenance time and costs by selecting native plant species that are well-adapted to the climate and conditions of the building site for the landscaping. Healthy native landscaping not only reduces watering costs, but offers other benefits, as well. Green vegetation helps counteract the urban heat island effect, and can cool its immediate vicinity by several degrees, both through shading and evaporation. In addition, native landscaping offers habitat potential for everything from birds to butterflies.

Casa Verde Builders in Austin, Texas, is one example of an affordable housing developer that has opted to complete their homes with extremely-low-water-use landscaping, also known as xeriscaping. Habitat for Humanity of Metro Denver also installs xeriscaping at the homes it builds, as well as low-water use fixtures that conserve water inside the home. In Seattle, Hopelink Place, a multifamily affordable-housing development, used drought-tolerant landscaping.

Landscaping can play a role in preventing stormwater runoff, as well. When paved areas are minimized and landscaping is designed to have pervious surfaces and stormwater retention areas like swales and ponds, additional infrastructure can be reduced or eliminated. The development may be able to avoid the cost of installing expensive stormwater management infrastructure like storm sewers, curbs and gutters. In many cases natural water retention systems have proven substantially cheaper than conventional stormwater treatment for large developments, and sometimes whole communities, to adopt.

There are some examples of innovative stormwater management in affordable housing. The Burnham Building redevelopment project in Irvington, New York created 22 units of affordable housing above a public library. The project plan included landscaping for stormwater runoff prevention. Similarly, the Colorado Court project, which provides 44 units of single-room occupancy for low-income renters in Santa Monica, California, created a site plan that preserved existing trees and provides for 95% stormwater retention on site.

Developers may be interested in taking the idea of stormwater retention one step further, and capturing runoff from roofs for household use. A variety of options are possible, from homemade systems that capture rainwater from eave gutters in barrels to systems that collect and treat captured rainwater for household drinking water. Although an extensive rooftop water collection and treatment system usually isn't inexpensive, it could be a worthwhile investment in areas where housing development is limited by water scarcity, but where affordable housing is needed.

Note that where rooftop water catchment is planned, roofing material is a particular concern. Although irrigation water can be captured from virtually any type of roof, capturing potable water is best accomplished off a metal roof—one that does not contain lead—to limit contaminants.

At the Casas de Don Juan, built through an affordable housing program in Santa Fe, New Mexico, on-site water catchment was included in the project. A capture pond for rainwater and regionally appropriate landscaping both help to reduce landscaping maintenance costs. In a colder climate, the Utah House demonstration collects rooftop rainwater and snowmelt in a cistern for use on its water-efficient native landscaping. Meanwhile the Florida House Learning Center not only demonstrates collecting rainwater in a cistern for irrigation use, but also reuses household greywater for irrigation.

Household greywater reuse for irrigation is allowed in some states, but not in others, so local opportunities can differ. Installing a greywater system typically adds to construction expense, because a complete blackwater system must also be installed, and the redundant systems increase cost.

Section 3: A Palette of Real-World Solutions for Affordable Sustainable Housing

Design Note 6
Energy-efficient Details

It is often said that the “devil is in the details,” and when it comes to energy efficiency, this seems particularly true. A home can have an energy-efficient design verified by computer modeling, and the most energy-efficient materials, yet be a poor energy performer once it is actually built, if energy efficient detailing isn’t properly done at the job site.

At the design stage, one important detail is orienting the house. Orienting a house with regard to the sun’s seasonal position can help keep it warm enough during the winter and comfortably cool in warm weather. When orientation is carefully coordinated with window placement, and when those windows are operable and placed to allow for cross ventilation, a home is well on its way to reducing energy use in operation.

A number of affordable housing developers have made use of orientation, floorplan and window placement to reduce their homes’ heating and cooling loads. From the T.E.S.T. house in the relatively mild climate of Portland, Oregon, to homes in the hot climates of Florida, Texas and New Mexico, affordable housing designers have been able to mitigate the effects of climate with orientation, shading designs, and ventilation.

No mater how good the design, installation practices are critical to energy performance. Whether installing insulation or employing air sealing techniques, the practices used by the crew in the field will determine how the completed house actually performs. The largest sources of air leakage in typical homes are not walls themselves, but sill plates, top plates, and window and door openings (not the window and door units.) When gaskets or sealants are used at these junctures, as well as at wall penetrations like electrical boxes, light fixtures, plumbing and ducts, a home’s energy performance can be vastly improved.

Well-built, energy-efficient housing is truly affordable for its residents, who will enjoy low heating and cooling bills for years to come. Some developers and the builders who construct their energy efficient homes are so confident of their energy performance that they will actually guarantee that home heating bills won’t exceed a set amount. Affordable housing developers in Chicago, Dallas and other cities have offered such guarantees.

In order to round out the package of energy efficient design and construction, some developers specify highly efficient HVAC systems and appliances, to ensure that home occupants will have low energy costs. High efficiency furnaces and air conditioners may cost more initially, but they help prevent affordable housing residents from spending a disproportionate amount of their incomes on household energy. Affordable housing developers in Texas, California, Indiana and Illinois are among those who have chosen to install especially energy-efficient mechanical and electrical systems. Meanwhile, working with the U.S. Department of Energy, Housing Authorities in Milwaukee and Chicago have been able to purchase more efficient refrigerators for their clients. Old, inefficient refrigerators are usually a home’s largest energy consumer after heat and water heating, so replacing them with efficient models can significantly lower household energy costs.

Section 3: A Palette of Real-World Solutions for Affordable Sustainable Housing

Design Note 7
Passive Solar Heating and Cooling

When a home is built to be energy efficient, it's often possible to downsize heating and cooling systems. This not only saves money when the systems are purchased, but throughout their lifetime of operation.

When housing is designed to take advantage of the sun with south-facing windows and thermal mass, the house is said to be "solar tempered." This can reduce the building's use of conventional energy without substantially increasing the cost of the house. In designing a house for passive solar performance, however, it's imperative to suit the house to the climate where it is located. Orienting windows correctly for desirable solar gain while shading them from summer overheating requires careful design consideration. Similarly, it's important to calculate whether windows may be responsible for greater nighttime heat loss than daytime heat gain in cold climates, and to include measures that can effectively mitigate excessive heat loss.

A number of design strategies can contribute to a building's passive solar performance, including building shape and orientation, room arrangement, window placement, size and construction, and building materials themselves. When passive solar heating strategies are properly and effectively applied, they can help keep a home comfortable at reduced energy cost.

Many affordable housing developers in a wide range of climates have successfully applied solar tempering to the designs of their homes.

At the other temperature extreme, sometimes air conditioning can be eliminated altogether—even in hot climates—when energy-efficient construction is combined with passive cooling strategies. Eliminating air conditioning not only helps keep the initial construction cost of a home lower, but can also reduce the operating cost of that home throughout its lifetime.
Doing without air conditioning doesn't mean that a home's occupants have to be uncomfortable. There are numerous examples of demonstration homes and private residences built without air conditioning, or with smaller or innovative air conditioning systems, that offer their occupants comfortable temperatures throughout the year.

Historically, people living in warm climates developed strategies that helped keep their homes cool. These included the thick, high-thermal-mass walls of adobe buildings in the Southwest, and the high surface-to-area ratio of "shotgun houses" in the Southeast. In addition, strategies such as shading, cross-ventilation and extended outdoor living areas helped people stay cool in homes across the country. Many of these strategies are still valid today as low-cost, effective means of cooling homes.

Entire cities are trying to counteract the urban heat island effect through passive cooling strategies like planting more vegetation and shade trees, and by changing roof colors from black to white. Employing the same techniques for a single house or a whole development can help keep the immediate area a little cooler. Just a few degrees can often be the margin between comfort and the need for supplemental cooling. Planting or protecting existing shady trees is a first, low-cost strategy for cooling a residence. A reflective white roof, rather than black asphalt shingles, may be more expensive for the developer, but can be worth the investment in some climates, especially in communities that offer “cool roof” incentives.

In addition to these low-tech and low-cost options, a number of developers have applied innovative strategies to cool homes at less cost and with less energy. In the mid-‘90s Davis Energy Group designed and built an ACT2 demonstration home in conjunction with Pacific Gas and Electric Co, in Davis, California. The highly-energy-efficient wall system, combined with careful detailing, made it possible to use an innovative low-cost cooling system—a chilled water system made of plastic hose under the foundation slab. A two stage evaporative cooler chills water within the slab at night when power is cheap and it's coolest outside. For very hot days, cool water in the floor is run through a cool-radiator. This inexpensive-to-operate cooling system creates no interior moisture, and furthermore, the 1,700 square foot house cost $1,500 less to build than comparable homes, due to an integrated approach to energy efficiency and material savings. The energy efficient home is also able to function with a radically downsized heating system, which offered further construction and operating cost savings.

Meanwhile, across the country, research at the Florida Solar Energy Center explored the potential for whole-house cooling using a central whole-house fan. Although humidity can limit the effectiveness of this strategy, studies have shown that planned operation of a whole-house fan can significantly reduce overall cooling energy use. The Florida Solar Energy Center also offers online Design Notes on several other elements of passive cooling, including roof overhangs, shading devices, and general information on passive cooling strategies. (See www.fsec.ucf.edu/Pubs/DESIGNNOTES/index.htm)

In addition to the examples above, there are some especially affordable homes that also make use of passive cooling rather than air conditioning to offer their occupants low-cost comfort. The Hawaii BuiltGreen Home developed by the Hawaii Department of Business, Economic Development & Tourism and Hawaii Department of Hawaiian Homelands is an affordable home designed not to need air conditioning, despite its location in a warm climate. The house is able to do without air conditioning because it is energy efficient, with a radiant barrier installed, and because it uses a variety of natural ventilation strategies, including orientation to catch breezes, large louvered windows and a venting skylight, as well as a light-colored roof that reduces heat gain. Leaving out the air conditioning made the home more affordable for buyers, as well as reducing its long-term operating cost.

In a slightly different approach, homes built by Casa Verde Builders in the Austin, Texas, area use cross-ventilation, ceiling fans and shading to help supplement the operation of a highly-efficient air conditioner.

Passive or natural cooling strategies are typically small investments that can quickly pay off for affordable housing by allowing air conditioning systems to be downsized, if not completely eliminated. In cases where air conditioning is still deemed necessary, passive cooling features can minimize the amount of use the air conditioning receives, thus lowering long-term operating costs.

Section 3: A Palette of Real-World Solutions for Affordable Sustainable Housing

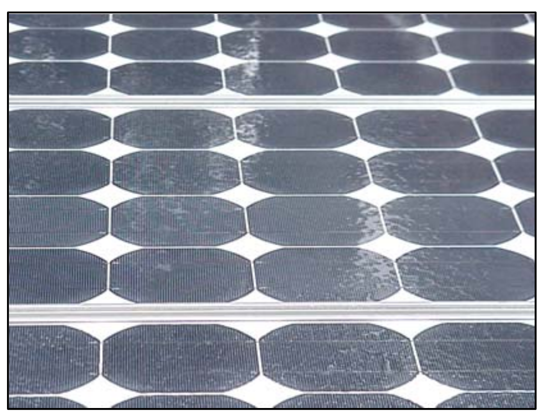
Design Note 8
Residential Photovoltaics

Solar electric systems are much too expensive for most affordable housing projects. In fact, solar electric photovoltaic systems produce electricity that is two to four times more expensive than utility-provided power. However, many utilities offer special incentives or grants to fund renewable energy demonstration projects. By taking advantage of these opportunities, affordable housing developers may be able to use renewable energy systems to reduce the cost of operating homes even below what energy efficiency alone can achieve.

Affordable single-family homes may make use of solar electric generating systems, also known as photovoltaics (PV). Residential photovoltaics can be either “stand-alone” systems that include battery systems to store electrical power for future use, or “utility-interactive” systems that are tied to the power grid. In this case the system draws power from the grid when the sun isn’t shining, and can feed excess power into the grid when it’s generating more than the house needs, running the electric meter backward. Stand-alone systems may be less expensive than utility line extensions to remote locations, but usually cost more than grid intertied systems, because of the significant cost of storage batteries. Affordable housing developments are likely to use utility-interactive systems, particularly when the photovoltaics are a demonstration project funded by the utility.

Grid intertie systems consist of a PV array to convert sunlight to electricity, a mounting structure, wiring, switches, and an inverter that converts the direct current electricity produced by the array into alternating current that can be used by conventional appliances or fed back into the utility grid. The array is usually PV panels, but may also be a building-integrated photovoltaic material such as a solar shingle or solar wall. A photovoltaic array may be mounted on the roof, or may be freestanding adjacent to the home. The amount of energy produced by a photovoltaic system will differ based on factors such as geographic location, the angle and orientation of the system array, the specific characteristics of the system components, and the quality of the installation. While a 1-kilowatt system will produce about 1,200 kilowatt-hours per year in Seattle, Washington, the same system used in Phoenix, Arizona, will produce about 2,000 kilowatt-hours. Typically, though, a 2-kilowatt system can offset about half the energy needs of an efficient home.

Solar-collecting arrays require about 100 square feet of space per kilowatt. A solar collection area should be unshaded from 9 a.m. until 3 p.m. each day. Due south is the best orientation, although a deviation of 45 degrees or less from true south is acceptable. Roof pitch is an important consideration for direct-mounted PV systems, and for most effective collection the roof pitch should be approximately equal to the latitude of the building site.



Even if a solar electric system is not affordable at the time when a house is built, houses should be designed to be “solar ready.” This means designing the building so that there are 200-400 square feet of south-facing roof area at a pitch that can readily accept solar panels in the future, if and when they become available. Designing a home to accommodate a potential future solar electric system is an inexpensive way to keep opportunities open.

Several affordable housing developments have already included rooftop photovoltaic systems, with support from a variety of grant programs.

Colorado Court, a 44-unit building in Santa Monica, California that provides single-room occupancy for low-income renters, is expected to provide 92% of its own power with an extensive photovoltaic system and a natural-gas powered turbine with cogeneration. The project's energy efficiency and renewable energy features have garnered $500,000 in grants from local and state energy programs. The Burnham Building redevelopment, in Irvington, New York, turned a vacant building into 22 units of affordable rental housing and a public library. The building features renewable energy powering a common space.

The Pine Street Housing Project will be constructed in several phases. The first phase of four houses will be equipped with one-kilowatt solar electric systems. These systems are expected to provide 20% to 30% of a typical natural gas heated unit's electric needs. The systems are funded by utility universal system benefits funds available to low-income homeowners. All Pine Street units are solar ready and will readily accept solar electric systems in the future.

Section 3: A Palette of Real-World Solutions for Affordable Sustainable Housing

Design Note 9
Panel-Style Cladding Omits Sheathing

Although household renewable energy systems are often perceived as expensive gadgets for high end or remotely-located homes, a number of affordable housing developments have been able to make use of solar water heating systems. In most of these cases, a renewable energy incentive or grant program from a state energy office or local utility has subsidized the installation costs for the renewable energy systems. When affordable housing developers can secure grants to offset the added cost of solar hot water systems, installing these systems can help reduce household operating costs, making the housing even more affordable for its occupants.

Solar hot water is perhaps the most common renewable energy system used in affordable housing. Solar hot water systems use the sun's heat—solar gain—to preheat water before it enters a conventional water heater. Solar water heaters can range from very simple seasonal direct-heat systems to more complex heat-transfer arrangements. In some climates and seasons, water from the solar water heater may not need any supplemental heating before use, but even when it does, overall water heating costs should be reduced by using a solar water heater, particularly in areas where electric water heating is used and electricity prices are high.

A solar water heating system will require a solar collecting area of approximately 400 square feet facing within 30 degrees of due south that is unshaded from 9 a.m. to 3 p.m. For most effective solar collection, the roof pitch should be about equal to the latitude of the building site. The collector panel for a solar water heater usually is an insulated flat metal frame that has a copper absorber plate and tube assembly through which a heat transfer fluid is circulated. In addition to the solar collection component, solar hot water systems also consist of a piping run and an 80- to 120-gallon water storage tank adjacent to the standard domestic water heater.

The major challenge for solar hot water heating in a northern climate is freeze protection, which is necessary if the system is to be used throughout the year. There are four basic types of solar water heating systems, each of which has a different approach to freeze protection. The simplest system is a passive system without a pump, that relies on thermosiphoning to draw cold water from an elevated storage tank into the collector system and returns warmed water to the storage tank where it rises to the top. The system operates as long as the sun is shining. In warm climates, the domestic water itself can be circulated through the heater, while in freezing climates a separate antifreeze solution loop transfers heat to the water.

A second type solar water heater, a draindown system, pumps potable water directly through the solar collectors. When sensors detect freezing temperatures, valves automatically open and drain the system. A similar type of system, the drainback, does not circulate potable water, but heats some other fluid and uses a heat exchanger to transfer this heat to the domestic water. When the collectors are cool, the pump shuts off and the collecting fluid drains by gravity into a storage reservoir.

Another option, the anti-freeze closed-loop system can operate continuously throughout the winter months, but must be pressurized. Because the antifreeze solutions used in the system are toxic, they must be separated from household water by a double-walled heat exchanger.

Even if a solar water heating system is not affordable at the time of construction, houses should be designed "solar ready." Solar ready means designing the building so that there are 200–400 square feet of south facing roof area that can readily accept solar panels in the future. Provision should also be made for installing the extra water storage tank, piping, and wiring needed for a future solar hot water system.

Solar water heating systems have been installed on affordable housing developments in Montana and are regularly installed on energy-efficient Habitat for Humanity homes built in Denver, Colorado. A solar water heating system was also included in the Hawaii Energy-Efficient Model Demonstration Home (BuiltGreen Home.) All Pine Street units in Hazleton, Pennsylvania have been designed solar ready to accept solar hot water and solar electric systems in the future.