



**National Center for  
Healthy Housing**

# **Green Housing=Improved Health: *A Winning Combination***

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Green building programs traditionally have focused on improving building performance while mitigating the negative environmental impacts of the built environment. They include measures to lower energy and water consumption, reduce greenhouse gas emissions, and minimize the amount of solid waste and construction debris that ends up in landfills. Green building programs typically specify environmentally-friendly materials, and address the design and development of a project, as well as its subsequent operations and on-going maintenance.

There is strong evidence supporting the benefits of green building in terms of energy efficiency and environmental impacts; and an increasing number of studies document the health benefits of certain green building programs. This paper provides background on the relationship between housing and health and, using case studies developed by the National Center for Healthy Housing (NCHH), illustrates how building affordable green housing provides health benefits to its low-income residents.

## Integrating Health and Housing

Numerous studies, dating back to the industrial revolution and beyond, have recognized the association between health and housing. Tenements, designed to solve the housing crisis of the 19th Century, were found to be breeding pools for contagious diseases. Tenement architecture, which favored narrow design, cheap building materials, and little to no ventilation or natural light, led to overcrowded and unsanitary conditions and was linked to the emergence and spread of infectious diseases including cholera, tuberculosis, and typhoid fever.<sup>1,2</sup>

In recent years, health issues related to building design and development as well as to the materials used in construction have taken center stage. Lead-based paint hazards cause severe developmental issues and brain damage, especially in children. Asbestos, the heat-resistant fiber used in housing construction materials ranging from flooring to roofing, is highly carcinogenic.

**You Can Take  
7 Steps to KEEP Your  
Home Healthy**

- Step 1.** Keep it dry.
- Step 2.** Keep it clean.
- Step 3.** Keep it pest-free.
- Step 4.** Keep it ventilated.
- Step 5.** Keep it safe.
- Step 6.** Avoid contaminants.
- Step 7.** Keep it maintained.



<sup>1</sup>Health, Morality, and Housing: The "Tenement Problem" in Chicago. Garb, Margaret. *American Journal of Public Health* | September 2003, Vol 93, No. 9, pp 1420-1430. Available at <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1447986/pdf/0931420.pdf>.

<sup>2</sup>Tenement Architecture. Available at <http://www.mapsites.net/gotham/sec8/tour2imanid2.html>.

And similar to the unintended consequences created by tenement architecture, early efforts to improve building performance may have contributed to "sick" buildings,<sup>3</sup> in which high levels of indoor air pollutants were found.

Indoor pollution levels range from two to five times higher (and in some instances 100 times higher) than outdoor pollutant levels and may pose greater health risks to individuals. People spend approximately 90 percent of their time indoors. Poor air quality increases the incidences of asthma and other respiratory diseases, making individuals that spend the greatest amount of time indoors, such as children, seniors and the chronically ill, the most susceptible to indoor pollutants and these ailments.<sup>4</sup>

A 1984 report by the World Health Organization (WHO) found that up to 30 percent of new and remodeled buildings had excessive indoor air quality problems due to:

- **Inadequate ventilation:** Conservation measures sparked by the 1970s energy crisis called for a reduction in ventilation from outdoor air sources. Although ventilation standards were later revised, inadequate ventilation remains an issue in many buildings as existing standards were largely designed to address comfort, not indoor contaminants.
- **Indoor chemical contaminants:** Indoor air pollution is caused by sources within the building itself, as well as by the occupants. Volatile organic compounds (VOCs)<sup>5</sup> such as formaldehyde may be released from building materials and cleaning products. Tobacco smoke creates high VOC levels, as well as other toxic compounds, such as particulate matter. Unvented or poorly vented appliances, fireplaces, kerosene and gas space heaters, and woodstoves can create combustion by-products such as carbon monoxide, nitrogen dioxide, and particulate matter.
- **Outdoor chemical contaminants:** Sometimes, even outdoor air that enters a building contributes to indoor air pollution. Poorly located intake vents, windows and doors may allow pollutants such as motor vehicle exhaust to enter buildings; improperly placed plumbing vents and building exhausts (e.g., bathroom and kitchens) can create a "short circuit," permitting pollutants that were intended to vent outside the building to re-enter. Cancer-causing radon gas can seep into homes through cracks or holes in the foundation. Pesticides and other outdoor contaminants can be tracked into the house on clothing and shoes.

<sup>3</sup>More information on "sick building syndrome" can be found at <http://www.epa.gov/iaq/pubs/sbs.html>.

<sup>4</sup>*The Inside Story: A Guide to Indoor Air Quality*, U.S. EPA/Office of Radiation, Office of Radiation and Indoor Air (6609). Cosponsored with the Consumer Product Safety Commission. Available online at <http://www.epa.gov/iaq/pubs/insidest.html>. Accessed January 4, 2011.

<sup>5</sup>VOCs are chemicals that may have short- and long-term negative health impacts. High concentrations of some VOCs cause chronic and acute health effects; others are known carcinogens. Even a low- to moderate-level of a combination of VOCs can cause acute reactions. VOCs are emitted as gases from a range of products typically used in construction and renovation such as paints and sealants, as well as in cleaning supplies, pesticides, and furnishings. More information about VOCs and other indoor air pollutants can be found on the U.S. EPA/Office of Radiation site in their report: *An Introduction to Indoor Air Quality: Volatile Organic Compounds*. Available online at <http://www.epa.gov/iaq/voc.html>.

- **Biological contaminants:** Biological contaminants include bacteria, mold (fungi), pollen and viruses. Excess moisture may increase the level of these contaminants. Stagnant or accumulated water can be found in ducts, humidifiers and drain pans, or leak into ceiling tiles, carpeting, insulation or even drywall. Insect droppings are additional sources of biological contaminants.

These contaminants are often mixed, creating a toxic soup of indoor exposures that add to other issues creating occupant discomfort such as inadequate temperature control, humidity, or lighting.

Green building programs include many measures aimed at reducing and eliminating these indoor air pollutants.

Green building programs include many measures aimed at reducing and eliminating these indoor air pollutants. Some of the most prevalent residential green building programs are the Leadership in Energy and Environmental Design (LEED) criteria established by the U.S. Green Building Council (USGBC), EarthCraft by Southface Energy, ICC-700 National Green Building Standard (NGBS) created by the National Association of Home Builders (NAHB) and the International Code Council (ICC), and the Green Communities Criteria designed specifically for affordable housing by Enterprise Community Partners.

## Green Building and Healthy Homes

For nearly 20 years, the National Center for Healthy Housing (NCHH) has worked to bring the public health, housing, and environmental communities together to create healthy, safe housing. With the growing emergence of green building programs, NCHH set out to determine how well green buildings standards aligned with healthy home principles. In 2006 and again in 2008,<sup>6</sup> NCHH examined the criteria used in nationally-recognized green building programs: the ICC-700 National Green Building Standard (NGBS); LEED for Homes (LEED-Homes); Green Communities; and the U.S. Environmental Protection Agency Indoor AirPLUS program.

NCHH examined how well the different programs stacked up next to the seven principles of healthy homes and discovered considerable differences in how the programs approached occupant health.

Most had criteria related to improving ventilation and reducing moisture, but none addressed home injuries; and the criteria inconsistently addressed contaminants such as radon and pesticides. The only program focused on the most vulnerable population when it came to housing and health-related issues (i.e., low-income families) was Enterprise Green Communities, which is designed specifically for affordable housing. The overall analysis, however, found that green building programs offer substantial

<sup>6</sup> The 2006 review included the NAHB Green Building Guidelines which later became a major basis for the NGBS and the American Lung Association Health House Builder Guidelines.



health benefits for residents along with the potential to move the housing market toward healthier building practices.

## Green Elements with Direct Impact on Occupant Health

The most common health criteria identified in green building programs include features such as ventilation improvements; radon testing and mitigation; integrated pest management; moisture management measures; and restrictions on the use of chemicals in construction materials. Other green building measures may also have an impact on resident health: temperature controls; tightened building envelopes; siting and landscaping; improved lighting quality and increased use of daylighting; and increased community connections.

Tightening building envelopes through improved construction techniques, vapor barriers, increased insulation, and installation of high performing windows and doors can improve the thermal comfort of homes and save families precious dollars in energy costs. They also reduce airborne irritants, allergens and dust,<sup>7</sup> significant triggers for asthma and respiratory illnesses. Measures that promote more efficient and natural light have been shown to improve productivity and have a beneficial impact on mental health. Efficient exterior lighting using daylight sensors or timers helps ensure that external paths are well lit in the evening, which can help reduce injuries caused by dark paths and stairwells,

<sup>7</sup> Air Sealing: Building Envelope Improvements, EPA Air and Radiation. Available at [http://www.energystar.gov/ia/new\\_homes/features/AirSealing1-17-01.pdf](http://www.energystar.gov/ia/new_homes/features/AirSealing1-17-01.pdf)



as well as reduce the stress associated with living in unsafe neighborhoods.

Green building standards have most recently evolved to incorporate other additional elements that may be beneficial to occupant health: more community linkages, such as walkable streets; connections to public amenities and open space; access to recreational facilities; and alternatives to driving, such as bicycling and public transport, all of which encourage physical activity and social interaction. LEED for Neighborhood Development (LEED-ND) now awards points for visitability and universal housing design, which can help reduce injuries related to housing access. Maturing green building standards also feature criteria supporting local food production, which could lead to more community gardens and better nutritional health for residents.

## The Health Case for Greening Affordable Housing

Low-income people tend to be disproportionately impacted by asthma, other respiratory illnesses, and a variety of other health problems related to poor housing conditions. Green building requirements are especially important when building and rehabilitating affordable housing because they not only extend the affordability of the home by using durable materials and lowering utility bills, but can also help improve residents' health, effectively lowering healthcare costs.

Although numerous anecdotal reports discussing the link between green building and improved health exist, only a few studies have been conducted to date. To fill this gap, NCHH documented the health benefits that accrued to residents from the following four low-income housing projects rehabilitated or developed using green building standards:

- Viking Terrace, Minnesota, a 60-unit complex renovated in 2006;
- Breathe-Easy Homes, Washington State, 60-units of a larger HOPE VI redevelopment completed in 2009;
- Wheeler Terrace, Washington, DC, a 116-unit complex renovated in 2010;<sup>8</sup> and
- Nuevo Amanecer, Oregon, a 90-unit farm worker development renovated in 2010.

Employing questions from the Centers for Disease Control and Prevention's (CDC) National Health Interview Survey and the U.S. Department of Housing and Urban Development's (HUD) National Survey of Lead and Allergens in Housing, NCHH evaluated the Viking Terrace and Wheeler Terrace projects to examine, track, and document the health impact(s) of meeting the Enterprise Green Communities Criteria. A team from the Department of Public Health, Seattle and King County (PHSKC) and Simon Fraser University (SFU) evaluated the Breathe-Easy Homes (BEH); and the Oregon Social

<sup>8</sup> Construction on Wheeler Terrace was completed in 2010, but resident health evaluations will not be completed until mid-2011.

Learning Center Latino Research Team (LRT) conducted the initial evaluation of resident health at Nuevo Amanecer.

## NCHH Case Studies

Three of the four projects NCHH reviewed were substantial rehabs and the fourth (Breathe-Easy Homes) was new construction. In each case, the pre-renovation living conditions were unhealthy. Common issues included mold and mildew; inadequate ventilation and insulation; failing operating systems; pest infestation; poor or non-functioning doors and windows; insufficient site drainage; unsanitary carpeting; non-existent connections to the surrounding community; little greenspace or recreational areas; inadequate lighting, both internally and in the buildings' external perimeter; and overall dilapidated buildings. These conditions contributed to health issues ranging from asthma and respiratory disease to sinusitis; chronic bronchitis; skin allergies; and possibly hypertension.

The conditions also contributed to a general malaise in the community. Parents in some of the complexes refused to allow their children to play outdoors—if in fact there was anywhere to play—because of safety issues. Many residents expressed public safety fears due to dark pockets throughout the project or inadequate lighting on walkways. Social interaction between residents in many of the complexes was null or in some instances tense. There were few linkages to the surrounding communities or access to facilities such as walking and biking paths or community gardens that promote a healthier lifestyle.

Project developers recognized that they needed resident and community buy-in as they determined the steps needed to restore the communities. Many held charrettes to garner resident feedback. Wheeler Terrace even had a full-day retreat dedicated to getting residents' advice, reaction and comments about development elements under consideration. Viking Terrace had a "winter celebration" to kick-off its renovation project.

Not all the projects started out with green in mind. Viking Terrace had considered some energy efficiency improvements during its renovation planning, such as geothermal heating and cooling, but could not get the necessary financing. Were it not for an intervention by Enterprise Community Partners they would not have been able to "go green" due to the increased costs associated with green building.



Viking Terrace's New Picnic Shelter



Viking Terrace

**Viking Terrace, Worthington, MN**

<b>Owner:</b>	Southwest Minnesota Housing Partnership
<b>Green Building Standard:</b>	Green Communities Criteria
<b>Originally built:</b>	1978
<b>Number of Units:</b>	60 one, two and three bedroom apartments in three buildings
<b>Demographics:</b>	One-third white; two-thirds immigrant; largest majority of immigrants from Ethiopia and Eritrea; remaining mix Hispanic and Vietnamese
<b>Eligibility:</b>	4 Units—income 30% AMI 47 Units—income 50% AMI Nine units available at Mkt Rate

**Breathe-Easy Homes, Seattle, WA**

<b>Owner:</b>	Seattle Housing Authority
<b>Green Building Standard:</b>	Seattle SeaGreen Washington State Evergreen ENERGY STAR
<b>Originally built:</b>	1942 for Defense Workers; Transferred to SHA: 1953 New Construction—Part of High Point 1,600-unit HOPE VI Redevelopment
<b>Number of Units:</b>	60 units
<b>Demographics:</b>	Immigrants from Latin America, Vietnam, Cambodia, Somalia and Ethiopia.
<b>Eligibility:</b>	Income—30% AMI to Mkt Rate; Must have a child with uncontrolled asthma (i.e., child continues to have asthma attacks despite following prescription drug regime); Must agree to live pet and smoke-free

**Wheeler Creek, Washington, DC**

<b>Owner:</b>	Community Preservation Development Corporation
<b>Green Building Standard:</b>	Green Communities Criteria LEED Gold
<b>Originally built:</b>	1947 as Veteran Housing
<b>Number of Units:</b>	116 one, two and three bedroom apartments in seven buildings
<b>Demographics:</b>	97% African-American 90% single-female headed household; 50% children. 73% residents have incomes: <\$10,000/yr Median community income: <\$5,600
<b>Eligibility:</b>	100%—Family income $\leq$ 60% AMI 97% of the units will remain Section 8 under renewed 20-yr contra

**Nuevo Amanecer, Woodburn, OR**

<b>Owner:</b>	Farmworker Housing Development Corporation
<b>Green Building Standard:</b>	Green Communities Criteria
<b>Originally built:</b>	Phase 1—1994; Phase 2—1999
<b>Number of Units:</b>	90 single-family attached houses with two, three and four bedrooms
<b>Demographics:</b>	100% Farm workers (55% family income must be derived from farm work) Phase 1: income $\leq$ 50% AMI Phase 2: income $\leq$ 40% AMI

Shortly after the stripped down project received a Low Income Housing Tax Credit (LIHTC) allocation, Enterprise and two Minnesota Philanthropic organizations announced the formation of Minnesota Green Communities. Viking Terrace was accepted as a pilot project based on the original concept. With a Green Communities grant and political support from Minnesota Green Communities, SWMHP was able to secure supplemental funding from the Minnesota Housing Finance Agency to make the project whole.

In large part, with the exception of the Breathe-Easy Homes, the desire to improve energy efficiency and lower utility costs proved one of the largest drivers in the decision to build to green standards. Although health concerns voiced by residents helped seal the green deal for half of the projects, the architects of the Breathe-Easy Homes set out with significant health goals in mind.



All of the developments evaluated had to meet specific green building criteria according to their funding source(s); yet each had a significant amount of leeway in the green elements they chose to incorporate. Project teams evaluated green elements according to considerations such as expected payback period, estimated on-going maintenance costs, value to green building certification, and of course, environmental, energy and health impacts.

All of the projects employed green elements intended to improve Indoor Environmental Quality such as improved ventilation systems; installation of bath and kitchen exhaust fans; tightened building envelopes; and low- or no VOC products, and environmentally-friendly building materials. All of the developments also incorporated energy- and water- efficiency measures to reduce associated utility costs. Almost all of the developments began Integrated Pest Management (IPM) programs to reduce pest infestations and the need for toxic pesticides.

Additionally, the developers did not limit themselves to “low-hanging fruit.” Escalating energy costs prompted project managers to thoroughly evaluate the most efficient heating and cooling methods for their projects. Even with high upfront costs, the considerable advantages of geothermal (and the relatively short payback period) led two of the developments to include geothermal heating and cooling systems. In response to resident input and to encourage physical activity, all of the developments employed landscaping techniques that improved community greenspace and provided additional walkability and recreational access. Two of the projects even added community gardens.<sup>9</sup>

## Health Returns

In each of these cases, developers preserved affordable housing and created a healthier, more energy efficient, and environmentally-friendly home. In general, residents reported feeling healthier and safer.

### Viking Terrace (Worthington, Minnesota)

Although Viking Terrace did not start out green, it became the first health evaluation of a green renovation project. NCHH partnered with Viking Terrace’s owner and NeighborWorks America® charter member Southwest Minnesota Housing Partnership (SWMHP), and the Center for Sustainable Building Research (CSBR) to assess resident health, housing conditions, and building performance before and after the renovation.

Even though NCHH’s baseline health assessment at Viking Terrace found residents generally in good health before the renovation, adult residents showed improvements in general health, chronic bronchitis, hay fever, sinusitis, and asthma soon after renovation. Hypertension also improved. In addition, there were improvements in children’s general health, with a decline in respiratory allergies and ear infections.

One-year post renovation, the health benefits continued to accrue: the percentage of adults reporting good or excellent health

<sup>9</sup> A more comprehensive list of the green elements ultimately chosen for each development can be found in the appendix.

## Southwest Minnesota Housing Partnership

Southwest Minnesota Housing Partnership (SWMHP), a NeighborWorks America® charter member, is a non-profit community development corporation formed in 1992 to provide safe, affordable housing in rural Minnesota. Originally created to serve fourteen counties in the southwestern region, SWMHP now serves thirty counties in both Southwest and South Central Minnesota. Since its inception, it has developed, financed, or rehabilitated more than 6,700 housing units, both single and multi-family, and invested more than \$330 million into rural Minnesota communities. SWMHP also has provided homebuyer education to over 3700 people and mortgage counseling to more than 925 households. In addition to affordable housing development and preservation, and housing education/counseling, SWMHP provides community planning and technical assistance to local governments, other nonprofit developers, and housing and economic development authorities. SWMHP also assists local governments and nonprofit agencies develop essential community facilities.

Building sustainable communities has been an important element of SWMHP's work for many years. In 1998, after devastating tornadoes ripped through southwest Minnesota and substantially damaged most of the City of St. Peter, the City reached out to SWMHP for its community planning assistance. The goal was to bring residents back home to their tight knit, historical community, rebuild in a sustainable fashion and attract new, young families to increase the City's energy.

SWMHP helped create a plan that maintained the community's "old town" feeling, encouraged growth in specific sections of the community to increase population and business opportunities while avoiding sprawl, and provided for economic, social, and environmental sustainability. A variety of housing types were integrated throughout the community to create a good balance of single and multi-family; rental and homeownership; and low-income and market rate. The plan's landscaping design featured narrower streets to slow traffic, additional greenery and trees, and trails and parks throughout the community to increase walkability.

SWMHP's work in St. Peter led to its first encounter with green building. In 2002, SWMHP partnered with the University of Minnesota's Center for Sustainable Building Research (CSBR) and the Greater MN Housing Fund (GMHF) on the Green Home Demonstration Project as part of the restoration of the City of St. Peter. The project's goal was to determine what impact green building had on housing affordability. Employing green construction techniques and energy efficiency measures in the "green house" cut energy costs nearly in half, substantially reducing monthly utility bills and maintenance. This experience led SWMHP to apply the techniques and measures they learned in the Green Home Demonstration to another of its St. Peter projects, Nicollet Meadows.

With design input from the University of Minnesota School of Architecture, SWMHP developed 20 affordable townhomes in the Nicollet Meadows community that incorporated a range of green building measures, including: recycled materials, soy-based countertops and linseed linoleum; energy efficient appliances and lighting, increased insulation, and on-site construction recycling. A growing familiarity with green building led SWMHP to investigate what energy efficient elements could be incorporated into the Viking Terrace renovation.

The experience SWMHP gained from Viking Terrace has prompted them to do more thorough evaluations of existing buildings at subsequent rehabilitation projects prior to renovation enabling them to incorporate additional elements and any necessary mitigation during the design stage. SWMHP now treats almost every project as a research assignment, setting out to determine what they can learn from the project and working with key organizations such as the Center for Sustainable Building Research (CSBR) and the Center for Energy and Environment (CEE) to help them develop an appropriate scope of work for the project and then evaluating whether the projects achieve their sustainability goals.

CSBR and CEE help SWMHP conduct basic audits that evaluate and suggest what steps should be taken to improve building performance and resident health. SWMHP has found this to be a much more cost-effective approach, allowing them to set specific energy conservation and health goals, and more accurately determine pay-back periods and return-on-investment. They also have found that it pays to get upfront buy-in from the whole project team, verify accurate application of energy and indoor air quality details through construction monitoring, and then conduct a final building commissioning prior to occupation.

Cherry Ridge, the next project SWMHP completed after Viking Terrace, achieved a 50% reduction in water usage with the installation of low flow showerheads, faucet aerators, and ENERGY STAR washing machines. This indicates that even minor improvements can have positive impacts on the building operations. SWMHP is now implementing green improvements to improve operations throughout their existing portfolio of nearly 1300 units.

This approach does present challenges: getting buy-in from key stakeholders is sometimes arduous and it is often difficult to secure funding for pre-assessment and commissioning. These costs are seen as "soft" or as an intermediary expense, which are not eligible under many funding scenarios. SWMHP's next step is to promote policy changes that make this type of testing and evaluation a key part of green building efforts.

### Key Green Features Employed by SWMHP

- Low-VOC paints, sealants & adhesives;
- Continuous ventilation systems for moisture control;
- Low flow showerheads;
- High efficiency HVAC systems;
- Increased insulation;
- High efficiency water heaters;
- On-Site Construction recycling;
- ENERGY STAR appliances & fixtures; and
- Native landscaping to reduce irrigation.



nearly doubled, and incidences of asthma, hayfever, sinusitis and hypertension were reduced; the percent of children with respiratory allergies and ear infections decreased from fifteen percent to four percent. Residents also reported that their homes were more comfortable and easier to keep clean after the renovation. The landscaping updates and addition of walkways, grilling shelters, and improved play areas have improved social connections and encouraged children to play outdoors more often.

Post-renovation tests also showed that most VOC levels were well below minimum health risk levels; that radon mitigation efforts successfully reduced radon levels below EPA action levels; and the improved ventilation systems greatly improved fresh air delivery and distribution. Visual assessments found no visible evidence of mold.

Additionally, Viking Terrace integrated adult/child outdoor space by co-locating a large picnic shelter with an adjacent playground, basketball court, and soccer field. This helped increase time spent outdoors by both adults and children, and provided a safe community space for the development.

### Breathe-Easy Homes (Seattle, Washington)

The City of Seattle and Washington State are on the forefront of the green building movement and all affordable housing subsidized by the State or City must meet green building standards.<sup>10</sup> Consequently, the developers of the High Point HOPE VI Redevelopment project originally conceived it as a green project.

However, the growing rate of asthma in the State, along with its prevalence among low-income children, led the Seattle Housing Authority (SHA) to reach out to the Department of Public Health, Seattle & King County to determine if there were specific green measures that could be included that might help lower asthma and respiratory illness triggers. The ensuing collaboration sparked the Breathe-Easy Home demonstration project.

Although High Point was built to high green building standards, Breathe-Easy Homes are the first green homes in the nation built specifically to improve indoor air quality. To lower risk factors associated with respiratory ailments and to reduce triggers that spark asthma, Breathe-Easy Homes incorporated additional features in three main areas: the exterior envelope, interior finishes, and ventilation. Airtight wall construction, high-quality windows and insulated foundations created an enhanced exterior envelope to optimize moisture-proofing; interior finishes such as low-VOC cabinetry, low-pile carpets, Marmoleum™ flooring, and walk-off door mats minimized dust and off-gassing; and an energy-efficient heat-exchange ventilation system offered significant filtration and a continuous fresh air supply. Additionally, Breathe-Easy Homes incorporated extra precautions during construction, such as protecting on-site materials from the weather and giving extra dry out time to minimize mold growth on material; curtailing dust

<sup>10</sup> The City requires affordable housing projects meet "SeaGreen" green building standards, while the State requires "Evergreen" standards. Information about these programs can be found at <http://www.seattle.gov/dpd/GreenBuilding/MultifamilyResidential/DesignToolsStrategies/SeaGreen/default.asp> and <http://www.commerce.wa.gov/site/1027/default.aspx>, respectively. Other states, including MN, have since followed this lead.



Breathe-Easy Homes Photos courtesy of the Seattle Housing Authority

### High Point Breathe Easy Home

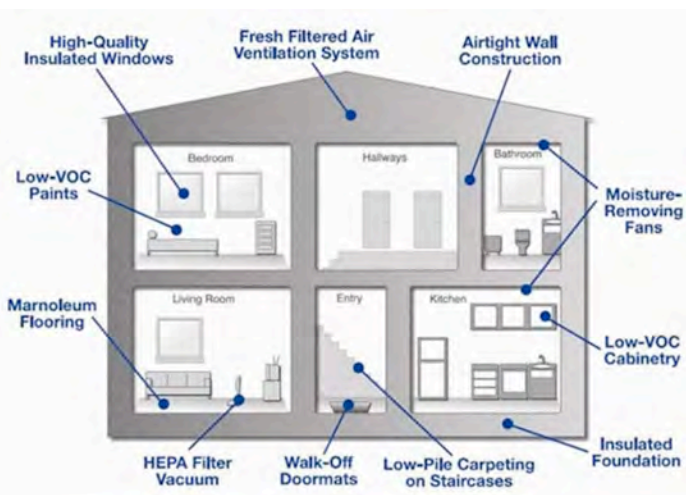


Diagram courtesy of Steve Barham



accumulation by protecting ductwork; and flushing out buildings prior to occupation to permit evaporation and material off-gassing.

A Healthy Homes grant from HUD and a grant from Enterprise Community Partners, funded a longitudinal study of the health impacts in which the health department examined the impact living in an asthma-friendly environment has on asthma clinical outcomes and exposure to environmental asthma triggers.

The modest improvements in housing design, materials, and construction greatly reduced asthma triggers and symptoms to produce significant health gains. Asthmatic children had 63 percent more symptom-free days than in their previous homes and showed dramatic improvements in lung function. Health improvements resulted in a 66 percent reduction in the need for urgent medical care. And as asthma symptoms and triggers declined, the quality of life for families living in Breathe-Easy Homes improved: fewer sleepless nights, less lost work and school days, increased exercise and outdoor activities, and lower medical expenses.

With the reduction in asthma triggers, children are able to engage in more outdoor and exercise-related activities. Along with the pedestrian-friendly street design, increased social interaction is possible. Walkable amenities, including a new library, retail center, community center and athletic fields and playgrounds further encourage physical, outdoor activity. A new medical and dental clinic, located within walking distance, provides greater access to healthcare.

Landscaping upgrades throughout the High Point community also provide substantial health and environmental benefits. The new drainage system is helping restore the water quality of Seattle's most significant salmon stream and the saving and planting of non-pollen emitting trees reduced another asthma trigger for residents. High Point's "Market Garden," where residents grow fresh fruits and vegetables to sell to local subscribers, also is providing health and economic benefits.

## Wheeler Terrace (Washington, DC)

What's the cost per foot to give your residents better health?

—Mark James, Project Manager, Wheeler Terrace

When Washington, DC passed its comprehensive Green Building Act, Wheeler Terrace was not yet subject to its requirements.<sup>11</sup> However, the project developer was interested in incorporating green elements and the architect had extensive green building experience, so they promoted the concept to building residents. The team reached out to Enterprise Green Communities staff for their green expertise, NCHH for input on healthy homes, and a local construction firm with green building experience. A 2007 grant to NCHH from HUD led to Wheeler Terrace becoming the first HUD green and healthy homes demonstration project.

<sup>11</sup> Washington DC's Green Building Act was implemented in stages; for more information go to <http://green.dc.gov/green/cwp/view,a,1231,q,460953.asp>.

The evaluation of how the green and healthy features integrated into the Wheeler Terrace rehabilitation are impacting resident health and exposure to allergens is ongoing. Post-renovation interviews with residents and analysis began in fall 2010 and will be completed in 2011. In addition to the evaluation, NCHH is training several residents as Community Health Workers (CHW) to provide healthy home information to other community members. Heightening the resident connection and encouraging peer education should help build resident engagement in maintaining healthy homes.



Wheeler Terrace Renovated apartment



Post construction bathroom



Community charette



Nuevo Amanecer Landscaping and walkways



Play area



Community Garden



Community Center

Parents report being less worried about letting their children play outside and the sound of random gun shots has subsided. The renovation has removed many stressors and increased on-site security measures, such as better exterior lighting and installation of a perimeter fence, has dissuaded unwanted visitors and helped eliminate illegal drug activity on the property to alleviate many safety concerns.

Wheeler Terrace's improved landscaping also appears to be encouraging residents to spend more time outdoors. Residents helped plant trees on the site and, in addition to looking forward to spring blossoms, have become proprietary over the trees themselves. Wheeler Terrace plans to establish a community garden which may encourage residents to get even more engaged in the community and a healthier lifestyle.

## Nuevo Amanecer (Woodburn, OR)

Health and respiratory issues are prevalent among farm workers constantly exposed to pesticides, natural fungi, and dust in the fields. As Nuevo Amanecer began its renovation efforts, the undercurrent of health concerns throughout the complex prompted project staff to reach out to the Oregon Social Learning Center Latino Research Team (LRT) to help evaluate the impact of the green renovations on their residents' health. NCHH contributed a series of healthy housing questions to LRT to include in its resident interviews. Unlike the other projects examined by NCHH, the Nuevo Amanecer evaluation was limited to an initial baseline assessment. It is hoped that the intimate engagement of Nuevo Amanecer staff with residents will provide some level of on-going analysis of the impact of the green building upgrades.

Renovations at Nuevo Amanecer were completed in the summer of 2009 and anecdotal evidence indicates great returns from the green and energy efficient upgrades. Mold, mildew, and dampness have been reduced or eliminated and the upgraded ventilation system automatically addresses day-to-day moisture issues within the apartments.

Landscaping changes have proven especially beneficial. Although LRT's pre-renovation interviews revealed that Nuevo Amanecer children played outdoors a great deal (nearly 70 percent reported daily outdoor activity), strategically moving the play areas around and reconfiguring the walkways resulted in more usable park areas. This allowed greater access to grassy areas where children can play and areas for community gardens. The reconfigured walkways also prompted people to walk around the grounds and socialize. This increases resident physical activity while keeping more "eyes on the street" to eliminate potential criminal activity, and improve residents' sense of safety.

For most of these developers, this was the initial foray into green building. The benefits they discovered, from financial and environmental to health, convinced them that renovating and building to green standards significantly improves not only their bottom lines, but also their overall affordable housing missions.

## Lessons from an Experienced Green Builder

REACH Community Development, Inc., an affordable housing developer and NeighborWorks America® charter member based



in Portland, OR, is an old hand at green building. Founded 29 years ago, REACH's portfolio consists of more than 1,400 units of new and renovated single-family homes, small complexes, large multifamily apartments, and mix-used developments. REACH is committed to green building practices that produce high quality and durable buildings that benefit its residents, its bottom line, and the environment.

REACH has incorporated renewable, energy-efficient practices into its affordable housing development for many years. REACH completed its first "green" project in 1995: an 18 unit mixed-income urban infill project featuring insulated panels and a significant amount of recycled building products. As the City of Portland took steps to encourage more sustainable development,<sup>12</sup> REACH also began incorporating a variety of green building practices, from low-VOC paints and finishes to rainwater harvesting.

REACH began building completely to meet green guidelines ten years ago. All projects completed since 2005 meet at least the LEED Silver or Earth Advantage criteria.<sup>13</sup> Similar to other green building programs, the Earth Advantage program promotes healthier homes by incorporating more sustainable building materials and finishes that do not off-gas; installation of air filtration systems; properly sealed gas combustion systems, and adequate ventilation procedures. Earth Advantage also incorporates criteria such as moisture barriers and rain screens to reduce excessive water intrusion.

REACH holds design charrettes with the development team, frequently obtaining resident and community stakeholders input to determine what features should be incorporated into its projects. To ensure residents understand the green, healthy features of their homes, REACH provides information and green products to residents when they move into their units. Additionally, REACH facilitates bi-weekly workshops at two of their properties that feature information on topics such as non-toxic cleaning materials and energy and water conservation methods.

## Integrated Pest Management (IPM)

In addition to its Green Building efforts, REACH partnered with the Multnomah County Department of Health (MCDH) on the Rose Healthy Homes Initiative. The Initiative is a community-based pilot project designed to educate and empower property managers and

<sup>12</sup>The City of Portland began exploring more sustainable development tactics in the mid-1990s. The green building initiative, which offered technical assistance, education and financial incentives was launched in 2000. By 2001 the City had adopted a green building policy requiring that new City-Owned buildings achieve LEED Silver certification. In 2005, the requirement was raised to LEED Gold with added requirements for energy performance, stormwater management, water conservation, ecoroof installation, and construction and demolition waste recycling. The Portland Development Commission (PDC) also adopted an affordable housing green building policy in 2001; it was strengthened in 2005 to require LEED Silver certification for new construction. PDC is currently in the process of revising its Green Affordable Housing policy to ensure it is aligned with citywide development practices.

<sup>13</sup>Earth Advantage is a rating system created by the Portland-based Earth Advantage Institute that employs green building criteria in five categories to meet certification. The five categories or "Pillars of Certification" are: energy efficiency, health, water conservation, environmentally-friendly building materials, and land development. More information about the Earth Advantage program can be found at <http://www.earthadvantage.org>.

### Green Features found in REACH Housing:

- Low-flow aerating faucets;
- Energy efficient lighting;
- ENERGY STAR appliances;
- Improved ventilation systems;
- Rainwater harvesting for flushing toilets.

### Enhanced Indoor Air Quality Measures:

- No and low-VOC paints, adhesives, sealants and solvents; Green Label Plus carpets; natural linoleum;
- Low or formaldehyde-free cabinets and countertops;
- Continuous exhaust bathroom ventilation and kitchen exhaust fans, all externally vented.



tenants on environmental health issues. MCDH brings public health expertise and REACH offers residential services.

The Initiative invited residents from the Rose Apartments, a single-room occupancy building sheltering formerly homeless women, to participate in classes facilitated by staff from REACH and MCDH. Participants were asked to identify a significant health-related concern on which they would like to focus; they chose pest control and the impact of toxic chemicals on residents.

Participants concerns coincided with REACH Management's desire to test an IPM approach which would employ a less toxic and more effective way to reduce infestations. The first steps in the approach entailed REACH Property Management, Maintenance and Resident Services staff jointly inspecting units at Rose Apartments for housekeeping and maintenance issues. REACH Resident Services staff then provided residents with information on how to improve their housekeeping practices at the same time that Property Management addressed maintenance issues. The initial inspection indicated that 43% of the units had some level of pest infestation. Instituting IPM led to a significant reduction in infestation: six weeks after implementation and without introducing toxic chemicals into the residents' living spaces, the units were 90% pest free. After twelve months, the property was re-inspected and found only one cockroach.

The results at the Rose led REACH to institute a portfolio-wide IPM program and dedicate one Property Management staff person (aka the "Bug Czar") to oversee pest control in all properties. Employing this approach, REACH staff first determines the level of infestation



by placing traps in several locations throughout each apartment. Areas where bugs can enter the apartment are then addressed, and a gel roach bait is used in a very focused manner. Treatment results are monitored every two weeks and baiting repeated, as necessary. REACH has seen great success with this approach. Residents have appreciated the elimination of spray treatment and have been impressed by the success of the less toxic and more effective approach.

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The use of pheromone traps to identify and monitor roach levels has also helped in early identification of bed bug infestations. REACH's protocol for bed bug treatment is also focused on prevention, monitoring, targeted use of chemical sprays, and the use of heat treatments to address large bed bug infestations.

## New Development

In recent years, REACH completed two new transit-oriented projects: Station Place and Patton Park; and two major renovation projects that provide affordable housing for seniors and the disabled: Walnut Park and the Admiral Apartments, a historic preservation project.

Patton Park was done in partnership with TriMet, Portland's transit agency, and designed specifically to provide affordable housing to families in danger of displacement from gentrification associated with light rail development. In addition to providing easy access to transportation, both Patton Park and Station Place are located in close proximity to neighborhood parks and bike trails to encourage outdoor activities.

Built on the site of an old rail yard, Station Place is a Brownfield redevelopment site, requiring significant mitigation to remove and reduce contaminants related to the land's previous use. Station Place now offers 176 mixed-income senior residences in the high-end Pearl District. It meets Earth Advantage and Greening Portland's Affordable Housing Guidelines,<sup>14</sup> as well as Enterprise Green Communities criteria, and LEED Silver standards. Station Place also features Portland's first commercial rainwater harvesting system: it reuses onsite rain water to flush 80 toilets on six floors.

## Community Gardens

As REACH worked with residents to create healthier homes, they recognized the importance of providing residents an opportunity to grow their own healthy food in community gardens. REACH began incorporating on-site gardening plots and developed policies and procedures to guide resident gardening. They also arranged for a discount program with Portland Nursery to help make gardening

supplies more affordable. The community gardens have met with great success: encouraging much healthier eating habits and more physical activity.

The community garden at Station Place initially consisted of three raised gardening boxes on the roof. It was so popular that management expanded the gardens to landscaped areas around the building; yet resident demand still exceeds available garden space. Because of the limited space, REACH holds a lottery to allocate gardening spots. Residents at several other REACH properties also have requested community gardens and REACH is in the process of installing gardens as feasible. So far, the only downside encountered with the gardens is when residents argue over the limited space.

## Property Management

REACH's operation and maintenance also reflects its commitment to healthy, green building. The regular maintenance schedule tests the effectiveness and safety of vents, filters, plumbing, and combustion equipment to ensure optimized operations. REACH also designed ventilated storage areas for cleaning supplies and paints.

Additionally REACH worked with the Zero Waste Alliance/Josiah Hill to review its current list of products for use in cleaning and painting to ensure the use of low toxin products. Armed with this information, they are in the process of completing a Resident Maintenance Handbook, which outlines green cleaning products, recycling tips, and how to properly use various green/conservation features in their buildings

## Smoke-Free Housing

To make its properties healthier and reduce maintenance costs associated with smoke damage, REACH made all of its buildings smoke-free in the spring of 2010. Before enacting the plan, REACH surveyed residents and found that the majority supported the proposed smoke-free policy. REACH worked with the American Lung Association to move to a smoke-free environment and, to help residents adjust to the new "no smoking" rules, REACH offered on-site smoking cessation classes. People are still allowed to smoke on the property, but only in outside designated areas.



<sup>14</sup> A copy of the guidelines can be found on REACH's website at [http://www.reachcdc.org/images/uploads/Greening\\_Portlands\\_Affordable\\_Housing.pdf](http://www.reachcdc.org/images/uploads/Greening_Portlands_Affordable_Housing.pdf).

## Going Green: Organization-Wide

Most recently, REACH began an ambitious organization-wide *Going Green* initiative to make every aspect of their operations greener and healthier. A six-month contest to reduce paper consumption resulted in a 23% reduction in paper use; automatic switches were put on lighting in all communal meeting areas, resulting in a 10% reduction in the office electric bill. A commuter challenge has several employees taking transit at least once a month, and a new incentive program for bikers and transit users began in early 2010.

## Going for the Triple Bottom Line

One of the major issues affordable housing developers often cite for not going green is the additional cost. Countless studies have shown that the upfront costs associated with green building are minimal and are offset by the returns provided from energy savings and related life-cycle costs of using more durable materials.<sup>15</sup> Moreover, as developers become more familiar with building to green standards, the upfront premium costs diminish rapidly. A recent Portland, OR study, where green building measures are now common, found “no statistically significant difference” between standard construction costs and those related to green building.<sup>16</sup>

Few studies have been conducted that directly associate health care costs with green building; however, findings from the Breathe-Easy Homes clearly show that the benefits gained from the green building measures are not limited to a reduction in sick days, they also extend to the pocketbook. Healthier living conditions reduced the need for urgent clinical care and prescription drugs, providing a significant monetary savings for both residents and the larger community. The modest \$5,000 to \$7,000 cost increase associated with the upgrades in the Breathe-Easy Homes is equivalent to a one-night hospital stay or the approximate annual amount a family pays in medical care.

And the health care cost savings are not limited to individual families: public costs related to acute asthma care are significant. The Asthma and Allergy Foundation of America estimates that the total care of asthma related conditions in the United States is

As the relationship between green building and health is studied further, it is anticipated that cost savings beyond those related to asthma and respiratory illnesses will emerge.

<sup>15</sup> A study done by New Ecology and the Tellus Institute, found that the upfront development costs related to green building ranged from “18% below to 9% above” conventional construction of affordable housing, with the average premium being about 2.4%. More information about the Costs and Benefits of Green Affordable Housing can be found online at <http://www.newecology.org/costs-and-benefits-green-affordable-housing-study>.

<sup>16</sup> Cost of Green Analysis for Affordable Housing in Seattle and Portland. Prepared by David Langdon, LLP. July 2009. Available online at <http://www.pdc.us/pdf/sustainability/greenbuilding/Langdon-Cost-of-Green-Affordable-Housing-Study.pdf>. Accessed January 11, 2011.

approximately \$18.3 billion annually. Direct costs, such as medicines and health services, account for \$10.1 of that amount, with the largest single medical expenditure being inpatient hospitalization services. Indirect costs related to lost productivity due to missed work and school days run approximately \$8.2 billion.<sup>17</sup>

As the relationship between green building and health is studied further, it is anticipated that cost savings beyond those related to asthma and respiratory illnesses will emerge. NCHH recently reconnected with its old Viking Terrace partners, SWMHP and CSBR, on the nation's first study examining the health impact of green renovations on older Americans. The Green Rehabilitation of Elder Apartment Treatments or “GREAT” Study will evaluate if green, healthy renovations improve the health of elderly residents in a public housing complex. The study will examine respiratory, cardiovascular, mental health, and overall health status.

The renovation site currently consists of 101 one-bedroom units. Residents exhibit a high prevalence of asthma, depression, and other health problems. Development improvements will meet Minnesota Green Communities Criteria, which includes standards for eight areas of housing renovation: integrated design process; location and neighborhood fabric; site; water conservation; energy conservation; materials and resources; healthy living environment; and operations and management. A major focus of the renovation from a healthy living perspective is the integration of internal and external walking trails, common space for meals, local clinic health services, and a smoke-free environment.

After adjusting for inflation, per capita health care costs for older people increased from \$8,644 in 1992 to \$13,052 in 2004. By 2030 the older population is expected to exceed 70 million people, representing nearly 20% of the population. Green healthy housing is being shown to improve health and help contain health care costs. If the trends continue, investing in green elder housing could be a cost-effective way to minimize health discomforts and improve health conditions for seniors. Although healthy housing has traditionally focused on childhood diseases and injuries associated with housing quality, the GREAT study will help determine if improvements are also evident in the at-risk and growing elderly population.

## Adapting to Climate Change: No Longer the Next Generation of Construction

Green building standards attempt to mitigate the negative impacts of the built environment on the environment by slowing greenhouse gas emissions. But is it enough? Many environmentalists and building professionals believe it is time the built environment adapted to climate change. Developers can incorporate many measures now to help begin adapting our homes to meet the demands of climate change. And similar to green building, most climate adaptation strategies offer benefits such as reduced operating costs, lower greenhouse gas emissions, and greater durability.

<sup>17</sup> Cost of Asthma. Asthma and Allergy Foundation of America at [www.aafa.org/display.cfm?id=6&sub=63](http://www.aafa.org/display.cfm?id=6&sub=63).

Adapting the built environment to climate change means constructing buildings so that they address specific climate issues.<sup>18</sup> Buildings in warmer climates should be designed to incorporate cooling-load-avoidance measures that limit exposure to solar gains, reduce excess waste heat generation from lighting and appliances, and allow natural ventilation to provide back-up cooling during power outages.

It means incorporating design and planning measures that reduce the potential and/or severity of water shortages in regions already suffering from droughts and water shortages, as well as anticipating water shortages in areas with relatively high levels of precipitation, which we are beginning to realize are not immune to droughts.

Although buildings often incorporate many water-efficient measures, adapting to climate change also suggests buildings should be plumbed to incorporate water-conservation measures and allow for graywater collection.<sup>19</sup> Measures should be taken to harvest rainwater, not only for outdoor irrigation, but also for toilet flushing and even for potable use after proper filtration and treatment.

Climate change promises more severe storms, which means flooding and high winds. Just as development should be discouraged in the driest regions to deal with drought and water shortages, building in flood zones should be avoided. Buildings should be designed and built with better wind resistance measures to handle extreme winds.

Another concept building and environmental professionals are examining, especially in the wake of Hurricane Katrina, is “passive survivability.” Passive survivability is the idea that buildings can be designed to safeguard basic human health and safety even if electricity or other utilities fail during a natural disaster.<sup>20</sup>

Finally, climate changes will also produce variations in predator-prey relationships leaving some pests flourishing with their prey disappearing. Designing homes and landscaping to restrict pest infestations will become even more important.

As affordable housing developers learn and incorporate more green building techniques into their construction practices, they should also proactively incorporate building practices that adapt to climate change. Historically, low-income families are the hardest hit by natural disasters and storms. Efforts to lower their risks and allow their homes to survive climate change impacts should be incorporated into construction practices as soon as possible.

## Lessons Learned

While the learning curve to build to green criteria may seem intimidating, resources for those interested in taking the plunge are

While the learning curve to build to green criteria may seem intimidating, resources for those interested in taking the plunge are growing every day.

growing every day. One of the best resources is learning from the experience of those who have gone before. Although each project is different and lessons are learned during each undertaking, here are some of the prime lessons the featured developers learned:

### Pre-Development: Before You Begin the Construction or Renovation Design Process

1. Start your visioning process with your staff and board to get early buy-in; then integrate residents as well as other stakeholders including funders and investors. Work closely with residents so that they understand the costs and benefits of green design. Their health and safety concerns, lifestyles, and cultural approaches can impact green health and housing decisions and effectiveness. Ask them for input on decisions, such as whether to go “smoke free,” how to incorporate IPM techniques, and also on the finishes that are being considered for their homes. Keep your residents and stakeholders involved throughout the design and construction process.
2. Make your green decisions early. Determine your building performance and health goals, then work with an architect, engineer, and general contractor skilled in green building to identify which green elements can best help you achieve them. Conduct cost/benefit analysis of each major green element to understand its value and operational payback period. Evaluate elements from both a first-cost and long-term benefit perspective to determine their ultimate value to the project. Make this analysis an essential part of your proposal(s) to potential investors and funders to help them understand long-term return-on-investment.
3. Conduct pre-renovation testing and evaluation to identify problems and set renovation priorities. Pre-testing helps target areas that need extra attention and provides essential information about your existing systems. It allows you to set benchmarks along the way to ensure you reach your goals.
4. Incorporate all green materials and systems into your construction drawings to ensure accurate bidding and that your contractors have the necessary green building expertise and experience your project requires.

### During the Construction/Renovation Phase

5. Conduct ventilation and environmental testing throughout the renovation process to detect problems early and ensure systems perform as intended.
6. Recognize that many new “green” systems are not intuitive. Systems such as geothermal require training for property management and maintenance staff to ensure proper system maintenance and care. During this stage, make sure your in-

<sup>18</sup> Alex Wilson and Andrea Ward, *Design for Adaptation: Living in a Climate-Changing World*, *Environmental Building News*, September 2009. Vol 18, No. 9. Available online at: <http://www.buildinggreen.com/auth/article.cfm/2009/8/28/Design-for-Adaptation-Living-in-a-Climite-Changing-World/>

<sup>19</sup> While several jurisdictions currently restrict graywater collection and reuse, it is highly likely those restrictions could be lifted in the future, especially under drought conditions.

<sup>20</sup> The Reality of Climate Change, Alex Wilson and Andrea Ward. *Environmental Building News*, Vol 18, No 9. September 1, 2009.



house staff receives the training necessary to meet system demands. Identify external vendors with the appropriate skills for the upkeep of your system(s).

7. Conduct building commissioning at the end of the process to ensure you hit your performance targets. Identify any remaining problems—and fix them—before residents move in.

### On-Going

8. Implementation of new products and practices that impact lifestyles require on-going resident education and interaction to succeed. Provide residential education and trainings to ensure that green measures achieve their desired impact. Energy efficiency and health measures are easily mitigated by a variety of factors including an influx of energy intense consumer products, using of toxic cleaning products, and resident behavior.
9. Get buy-in from maintenance staff, especially when improved indoor environmental quality is a major goal. For example, filters must be changed frequently to ensure that ventilation systems work properly. Provide on-going trainings to help maintenance staff understand how new green products and techniques work.
10. If one of your major goals is helping improve your residents' health, have community health workers make regular visits to homes to provide healthy living tips/lessons to residents and develop individual strategies to help improve health conditions and make referrals for support, when necessary. Make sure health workers speak the native language of residents or provide translators. When possible, train and hire residents as community health workers. Studies show that peers carry more

weight than government agency staff or other officials who do not come from the community.

### Conclusion

Although further study is needed, there are clearly numerous health benefits of “going green.” Asthma and other respiratory illnesses improve for residents in housing built or retrofitted to green building criteria. Measures that tighten building envelopes to improve performance help significantly reduce airborne contaminants. Installing radon resistant building features reduces a major lung cancer risk. Vapor barriers and improved ventilation systems, including better exhaust fans in kitchens and baths, minimize moisture within homes to help eliminate mold and mildew. Installing programmable heating and cooling systems improves residents' thermal comfort. Natural lighting helps improve residents' mental outlook. IPM controls reduce exposure to pests and harmful chemicals.

The health benefits of green building are not limited to improving indoor environmental quality alone. Siting and landscaping efforts that include walking and bike paths as part of access to local retail and amenities lead to increased outdoor physical activities. Green building standards that promote community gardens and other outdoor improvements help raise not only nutritional and social benefits for participating residents, but also, in some instances, economic benefits.

Continued collaboration between housing, health, building, and environmental professionals can ensure that green and healthy renovations are done holistically to gain the greatest economic and health benefits. They can also ensure that buildings not only help mitigate their negative impacts on the environment, but also meet the demands that a changing climate will bring.



## Appendix: Key Green Elements of the NCHH Case Studies

Viking Terrace	Wheeler Terrace	Nuevo Amanecer	Breath-Easy Homes
<ul style="list-style-type: none"> <li>• High-efficiency geothermal heating and cooling system</li> <li>• Tightened building envelope through weather sealing, improved siding and upgraded insulation;</li> <li>• ENERGY STAR appliances</li> <li>• Water conserving appliances and fixtures, such as dual flush toilets and low-flow shower heads</li> <li>• Whole Unit ventilation system, including continuous bathroom ventilation</li> <li>• Low-VOC paints sealants and adhesives</li> <li>• Cement-board siding</li> <li>• Interior finish materials with recycled content</li> <li>• On-site recycling of demolition and construction materials</li> <li>• Metal roof and truss system</li> <li>• Radon, testing, monitoring and remediation</li> <li>• Increased green space surrounding complex buildings</li> <li>• Located close to public transportation, retail and other services</li> <li>• Occupancy sensors</li> <li>• On-site tenant education</li> <li>• Integrated pest management construction</li> </ul>	<ul style="list-style-type: none"> <li>• Geothermal heat pump with DeSuperheater for hot water</li> <li>• Sealed building envelop for moisture control and pest intrusion*</li> <li>• High-efficiency Insulation</li> <li>• ENERGY STAR appliances and lighting</li> <li>• Water efficient fixtures, including low-flow shower heads, dual flush toilets</li> <li>• Improved ventilation system that provides fresh air supply and distribution*</li> <li>• Operable energy-efficient windows</li> <li>• Installation of energy-efficient bathroom and kitchen exhaust fans*</li> <li>• Low-VOC paints, sealants, adhesives, cabinets, carpet and flooring.</li> <li>• Environmentally-friendly building materials with high pre- and post-consumer recycled content (flooring, gypsum board and concrete)</li> <li>• Preserved/Salvaged: 100% structural elements; 80% nonstructural elements</li> <li>• Recycled construction waste</li> <li>• Flat roofs replaced with energy efficient white/ reflective polymer pitched roof that does not add to HIE</li> <li>• Upgraded infrastructure and sewage system</li> <li>• Stormwater sand filter system</li> <li>• Integrated Pest Management *</li> <li>• Green opportunities center w/ interactive green education exhibits and community space</li> <li>• Community garden</li> <li>• Transportation accessible: Bus stop in front of complex; Metro ½ mile away</li> <li>• Construction and development staff training*</li> <li>• Healthy homes resident education*</li> <li>• Rubber walk-off mats*</li> </ul>	<ul style="list-style-type: none"> <li>• Energy-efficient water heaters</li> <li>• PV hot water heater for community laundry</li> <li>• Most buildings PV-ready</li> <li>• Upgraded, weatherized building shell;</li> <li>• New insulation</li> <li>• Energy-efficient doors and windows</li> <li>• ENERGY STAR appliances and fixtures</li> <li>• Installed whole building ventilation system</li> <li>• Automatic mechanical ventilation system</li> <li>• ENERGY STAR bathroom exhaust fans equipped with timers</li> <li>• Kitchens vented to outside</li> <li>• Low/No VOC paints, sealants and adhesives</li> <li>• Improved outdoor lighting; lighting on motion sensors and timers</li> <li>• Salvaged and recycled material in construction</li> <li>• On-site construction recycled</li> <li>• High-efficiency irrigation system</li> <li>• Enhanced landscaping to reduce irrigation needs</li> <li>• Integrated Pest Management</li> <li>• Walkable to community amenities</li> <li>• Bus transportation on-site; additional bus stops within ¼ mile</li> <li>• Smoke-free site</li> <li>• Limited carpeting within units and common areas to avoid tracking in pesticides</li> </ul>	<ul style="list-style-type: none"> <li>• Hydronic (water/radiator) heating system</li> <li>• Airtight drywall installation</li> <li>• Insulated windows and foundation</li> <li>• Advanced air filtration system with filtered fresh air intake ports in all living spaces and bedrooms</li> <li>• Quiet, whole-house fan</li> <li>• Low off-gas vinyl flooring with recycled content in bathrooms and kitchens</li> <li>• Low -VOC paints, caulking and sealants</li> <li>• Sealed cabinet construction</li> <li>• Unit/housing layouts which feature open floor plans and large windows for good daylight penetration</li> <li>• Walkable amenities: medical and dental clinic, new library, retail center, community center and athletic fields, more than 20 acres of land for parks, open space and playgrounds for outdoor activities</li> <li>• Positive whole house ventilation systems: Removes stale air, filters incoming air and reduces moisture**</li> <li>• Linoleum flooring in living areas and bedrooms, recycled content vinyl flooring in bathrooms and kitchens, lowpile carpeting in stair and halls to reduce allergens**</li> <li>• Low/no off-gas trim and mill work to reduce urea formaldehyde bonding agents**</li> <li>• Low/no off-gas or VOC cabinet construction**</li> <li>• HEPA filter vacuums to remove allergens**</li> <li>• Walk-off doormats to reduce dirt in the homes**</li> <li>• Special attention to protect building materials from moisture during construction including: extra dry-out time to minimize mold growth; weather protection of on-site materials; ductwork protection to minimize dust, extra clean cycling with low/non-toxic and non-allergenic cleaners; and flush-outs to allow evaporation and off-gassing of materials**</li> <li>• Window blinds instead of curtains to reduce dust**</li> </ul>

\* Specific Healthy Homes Additions

\*\* Specific Healthy/Breathe-Easy Elements