THE COSTS & BENEFITS OF GREEN AFFORDABLE HOUSING

New Ecology Inc. Environmental Protection and Economic Development in Urban Communities

Tellus Institute for a Great Transition

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The Costs and Benefits of Green Affordable Housing

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&
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Executive Summary

Green building has emerged over the past decade as a robust movement to create high-performance, energy-efficient structures that improve occupant comfort and well-being while minimizing environmental impacts. Supported by organizations such as the U.S. Green Building Council and its Leadership in Energy and Environmental Design (LEED) standards, both public and private entities are increasingly pursuing green buildings in the institutional, commercial, and residential sectors. While this progress is impressive, for a number of reasons it has not included significant numbers of affordable housing projects. These reasons, several of which are unique to affordable housing, include: an almost exclusive focus on "first costs," the existence of per unit cost caps, regulatory rigidity that limits green innovation, and a finance system that fails to recognize the long-term value of green investments.

A common perception has been that green costs more and is, therefore, not suitable for affordable housing. Recent studies have documented the costs and benefits of green building in the commercial and institutional sector,[1] reporting that green buildings have a modest initial cost premium, but that long-term benefits far exceed the incremental capital costs. These findings have bolstered green building activity in these sectors, but their applicability to affordable housing development has been viewed with considerable skepticism.

Until now, however, no such systematic study has evaluated the costs and benefits of greening in the affordable housing sector. The current report attempts to fill this gap. We have surveyed green affordable housing projects around the country and conducted detailed case study analyses of the costs and benefits of sixteen projects for which adequate data was available.

Notwithstanding significant data gathering and methodological challenges, analysis of these case studies have led to several key findings, including:

- Community development corporations (CDCs) and other mission-driven community-based organizations are natural leaders in the effort to build green affordable housing.
- The current system to assess financial viability of green affordable housing, focused on initial capital costs, is deeply flawed. Life-cycle costing in which both capital and operating costs are considered over the expected life of a building provides a better understanding of project economics.
- Using a life-cycle approach, green affordable housing is more cost effective in net present value (NPV) terms than conventional affordable housing.
- The existing financing system for affordable housing is complex and rigid, and typically does not recognize the long-term value of green investments. This serves as an impediment to widespread development of green affordable housing.

Total development costs for the green projects reviewed in this report ranged from 18% below to 9% above the costs for comparable conventional affordable housing. On average, the sixteen case studies show a small "green premium" of 2.42% in total development costs.[2] These incremental costs are largely due to increased construction (as opposed to design) costs.

From a life-cycle net present value perspective, the case studies show that the benefits of green affordable housing are real and, in some cases, substantial. In virtually all the cases, energy and water utility costs are lower than their conventional counterparts. In many cases, decreased operating expenditures alone more than pay for the incremental initial investment in greening the project in present value terms.[3] The use of more durable materials and equipment in several of the case study projects result in reduced replacement costs and provide additional life-cycle financial benefits. Moreover, the value of improved comfort and health for residents, as well as reduced environmental impacts, is substantial, although not captured quantitatively in our analyses.

While the case studies presented in this report demonstrate that life-cycle green building benefits exceed costs in almost all cases, those economic impacts are not the same for all parties. Developers, owners and residents experience different life-cycle costs and benefits of green affordable housing. For example the costs to developers range from about $9,700 more per unit to $34,800 less per unit in net present value terms than the non-green alternative. This wide range and whether developers experienced gains or losses depends largely on whether the developer retains a long-term ownership interest and whether the owners or residents are responsible for utility costs (and savings). In five of the sixteen case studies, developers received net benefits from greening, in two cases greening the project had no net financial effect on the developers, while in nine cases the developers experienced net losses relative to investing in comparable conventional projects.[4]

For residents of affordable housing units, the life-cycle financial outcome is almost always positive, ranging from a NPV of -$140 to $59,861 per unit. This is the case largely because owners/residents are not responsible for the incremental capital costs of greening, but they receive the benefits of lower utility costs, not to mention the unquantified benefits of improved comfort and better indoor air quality. In 14 of the 16 cases owners/residents receive a net benefit from greening; in one case, there is no impact on the financial condition of residents, since they are not responsible for any of the utility costs; and in one case residents experience higher net costs from greening, though the project developer attributes this to anomalies in project design and resident demographics.[5]

Several factors have limited the scope of this research. First and foremost, there are a limited number of completed green affordable housing projects with comprehensive data, particularly with respect to green operating costs and the capital and operating costs of comparable conventional projects. With this small data set, broad conclusions from this research must be made cautiously. Moreover, when cost data are available they are often in non-standard formats and stored in disparate locations.

The final section of the report presents a number of suggestions for further research, which if carried out, would provide a larger set of reliable data in a consistent format and help address the limitations of the existing data. We offer additional suggestions to improve understanding of non-economic benefits of greening, the importance of building commissioning, and how the finance system can support greening of affordable housing.

Finally, we provide recommendations for green affordable housing developers and policymakers. We suggest developers focus on assembling an experienced green team, employing an integrated design approach, and utilize life-cycle costing in evaluating the economics of a project. For policymakers, we suggest creating innovative funding mechanisms that recognize the long-term value of green projects, instituting higher mandatory standards for energy efficiency in building codes, and adoption of minimum green standards for affordable housing.

It is our intention that this report informs the broad range of actors involved in developing affordable housing and provides a solid starting point for a better understanding of the costs and benefits of greening these projects. We believe that it makes a strong case that greening affordable housing is cost effective and should be pursued with vigor.

(Endnotes)

[1] The most definitive analysis is contained in a report commissioned by the Sustainable Building Task Force, a group of 40 California state government agencies. *The Costs and Benefits of Green Buildings*, was authored by Greg Kats of Capital E and others, and was published in October 2003.

[2] This premium drops to 1.73% if photovoltaic panels are not included. Often inclusion of such technologies would not have occurred without targeted grant funding support from public agencies or utilities. We calculated the first-cost premium of greening based upon the non-subsidized costs.

[3] Throughout this report, life-cycle costs and benefits are reported in present value terms to account for the time value of money and express the net results in present day dollars. We assume a 30-year life for projects studied.

[4] These results change when green subsidies are included. After grants and rebates specifically for green building features, seven developers have green building benefits that outweigh costs, three break even, and six have costs that outweigh benefits.

[5] See the Brick Capital case study for details.

BACKGROUND

ORGANIZATION OF THIS REPORT

WHAT IS GREEN AFFORDABLE HOUSING?

COMMUNITY BASED ORGANIZATIONS AS VEHICLES FOR GREEN AFFORDABLE HOUSING

CHALLENGES OF BUILDING GREEN AFFORDABLE HOUSING

WHY FOCUS ON AFFORDABLE HOUSING?

INTRODUCTION

Background

Over the past decade there has been a virtual explosion of activity in the green building field. While the goals of green building are easy to embrace in concept – resource efficiency, habitat conservation, improved occupant health, better pedestrian environments, and a commitment to high-quality buildings – they are more difficult to achieve in practice, especially in affordable housing. Many colleagues in the affordable housing world are sensitive to the environmental and community impacts of development, but feel that their work is already too difficult to afford the luxury of addressing green building concerns. A precious few see housing affordability, sprawl, indoor environmental quality, loss of habitat, loss of community character, and resource and material waste as a set of interconnected problems calling out for more comprehensive solutions. Many of those colleagues have managed to conceive of green projects and sometimes even build them, but this has presented a new set of problems. The current affordable housing finance system, characterized by a focus on initial capital costs, cost caps, and other regulatory and financing constraints, often impedes the realization of the benefits of green building.[1]

At the same time, many institutional actors have developed green building standards that support and promote a more sustainable building stock. In 1993, the U.S. Green Building Council (USGBC) developed the Leadership in Energy and Environmental Design (LEED) system, a voluntary consensus-based national standard for developing high-performance, sustainable commercial buildings. To date, about 275 commercial buildings have been LEED certified and over 2,000 buildings have applied for certification. LEED's efforts have been paralleled (and sometimes preceded) by regional and local efforts to green buildings, most often housing. Since 1992, over 80 municipal and state green rating programs have been developed, and while there is a great deal of variation in the structure and administration of these programs, most of them focus on residential buildings, usually single-family homes. In addition, the U.S. Environmental Protection Agency and Department of Energy's Energy Star Homes and the National Association of Homebuilders have both developed national standards by which greenness can be measured and compared. The current report is a major contribution to a growing movement to extend this .institutional effort to green affordable housing.[2]

In the course of working with Massachusetts community development corporations in recent years, a strong interest has been expressed among community developers in achieving the benefits of green development strategies. However, a common question has been, "What effect will this new approach to building have on my projects' bottom-line?" In order to provide CBOs a full picture of what they might expect when building green, we developed this detailed analysis of actual experience concerning the costs and benefits of green affordable housing projects. Simply, this report grew out of a demand by community-based developers for information about how green building applies to affordable housing and the implications for the economics of such projects. The main goal of this report is to help address the important questions of how community based developers have successfully greened affordable housing projects and whether or not these projects were cost effective.

Organization of This Report

The report is divided into several sections. Following this introduction, the second section describes our methodology and process for data gathering and analysis. The third section presents sixteen detailed case studies from completed green affordable housing projects throughout the U.S. It also highlights any case-specific variation from the standard procedure presented in the methodology section. The final section details our findings and includes discussions of the limitations of the report, future areas for study, and recommendations to align affordable housing finance and policy with green development approaches.

Before proceeding it is important to establish a common understanding of what we mean by green affordable housing and the process used for carrying out this research.

What is Green Affordable Housing?

According to the United States Department of Housing and Urban Development (HUD) affordable housing is housing whose cost (in rent or mortgage payments) does not exceed 30% of the gross monthly income of a low-income household. Low-income households are defined through a HUD-promulgated formula that accounts for variation in area median income and family size. Whether a particular home is affordable for a given household is a function of price, area income, the family's income, and family size. Often, the term affordable housing is confused with public housing, which is housing that is owned and operated by a public agency, usually a local housing authority. In reality, the majority of the affordable housing built in the last 15 years (even publicly-funded affordable housing) is privately owned, either by community-based organizations (described in more detail below) or by for-profit developers taking advantage of the federal Low-Income Housing Tax Credit (LIHTC) program.[3] In this report, affordable housing refers to housing that is developed to be affordable for low and moderate income households defined by HUD as 80% or less of area median income (AMI), and 81%-120% AMI, respectively.

The other half of the definition of green affordable housing rests on an understanding of green building. According to urban economist Mark Smith and architect Deborah Weintraub, green building "includes three important components: resource conservation during design and construction; resource conservation during operations; and protection of occupants' health, well being, and productivity."[4] Others emphasize the protection of more ephemeral things like "community and cultural sensitivity," saying that green projects "blend in with the natural environment and protect open space; increase a sense of community, and address cultural issues."[5] The most complete definitions add a financial emphasis, embedding the claim that more effectively utilizing human and natural capital will reap financial rewards. The Green Development Services arm of the Rocky Mountain Institute says green development is a "field in which the pursuit of environmental excellence produces fundamentally better buildings and communities – more comfortable, more efficient, more appealing, and ultimately more profitable."[6] For the purposes of this report, we have used a broad definition incorporating various elements of the above.

Though green buildings are often promoted as reducing impacts on the environment – less natural resources and energy use, improved air quality through use of non-toxic materials, lower greenhouse gas emissions – it is important to consider green building in the context of the conventional goals for affordable housing: affordability, performance, and health. Green building principles can help achieve these objectives while at the same time improving environmental performance.

- **Affordability:** Green housing is not necessarily more expensive to construct and in some cases can be built below the cost of conventional housing. From a long-term (building lifetime) perspective, the improved efficiency of a green building reduces the operating costs associated with electricity, heating fuel, and water.
- **Performance:** Green practices can improve the durability of a building so that it lasts a long time without significant degradation, thereby reducing maintenance requirements and avoiding future replacements. Improved building envelope, temperature control, and appropriate ventilation can lead to higher levels of comfort, an important element of green buildings.
- **Health:** By choosing materials carefully during the design phase and through proper installation and maintenance of heating, ventilation, and air conditioning systems, indoor air quality can be made healthier for the building's inhabitants, and emissions to the environment can be reduced.

There are considerable opportunities for greening throughout the building process, from site selection and design, to material selection and construction, to operations and maintenance.[7] Each building project, whether new construction or renovation, must identify those that are most appropriate and feasible for the particular circumstances, while keeping in mind the overall goals of affordable housing listed above. It is useful to think of greening alternatives as a series of menu options that project developers (along with other project stakeholders) need to review in the planning and design process. Examples of these opportunities include but are not limited to the following:

- Site selection:
  Is it possible to locate the project on a brownfield site or as an infill project?
  Is the project site served by existing infrastructure (i.e. utilities, roads)?
  Can the project be located near public transportation?

- Site design:
  Can the project take advantage of low-water and low-chemical landscaping?

Is it possible to incorporate pervious pavement to minimize runoff?

- Building design:
  Has an integrated design process been used in which a "whole-building" approach identifies how different building components work together in order to maximize green benefits?
  Can the building be situated to maximize daylighting and passive solar heating?
  Can sustainably harvested wood be used?
  Are non-toxic flooring and low-VOC paints options?
  Have durable materials been selected?

- Construction methods:
  Is modular construction or use of modular building components possible?[8]
  Can optimal value engineering or advanced framing techniques be used to lower the material, labor and energy requirements?
  Is a construction waste management plan in place to maximum recycling?

- Energy efficiency and indoor air quality:
  Is the building envelope tight and is adequate insulation utilized?
  Are heating, ventilation, and air cooling systems efficient and properly sized?
  Are non-toxic construction materials and finishes used?

- Building operations and maintenance:
  Have highly durable materials and equipment been utilized?
  Are residents responsible for their own utility costs and, therefore, more motivated to consume less energy and water?
  Do residents know how to properly operate and maintain heating, ventilation, and cooling systems?

- Project financing:
  Have the benefits of lower operating, maintenance and replacement costs been considered by project financiers?
  Have utility rebates and other non-traditional financing sources been explored?

This report does not explore the costs and benefits of each of these opportunities individually. In fact, given the many project-specific factors that impact such costs and benefits – e.g., climate, site conditions, distance to suppliers of building materials and equipment, labor costs – plus the relationships among green elements, such an exploration would be extremely difficult. Rather, we have utilized integrated design and a life-cycle costing framework.. Integrated design has important cost implications as it fundamentally alters how the design and construction team interact and significantly impacts the selection of materials, components, and systems. Life-cycle costing is critical for understanding the economics of a building over the long term and for comparing the costs and benefits of green affordable housing with conventional projects.

Integrated Design

The integrated design process involves all members of a project team (owners, facility managers, design professionals, contractors, and subcontractors) from the outset of the design process in order to provide a shared understanding of project goals, priorities, and constraints. In particular, integrated design involves a whole-building approach in which designers and building professionals from different disciplines gain an overall picture of how the different building components can work together intelligently. It integrates the architecture with the mechanical, electrical, and plumbing systems to identify synergistic benefits.

Integrated design aims to promote high benefit at low cost by achieving synergies across disciplines and technologies. In theory, green building projects that are well integrated and are comprehensive in scope can result in project development costs that are comparable to or sometimes lower than those of conventional buildings. Integrated design can use the savings from some strategies to pay for the incremental cost of others. For example, energy-efficient building envelopes can reduce equipment needs – downsizing some equipment, such as boilers, or in some cases even eliminating equipment, such as perimeter heating. To date, there has been little hard data available that addresses the degree to which integrated design impacts the costs of developing and operating green buildings, especially green affordable housing. This report attempts to fill this gap.

Though resource efficiency improvements are the easiest to quantify, improved health and environmental quality, as well as enhanced community aspects of green design, are also important benefits. The benefits of greening can be categorized as follows.

Resource Efficiency

Techniques that reduce impacts resulting from less use of resources throughout the life cycle of the building include those relating to siting and land use decisions, whole-building integrated design, as well as material selection and building practices. For example, green approaches aim to reduce wasted materials during construction or employ advanced framing techniques that minimize wood requirements. More importantly, integrated heating and cooling system design, energy-efficient windows, design for passive solar, and energy-efficient appliances can reduce the amount of energy, water, and waste generated during the use of the building. The use of more durable materials and components is another green design technique that saves materials (and costs) through avoided maintenance and replacement.

Improved Health and Environmental Quality

There is now strong evidence that residents of low-income housing suffer disproportionately from elevated levels of asthma and upper respiratory conditions.[9] Building practices that reduce impacts on human health and the environment include the use of less toxic materials and better heating, cooling and ventilation design to improve indoor air quality. Using low-VOC paints, adhesives, and carpets, for example, lowers toxic exposures experienced by workers and occupants and ultimately reduces releases into the air, water, and land. Environmental benefits can be gained through product selection, such as the use of sustainably harvested wood and the use of products made from recycled materials. Many of these techniques and products only require forethought and investigation during design and may not add to the cost of the building. Moreover, costs for many green products and services are decreasing as they become more commonplace.

Enhanced Community
Part of comprehensive green affordable housing design includes consideration of how the project fits into and enhances the surrounding community. This starts with the selection of an appropriate site (e.g., consistent with a neighborhood development plan, an infill project, and/or proximate to transportation and other services) and takes into account the quality and quantity of human interaction in and around the development. It includes attention to exterior lighting and other safety features and the design of public spaces to foster a sense of involvement and neighborliness. Appropriate site selection and project design can minimize strain on local infrastructure and add to the cohesiveness and quality of life of a neighborhood.

Community-Based Organizations as Vehicles for Green Affordable Housing

Community-based organizations (CBOs) and other non-profit developers have played a critical role in providing housing, commercial development, job training, and other services in low- and moderate-income neighborhoods throughout the U.S. since the 1970s. In turn, these efforts have produced direct and substantial environmental benefits by creating and restoring mixed-use developments near mass transit and other existing infrastructure and reducing exposure to hazardous building materials such as lead paint. CBOs are important levers for community change and, ultimately, sustainability itself.

The National Congress for Community Economic Development (NCCED) summarized the national accomplishments of CBOs in its 1999 report *Coming of Age: Trends and Achievements of Community-based Development Organizations*.[10] The report describes how the nation's 3,600 community-based development organizations built a thirty-year track record of successful neighborhood revitalization. These 501(c)(3) nonprofit organizations:

- Helped people live in 550,000 affordable homes and apartments;
- Produced 71 million square feet of commercial and industrial space, creating jobs and business activities;
- Loaned $1.9 billion to 59,000 businesses; and
- Created 247,000 private sector jobs.

In addition, CBOs frequently provide social services and push for policy reform to ensure that residents of the community have access to economic supports such as banking services and investment, home ownership, and business opportunities. It is estimated that the work of CBOs affects 25 million people throughout the U.S.[11]

State Level Contributions: Massachusetts CDCs

In Massachusetts, for example, the over 65 CDCs have benefited over 36,000 households by providing new housing for rent or home ownership, renovation of existing housing, homebuyer counseling, lead paint abatement, and tenant-landlord mediation. The state's CDCs have also combated blight by attracting new businesses, developing commercial and office space, and preserving historic buildings. According to the Massachusetts Association of CDCs 2001 Production and Pipeline Report, Massachusetts CDCs have developed more than 50 commercial and over 20 mixed-use developments (residential and commercial), resulting in 1.7 million square feet of improved or newly created commercial space, and almost 1,500 jobs. Though mixed-use developments are complex and difficult to finance, CDCs are among their strongest proponents as they recognize the positive impacts that such developments can have on the quality of life of neighborhoods.

CBOs provide affordable housing while advocating environmental sustainability, protection of human health, and community development. This unique combination of attributes makes CBOs a highly suitable vehicle for delivering green affordable housing projects. Developing green housing is an effective way for CBOs to both meet community housing needs and their community development goals. The following table presents some of the advantages enjoyed by CBOs in the context of green building.

Non-Profit Developers as Green Builders	
Trusted Local Institutions	*CBOs already engage in affordable housing development and understand the needs of their clients and the social and political landscape in the areas they operate.*
Visibility	*Housing developments implemented by CBOs are often highly visible projects that can be used to demonstrate the viability of green buildings.*
Smart Growth	*CBOs are increasingly participating in "smart growth" initiatives.*
Cost Effective	*Economies of scale for building multiple units increase the cost-effectiveness of using innovative practices and materials and facilitate their mainstreaming. Moreover, as non-profit developers, CBOs often have access to grants or low-cost financing.*
Health of CBO Target Population	*There are often significant residential health issues with the target population of CBOs, therefore making health a major issue to CBOs. Noticeable health benefits occur from improved indoor air quality of green buildings.*
Maintenance Cost Responsibility	*Traditional affordable housing projects tend to require more maintenance than market-rate housing. Maintenance costs are often the responsibility of CBOs; green buildings can be built to be more durable and require less maintenance.*
Community Integration	*The additional up-front planning of green design can lead to projects that are more consistant with the existing community fabric. CBOs are uniquely positioned in the community, facilitating acceptance of their projects.*

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Challenges to Building Green Affordable Housing

Notwithstanding the motivations for community-based non-profits in green housing development, barriers remain that hinder the ability of CBOs to successfully build green housing development projects. Such barriers include the following:

Perceived risk
CBOs have little room for risk or project failure. There is a reluctance to use new materials and methods for publicly funded projects. Anything new is considered risky – innovative or untested green features can reduce confidence. Many developers, funding sources, and contractors fear that following a green agenda will delay project schedules and raise costs. This has led to widespread perception in the non-profit affordable housing community that it is difficult to retain the full developer's fee if a project is going to concern itself with environmental issues. Developer's fees are crucial to CBOs' abilities to finance future projects.

Multiple funding sources
Affordable housing projects often have many funding sources, making it difficult for all parties to agree to and negotiate the inclusion of new and innovative ideas. In addition, funding sources are becoming more and more difficult to find even for conventional projects, and it follows that innovative green development projects face stiff competition.

Many players
There are often more players in an affordable housing project than in a conventional market-rate private development (e.g., underwriters, development consultants, builders, maintenance staff, residents, and the surrounding community), all requiring buy-in. Moreover, new affordable housing projects often face local opposition.

Regulatory burdens
Affordable housing projects that include public financing have even a harder time building green than privately financed projects. In addition to per unit cost caps, they are often subject to local design requirements that limit the opportunity for green design.

Lack of documented success
With the exception of energy efficiency, green building principles have not been widely applied to affordable housing, and actual experience in terms of incremental costs and benefits has not been well documented.

Contracting constraints
CBO construction contracts must often be granted to the lowest bidder, making it difficult to select a contractor with specialized training and knowledge in green building.

Short-term cost focus
Developers and funders often think front-loaded planning and design for green projects will cost more and delay project schedules.

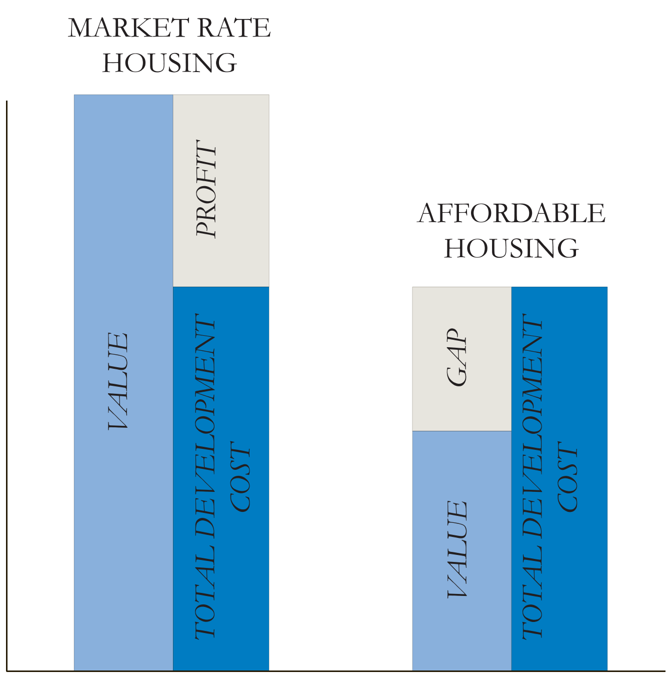
Limited institutional capacity
Low salaries, high turnover, lack of experience drafting green specifications, limited construction supervision expertise, and limited resources to adequately document innovative projects are common problems at CBOs.

Learning curve
There is a significant learning curve required of leaders in any field, and that is especially true with green development. Many CBOs that would like to develop projects that are more environmentally responsible lack readily available information on green contractors and consultants, materials, systems, techniques, and technologies.

Why Focus on Affordable Housing?

In at least one important respect affordable housing development undertaken by CBOs differs from conventional development: it is built to fulfill the social mission of providing low- and moderate-income households with affordable places to live. The cost of affordable housing development often exceeds the revenues that can be derived from property sales or rentals, usually because of sales price or rental caps that ensure affordability. Thus, the costs of constructing and operating affordable housing are almost always subsidized. Because obtaining this subsidy is so difficult, project costs often become the driving variable in how affordable housing is designed, developed, and financed. In contrast, the value of a completed conventional development project must meet or exceed its cost (including developer profit).

Figure 1: Market Rate versus Affordable Housing



Two common strategies are employed by affordable housing financiers to control project costs and limit the resources used to fill the gap for any one project. First, many groups place price caps on construction costs. These caps effectively limit the total development costs that a particular funder will support, and they vary based on geography. (Often a major funder in an area will create a cap and other affordable housing funders follow that standard.) Projects where total development costs exceed this cap are very difficult to finance, and generally will not be built. Second, many funders limit the size of a single award or establish an application system that rewards groups who request smaller amounts of funds.

In green affordable housing, this issue becomes even more important. Recent studies on the costs and benefits of green building in the commercial and institutional sectors show that green buildings often cost 2-3% more in total up-front development costs, but that the present value of operating savings over the life of the buildings more than offset the incremental capital costs.[12] While these life-cycle benefits are increasingly being recognized in the commercial and institutional building market place – as evidenced by the boom in the development of green buildings for corporate offices and college campuses – this has not been the case in the affordable housing arena. In effect, for green affordable housing there is a time mismatch in the way that the standard financing system works. Green affordable housing financed under a system that fails to adequately account for the operating savings over the life of the building; moreover, the controls or caps on initial costs limit the ability of developers to pay any up-front green premium.[13]

This means several things for green affordable housing:

1. Green affordable housing is difficult to develop under the current financing system because it often requires slightly higher up-front costs, while low initial capital costs are the critical factor in funding allocations.
2. Affordable home ownership projects may require direct, up-front subsidy for greening, because it is difficult for the developer to recapture the value in the initial sales transaction. In market-rate green housing, the long-term benefits of greening (i.e. operating savings) may be reflected in a higher sales price, allowing the developer to recoup any incremental costs of greening.[14]

However, project residents benefit the most from this mismatch between investor and beneficiary in the way that green affordable housing is financed and operated. While they generally are not responsible for higher initial development costs, their operating costs are reduced due to the more efficient green features of the buildings. Moreover, they often enjoy more comfortable and healthier living quarters that result from greening.

(Endnotes)

[1] We do not intend to imply that affordable housing finance pays no attention to operating or replacement costs. Instead, we are suggesting that first costs are paramount in funding decisions about affordable housing because the value of most affordable housing does not support its cost. See the sub-section "Why Focus on Affordable Housing" in this introduction for more discussion of this point.

[2] Important contributors to the green affordable housing movement include: Global Green, New Jersey Green Home Office, the cities of Portland, OR, and Seattle, WA, the Green Affordable Housing Coalition of the San Francisco Bay area, and most recently the Enterprise Foundation.

[3] The LIHTC program provides a federal guarantee (indirect subsidy) of a stream of 10 years of tax credits (direct deductions from tax liability) for investments in a property that meets the program's criteria. The most essential requirement that a project must meet in order to qualify for the tax credits is either one of the following: At least 20 percent of the units must be occupied by households with incomes at or below 50 percent of AMI, or at least 40 percent of the units must be occupied by households with incomes at or below 60 percent of AMI.

[4] "Breaking Ground: Environmental Practices and Big Developers," Mark Rodman Smith and Deborah Weintraub, Home Energy Magazine Online, September/October 1998.

[5] See the US Department of Energy, Smart Communities Network website. Green Development Benefits and Basic Elements Page. http://www.sustainable.doe.gov/greendev/benefits.shtml. Accessed on June 24, 2005.

[6] See Rocky Mountain Institute website, Green Development Services homepage. http://www.rmi.org/sitepages/pid168.php. Accessed on June 24, 2005.

[7] See, for example, *A Blueprint for Greening Affordable Housing*, Global Green USA, 1999; and *Green Building: Project Planning & Cost Estimating*, R.S. Means Company, 2002.

[8] Modular construction can be beneficial in at least two ways: 1) reduced labor time and costs; and 2) reduced construction waste.

[9] See New England Asthma Regional Council (ARC) website www.asthmaregionalcouncil.org and the Boston Urban Asthma Coalition's at http://www.buac.org.

[10] *Coming of Age: Trends and Achievements of Community-based Development Organizations*, National Congress for Community Economic Development, 1999.

[11] Ibid.

[12] See, for example, *The Costs and Financial Benefits of Green Buildings*, A Report to California's Sustainable Building Task Force, Greg Kats, et. al., October 2003.

[13] Currently, utility allowances do not vary according to the energy efficiency of a building. Making such allowances flexible to reward increased efficiency/lower utility costs is one way to reflect the value of the green investments.

[14] See "Buying Green" MIT Masters Thesis by Will Bradshaw which shows that green single-family homes in Austin, Texas sell at a 9-10% price premium to unrated homes. Forthcoming.

DATA COLLECTION PROCESS AND SURVEY INSTRUMENT

ANALYZING DATA AND FILLING GAPS

NET PRESENT VALUE ANALYSIS

METHODOLOGY

Methodology

This section describes the data gathering and analysis process used in this report. It is organized into several sections: Data Gathering Process and Survey Instrument, Analyzing Data and Filling Gaps, and Net Present Value Analysis.

Data Gathering Process and Survey Instrument

The project team conducted an extensive literature and internet search to identify possible green affordable housing case studies. Key resources we reviewed include the U.S. Green Building Council's LEED Certified Project List, the U.S. Department of Energy's High Performance Buildings Database and Smart Communities list of green building success stories, and Rocky Mountain Institute's Green Developments database. This was complemented by an outreach effort to national networks of affordable housing funders and developers, and other professionals in the green building field (e.g., Global Green, Southface, and Center for Maximum Potential Building Systems) who have been involved in or are knowledgeable about green affordable housing projects. Through this process, we identified 59 recently constructed green affordable housing projects from around the country (see Appendix 1). We then screened this list of projects based on the following criteria:

- At least 80% of the project had to be reserved for low- and moderate-income households.
- The project had to be predominantly housing.
- The project had to be built without the benefit of sweat-equity or contractor apprenticeship programs.[1]
- The project had to be environmentally superior to standard projects in the area, either by exceeding local code requirements or by including unique green building objectives not commonly associated with such projects.
- The project needed to be completed, occupied, and have at least one year of actual operating experience.

Many projects were removed from consideration because they did not meet one or more of the criteria. The most common reasons for removing a project from consideration were that it did not meet the 80% affordable threshold or it did not have one year of actual operating experience.[2] This decreased our pool of potential projects substantially, from 59 to 32.

We chose to include both homeownership and rental projects and projects of varying size. This decision allowed for a wider pool of potential projects, but it also made data gathering more difficult. There are often significant differences in the way that homeownership and rental projects are financed. In addition, rental projects have access to ongoing operating data that homeownership projects usually do not. While this choice complicated our data gathering and analysis, it did expand the range and scope of projects that we could study.[3]

The research team developed a survey instrument to gather detailed cost and financing data for each project. The survey was pilot tested by managers of two case study projects, who provided valuable feedback on the instrument's clarity and the availability of the requested data. The final survey can be found in Appendix 1. It contains four parts: Instructions, Project Information, Capital Costs and Operating Savings, and Project Financing. Each part is summarized below.

1. *Instructions* – Provides the respondent with basic information about the scope of the research, how the information will be used, the type of information requested, and how to contact members of the research team.
2. *Project Information* – Focuses on basic information such as type of housing, number of units, project completion date, project team members, square footage, total development costs, and operating history.
3. *Capital Costs and Operating Expenses* – Asks for information about how much the green project cost to build and how much it would have cost to build conventionally. Beyond the aggregate comparison, respondents are asked to provide capital costs for each green aspect of the project.[4] In addition, this section asks for detailed information on operating savings relating to energy and water utility costs, plus maintenance and replacement expenses, realized due to the green features.
4. *Project Financing* – Requests information on how the project was financed from pre-development through permanent financing. For each funder, the respondent is asked to report on: the type of funder, the amount and type of funding, the terms of loans, any awareness the funder had of the project's green building objectives, the funder's response to those goals, and whether the funder did any monitoring of the green features.

Once the survey instrument was developed, the team assigned several potential cases to each researcher. For each assigned case, a researcher was responsible for contacting a potential respondent involved in the development (usually a project manager), soliciting that person's involvement in the research, and ultimately getting that person to fill out the survey instrument. The survey instrument could be filled out by the respondent and emailed back, or it could be completed in a phone interview between the researcher and the respondent. At times a combination of a phone interview and respondent completion was used. Ultimately we received completed surveys for 16 cases, roughly a 50% response rate from projects we contacted. (See *Case Study Introduction* section for listing of completed case studies.) These cases appear representative of the larger pool of green affordable housing projects.

In filling out the survey instrument, respondents were asked for several standard documents, including:

- One of the following – the final construction requisition, drawdown request summary, or a final cost certification summary. If these were not available, we asked the respondent to provide the final project development costs.

- One of the following – a 12-month budget to actuals operating report, operating expense information as included in a project audit, or an annual operating report submitted to a lender or regulatory agency. For homeownership projects, we asked if any outside agency had information about the operating performance of these buildings.

The project team used these standard documents to cut down on the variation in information that we received, and to minimize the amount of time and effort required from respondents. While this was helpful in a number of cases, we found that significant follow-up was often needed to translate the standard documents into the categories we used to summarize costs and savings. These categories were based on the LEED system,[5] even though very few of the projects sought out or received LEED certification.

Once the survey was completed, the researcher was responsible for filling in gaps and completing any analysis necessary to translate the survey information into a case study write-up. The process used to do this analysis will be discussed in the next two sections, Analyzing Data and Filling Gaps and Net Present Value Analysis.

Analyzing Data and Filling Gaps

We gathered many different types of information and received data in a variety of forms. The table below shows the types of data that we attempted to gather and the obstacles we encountered for each data type.

Project level background data

Project background data was contained on the project information and capital costs and operating expenses sheets. It included things like how many units were built, how many were affordable for low-income households, the total development cost to build the project, and the costs broken out by LEED categories and by various components and systems. This type of information was the most clearly defined, it was the easiest to obtain, and the data quality was good. When we had problems gathering this type of information, it was usually because the project team was either unwilling or unable to devote time to the survey and research process. Often this was related to staff turnover or limited staff time.

Table 1: Data Types

Data Type	Data Quality	Ease to Obtain	Cleary Defined	Biggest Obstacle
Project Level Data	Good	Easy	Yes	Respondent participation
Green Operations Data	Fair	Fair	Somewhat	Respondent participation
Green Replacement data	Fair	Hard	Yes	Respondent participation
Comparative Operations Data	Poor	Hard	No	Modeling problems
Comparative Replacement Data	Poor	Hard	No	Modeling problems

The biggest hole in the project level data was when developers had not broken down system and component costs beyond the sixteen division CSI (Construction Specifications Institute) format generally used on project specifications and bidding documents. We asked specifically for the cost of green materials and systems, and sometimes this data was not broken out in an accessible way. When information on green material and system costs was not readily available, we asked the project team to provide their best estimate for these costs. In the cases where this was not fruitful, we estimated costs based on RS Means Construction Cost Guides, adjusting for year of construction and project location. Any estimate made by researchers with RS Means was ultimately reviewed and approved by the project team involved in developing the project in question.

Green operations data

Green operations data was reported on the capital costs and operating expenses sheet. This sheet focused on how much it cost to own and operate these buildings, specifically on what the utility costs (including water and sewer) were and how they compared to utility modeling done for the project, if such modeling existed. There was some confusion over the type of data we were trying to gather here, largely in how green operations data overlaps with green replacement data (i.e. should the cost of repainting the exterior be an operations or replacement cost?). Because of the algorithm we used for calculating net present value (discussed later in this section), we focused green operations data on expenses that would occur annually and focused replacement data on expenses that occurred less frequently. For that reason, many common maintenance activities were treated as replacement data and not operations data.

The biggest obstacle in obtaining this information was respondent participation, and the quality of the information obtained was not as good as with the project level data. For homeownership projects in particular, much of the operating data was not available, but we found that even many rental projects did not have reliable mechanisms in place for tracking this information and comparing it to conventional projects. This was true even when the projects made significant investments in green technologies with expectations that savings in utility use and operations would result. When we could not get utility usage information directly from a project team, we worked with the local utility to obtain usage information (often with the support of the project owner). Also, we often had a problem where property management records had utility expenditures over time, but no information about usage or rates. In these cases, we obtained historical usage information directly from the utility and used that to extrapolate usage amounts from the expenditure information contained in property management reports.

Green replacement data

Green replacement data was gathered through follow-up interviews with respondents, through specification information, and from the capital costs and operating expenses sheet. We used the first cost of a given material or system to represent the future replacement cost (grown by our inflation estimate of 4% per LISC underwriting guidelines), and estimated that replacement would occur at some year in the future as supplied by respondents or material specifications. The information on replacement costs was difficult to gather; the biggest limiting obstacle was respondent participation. Moreover, replacement cost data was less reliable and more speculative than the operating data. This lack of reliability resulted in part from the lack of actual replacement cost information (most of these buildings have not had to replace any of the systems in question).

Comparative operations data

Comparative operations data was included on the capital costs and operating expenses sheet and was intended to provide information about how much it would cost to own and operate a hypothetical, comparable conventionally constructed building on the same site. This information was hard to obtain and, by its nature, was the result of some modeling process. In the experience of the research team, energy models vary widely in their accuracy, ,limiting the reliability of comparative operations data. Beyond this, most projects simply did not have estimates of operating costs for a comparable conventional project. While large commercial and institutional projects often conduct such modeling and have estimates for a comparable conventional building, green affordable housing projects generally do not. With very limited project resources, it is unlikely that developers, owners, or property managers will calculate the operating costs for a hypothetical building purely for the sake of comparison. However, most property managers and owners have a good idea of what utility usage and costs are for their portfolio. This data provides a basis for comparison.

To collect comparative operations data, we asked project participants to provide whatever information they had about expected operating costs for a conventionally constructed project. In cases where project managers did not have any information, we relied on already established estimates from utilities, building codes, or Energy Star.[6]

Comparative replacement data

Comparative replacement data was contained on the capital costs and operating expenses sheet and also solicited through interviews with project team members and specification information. It consisted of information about the construction cost and expected life of conventional materials and systems that would have been included in a more conventional project. For example, if a project included linoleum flooring in the kitchen, the conventional flooring alternative would likely have been vinyl tile. Comparative replacement data would have consisted of an estimate of how much it would have cost to install vinyl flooring in the units and an estimate for how long these vinyl floors would last. Some projects had this information, often because estimates were developed through the bidding and specification process, but many other projects did not have the information.

Though challenging, the research team correlated the standard 16-division Construction Specifications Institute (CSI) format that many projects used in reporting their data to the LEED categories used in our analysis. Remaining gaps in the data were filled with construction cost estimates from project teams, including general contractors, or with estimates by the research team using the RS Means Construction Cost Guides, adjusted for location and year of construction.

Thus, we had a wide array of information on these projects that came in varying forms and with varying quality. For most projects there was some special circumstance which required extrapolation or follow-up in order to ensure that we had the best possible information. Often, even the best possible information amounted to little more than extrapolation on the part of either a project team member or a researcher. All instances of such extrapolation are clearly indicated in the case studies and the line of reasoning used by the research team to fill in the gaps is made transparent. In addition, funding agencies often do not follow up to ensure that the investments they have made in green projects are functioning as expected. Some notable exceptions do exist. The state of Illinois Department of Commerce and Community Affairs has a program to track the performance of green materials and systems that are installed in affordable housing. This program was employed by both the Woodlawn and New Homes for South Chicago projects. If broadly employed across the country, this type of program would be invaluable in providing documentation on actual performance of green affordable housing.

In summary, two ideas were paramount in our approach to data analysis and filling in data gaps. First, we used modest estimates of the savings related to efficient operations and lower replacement costs. This is particularly important for affordable housing, because the community-based organizations and affordable housing residents cannot afford housing that over-promises and under-delivers on benefits. Second, we wanted to show both the impact of greening in real economic terms and the effect that rebates and grants for greening had on the costs and benefits. This approach carried over into the net present value analysis described below.

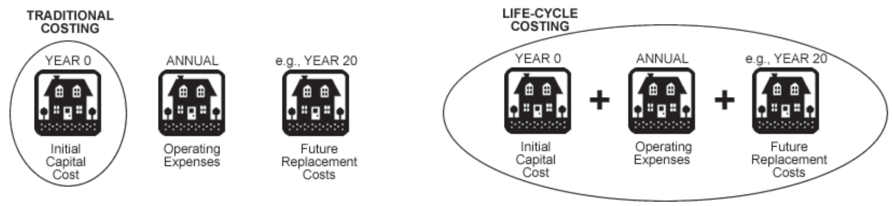
Net Present Value Analysis

This report uses life-cycle costing and present value discounting to analyze and compare the cost of green affordable housing versus conventional affordable housing over a thirty-year life cycle. These related techniques allow one to consider a building's performance over time and to translate current and future expenditures into present day dollars.

Life-Cycle Costing

Traditional costing methods generally do not capture the benefits of greening. For ownership projects, only the initial costs of construction are usually considered. This precludes the inclusion of the future cost savings (e.g., reduced utility bills) achieved through green building techniques. While developers of rental projects do consider operating costs in their financial analyses, generally the reductions in such costs associated with green building have not been fully recognized. Life-cycle costing methods do systematically take into account long-term costs of building operation and maintenance to provide a more accurate picture of the total costs associated with design decisions (e.g., up-front costs, operating costs, future repair costs). Thus a life-cycle costing approach provides a more complete understanding of the economics of green housing and how it compares to conventional housing.

The following graphic presents a simple depiction of traditional up-front versus life-cycle costing.



Increasingly some in the development community are recognizing the importance of life-cycle costing. John Knott, developer of a low-impact housing development on Dewees Island, South Carolina, concludes that "we focus on design and development, yet this is only 20 percent of a building's life; nobody talks about the 80 percent — the operation and life cycle of the building over time."[7] While the economics of affordable housing developments certainly differ from those of communities like Dewees Island, the need to address the life-cycle costs and impacts is equally relevant.

Life-cycle costing accounts for factors beyond the initial design and construction cost of a building and includes costs that occur during the operational phase (e.g., energy, water, maintenance) as well as future costs (e.g., floor or siding replacement, final disposal/recycling of materials). For example, energy-efficient windows may cost more up front, but reduce monthly energy bills down the road. Unlike traditional costing, life-cycle costing takes into account the benefits associated with these future cost savings which offset, at least in part, the incremental purchase cost of the better windows. Of course, future costs and savings must be adjusted to their equivalent value today (i.e. their "present value"). Such discounting procedures provide for the expression of cost streams over time on a consistent basis, and allow for meaningful cost comparisons among different projects or building approaches.[8]

Our Methodology

Using a life-cycle cost framework and present value discounting, we developed a methodology that can be used by affordable housing developers to evaluate the long-term economics of green housing versus traditional housing projects. This methodology focuses on the building itself (not site related work or landscaping) and breaks down costs into four categories: initial capital costs, interest expenses, annual operating costs, and future replacement costs.[9]

1. **Initial capital costs.** This category includes the design and

construction costs of the building. The research team compared the initial capital costs for a green project versus the same project if it had been conventionally designed and constructed. This was done in one of two ways: (a) comparing a green project to a benchmark of a local average for costs; or (b) conducting a side-by-side comparison of a green versus a comparable traditional development (actual or hypothetical).[10] Any increase in initial capital costs for building green is referred to as the green premium.

2. **Additional interest paid on total development costs.** In cases where a green building costs more than a conventional building, the developer incurs more interest on the portion of the building's cost that is financed by long-term debt. Based on the experience of the Local Initiatives Support Corporation (LISC), we estimated that 40% of affordable housing project costs are financed by long-term debt, and that standard terms include a 20-year mortgage, paid monthly. In other cases, where available, we used actual debt figures and terms. With these assumptions and the project's prevailing loan rate, we modeled the additional interest cost due to changes in the initial development costs of a green building. In this calculation, we ignored repayment of additional principal because it is accounted for by including the green premium (or reduction) in present value calculations. Note that in the one case where total development costs for the green project were less than for a comparable conventional project (Erie Ellington), we did not include interest savings in our net present value calculation. We did not include such savings because they do not correspond to any actual project cost (i.e. if a project costs $80,000 less to build, the developer does not earn interest on some equity portion of this savings at the prevailing rate of debt).

3. **Operating cost comparison.** This category includes the costs of operating the building, such as utilities (e.g., electricity, natural gas, heating oil, water and sewer, insurance). In carrying out this analysis, we assigned the benefits to the parties responsible for paying the operating costs. Affordable housing developers such as CBOs and housing authorities often pay for residents' utilities. In such cases, greening benefits accrue directly to the developer. In cases where residents pay for utilities, they directly benefit from lower operating costs. This same principle applies to maintenance and repairs – additional up-front investment in a more durable design can lead to cost savings down the road, and should be quantified as best as possible. Costs and benefits relating to common spaces were accounted for in the analysis for the developer/owner.

   Operational savings are usually easiest to quantify with energy and water, but can also be realized through lower maintenance requirements and a reduction in waste generation. We asked respondents to provide a full year of actual operating data for their projects as well as an estimate for conventional operating costs.[11] This information generally focused on energy and water consumption, as that data was most readily available and accounts for a significant portion of the operating costs for a residential unit. We have also projected a 4% annual increase in operating costs.[12] From these assumptions, we have built a thirty year estimate of the annual operating costs for a green project and a comparable conventional project.

4. **Future replacement costs.** This category includes large capital improvements that are needed as major systems require replacement (e.g., roof, siding, flooring, furnace). The extent and timing of replacements is related to the quality of the initial building. In an effort to maintain as low a first cost as possible, affordable housing projects typically choose lower-quality materials and equipment that have a shorter expected life. In contrast, the use of more durable materials and equipment in green projects can avoid or delay replacement costs in the future. The incremental up-front costs and the savings in maintenance and replacement costs are quantified and included in the life-cycle costing analysis. Future costs and savings are discounted to present day (the time of project completion) dollars.

Using these projections for total development costs, interest payments, annual operating costs, and future replacement costs, we modeled thirty years of life-cycle costs for each green project and its hypothetical, conventionally-constructed counterpart. Using a 5% annual discount rate,[13] we were able to translate these cash streams into a total cost in present day (time of project completion) dollars.

The difference between the green total cost and the conventional total cost describes the expected cost increase or savings that green building owners and green building residents will experience. Our calculation measures what a conventional project would cost over thirty years, compares this to what the green project is expected to cost over the same time, and then reports the difference in present day dollars.

Note that this analysis does not account for changes in comfort, amenities, indoor air quality, or occupant health that result from green building. These benefits are very important but cannot easily be quantified in dollar terms. They are identified and described qualitatively in the case studies. Examples include:

- Improved health of residents such as reduced exposure to toxics and reduced incidence of asthma;
- Enhanced comfort, quietness, and operating performance due to tighter building envelopes and better heating, air conditioning and ventilation systems;
- Environmental benefits resulting from improved operating performance (e.g., lower green-house gas emissions, reduced energy consumption, reduced raw materials consumption); and
- Property value maintenance and ease of renting or selling green housing.[14]

(Endnotes)

[1] This criterion was used because of the difficulty in estimating the dollar value of volunteer labor.

[2] This decision was made on most projects in 2004, so projects built after 2003 were not considered.

[3] See data gathering challenges discussion later in this report.

[4] The Leadership in Energy and Environmental Design (LEED) categories are used to organize green features. In effect, respondents were asked to name all the aspects of their project that fit into each LEED category (Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, and Innovation and Design) and to provide an overall cost differential between the green project and a comparable traditional project.

[5] While the project team's use of the LEED categories made sense for comparative purposes, it presented challenges for tracking costs and benefits as they are rarely reported by LEED category.

[6] Energy Star has a cost calculator that will estimate expected usage and costs given a certain material or system. This was used for several cases in our report for conventional lighting estimates and individual appliances.

[7] *Green Development: Integrating Ecology & Real Estate*, Alex Wilson et al of Rocky Mountain Institute, John Wiley & Sons, 1998.

[8] For a more complete description of how present value discounting works, please see Appendix 2.

[9] In all of our present value analysis, we have assumed that the applicable discount rate is 5% (the inflation rate we used is 4%).

[10] In any case where the cost estimates were provided by the respondent or a local colleague, we have noted that and provide information about the source of those estimates and their perceived reliability.

[11] We note where respondents have not provided a full year of actual operating data or a respondent-generated estimate for conventional operations. This is true in numerous cases, as operating data was one of the areas where we had the most difficulty obtaining reliable data. (See section on challenges and limitations of this study.)

[12] This is a standard underwriting estimate that LISC uses in their underwriting process.

[13] The discount rate is not intended to account for the opportunity cost of capital invested by a developer. Instead, it is meant to more closely approximate a risk-free rate. For more discussion of these concepts, see the note on present value in the appendix.

[14] Another potential advantage of green developments is that they may enjoy faster leasing or sales rates due to differentiation from the competition. This is supported by anecdotal evidence from production home builder McStain Enterprises concerning Greenlee Park, 170 units of affordable green homes in Lafayette, Colorado.

CASE STUDIES

Case Study Introduction

The following section highlights the sixteen cases which form the backbone of this report. These green projects were built in eight different states in various regions of the country. They include rehabilitation and new construction, homes for sale and for rent, and they range in size from 3 units and 3,922 square feet to 90 units and 126,900 square feet. The chart below provides some basic information about the cases which will assist the reader in determining which cases are most applicable or appropriate for his/her review.

Project Title	Location	Rehabiliation or New Construction	Number of Units	Total Sq. Ft.	Detached/ Attached	Benefits > Costs?	Reference Page
Rental Projects:							
20th Street Apartments	Santa Monica, CA	Rehabilitation	34	30,592	Attached	Yes	43
Betty Ann Gardens	San Jose, CA	New	76	73,922	Attached	Yes	55
Colorado Court*	Santa Monica, CA	New	44	30,000	Attached	Yes	68
Columbia Terrace (CAST)	Cambridge, MA	Rehabilitation	42	38,931	Attached	Yes	76
Erie Ellington	Boston, MA	New	50	69,390	Detached	Yes	91
Johnson Creek Commons	Portland, OR	Rehabilitation	15	11,436	Detached	Yes	98
Linden Street Apartments	Somerville, MA	New	42	50,970	Attached	Yes	105
Positive Match*	San Francisco, CA	Rehab./New	7	8,620	Attached	No	127
Riverwalk Point	Spokane, WA	New	52	61,716	Attached	Yes	134
Traugott Terrace*	Seattle, WA	Rehab./New	50	38,483	Attached	Yes	143
Woodlawn Building	Chicago, IL	Rehabilitation	10	11,694	Attached	Yes	151
Ownership Projects:							
Arroyo Chico	Santa Fe, NM	New	17	20,000	Detached	Yes	49
Brick Capital Scattered Site Homes	Sanford & Broadway, NC	New	5	5,774	Detached	No	62
Emeryville Resourceful Building	Emeryville, CA	New	3	3,922	Detached	Yes	83
Melrose Commons II	Bronx, New York	New	90	126,900	Detached	Yes	112
New Homes for South Chicago	Chicago, IL	New	25	63,300	Detached	Yes	120

** Units in these projects are dedicated to the homeless or formerly homeless*

Each case write-up is broken up into consistent sections. First, we provide an overview of the project in general. This is followed by a more detailed description of the costs for green design and construction and a summary of the green features included. We then provide information about project operating costs and expected replacement costs. This information feeds into our net present value analysis which makes a determination as to whether or not the life-cycle benefits of greening outweigh the life-cycle costs over a 30-year assumed project life. The net present value of each project describes, to the best of our research team's ability based on information available, the net difference between project benefits and project costs in current day dollars.

A detailed list of the 59 projects we originally considered for case studies can be found in Appendix 1.

20th STREET APARTMENTS

SANTA MONICA, CA

Project Information

Number of Units	34
Unit Type	Multi-Family, Attached
Construction	Rehabilitation
Target Occupant	Low-income families
Developer	Community Corporation of Santa Monica
Development Consultant	Syska & Hennessy
Contractor	The Best Merit Company
Architect	Ralph Mechur Architects
Total Square Footage	30,592
Total Development Cost	$3,482,864
Average Cost per Unit	$102,437
Average Cost per Foot	$114
Incremental Cost to Build Green	$110,290
Green Building Focus	Energy and Water Efficiency
Financing Sources	City of Santa Monica, Bank of America, Regional Energy Efficiency Initiative

"Fixing up dilapidated buildings turns around neighborhoods, preserves affordable housing, and improves the environment."

Community Corporation of Santa Monica

Overview

The Community Corporation of Santa Monica (CCSM), developer of notable new construction green affordable housing projects such as Colorado Court, also has a program to acquire and rehabilitate existing multifamily housing projects in the city. This program is focused on efforts "to extend the buildings' useful life by 40-50 years, to improve the quality of life for the residents, and to upgrade the built environment in the neighborhood."[1] One such rehabilitation project is 20th Street Apartments. These apartments were originally built in the late 1960s and, like much of the housing built in California at that time, were not energy-efficient. The rehab of the 20th Street Apartments, completed in Spring 2001, was focused on improving energy efficiency and affordability for residents.

To complete this project, CCSM hired Ralph Mechur Architects as lead designers, the Best Merit Company as the general contractor, and Syska & Hennessy as an energy and systems consultant. The project includes two buildings totaling 30,592 square feet, with 34 one and two-bedroom units.

Total development costs were approximately $3.5 million, with construction costs of $643,000 and architecture and engineering costs of $41,405. The majority of the project cost came from the $2.5 million purchase price for the buildings. Project financing included loans from the City of Santa Monica ($2,990,951) and Bank of America ($282,137), rebates from the Regional Energy Efficiency Initiative (a joint program of Southern California Edison, California Energy Coalition, and the Cities of Irvine and Santa Monica) totaling $37,400. Southern California Edison also provided Energy Star refrigerators to income-qualified residents at no charge. Table 1 breaks out the total development costs (below).

Green Design and Construction

Green features, primarily energy efficiency improvements, added $110,290 or $2.31 per square foot to the cost of rehabilitating the 20th Street Apartments. This premium represents 14.7% of combined design and construction costs of $648,401. In addition, CCSM received $37,400 in rebates specifically for energy-efficiency improvements, which effectively reduces the net cost of greening to $63,864, a premium of only 9.8%. Table 2 (below) breaks these costs into design and construction components and Table 3 (next section) shows the cost by categories for greening.

The net cost of greening figure above represents the actual costs for green features included in the project. Unlike other cases in this study, theoretical traditional costs for the project were determined by subtracting the cost of green features from the overall design and construction costs not related to the green features. In this case, the traditional alternative was conceived as leaving the existing building feature in place and not replacing it during the rehab, (i.e. no-cost alternative). Because of this, the per-square-foot costs and cost of greening as a percent of total design and construction costs figures for this rehab project will almost certainly be higher than other cases in this study.

Table 1: Total Development Costs

Activity	Dollar Amount
Property acquisition	$2,531,580
Final construction cost	$642,996
Architecture and engineering	$41,405
Environmental assessment and testing	$3,930
Development consultant(s)	$0
Legal	$4,167
Lender fees and costs	$25,160
Construction and pre-development loan interest	$52,547
Sponsor/Developer project management and overhead	$0
Other Soft Costs	$12,416
Developer fee/profit	$155,199
Capitalized Replacement Reserves	$0
Capitalized Operating Reserves	$13,464

Table 2: Net Cost of Greening

	Cost	Cost/square foot	% of Total Dev. Costs
Green Design	$41,405	$1.35	1.19%
Traditional Design	$41,405	$1.35	
Green Design Cost	$0	$0	
Green Construction	$642,996	$21.02	18.46%
Traditional Construction	$532,706	$17.41	
Net Cost of Greening	$110,290	$3.61	3.17%

Table 3: Green Premium (Savings) by Category

Category	Traditional Cost	Green Cost	Green Premium
Sustainable Sites	$0	$0	$0
Water Efficiency	$0	$4,000	$4,000
Energy & Atmosphere	$0	$106,290	$106,290
Indoor Environmental Quality	$0	$0	$0
Materials and Resources	$0	$0	$0
Innovation in the Design Process	$0	$0	$0
Total	$0	$110,290	$110,290

Green Features

One of the central green aspects of the 20th Street project is that it is a rehab project. By reusing an old building and extending that building's useful life, CCSM has saved a huge amount on materials, embodied energy, and infrastructure development that would have been necessary for a new construction project. However, being a rehab project also limits some of the possibilities for greening. With the building already constructed and site already in use, attention centered on upgrading existing systems. CCSM retained energy consultants Syska and Hennessy to help determine which retrofit options made the most financial sense in terms of construction costs, operating cost savings from energy efficiency (estimated with the TRACE computer model), and the expected lifespan of each potential upgrade.

The project team also limited themselves to familiar green features and materials with which they were comfortable working. This helped avoid surprises during construction and helped ensure effective operation and performance once the project was occupied. Table 3 shows these costs (below). As mentioned earlier, the green costs represent total costs for green features included in the project and traditional costs were considered to be the cost of not upgrading (no net expense) the system or component in question.

Sustainable Sites
By retrofitting existing stock in a dense urban neighborhood, CCSM is providing quality housing cost-effectively and not contributing to urban sprawl. Residents of the 20th Street Apartments have ready access to jobs, retail, and cultural opportunities in the immediate area. These benefits come at no additional cost to the developers or residents.

Water Efficiency
Low flow showers, toilets and bathroom and kitchen faucets were installed throughout the project at a cost of $4,000. Drought-tolerant plantings are featured in the exterior landscaping at no additional cost.

Energy and Atmosphere
As noted above, a primary motivation for the project, and the focus of most of the upgrades, was energy efficiency. The buildings were retrofitted with new R-30 attic insulation ($9,020 cost) and R-11 insulation was blown into the walls ($16,300 cost). New dual-glazed windows and sliding doors were installed at a cost of $38,400.

The property's existing solar-assisted hot water heating system was refurbished for $5,000. The project team considered options that would have replaced the existing electric space heating with wall-mounted furnaces, heat pumps, or an upgraded solar hot water system, but these were ultimately rejected for cost and other feasibility issues. Traditional thermostats were replaced with programmable setback models for $2,200 and air-sealing was performed on all units for $3,354.

Fluorescent lighting fixtures and compact fluorescent bulbs were installed for $2,490. More efficient electric kitchen ranges were placed in all units for $20,500 and Southern California has provided ten Energy Star refrigerators for tenants at no cost. Skylights were added to stairwells to reduce lighting loads in common areas.

Materials and Resources
Although energy efficiency was the focus of the rehab project, Trex recycled plastic lumber was used for new patio fences and a recycled rubber mat was installed in the playground.[2]

Indoor Environmental Quality
There was very little focus on indoor environmental quality in this project; however, some of the energy efficiency upgrades do have air quality and ventilation benefits.

Innovation in the Design Process
For the most part, a standard design process was used in this project. The comprehensive energy model is one somewhat innovative feature, but this has also been institutionalized in California. Title 24 regulations require all multifamily housing projects to complete an energy model. Due to this requirement, there was no additional cost for greening associated with the design process.

Operating Savings: Green vs. Traditional

Based on the Syska and Hennessy energy model developed before construction, the energy- and water-efficiency improvements should save CCSM and tenants an annual total of $11,375 or $0.37 per square foot when compared with the pre-rehab structure. Table 4 breaks down the total expected annual savings for each retrofit feature, according to the model.

Reliable actual billing records for both the pre- and post-rehab periods were not available for gas, electricity, and water. Because of this, the research team could not test the model results conclusively, and had to rely on the model to fill gaps in the information available about energy and water use on site. We had good information about:

Traditional electricity costs for the full building and green electricity costs for the common areas,
Traditional gas usage and costs for the full building as well as green gas costs for the full building,[3] and
Green water costs for the full building.

We used the model to fill in gaps that allowed us to estimate operating savings. The results of these estimates are displayed in Table 5, below.

CCSM has begun monitoring

Table 4: Expected Savings from Energy Efficiency Features

Feature	Est. Annual Savings
R-30 Atttic insulation	$350
R-11 Wall insulation	$743
Dual-glazed windows	$2,800
Refurbish soar-assist hot water heater	$1,600
Programmable thermostats	$410
Fluorescent lighting	$1,340
Efficient kitchen ranges	$1,800
Energy Star refrigerators	$1,700
Air sealing	$390
Low flow water fixtures	$240
Total	$11,375

Table 5: Operating Costs

Operating Cost Category	Traditional usage	Traditional costs	Green usage	Green costs	Operating Savings
Electricity (kwh)*	no data	$15,600	no data	$6,065	$9,535
Gas (Therms)**	12,429	$10,162	10,309	$8,461	$1,701
Water (gallons)***	no data	$20,514	no data	$20,274	$240
Total		$46,276		$34,800	$11,476

** Traditional electricity costs are from actual records. Green costs are estimated from the Syska and Hennessy model.*

*** Green gas usage is estimated based on actual expenditures from 2002-2003. Traditional usage are from actual records from pre-rehab. Traditional expenditures are traditional usage amounts at 2002-2003 rates.*

**** Green water costs are from actual expenditures from 2002-2003. Traditional expenditures are the green costs plus the expected savings from the model.*

actual energy consumption since the retrofit and will compare the results with billing information from before the project to verify the savings estimates provided by energy modeling. However, we do not yet have access to that information.

Net Present Value Summary

Although the actual design and construction costs for 20th Street Apartments were 14.7% higher than they might have been for a project that did not include energy and water efficiency improvements, our net present value analysis shows that these changes are worth $165,000 over the life of the building. However, the project owner and project residents do not share equally in the costs and benefits of these changes.

CCSM pays for all the first-cost increases associated with greening and receives the benefit of reduced water usage, reduced hot-water heating costs, and reduced common area electric costs which includes common area heating and cooling. The residents do not have to pay for any of the up-front costs and benefit from lower electricity bills in their units[4] and a range of more difficult to quantify benefits like better ventilation and comfort. The analysis below breaks out the costs and benefits that accrue to residents and the owner, calculating what these changes are worth to each group. Tables 6 and 7 show the impact on the residents, and Tables 8 and 9 show the impact on the owners.

Residents receive a benefit of $219,643 over the building's expected thirty-year lifespan. This equates to an almost $6,500 benefit per unit. This benefit is due entirely to changes in the electrical efficiency of the units, which includes heating and cooling. Residents do not bear any costs to make the green changes, and they do not receive any benefits from reduced water usage, water heating, or gas usage because those costs are all paid for by the building owner.

Table 7 presents the same results from a slightly different perspective, organizing expected benefit around increased interest expenses, savings from building operation, and savings from replacing systems and components that do not wear out as quickly as conventional components.

CCSM does not make out quite as well as the 20th Street residents. They actually have a life-cycle cost of nearly $55,000 as a result of the changes made to the project. This cost is substantially reduced when one considers the $37,400 in rebates that they received from REEI, but, even with the rebates, they lose over $17,000 in value from the changes they have made. Table 8 breaks down this result, showing that the gas efficiency and water efficiency measures included in the project generate a value of over $44,000. However, that value does not offset the cost of the electrical efficiency measures ($83,986) or the increased interest that the project must carry because of the green features that were included ($14,735). Because we had no good information about the cost of and traditional alternatives to the recycled rubber playground mat or the trex decking installed in the project, we assumed that the green materials and conventional materials had no life-cycle cost difference.

Table 9 breaks out this result in a somewhat different format. From this table, we see that nearly $15,000 in additional interest cost accrues to the owner due to the changes made in the project and nearly $40,000 in costs accrues due to the energy efficiency features.

In the end, the costs paid by CCSM are more than made up for with the benefits that accrue to the residents. In effect, CCSM has paid an additional $55,000 ($17,000 with rebates included) in order for project residents to receive a benefit of $219,000.

Table 6: Resident NPV by Feature

	Green savings (cost)
Additional Interest	$0
Electrical Efficiency	$219,643
Gas Efficiency	$0
Water Efficiency	$0
Green Materials	$0
Total	$219,643

Table 7: Resident NPV by Category

	Green Savings (cost)
Additional Interest	$0
Operating Costs	$219,643
Replacement Costs	$0
Total	$219,643

Table 8: Owner NPV by Feature

	Green savings (cost)
Additional Interest	($14,735)
Electrical Efficiency	($83,986)
Gas Efficiency	$42,108
Water Efficiency	$1,989
Green Materials	$0
Total	($54,624)

Table 9: Owner NPV by Category

	Green Savings (cost)
Additional Interest	($14,735)
Operating Costs	($39,889)
Replacement Costs	$0
Total	($54,624)

References and Acknowledgements

- Nicole Smith of Community Corporation of Santa Monica provided overall and itemized cost figures for the project as well as a copy of the energy modeling report and financial statements.
- Other sources included:

Global Green USA's Greening Affordable Housing Initiative Case Study (http://globalgreen.org/pdf/20TH_ST-CS.pdf).

(Endnotes)

[1] There is no reference for this quote. Hunt it in other sources.

[2] No traditional or green construction costs were supplied for these changes and the research team did not have enough information to develop an estimate.

[3] Utility rates have changed dramatically in California between 1999 and 2003 (the pre- and post-construction time periods used in our analysis). Because we had gas usage information, we were able to use the rate changes to estimate the cost in 2002-2003 rates of the 1999-2000 usage in the project. We were also able to use the 2002-2003 rates to estimate the usage in 2002-2003 based on the cost paid by the project. Because we did not have water or electricity usage information, we were not able to do the same thing for water and electricity.

[4] To break out the resident and owner expenditures for electricity, we assumed that 80% of the gross building area was used for residential space and 20% was common area and circulation. We also assumed that residents used three times as much electricity per square foot of living area as the owner.

ARROYO CHICO

SANTA FE, NM

Project Information

Number of Units	17
Unit Type	Single-Family, Detached
Construction	New
Target Occupant	Low-Income, First-time Homebuyers
Developer	Santa Fe Community Housing Trust
Development Consultant	Guy Stanke
Contractor	Sage Builders
Architect	Suby Bowden
Total Square Footage	20,000
Total Development Cost	$2,337,477
Average Cost per Unit	$137,499
Average Cost per Foot	$116.87
Incremental Cost to Build Green	0.90%
Green Building Focus	Material and Resource Efficiency
Average Price of House	$152,647
Financing Sources	Charter Bank, New Mexico Mortgage Finance Authority, Federal Home Loan Bank of Dallas

"Homeownership no longer means a mobile home sixty miles outside of town."

Enterprise Foundation comments on the Santa Fe Community Housing Trust

Overview

The Santa Fe Community Housing Trust (SFCHT) arose out of community planning and organizing efforts in the early 1990s. Beginning in 1991, the Enterprise Foundation funded a community-wide effort to improve affordable housing options for low-income people in Santa Fe County. In 1993, SFCHT was established as an umbrella organization focused on increasing affordable housing opportunities for low-income residents. In that year, the City and County passed inclusionary zoning legislation that required market-rate builders to either provide affordable housing or pay into an affordable housing trust fund. SFCHT became the executor of that trust fund, acting both as a pass-through entity and a housing developer. In addition, they administer a county-wide affordable housing land trust. The community land trust model reduces the first cost of for-sale housing and protects the long-term affordability of a home.[1] Beyond these programs, SFCHT also offers the following services:

- Homebuyer education and counseling – SFCHT offers a homebuyer education course, provides homebuyer screening and individual counseling, helps identify first mortgage opportunities for buyers, and provides deferred payment second mortgages.
- Housing assistance to special needs populations – SFCHT offers reverse mortgage products to disabled residents, provides rent subsidies and other housing services to people living with HIV/AIDS.
- Management of public funds – In addition to administering the City and County Affordable Housing Trust Fund, SFCHT has also managed a single-family bond issue and operates a predevelopment loan fund for affordable housing.

Arroyo Chico represents one of the affordable housing development projects that SFCHT has taken on. It consists of 17 single-family detached homes for sale in three floor-plans. These homes average 1,175 square feet, not counting the garage. All have two bathrooms, with two and three-bedroom plans available. SFCHT used Guy Stanke as a development consultant. Sage Builders was the contractor and Suby Bowden was the architect. Construction was completed on the final unit in June of 2003 and units were occupied between February and October of 2003. The new construction units did not have basements, and all units were made available to low-income families.[2]

SFCHT purchased the property with their funds, and obtained a construction loan from Charter Bank. Costs to homeowners were reduced through HOME funds that were part of the Community Housing Development Organization set-aside from the New Mexico Mortgage Finance Authority and some down payment assistance was provided by the Federal Home Loan Bank of Dallas through their Affordable Housing Program (AHP). Homeowners were responsible for obtaining their own mortgage financing for the balance of the mortgage loan.

The project cost $2,337,477 ($116/sf). Acquisition costs were $407,390 (16.4% of the total project cost). Construction costs were $1,784,885(76.4%) and soft costs, including construction loan interest, were $145,202 (6.2%). Total development costs are shown in Table 1. The homes sold for between $140,000 and $165,000, and each home had an average of over $19,000 in down payment assistance through the CHDO set-aside, the AHP, or both.

Overall Construction Costs: Green vs. Traditional

As previously mentioned, the total construction cost for this project was $1,784,885 including green features. The total cost of a project with conventional features was estimated to be $1,767,597.[3] The total first cost of greening this development was $17,288, or less than 1% of total development costs. There were no differences in design costs. Total costs for green versus conventional construction are reflected in Table 2.

Green Features

Table 3 breaks out the incremental costs of changes made to the homes in Arroyo Chico, as compared to the estimates made by the research team about what more traditional features would have cost.

The SFCHT has focused its green development efforts around material and resource efficiency. This commitment to efficient use of resources reaps a myriad of benefits for homeowners including: cost savings on energy bills, longer lasting flooring and roofing, and an ability to maintain healthy landscaping through periods of severe drought. They have also made these changes at very little cost. As Tables 2 & 3 show, the first cost increase due to green features was less than 1% of the total development costs, but the rewards are much greater. We will discuss the present value impact of greening in more detail in a later section, but the value of the changes they have made in these houses is estimated at nearly $8,000 per house over a 30-year time period or $132,267 for the development as a whole.

Table 1: Total Development Costs

Activity	Dollar Amount
Property acquisition	$407,390
Final construction cost	$1,784,885
Architecture and engineering	$64,702
Environmental assessment and testing	$0
Development consultant(s)	$8,000
Legal	$0
Lender fees and costs	$0
Construction and pre-development loan interest	$30,000
Sponsor/Developer project management and overhead	$0
Other Soft Costs (closing on each house)	$42,500
Developer fee/profit	$0
Capitalized Replacement Reserves	$0
Capitalized Operating Reserves	$0
TOTAL	$2,337,477

Table 2: Net Cost of Greening

	Cost	Cost/square foot	% of Total Dev. Cost
Green Design	$64,702	$3.24	2.77%
Traditional Design	$64,702	$3.24	
Green Design Premium	$0	$0.00	0.00%
Green Construction	$1,784,885	$89.24	76.36%
Traditional Construction	$1,755,243	$87.76	
Net Cost of Greening	$29,642	$1.48	1.27%

Table 3: Green Premium (Savings) by Category

Features Category	Green Cost	Traditional Cost	Cost of Greening
Sustainable sites	$0	$0	$0
Water efficiency	$6,800	$0	$6,800
Energy and atmosphere	$29,324	$12,354	$16,970
Materials and resources	$82,400	$76,528	$5,872
Indoor environmental quality	$0	$0	$0
Other	$0	$0	$0
Total	$118,524	$88,882	$29,642

Sustainable sites

All the Arroyo Chico homes were oriented and designed for passive solar gain. No windows were placed on the north elevations and minimal windows were placed on the west elevations. There were no costs related to this change, but it has helped to reduce heating and cooling loads in the peak winter and summer months. In addition, a water harvesting system was installed where each roof drains into a 550-gallon polytank used to store water for landscaping. The system cost $6,800 to install, and while it has created no direct savings, it has provided a water source with which residents can maintain healthy landscaping through frequent periods of severe drought. During these times, municipal water cannot be used for watering lawns or outdoor plants. Because this system harvests water on-site, Arroyo Chico residents have access to water for landscaping when none of their neighbors do. This allows them to keep their fruit trees and grapevines alive and healthy without reliance on the municipal water system.

Water efficiency
The xeriscape approach to landscaping was used for outdoor spaces. This technique uses native plants to reflect local character and cut down on external water use needed to keep plants alive. By using only local species, homeowner's yards are filled with plants that would grow in this climate naturally, meaning that they will require less maintenance and water than other species. They also installed low-flow toilet and shower fixtures, but did not exceed the local code in this capacity.[4]

Energy and atmosphere
Blown-in insulation was used in all the houses in place of rigid insulation. This fiberglass based insulation material has a higher R-value than rigid foam insulation and costs only slightly more ($4,570 more for all 17 houses). Better insulation was also used around the baths at an incremental cost of $1,900 for all the houses. In addition, low-e windows were used which added $10,500 in incremental costs. These changes, when coupled with the passive heating and cooling, saved the homeowners $25-30 per month in utility bills from November to March. This translates into over $125 per year,[5] which is one eighth of the nearly $1,000 cost per house of the energy and atmosphere upgrades. In addition, Arroyo Chico homes have radiant floor heating, something that SFCHT installs standard in all of their homes. With this system, water is heated in a small boiler and moved through WIRSBO plastic tubing to heat the slab which releases heat into the room. Radiant floor heat is considered a "superior" product in the Santa Fe area, and it is used most often in high end houses. Aside from making it pleasant to walk around barefoot in the winter, such systems eliminate ductwork, noise and other side effects of forced air gas systems. According to Jim Hannan, SFCHT typically uses a three zone system, with each zone having its own thermostat: common living areas, master bedroom, and other bedrooms. One disadvantage of radiant floor heat is that it does take longer to heat up a house. We have included no cost here because radiant floor systems are standard for SFCHT.

Materials and resources
Ceramic tile was used in every room except the bedrooms. According to SFCHT, the ceramic tile will last 2.5 times longer than carpet, with a lifespan of roughly 25 years. In addition, they used a metal roof instead of composite shingles, which should last twice as long as a regular roof, up to fifty years before it needs to be replaced.

Indoor environmental quality
The SFCHT did very little specifically related to indoor environmental quality, but the change to tile over carpeting greatly improves indoor air quality in the houses.

Innovation in the Design Process
SFCHT put a large focus on passive solar design, as previously mentioned. No other significant design innovations were employed.

Operating Savings: Green vs. Traditional

Arroyo Chico homes were all sold to low-income homebuyers, and SFCHT has no ongoing maintenance expenses related to them, nor do they have information about the standard costs for each homeowner. However, they have estimated that the Arroyo Chico homes save $25-30 per month on gas heating and cooling from November to March due to the improved insulation and other energy considerations. Table 4

shows the expected differentials in operating costs. It should be noted that the maintenance expenses for the rainwater irrigation system[6] have no traditional alternative cost (i.e. one would not spend this money on other methods of watering if the tanks weren't in place). However, this expenditure, like the expenditure to install the tanks, ensures that the landscaping installed at Arroyo Chico will survive through periods of extreme drought when no municipal water can be used in the yard. The addition of water harvesting in the project does not result in any savings on water usage, because in periods of severe drought no one can use municipal water sources for landscaping. In Arroyo Chico, the harvested water is used for landscaping in periods of drought, allowing homeowners to keep their gardens alive when others cannot thereby preserving the landscaping asset.

They have also used a tile floor that lasts 2.5 times longer than carpet and a roof that lasts twice as long as composite shingles. While the homeowner sees no direct operating cost savings related to these decisions in the early years of ownership, these decisions can save the homeowner significant repair costs ten and twenty years down the road, when a more conventional system would need to be replaced.

Table 4: Operating Costs

Green System List	Green Operations	Traditional Operations
Energy Efficiency*	$0	$2,125
Water Efficiency**	$500	$0
Total	$500	$2,125

** Operations data is incremental development estimate (we have savings for green). Traditional cost from RS Means.*

*** Researcher estimate at operating cost. No savings, but keeps garden alive through drought.*

Table 5: Replacement Costs

Green Feature List	Green Cost	Traditional Cost	Expected Life (Years)	Traditional Life (Years)
Flooring*	$31,400	$45,730	25	10
Roof**	$51,000	$30,798	50	25

** Traditional cost from RS Means, green cost actual. Life span estimate by researcher.*

*** Traditional cost from RS Means. Life span estimate by researcher.*

Net Present Value Summary

While the actual design and construction costs for Arroyo Chico increased development costs by less than 1%, they generated more than a sevenfold return. Our net present value analysis shows that these changes are worth almost $8,000 per house (over $132,000 for the full project) over the building's life and only cost the homeowners $1,016 per house in upfront costs.

SFCHT paid for all first-cost increases, but they were able to pass these slightly increased costs on to the homebuyers. They do not carry additional interest past the construction period, and they did not need to raise additional funds to afford green features included in the project. SFCHT also has no continued interest in the operation of the buildings and realizes no direct savings due to improved energy or water efficiency, or the more durable, longer-lasting materials that were used in each home. All benefits and costs accrue to the residents, and the net present value (NPV) impact on SFCHT is zero. For this reason, we have not shown NPV tables for the developer in this case.

Residents/Homeowners do pay additional costs for and receive benefits from the green features that are used, as shown in Table 6. The first cost premium results in a life-cycle interest increase of $3,500, and water efficiency improvements (largely because we do not have good ways of accounting for the benefits of the rainwater harvesting system) create an added life-cycle cost of nearly $20,000. However, these cost increases are more than paid for by the energy efficiency and material efficiency changes that were made to the design. The largest benefit comes from the more durable flooring that was installed, generating a net present value of over $100,000 (over $6,000 per house).

When looked at from a slightly different perspective (see Table 7), one can gain even more insight about the value of the changes made. Changes that had an impact on ongoing operating costs (water efficiency and electrical efficiency) generated a value of nearly $2,000 per house over the life of the project. Changes that had an impact on replacement costs generated over $6,000 per house. There was a slightly increased interest cost, due to the first cost premium of just over $17,000.

As mentioned before, these estimates also do not include any value related to the inclusion of the water system, because no direct savings or reduced maintenance expenses will accrue to the homeowners. However, the ability to maintain native fruit trees, grapevines, and other plant life through severe droughts undoubtedly will have some positive value, one that is likely seen in resale. We have made no attempt to estimate this value increase for this study, but did want to point out that it exists. Even without it, the investment in green technologies and systems proves to be tremendously valuable.

Table 6: Owner NPV by Feature

	Green savings (cost)
Additional Interest	($5,992)
Energy Efficiency	$36,060
Water Efficiency	($19,278)
Flooring	$103,252
Roofing	$4,043
Total	$118,085

Table 7: Owner NPV by Category

	Green Savings (cost)
Additional Interest	($5,992)
Operating Costs	$16,782
Replacement Costs	$107,295
Total	$118,085

References and Acknowledgments

- Jim Hannan from the Santa Fe Community Housing Trust completed our survey and had several conversations with researchers.

(Endnotes)

[1] For more information on community land trusts, see the Institute for Community Economics at www.icelt.org.

[2] The affordability restriction only lasts for five years, after which the home owner may resell to anyone at market price.

[3] Estimates were developed using RS Means Building Construction Cost Data 2003 edition and RS Means Square Foot Costs 2003 edition (the assemblies section). Methodology will be described in an appendix. In addition, some assumptions had to be made about features that were included by Santa Fe Community Housing Trust. When making estimates, similar quality materials (as determined by pricing for related materials) were used for conventional features. For example, when comparing the cost of tile flooring with the cost of carpet, we would identify the relative quality of the tile flooring used from RS Means data and choose a similar quality carpet (i.e. if the most expensive tile was used, then we compared that cost to the most expensive carpet). Also several assumptions were made based on information gathered from Santa Fe Community Housing Trust. We were told that low-e windows for the full development cost $10,500. This would equate to roughly 1.5 windows per home at pricing from $300-500 per window installed. We have assumed that this was the incremental cost for windows and not added an additional conventional cost into our calculation.

[4] Since low-flow fixtures are not an upgrade, but rather a code mandate, we have not added them to the cost of green features.

[5] Because of the climate in Santa Fe, the period from November to March includes almost all the heating days, and there are almost no cooling days through the summer months. So this five month time period has been assumed to account for all the cost savings in heating and cooling.

[6] These expenses were estimated by the research team at $100 per year per tank.

BETTY ANN GARDENS

SAN JOSE, CA

Project Information

Number of Units	76
Unit Type	Multi-Family, Attached
Construction	New Construction
Target Occupant	Low-income families
Developer	First Community Housing
Contractor	Branagh Construction
Architect	Office of Jerome King
Total Square Footage	73,922
Total Development Cost	$18,796,939
Average Cost per Unit	$247,328
Average Cost per Foot	$254
Incremental Cost to Build Green	$360,231
Green Building Focus	Energy Efficiency, Indoor Air Quality, Durability
Financing Sources	Citibank, City of San Jose, Tax Credit Equity

First Community Housing is committed to building high quality , sustainable affordable housing and passing energy savings along to our tenants.”

First Community Housing mission statement

Overview

In San Jose, California, a majority-minority city in one of the least-affordable housing markets in the nation, First Community Housing has developed Betty Ann Gardens, 76 units of new housing completed in August 2003. First Community Housing has built nearly 800 units of affordable housing since 1986 and for the past several yeas has applied green-oriented construction standards in all of its developments. This commitment is driven by the recognition that building green can lower their costs of ownership and improve affordability and environmental quality for tenants.

Betty Ann Gardens sits on a 3.87 acre site and contains 16 one-bedroom, 36 two-bedroom, 20 three-bedroom and 4 four-bedroom units in a total of 73,922 square feet of floor area. Eight units are targeted at families earning 30% of area median income (AMI), 15 units for families at 50% of AMI, and 52 units for families at 60% of AMI. One unit is reserved for an on-site property manager.

The lead architect for the project was the Office of Jerome King and Branagh Construction was the general contractor. The $18.9 million project (approximately $11 million construction costs, $7.9 million soft costs) was built with a long list of green features and an integrated design/construction process despite being financed with fairly traditional funding sources: $7.6 million in tax exempt bonds, approximately $6 million in Low Income Housing Tax Credit equity and approximately $5.3 million in loans and grants from the City of San Jose. Table 1 shows the break down of total development costs.

Overall Design and Construction Costs: Green vs. Traditional

Betty Ann Gardens had construction costs of $10,846,858, or $146.73 per square foot. Design and engineering costs were $856,175, or $11.58 per square foot. Traditional design and engineering costs were estimated to be slightly lower at $773,675, or $10.46 per square foot[1]. We estimate the traditional construction costs to be $10,569,127, or $142.98 per square foot which indicates a 2.63% cost premium for the green measures taken.[2] Table 2 shows the breakdown of total costs for green design and construction.

We were unable to obtain detailed development costs by feature, and have not included a breakdown of those feature costs by category (Energy and Atmosphere, Water Efficiency, Indoor Air Quality, etc.). However, we do have information about the type of features that were included in the building and we have described those below.

Table 1: Total Development Costs

Activity	Dollar Amount
Property acquisition	$3,394,512
Final construction cost (includes all approved and likely-to-be-approved change orders)	$10,846,858
Architecture and engineering	$856,175
Development consultant(s)	$111,327
Legal	$23,209
Lender fees and costs	$726,273
Construction and pre-development loan interest	$731,732
Other Soft Costs	$719,389
Developer fee/profit	$1,200,000
Capitalized Operating Reserves	$187,464
TOTAL	$18,796,939

Table 2: Net Cost of Greening

	Cost	Cost/square foot	% of Total Dev. Costs
Green Design	$856,175	$11.58	4.55%
Traditional Design	$773,675	$10.46	
Green Design Premium	$82,500	$1.12	
Green Construction	$10,846,858	$146.73	57.71%
Traditional Construction	$10,569,127	$142.98	
Green Construction Premium	$277,731	$3.75	
Net cost of greening	$360,231	$4.87	1.92%

Design Process

The development team utilized an integrated design/build process where the general contractor, Branagh Construction was pre-selected via a negotiated bid (rather than low-bid) and, along with all major subcontractors, was involved in the project from the earliest schematic design phases. In fact, most of the green features were added to the design after the contractor was selected. Compared to the traditional linear design process, this helped avoid costly and time-consuming confusion among team members once construction started. All members were involved in the design and all had input on potential construction-phase changes. To reassure funders and contractors, the designers emphasized the similarities between green and conventional materials and practices, rather than the differences. The following is a description of the green components utilized in the design and construction of the project.

Sustainable Site

To improve transportation options for residents, an adjacent public transit stop was rehabilitated and all residents are provided with free county-wide bus and light rail transit passes. Additionally, the site is located near a shopping and employment district and job training, computer training, ESL and kids' homework club classes are offered at the on-site community center.

The project design protected existing heritage trees on the site and restored an adjacent creek and riparian area, providing enhanced scenic qualities, recreational opportunities and stormwater management.

Water Efficiency

Low-flow fixtures are installed throughout Betty Ann Gardens to reduce resource consumption and operating costs.

Energy and Atmosphere
Gas-fired Apollo combined space/hot water heating units with hydronic (hot water forced air) heat distribution are highly efficient when compared with the electric heat and hot water units common in California and they also contribute to lower energy bills for residents.

Insulation efficiency does not exceed traditional standards (R-13 exterior walls and R-19 attic), but vinyl-framed double-glazed windows and sliding doors reduce solar heat gain in summer and conductive heat transfer in all seasons, contributing to lower energy consumption and utility bills.

Gas cooking ranges are more efficient per BTU than electric alternatives, and Energy Star certified air conditioners, dishwashers and refrigerators are featured in all units. Compact fluorescent light bulbs in living rooms and bedrooms reduce electricity use and their longer lifespan lowers maintenance and replacement costs compared to incandescent bulbs.

Materials and Resources
All of the structures at Betty Ann Gardens feature engineered framing components (I-joists and trusses) with straighter, more uniform dimensions than traditional solid wood alternatives, enhancing durability of the buildings. These components and the oriented strand board (OSB) sheathing used for exterior walls and roof sheathing are fabricated with less solid wood, in some cases wood scraps, for a more efficient use of timber resources. Hardiboard fiber-cement siding also reduces wood consumption, is more durable, fire resistant and requires less maintenance than traditional solid wood siding.

The Community Center's roof has an Eco-Star rating and is made from 100% recycled materials. The molded roof tiles are made of reinforced vinyl and cellulose fiber and are highly durable with a 50 year warranty and class-A fire rating. Carpeting in living rooms, bedrooms and common areas is a recycled-content, fully recyclable product from Interface that is laid in "tiles" so that worn areas can be replaced without scrapping the entire carpet.

Office furniture is constructed from a composite "wood" made from wheat straw and is 99% recyclable. Benches and lobby furniture are made with sustainably harvested teak wood.

Indoor Environmental Quality
Kitchen and bathroom floors are natural linoleum, more expensive

than vinyl flooring, but without harmful off-gassing and are the product of more sustainable manufacturing processes. Linoleum is far more durable than vinyl, requires less maintenance and is also recyclable.

Other interior materials and finishes were selected with indoor air quality in mind. Formaldehyde-free medium-density fiberboard (MDF) made from 90%+ pre-consumer recycled wood was specified for cabinetry and trim. Attic and wall batt insulation and counter substrates are also formaldehyde-free. Water-based low-VOC paints and varnishes were used throughout.

Operating Costs

Energy modeling for this project was conducted by Gabel Associates of Berkeley, California. While actual operating data for Betty

Table 3: Operating Costs

	Electricity		Gas		Water**		total cost
	KWh	Cost	Therms	Cost	Gallons	Cost	
Trad./Title-24*	218080	$30,532	24420	$17,093	147060	$611	$47,625
Betty Ann Gardens	148637	$20,809	19026	$13,318	84455	$351	$34,128
Savings	69443	$9,722	5394	$3,775	62,605	$260	$13,497
% Savings	32%		22%		43%		28%

**Traditional cost estimates are based on Title 24 calculations for unit heating and utilized the Energy Star Calculators to calculate savings for refrigerators, dishwashers, air conditioners and lighting.*

***Water calculations are only for dishwashers, and do not include any other water usage.*

Ann Gardens was unavailable as of the time of this writing, modeling indicates that the residential units in the project would exceed California's stringent Title-24 energy requirements by approximately 28% providing substantial savings to the buildings occupants.[3] The modeling, however, only accounts for space heating requirements, which would be fairly minimal given the mild climate in San Jose.

Other operating savings are the result of the energy efficient appliances utilized throughout the project which include Energy Star rated refrigerators, dishwashers, air conditioners and light fixtures. The savings resulting from these fixtures, when combined with the savings indicated from the Title-24 test results are illustrated in Table 3.

Table 4: Resident NPV by Feature

	Green savings (cost)
Additional Interest	$0
Energy - Electricity	$430,012
Energy - Gas	$89,368
Total	$519,380
total for entire complex	

Table 5: Resident NPV by Category

	Green Savings (cost)
Additional Interest	$0
Operating Costs	$519,380
Replacement Costs	$0
Total	$519,380
total for entire complex	

Table 6: Owner NPV by Feature

	Green savings (cost)
Additional Interest	($72,821)
Lighting	$103,934
Water Efficiency	$6,488
Flooring-Carpet	$56,155
Flooring-Linoleum	$252,462
All Other Green Features	($313,090)
Total	$33,129

Table 7: Owner NPV by Category

	Green Savings (cost)
Additional Interest	($72,821)
Operating Costs	($202,668)
Replacement Costs	$308,618
Total	$33,129

Net Present Value Analysis

As described earlier in this report, for each case we have estimated the financial impact of green building decisions over an expected thirty-year building lifespan. In the case of Betty Ann Gardens, we have less detail than with other cases in this report. For this case, we were only able to obtain aggregate green building premiums for most items (we do have green and conventional capital costs for linoleum, recycled carpet, and fluorescent bulbs) and operating cost differentials for gas and electricity use. With this information, we have carried out a partial life-cycle analysis that is based on the following key assumptions:

- We have assumed that all green systems and materials installed with the exception of linoleum flooring, recycled carpet, and fluorescent bulbs have no effect on the durability of the building and individual building components. This assumption almost certainly underestimates the life-cycle value generated by a longer lasting material (benefits which would accrue entirely to the developer/owner), but without reliable information on the initial costs of green and conventional systems, we could not complete a more detailed analysis.
- We have assumed that water usage for everything except the dishwashers remains unchanged despite the inclusion of low-flow fixtures. The low-flow fixtures installed meet the requirement set by the State of California. Thus, we focused on the water savings which results from the use of the Energy Star dishwashers, which use considerably less water per load than conventional dishwashers. The usage estimates applied were obtained directly from Energy Star.
- We have assumed that residents use three times as much electricity per square foot in their units than the building owner pays for in the common areas. This assumption allows us to break down the aggregate energy expenditures into a common area expenditure and a residential unit expenditure, effectively allocating costs and savings between owner and resident.

The changes made by the project are intended to create long-term value, but only a portion of that value accrues to the owner (and we have only been able to document a portion of the benefits that the owner receives).

The remainder of the benefit is realized by residents who did not have to invest in the green building approach. In order to clearly show this, we have broken down the costs and benefits tracing which accrue to the owner and which accrue to the residents. This also provides a clearer picture of the overall benefit of green building for this project, because it shows whether or not these changes make financial sense for both the project owner and the project residents. In calculating these life-cycle costs and benefits, we have assumed that residents receive the savings related to energy use in the unit,[4] and that initial construction costs, water use, and common area energy use are borne by the project owner.

Overall, the green building features of Betty Ann Gardens that were able to be documented have a benefit of over $33,000 for the building owner and a benefit of $6,833 per unit (a total of $519,830) for the residents. As mentioned earlier, the $33,129 benefit to the building owner includes very few of the many changes related to material durability. We only had enough information to show replacement cost (durability) savings for linoleum flooring, recycled content carpet, and fluorescent lighting. According to Jennifer Seguin at First Community Housing, many of the systems that were installed have much longer lifespans than conventional systems, and this increased durability makes the green product much cheaper over thirty years. Because we did not have specific information about material durability (except for these three features), we were unable to include more in the analysis. Tables 4-7 summarize these results, first for the project residents and then for First Community Housing.

Over a thirty-year period, residents are expected to save over $430,000 (nearly $5,700 per unit) in present value terms on their electricity bills and over $89,368 on their gas bills (nearly $1,200 per unit).

All the tracked savings that accrue to residents come in the form of decreased expenses for energy in the units. We expect that residents also recognize benefits from better indoor air quality. They do not have to pay any additional interest for the added first cost of these green features, nor are they responsible for the replacement or maintenance of those features.

The story for First Community Housing is somewhat different. They bear all the costs for green building and what we were able to document shows they receive very little of the benefit from decreased utility usage. They do receive all the durability benefits from longer lasting materials, but unfortunately, we could only reliably measure the durability benefits for linoleum flooring, recycled content carpet, and fluorescent lighting. In the end, we assumed that all other durability benefits were 0. Based on this analysis, all changes made by the project team create $33,129 in value for First Community Housing.

This benefit arises from over $72,000 in additional interest payments, and a cost of just over $313,000 for all green features except lighting, carpeting, dishwashers, and linoleum flooring.[5] But the value of changes made to lighting, linoleum, dishwashers, and carpeting more than made up for the increased life-cycle costs that we calculated for interest and other green features. Fluorescent lighting is expected to save the owner over $103,000 in current day dollars over the thirty-year life of the project.[6] The decision to use recycled content carpet from Interface was worth over $56,000 in current day dollars,[7] and the linoleum flooring is expected to generate over $252,000 in benefits to the owner.[8]

In the end, the green building decisions made at Betty Ann Gardens generate value for the residents and the project owner. The residents gain more than $519,000 in present value terms over the building lifespan and First Community Housing gains $33,129 over that same span. This represents a total life-cycle benefit of just over $552,000. In addition, the benefits to the developer that we have shown does not include any benefit from the air quality and water-efficiency changes other than the dishwasher, nor does it include the decreased maintenance expenditures from greater building and component durability.

References and Acknowledgements

- Marty Keller of First Community Housing provided overall cost figures for the project.
- Jennifer Seguin of First Community Housing provided additional data on the project and made certain the case was as accurate as possible.
- Paul Lippert, City of San Jose, Department of Housing assisted in calculating baseline traditional building costs for the project.
- Jerome King, AIA provided estimates for the incremental cost of incorporating "green" into the design process.
- Michael Gabel of Gabel Associates provided energy modeling information for the 1998 Title-24 guidelines and was gracious and interested enough to remodel the building to see how it would fair by the 2001 Title-24 standards.
- Other sources included two case studies:

Global Green USA's Greening Affordable Housing Initiative:
http://www.globalgreen.org/pdf/FCH-Final-Web.pdf

The Green Affordable Housing Coalition "Case in Point" case study:
http://frontierassoc.net/greenaffordablehousing/CaseStudies/Betty-Ann-CaseStudy.pdf

(Endnotes)

[1] Traditional design costs are based on conversations with the architect, Jerome King, who estimated a 15-20% increase in costs for the design fees of Betty Ann Gardens. Of the overall design costs, it is estimated that approximately 65% are directly attributable to architectural fees. A 15% premium was deducted from this value to arrive at the estimated *Traditional Design* costs.

[2] Traditional construction cost estimates based on *RS Means: Square Foot Costs for Residential, Commercial, Industrial and Institutional Projects*. The project was estimated based on the square foot costs of the "1-3 Story Apartment" typology with a series of cost additives derived from our research on the project and also adding in the "location factor" for the San Jose area. Given that the traditional costs of the project were available to us at the time of this study, we have tried to construct these costs as best we could. Actual "traditional" costs could vary from what we have indicated.

[3] It should be noted that Betty Ann Gardens qualified for consideration under the 1998 version of California's Title-24 Energy Code. Shortly after the building was permitted, the State of California adopted the 2001 version of that same code. If Betty Ann Gardens were modeled under the 2001 code, the four residential buildings would have exceeded the requirements by an average of 12.05% (compared with the average 27.58% margin on the 1998 code). California is set to adopt a new version of Title-24 in 2006, and by this new standard, it is questionable whether or not Betty Ann Gardens would be in compliance. For the cost analysis of this survey, we felt it was fair to judge the project against comparable "baseline" projects built at the same time, and thus we based our cost savings on the 1998 Title-24 standards.

[4] We only have data on residential heating use. To allocate costs to residents and the owner, we have assumed that residential space uses three times as much heating and cooling energy as common area (only parts of the common area are conditioned) and calculated the owner costs based on how much of the building square footage is residential units and how much is ingress, egress, and common space.

[5] Since we did not have detailed cost data and only limited operating data, we put most of the green building premium into the operating cost category and then calculated the savings (costs) to the owner based on this premium and expected operations. Some of the costs included here should be in replacement costs or other green features, but we have not received sufficient information to break them out.

[6] Jennifer Seguin from First Community Housing has estimated that incandescent bulbs cost $0.75 to purchase but $15.68 to operate for 1 year and that fluorescents cost $11 to purchase but $5.40 per year to operate. Based on a list of lighting fixtures installed in a standard 2 bedroom unit, we have estimated that each 1 and 2-bedroom unit has 4 fluorescent bulbs and each 3 and 4-bedroom unit has 6 fluorescent bulbs. In addition, all common area lighting was fluorescent as well, and we have estimated that they had 20% as many fluorescent bulbs in common spaces as they did in the interior of units.

[7] First Community Housing paid $159,600 for the recycled content carpet and had a bid of $135,950 for conventional carpeting. The recycled content carpet is expected to last for 15 years and the conventional is expected to last for 10.

[8] First Community Housing used Armstrong Marmorette flooring at a cost of $55,305 and had a bid for vinyl flooring at a cost of $88,312. The Armstrong Marmorette has an expected life of 40 years versus 10 years for vinyl.

BRICK CAPITAL COMMUNITY DEVELOPMENT CORPORATION

SANFORD & BROADWAY, NC

Project Summary

Number of Units	5
Unit Type	Detached, single-family homes
Construction	New
Target Occupant	Low-income first-time homebuyers
Developer	Brick Capital Community Development Corporation
Contractor	Gerald Womble
Architect	None
Total Square Footage	5,774
Total Development Cost	$431,649
Average Cost per Unit	$86,330
Average Cost per Square Foot	$74.76
Incremental Cost to Build Green	$7,090
Green Building Focus	Energy-Efficiency
Average Sales price	$86,330
Financing Sources	First Citizen's Bank, North Carolina Housing Finance Agency, SunTrust Mortgage Company, North Carolina Community Development Initiative, US Department of Agriculture Rural Development Office

"What is the American Dream?

We believe it begins with an

investment in communities."

Brick Capital Community Development Corporation mission statement

Overview

Brick Capital Community Development Corporation is a housing advocacy, education, and development organization working in Lee County, North Carolina. Incorporated in 1990, Brick Capital has built over seventy-five units of housing. They focus on building ten homes for first-time homebuyers each year, but they also have experience with affordable rental housing and special needs housing both for victims of domestic violence and people suffering from mental illness.

In the last half of 2002, Brick Capital developed and sold five scattered site, single-family homes to first-time homebuyers in Broadway and Sanford, NC. Gerald Womble built these three bedroom, two bath homes that ranged in size from 1,112 to 1,200 square feet. All together, these homes included 5,774 square feet of living area that cost $431,649 to build. The homes were all new, pier and beam construction without access to attic crawl spaces, and they were all sold to low-income families or individuals. Purchase prices ranged from $78,250 to over $97,350. No architect worked on the project.

These homes were developed with support from a high performance building program run by the North Carolina Community Development Initiative (the Initiative) and Advanced Energy, a building science and energy consulting firm operating in Raleigh, NC. Advanced Energy has developed a construction training and home energy analysis tool that can improve indoor air quality and lower utility expenses related to heating and cooling. Working with the Initiative,[1] they have offered this program to community development corporations throughout the state in an attempt to improve the quality of affordable housing built in North Carolina. Under this partnership, Advanced Energy analyzes house plans, trains the general contractor, the insulation sub-contractor, and HVAC sub-contractors, recommends a set of upgrades or changes to the house, and inspects homes throughout construction and upon completion. The Initiative pays the increased cost of training and material upgrades. After completion, Advanced Energy signs a contract with the new owner, guaranteeing the amount of heating and cooling energy that the home will use in its first two years.[2] According to their Executive Director, Kate Rumely, Brick Capital utilized this program for two reasons:

- They had a commitment to lower the energy and maintenance costs to the greatest extent possible.
- The program required no additional capital from either Brick Capital or the prospective buyer. The Initiative took on the increased cost.

In many ways, these motivations separate Brick Capital from the other case studies included in this report. Brick Capital had access to a program that would lower energy costs without changing the cost to Brick Capital or the homebuyer. The air quality benefits related to increased air circulation and ventilation were a bonus. They made no changes to their standard construction model except those recommended by Advanced Energy.

The homes were financed by various lenders. Construction financing was provided by a revolving construction fund controlled by Brick Capital and First Citizen's Bank. First mortgages were provided to homebuyers by the United States Department of Agriculture's Rural Development Office, First Citizens Bank, and SunTrust Mortgage Company. Soft second mortgages were provided by the North Carolina Housing Finance Agency.

Green Design and Construction

The changes recommended by Advanced Energy (summarized in the following section) brought an added cost of $1,418 per unit, which was paid for entirely by the Initiative. Tables 1 & 2 show the additional costs on a total and square footage basis. These additions account for a first-cost premium of 1.76%.

Table 1: Total Development Costs

	Total
Acquisition Costs	$24,768
Hard Costs	$366,370
Soft Costs	$10,626
Developer Fee	$29,886
Total Costs	$431,649

Table 2: Net Cost of Greening

	Total	Total/SF	% of Total Dev. Cost
Green Design	$0	$0.00	0.00%
Traditional Design			
Green Design Premium	$0	$0.00	0.00%
Green Construction	$401,763	$69.58	93.08%
Traditional Construction	$394,673	$68.35	
Net Cost of Greening	$7,090	$1.23	1.64%

Table 3: Green Premium (Savings) by Category

Category	Traditional Cost	Green Cost	Green Premium
Sustainable Sites	$0	$0	$0
Water Efficiency	$0	$0	$0
Energy & Atmosphere	$0	$4,727	$4,727
Indoor Environmental Quality	$0	$2,363	$2,363
Materials and Resources	$0	$0	$0
Innovation in the Design Process	$0	$0	$0
Total	$0	$7,090	$7,090

Note: Based on the list of changes provided by the development team, we have assigned 2/3 of costs from greening to energy and atmosphere and 1/3 to indoor environmental quality. We do not have actual costs for changes. No changes were made in other categories.

Green Features

Some of Brick Capital's standard practices already promote environmentally sustainable development. They build infill housing exclusively, focusing on areas with existing services and infrastructure. Beyond this, they provide well-constructed, durable buildings that will be easy to maintain and easy to use. This commitment has led to an internal policy to build brick buildings, and to the standard practice of using double-paned windows in all of their homes. In working with Advanced Energy, Brick Capital had to expand on this set of practices to include other materials and methods that could improve ventilation and energy efficiency. Brick Capital:

- removed drop-down stairwells from their attic to provide an unbroken insulation barrier between the attic and the house,
- used low-e double-paned windows, instead of just double-paned windows,
- raised trusses in the roof system so that insulation could be uniformly installed,
- insulated to the edge of the house,
- required that their insulation contractors follow a revised installation process that protected R-value at breaks in the insulation (like electrical outlets),
- vented between rooms when one room didn't have a return,
- brought fresh air into the home at increased rates, particularly in the kitchens and bathrooms.

These changes resulted in the costs described in Table 3.

Sustainable Sites
As mentioned above, all Brick Capital homes are built on infill sites with already established infrastructure. This commitment does not increase costs, but does ensure that residents served by Brick Capital developments have better access to community resources and that less infrastructure development is needed to serve Brick Capital projects.

Water Efficiency
There were no significant water efficiency changes made in this project.

Energy and Atmosphere
The changes that Brick Capital

Table 4: Operating Costs for Green versus Conventional Homes

	Monthly heating and cooling cost	Annual heating and cooling cost
Advanced Energy Homes	$23.02	$276.19
Brick Capital Standard	$22.54	$270.53

made on this scattered site project focused on energy and atmosphere and indoor air quality as it relates to ventilation. The Energy and Atmosphere changes include: removal of drop-down stairwells to provide an insulation barrier between the attic and the house, using low-e double-paned windows instead of their standard double-paned windows, raising roof trusses so that insulation can be uniformly installed, insulating to the edge of the house, and using an insulation installation process that protects R-value at breaks in the insulation (like electrical outlets).

Materials and Resources
Brick Capital uses double-paned windows and brick in all their projects, and we have included no cost differences for these changes because they are a Brick Capital standard. There were no other significant green changes related to material choices.

Indoor Environmental Quality
Brick Capital also focused on indoor environmental quality and especially on ventilation in the unit. They increased the rate at which fresh air was brought into the green homes, with a particular focus on venting in the kitchens and bathrooms. They also vented between rooms when one room did not have a fresh air return.

Innovation in the Design Process
The Advanced Energy program represents an important innovation in the design and development process, where a statewide expert on building science provides on-site training and technical assistance to contractors and sub-contractors. This program is made all the more effective through the commitment of the Initiative to pay for any cost increases due to these changes.

Operating Savings: Green versus Traditional

Brick Capital has supplied the research team with a small comparative sample of five homes built in the first half of 2002 that did not involve the Advanced Energy program. Working with the utility company which provides service to these homes, they have pulled information for 10 homes (5 built with Advanced Energy's program, 5 without) and removed identifying information. This comparative sample allows one to directly compare the energy costs in homes built to Advanced Energy standards and those that were not. Brick Capital has also shared that the sample of five homeowners living in the Advanced Energy upgraded buildings have significantly more disposable income than the homeowners living in the conventional buildings. These higher-income families that are living in the green homes also have more small appliances and therefore have higher energy loads than the families in the conventional houses. In order to control for the differences in heating and cooling costs, we calculated a base energy load (non-heating and cooling) for each house in the sample. We did this by looking at the average utility expenditure for the months of April, May, September, and October – the months with the lowest heating and cooling needs in North Carolina – over the 16 month period for which we had data. Subtracting this base energy load from the total monthly energy use for each house, we estimated the heating and cooling use by each household.

The non energy efficient homes ranged in size from 1,186 square feet to 1,200 square feet, and are slightly larger than the energy efficient homes. The median size of the non-energy efficient homes (1,189 sf) is 1.19% higher than the median size of the energy-efficient ones (1,175 sf). Because identifying information has been removed from the utility records of each house, we cannot match the square footage with energy usage, and do not have an estimate of energy use per square foot of living area.

According to this information, the homes built to Advanced Energy's standards are using more energy than homes which were not. Brick Capital believes that much of this can be explained by the economic situations of the home owners in the two samples, even after accounting for household by household differences in base electric loads. Either way, both homes perform very efficiently, requiring just over $20 per month in heating and cooling costs.

Net Present Value Summary

Because the Advanced Energy Program is financed by the North Carolina Community Development Initiative (the Initiative), which pays for all green upgrades and associated contractor training, the life-cycle calculations are fairly different for this case than our others. Brick Capital and the residents both bear no increased capital costs for green building. These costs are borne entirely by the Initiative. In addition, Brick Capital gets no ongoing benefit from including these technologies in the homes, because as a homeownership project Brick Capital is never responsible for the operation or maintenance of the buildings. In effect, the life-cycle difference for Brick Capital is zero.

The residents have a somewhat different picture. While they bear no increased costs due to the green upgrades included in the building, they do receive any benefit that accrues due to these changes. In this case, that benefit would come entirely as a result of improved heating and cooling efficiency and improved indoor air quality, the two things on which Advanced Energy focuses. We have no reliable way to measure life-cycle savings related to indoor air quality and therefore have not included it in this analysis. We have measured differentials in the heating and cooling costs, and, as shown in the previous section, the Brick Capital standard buildings actually perform slightly better on average than the Advanced Energy upgraded buildings. Using these results alone, the life-cycle cost borne by the residents are shown in Tables 5-6. This amounts to a loss of over $140 per household over a thirty-year building lifespan or a total of $706 for the project.

All the increased life-cycle costs come from features that were supposed to improve indoor heating and cooling efficiency. The actual energy-use data show that the opposite effect occurred and the green homes have an increase in heating and cooling bills that amounts to roughly $0.50 per month per unit or $706 for all five homes over a 30-year lifespan.

Table 5: Total resident NPV by feature

	Green savings (cost)
Additional Interest	$0
Energy Efficiency	($706)
Total	($706)

Table 6: Resident NPV by Feature

	Green Savings (cost)
Additional Interest	$0
Operating Costs	($706)
Replacement Costs	$0
Total	($706)

References and Acknowledgements

- Phone interviews with Kate Rumely, Executive Director of Brick Capital CDC. Carried out by Will Bradshaw from May to July 2004.
- Brick Capital CDC press packet. Sent from Kate Rumely, Executive Director of Brick Capital CDC.
- Profit and Loss Statements for each Brick Capital home, energy efficient and non energy efficient. Sent from Kate Rumely, Executive Director of Brick Capital CDC.
- Progress Energy utility usage reports over the last 24 months. Sent from Kate Rumely, Executive Director of Brick Capital CDC.
- Advanced Energy program description and energy-use contract. www.advancedenergy.org

(Endnotes)

[1] There is a complementary program run through the North Carolina Housing Finance Agency (NCHFA). The services that Advanced Energy provides are identical in the two programs, and the financial partner (the Initiative or NCHFA) covers the full cost of building improvements and training in both.

[2] Advanced Energy does not guarantee a price for energy, but rather a given amount of energy that will be used for heating and cooling. They have a process through which the house's heating and cooling load is determined, backing out the energy used by other appliances and systems. Their guarantee also requires a set of behaviors from the resident, specifying maximum and minimum thermostat placements based on season, and requiring that people close windows and doors, etc.

COLORADO COURT

SANTA MONICA, CA

Project Information

Number of Units	44
Unit Type	Multi-family, Attached
Construction	New Construction
Target Occupant	Very Low-income Tenants
Developer	Community Corporation of Santa Monica
Contractor	Ruiz Brothers Construction Co.
Architect	Pugh Scarpa Kodama
Total Square Footage	29,858
Total Development Cost	$5,900,000
Average Cost per Unit	$134,091
Average Cost per Foot	$198
Incremental Cost to Build Green	$536,215
Green Building Focus	Energy Efficiency
Financing Sources	City of Santa Monica, State of California Multifamily Housing Program, Federal Home Loan Bank Affordable Housing Program, California Affordable Housing Program, Regional Energy Efficiency Inititative, Bank of America

"This project is an excellent model of sustainable development in an urban environment, provides a model for private/public partnerships that benefit the community, and promotes diversity in an urban environment through strategically placed affordable housing."

U.S. Green Building Council comments on Colorado Court

Overview

By many standards, Santa Monica is one of the most desirable places to live in the country. It sits on the Pacific Ocean just west of Los Angeles. It has a rich employment base and entry-level job market, extensive transit service and the political will to promote green affordable housing. But since vacancy-decontrol in 1999, average rents have doubled. The city lost an estimated 5,000 affordable units from 1999-2003.

Colorado Court was an effort to address this affordable housing challenge in an environmentally sustainable way. Located at a major intersection in downtown Santa Monica, Colorado Court is a highly visible model of sustainable development. Its striking design and location send a powerful message that affordable housing and sustainable housing can be accomplished in the same project. It is the first affordable-housing project in the United States to be 100% energy neutral.

The team comprised the City of Santa Monica, the Community Corporation of Santa Monica (CCSM), and Santa Monica-based architects Pugh Scarpa Kodama (PSK). The Community Corporation of Santa Monica owns and operates several affordable housing projects in the City (including 20th Street Apartments, detailed in this report) and Pugh Scarpa Kodama have years of experience in green building.

Completed in the fall of 2001, the project provides critically-needed affordable SRO units in a contextual and sustainable design in downtown Santa Monica. At 5 stories high and nearly 30,000 square feet, it contains 44 SRO units and 2,300 square feet of community space. Each unit is equipped with a functional kitchen and bath, and all tenants have access to the complex's community room, mail room, outdoor common courtyard spaces, covered parking for 20 cars, and ample bike storage. Passive solar design and natural ventilation throughout Colorado Court dramatically enhance the indoor environmental quality building.

Energy efficiency was PSK's primary green design goal. Nearly 200 photovoltaic panels integrated into its façade and roof supply most of the peak-load energy demand. Unused energy from these solar panels is fed into the grid during daytime hours and retrieved from the grid at night as needed. A natural gas turbine cogeneration system supplies the building's base load power needs, while waste heat from the system is used to heat the building's water. Excess energy is fed back into the utility grid.

The total development cost of Colorado Court was $5.9 million. Hard costs totaled $4.7 million, amounting to about $156/square foot. The property was purchased by the City and leased for 87 years to CCSM. Santa Monica also provided more than $4 million dollars in forgivable loans for the project. The California multi-family housing loan program and the Federal Home Loan Bank provided over $1.6 million and $207,000, respectively.

Colorado Court was able to obtain funding to pay for $555,515 in green measures. The Regional Energy Efficiency Initiative, a state program, provided $257,000 for energy measures and consulting. CCSM contributed $70,015 towards green measures. Since so much of the project's financing is not available to the majority of developers, it is useful to consider Colorado Court as a model of energy efficiency techniques, healthy affordable housing design and alternative funding mechanisms. Overall, 12% of the $4,620,958 in total hard costs and 9% of the $6,161,278 total budget were paid for with outside funding for green measures.

Green Design and Construction

The majority of the green measures and costs were intended to increase energy efficiency. $443,000 from CCSM, the City of Santa Monica and REEI went towards upgrading materials, photovoltaic panels and hardware, and the cogeneration system. Consulting services, upgraded stormwater collection and other green material upgrading account for the remainder of green costs. Greening measures increased hard costs by 13% and the overall budget by 10%. Tables 2 and 3 show the cost premiums related to greening.

The project's stated goals were 50% reduction of energy use beyond California's energy standard, Title 24; a power generation that meets 100% of the development's energy needs and LEED certification. It successfully attained LEED gold status and dramatically reduced energy needs. The following section, Green Features, further discusses the power generation system.

The public-private partnership behind Colorado Court helped change restrictive regulations that originally limited the extent of possible greening. The City of Santa Monica owns the land and is leasing it to CCSM. The design by PSK meets the needs of SRO tenants and addresses the concerns of neighbors.

Colorado Court was also instrumental in changing regulations in California. The team successfully lobbied the California Public Utilities Commission (PUC) to increase the limit for net metering from 10 kilowatts to 100 kilowatts for renewable energy systems. The USGBC followed suit and lobbied

Table 1: Total Development Costs

Activity	Dollar Amount
Property acquisition	$0
Final construction cost	$4,700,000
Architecture and engineering	$250,000
Environmental assessment and testing	$13,000
Development consultant(s)	$145,500
Legal	$25,000
Lender fees and costs	$0
Construction and pre-development loan interest	$0
Sponsor/Developer project management and overhead	$0
Other Soft Costs	$277,000
Developer fee/profit	$330,000
Capitalized Replacement Reserves	$0
Capitalized Operating Reserves	$159,500
TOTAL	$5,900,000

Table 2: Net Cost of Greening

	Cost	Cost/square foot	% of Total Dev. Costs
Green Design	$250,000	$8.37	-
Traditional Design	$250,000	$8.37	-
Green Design Premium	$0	$0	-
Green Construction	$4,700,000	$157.41	-
Traditional Construction	$4,085,778	$142.98	-
Green Construction Premium	$614,222	$3.75	13.07%
Net cost of greening	$614,222	$3.75	13.07%

note: (-) means that result is not applicable.

for expanding the definition of "eligible customer" to include those using multiple energy-generation sources,[1] such as the dual-generation system of Colorado Court. The project effort also led to the California State Tax Credit Committee and Multi-Family Housing Program expanding incentives for green design.

That being said, Colorado Court came up against many regulatory impediments to green design. After the successful lobbying of the PUC, Colorado Court still had to negotiate with the local utility to permit "net-metering" on a dual-generation system. The utility did not agree to buy back electricity at existing rates, so the value of returning electricity into the grid has yet to pay off.[2]

The education of subcontractors in the installation of new and innovative energy systems also posed a challenge to Colorado Court. For example, a subcontractor initially only connected the boiler to the space heating system, bypassing the micro-turbine altogether because he was unfamiliar with co-generation systems.

The project also paid prevailing wage rates for construction. This requirement for affordable housing construction increased the construction costs by 20%, compared to market-rate developer projects. To ensure future efficiency and improvements, the project created an operation and maintenance program, an operations manual and ongoing monitoring process.

Green Features

While the project focused on energy efficiency and energy generation, there were many other green features included. Those features are highlighted below.

Sustainable Sites
Colorado Court is sited on a previously-developed site at a prime intersection of a freeway-exit road and major road. It showcases the possibilities for affordable housing and green design in a highly visible location. But more importantly for the tenants, it lies within easy walking and transit access of entry-level employment, services and community facilities. It also provides much-needed community space in the 2,000 square-foot public meeting room. Combined with bike parking and a vehicle parking ratio of 0.25 spaces/unit, all of these measures minimize automobile use and increase job access for tenants.

The low lot coverage ratio and landscape design improve storm water management for the site and the entire community. The footprint is just over 50% of the 15,000 square-foot lot. With permeable pavers, limited parking areas and subsurface infiltration basins, the Colorado Court site collects and cleans the entire block's storm water runoff. Planting indigenous species and preserving existing trees increase the longevity of the landscape. By preserving existing root structures and planting species likely to survive, erosion and runoff are minimized.

The project team analyzed microclimate conditions to best integrate solar gain, cross ventilation and light within the units. The three arrays of solar panels cover the southwest facades of Colorado Court. They are oriented just askew of the optimum angle in a compromise with limited roof space, aesthetic concerns, and the savings in additional infrastructure. One related setback was the lower energy output of the solar panels because mornings in Santa Monica are often cloudy.

Water Efficiency
Colorado Court minimizes water use through plumbing fixtures and landscaping measures. Low flow toilets and shower controls lower the tenant consumption of water (though these things are required by California code). Potable water use per unit area is a low 21.6 gallons/sq ft. Drip irrigation system and drought-resistant plants also reduce the water demand of the site.

Energy and Atmosphere
Colorado Court's energy efficiency is largely driven by its rooftop cogeneration system and 197 solar photovoltaic panels. The cogeneration system is a natural gas powered turbine/heat recovery system which converts natural gas to electricity to meet the base load

Table 3: Green Premium by Category*

	Traditional Cost	Green Cost	Green Premium
Sustainable Sites	$0	$30,700	$30,700
Water Efficiency	$0	$0	$0
Energy & Atmosphere	$0	$443,000	$443,000
Indoor Environmental Quality	$47,289	$92,804	$45,515
Materials and Resources	$30,718	$47,718	$17,000
Innovation in Design	$0	$0	$0
	$78,007	$614,222	$536,215

power needs of the building. Waste heat is captured to produce hot water for the building throughout the year as well as space heating needs in the winter."[3] For this reason, units are heated with radiators rather than forced air. The micro-turbine has a conversion efficiency factor of more than 70%, where as primary energy delivered by the utility grid has a conversion efficiency of less than 30%.[4] Payback for the system was estimated after five years.[5]

The photovoltaic panels, installed on the facade and roof of the building, supply most of the peak load electricity demand on site with zero emissions. Unused energy produced by the photovoltaic panels will be sold to the grid. According to project estimates, these systems would have generated $10,000[6] in annual natural gas and electricity savings and would have paid off their associated costs of purchase and installation within ten years, assuming electricity buyback rates commensurate with the costs to purchase electricity.

The cogeneration and photovoltaic technologies are accompanied by other elements of green design including north-south solar building orientation, use of breezeways for improved circulation, awnings, and a light colored exterior façade. A high efficiency heat pump in the lobby supplies heating and cooling. Sliding doors and cross ventilation obviate the need for cooling[7].

Materials and Resources

Materials for the project were given priority for their recycled content, proximity of manufacturer and durability. Many of the buildings energy-saving designs reduce or eliminate material use altogether. Because of the low power demand, the building uses ventilation shafts rather than traditional piping, and they were able to reduce piping, wire usage, and roof penetrations.

Insulation is made from properly-treated recycled newsprint, oriented strand board was used in place of plywood, and engineered wood and composite structural elements were used in place of dimensional lumber. Over 75% of construction material was recycled. Recycled content and natural materials were used in the flooring, carpeting and wallboards. The concrete contained a high percentage of fly-ash.

Natural modeled finishes ensure that materials will show less wear and last. Natural stucco pigments and natural linoleum are also likely to last longer than conventional products. Although, we did not have enough information to estimate the impact of these longer lasting materials on life-cycle costs.

Indoor Environmental Quality

The passive solar orientation of the building largely contributes to the improved indoor environmental quality in every Colorado Court unit. The interiors have been shaped and planned to enhance daylight and natural airflow distribution via high ceilings and smartly designed windows. In order to maximize sunlight in the morning and afternoon hours while avoiding mid-day overheating, awnings have been installed over south-facing windows and west-facing glazing has been reduced.

Indoor, zero-VOC acrylic latex paints were used on all indoor surfaces, as is standard in California. Formaldehyde-free products were used when possible, such as the MDF moldings.

Operating Savings: Green versus Traditional

Energy modeling and system design were provided by John Ingersoll of Helios International. All utilities are paid for and operated by CCSM. The unwillingness of the utility to buy excess electricity at the same rate at which they sell it makes selling electricity back to the grid difficult. Unfortunately, the energy system was designed with this idea in mind. CCSM is currently monitoring residential gas consumption to determine the most cost-effective use of the dual-generation system. Tables 4-6 show operating costs for the project at different times and under different scenarios. Table 4 shows the operating costs in 2003-2004, before the demand meter was installed.[8] Table 5 shows operating costs in 2004-2005, after the demand meter was installed. Table 6 shows what operating costs would be if the utility had a full buy-back policy.

Net Present Value Summary

As described earlier in this report, for each case we have estimated the financial impact of green building decisions over an expected thirty-year building lifespan. In the case of Colorado Court, we have less detail than with other cases in this report. For this case, we were only able to obtain aggregate green building premiums and operating cost differentials for gas and electricity use. With this information, we have carried out a partial life-cycle analysis that is based on the following key assumptions:

Table 4: Operating Costs (2003-2004)

	Electricity	Gas	Total Cost
Trad./Title-24	$14,317	$16,817	$31,133
Colorado Court	$3,180	$22,347	$25,528
Savings	$11,136	($5,531)	$5,606
% Savings			22%

Table 5: Operating Costs (2004-2005)

	Electricity	Gas	total cost
Trad./Title-24	$14,317	$16,817	$31,133
Colorado Court	$12,746	$9,638	$22,384
Savings	$1,571	$7,178	$8,749
% Savings			39%

Table 6: Operating Costs (with Full Buy-back)

	Electricity	Gas	Total Cost
Trad./Title-24	$14,317	$16,817	$31,133
Colorado Court	($5,522)	$22,347	$16,825
Savings	$19,839	($5,531)	$14,308
% Savings			85%

The research team has estimated the conventional cost of natural linoleum and recycled content carpet by looking at the cost in another case study. We calculated the material installation cost per unit at Betty Ann Gardens for regular carpet and vinyl flooring. We then adjusted this per unit cost based on the average square footage per residential unit in each project. CCSM had supplied green premiums, and we added those premiums to our calculated conventional cost in order to estimate the green construction cost.[9]

We have assumed that all other materials and systems which are supposed to be more durable have no effect on replacement costs. This assumption almost certainly underestimates the life-cycle value generated by longer-lasting materials, like natural stucco pigments. But without reliable information on durability and cost of such products and their conventional counterparts, we could not complete a more detailed analysis.

We have assumed that water usage in the building remains unchanged despite the water efficiency upgrades made. We have been unable to obtain operating data on water use (which would allow us to extrapolate cost and operating information). This assumption almost certainly reduces the life-cycle value of greening by not including savings from the reduced water usage.

We have compared gas usage figures from before and after a demand meter was installed. The project had been designed to use electricity produced by the natural-gas fired micro-turbine. But since surplus electricity generated by the photovoltaic system was not purchased at the cost of use of the micro-turbine, the dual-generation system has not been as cost-effective as anticipated. A demand meter was therefore installed to more efficiently utilize gas. While CCSM is still refining the use of the dual-generation system, significantly less gas was consumed after the demand meter was installed. Had CCSM been compensated for surplus electricity at the cost of use, there would have been increased demand on gas from the dual-generation system, lower electricity demand from the grid, and therefore lower overall utility costs (this can be seen in Tables 4-6 above).

As detailed above, the owner pays for all utility costs on site, and so the residents bear none of the increased capital costs and receive none of the benefits from energy efficiency and energy generation. For that reason, the analysis done in this section will focus exclusively on the project owner, CCSM. The NPV analysis will be carried out under

three different scenarios: before the demand meter, after the demand meter, and with full buy-back as originally designed.

Before the demand meter was installed, the green building changes made would have cost CCSM nearly $306,000 over a thirty-year time period. This is substantially less than the $555,515 in grants and rebates that they received to pay for greening, and after these grants and rebates, CCSM comes out almost $250,000 ahead in present value terms. After the demand meter, the green building changes cost only $227,513, which would leave CCSM $328,000 ahead after grants and rebates. Had the utility bought back electricity at the rate which it charges, and assuming all other utility usage remained equal to the year before the demand meter was installed, the NPV of green building costs would have been as low as $88,780, putting CCSM $466,735 ahead. In all three scenarios, the rebates alone more than pay for the life-cycle costs of green building. Tables 7-12 illustrate these results.

These figures also show the great effect utility costs and system design can have on the cost of greening. If the local utility were amenable to net-metering for co-generation systems, as the project was designed, the NPV of greening Colorado Court may have cost between $150,000 and $200,000 less than it did. As it stands now, the project financially outperforms conventional designs, when rebates are taken into account.

Table 7: Owner NPV by Feature (before demand meter)

	Green savings (cost)
Additional Interest	($17,324)
Energy Efficiency	($303,111)
Natural Linoleum	$70,335
Recycled Content Carpet	$25,359
Other Green Features	($81,215)
Total	($305,956)

Table 8: Owner NPV by Category (before demand meter)

	Green Savings (cost)
Additional Interest	($17,324)
Operating Costs	($303,111)
Replacement Costs	$95,694
All Other Green Features	($81,215)
Total	($305,956)

Table 9: Owner NPV by Feature (after demand meter)

	Green savings (cost)
Additional Interest	($17,324)
Energy Efficiency	($224,668)
Natural Linoleum	$70,335
Recycled Content Carpet	$25,359
Other Green Features	($81,215)
Total	($227,513)

Table 10: Owner NPV by Category (after demand meter)

	Green Savings (cost)
Additional Interest	($17,324)
Operating Costs	($224,668)
Replacement Costs	$95,694
All Other Green Features	($81,215)
Total	($227,513)

Table 11: Owner NPV by Feature (assuming full buy-back of energy)

	Green savings (cost)
Additional Interest	($17,324)
Energy Efficiency	($85,935)
Natural Linoleum	$70,335
Recycled Content Carpet	$25,359
Other Green Features	($81,215)
Total	($88,780)

Table 12: Owner NPV by Category (assuming full buy-back of energy)

	Green Savings (cost)
Additional Interest	($17,324)
Operating Costs	($85,935)
Replacement Costs	$95,694
All Other Green Features	($81,215)
Total	($88,780)

References and Acknowledgements

• Robin Raida, Community Corporation of Santa Monica, provided information and review of this case study.

(Endnotes)

[1] http://leedcasestudies.usgbc.org/process.cfm?ProjectID=188

[2] In the operating cost and NPV analysis sections, we will refer to full buy-back. The term full buy-back refers to the utility paying full price for surplus electricity generated by the dual-generation system at Colorado Court. Under their original agreement with the PUC, the project receives a dramatically reduced rate on the electricity that they sell back to the grid, generally less than it costs them to produce it.

[3] Source: http://www.pugh-scarpa.com/indexmain.html

[4] Source: Million Solar Roofs, 2003.
http://www.millionsolarroofs.org/articles/ static/1/binaries/Colorado_Court_PV_Cogen_Case_Study.pdf

[5] Assuming "net-metering." Source: Million Solar Roofs, 2003.
http://www.millionsolarroofs.org/articles/ static/1/binaries/Colorado_Court_PV_Cogen_Case_Study.pdf, Correspondence with Robin Raida.

[6] Source: Million Solar Roofs, 2003.
http://www.millionsolarroofs.org/articles/ static/1/binaries/Colorado_Court_PV_Cogen_Case_Study.pdf

[7] Source: Million Solar Roofs, 2003.
http://www.millionsolarroofs.org/articles/ static/1/binaries/Colorado_Court_PV_Cogen_Case_Study.pdf

[8] The demand meter ramps up the dual-generation system at times when energy needs are highest. Because it was uneconomical for Colorado Court to sell energy back to the grid due to the PUC's pricing arrangement, CCSM has tried to cut down on the surplus energy that their system generates.

[9] Betty Ann Gardens used similar materials in their project, which was also built in California, the year before Colorado Court.

COLUMBIA TERRACE

CAMBRIDGE, MASSACHUSETTS

Project Information

Number of Units	42
Unit Type	Multi-Family, Attached
Construction	Rehab
Target Occupant	Low-income family tenants
Developer	Homeowner's Rehab, Inc. (HRI)
Contractor	George B.H. Macomber Company
Architect	Mostue and Associates, Inc.
Total Square Footage	35,355
Total Development Cost	$9,587,297
Average Cost per Unit	$228,269
Average Cost per Square Foot	$271
Incremental Cost to Build Green	$58,955
Green Building Focus	C&D Waste Management, Energy Efficiency, IEQ
Financing Sources	MA Community Economic Development; Assistance Corp. (CEDAC); City of Cambridge; Fleet Bank; MA Department of Housing and Community Development; MA Housing Investment Corp.; Cambridge Neighborhood Apartment Housing Services (CNAHS, an HRI affiliate); MA Housing Partnership Fund

"What's been done here is all about people caring for future generations….."

Vincent P. McCarthy
Chair, Massachusetts
Housing Partnership

Overview

In 2003 Homeowner's Rehab, Inc. (HRI) completed the CAST I, Columbia Terrace project in the Central Square area of Cambridge, Massachusetts, a diverse multi-ethnic neighborhood in this city of more than 100,000 people located across the Charles River from Boston. HRI is a nonprofit community development corporation, which has been creating and preserving affordable housing in Cambridge since 1972. It has developed over 1,400 units and owns more than 870 units. Over the past few years HRI has increasingly focused on greening their developments and portfolio, recognizing the health and quality-of-life benefits that result. Moreover, they understand that by reducing operating costs the units actually become more affordable.

The CAST project renovated 42 one- to five-bedroom affordable apartments in three buildings. The residential units comprise 34,195 square feet, with an additional 1,160 square feet for a common laundry room. Twenty-four of the 42 units have three or more bedrooms. Thirty-seven of the units are affordable to families with incomes at or below 60% of median income; five units are for families at or below 80% of median income. From project inception, HRI was committed to incorporating green building strategies, notwithstanding the significant budget constraints on the project. The renovation work included refinishing and upgrading all kitchens and bathrooms, improving common entry areas (including additional lighting and a security system), and making site improvements to address stormwater management issues. In their greening effort HRI focused on use of energy efficient appliances and lighting, selection of environmentally friendly materials, including non-vinyl flooring and low-VOC paints, and low water-use landscaping. In addition, HRI required the contractor to implement a Construction and Demolition Debris (C&D) Waste Management Plan that recycled almost 90% of C&D material from the overall site.

The architect for the project was Mostue and Associates, and George B.H. Macomber Company was the general contractor. The total project development costs were $9,587,000 (see Table 1). The project was financed by a variety of sources. Predevelopment financing was provided by the Massachusetts Community Economic Development Assistance Corporation (CEDAC) a public-private, community development finance institution; the City of Cambridge; and Fleet Bank. Construction financing came from Fleet Bank, while permanent financing was from the Massachusetts Department of Housing and Community Development's Capital Improvement and Preservation Fund (CIPF); the Massachusetts Housing Investment Corporation (a private lender and investor specializing in the financing of affordable housing); the City of Cambridge Federal Home Funds; Cambridge Neighborhood Apartment Housing Services, Inc. (CNAHS), an affiliate of HRI; and the Massachusetts Housing Partnership Fund.

Two important features of the CAST project are worth mention. First, as noted by the Massachusetts Housing Partnership, which provided permanent first mortgage financing for the project, CAST "is an example of 'expiring use,' a common situation in which affordable apartments financed under a federal program called Section 236, can be sold at market rate" after their 30-year, federally subsidized mortgage restrictions expire or after 20 years, if the owner opts to pre-pay out of the program.[1] Real estate prices had surged since the project was purchased with a 236 loan back in 1971, and in the late 1990s CAST was at risk of transitioning to market rate housing. With support from the City of Cambridge, HRI's purchase of the property allowed CAST to remain part of the City's affordable housing stock.

The second important feature is that the significant renovations to CAST were made while it was occupied. Individual tenants were relocated (within CAST) while their units were under construction, with empty units serving as "hotel" units so residents had a place to go while their kitchens and bathrooms were renovated. While this was beneficial in terms of minimizing relocation costs, as well as inconvenience to the residents, it created significant challenges in terms of construction logistics such as maintaining a safe worksite for ongoing residential life and space management to implement the source-separated C&D waste management plan (see further details below).

Green Design and Construction

Construction costs for the CAST rehabilitation project totaled $2,776,917, or about $79 per square foot. Design and engineering costs were $317,691 or almost $9 per square foot. Other than additional time on the part of the HRI project manager on specifications and development of the Waste Management Plan, there were no incremental design costs. HRI estimated the traditional construction costs at $2,717,962 or almost $77 per square foot, which indicates a $58,955 or 2% construction cost premium for the green measures installed. Note that the Energy Star program provided the project with refrigerators as well as grants totaling $58,024 for appliances, lighting, steel-insulated doors, and some administrative costs. This virtually fully offset the incremental construction costs of greening. Table 2 provides a summary comparison for green versus traditional capital costs for the CAST project.

A breakdown of the incremental costs of greening CAST by LEED category is presented in Table 3. Note that the Energy Star rebate of $58,024 is not reflected in this table.

Table 1: Total Development Costs

Activity	Dollar Amount
Property acquisition	$4,500,000
Final construction cost	$2,776,917
Architecture and engineering	$317,691
Environmental assessment and testing	$13,250
Development consultant(s)	$24,938
Legal	$210,581
Lender fees and costs	$62,599
Construction and pre-development loan interest	$89,402
Sponsor/Developer project management and overhead	$210,000
Other Soft Costs	$459,063
Developer fee/profit	$210,000
Capitalized Replacement Reserves	$377,600
Capitalized Operating Reserves	$335,256
TOTAL	$9,587,297

Table 2: Net Cost of Greening

	Cost	Cost/square foot	% of Total Dev. Costs
Green Design	$317,691	$8.16	3.31%
Traditional Design	no data	no data	
Green Construction	$2,776,917	$71.33	28.96%
Traditional Construction	$2,717,962	$69.81	
Net Cost of Greening	$58,955	$1.51	0.62%

notes: construction premium does not include $58,024 Energy Star rebates received.

Table 3: Green Premium (Savings) by Category

	Green Costs	Traditional Costs	Green Premium
Sustainable Sites	$47,800	$15,500	$32,300
Water Efficiency*	no data	no data	no data
Energy and Atmosphere	$28,984	$23,999	$4,985
Materials and Resources	$44,793	$23,123	$21,670
Indoor Environmental Quality**	no data	no data	no data
Total	$121,577	$62,622	$58,955

** Low-flow fixtures required by MA Building Code; no incremental cost.*

*** No incremental costs associated with use of low-VOC paints.*

Green Features

Efforts to green CAST focused on providing better quality units and minimizing C&D waste during the construction process. However, a wide variety of green building techniques and systems were used, as detailed below.

Sustainable Site

The CAST project is in an urban setting about a third of a mile and walkable to the Central Square subway stop and multiple bus lines. As a rehab project, it continues to use an existing site with existing buildings, thereby avoiding development of a new site and more extensive construction. In addition, new deeper underground sanitary separation/catch basins were installed to slow the rate of stormwater from the site entering the City's system; an especially important feature since this part of Cambridge still operates combined storm and sewer pipes. Outside of the buildings the project included the removal of asphalt and installation of pervious pavers (made from local materials) to reduce runoff. In addition, "field turf" was used in lieu of grass for a small playground on the property. This not only reduced water use, but also other inputs and maintenance costs.

Water Efficiency

While there is minimal landscaping on the site, native plants and ones that require less water were selected. As mentioned above, the small playground area uses field turf instead of grass. In addition, as required by the Massachusetts building code, low-flow showerheads and toilets were installed in all CAST units, which reduces resource consumption and operating costs. The installation of Energy Star dishwashers in all the units reduces water use considerably (over 60%) compared with washing dishes by hand.

Energy and Atmosphere

As a relatively modest effort that was not a "gut rehab," the CAST project addressed certain energy related issues but not others. The CAST project did include Energy Star appliances (refrigerators, stoves, fume hoods, and dishwashers) in the kitchens as well as Energy Star lighting throughout all units and the common areas. The Energy Star lighting includes compact fluorescent light bulbs, reducing electricity use and extending bulb lifespan, thus lowering maintenance and replacement costs relative to standard lighting. The refrigerators were provided by a non-profit service agency, the South Middlesex Opportunity Council (SMOC), which has an energy and weatherization program for homeowners and tenants. While the project did include minor heating systems enhancements to increase efficiency, boilers and windows were not replaced.[2]

Materials and Resources

In terms of greening the project, HRI had a significant focus on materials and resources, especially in terms of selecting alternative non-toxic materials and paints as well as implementing an extensive C&D waste management plan. Specifically, marmoleum flooring was used in common areas and ceramic tile in the bathrooms instead of vinyl composition tile (VCT). Steel insulated apartment doors were used and the sprinkler system was made from cast iron, not polyvinyl chloride (PVC). Also, new electric service and panels were installed, and the old wiring was recycled.

HRI worked very closely with its general contractor, George B.H. Macomber Company, to develop and implement an extensive C&D waste management program. This involved an iterative process whereby the HRI project manager identified the recycling and reuse goals by material and Construction Specification Institute (CSI) divisions, and pushed for highest use for the recycled materials, rather than use as landfill cover. This required on-site source separation of several materials, including cardboard, plastic, white goods, and steel and other metals. This was particularly challenging given the space constraints associated with this small urban site and the fact that residents remained on-site throughout construction.

The results of implementing the C&D waste management plan were impressive. Virtually 100% of the approximately 520 tons of asphalt, concrete, and fill generated during demolition (of paved areas and entrances) and site preparation were recycled, 297 tons of which (57%) were reused on-site. More than 19 tons of source separated material was recycled, including more than 6 tons of cardboard, almost 4 tons of steel and a ton of copper and aluminum, 3 tons of wood, 2.5 tons of plastic, and 2 tons of white goods. An additional 27 tons of material (sheet rock and insulation, metals, cardboard, other) from the interior renovations were recovered from the project waste stream at the off-site processing facility. Finally, 17 kitchen cabinets were taken from the site for reuse by the Boston Building Materials Resource Center as were 25 china toilets (.75 tons) by a local vendor. Overall, well over 90% of total C&D waste from the CAST project was recycled or reused. The general contractor tracked costs throughout the construction process and although source separating the material on-site involved more labor time and cost, according to the contractor this was fully offset by the reduction in tip fees for disposed material.

In conjunction with the C&D waste management program, HRI implemented a resident recycling program, including training, which has resulted in a small reduction (less than 5%) in waste generation and a

4% reduction in waste management costs at CAST on an ongoing basis. HRI's efforts on the CAST project were awarded the City of Cambridge GoGreen Business Award for small business recycling.

Indoor Environmental Quality
The CAST renovations included an asbestos abatement program. In addition, marmoleum flooring was used in common areas and tile was installed in bathrooms instead of VCT. In addition, low-VOC paints were used throughout all the units and common areas. This was particularly important for improving air quality in hallways where there is minimal natural ventilation.

Operating Savings: Green versus Traditional

Because utility costs at CAST are paid directly by the tenants, we do not have actual data for operating costs. Moreover, a direct comparison of operating costs before and after the rehabilitation project is complicated by the fact that the project added several energy-using amenities that residents had not previously enjoyed. For example, dishwashers were added to all units, additional lighting was added to the hallways, a handicap lift and an upgraded fire alarm system and security cameras were installed. Some of these were required to comply with an updated building code, while others were to improve tenants' comfort.

Since only minimal improvements were made to the heating systems and shells, we do not expect measurable differences in heating loads or costs. Thus, in order to develop an estimate of the impacts of the CAST renovations on operating costs we have focused on the impacts related to the new appliances and lighting. Based on the actual equipment installed at CAST, we have used the Energy Star online calculator to estimate operating cost savings. This simply compares the average cost of operating the Energy Star appliances and lighting installed at CAST with the average cost of operating (new) conventional appliances and lighting.

Table 4: Operating Costs

Operating Cost Category	Green Costs	Traditional Costs	Annual Savings
Electricity (Kwh)	$5,762	$8,448	$2,686
Gas (Therms)	$412	$981	$569
Water (Gallons)	$183	$506	$323
Total	$6,357	$9,935	$3,578

note: estimates base on Energy Star savings calculator

Except for minor savings from the common area hallways and the small laundry room, the operating cost savings related to the installation of Energy Star appliances and lighting accrue to the tenants. Based on the calculations of the Energy Star on-line calculator, we estimate net electricity savings at CAST of almost 26,000 kwh worth approximately $2,686 per year. This is mostly related to savings from more efficient lighting ($2,974). Modest savings are from the Energy Star refrigerators ($412), while the new dishwashers actually add to electricity use and reduce savings ($701 in additional costs). Because dishwashers use less water and therefore less gas to heat the water compared with hand washing, there are gas savings of approximately 464 therms worth about $569 and water savings of more than 82,000 gallons or $323. Thus, overall annual operating savings at CAST total about $3,578. Table 4 summarizes these results for the CAST project.

Net Present Value Summary

As described earlier in this report, for each case we have estimated the financial impact of green building decisions over an expected thirty-year building lifespan. The CAST project was a rehabilitation effort as opposed to new construction. The green features only modestly address energy use and costs, focusing entirely on appliances and lighting rather than building shell and heating systems, and no energy modeling of the project was done. Based on our understanding of the incremental capital costs and the operating savings as estimated using the Energy Star on-line calculator, we have completed a life-cycle analysis focusing on the key improvements at CAST.

The changes made by the project are intended to create long-term value and improved amenities, but only a fraction of that value accrues to HRI. In addition to increasing the overall asset value of the project, the benefits to HRI include increased affordability of the units resulting in less pressure on tenants and perhaps less bad debts (no data is available on this), as well as reduced turnover costs (though this generally happens for any well-done rehab). Though they did not have to invest in green building improvements, the vast majority of the benefits are realized by the CAST residents in terms of reduced utility costs

Table 5: Resident NPV by Feature

	Green savings (cost)
Additional Interest	$0
Energy Efficiency	$80,899
Water Efficiency	$8,022
Materials and Resources	$0
Sustainable Sites	$0
Indoor Environmental Quality	$0
Total	$88,921

Table 6: Resident NPV by Category

	Green Savings (cost)
Additional Interest	$0
Operating Costs	$88,921
Replacement Costs	$0
Total	$88,921

note: Total is for the whole development

Table 7: Owner NPV by Feature

	Green savings (cost)
Additional Interest	($171)
Energy Efficiency	($4,654)
Water Efficiency	$33
Materials and Resources	$15,714
Sustainable Sites	($32,300)
Indoor Environmental Quality	$0
Total	($21,378)

Table 8: Owner NPV by Category

	Green Savings (cost)
Additional Interest	($171)
Operating Costs	($4,621)
Replacement Costs	($16,586)
Total	($21,378)

as well as improved amenities and comfort. We have estimated that green building changes provide a benefit of $88,921 (over $2,100 per unit) in current day dollars to the residents, and that the changes cost HRI $21,378 before the rebates. With the $58,024 in rebates that the project receives, HRI realizes a life-cycle benefit of nearly $37,000 in current day dollars. These results are summarized in Tables 5-8.

Tables 5 and 6 illustrate the lifecycle savings generated by the green building features at CAST as they accrue to the residents. Annual utility savings include $3,241 savings in energy use[3] and $321 in water use for a total savings of $3,562. Over a thirty year period, these annual savings translate into a present value savings of $88,921. The operating savings represent the sum total of the present value benefits to the residents.

Tables 7 and 8 show the lifecycle costs and benefits as they accrue to HRI. Because the Energy Star grant offsets virtually all the incremental costs of greening the project, HRI incurs a very small additional interest cost related to investing in these green features of about $171 in present value terms. Because of the limited common areas at CAST, energy savings from operations are very modest and do not offset the incremental investment costs, resulting in a net present value cost of $4,654.

Despite its significantly higher initial cost, the durability of marmoleum flooring and ceramic tile instead of vinyl composition tile (50 years versus 15 years) in the common areas and bathrooms, results in a present value savings for HRI of $15,714. The investment in concrete pavers instead of asphalt, however, has a present value cost of $32,300. Overall for HRI the impact of greening the project is an additional cost of over $21,000 in present value terms. However, this cost is more than paid for by the $58,024 in energy star rebates, resulting in a present-value benefit of nearly $37,000 for HRI.

In sum, over the life of the buildings, greening the CAST project has benefits of almost $89,000 for residents and a cost of over $21,000 to HRI (a cost which is paid for and more by the energy star rebates). Virtually all of the operating savings at CAST will accrue to residents, who are responsible for their own utility bills. Residents will also benefit from better indoor air quality resulting from the use of environmentally preferable materials (especially flooring and paint), improved amenities from the installation of dishwashers and upgrading of other appliances and lighting. In addition, and perhaps more importantly, there are additional benefits to tenants' health, comfort and well-being.

The success of the CAST project has meant that HRI has decided to pursue greening strategies in virtually all of its future projects. Its latest project is Trolley Square, a 40-unit mixed use affordable housing development that plans to pursue LEED certification.

References and Acknowledgements

- Jane Jones, a Senior Project Manager at Homeowner's Rehab provided overall background information and cost figures for the project.
- Len Tatem, an Asset Management Consultant to HRI, provided additional information on operational aspects and costs of the project.
- Operating savings associated with the Energy Star appliances and lighting were calculated using the Energy Star on-line calculator, found at:
  http://www.energystar.gov/index.cfm?c=appliances.pr_appliances.

(Endnotes)

[1] Massachusetts Housing Partnership website, see www.mhp.net/news_ideas/latest_news.php?function=show&ID=235.

[2] According to HRI's Asset Management Consultant, the windows still had a useful life of 5-7 years.

[3] Note that in terms of water use, we have assumed reductions only related to the installation of dishwashers instead of washing by hand. We have assumed no savings from reduced outdoor water usage in the CAST project as detailed information about the potential reduction in irrigation due to the planting of native species and the installation of a small field-turf area in lieu of grass is not available. Given the small area that is landscaped we expect any savings would be modest. We have also not included water savings from installation of low-flow fixtures since such fixtures are required by the Massachusetts Energy Code and therefore would have been required in a traditional rehab.

EMERYVILLE RESOURCEFUL BUILDING

EMERYVILLE, CALIFORNIA

Project Information

Number of Units	3
Unit Type	Attached and Single-family
Construction	New
Target Occupant	Moderate income; first-time home buyers
Developer	Emeryville Redevelopment Agency
Architect	Siegel & Strain Architects
Total Square Footage	3,922
Total Development Cost	$731,313
Average Cost per Unit	$243,771
Average Cost per Foot	$186
Incremental Cost to Build Green	$13,005
Green Building Focus	Intergrated design; materials selection; use of life-cycle costing
Financing Sources	Emeryville Redevelopment Agency Housing Bond Fund; Alameda County Source Reduction and Recycling Board; Alameda County Waste Management Authority

"The Emeryville Resourceful Builidng Project combines environmental goals with the economic and social goals of providing affordable housing."

Siegel & Strain
firm website

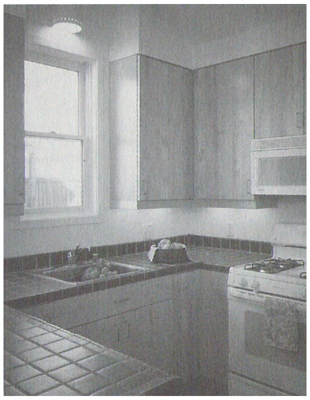


Photo Credits: Muffy Kibbey, 3-d model by Siegel & Strain Arcchitects

Overview

The Emeryville Resourceful Building (ERB) is a three-unit infill housing project built in 1999 on an empty lot in an otherwise developed, moderate-income, residential neighborhood of older homes and apartments in the City of Emeryville, California. Emeryville is located between Berkeley and Oakland in Alameda County, across the Bay from San Francisco. Developed by the Emeryville Redevelopment Agency, the project consists of one two-story duplex and one two-story single family home for a total of 3,922 square feet of living space plus 727 square feet of garage space. Built on a 5,500 square foot lot, the limited size and proportion of the site as well as parking space requirements in the local zoning regulations constrained the project. The ERB was built for moderate income families earning between 89-120% of area mean income. The project was modestly designed to fit into the surrounding neighborhood. The total development cost of the project was $731,313.[1] ERB was named one of the "2000 Earth Day Top Ten" by the American Institute of Architects Committee on the Environment, and received a 1999 Research Award from Architecture, a leading industry journal.

The project team was led by Siegel & Strain Architects, which employed a sophisticated design process. The firm has a long history with sustainable design, dating back to the 1970s when it was involved in incorporating solar installations in its work. The ERB project had five goals:

1. Provide energy-efficient housing.
2. Provide housing that is easy and inexpensive to operate and maintain.
3. Reduce resource consumption.
4. Create a healthy indoor environment.
5. Provide a model for environmentally sound affordable housing

Project construction costs totaled just under $472,000 and were funded by the Emeryville Redevelopment Agency as part of its first-time home buyer program, along with the green demonstration grants from the County Source Reduction and Recycling Board and the Waste Management Authority, mentioned above. Property acquisition and environmental work totaled nearly $168,000. Table 1 shows the breakdown of total development costs.

Because the ERB project was publicly funded, state law required that the developer open up to public bids and the project was obligated to accept the lowest bid. According to a report by the project architect, the selected contractor did not have any particular interest or expertise in environmental measures and was at first skeptical of unfamiliar methods and materials. Because one of the goals of the project was the utilization of mainstream materials and technologies, most environmental measures specified were successfully implemented despite the contractor's lack of experience with them.

The project demonstrates that, at least on a small scale, careful selection and installation of mainstream materials, along with the use of new and recycled materials and alternative construction methods, can create cost-effective affordable housing with improved environmental performance.

Green Design and Construction

The ERB project was constructed for $471,405 comprised of about $111 per square foot of residential space plus $50 per square foot of garage space. These up-front capital costs were $3.32 (3%) more per square foot than for a comparable traditional project using standard construction materials and techniques (estimated at $458,400 or about $108 per square foot residential space assuming no change in the cost per square foot of garage space). Table 2 presents a summary of the green versus traditional design and construction costs.

Detailed capital cost comparisons between traditional and green design are available for the project's "envelope" assemblies and are presented in Table 3. The "envelope" assemblies include exterior wall, ground floor (both carpet and resilient covering), second floor (carpet), interior wall, roof, roofing material, and siding. These components represent about half of the total construction cost and had an incremental cost of $21,606. HVAC, lighting system, and appliance capital cost comparisons (refrigerator, washer/dryer) are not available. However, the project did incorporate a high-efficiency furnace and efficient lighting. In addition, detailed finish construction costs beyond the basic envelope assemblies are not available.

Table 1: Total Development Costs

Activity	Dollar Amount
Property acquisition	$109,109
Final construction cost	$471,405
Architecture and engineering	$59,250
Environmental assessment and testing	$58,449
Development consultant(s)	$5,000
Legal	$5,000
Lender fees and costs	$0
Construction and pre-development loan interest	$0
Developer overhead	$0
Other Soft Costs	$23,100
Developer fee/profit	$0
Capitalized Replacement Reserves	$0
Capitalized Operating Reserves	$0
Total	$731,313

Table 2: Net Cost of Greening

	Cost	Cost/square foot	% of Total Dev. Cost
Green Design	$45,000	$12.16	6.15%
Traditional Design	$45,000	$12.16	
Green Design Premium	$0	$0	
Green Construction	$478,644	$122.04	65.45%
Traditional Construction	$458,400	$116.88	
Net Cost of Greening	$20,244	$5.16	2.77%

Table 3: Green Premium (Savings) by Category

Features Category	Green cost	Traditional cost	Green Premium (Savings)
Sustainable sites	$0	$0	$0
Water efficiency	$0	$0	$0
Energy and atmosphere	$40,320	$38,784	$1,536
Materials and resources	$173,916	$164,506	$9,410
Indoor environmental quality	$29,690	$19,030	$10,660
Other			
Total	$243,926	$222,320	$21,606

Green Features

The following is a description of the green features utilized in the project. Paramount in these considerations was the integrated design process led by Seigel and Strain Architects.

Design Process

The schematic design for the project had already been approved by the Emeryville Planning Commission when the team learned of research and construction grant programs for green demonstration projects being offered by the Alameda County Source Reduction and Recycling Board and the Alameda County Waste Management Authority. Because the schematic design was complete and due to the site constraints mentioned above, it was difficult for the team to change the basic design, so they "looked for simple, cost-effective ways to reduce environmental impacts, using mostly conventional means of construction, while maximizing benefits to future occupants."[2] An architect and researcher at Siegel & Strain characterized the design process at ERB as follows: "We made design decisions using a circular process wherein data from each consultant was analyzed jointly with data from other consultants to determine the most cost effective, resource efficient materials, systems and assemblies. In selecting systems and materials, the team gave priority to components that would have the greatest environmental benefit for the least amount of extra expense and would provide the greatest long-term cost savings."[3]

The design team also included Davis Energy Group for mechanical system design and energy efficiency measures, Komendant Engineering for structural design, Boustead Consulting Engineers, Ltd. for environmental life-cycle assessment of certain materials, and Baker Pre-construction for cost estimating.[4]

The team's approach to design had several unique elements. From the outset, Siegel & Strain recognized the importance of and implemented a life-cycle costing approach for selecting materials. Second, they compared the environmental impacts and costs of whole structural systems and assemblies such as walls or roofs, rather than individual materials, because they recognized that a material's performance is dependent on other materials in the system.[5]

The inclusion of environmental measures in the project required changes to typical project documentation. Materials, systems, and construction methods not common to affordable housing required additional instructions and specification sections in the project documents. A "Project Manual" contains bidding instructions and specifications that establish standards for the materials and methods of construction for a building project. The ERB project made alterations to the manual to document environmental goals, methods, and materials. Minimal effort was needed to incorporate environmental criteria into the specifications. The following list presents the highlights of the changes made to the manual.

Section 00100, Request for Bids: This section briefly describes the project, project goals, special requirements, and criteria for selecting the winning bidder. ERB project planners identified the elements unique to this project and set more stringent environmental standards than those for conventional affordable housing. The list of environmental features enumerates each measure, material, and system that differs from standard affordable housing practice. The revised manual added two selection criteria: "Bidder must be able to carry out the specific energy and resource-efficiency measures identified," and "Bidder must be willing to reduce job site waste through the design and implementation of a Waste Management Plan."

Section 01505, Construction Waste Management, though not currently a standard specification section, it is becoming more common and was included in this project. For the ERB project it required waste management goals, references for the contractor, and requirements for the project.

Other sections: All materials and measures that contribute to environmentally sound construction were shown in bold to give the contractor a quick overview of unique characteristics of the project. Contact information was included for products that were potentially unfamiliar to the bidder. Submittals were made mandatory for unique materials and requirements, such as certified lumber.

Sustainable Sites
The ERB is an infill project, constructed on an empty lot in a developed neighborhood. Thus, there was existing infrastructure in place and no need to disturb previously undeveloped land. The project was designed to fit in with the existing neighborhood and strengthen the community fabric by using a vacant parcel.

Water Efficiency
Low-flow fixtures were installed throughout the ERB to reduce water consumption and operating costs. These fixtures are required under California law, so no incremental costs or savings are associated with these measures. Because the project site was so small (5,500 square feet) there was minimal landscaping and this was not a focus of the greening efforts.

Energy and Atmosphere
The project team studied many possible energy efficiency improvements for the ERB, and ultimately incorporated several into the project including: a high-efficiency condensing furnace, .35 U-value windows with low-e-

insulated glazing to reduce solar heat gain, R-20 spray insulation in the walls, high efficiency ductwork, fluorescent lighting in selected locations, low-flow water fixtures (reduces energy needed for water heating) and an R-13 water heater insulation blanket.

In addition, Boustead Consulting Engineers used an abbreviated life-cycle analysis (LCA) of the materials for a range of floor, roof and wall assemblies, including the energy used in their production. The results of this analysis are expressed as gross energy requirements, which calculate the energy associated with the production and delivery of fuels, the use of the fuels, transport energy and feedstock energy. This detailed life-cycle analysis of materials is unique, and provided the project team with important information in their assembly selection process.

Materials and Resources

The ERB project placed considerable emphasis on materials choices. As described above, the team considered major assemblies (roof, walls, floor), rather than individual materials in isolation in order to better understand and capture how materials actually perform in relation to other materials in an assembly.

A key element of the project was the selection of wood from "certified" forestry operations to minimize negative environmental impacts. All lumber used was readily available from a local supplier. The contractor was required to submit a chain of custody certificate ensuring that the supplier provides lumber from a certified source. The use of certified wood increased the cost of wood by about 5 percent. Another element of the project was the utilization of an optimized framing system, which was modified from "Optimum Value Engineering" (OVE) framing techniques developed by the National Association of Home Builders (NAHB) Research Center. OVE relies on design as well as resourceful field practices. In order to make the techniques available to a builder with no previous experience with OVE, only the most straightforward OVE techniques were selected. Changing the stud spacing from the standard 16 inches to 24 inches on center had the greatest impact on wood savings. OVE framing techniques decreased the amount of lumber used by about 19 percent. This reduction allowed for the inclusion of the higher-cost certified wood but still kept the overall project cost close to that of traditional construction. Roof trusses instead of standard framing also reduced wood waste.[6]

As described above, detailed life-cycle assessment conducted by Boustead Consulting was used as the basis for considering environmental impacts associated with the manufacture and transport of various building materials. A streamlined LCA focusing on upstream processes allowed the team to create eco-profiles for comparing standard and green building assemblies. The profiles included both inputs (fuel and energy, raw materials) as well as outputs (air, water, and solid waste) through the manufacturing and procurement process. It did not include downstream processes such as operating energy, which was covered in a separate analysis, nor ultimate waste disposal, since the options for materials reuse and disposal many decades in the future is so uncertain.

With the streamlined LCA as an important consideration, key materials and resources selected for the ERB include:

- Roof truss assemblies that used less wood and improved energy performance; the expected life of the roof is 30 years as opposed to 25 years for a standard roof
- Exterior wall assembly, which reduce the amount of framing by about 20%
- Ground floor assemblies that use concrete (fly ash)
- Interior wall assemblies (reduced amount of wood, used certified wood)
- Cement Fiber Siding (durable: 50 year life vs. standard 25 year life)
- Cement Fiber Shakes Roofing (durable: 30 year life vs. standard 25 year life)
- Ground floor carpet (low VOC adhesive, recycled content, 20-year durability)
- Ground floor linoleum (substitute for vinyl; also has 40 year life versus 20 year for vinyl)
- Interior Wall assemblies (low VOC caulks, paints, and glues)

Indoor Environmental Quality

The ERB project used low VOC paints, caulks and glues throughout the project to minimize off-gassing and maintain good indoor air quality. In addition, the installation of energy efficient assemblies resulted in improved comfort for the residents.

Operating Savings: Green Versus Traditional

Energy modeling for this project was conducted by Davis Energy Group. Expected energy savings were determined through the use

Table 4: Operating Cost

Operating Cost Category	Green cost	Traditional cost	Annual Savings
Electrical Efficiency	$0	$546	$546
Gas (Therms)	no data	no data	
Oil (gallons)	no data	no data	
Water (gallons)	no data	no data	
Maintenance	no data	no data	
Other (incl. replacements)	no data	no data	
Total	$0	$546	$546

of the MICROPAS 4.50 computer model, a residential building analysis and energy code compliance tool. Comparisons were made to a similar structure that adheres to the minimum prescriptive requirements of the standard California Title 24 Energy Code. Results indicate that the ERB is about 33 percent more efficient than Title 24 requirements. Annual energy savings of the buildings as compared with the minimum conventional standards were calculated to be about $546[7] per year for all three units. Note that these modeled savings were confirmed by actual utility data which showed electricity consumption within 1% of the model and gas consumption within 5% of the model.[8] The greatest savings were due to reduced heating costs due to a tight envelope, better insulation, a high-efficiency condensing furnace, and improved windows.

Emeryville has a temperate climate and therefore does not typically require air conditioning. Thus, air conditioning was not installed in these units, but design elements such as window awnings, low-emissivity glazing, shade screens, and efficient lighting were incorporated into the ERB project to reduce peak summer temperatures. Though not modeled, the aim was to increase comfort and avoid resident-installed air conditioning units. The cumulative effect of these measures reduced peak indoor air temperature by about 5 degrees fareinheit.

Long-term savings can be calculated for certain construction elements that have a longer life span than traditional elements. A prominent example of this is the siding used on the ERB project. The green siding option selected for this project has an expected life of 50 years, while conventional siding has an expected life of only 25 years.[9] These savings are further elucidated in the Net Present Value analysis below.

The benefits of reduced energy consumption are captured in the cost analysis as a cost savings. However, there are also important environmental benefits associated with reduced energy consumption, such as reduced greenhouse gas and acid rain generating emissions and reduced impacts resulting from the extraction, production, and delivery of fossil fuels. A consultant to the project studied a variety of environmental impact characteristics of the project. Calculations of air emission reductions were done by the ERB project consultant using the National Institute of Standards and Technology (NIST) Building Life-Cycle Cost (BLCC) Analysis Program Version 4.3-96 comparing the ERB against a baseline model consistent with the California Title 24 Energy Code. The results showed a 23% decrease in CO2 emissions, a 14% reduction in SOx, and an 18% decrease in NOx.[10]

Net Present Value Summary

As described earlier in this report, for each case we have estimated the financial impact of green building decisions over an expected thirty-year building lifespan. The analysis is based on the capital costs, additional interest, replacement cost and operating costs of the buildings. Analyzing each of these cost savings individually provides a clearer understanding of the green building benefits. The project's focus on the lifecycle of the building materials, especially of upstream processing, provided information about environmental benefits that this NPV analysis was not designed to show.

We have also broken out the impact of greening on both the developer and the homeowners who bought these units. In allocating costs and benefits to each group, we have

Table 5: Expected Life for Green vs Conventional Materials

Green Feature List	Green life (yrs)	Conv. Life (yrs)
Roof Assemblies	30	25
Cement Fiber Siding	50	25
Cement Fiber Shakes	30	25
Ground Floor Linoleum	40	20

assumed that the developer paid the up-front premium for greening, and that the residents get the benefit from decreased operating and replacement costs.[11] We have not shown an additional interest cost for either group because we have assumed that additional capital costs were paid for with the up-front subsidies that came into this project ($443,300 in total, some of which was specifically for green building measures). As mentioned in an earlier section, the three units in the project were sold to moderate-income, first-time homebuyers. The costs and benefits are detailed in Tables 6-9.

The net present value of the homeowners' savings amounts to over $34,500. Almost $21,000 in savings came from materials which lasted longer than traditional materials. The most significant savings came from the cement fiber siding, which last 50 years – twice as long as conventional siding. The remaining savings came from lower energy costs.

The developer spent an additional $21,606 in up-front costs for greening. Tables 6 and 7 show how these costs break down by specific feature. Because the developer has no on-going interest in the project, they do not share in the benefits from greening. However, we have assumed that this increased first cost was absorbed by the significant subsidy (over $440,000) that went into the project.

Overall, the project created almost $13,000 in value from greening, and this only accounts for operating costs, replacement costs, and additional interest (which is assumed to be zero in this case). The project also paid careful attention to the upstream effects of material production, and specifically selected materials with low environmental impacts. Our analysis does not try to account for these things; nor does it account for improved health and air quality in the buildings. Overall, the ERB demonstrates that the possibilities for green building are significant, even when using traditional designs, mainstream materials and contractors who are not exclusively "green." The Emeryville Resourceful Building project serves not only as a demonstration of green building, but of the great potential for building affordable green housing in cost-effective ways.

References and Acknowledgements

Table 6: Developer NPV by Feature

	Green savings (cost)
Additional Interest	$0
Roof Assemblies	($1,536)
Cement Fiber Siding	($3,183)
Cement Fiber Shakes	($4,000)
Ground Floor Linoleum	($420)
Energy Efficiency	$0
Other Green Features	($12,467)
Total	($21,606)

Table 7: Developer NPV by Category

	Green Savings (cost)
Additional Interest	$0
Operating Costs	$0
Replacement Costs	($9,139)
All Other Green Features	($12,467)
Total	($21,606)

Table 8: Owner NPV by Feature

	Green savings (cost)
Additional Interest	$0
Roof Assemblies	$274
Cement Fiber Siding	$22,548
Cement Fiber Shakes	($2,737)
Ground Floor Linoleum	$809
Energy Efficiency	$13,625
Other Green Features	$0
Total	$34,519

Table 9: Owner NPV by Category

	Green Savings (cost)
Additional Interest	$0
Operating Costs	$13,625
Replacement Costs	$20,894
All Other Green Features	$0
Total	$34,519

- Nancy Malone, Siegel & Strain Architects, provided detailed project design information and costs.
- Christina Manansala, Davis Energy Group, and Henry Siegel, Siegel & Strain, provided operating cost data.
- Ignacio Dayrit, City of Emeryville, provided overall cost figures for the project.
- Other sources included:

"Emeryville reSourceful Building: Environmentally Sound Affordable Housing," Siegel & Strain Architects, no date.

"Designing an Affordable Green Housing Project," Nancy Malone, Siegel & Strain Architects, in Home Energy Magazine Online, March/April 2000.

(Endnotes)

[1] Construction costs for all three units was $471,405.

[2] "Emeryville reSourceful Building: Environmentally Sound Affordable Housing," Siegel & Strain Architects, no date.

[3] "Designing an Affordable Green Housing Project," Nancy Malone, Siegel & Strain Architects, in Home Energy Magazine Online, March/April 2000.

[4] "Emeryville reSourceful Building: Environmentally Sound Affordable Housing," Siegel & Strain Architects, no date.

[5] "Emeryville reSourceful Building: Environmentally Sound Affordable Housing," Siegel & Strain Architects, no date.

[6] Note that though certified wood was specified for the roof trusses, there was no way to control the materials used by the selected truss fabricator. This provided a lesson to the team concerning the need to ensure a supply of certified lumber to off-site fabricators, a task usually beyond the scope of a project team.

[7] In year 2000 dollars.

[8] Personal communication from Henry Siegel, Siegel and Strain Architects, October 2004, citing a previous communication regarding utility bill analysis from Christina Manansala,, Davis Energy Group.

[9] "Emeryville reSourceful Building: Environmentally Sound Affordable Housing," Siegel & Strain Architects, no date.

[10] "Designing an Affordable Green Housing Project," Nancy Malone, Siegel & Strain Architects, in Home Energy Magazine Online, March/April 2000.

[11] It is important to note here that the operating savings that we used in this case likely underestimate actual operating savings, as discussed in the operating savings section above.

ERIE ELLINGTON

BOSTON, MA

Project Information

Number of Units	50
Unit Type	Multi-Family, Attached (20 buildings)
Construction	New
Target Occupant	Low-income family tenants and five one-bedroom units for handicapped
Developer	Codman Square Neighborhood Development Corporation
Contractor	CWC Builders & Thomas Construction Co.
Architect	Bruce Hampton, Green Village Company
Total Square Footage	69,390
Total Development Cost	$9,008,528
Average Cost per Unit	$180,171
Average Cost per Square Foot	$130
Incremental Cost to Build Green	-$1,651,336
Green Building Focus	Energy Efficiency, Material & Resource Efficiency
Financing Sources	Boston Private Bank and Trust MA Dept. of Housing and Community Dev. MA Community Economic Development Assistance Corporation (CEDAC) Federal Home Loan Bank of Boston City of Boston Public Facilities Department Codman Square NDC

"We wanted to prove that affordable housing can be designed with quality & durability, and that costs will be within the budget of standard low- and moderate- income housing development projects."

Mark Kelley
Green Village

Overview

Erie-Ellington Homes is a low-income residential rental development completed in 2000 on seven scattered parcels in the Dorchester neighborhood of Boston. Comprised of 19 three-story duplex and triplex buildings (50 units in total) plus a community building, the majority of the units are two to three bedrooms, though five are one-bedroom, first-floor, handicapped-accessible apartments. All 50 units were designed for households at or below 70 percent of the area's median income. The buildings have a total area of 69,390 square feet, with individual units ranging from 707 to 1,450 square feet. The community building is used by residents of Erie Ellington as well as the broader community.

The immediate neighborhood had been gradually abandoned over the past half century, leaving behind many empty lots (24 percent by some estimates) and decaying buildings. Moreover, the failed Jacob's Place affordable condominium townhouse development in the 1980s contributed to the neighborhood's troubles. Yet the location is close to public transportation, much of the remaining occupied housing is in reasonable condition, and the area has experienced some revitalization since the late 1990s.

The project was developed by the Codman Square Neighborhood Development Corporation with total development costs of just over $9 million ($.6 million for acquisition, $6.9 million for design and construction, and $1.5 million in soft and other costs). Codman Square NDC hired the Hickory Consortium to work with them to redesign and "reknit" the neighborhood. Hickory Consortium is a partner in the U.S. Department of Energy's Building America program that seeks to apply systems engineering solutions for cost-effective, energy-efficient, and environmentally-sound housing. The Hickory Consortium includes builders, architects, scientists, and manufacturers working together to provide energy-efficient and safe homes at costs comparable to or less than those of traditional homes. For the Erie-Ellington project, Hickory members provided architectural, energy systems design, as well as systems and process consulting. Bruce Hampton was the lead architect. The contractors were CWC Builders and Thomas Construction Company. Table 1 provides a breakdown of total development costs.

The project had numerous funding sources, including $5.175 million low income housing tax credits through LISC's National Equity Fund, as well as loans totaling about $3.73 million from Boston Private Bank and Trust, the Massachusetts Department of Housing and Community Development, the Massachusetts Community Economic Development Assistance Corporation, the Federal Home Loan Bank, the City of Boston's Public Facilities Department, and the developer, Codman Square NDC. It should be noted that the financiers were willing to underwrite the project based on standard loan criteria related to first-cost financial feasibility (e.g., the borrower's capabilities, the funding sources, the budget, the appraisal, and the environmental review) and did not engage in discussion of or consider the green design elements of the project.[1]

Erie-Ellington Homes feature what is known as "eco-dynamic" specifications, developed by the Hickory Consortium, which seek to apply a systems approach to building, combining ecological and economic performance. This approach resulted in multi-family houses with units made from energy-efficient panelized construction, energy-efficient building envelopes to maintain comfort and save energy, the utilization of high-quality materials, and high-efficiency appliances. The EcoDynamic specifications include performance requirements that significantly exceed U.S. DOE/EPA Energy Star requirements. Early involvement of all the players — the CDC, city agencies, the architect, project lenders, subcontractors, and workers — was critical to the success of the project.

Green Design and Construction

The total design and construction cost for Erie Ellington was $6.9 million or about $99 per square foot. According to the Boston Department of Neighborhood Development, this is about 20% less than comparable conventional buildings in the city, which were being built for roughly $120-125 per square foot.[2] This translates into initial capital cost savings of more than $1.65 million. Table 2 summarizes the costs for green versus traditional design and construction. These costs include design and construction costs, but do not include site acquisition, the costs associated with environmental assessments, or other soft costs.

Several factors contributed to the significant construction cost savings, including the integrated "whole-building" design process and development of the "EcoDynamic" specifications by the Hickory Consortium, use of panelized construction in which the buildings' frames were constructed off-site in pieces, installation of one high-efficiency boiler for space heat and hot water in each duplex or triplex building rather than one for each unit (made possible by improved insulation and envelope tightness), and other measures.

The significant capital cost reductions are net of minor incremental costs associated with water efficiency measures, which were calculated to be about $500 per unit or $25,000 total, and incremental costs associated with energy efficiency measures, which were calculated at about $1,000 per unit or $50,000 total. These additional costs were offset by the approximately $1,900 per unit or $95,000 total savings from use of the single boiler system per building plus Energy Star and Boston Gas rebates totaling $66,330 for energy efficient equipment installations. Due to these savings in the costs of project construction, the need for borrowing was decreased somewhat, thereby lowering the costs that would have been paid in interest on project debt.[3] A breakdown of the savings associated with greening the Erie Ellington project by LEED category is presented in Table 3.

Table 1: Total Development Costs

Activity	Dollar Amount
Property acquisition	$464,000
Final construction cost	$6,605,343
Architecture and engineering	$295,000
Environmental assessment and testing	$141,515
Development consultant(s)	$0
Legal	$180,300
Lender fees and costs	$45,369
Construction and pre-development loan interest	$116,307
Sponsor/Developer project management and overhead	$325,000
Other Soft Costs	$315,263
Developer fee/profit	$359,000
Capitalized Replacement Reserves	$151,556
Capitalized Operating Reserves	$9,875
TOTAL	$9,008,528

Table 2: Net Cost of Greening

	Cost	Cost/square foot	% of Total Dev. Costs
Green Design	$295,000	$4	3.27%
Traditional Design	$295,000	$4	
Green Design Premium	$0	$0	
Green Construction	$6,605,343	$95	73.32%
Traditional Construction	$8,256,679	$119	
Green Construction Premium	($1,651,336)	($24)	
Net Cost of Greening	($1,651,336)	($24)	-18.33%

Table 3: Green Premium (Savings) by Category

	Traditional Capital Cost	Green Capital Cost	Incremental Capital Cost/ (Savings)
Sustainable Sites	no data	no data	$0
Water Efficiency	no data	no data	$25,000
Energy and Atmosphere	no data	no data	($111,330)
Materials and Resources	no data	no data	$0
Indoor Environmental Quality	no data	no data	$0
Innovation in Design	no data	no data	($1,565,006)
Total	$8,551,679	$6,900,343	($1,651,336)

Green Features

Erie Ellington included a wide range of green features with a particular focus on material, energy, and water efficiency. These features are discussed below.

Sustainable Site
Erie Ellington Homes is in an urban setting easily accessible to multiple bus lines. It is an infill project on seven scattered sites near Codman Square. It fills in vacant lots in a developed area with existing infrastructure, thereby avoiding development of a new undeveloped greenfield site.

Water Efficiency
Landscaping at Erie Ellington used native planting that required less water. In addition, as required by the Massachusetts building code, low-flow faucets, showerheads and toilets were installed in all units, which reduce resource consumption and operating costs. The installation of Energy Star dishwashers in all the units reduces water use by about 18% compared with non-Energy Star units and considerably more relative to washing dishes by hand.

Energy and Atmosphere
Since all units at Erie Ellington are within duplex or triplex buildings, they are by definition more efficient than single family houses. The design of the buildings incorporated a range of energy efficiency measures including: R-30 insulation in roofs and R-19 insulation in basement walls; large low-e Pella windows in each unit providing the benefits of passive solar; use of one energy efficient sealed-combustion boiler per building for both space heat and hot water, rather than separate boilers and water heaters for each unit; well-sealed ducts and pipes to prevent air leakage; and Energy Star refrigerators, dishwashers, whole-house ventilation fans, 13-watt compact fluorescent lighting fixtures, and thermostats.

The attention to building tightness was new to the construction crew. In addition to sealing all ducts and pipes, this included foam-insulating the buildings' corners and double-sealing the siding. According to CWC Builders construction superintendent, John Estano, "I've worked in construction for the better part of 40 years, and this is the first time we've put so much effort into sealing the building. It took me quite a while to believe all the engineering figures, but they've got the numbers right."[4] Given their unfamiliarity with this approach, he went on to say that one of his most important tasks was to make sure the subcontractors closely followed the architect's specifications. Until green building practices are widely employed, the need for tight supervision of subcontractors will remain a critical responsibility for green building project managers.

Materials and Resources
The design team was committed to using environmentally preferable non-toxic materials wherever possible and to minimizing on-site waste. In the context of the whole building design process this was seen as especially important due to the tight envelope created by the additional insulation and careful attention to air sealing. Thus, enhanced ventilation systems were installed in all units (see details below in Indoor Environmental Quality section). Marmoleum that is manufactured "green" and more durable was used in bathrooms instead of traditional linoleum. Also, certified recycled content carpet was used to minimize use of nonrenewable resources and manufacturing-related emissions, maximize recyclability, and minimize off-gassing.

The use of panelized construction methods whereby the building's frame was constructed off-site, in pieces, then assembled on site, reduced wood waste considerably. This computer-assisted approach allows more reuse of scrap wood than is usually feasible in the field. While vinyl siding is typically used for this type of affordable housing, the Hickory team selected Hardiplank cementitious siding made of cement and wood fiber. By not using vinyl or wood siding, the environmental concerns associated with vinyl manufacturing were avoided, as was the use of virgin wood. Moreover, according to project architect Bruce Hampton, the belief that "vinyl is final" is a myth. Not only does vinyl fade, it warps and breaks down in sunlight and generally has to be replaced in about 15 years, creating a lot of waste and a considerable expense. The cementitious siding is more durable than wood or vinyl and requires less maintenance.[5] In addition, the window frames were made with certified wood, as were Trex floorboards containing recycled content, thereby reducing the use of virgin materials.

Indoor Environmental Quality
Indoor environmental quality is closely related to the tightness of a building, how well it is ventilated, and the characteristics of the materials installed. As described earlier, the design team focused considerable attention on building

tightness and adequate ventilation. Every unit at Erie Ellington has a continuous positive exhaust ventilation system with automatic controls, bathroom automatic exhaust fans, as well as manual exhaust fans on kitchen ranges to ensure high quality indoor air. In addition, low-VOC paints, marmoleum, and certified carpet were used to minimize off-gassing. Though there is only anecdotal evidence that these practices resulted in improved air quality, the Hickory Consortium interviewed residents and found that "symptoms were noticeably reduced in 8 out of 18 children with asthma problems."[6]

Operating Costs: Green versus Traditional

Based on utility cost data that was tracked for Erie Ellington, operating costs are about 35% less than comparable conventional new buildings ($89,189 versus $136,999) for an annual savings of $47,810.[7]

These savings are achieved by going beyond building code requirements in a number of areas, including a much tighter building envelope; efficient low-e windows; more efficient space and water heating with a single, high-efficiency, sealed-combustion boiler per building; low-flow water fixtures and Energy Star dishwashers; plus energy efficient and/or Energy Star lighting and appliances throughout all units, including refrigerators, thermostats, and ventilation systems. The annual operating savings at Erie Ellington for 2001 were comprised of over 104,000 kWh of electricity worth almost $17,000, almost 19,000 therms of gas worth about $22,000, and over 841,000 gallons of water worth almost $9,000. This represents a 59% reduction in electricity use compared with traditional new construction that meets the Massachusetts building code, a 38% reduction in gas use, and an 18% reduction in water use. The operating savings are summarized in Table 4.

Net Present Value Summary

As described earlier in this report, for each case we have estimated the financial impact of green building decisions over an expected thirty-year building lifespan. Given that the Erie Ellington project has savings in construction costs and in its operations, the life-cycle benefits of the project are very significant, but they do not accrue equally to the building owner and the residents. To show the impact of green building decisions on both groups, we broke out costs and benefits based on the party to which they accrue. In making these calculations we have made two important assumptions:

- Residents use three times as much heat, electricity, and water per square foot as the building owner pays for in common areas. This allows us to divide aggregate utility expenditures into resident and owner expenses.
- Because of a lack of cost information on green and conventional systems, we have not been able to show any replacement cost savings from including longer lasting materials. This almost certainly underestimates the benefits of some of the features included in Erie Ellington.

Our analysis has residents obtaining the benefit from decreased gas, electricity, and water usage in the unit, and the owner accruing all costs and benefits from first costs and operating costs in the common areas.

Based on our understanding of construction cost and operating cost savings, we found that residents receive a benefit of $1.14 million in current day dollars (almost $23,000 per household) and that Codman Square NDC accrues a nearly $1.7 million benefit from building green. In addition to these estimates, benefits also include the increased asset value of the project. These results are summarized in Tables 5-8.

Though they did not have to invest in green building improvements, much of the benefit is realized by the Erie Ellington residents through reduced utility costs as well as improved amenities and comfort.

Table 4: Operating Costs

	Electricity		Gas		Water		
	kwh	Cost	Therms	Cost	Gallons	Cost	Total Savings
Erie Ellington	71,862	$11,636	31,146	$36,253	3,885,177	$41,300	$89,189
Traditional	176,344	$28,553	50,000	$58,199	4,726,750	$50,246	$136,999
Savings	104,482	16,918	18,854	$21,946	841,573	$8,946	$47,810
% Savings	59%		38%		18%		35%

Residents spend $37,285 less on energy (this equates to a savings of $62 per month on energy per household) than they would have in a unit built to the standards of the Massachusetts Energy Code. As summarized in Tables 5 and 6, the residents enjoy a present value savings of about $1.14 million over a 30-year lifetime of the building. Over 80% of these savings are associated with reduced energy costs, while the remainder results from lower water costs.

From the owner's perspective, the green building features and techniques used at Erie Ellington reduced overall capital costs relative to traditional new construction by almost $1.7 million. As shown in Tables 7 and 8, the vast majority of savings (96%) associated with greening the project were due to a whole-building integrated design process and the use of panelized construction techniques to reduce labor and materials cost and streamline the construction process. This approach led to properly sized systems, the use of single boilers per building for both heat and hot water (saving $1,900 per unit for boilers alone), and taking advantage of $66,330 in Energy Star and utility rebates for energy efficient appliances, windows, and lighting. The operating savings accruing to Codman Square NDC were modest, totaling over $68,000 in present value terms and accounting for about 4% of overall savings to the owner.

In sum, the Erie Ellington project is a clear case where a green development approach resulted in a "win-win" situation for the owner and the residents. Overall, the project had a net present value savings of more than $2.8 million or over 31% of the total development costs for the project, showing that while savings of this size are unusual, they are certainly not impossible.

Table 5: Resident NPV by Feature

	Green savings (cost)
Additional Interest	$0
Energy Efficiency	$930,459
Water Efficiency	$214,183
Siding	$0
Sustainable Sites	$0
Materials and Resources	$0
Indoor Enironmental Quality	$0
Innovation and Design	$0
Total	$1,144,642

Table 6: Resident NPV by Category

	Green Savings (cost)
Additional Interest	$0
Operating Costs	$1,144,642
Replacement Costs	$0
All Other Green Features	$0
Total	$1,144,642

Table 7: Owner NPV by Feature

	Green savings (cost)
Additional Interest	$0
Energy Efficiency	$84,387
Water Efficiency	($15,934)
Siding	$0
Sustainable Sites	$0
Materials and Resources	$0
Indoor Enironmental Quality	$0
Innovation and Design	$1,631,336
Total	$1,699,789

Table 8: Owner NPV by Category

	Green Savings (cost)
Additional Interest	$0
Operating Costs	$68,453
Replacement Costs	$0
Building Synergies	$1,631,336
Total	$1,699,789

References and Acknowledgements

- Bruce Hampton and Mark Kelley of the Hickory Consortium provided valuable cost and performance data on the project.
- Mat Thall from Boston LISC and Tracey Ferrara from the National Equity Fund provided the NEF "Sponsor Package" for Erie Ellington dated September 23, 1999, with detailed data on project financing, including the sources and uses of funds.

- Other sources included:

"Erie-Ellington Homes: A New Paradigm, Sustainable Urban Low Income Housing," Mark E. Kelley III, P.E., and Bruce Hampton, A.I.A., Hickory Consortium, n.d.

"Erie Ellington Update: Actual Performance Figures," Hickory Consortium, n.d.

"Erie-Ellington Homes, The Green Story," fact sheet from GreenVillage Company/ Hickory Consortium, n.d.

"All Systems a Go: Erie-Ellington's Award-Winning, Holistic Approach," from Tools for Housing and Community Economic Development newsletter, Issue No. 20, Summer 2003, Federal Home Loan Bank of Boston.

"Thinking Green in Dorchester: Development is affordable and environmentally friendly," *Boston Herald*, March 17, 2000, p. 49.

(Endnotes)

[1] This is not unique to the Erie-Ellington project and is, in fact, the norm for financial institutions considering affordable housing projects.

[2] As cited in "All Systems a Go: Erie-Ellington's Award Winning, Holistic Approach," from Tools for Housing and Community Economic Development newsletter, Issue No. 20, Summer 2003, Federal Home Loan Bank of Boston.

[3] A traditional building at the higher capital cost would have cost an additional $2.5 million in interest over the 30 years, $898,000 in net present value terms.

[4] As quoted in the Real Estate section of the Boston Herald, March 17, 2000, p. 49.

[5] Though marmoleum flooring and Hardiplank siding are more durable than standard linoleum and vinyl siding, because we did not have specific cost figures for these materials our cost analysis does not include the savings that would result from their use and avoiding the need for replacements.

[6] Erie Ellington Update: Actual Performance Figures, Hickory Consortium fact sheet, n.d.

[7] Initially, there were problems with the internal boiler controls, and the HVAC system did not operate efficiently. Once identified, the problem was fixed under warranty by the property management company and HVAC contractor at no cost to the project.

JOHNSON CREEK COMMONS

PORTLAND, OR

Project Information

Number of Units	15
Unit Type	Multi-Family Apartment
Construction	Rehabilitation
Target Occupant	Low-income family tenants
Developer	Sustainable Communities Northwest ROSE Community Development
Contractor	All Weather Remodelling
Total Square Footage	11,436
Total Development Cost	$907,332
Average Cost per Unit	$60,489
Average Cost per Foot	$79
Incremental Cost to Build Green	$65,761
Green Building Focus	Energy Efficiency, Water Efficiency, Materials & Resources
Financing Sources	Portland Development Commission, Shorebank Pacific, U.S. Bank, Developer Equity, Portland General Electric

"Johnson Creek Commons demonstrates some great cost-effective solutions. I hope many more apartment owners and developers follow this example."

Erik Sten
Commissioner
City of Portland

Overview[1]

Johnson Creek Commons is a 15-unit, four-building apartment complex located in the Outer Southeast section of Portland, Oregon. Built in 1973, it was operated until 1998 as market-rate housing at which point two regional Community Development Corporations — ROSE Community Development and Sustainable Communities Northwest — created a limited liability corporation to purchase, rehabilitate, and manage the property. The 14 two-bedroom units (775 square feet each) and one one-bedroom unit (420 square feet) were rehabilitated and converted into low-income rental housing. Ten of the 15 units are rented to families earning up to 50% of the area median income and five units are for households earning up to 30% of area median income. The rehabilitation took about eight months and was completed in 1999.

Johnson Creek Commons serves a critical need due to a serious shortage of affordable housing in the Brentwood-Darlington neighborhood, an area the Portland Development Commission and the City's Bureau of Housing and Community Development had designated as a "target" area for affordable housing. The project is situated on almost an acre of land and is located in close proximity to schools, shopping, jobs, green space, and public transportation. Most tenants are currently low-income Hispanic families with children.

With the objectives of combining affordability with ecological sustainability in a low-income apartment rehabilitation, the project incorporated green design principles into the renovations. Physical improvements included replacing rotten siding, kitchen flooring, windows and doors, augmenting building insulation, installing water saving measures, replacing electric baseboard heaters, as well as sidewalk and fencing repairs. In addition, to provide fresh food for tenants the interior courtyard and the perimeter of the apartments were planted with vegetables, fruit trees, and native plants.

Development costs totaled about $907,000, including $660,000 for site acquisition, almost $169,000 for construction, and soft costs of over $78,000. The contractor for the project was All Weather Remodeling. Table 1 provides a breakdown of total development costs.

The Portland Development Commission provided a low-interest loan of $350,000 and an equity gap grant of almost $285,000 to finance the bulk of the development costs, and a local bank, Shorebank Pacific, provided an additional market-rate loan of $245,000. The remaining development costs were covered by a rebate from Portland General Electric of $15,200, a grant from U.S. Bank for $10,000, and $2,500 equity from the developers. In addition, help on financial packaging and construction management was provided by the Housing Development Center, a nonprofit project development organization that provides technical assistance to community development corporations in the region.

Green Design and Construction

The direct construction cost for the Johnson Creek Commons rehabilitation project was almost $169,000 or about $15 per square foot. The developers estimated that this is about $81,000 or $7 per square foot more than a comparable conventional rehabilitation. With energy-efficiency rebates of $15,200 from Portland General Electric, this first cost premium was reduced to just under $66,000 or $6 per square foot. Including soft costs, the project cost almost $22 per square foot versus about $16 per square foot for a comparable traditional rehabilitation. Note that these figures include construction costs, and do not include site acquisition costs. As a modest rehabilitation project, specifications were developed, but there was not a full-blown architectural design process or contract. Table 2 summarizes the costs for green versus traditional design and construction.

Table 1: Total Development Costs

Activity	Dollar Amount
Property acquisition	$660,000
Final construction cost	$168,868
Other Soft Costs	$78,464
TOTAL	$907,332

Table 2: Net Cost of Greening

	Cost	Cost/square foot	% of Total Dev. Costs
Green Design	no data	no data	
Traditional Design	no data	no data	
Green Construction	$168,868	$15	19%
Traditional Construction	$103,107	$9	
Green Construction Premium	$65,761	$6	
Net Cost of Greening	$65,761	$6	7%

Table 3: Green Premium (Savings) by Category

	Traditional Capital Cost	Green Capital Cost	Green Premium
Sustainable Sites	$0	$0	$0
Water Efficiency	$1,500	$3,405	$1,905
Energy and Atmosphere	$4,356	$50,298	$45,942
Materials and Resources	$4,392	$41,330	$36,938
Indoor Environmental Quality	$1,050	$10,110	$9,060
Innovative Design	$0	$0	$0
Total	$11,298	$105,143	$93,845

Several factors contributed to the increased capital costs for greening Johnson Creek Commons, including numerous energy efficiency upgrades to the buildings' envelopes, use of Hardiplank siding and marmoleum flooring, and installation of high-flow bathroom fans to reduce moisture. The energy efficiency investments to the envelope were partly offset by rebates from the local utility, Portland General Electric. A breakdown by LEED category of the incremental capital costs associated with greening the project is presented in Table 3.

Green Features

As mentioned earlier, Johnson Creek Commons includes a wide array of green features. While the project team focused on energy efficiency in the material and system choices that they made, they included many features which make this project more attractive and more livable for residents.

Sustainable Sites

Johnson Creek Commons is in an urban setting easily accessible to public transportation, schools, shopping, and other amenities. By rehabilitating an existing building the project is preserving existing housing and avoiding greenfield development.

Water Efficiency

The developers worked with the City of Portland Water Bureau to implement a three-year pilot water efficiency program at Johnson Creek Commons. The developer/owner pays the water bill and water use in each building is metered, but individual apartment use is not. The pilot program included audits of the plumbing fixtures in each unit, installation of low-flow faucet aerators and toilet tank displacement bags, installation of high-efficiency front-loading washing machines and submetering in the laundry room, drip irrigation and landscaping to minimize water use, and education of tenants and the property manager.

Energy and Atmosphere

A number of envelope energy efficiency improvements were made at Johnson Creek Commons, including: upgrading ceiling insulation from R-11 to R-38 blown-in insulation, upgrading floor insulation from none to R-30, adding rigid wall insulation (with the new siding) to walls with R-8 batt insulation, replacing single-pane aluminum-frame windows and sliding glass doors with vinyl-framed, double-pane, low-emissivity, argon-filled glazing with a U-value of 0.35. In addition, the developers worked with the Portland Energy Office to install compact fluorescent bulbs in most of the exterior lighting fixtures. In coordination with the local utility, Portland Gas & Electric, energy efficient refrigerators were installed in many of the apartments. Five existing water heaters were replaced with new more efficient electric water heaters.

Materials and Resources

In several units Marmoleum brand linoleum flooring was used to replace worn vinyl flooring. Made from natural materials — linseed oil, limestone, pine tree rosin, and jute — it is environmentally preferable to vinyl flooring in all phases, from production to use and disposal. While more costly than vinyl, it is more durable and results in lower maintenance and replacement costs over time. Carpeting was replaced in two units using carpet made from recycled plastic bottles (PET) to minimize use of nonrenewable resources and manufacturing-related emissions and minimize off-gassing. Also, recycled paint was used on the exterior of the building, and low-VOC solvent-free paint on the interior.

While vinyl siding is often used for this type of affordable housing, the developers used Hardiplank cementitious siding made of cement and wood fiber at Johnson Creek Commons. By not using vinyl or wood siding, the environmental concerns associated with vinyl manufacturing and timber harvesting were avoided. The cementitious siding is more durable than wood or vinyl and requires less maintenance.[2] In terms of construction and demolition waste management, the contractor was required to minimize waste generation and maximize reuse and recycling, though data about this are not available.

Indoor Environmental Quality

Indoor environmental quality is closely related to the tightness of a building, how well it is ventilated, and the characteristics of the materials installed. A major issue at Johnson Creek Commons was mold, so one of the key actions to improve indoor air quality was to clean mold from bathroom walls and replace the bathroom fans in all units with high flow rate fans. Slotted windows were also installed in the units to improve ventilation. As described earlier, low-VOC paints, marmoleum, and recycled-content carpet were used to minimize off-gassing.

Operating Savings: Green versus Traditional

Johnson Creek Commons is one of the few green affordable housing projects where detailed life-cycle cost analysis has been performed to better understand the long-term economic impacts of greening. The results of the study were included in a report commissioned by the Portland Energy Office in 2000.[3] Unfortunately, this analysis focused only on the envelope energy efficiency measures (e.g., improved floor, wall, and ceiling insulation; plus installation of energy-efficient windows). Operating and replacement data for other building improvements (e.g., installation of energy efficient appliances and lighting, use of Marmoleum and Hardiplank) were not tracked and reported in this study and therefore it does not contain a life-cycle cost analysis for these. While we were able to identify sufficient data and include a life-cycle cost analysis for the use of Marmoleum flooring, for the remaining green features only the capital costs have been included, not any savings created through lower operating costs. In addition, changes to indoor air quality that are not expected to generate operating or replacement cost savings (such as the use of recycled materials and low-VOC paint), but can dramatically improve quality of life for residents, were not included. Our analysis, therefore, under-reports the

Table 4: Operating Costs

	Electricity		Gas		Water		Total Costs/ (Savings)
	kwh	Cost	Therms	Cost	Gallons	Cost	
Johnson Creek Commons	33,365	$1,944	no data	no data	no data	no data	$1,944
Traditional	136,570	$7,955	no data	no data	no data	no data	$7,955
Savings	103,205	6,012					$6,012
% Savings	76%						76%

life-cycle savings at Johnson Creek Commons.

Nonetheless, the operating cost savings from just the envelope energy efficiency improvements are substantial. The WATTSUN computer model was used to estimate changes in energy consumption resulting from the energy-efficiency retrofits.[4] The characteristics of the buildings prior to the rehabilitation were provided by a Portland General Electric audit. The results of the modeling showed dramatic reductions in annual energy use for space heating from 136,570 kWh before the rehabilitation to 33,365 kWh afterwards, a savings of 103,205 kWh (76%) or $6,012 per year based on 2000 electricity prices. The operating savings are summarized in Table 4.

Net Present Value Summary

As described earlier in this report, for each case we have estimated the financial impact of green building decisions over an expected thirty-year building lifespan. In the case of Johnson Creek Commons this is a conservative assumption since the developers have committed to the Portland Development Commission, a key funder, that the property will be maintained as low-income housing for 60 years.[5] Based on our understanding of the incremental capital costs, the operating cost savings related to reduced electricity consumption for heating, and the replacement cost savings from using Marmoleum flooring, we have completed a partial life-cycle analysis for Johnson Creek Commons. The life-cycle analysis is not comprehensive because operating cost data for savings associated with other building improvements was not available. Specifically, we did not have adequate replacement cost data for any more durable system or material except for Marmoleum. We have assumed that all other green systems and materials installed have no effect on the durability of the building and individual building components. This assumption almost certainly underestimates the life-cycle value generated by a longer lasting material, but without reliable information on the initial costs of green and conventional systems, we could not complete a more detailed analysis.

The improvements made at Johnson Creek Commons were intended to create long-term value for the developers/owners (Sustainable Communities Northwest and ROSE Community Development) and improve amenities for the residents, while meeting the dual

Table 5: Resident NPV by Feature

	Green savings (cost)
Additional Interest	$0
Energy Efficiency	$149,289
Water Efficiency	$0
Marmoleum Flooring	$0
Hardiplank siding	$0
All other green features	$0
Total	$149,289

Table 6: Resident NPV by Category

	Green Savings (cost)
Additional Interest	$0
Operating Costs	$149,289
Replacement Costs	$0
All Other Green Features	$0
Total	$149,289

Table 7: Owner NPV by Feature

	Green savings (cost)
Additional Interest	($13,537)
Energy Efficiency	($45,209)
Water Efficiency	($1,905)
Marmoleum Flooring	$10,363
Hardiplank siding	$1,314
All other green features	$6,140
Total	($42,834)

Table 8: Owner NPV by Category

	Green Savings (cost)
Additional Interest	($13,537)
Operating Costs	($47,114)
Replacement Costs	$11,677
All Other Green Features	$6,140
Total	($42,834)

objectives of affordability and ecological sustainability. Our analysis is presented both from the perspective of the building developers and from that of the residents. The rehabilitation costs and the common area utility costs are paid for by the developers, while tenants are responsible for heating costs (and savings) within their unit, and are therefore the beneficiaries of most of the operating costs savings related to reduced energy use. Overall, the residents have a present value benefit of almost $10,000 per unit, for a total benefit of $149,289. On the other hand, the developers bear a present value cost of just under $43,000, which is partially offset by the $15,200 rebate that they received from Portland General Electric. Tables 5-8 summarize the net present value analysis that we have completed for residents and the developer.

Residents are not responsible for the cost of any of the improvements, but they receive the majority of benefits from lower utility bills. As presented in Tables 5 and 6, the energy efficiency improvements result in operating savings of approximately $6,012 annually, equivalent to just under $150,000 over the assumed 30-year project life on a present value basis.[6]

The story for the developers is somewhat different. The green building features used at Johnson Creek Commons increased overall capital costs by $80,961 (which does not include the $15,200 in rebates from Portland General Electric). As noted previously, this increase was primarily due to the added investment in energy efficiency measures, particularly the improved windows and glass doors, plus the use of HardiPlank siding; an investment from which the residents reaped the majority of benefits. According to our analysis, the energy-efficiency measures resulted in a present value cost to the developers of over $45,000 (see Table 7).

Due to the incremental costs of project construction, the need for borrowing was increased somewhat, thereby increasing interest costs. The additional interest cost associated with the incremental capital cost totals $19,586 in net present value terms. On the positive side, the replacement cost savings associated with use of the more durable Marmoleum flooring resulted in a present value savings of $10,579. There were also small NPV benefits related to the longer lasting Hardiplank ($1,314) and other features ($6,140). Overall, as presented in Tables 7 and 8, greening Johnson Commons II cost the developers an additional $42,834 in today's dollars. This total is reduced to $27,634 by the rebates from Portland General Electric.

In summary, the developers incurred a high incremental capital cost of almost $66,000 (64% higher direct construction costs than a comparable conventional rehabilitation project). From a life-cycle perspective, this was only partly offset by the use of more durable materials replacement cost savings, and operating savings in common areas. The net present value incremental cost to the developers was almost $43,000. As in the other case studies, the residents enjoy significant operating cost savings, primarily due to the energy efficiency improvements. Net present value savings to residents total over $150,000. At the project level, the benefits of greening outweigh the costs, totaling almost $107,000 and over $122,000 with the energy-efficiency rebates included. In effect, the green building choices made at Johnson Creek Commons transfer value from the developers and project funders to project residents, making Johnson Creek Commons a more affordable place to live.

References and Acknowledgements

- Nick Sauvie of ROSE Community Development provided overall project information including capital and operating costs as well as project financing.
- Allen Lee, Ph.D. of Quantec, LLC, a consultant to the project, provided operating cost data.
- Other sources included:

  "Low-Income Housing Rehabilitation for Sustainability and Affordability," prepared for Portland, Oregon Energy Office by XENERGY, Inc. and Sera Architects, August 2000.

(Endnotes)

[1]Much of the background information on Johnson Commons is from "Low-Income Housing Rehabilitation for Sustainability and Affordability," prepared for Portland, Oregon Energy Office by XENERGY, Inc. and Sera Architects, August 2000.

[2] Though Hardiplank siding is more durable than vinyl siding, because we did not have specific cost figures our cost analysis does not include the operating savings that would result from the use Hardiplank and avoiding the need for replacements.

[3] "Low-Income Housing Rehabilitation for Sustainability and Affordability," prepared for Portland, Oregon Energy Office by XENERGY, Inc. and Sera Architects, August 2000.

[4] WATTSUN 5.6 was used for the analysis. The model was developed by the Washington State University Energy Program and uses building characteristics and long-term weather data to estimate space heating consumption.

[5] Note that the "Low-Income Housing Rehabilitation for Sustainability and Affordability" report analyzed life-cycle costs for both a 25 and 60 year period since the developers have committed to the Portland Development Commission that the project will be maintained as affordable housing for 60 years.

[6] The life-cycle analysis of envelope improvements presented in the "Low-Income Housing Rehabilitation for Sustainability and Affordability" study for the City of Portland used different assumptions about inflation, discount rate, etc. and reported combined owner/resident life-cycle savings of $83,400 for a 25-year period and $144,800 for a 60-year period. Though our life cycle analysis is more comprehensive and presents the results separately for the owners and residents, it is generally consistent with the earlier study in the sense that we show a project-level benefit of greening of $108,000 for a 30-year time period.

LINDEN STREET APARTMENTS

SOMERVILLE, MA

Project Information

Number of Units	42
Unit Type	Multi-Family, Attached
Construction	New
Target Occupant	Low-Income, Including Section 8
Developer	Somerville Community Corporation
Development Consultant	Paula Herrington
Contractor	Landmark Structures Corporation
Architect	Mostue & Associates
Total Square Footage	50,970
Total Development Cost	$9,013,785
Average Cost per Unit	$214,614
Average Cost per Foot	$177
Incremental Cost to Build Green	$20,150
Greening as % of Total Dev. Costs	0.22%
Green Building Focus	Material and Resource Efficiency
Financing Sources	Citizen's Bank - Boston Community Capital, Massachusetts Department of Housing and Commuinty Development, City of Somerville, Local Initiatives Support Corporation - National Equity Fund, Federal Home Loan Bank, Boston Community Loan Fund

"To create a green

frame for living....."

Linden Street
Development Team
Project Goal

Overview

The Union Square area of East Somerville has always been a blue-collar, residential neighborhood, but the encroachment of commercial and industrial interests have threatened that character. Some area residents, like Beverly Lipinski, have spent decades advocating for more environmentally friendly, residential development in their neighborhood. Ms. Lipinski "started working with two mayors back, and three aldermen back on the redevelopment of Ward 2. We first started almost twenty years ago, when we envisioned changes and what we could do to beautify our neighborhood. But they always told us our time will come" (HUD Daily News). That time did come in November of 2002 when the Somerville Community Corporation completed development of the Linden Street Apartments.

The project redeveloped a contaminated industrial site with no trees and no pervious cover into 42 one, two, and three bedroom units of affordable housing set in a large green space. This open area (which amounts to nearly ¾ of an acre) is available not only to project residents, but to their Union Square neighbors – creating urban parkland from a once contaminated space.

This commitment to enhancing environmental quality did not stop with site planning and brownfield redevelopment. Construction materials and methods were chosen to reduce material use during the construction process, reduce energy, water, and other resource use during operation, and to reduce the need for and frequency of long-term maintenance. The project also achieved Energy Star Homes certification. These environmental upgrades were made at a first-cost increase of $20,150 (less than $.50 per square foot and less than one quarter of one percent of the total development cost). But they accrue a benefit of over $280,000 to the project developer and over $58,000 per resident household over a thirty-year building lifespan.[1]

The total development cost of the Linden Street project was $10,013,785 of which $1,000,000 was for property acquisition, $6,796,456 for construction, and $2,217,329 for project soft costs. The project included 39,900 square feet of residential space, a 600 square foot property management office, and 10,470 square feet of common areas. All 42 units are rental and reserved for low-income and very-low income residents. Eighteen units have project-based Section 8 funds through the Somerville Housing Authority, and the 42 units replace 40 units of affordable housing that have been lost in the Somerville area during the last decade. The homes are spread throughout several buildings that range in size from three units to twelve units each. The buildings are designed to enhance the character and scale of other homes in the neighborhood, which are generally two- and three-family triple-decker homes.

Funding was obtained from multiple sources including the Low-Income Housing Tax Credit Program administered through the Massachusetts Department of Housing and Community Development, the Federal Home Loan Bank, the Boston Community Loan Fund, Boston Community Capital, the National Equity Fund, the City of Somerville, the Massachusetts Affordable Housing Trust, the Somerville Affordable Housing Trust, and the Somerville Community Corporation.

Green Design & Construction

Table 1 shows that the cost to upgrade to green materials and methods was minimal when compared to the overall project cost. The $20,150 cost of greening represents about one fifth of one percent of the total development cost and less than one third of one percent of the construction hard cost.[2] In addition, it does not consider the $50,400 rebate that the developer received for green building and energy-efficiency measures that were included. With this rebate, there was a first cost savings of just over $30,000. Table 2 shows the premium for green building as broken down by design and construction costs.

Table 1: Net Cost of Greening

	Cost	Cost/square foot	% of Total Dev. Costs
Green Design	$427,958	$8.40	4.75%
Traditional Design	$427,958	$8.40	
Green Construction	$6,796,456	$133.34	75.40%
Traditional Construction	$6,776,306	$132.95	
Net Cost of Greening	$20,150	$0.40	0.22%

Table 2: Green Premium (Savings) by Category

Category	Green cost	Traditional cost	Additional First Cost or (Savings)
Sustainable sites	$0	$0	$0
Water efficiency	$0	$0	$0
Energy and atmosphere	$35,800	$23,000	$12,800
Materials and resources	$0	$0	$0
Indoor environmental quality	$7,350	$0	$7,350
Innovation in Design	$0	$0	$0
Total	$43,150	$23,000	$20,150

Green Features

When the project team began the Linden Street Development, they wanted to create a "green frame for living." This ideal served as a guide for decision-making, influencing everything from site planning and remediation to material choices to the extraordinary efforts to minimize on-going utility costs while maintaining occupant comfort. The team's overarching goal was to design, develop, and construct a model housing development that provided measurable quality of life benefits to residents, owners, and neighbors. The site served as the perfect location for such an effort. Once a contaminated industrial parcel, the project transformed the area into parkland that is used by residents and the wider Union Square community. To maximize available land, the team decided to cluster the units in one area of the site, preserving the remainder for open space. But remediation and open space protection were not the only site design goals. Native plants were used in the landscaping to reduce the need for watering and upkeep. Units were designed to have visual and physical access to the open space through porches and patios. Buildings were designed to match the character and scale of the surrounding neighborhood fabric, an area that is mostly triple-decker style homes. In every way, the project team attempted to knit Linden Street into the surrounding community, making it part of the wider community fabric and expanding community amenities through its presence. And the "green frame for living" did not stop with the site design and planning. Low-flow toilets were installed to minimize the amount of water used by each household. Insulation and mechanical systems were designed to heat and cool units in a highly efficient manner, and to preserve indoor comfort levels.

Sustainable sites

Many site planning features reflect Linden Street's effort to create a "green frame for living." First, the project is a redeveloped brownfields site, and it has, through development, turned an environmental liability into a neighborhood park. To maximize the size of this park, apartments were clustered together, preserving the majority of the site as open space. Beyond this, the project is located near many local businesses, and it has good access to shopping, transportation, and many area amenities. Because of this excellent access, the project team was able to reduce their parking requirement below levels usually required by zoning. To make the project more accessible to wheelchair-bound people, the open space was carefully graded to eliminate ramps, thereby reducing material usage. Bike racks were placed around the units and in the common space to encourage residents to use alternative means of transportation. In addition, rainwater that was collected on the roof was recharged into the ground around the site, instead of adding to the local storm water system.

Water efficiency

Water efficiency was a key aspect of the "green frame" espoused by the project team. As mentioned before, rainwater was recharged directly into the ground instead of adding to the local storm water system. Landscaping was done with native plants that require little or no irrigation. This technique, called xeriscaping, can also serve as an ecological education tool, teaching residents and community members about the flora that are indigenous to their area. Additionally, the project team installed low flow toilets in each unit to minimize the amount of water and sewer services used by each family.

Energy and atmosphere

One of the critical areas of concern for the project team was energy usage. This concern grew from two areas. One was a desire to reduce the energy footprint that their development would have, in some small way minimizing the power generation needs for the wider community. But more importantly, they wanted to minimize the ongoing operating costs for future residents and the building owner, Somerville Community Corporation. To do this, they upgraded the insulation package to include Icynene (R-40) in the roof, spray-on cellulose (R-20) in the walls, low-E glass and argon filled windows, a concrete slab on grade with a thermal break at the edge and continuous insulation underneath, and foam in place sealants around the windows and wall panels. They also made sure that open corners were incorporated during construction to maximize the insulating factors of the wall units. This insulation package led to a reduction in the number of boilers needed to heat and cool the individual units.

Materials and resources

To minimize the amount of waste generated from project development, the team used pre-fabricated panelized wall frames and roof trusses. They also chose to install Hardi-Plank siding with a 15-year paint warranty, a dramatic improvement over the 5-7 year lifespan of a normal exterior paint job on wood siding. They also eliminated basements in most areas and used first floor slab on grade.

Indoor environmental quality

While indoor environmental quality was not at the top of the greening agenda, the project team did choose strategies that minimized danger due to off-gassing, such as nailing down all carpeting rather than using high VOC adhesives. They also installed quiet, high efficiency Panasonic bathroom fans with timers to reduce moisture and improve air quality.

Innovation in the Design Process

While there was a learning curve associated with the new strategies and materials used in this project, no changes to the traditional design process were made during this project. The newness of the team to these strategies did cause some minor delays and change orders, but nothing that necessarily added cost to the overall budget.

Other

As part of the outdoor park area, the project developers installed a play space for young children. Additionally, extra tall windows were installed in the units to add daylighting and improve views of the common areas, making it easier

Table 3: Operating Costs

Operating Cost Category	Green operations	Traditional operations	Annual Operating (Savings) or Cost
Energy	$70,216	$179,203	($108,988)
Water	$1,643	$2,787	($1,144)
Maintenance (annual painting costs)	$10,159	$15,673	($5,514)
Replacement	no data	no data	no data
Other	no data	no data	no data
Health-related (estimate)	no data	no data	no data
Total	$82,018	$197,663	($115,645)

for parents to observe children playing in the courtyard and for residents to maintain the safety of their homes by being able to see who is coming and going. They also put porches and balconies on each unit.

Operating Savings: Green versus Traditional

• Energy – The focus on well-insulated buildings not only allowed Somerville Community Corporation to install fewer *and* smaller boilers that cost less to operate, but it ensured that the same level of occupant comfort could be reached and maintained with lower energy use. Conservation Services Group, the company responsible for running the EPA's Energy Star Program in the State of Massachusetts, modeled natural gas usage for heat and hot water to estimate expenditures for a standard 2-bedroom unit. They estimated that a typical Linden Street 2-bedroom would use 43% less natural gas than a comparable unit in Somerville. However, when tested, Somerville Community Corporation found that a typical unit over a full year only used 41% of the natural gas that the model predicted, resulting in an 82.4% drop in natural gas expenditures.[3] We also assumed that electricity usage was unchanged in the units between green and conventional. This results in a predicted savings of nearly $109,000 per year on energy costs alone, almost five times the total cost of all green materials and methods.

• Water[4] – There were also significant savings related to water usage, both in the lower amount of water used by low-flow toilets and the choice of indigenous plants that would not require watering for the public green spaces. We have estimated that the low-flow toilets save each household $23 per year[5] and the native plants save Somerville Community Corporation $158 per year[6] in water costs (this does not include what it would cost to pay someone to water and maintain the green space). This amounts to a total savings of $1,144 per year to residents and the developer.

• Maintenance/Replacement – There are significant maintenance/replacement savings related to the choice of Hardi-plank and the 15-year paint warranty for the building exterior. Using the 2004 RS Means Building Construction Cost Data Guide, we estimated that painting the Linden Street Project would cost $50,241.[7] Extrapolating these costs out over 30 years[8] and annualizing the total expenditure, we have estimated that the green material choice saves over $5,500 nominally each year.[9]

Net Present Value Summary

The changes made by Somerville Community Corporation create long-term value, but only a portion of that value accrues to the developer. The remainder of the benefit is realized by residents who did not have to invest in the green building approach. In order to clearly show this, we have broken down the costs and benefits labeling which accrue to the developer and which accrue to the residents at Linden Street. This also provides a clearer picture of the overall benefit of green building for this project, because it shows whether or not these changes are financially viable for both the project owner and the project residents. In calculating these net present values, Table 4 breaks down how benefits and costs were assigned between the project developer and the resident households.

Overall, the green building features have a net present value of $292,578 for the developer when considered over a 30-year building life. This value increases to over $342,978 when one considers the $50,400 rebate for green building features that the developer received. In addition, they have a net present value of $59,861 per resident household over the same time period. Those results are summarized in Tables 5 through 8 – first for Linden Street residents[10] and then for Somerville Community Corporation.

The energy features, which cost the residents nothing, have a value of almost $60,000 per household over a 30-year time period. In addition, the low-flow toilets are worth nearly $600 per household over the same time period.

All the savings that accrue to residents come in the form of decreased expenses for heating, cooling, and water usage. They do not have to pay any additional interest for the added first cost of the green features, nor are they responsible for the costs of green features that need to be maintained, repaired, or replaced.

The story for Somerville Community Corporation is somewhat different. They bear all the costs for improved utility performance, lower maintenance, etc. but they also get substantial benefits. In the end, the changes made by Somerville Community Corporation have a total value of $292,578 over a 30-year time period (almost $343,000 when rebates are included).

The project carries no additional interest payments because there was no premium for green building after rebates. And over $292,000 of the green building benefits accrue to the owner.[11] At a project level, green building decisions made at Linden Street generate benefits of over $2.8 million in current day dollars for the project owner and the residents.

Table 4: Cost and Benefits by Recipient

Costs and Benefits Accruing to Project Developer	Costs and Benefits Accruing to Resident Household
Initial construction cost	Individual utility bills
Maintenance of building and grounds	Bills for water and sewage use in individual units
Maintenance of common areas	
Additional mortgage interest for increased first cost	

Table 5: Resident NPV by Feature

	Green savings (cost)
Additional Interest	$0
Energy	$59,275
Water Use	$586
Total	$59,861

Table 6: Resident NPV by Category

	Green Savings (cost)
Additional Interest	$0
Operating Costs	$59,861
Replacement Costs	$0
Total	$59,861

Table 7: Owner NPV by Feature

	Green savings (cost)
Additional Interest	$0
Energy	$199,087
Water Use	$3,945
Hardi-Board	$89,546
Total	$292,578

Table 8: Owner NPV by Category

	Green Savings (cost)
Additional Interest	$0
Operating Costs	$203,032
Replacement Costs	$89,546
Total	$292,578

References and Acknowledgements

United States Department of Housing and Urban Development (HUD) The Daily Message from Wednesday, January 9, 2002. http://www.hud.gov/news/focus.cfm?content=2002-01-09.cfm.

Northeast Sustainable Energy Association (NESEA) 2004 Green Building Awards program. http://www.nesea.org/buildings/buildingawards/2004winners4.html.

National Equity Fund Project Report. http://smt.nefinc.org/uploadProject%5CProject/34linden.pdf.

"Post-Industrial Affordability." By Architecture Week. February 12, 2003. Page E1.1. On the web at: http://www.architectureweek.com/2003/0212/environment_1-1.html.

"The Linden Street Project." BuildingGreen.com case study available to subscribers at: http://www.buildinggreen.com/hpb/.

Energy Star Homes Spring 2003 Newsletter. "Affordable Housing News." Page 4. http://www.energystarhomes.com/documents/newsletter_spring_2003.pdf.

Interview with Iric Rex from Mostue and Associates.

Survey completed by Katie Anthony of Somerville Community Corporation.

(Endnotes)

[1] See section on Net Present Value of Greening to learn more about how this estimate was obtained.

[2] All information for costs to build green was supplied by the Linden Street Project Team.

[3] In estimating energy usage, we have used the following assumptions:

- Residential units will use three times more energy for heat and hot water than common areas and the management office.
- There will be no difference in the electricity usage for a green unit versus a conventional unit.
- The Conservation Services Group model said that the unit should use 43% of the natural gas as a conventional Somerville unit. Testing said that the unit used 41.2% of the energy the model had predicted. Combined, this results in 43% * 41.2% = 17.6% of the energy of a normal Somerville unit.
- Each unit will use the same amount of energy for heat and hot water as the typical 2-bedroom unit tested and modeled.

[4] The research team estimated the green and conventional operating costs due to water efficiency on the project. Using a methodology developed in the Texas Rainwater Harvesting Guide for calculating total household water use, we estimated the amount of water used by each household to flush toilets (assuming 136 people live in the project or 3 per unit). Using this same methodology, we estimated the annual savings in water usage for landscaping based on the water needs of St. Augustine grass and the annual rainfall in the Somerville area over the last 30 years (as reported by the NOAA). This methodology will be included in the appendices.

[5] Need to add some notes here about how the model was established and maybe reference a place where I show the steps.

[6] See above.

[7] This estimate was built using the unit costs for 09910 – Paints. We selected 0570 – Siding, Misc. Spray primer and 2 coats exterior latex and 0580 – one coat of waterproof sealer. This information is on page 307 of that year's RS Means guide. We assumed that the cost to paint wood siding and the cost to paint hardi-board was the same, but that hardi-board needed to be painted every 15 years (per manufacturer warranty) and wood siding needed to be painted every 7 years (per researcher estimate).

[8] To extrapolate these results over a 30-year time period we have assumed a 4% inflation rate in costs.

[9] The results reported in this section are nominal (we have not tried to convert into real dollars) and the reported savings are nominal. The net present value differentials reported later will not be nominal – they will convert any differential between green and conventional costs back into present day dollar values.

[10] All results are for a single household. To get the value for the full development, multiply the household results by 42.

[11] The results in this section are very sensitive to several changes in the assumptions. First, if we assume that the tested unit (which showed energy usage that was 41.2% of the model's predicted use) is atypical and that the model reflects actual energy performance, then the energy savings over the 30-year life-span drop by a huge amount (to $34,173 for Somerville Community Corporation and to $16,818 for each household). In addition, if wood siding needs to be painted every 8 years instead of every 7, then there is a substantial drop in the value of that change (to $48,525). In effect, this note is saying that the pricing of these estimates are extremely sensitive to small changes in the assumptions. What does remain true, however, is that there is a significant positive value in the choice to build green in this case.

MELROSE COMMONS II:
SUNFLOWER WAY

BRONX, NEW YORK

Project Information

Number of Units	90
Unit Type	Multi-Family, Attached
Construction	New
Target Occupant	Low-income first-time homeowners
Developer	MC II Associates, Les Bluestone
Contractor	Blue Sea Construction Corporation, Les Bluestone
Architect	David Danois Architects, PC
Green Consultant	Steven Winter Associates
Total Square Footage	126,900
Total Development Cost	$11,947,082
Average Cost per Unit	$132,745
Average Cost per Square Foot	$94
Incremental Cost to Build Green	$354,990
Green Building Focus	Energy Efficiency, IEQ
Financing Sources	MCII Associates, NYC Second Mortgage Program, NYC Special Subsidy Article 16, Borough Presidents (Resolution A), NY State Affordable Housing Corporation, JP Morgan Chase, NYSERDA, Deutche Bank

"The project was conceived to provide affordable housing and to incorporate energy saving and green building features for an income gorup that would not normally have these options available to them."

NESEA
2003 Green Building Awards

Overview

Melrose Commons II is a development of 30 three-family homes located in the Melrose section of the South Bronx in New York City. For decades starting in the 1960s this section of the City was characterized by disinvestment and abandonment. As part of an effort to address this problem, in 1994 the Melrose Commons Urban Renewal Plan was adopted, focusing on a 35-block area in the heart of the neighborhood. The Plan called for 1,700 units of new housing as well as commercial space, community facilities, and open space. Melrose Commons II, also known as Sunflower Way, is part of this overall Plan.

Melrose Commons II is a $12 million, 90-unit multi-family project featuring multi-level owner apartments and second- and third-floor single-story rental flats.[1] (See Table 1 for a detailed summary of project development costs.) Completed in 2002, it is part of the High Performance or "Green" building program of New York City's Housing Partnership. This complex of 30, three-story, three-family homes totals 126,900 square feet of living area. The basement, the first floor, plus half of the second floor comprise the owner's three-bedroom unit. Half of the second floor is a one-bedroom rental apartment, and there is a two-bedroom rental apartment on the third floor. The development is specifically for first-time homebuyers. The homes were designed and financed to be affordable for families making as little as $42,000 a year (or 80% of Area Median Income). On average, each three-family, 4,230 square foot home sold for $289,000, and buyers could use the rental income from the other two units to meet their mortgage payments.

As part of the U.S. Department of Energy's Building America program, every home in Melrose Commons II is an Energy Star home. In fact, it is the first affordable housing development in New York to earn the "EnergyStar® Homes" label from the U.S. Environmental Protection Agency and the New York State Energy Research and Development Authority.[2] The project has been recognized with awards from the U.S. Department of Housing and Urban Development (HUD) and the Northeast Sustainable Energy Association (NESEA).

Green Design & Construction

Construction accounted for 77% of the total development costs, while property acquisition and soft costs accounted for 6% each, developer fee about 5%, and pre-development and construction loan interest was about 4%.

The incremental cost to make Melrose Commons II a green project was estimated by the developer to be about $354,990, of which $54,990 was paid for directly with green rebates for a post rebate premium of $300,000 (about 2.5% of total development costs or about $2.36 per square foot). As shown below in Table 2, these incremental costs were borne during the construction phase.

The main focus of greening at Melrose Commons II, and the major reason for the increase in capital costs, was improved energy efficiency. Secondarily, use of recycled materials conserved natural resources, use of non-toxic paints and sealants helped protect indoor environmental quality, and installation of low-flow fixtures conserved water resources. Of the total incremental post-rebate cost of $300,000, almost $183,000 (61%) was for higher-cost energy efficiency measures and equipment (insulation, windows, water heaters, boilers, appliances, etc.); $35,250 (12%) was related to material choices (recycled carpet and padding), while the remainder was due to increased labor for additional interior and exterior sealing and caulking, use of solid wood and plywood instead of particle board, use of low-VOC paints, and other factors. All incremental costs from greening are shown in Table 3, and the costs of these other green features appear in the final line of that table, labeled as Other Green Features (Unspecified).

Table 1: Total Development Costs

Activity	Dollar Amount
Property acquisition	$711,800
Final construction cost	$9,172,950
Architecture and engineering	$136,000
Environmental assessment and testing	$0
Development consultant(s)	$0
Legal	$45,000
Lender fees and costs	$92,657
Construction and pre-development loan interest	$516,637
Developer project management and overhead	$0
Other Soft Costs	$712,097
Developer fee/profit	$559,941
Capitalized Replacement Reserves	$0
Capitalized Operating Reserves	$0
TOTAL	$11,947,082

Table 2: Net Cost of Greening

	Cost	Cost/square foot	% of Total Dev. Costs
Green Design	$136,000	$1.07	1.14%
Traditional Design	$136,000	$1.07	
Green Construction	$9,172,950	$72.28	76.78%
Traditional Construction	$8,817,960	$69.49	
Net Cost of Greening	$354,990	$2.80	2.97%

Table 3: Green Premium (Savings) by Category

Category	Incremental Cost
Sustainable Sites	$0
Water Efficiency	$0
Energy & Atmosphere	$206,490
Materials & Resources	$35,250
Indoor Environmental Quality	$9,000
Innovation in Design	$0
Other Green Features (Unspecified)	$104,250

Green Features

Efforts to green Melrose focused on using precast concrete construction, improving energy efficiency through a variety of measures, and selecting environmentally preferable materials. The green building techniques and systems that were used are detailed below.

Sustainable Sites

As described above, the Melrose Commons II project is in the heart of the South Bronx, conveniently located to several subway, bus and train lines, as well as shopping and recreational facilities. Moreover, the project was constructed on a former brownfield site, so this is a redevelopment of a previously built area with the full range of existing infrastructure and services.

Water Efficiency
Low-flow shower controls, faucets and toilets were installed in bathrooms and kitchens of all of the units to reduce water use. No other significant water efficiency measures were implemented.

Energy and Atmosphere
The project focused considerable attention and resources on energy and atmosphere, including a number of building envelope improvements as well as high-efficiency equipment.

The project used faced R-11 batts in frame walls and ½-inch rigid expanded polystyrene (EPS) insulation board between metal studs and exterior walls to prevent thermal bridging. In addition, 2-inch EPS was used in the basement up to two feet below grade, with 2-inch rigid fiberglass insulation on all exposed cellar walls. For roof insulation R-21 3.1-inch foam board was installed as were aluminized roof coatings to reflect summer sun.

Large area double glazed low-e (Comfort E2) coated glass vinyl frame windows from a local manufacturer were installed in rooms and public spaces to improve envelope performance and increase natural lighting. Use of the vinyl frame windows rather than aluminum was one of the factors allowing for the properly sized smaller boiler.

The entire Melrose Commons II complex was constructed with structural precast panelized concrete and brick system (Oldcastle Precast) to create a tighter envelope. Each precast concrete-framed unit included poured concrete foundations, hollow core floor and roof planks, weight-bearing and non-weight-bearing wall panels, interior and exterior steps, U-shaped channels and cornices, and sills and lintels cast into the brick inlay exterior panels. The advantages of precast construction include reduced construction time, reduced labor, less on-site waste generation, and increased envelope tightness due to fewer seams. In addition, interior and exterior sides of all walls and exterior penetrations, including exhaust ductwork were sealed and caulked.

The project uses a single high-efficiency (87+%) sealed-combustion direct-vent (Burnham Revolution) gas boiler with a 65-gallon (Bradford White) automatic-storage indirect water heater to provide heat and hot water for each building, rather than separate ones for each of the three units per building. Traditional combustion equipment configurations are often oversized, can be inefficient, and can lack proper control mechanisms. The decision to use a single, properly-sized, high-efficiency sealed boiler for heat and hot water instead of two oversized appliances was based on input from project consultant Steven Winter Associates concerning the reduced infiltration and tighter buildings resulting from the use of precast concrete. Use of sealed-combustion direct-vent boilers eliminated the need for costly chimneys and was an important decision in terms of overall efficiency and cost savings. In addition, the project used digital programmable thermostats and an outdoor reset control to modulate water temperatures in the radiators depending upon outdoor temperature. These adjustments help to reduce overheating, resulting in reduced energy use and improved resident comfort. Similar to most NYC apartments heated by boilers and radiators and without duct systems, central air conditioning was not installed.

Energy Star compact fluorescent lighting fixtures are used throughout the Melrose Commons II complex. Furthermore, all units have Energy Star refrigerators and dishwashers.

Materials and Resources
To reduce use of virgin materials and conserve natural resources, the project used 100% recycled content PET carpeting made from recycled plastic bottles and containers laid over recycled rubber padding. In addition, recycled content vinyl composition tile (VCT) flooring was used in kitchens. Note that while the use of recycled content flooring is a definite plus, significant concerns have been raised about the environmental impacts, particularly air emissions, in the vinyl manufacturing process.

Indoor Environmental Quality
To minimize impacts on indoor air quality low-VOC paints were used throughout the project as were low-VOC latex acrylic sealants throughout the interiors. In addition, solid wood and plywood were used instead of particle board in kitchen cabinets and countertop substrates with low-VOC lacquer finishes on the cabinets.

To meet Energy Star requirements, the Melrose Commons II project had to be both tight and properly ventilated. Using proper ventilation techniques ensures that homes will not experience unsafe levels of moisture and prevents the likelihood of combustion. High levels of moisture can cause mold or mildew growth. The growth both deteriorates ceilings and walls and has serious health effects on residents, especially those with allergies and respiratory problems such as asthma. Likewise, combustion products from the building's heating equipment must be removed from the building to ensure the health of the residents. To achieve the proper ventilation, the project used a separately-vented sealed combustion boiler and installed exterior fans.

Innovation in Design
Many of the green features described above — particularly the pre-cast-concrete construction — can be considered innovative and required close coordination among various members of the design and construction team. For example, the choice of a single down-sized boiler for heat and hot water for each building resulted from this intensive up-front collaboration.

Operating Savings: Green versus Traditional

Melrose Commons II was the first affordable housing development in New York to earn the "EnergyStar® Homes" label from the US Environmental Protection Agency and the New York State Energy Research and Development Authority (NYSERDA). To achieve this rating, a home must be 30 percent more energy efficient than standard homes. As described above, to improve energy efficiency, the project used efficient heating systems, improved the insulation and the tightness of the building, and installed energy-efficient appliances. Improved tightness was achieved by using panelized exterior components during construction; improving the sealing of exterior openings, projections, and joints with special attention on sealing and caulking openings and ductwork, an important but often overlooked activity; and using low-emissivity, vinyl frame windows instead of traditional aluminum frame windows.

With funding from the U.S. Department of Energy's Building America program and the non-profit New York City Partnership, Steven Winter Associates (SWA) was hired to conduct energy modeling and consult to the developers on energy efficiency. SWA's modeling showed that thermal bridging between the concrete exterior and the metal studs would significantly reduce the R-value of the wall insulation. They recommended the installation of a half-inch expanded polystyrene board between the exterior walls and the studs, which was done throughout the building. SWA tested each building type in each row of homes (end units, middle units, and detached units), 27 of the 90 units, for air tightness using blower door tests. All testing results met the modeled tightness (0.5-0.35 air changes per hour or ACH under natural conditions).

SWA's pre-construction energy modeling estimated that heating usage in a typical Melrose Commons II building would be less than 5 Btu/ft^2/heating degree-day (HDD), and that hot water heating would account for about 40% of total gas usage. These estimates of very significant energy savings have been achieved and were recently documented by SWA based on gas and electricity bills from 2003 for three randomly selected Melrose buildings. The analysis shows an average energy use for heating of 4.45 Btu/ft^2/HDD (the model estimated less than 5), accounting for 41% of total building energy use. The remaining 59% of gas is for "base usage" including hot water, stove gas, and possibly one dryer in the owner's unit. The split differs somewhat from the preconstruction modeling, which estimated hot water heating would consume 40% of gas used.

Table 4 presents the Melrose Commons II operating costs compared with that of a comparable traditional NYC affordable housing development. Note that data for water savings are not available.

Table 4: Operating Costs

Operating Cost Category	Traditional Building*	Melrose Building	Savings per Building	Total Melrose Savings**
Annual cost of gas for heating	$2,701	$858	$1,842	$55,266
Annual cost of gas for water heating, etc.	$2,701	$1,235	$1,465	$43,960
Annual electricity cost for lights & appliances	$1,075	$914	$161	$4,840
Total energy cost	$6,477	$3,008	$3,469	$104,066

**each building contains 3 units*

***total complex contains 30 buildings*

In order to estimate energy usage in comparable traditional buildings we reviewed several sources. For example, in a 1996 study by Steve Winter Associates reviewed the energy use in 400 buildings of low-income housing in NYC that were preparing to enter the Weatherization Assistance Program (WAP). This study showed average heating usage at more than 24 Btu/ft^2/HDD, plus an equivalent energy use for domestic hot water heating for a total gas usage approaching 50 Btu/ft^2/HDD.

While much of the City's affordable housing may still be consuming these high amounts of energy for heating and hot water, we are using considerably better performing recent developments as comparable traditional projects. For example, the Public-Private Partnership for Advancing Housing Technology (PATH) cites a recently completed comparable project in Harlem performing at 14 Btu/ft^2/HDD for heating. Thus, in our analysis we used this level of performance as indicative of the energy use for heating, and assume that heating consumes roughly 50% of non-electricity use.

Even with this assumption, the results show the Melrose Commons II units are using 54% less overall energy relative to comparable traditional NYC affordable housing. The Melrose units are using 68% less energy just space heating, 54% less for hot water and ancillary gas usage, and an estimated 15% less electricity for lighting and appliances. As Table 4 shows, in current dollar terms, in 2003 annual operating savings averaged $3,469 per 3-unit building or more than $104,000 for the entire complex.

It should be noted that savings associated with reduced heating costs benefit the homeowners, while electricity savings accrue directly to residents of each unit (the two rental units and the owner's unit). Again, these savings would be even greater if the project were compared to the older traditional, more inefficient affordable housing described above.

Net Present Value Summary

As described earlier in this report, for each case we have estimated the financial impact of green building decisions over an expected thirty-year building lifespan. The common assumptions for this analysis are detailed in the Methodology section presented earlier; however, we have one different assumption for Melrose Commons II.

Table 5: Tenant NPV by Feature

	Green savings (cost)
Additional Interest	$0
Electrical Efficiency	$60,267
Gas Efficiency	$0
Carpet	$0
Flooring	$0
Indoor Air Quality	$0
All Other Green Features	$0
Total	$60,267

Table 6: Tenant NPV by Feature

	Green Savings (cost)
Additional Interest	$0
Operating Cost	$60,267
Replacement Costs	$0
All Other Green Features	$0
Total	$60,267

Table 7: Owner NPV by Feature

	Green savings (cost)
Additional Interest	($85,657)
Electrical Efficiency	($1,473)
Gas Efficiency	$3,484,652
Carpet	($35,250)
Flooring	$0
Indoor Air Quality	($9,000)
Other Green Features	($91,830)
Total	$3,261,441

Table 8: Owner NPV by Category

	Green Savings (cost)
Additional Interest	($85,657)
Operating Cost	$3,483,178
Replacement Costs	($35,250)
All Other Green Features	($100,830)
Total	$3,261,441

We have assumed that homeowners, on average, have financed 69% of the purchase price with debt. This assumption is based on the information we gathered from the developer on project financing. In addition, we have organized this case differently because of the long-term ownership structure. Melrose Commons II consists of three-unit, owner-occupied buildings with two renters in each building. We have analyzed the impact of greening on the homeowner and on the two tenants for each building.

As detailed above, the vast majority of the green improvements and associated incremental capital expenditures, as well as the operating savings, at Melrose Commons II are energy related. Thus, our life-cycle analysis focuses primarily on energy aspects. In order to clearly show the costs and benefits from the perspective of the developer, the building owners, and the tenants, we have traced which accrue to each party. This also provides a clearer picture of the overall benefit of green building for the project, because it shows whether or not these changes make financial sense to the developer, the new homeowners, and the tenants.

As mentioned, the developer sold all 30 units in Melrose Commons to first-time homebuyers. It is worth noting that costs to the building owners reflect about $3 million of grants from City and State programs in support of green affordable housing. We have assumed that incremental capital costs, net of these grants and green rebates, are passed on directly to the homeowner with the exception of a $919 per building cost that reduces the developer fee.[3] Beyond this developer payment of $27,570 to the project, the NPV analysis assumes the developers "remain whole," meaning that they neither incur the incremental capital costs of building green, nor reap any of the savings in operating costs. These costs and benefits are broken out between homeowners and tenants. Homeowners pay for the incremental capital costs of $272,430, net of rebates and the developer contribution,[4] and also enjoy the bulk of the operating savings. Homeowners also pay for all gas (including heating) and for electricity in their units. Tenants enjoy the modest savings associated with lower electricity costs in their units.

The NPV analysis shows that green building changes at Melrose Commons II required an up-front investment of $272,430 by the homeowners, but that the savings that accrue over the buildings' life totals $3,261,441 in today's dollars (more than 10 times the incremental capital investment) or nearly $110,000 per 3-unit building. Tenants also enjoy a small benefit due to lower electricity costs totaling more than $60,000 in present value terms over the 30 years. In addition to reduced utility bills, we expect that owners and tenants also benefit from improved comfort and better indoor air quality, though these are not quantified in our analysis. Tables 5-8 detail the analysis we have done for new homeowners and tenants.

While we did not have the data to analyze this fully, the use of precast concrete exterior panels instead of a traditional wood exterior should result in increased building durability. The building developer stated that the advantages of precast concrete panels include improved insulation, fire resistance, and long-term durability, noting, "A lot of the typical call-backs we would experience with wood are minimized or nonexistent with precast."

The Melrose Commons II project powerfully illustrates the importance of going beyond first costs when considering a project's costs and benefits. While the project was slightly more expensive to build in terms of up-front capital costs (2.5%), a small portion of which was subsidized by the developer, these were largely passed on to the new building owners and or covered by additional subsidies or utility rebates. The net long-term benefits to the new homeowners far exceed the incremental costs and total over $3 million.

References and Acknowledgements

- Patty Noonan from the Partnership for New York City and Les Bluestone from Blue Sea Development Company, LLC provided much of the initial development cost data on the Melrose Commons II project.
- Architect Chris Benedict and building energy specialist Henry Gifford provided valuable feedback on the relationship between building design and construction practices, heating and ventilation systems, and operating costs.
- F.L. Andrew Padian, Senior Housing Specialist with Steve Winter Associates provided the utility cost data on Melrose operations and invaluable feedback on many aspects of the Melrose project, from design and construction to operations.
- Other sources included:

Steven Winter Associates, "Getting to Energy Star in Affordable Housing" (Draft), A Guide for Developers, Architects, Engineers, and Affordable Housing Providers, October 2002.

"New York State's First 'Green" Affordable Housing Development is Celebrated in the South Bronx," press release from New York City Housing Partnership, October 25, 2002.

(Endnotes)

[1] Total development cost for the project was $11,947,082. Source: Les Bluestone, 3/30/04.

[2] Energy Star homes are certified to meet EPA's strict guidelines for energy efficiency.

[3] In effect, we have assumed that the developer earns $559,941 in developer fee for building a green project, rather than the $587,511 the developer would have earned from a comparable conventional project. The $919 per building investment by the developer represents this difference.

[4] In addition to the developer contribution, NYSERDA has provided a rebate of $1,500 per building ($45,000 total) for energy-star appliances and other energy-related changes. Deutsche Bank has provided a grant of $333 per building ($9,990 total) for greening.

NEW HOMES FOR SOUTH CHICAGO

CHICAGO, IL

Project Information

Number of Units	25
Unit Type	Single-family and Duplex
Construction	New Construction
Target Occupant	Low-income families
Developer	Claretian Associates
Contractor	South Chicago Workforce
Architect	Sam Marts and Associates
Total Square Footage	63,300
Total Development Cost	$4,494,726
Average Cost per Unit	$179,789
Average Cost per Foot	$71
Incremental Cost to Build Green	$366,300
Greening as % of Total Dev. Costs	8.15%
Green Building Focus	Energy and Resource Efficiency
Financing Sources	Local Initiatives Support Corporation, Chicago Department of Commerce and Economic Opportunity (DCEO), Chicago Department of Energy, Clean Energy Foundation, Harris Bank, Neighborhood Housing Services, Marquette Bank, LaSalle Bank, Pullman Bank

"...to serve as a catalyst in creating innovative solutions to community problems."

Claretian Associates
mission statement

Overview

South Chicago sits at the southern edge of Chicago, almost in Indiana, and it is home to 42,400 residents, 93 percent of whom are minorities. The neighborhood has seen household poverty rise to 26 percent since 1990 and unemployment hovers around 11 percent. Many residents used to work in the surrounding steel mills, but economic hardship has increased as the steel mills have closed. In 1992, one of the largest mills, United States Steel South Works, shut its doors, and the former site is now up for sale. The redevelopment of the 576-acre South Works site may hold the key to the future of South Chicago.

Groups like Claretian Associates, the New Homes for South Chicago developer, and Woodlawn Development Associates, who re-developed the nearby Woodlawn Building also featured in this report, bring investment and new opportunities to this neighborhood. Claretian Associates, a non-profit affordable housing developer, has been in business for 14 years. New Homes is their latest project, and it will ultimately include 25 new structures, of which 12 units will be single-family and 13 will be duplex. The homes are being built in groups of three, and six have been completed as of the Spring of 2005. All 25 units are scheduled for completion in December 2006.

Each single family home will have 1,700 ft^2 of space, not including the finished basement, with 3 to 4 bedrooms. Each duplex will have 3,300 ft^2 of space with 3 to 4 bedrooms in a 2-story unit above a basement rental apartment.

The total development cost per unit is $179,789. Total hard costs are $169,500 per unit, and total soft costs are $10,289 per unit. The architects found that this project did not cost them any more to design than another comparable project. This is mostly attributable to two facts: 1.) the general contractor did most of the leg work in identifying and specifying the green materials, and 2.) the architects had previous experience in greening projects.

With support from the Chicago Department of Housing, Claretian is selling the single-family homes at a base price of $165,000, and the duplexes at a base price of $230,000. Depending on family size and income, however, owners may qualify for subsidies that lower the purchase price of their new home. The final purchase price for a single-family home may be as low as $125,000, and for a duplex as low as $196,500.

Funding sources for pre-development included a recoverable grant from the Local Initiatives Support Corporation and a grant from a local bank. Construction was funded by a low interest construction loan from Charter One Bank, which is funding the houses 3 at a time. Funding specifically for green features came in the form of grants from The Department of Commerce and Economic Opportunity, The Chicago Department of Energy, and the Clean Energy Foundation. These grants were particularly important for this project because, as a homeownership project, the developer never shares in the reduced operating costs that arise from greening. Since affordable housing products are price-constrained (if a project costs more, the developer cannot usually increase sales prices), any cost increase from greening not covered by grant funds is a lost investment for the developer.[1]

Green Design and Construction

The total project is expected to cost just under $4.5 million, with the vast majority of this amount in construction costs. Table 1 illustrates the cost breakdown.

The cost of greening represents just over 8% of the total development costs, but nearly half of the net cost of greening ($180,000) is due to the installation of photovoltaic panels (PV) on the roofs of twelve of the houses. The cost for the PV installation was paid for entirely by outside grants. In addition, there was no additional cost for green design. These costs are broken out in Table 2.

Table 1: Total Development Costs

Activity	Total Costs
Property acquisition	$1
Final construction cost	$4,237,500
Architecture and engineering	$75,000
Environmental assessment and testing	$4,725
Development consultant(s)	0
Legal	0
Lender fees and costs	$50,000
Construction and pre-development loan interest	$2,500
Project management and overhead	0
Other Soft Costs	*included in construction*
Developer fee/profit	$125,000
Capitalized Replacement Reserves	0
Capitalized Operating Reserves	0
Total	$4,494,726

Table 2: Net Cost of Greening

	Cost	Cost/square foot	% of Total Dev. Costs
Green Design	$75,000	$1.18	1.67%
Traditional Design	$75,000	$1.18	
Green Design Premium	$0	$0	
Green Construction	$4,237,500	$66.94	94.28%
Traditional Construction	$4,051,200	$64.00	
Green Constrcution Premium	$186,300	$2.94	
Net cost of greening	$366,300	$5.79	8.15%

Note: Construction costs do not include $180,000 cost for installing PV

Table 3: Green Premium by Category

Features Category	Green cost	Traditional cost	Green Premium (Savings)
Sustainable sites	0	0	0
Water efficiency	0	0	0
Energy and atmosphere	$576,500	$242,000	$334,500
Materials and resources	$29,600	$8,525	$21,075
Indoor environmental quality	$10,725	0	$10,725
Other			
Total	$616,825	$250,525	$366,300

Green Features

New Homes for South Chicago has an impressive list of green features. The general contractor, South Chicago Workforce, is known citywide for their commitment to quality construction and use of environmentally sound building products. They were also the general contractor on the Woodlawn Development Associates' project also included in this report. The green building focus of New Homes was on energy efficiency and energy generation, as can be seen from the level of investment in green features shown in Table 3. A secondary focus for the project was on material and resource-efficiency in addition to indoor air quality.

Sustainable Sites

The project is being built in an urban setting with access to existing services and infrastructure. In addition, New Homes is revitalizing blighted lots and turning them into affordable housing. These significant commitments to sustainable sites are important in the project, but do not entail costs that are extraordinary in comparison to a more conventional development in this neighborhood. We have included no cost differences for recycling a site.

Water Efficiency

There were no significant water efficiency measures in the project.

Energy and Atmosphere
The central green building focus for the New Homes project is on energy and atmosphere and the vast majority of their investment has been placed here. The Energy and Atmosphere improvements include the following:

- Construction with Structural Insulated Panels [2]
- Air-infiltration building wrap on exterior of all walls
- R-24.7 insulation in walls and R-42.5 insulation in roof
- Double glazed Low-E vinyl frame windows
- Insulated metal exterior doors
- High efficiency gas-fired forced air heating system
- Air Cycler control system to regulate ventilation
- High efficiency gas-fired 50 gallon hot water heater
- Solar power generation system on houses with roofs pitched north/south
- Mixture of energy efficient florescent and incandescent lighting
- Energy efficient refrigerators

Solar Power
Of the 25 houses being built in this project, 12 of them will be partially solar powered. Each of the solar homes will have a 1.2 KW system (81%-84% efficiency factor) incorporated into it. The systems, priced at $18,000 per house were made available at a discount to the project. With the discount, the total cost for installing the systems came to be $15,000 for each home. Since the first installation, market prices for the solar systems have come down considerably. It is estimated that a homeowner could get a similar system installed for about $10,000; with $7,000-$8,000 being for materials and the remaining $2,000-$3,000 for installation. It is anticipated that each of these systems will cover approximately 25% of the energy load for each energy star-rated home. For a conventional home, it would cover about 20% of the load. Based on energy modeling, a 4 KW system would be able to cover most of the base load of a typical home – lighting, heating/cooling, appliances and fans for furnaces. The state of Illinois covered the cost of including solar in this project through several state grant programs.

Materials and Resources
There was a secondary focus on material and resource-efficiency in specifying materials and methods for this project. In place of vinyl flooring, the project team used cork flooring in several areas. In addition, recycled glass and ceramic tiles were used instead of conventional ceramic tile. They also used structural insulated panels, accounted for in the previous section, which helped reduce construction waste by engineering and manufacturing wall panels off-site.

Indoor Environmental Quality
Indoor environmental quality was also a secondary area of focus for the project team. They used low volatile organic compound (VOC) paints and primers throughout the project. An air cycler ventilation system was installed to increase the amount of fresh air introduced into the units, and an energy recovery ventilation system has been installed in one house to date. Bathroom fans with timer controls were also installed.

Innovation in the Design Process
Aside from the inclusion of the PV panels, which have been previously discussed, there were no significant design process innovations.

Operating Savings: Green versus Traditional

Having tracked the heating bills for the units completed to date, the average energy consumption of the high-efficiency gas heaters has averaged $0.65/therm. This comes to approximately $300 per winter heating season. While these furnaces and water heaters are very gas-efficient, they are not as electrically-efficient. The most efficient fan motors for the furnaces would have been prohibitively expensive and were not included.

Electricity usage has not been tracked, and we had to develop an alternate method for estimating use. In calculating operating costs for electricity use, we have assumed that an average house uses about $100 worth of electricity per month. The project developers expect that an energy-star rated home like those at New Homes will use 80% of the electricity of a conventional home. In addition, the homes with PV panels will have one quarter of their electrical load covered by PV generation. Using this assumption and the information from the development team, we were able to estimate the electrical usage on these units. Those estimates are reflected in Table 4.

Table 4: Operating Cost

Operating Cost Category	Green cost	Traditional cost	Annual Savings
PV generation	$720	$960	$240
Electrical Efficiency	$960	$1,200	$240
Gas (Therms)	$300	$485	$185
Oil (gallons)	no data	no data	no data
Water (gallons)	no data	no data	no data
Maintenance	no data	no data	no data
Other (incl. replacements)	no data	no data	no data
Total	$1,980	$2,645	$665

Note: All estimates are per unit. Gas usage is for a winter heating season.

Table 5: Expected Life for Green vs Conventional Materials

Green Feature List	Green life (yrs)	Conv. Life (yrs)
Cork Flooring vs Vinyl	over 30	10
Recycled Glass vs Ceramic tile	over 30	25

Net Present Value Summary

As described earlier in this report, we have estimated the financial impact of green building decisions over an expected thirty-year building lifespan for each case. In the case of New Homes, this estimate was made more difficult because we have only part of the operating data we need to measure benefits, particularly electricity-use benefits. However, we have carried out a partial life-cycle analysis. This analysis is based on the operating cost assumption described in the previous section, that a conventional Chicago home pays $100 per month for electricity. We have made additional assumptions about the expected life of certain materials and features installed in the building, in order to calculate replacement cost differentials. Those assumptions are displayed in Table 5.

The New Homes project is different than many others in this study in the sense that the developer took on significant green building costs and did not ultimately reap the benefits of those changes. Even other homeownership projects that our research team has investigated, such as Brick Capital CDC, did not have the same level of investment in green building that was made by Claretian Associates and their project team. We have broken out project costs, which accrue to the developer, and project benefits, which accrue to the homeowner, to show the impact that the green building decisions had on each. Table 6 shows that Claretian spent an additional $366,300 on green building features in the project. At the time of this writing, over $266,000 of these costs had been funded by outside grant sources with another $125,000 application pending.

The reader should note that the life-cycle cost borne by the developer is exactly equal to the green building premium. This is no accident. The developer is paying for all the green features, and the eventual homeowner accrues all the savings over the life of the building.

Unit heating and hot-water heating is gas-fired, and the gas efficiency measures have a life-cycle benefit of $4,600 for each homeowner ($115,417 total). In addition, the electrical efficiency and energy generation benefits are worth nearly $8,900 for each homeowner over the life of the building. The replacement cost savings associated with cork and the recycled tile result in a value of $220 for each homeowner. Over a thirty-year life, New Homes residents will receive over $13,000 in present-value benefits from the green building choices made.

The reader should also note that

Claretian is paying about $14,000 more in a green-building premium than the eventual homeowners will receive in present-value benefits. In effect, this shows that the choices made in this project cost more than they are worth over the life-cycle of the building. But closer inspection of Table 6 and Table 8 reveals an additional point. The PV panels cost $108,000 more in green premium than they are worth in present value benefits. All the other green building features create an estimated $94,000 present-value benefit over the life of the project. In addition, if the PV panels were installed today, they would only cost $120,000 up front, a $60,000 reduction from their original cost. This would make the investment in green positive when one considers the cost to the developer and the present value benefit that accrues to the homeowner.

The green building changes in this project can be seen as a transfer of value from the groups who have funded the green building materials and methods to the eventual homeowners. In addition, green building cost more than it was worth in this case, but that differential was due entirely to the inclusion of PV in twelve of the homes in the project. Other green building features add a positive net value when both developer and owner are considered. In addition, all the green building features provided long-term value for the homeowners.

Table 6: Developer NPV by Feature

	Green savings (cost)
Additional Interest	0
Gas Efficiency	$(38,225)
Electrical Efficiency	$(4,000)
PV	$(180,000)
Wall Framing	$(120,500)
Other Green Features	$(12,000)
Flooring	$(5,275)
Tile	$(6,300)
Total	$(366,300)

Table 7: Developer NPV by Category

	Green Savings (cost)
Additional Interest	0
Operating Costs	$(222,225)
Replacement Costs	$(132,075)
Other Green Features	$(12,000)
Total	$(366,300)

Table 8: Homeowner NPV by Feature

	Green savings (cost)
Additional Interest	(40,362)
Gas Efficiency	$115,417
Electrical Efficiency	$149,731
PV	$71,871
Wall Framing	0
Other Green Features	0
Flooring	$5,529
Tile	0
Total	$302,186

Table 9: Homeowner NPV by Category

	Green Savings (cost)
Additional Interest	(40,362)
Operating Costs	$337,019
Replacement Costs	$5,529
Other Green Features	0
Total	$302,186

References and Acknowledgements

- Kathy Kelleher, Project Manager, Claretian Associates
- William Boardman, Principal, South Chicago Workforce
- David Sullivan, Principal, South Chicago Workforce
- Paul Knight, Architect and Energy Consultant, State of Illinois
- Robb Aldrich, Engineer, Steven Winter Associates
- Sam Marts, Principal, Sam Marts Architects and Planners
- Julie Wentworth, Architect, Sam Marts Architects and Planners
- Mark Burger, Sales Manager, Spire Solar Chicago

(Endnotes)

[1] This discussion overlooks the important fact that the mission of many affordable housing development organizations may provide additional motivation to build green. Decreased operating costs for owners, decreased maintenance, and improved occupant health are all powerful reasons to create better buildings. However, one cannot entirely escape the economic reality. If something costs you more to make than its closest substitute and you cannot sell it for more, then there is a gap that must be filled or you will not be in business for very long.

[2] This is also a materials and resources improvement, as waste can be minimized with off-site construction of the structural insulated panels. Its placement in this category was a judgment call on the researcher.

POSITIVE MATCH

SAN FRANCISCO, CA

Project Information

Number of Units	7 Residential Units + Commercial Space
Unit Type	Rental Apartments
Construction	New and Renovation
Target Occupant	Multiply diagnosed, formerly homeless mothers with HIV/AIDS and their children
Developer	Housing Services Affiliate of Bernal Heights Neighborhood Center
Contractor	Pacific Engineering Builders
Architect	Singer and Associates with Okomoto/Saijo
Total Square Footage	8,620 (5,910 residential, 2,710 commercial)
Total Development Cost	$3,400,110
Avg. Cost per Residential Unit	$333,024
Average Cost per Foot	$394
Incremental Cost to Build Green	$99,582
Green Building Focus	Indoor Air Quality and Human Health
Financing Sources	Housing and Urban Development Housing Opportunities for People with AIDS (HOPWA) Program, San Francisco Mayor's Office of Housing, San Francisco Redevelopment (HOPWA), Local Initiatives Support Corporation, McKinney SHP

"To preserve and enhance the ethnic, cultural and economic diversity and well-being of the Bernal Heights Community"

Bernal Heights Neighborhood Center mission statement

Overview

In 1978, five-hundred residents of San Francisco's Bernal Heights' neighborhood organized against building eleven market-rate homes in one of the area's last remaining open spaces. After successfully resisting this project, community members recognized a need for a neighborhood organization that could represent local interests through long-range planning and development oversight. The Bernal Heights Neighborhood Center (BHNC) became this organization. Today they focus on four areas: community organizing, affordable housing services, senior services, and youth services. These focus areas support and advance BHNC's goals of being a "provider of essential services, a builder of community, and a force for organizing neighborhood change."[1] BHNC began developing housing in 1982, and since then has developed 1 limited equity homeownership project and 11 rental projects with a total of 196 units. Eight of these buildings, including Positive MATCH, have served residents with special needs. In 2000, they received a Maxwell Award of Excellence from the Fannie Mae Foundation for the development of the Bernal Gateway apartments. Since 2002, they have been leading a land use planning project for a section of Mission Street, one of the area's main thoroughfares.

Positive MATCH is an affordable housing residence for formerly homeless families, largely single mothers with children, who have been diagnosed with disabling HIV/AIDS and another disease. Many of the children are also HIV positive. The project was developed by the Housing Services Affiliate of the Bernal Heights Neighborhood Center. Positive MATCH includes seven units in a multi-family building, and offers health care services on-site. Working with four social service agencies, women and children in the housing obtain social, legal, and mental health services. The apartment building is an adaptive reuse of an historic, formerly commercial building. The renovation created seven apartment units and 2,900 square feet of space for social service provision.

The green building features focus on indoor air quality and other interior health considerations important for potentially immune-deficient populations. The project consists of 8,500 square feet of total space, of which 5,600 is devoted to living area and 2,900 to the supportive services offices. Each apartment has 2 bedrooms and the project was completed and occupied in November of 2002. Total costs for the project are $3,400,110. The costs are broken down in Table 1.

Funding came from the Housing Opportunities for People with AIDS (HOPWA) program of the Department of Housing and Urban Development, the San Francisco Redevelopment Authority's HOPWA program, McKinney SHP, the San Francisco Mayor's Office of Housing, Local Initiatives Support Corporation (LISC), and the Bernal Heights Neighborhood Center. The partnership between Bernal Heights Neighborhood Center and the project's social service providers creates a continuum of care for mothers with HIV and their children before and after the parent's death.

Green Design and Construction

The green features installed cost just under $10,000 per residential unit in incremental first cost and just over $31,000 for the commercial space. These features focused on indoor air quality and other health related concerns. Such concerns are paramount for the immune-deficient people who occupy the housing and also have potentially large effects on the public health care expenditures related to medical services that residents need. Table 2 shows the net cost of greening the project, breaking out the total development costs as built and comparing them to an estimate for what the project would have cost if it had been built more conventionally.

Table 1: Total Development Costs

Activity	Amount
Property acquisition	$621,325
Final construction cost (includes all approved and likely-to-be approved change orders)	$2,165,771
Architectural and engineering	$180,235
Environmental assessment and testing	$84,458
Development consultant	no data
Legal	$33,227
Lender fees and costs	$11,351
Construction and pre-development loan interest	no data
Developer project management and overhead	$90,234
Other soft costs	$161,172
Developer fee	$28,000
Capitalized replacement reserves	$8,000
Capitalized operating reserves	$16,337
Total	$3,400,110

Table 2: Net Cost of Greening

	Cost	Cost/Square Foot	% of Total Dev. Cost
Green Design	$180,235	$20.91	5.30%
Traditional Design	$180,235	$20.91	
Green Design Premium	$0	$0	
Green construction	$2,265,353	$262.80	66.63%
Traditional construction	$2,165,771	$251.25	
Net cost of greening	$99,582	$11.55	2.93%

Table 3: Green Premium (Savings) by Category

Features Category	Green cost	Traditional cost	Cost of Greening
Sustainable sites	$0	$0	$0
Water efficiency	$0	$0	$0
Energy and atmosphere	$400	$0	$400
Materials and resources	$75,560	$37,780	$37,780
Indoor environmental quality	$195,638	$148,236	$47,402
Other - innovative design	$14,000	$0	$14,000
Total	$285,598	$186,016	$99,582

Green Features

From the beginning, the Positive MATCH project team focused on decreasing occupants' exposure to air-borne contaminants, because the project houses immune-deficient mothers and children. This focus led to inclusion of a variety of features like low VOC paints and finishes, a hydronic heating and cooling system with separate piping for each unit, and the exclusion of vinyl and PVC-pipe from the home entirely. Table 3 breaks out the additional cost for green features by category, and it reflects this focus on indoor air quality and health benefits.

Sustainable sites

The site has less parking than would have normally been required because of the number of disabled residents living there.

Water efficiency

There was very little focus on water efficiency and no improvements that stand out in this category.

Energy and atmosphere

The project utilized Energy Star refrigerators and received rebates for the refrigerators that they installed. In addition, Bernal Heights Neighborhood Center's (BHNC) Housing Services Affiliate has now made the provision of Energy Star refrigerators standard in their developments. This change had a total cost of $400 or $50 per refrigerator purchased after the rebate.

Materials and resources
A major focus of the green aspects of the project, Positive-MATCH did not use vinyl. Instead of vinyl flooring, they used a variety of other resilient flooring types including tile, linoleum, cork, bamboo, and rubber. In addition, carpet was never considered as a flooring option because of its connections to respiratory illness. These changes led to a significant increase in cost, vinyl would have cost half as much, but some of this cost difference will be made up by the longer lifespan associated with the flooring options used (see NPV analysis below).

Indoor environmental quality
Indoor environmental quality was the central focus in greening the building specifications. Changes in materials and in design were related to improving the indoor environment for immune-deficient residents. No-VOC paints and sealants were used throughout, at a total first cost premium of $3,300 ($323 per residential unit and $1,037 for the commercial space). In addition, PVC pipe was replaced with an alternative pipe material. This change increased piping costs by $44,000, nearly 43% more than the cost for PVC.

Innovation in the Design process
BHNC installed separate piping for gas in each unit, which would allow units to cover their own gas costs for hot water, space heating, and cooking. Lighting and small appliances are electric. This change cost an additional $2,000 per unit, but decreases what BHNC would need to pay for operation of the unit (though it does not make the unit more efficient and we have not included it as an operating cost savings).

Operating Savings: Green vs. Traditional

Very few of the changes made by Bernal Heights result in any ongoing operating cost savings due to decreased utility usage or greater efficiency. However, the Energy Star refrigerators installed will use less energy than their standard counterparts. Bernal Heights did not have any actual operating numbers, but they estimate that the refrigerators saved $5 per month ($60 per year) in energy bills.[2] This estimate is reflected in Table 4, below.

Despite the modest operating savings generated from the green building features incorporated into Positive MATCH, there are other significant benefits. The most important benefit, the improved health of occupants, is the most difficult to quantify and we have not included a methodology to do this. However, the project team included many materials that have longer lifespans than their conventional counterparts. For example, replacing PVC and vinyl with alternative materials not only improves indoor air quality and protects manufacturing workers from exposure to dangerous gases during the construction process, but alternatives also have a longer functional lifespan than vinyl counterparts. In Positive MATCH this means that the piping and the flooring will not need to be replaced for many years, much longer than the standard vinyl flooring or PVC pipe. Table 5 highlights the

Table 4: Operating Costs

Green Feature	Green Costs	Traditional Costs	Operating Savings
Energy Efficient Appliances	$400	$460	$60
HVAC controls in each unit	$0	$0	$0
Total	$400	$460	$60

Table 5: Replacement Cost Assumptions

	Green Cost	Traditional Cost	Expected life (years)	Traditional Life (Years)	
Flooring	$75,560	$37,780	40	15	*Developer cost estimate, researcher expected life estimate.*
Paints	$48,750	$45,414	12	12	*RS Means cost estimate; researcher expected life estimate.*
Piping	$146,888	$102,822	100	50	*Developer cost estimate, researcher expected life estimate.*
Total	$271,198	$186,016			

materials with the most significant replacement cost impact.

Most of the green building efforts focused on indoor air quality and minimizing health effects on the immune-deficient resident population. While such efforts are paramount, effectively estimating their benefits is difficult and those benefits have no impact on the operating costs of the real estate project (i.e. BHNC does not have lower operating costs when Positive MATCH residents are healthy). For these reasons, we have not included an estimate of health-related savings for this project, effectively saying that these changes have no financial value. While this may be literally true from the narrow financial perspective of BHNC, it's clearly untrue if residents of Positive MATCH can live longer and healthier lives because of changes made to their building. In fact, helping residents live longer and healthier lives may be the most important thing that a building could ever do. However, we have no good way to account for such changes within our methodology.

Table 6: Resident NPV by Feature

	Green savings (cost)
Additional Interest	$0
Flooring	$0
Paints	$0
Piping	$0
Energy Efficient Appliances	$1,497
HVAC controls in each unit	$0
Total	$1,497

Table 7: Resident NPV by Category

	Green Savings (cost)
Additional Interest	$0
Operating Costs	$1,497
Replacement Costs	$0
Total	$1,497

Table 8: Owner NPV by Feature

	Green savings (cost)
Additional Interest	($23,985)
Flooring	$23,300
Paints	($8,962)
Piping	($44,066)
Energy Efficient Appliances	($400)
HVAC controls in each unit	($14,000)
Total	($68,113)

Table 9: Owner NPV by Category

	Green Savings (cost)
Additional Interest	($23,985)
Operating Costs	($14,400)
Replacement Costs	($29,728)
Total	($68,113)

Net Present Value Summary

The changes made to Positive MATCH Family Housing will cost over $66,000 during an expected 30-year lifespan for the building. However, these benefits and costs are not uniformly distributed between the project owner and the residents. In this case, the project owner bears all the up-front costs of greening and receives benefits from reduced replacement costs. On the other hand, all energy efficiency benefits from the Energy Star refrigerators accrue directly to project residents. We will look first at the financial impact that greening has for residents and then look at the financial impact that greening has on BHNC.

Residents receive a value of $1,497 over the project's thirty-year life-cycle. As Table 4 show, this value accrues entirely from the Energy Star refrigerators.

One can also think of the savings from the Energy Star refrigerators as being an operating cost savings, as shown in Table 7. Residents have no responsibility from any increased interest payments due to higher first costs or to the ongoing replacement and maintenance of materials and systems.

The story for the owners is somewhat different. BHNC will pay nearly $70,000 more in present value terms to own and operate Positive MATCH than they would have paid to own and operate a conventional building. This cost comes mostly from the choice not to use PVC pipe and the additional interest expense.

Their flooring choices, despite the 100% increase in first cost, are projected to create over $23,000 worth of value through decreased replacement costs over the building's life.

Table 9 breaks these life-cycle impacts into categories, summing the effect of additional interest expenses, changes that affect operating costs, and changes that affect replacement costs on the long-term value of the project.

In the end, BHNC has developed a building that takes special care to mitigate the health impacts of the building on their target residents. More than anything else, our case highlights the inadequacy of this methodology for testing the effect of green building changes on occupant health. What this analysis does do is distill the issues around this development into a single question--is an investment of $68,113 today worth the health-related benefits that project residents will receive over the next thirty years? BHNC and its partners believe that it is.

References and Acknowledgements

- Phone Interview with Mary Lucero-Dorst at the Bernal Heights Neighborhood Center's Housing Services Affiliate.
- Survey Instrument returned by Mary Lucero-Dorst.
- Conversation with Mathew Thall at the Boston Office of the Local Initiatives Support Corporation.

- Other sources include:

Executive Summary of the HOPWA application for Positive MATCH. at:
http://www.hud.gov/offices/cpd/aidshousing/reporting/

Project Architect's website (Okamoto-Sauo Architects) at:
http://www.os-architecture.com/

(Endnotes)

[1] From BHNC mission statement, as reflected on their website at http://www.bhnc.org/housing.htm.

[2] Estimate is from BHNC. Energy Star estimates that a similar type refrigerator would save $6 per year, for a total of $48 of annual savings for Positive MATCH (they have 8 refrigerators).

RIVERWALK POINT

SPOKANE, WA

Project Information

Number of Units	52
Unit Type	Multi-Family, Attached
Construction	New, reuse of long-vacant site
Target Occupant	Very low-income families
Developer	Spokane Neighborhood Action Programs (SNAP)
Development Consultant	Sustainable Housing Innovation Partnership (SHIP), an informal community partnership
Contractor	KOP Construction
Architect	Bernardo-Wills Architects
Total Gross Square Footage	61,716
Total Development Cost	$6,144,695
Average Cost per Unit	$118,167
Average Cost per Foot	$100
Incremental Cost to Green	$317,285
Greening as % of Total Dev. Costs	5.16%
Green Building Focus	Material & Resource Efficiency, IEQ
Financing Sources	Impact Capital, Spokane County CHDO TA (Predevelopment) Loan, Spokane County HOME Program, Washington State Housing Trust Fund, LIHTC Equity, Washinton Mutual, Avista Corporation (local utility), Paul Allen Foundation, Foundation Northwest, and US Bank

"....a commitment to sustainability and affordability all in one collavborative effort."

Ray Rieckers
Director of Housing Opportunities, SNAP

Overview

Since 1966, Spokane Neighborhood Action Programs (SNAP), a private, 501(c)(3) non-profit community action agency has served families and individuals in Spokane County, Washington. Over the past 14 years, SNAP has acquired, rehabilitated, designed, and developed (often on a collaborative basis) 29 multi-family and single-family sites. Since 1991, SNAP has raised over 18 million dollars to develop over 400 units of shelter, transitional, rental and homeownership housing. SNAP currently has a portfolio of 25 properties totaling 355 units. Of the 355 SNAP-owned units, SNAP provides property management, maintenance, and asset management services for 270 of these units.

In December 1997, SNAP's first green project, the Spokane Resource Efficient Affordable Demonstration (SPREAD) home, was completed. Collaboratively designed and built, the SPREAD home was the first single-family, straw bale house permitted within the City of Spokane and primarily funded with public dollars. SNAP has also undertaken three rehab projects since 1997 that have incorporated green building principles and construction practices.

In 1999, SNAP facilitated the creation of the Sustainable Housing Innovation Partnership (SHIP), an informal coalition of 70 community members (and groups) either knowledgeable and/or interested in the development and construction of sustainable affordable housing. Riverwalk Point-I arose from this collaboration, and became a regional model for sustainable affordable housing development.

The project includes a full range of sustainable elements, including a community-based design process, sustainable construction practices, recycled materials, and energy-efficient operations. The Evergreen Builder's Guide, a green building rating system developed by the City of Issaquah, Washington for market-rate housing, was adapted by SHIP as the framework for design and construction. Recognizing that funders typically do not consider life-cycle costs, the design team adopted a guideline that investments in sustainability and energy efficiency should be kept within 10% of overall construction costs. As the first experience in larger-scale sustainable development of affordable housing for most of the project team, Riverwalk Point I was seen as an important demonstration project in the region. To share the lessons learned, SNAP has completed a thorough review of the development process.

The project is located on a long-vacant site in a residential neighborhood adjacent to the Spokane River and the Spokane Centennial Trail. Various employers, shopping centers, and a community college are located within two miles. The fifty-two units are spread among five separate two and three-story newly constructed multi-family buildings totaling 48,000 square feet of living space (61,716 gross square feet). Fifty units (six one-bedroom, twelve two-bedroom, twenty-four three-bedroom and eight four-bedroom) rent to very-low income families at or below 30% and 50% of area median income, with another two units set aside for resident managers. Among the fifty units, ten are designated as housing for the formerly homeless, ten are reserved for residents with disabilities, and ten are set aside for large families. Riverwalk Point I, which opened in the spring of 2003, is the first of potentially three planned phases that will include approximately 110 units.

Total project costs for Riverwalk Point I were $6,144,695, including $142,645 for property acquisition and $4,614,591 in construction costs. The remaining $1,530,104 is attributable to various soft costs (including $129,575 in a capitalized operating reserve). This was SNAP's first Low Income Housing Tax Credit (LIHTC) financed project, and $3,644,636 was raised through the LIHTC syndication process. Other financing sources included $1,673,304 in low-interest loans from the Washington State Housing Trust Fund, a $347,786 low-interest loan from Spokane County, $184,057 in deferred developer's fees, $151,000 in privately contributed capital, and a $150,000 grant from Avista, a local energy utility and SHIP partner, specifically for sustainability measures. Washington Mutual Bank also provided a $2.6 million construction loan.

Green Design and Construction

Prior to construction, the design team estimated the difference in materials and construction costs between each proposed green feature and the conventional alternative. Totaling these "green premiums" for all of the features included in the final design, Riverwalk Point I had a construction premium of $311,673, or just over $5 per square foot. This cost of greening represented 6.8% of the actual construction costs of $4,614,591, well under the 10% threshold set by the design team. Additional design costs for greening the project amounted to $5,612. The combined design and construction costs of greening were $317,285 which amounts to $5.14 per square foot and 5.2% of total development costs. These costs are broken down in Table 1. As mentioned previously, the costs to SNAP for the green premium was reduced by $150,000 through a grant from Avista, the local gas and electric utility.[1]

Overall project cost information came from the Final Cost Certification documents prepared for the Washington Housing Finance Commission. Cost figures for specific green project features were developed from pre-construction estimates prepared by SNAP and adjusted where necessary based on actual costs.

Table 1 - Net Cost of Greening

	Cost	Cost/square foot	%of Total Dev. Costs
Green Design	$461,907	$7.48	7.52%
Traditional Design	$456,295	$7.39	
Green Design Premium	$5,612	$0.09	
Green Construction	$4,614,591	$74.77	75.10%
Traditional Construction	$4,302,918	$69.72	
Green Construction Premium	$311,673	$5.05	
Net cost of greening	$317,285	$5.14	5.16%

Table 2 - Green Premium (Savings) by Category

Features Category	Traditional Cost	Green Cost	Green Premium
Innovation and Design	$1,500	$54,112	$52,612
Sustainable Sites	$3,459	$56,354	$52,895
Water efficiency	$115,842	$132,043	$16,201
Energy and atmosphere	$422,750	$500,790	$78,040
Materials and resources	$539,366	$564,753	$25,387
Indoor environmental quality	$311,920	$404,070	$92,150
Total	$1,394,837	$1,712,122	$317,285

Note - Green costs only represent features where there is some cost differential between the project as built and a "conventional" building. They do not represent total development costs.

Green Features

SNAP and SHIP set out from the beginning to build a sustainable project, and a broadly collaborative process was used in all aspects of planning. Community design charettes, various working groups, a public website and outreach to neighbors all informed the design and construction. The design team was co-chaired by SNAP's Construction Manager and an Avista Utilities Energy Specialist – both familiar with sustainable building design and construction. The architectural firm, Bernardo-Wills Architects, had limited experience in green design. Research into green materials and practices was provided at no cost to the project by the Inland chapter of Northwest Eco-building Guild and other members of the SHIP partnership.

The general contractor, KOP Construction, had no prior experience with green building and was not involved in the early stages of the design process. While there were no major contractor-related problems reported, involving the contractor earlier in the process might have yielded even better results. The development process could also have been improved by finalizing the major mechanical systems earlier. For various reasons, some of these decisions were left open long enough to negatively impact the efficiency of construction.

Several green energy efficiency features (SIP panels, geothermal heat pump, heat recovery ventilators) were included in separate buildings in order to compare the various features.

The Evergreen Builder's Guide, adapted by SHIP for application to affordable housing, was the primary framework for determining and prioritizing green features. Riverwalk Point I achieved the highest four-star rating under this system, receiving high marks for community enhancement, energy conservation and environmental quality. Relatively lower scores were achieved for water quality and conservation and resource management categories.

Riverwalk Point's sustainable design goes beyond the typical green elements to include an extensive community art component. Residents, neighbors and professional artists worked together to integrate functional art into the site by creating such features as path benches, picnic tables and benches, a water feature, an on-site stone amphitheater, and wood quilts made from scrap construction wood with building logos. The $42,000 art program was funded entirely by a grant from the Washington Mutual Foundation.[2] The $42,000 cost (approximately 80% of the reported $52,612 premium from Table 2) represented 0.83% of total design and construction costs.

Finally, the residential units at Riverwalk Point I were designed to provide an efficient living space in a smaller size, in square footage terms, than typical units in Spokane. The Spokane area average size for a residential development with 52 units and the same number of bedrooms is 57,087 square feet (including living space, community, storage and mechanical areas and excluding decking, stairways, porches and landings) and Riverwalk Point I is 48,000 square feet, a difference of 9,087 square feet. The smaller units and resulting buildings have proportionally lower energy loads and operating costs, allow for more open space on the site and, perhaps most significantly, reduce construction costs for materials and labor. These construction cost savings can effectively help pay for the additional cost of green features. It is difficult to quantify the construction cost savings SNAP realized from the smaller design. For clarity in describing the costs of the various green features, the "traditional" building alternative considered in the analysis is the same small size as the actual Riverwalk Point I development. However, in reality a typical traditionally-built development would be larger and thus have higher construction costs, suggesting a green premium smaller than what we have calculated here.

To illustrate this, consider Riverwalk Point's actual design and construction cost of $5,076,498 for 48,000 finished square feet of residential space. Applying the design and construction cost calculated for traditional development, $105.76 per finished residential square foot, to a theoretical 52-unit development of typical Spokane dimensions, 57,087 square feet, yields a cost of $6,037,543. Under this scenario, Riverwalk Point I, as designed and built, is actually $961,045 less expensive than the larger 52-unit traditional development. The numbers in this example are not reflective of the full market, as the per square foot costs for traditional building are based on only one hypothetical case of a different size, but the conceptual conclusion remains – a smaller building can help pay for green features.

Sustainable Sites

Riverwalk Point's location in an existing residential neighborhood, proximate to work, shopping, educational and recreational resources, provides for transportation efficiency, as residents are required to drive less often, in addition to driving decreased distances, than if the development were an outlying "sprawl" site. Secure bicycle parking, in close proximity to the Spokane Centennial Trail as well as other bicycle and pedestrian facilities and a "community art" school bus shelter on-site also enhanced the sustainability of Riverwalk Point I. An estimated premium of $52,895, or 1% of total design and construction costs, was spent on bicycle/pedestrian amenities, traffic calming features and the bus stop.

Water Efficiency

Riverwalk Point I features low-flow fixtures throughout, with 2 gallon per minute maximum faucets in kitchens and 1.5 gallons per minute maximum faucets in bathrooms. Toilets use less than 1.6 gallons per flush.

Exterior landscaping is made up of native and drought-resistant plantings that minimize irrigation and maintenance needs for no additional up-front expense. Rainwater is used to irrigate landscaping immediately around the buildings through downspouts. The landscaping plan also minimizes impervious surfaces, using grass-infill pavers for secondary parking areas at a $2,700 additional cost. Water efficiency upgrades added 0.3% to total design and construction costs.

Energy and Atmosphere

All five buildings at Riverwalk Point I feature high-efficiency heating and ventilation systems, good insulation, and have been tested for air leakages. Buildings are solar-oriented for maximum daylighting and wintertime passive solar gain without additional cooling loads in the summer. Four buildings have gas-fired, sealed-combustion forced air heating while the fifth building features a geothermal heat pump which regulates building temperature by exchanging heat with the earth below. This building also features air-to-air heat recovery ventilators for each unit. The upper floors of another building are constructed with Structural Insulated Panel (SIP) exterior walls. Prefabricated SIPs are a load-bearing material made of rigid foam and fiberboard and can be used with or without conventional framing, offering exceptional R-values.

Interior lighting fixtures are efficient compact fluorescent and T-8 fluorescents that use approximately 30% less electricity than conventional fluorescent lighting. Beyond this, all units are equipped with Energy Star appliances and forty re-used range hoods were installed, provided by the Second Harvest materials exchange program. Recognizing that the efficiency benefits of these designs and technologies can only be realized if the systems are properly operated, "Living Green" energy conservation educational materials are provided to all tenants. SNAP Housing Improvements Programs staff also periodically teaches a "Living Green" course on site.

The total additional project cost for these Energy and Atmosphere features amounted to $78,040, 1.54% of total design and construction costs. The SIP panels added $20,490[3] and the HVAC systems added $24,350. Lighting upgrades carried a $15,000 premium and Energy Star appliances included a $10,000 markup. There was no significant additional cost from daylighting due to building design and orientation, air sealing and testing, and the guidance materials for tenants.

Materials and Resources

SNAP and SHIP's sustainability planning for Riverwalk Point I gave careful consideration to conservation of resources and selection of materials. The total invested premium for these measures was $25,387, or 0.5% of total design and construction costs.

As much as possible, existing natural features on the site were integrated into the design. Site work and grading minimized the amount of cut-and-fill and import and export of soil materials, relying on the site's natural contours for drainage. This lowered transportation and materials costs by approximately $1,000.

The site was formerly both a fruit and vegetable farm nestled next to the Spokane River. As part of site planning, the project team included an unfenced, native vegetation wildlife corridor along the river and preserved many of the original trees and much of the original vegetation. Any trees that were cut were chipped on-site and used as landscaping mulch. These resource conservation measures did not add any additional cost to the project.

During construction, contractors followed procedures designed to maximize conservation of resources and reduce exposure to toxics. A job site recycling plan, developed by the Spokane Regional Solid Waste System, encouraged reuse and recycling of construction materials such as wood, drywall, cardboard and metals. The plan was projected to save between 25 and 50 percent of material disposal costs, and was successfully implemented for the first half of the construction process. However, the recycling plan was not followed as carefully during the later stages of construction.

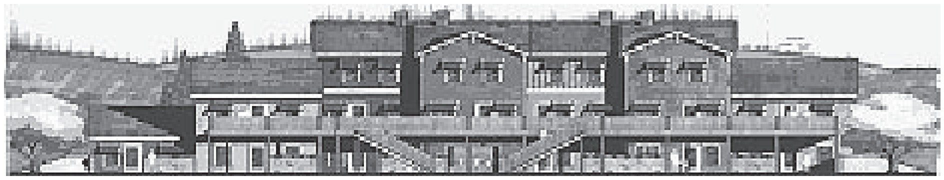
Hazardous materials were carefully managed during construction and continue to be as the project is occupied. Paints, solvents, waste oil and other toxics were recycled or properly disposed of during construction. Each residential unit is provided with a secure hazmat storage area. Additional cost for the construction-phase program was $2,500 and the residential provisions added $5,200.

All concrete used for the project contains 15-25% fly ash, a byproduct of coal-burning power plants. This saved $1,500 over conventional concrete. At no additional cost, contractors used low-toxic rather than petroleum-based concrete form release agents and washed out all concrete trucks at the pouring location to protect other areas of the site from damage or contamination.

To help reduce wasted materials, the buildings at Riverwalk Point I were designed using standard dimensions for ceiling heights, window size, etc. Advanced framing techniques were specified to enable better insulation of the building envelope. Advanced framing also reduces the amount of lumber required to frame a building, and this led to a $12,294 savings on the project. For the same cost as conventional lumber, the project utilized finger-jointed lumber and engineered I-joists where appropriate. Rather than milling each piece of lumber from a single tree, finger jointing uses smaller size and scrap wood glued together to form lumber. I-joists effectively replace solid wood 2x8 beams with fiberboard and lumber assemblies that use much less wood and allow for additional insulation.

Oriented Strand Board (OSB) was used instead of conventional plywood for roof and wall sheathing, resulting in more efficient use of forest resources and a $12,300 savings in materials cost to the project. Fiber-cement siding, fascia and trim were chosen for the material's durability, fire resistance, and appearance. Fiber-cement products, which can be painted, typically cost more than vinyl but are equal to or less expensive than wood or stucco. Additionally, fiber-cement will typically last longer than any of these materials. For Riverwalk Point I, there was a $16,000 premium over the vinyl alternative. Architectural asphalt shingles, which have an expected life-span of over 30 years, were also used as siding on the upper stories to help offset the cost of the fiber-cement siding. The shingles also add a textural accent to the design.

Riverwalk Point I utilized a variety of recycled and recycled-content materials. Locally produced silica asphalt and durable pathway pavers saved approximately $1,000. Recycled-content metal roofing added $7,920 to the project cost but is highly durable and does not contaminate captured rainwater used for landscape irrigation. Recycled plastic drainpipes and recycled-content drywall were included at no additional cost. Recycled-content carpet with reduced off-gassing was specified for a $6,667 cost increase.



Outside, recycled-content, low-toxic landscaping and deck materials were utilized, including forty gallons of wood preservative from the Second Harvest materials exchange program.

Indoor Environmental Quality

Numerous design features at Riverwalk Point I help to ensure healthy indoor air quality. Together, these incurred a $118,650 premium, 2.3% of total design and construction costs.

To prevent off-gassing of formaldehyde, cabinets and sub-floors were sealed with a water-based sealant. The project designers limited the use of carpet to 50% of each unit's floor area (not including kitchens and bathrooms) to help control dust, mites, and other allergens. A $90,000 premium was incurred for specifying alternate, non-vinyl flooring surfaces. High efficiency exhaust fans in all bathrooms remove moisture to control mold and mildew problems. The fans share a wall switch with bathroom lights and cost $1,300 total to install.

Several indoor air quality-enhancing features were included for little or no additional cost to the project. Low volatile organic compound (less than 20 grams of VOCs per liter) products for interior and exterior paints and finishes were specified for which the cost premium was kept below $1,000. Water-based, low toxic adhesives, mastics and grouts came in at no additional cost. Non-toxic or less toxic cleaning products were used during construction and continue to be used for ongoing maintenance. Tenants are encouraged to use such products through the "Living Green" outreach program.

It should be noted that several features previously discussed, including recycled-content carpet and the heat recovery ventilator, have indoor air quality benefits in addition to their resource conservation, energy efficiency advantages.

Operating Savings: Green versus Traditional

SNAP and SHIP's energy efficiency design goal for Riverwalk Point I was a 30% energy savings over the State of Washington's efficiency code for new buildings. Lower energy use, in addition to its regional and global environmental benefits, leads to significant financial operating cost savings for SNAP, who is responsible for all utility bills (water, gas and electric) for the site including those of the individual households.

SNAP has received assistance tracking energy use and building performance from the Energy Program at Washington State University and the US Department of Energy's Rebuild America program. A detailed study conducted during the first year of occupancy revealed that Riverwalk Point's energy use for space heating beat the state energy code by 53%. In the climate of eastern Washington, heating energy represents the greatest potential operating savings to be gained from green building. Complete figures for non-heating energy use and other operating cost categories were not available.

Washington State/Rebuild America used energy modeling software to estimate that a development with the same size and configuration as Riverwalk Point I, built to the standards of the state energy code, would consume 2,723 million metric BTUs (MMBTU) for space-heating per heating season (September to May in Spokane). Calculations from Riverwalk Point I utility bills from September 2003 through May 2004 revealed that actual space heating energy consumption was 1,274 MMBTU.

In terms of cost, the actual aggregated heating bill for Riverwalk Point I for May 20, 2003-May 19, 2004 was approximately $11,652, or $0.21 per square foot, based on figures published by Avista Utilities. A comparable development, built to code with inexpensive electric radiators, as most multi-family housing developments in the Spokane area are, would have a space heating cost of $46,372, or $0.85 per square foot. Riverwalk Point I provided a 75% annual savings of $34,720 or $0.64 per square foot over traditional (electric) construction. It is important to note that as the per-BTU cost of natural gas is significantly less than electricity, savings over a comparable gas-heated development were 46%, $9,832, or $0.18 per square foot.[4]

As a demonstration project and three of the five Riverwalk Point I buildings were designed with the intention of evaluating the energy savings performance of different technologies. Building 5 features a ground-source geothermal heat pump and heat exchange ventilators (both electrically operated) rather than the gas-fired heating found elsewhere in the project. Building 4 features SIP wall construction on the upper floors. Building 1 serves as a control, with an identical footprint and square footage to buildings 4 and 5.

Examining the billing information for the individual structures, building 5 did have the lowest annual energy consumption for heating, 175 MMBTU compared with 224 MMBTU for the control building. However, this 22% savings is far less than the expected 60-75% increase in efficiency predicted by the model. Moreover, since the geothermal heat pump and heat exchange ventilators were consuming BTUs of electricity rather than gas, the annual heating cost for building 5 was $2,980 compared with $1,767 for the control building, an increased cost of 68%, or 11 cents per square foot. Cost savings of 15-40% or 2-8 cents per square foot were expected from these technologies. No significant savings in energy consumption or costs were evident in the SIP wall building. Research is underway by Washington State/Rebuild America to determine the factors responsible for these unexpected results. Initial scrutiny has focused on installation and operation of the heat pump and air sealing of ventilation ducts. If these problems can be solved, future energy cost savings should be closer to those originally projected.[5]

Net Present Value Summary

The changes made by the project team create long-term value, which accrues entirely to the project developer, as residents do not pay any of their own utility bills. In order to show the benefits which accrue to the project developer as a result of the measures taken, we have broken own the Owner NPV for a variety features and categories. However, e have no data on a significant ortion of the benefits for Riverwalk oint I, namely the savings related electricity use and water and wer use. Where data does not ist, we have assumed that there no difference between a green oject and a conventional one. This s, undoubtedly, underestimated the savings that SNAP receives on overall utility costs for the project.

Overall, the green building features of Riverwalk Point I cost the owner over $121,000 (the original green premium minus any subsidies received for the project) and provide

Table 3 - Operating Costs

	Heating	
	MMBTU	Cost
Control Building	2,723	$46,372
Riverwalk Point	1,274	$11,652
Savings	1,449	$34,720
Savings %	75%	

Note - RWPI heating costs include both electric and gas service. Heating costs for a conventional building include just electric heat, which is considered the Spokane-area standard for multi-family development.

the owner with over $840,000 in benefits over the assumed thirty-year lifespan of the project. Tables 4-5 summarize these results for SNAP.[6] This is, essentially, a $16,200 payback for each unit.

The heating efficiency features, alone, generate a lifecycle savings of close to $826,000. Since this calculation does not include savings related to other changes in electrical usage, the benefit enjoyed by the owner is likely greater than this. Choosing longer lasting materials has also generated over $6,600 in lifecycle benefits.[7] All the green features that do not dramatically affect operating or replacement costs (mainly indoor air quality changes that may improve resident health), cost over $121,292 in present value dollars. The fact that SNAP is paying the utilities of its residents makes the initial investment in greening the project an incredibly valuable capital outlay and Riverwalk Point I should serve as a model for other affordable housing developers who choose to assume the utility burdens of their residents.

Table 4 - Owner NPV by Feature

	Green savings (cost)
Additional Interest	($30,176)
Heating Efficiency	$825,945
Water Efficiency	$186,235
Electrical Efficiency	($25,000)
Flooring	($15,450)
Siding, Fascia, and Trim	$9,922
Roofing	$2,597
Durable Paving	$9,557
Transportation Features	($52,895)
Other Recylced Materials	($3,685)
HazMat Storage & Management	($7,700)
Air Quality	($2,150)
Landscape/Environmental Management	($61,300)
Design, Education, and Marketing	($5,862)
Other Green Features	$12,300
Total	$842,338

Table 5 - Owner NPV by Category

	Green Savings (cost)
Additional Interest	($30,176)
Operating Costs	$987,180
Replacement Costs	$6,626
All Other Green Features	($121,292)
Total	$842,338

References and Acknowledgements

- Margy Hall and Holly Martin (Millar) were with SNAP during the development of Riverwalk Point I and generously provided much information and documentation for the project, including cost estimates for sustainable features versus traditional alternatives, official project cost certification documents, operating pro forma and detailed financing information.
- David Hales of Washington State University Extension Energy Program provided all energy use data.

- Other sources included:

    A short case study from the U.S. Department of Energy's Rebuild America program available at http://www.rebuild.org.

(Endnotes)

[1] The life-cycle cost calculations that we do in this project will subtract the value of this grant before calculating the total impact on the project.

[2] The value of this grant will be subtracted from the total costs when carrying out life-cycle cost evaluations.

[3] We have estimated that the SIP panels incurred a 25% cost premium over traditional framing techniques. While it is doubtful that the SIPs cost any more than this, the number seems reasonable given that the SIPs were so minimally used (thus preventing the economies of scale which often make SIPs a more attractive investment) and that there was the added costs of wiring the SIP portion of the building.

[4] Because SNAP says that electric heating systems are the Spokane-area multi-family standard, we have used the electric heating cost for a conventional building in all future calculations in this study.

[5] See "Performance Analysis of the RWPI/SHIP Project."

[6] SNAP has noted that the assumed life of this particular project is 40 years and that the Washington State funding is a 40 year loan. For the sake of consistency across all of the case studies we have performed a 30 year Net Present Value analysis. Had we used the 40 year lifespan, the numbers would undoubtedly be higher.

[7] The following assumptions were made in calculating replacement costs for different green features:

- Alternative flooring (tile, wood, linoleum) is expected to last 40 years while carpet is expected to last 10 years.
- Cement fiber siding is expected to last 40 years while wood siding is expected to last 25 years.
- Recycled content roofing with a 40-year warranty is expected to last 40 years while a composite shingle roof is expected to last 25 years.
- Durable outdoor paving is expected to last 20 years while conventional alternatives are expected to last 15.

These product life-cycle estimates were made by the research team except in the case of the recycled roofing material, where the life-cycle estimate was based on the product's warranty. All cost estimates came directly from the developer. It should be noted that any product with an expected life longer than 30 years shows up as being purchased only once (when the project is built).

TRAUGOTT TERRACE

SEATTLE, WA

Project Information

Number of Units	50
Unit Type	Multi-Family, Attached
Construction	New with commercial renovation below
Target Occupant	Very low-income, formerly homeless recovering substance abusers
Owner/Developer	Archdiocesan Housing Authority
Development Manager	Beacon Development Group
Contractor	RAFN Company
Architect	Environmental Works
Total Square Footage	38,483
Total Development Cost	$6,384,768
Average Cost per Unit	$127,695
Average Cost per Sq. Foot	$166
Incremental Cost to Build Green	$296,839
Greening as % of Total Dev. Costs	4.65%
Green Building Focus	Material and Resource Efficiency
Financing Sources	Homestead Capital (Low-Income Housing Tax Credits), City of Seattle Office of Housing, Washington State Housing Trust Fund, Seattle City Light Built Smart Program (energy efficiency rebates), The Russell Family Foundation (LEED assistance)

"For people to live with dignity....."

Archdiocesan Housing Authority mission statement

Photo credits: upper right hand corner- Dave Sarti; all others- Greg Krogstad

Overview

Traugott Terrace, in the Belltown neighborhood of downtown Seattle, is the nation's first LEED certified affordable housing project. Built literally on top of the Matt Talbot Center (the Talbot Center), Traugott Terrace provides transitional and permanent housing for recovering alcoholics and addicts, many of whom have been previously homeless. One of the project sponsors, the Talbot Center is a multi-service facility that offers Seattle's homeless population a core of programs built around initiatives to stop substance abuse and prevent relapse. Realizing a long-term goal to create housing as part of their recovery program, the Talbot Center teamed with the Archdiocesan Housing Authority (AHA) to create 50 new housing units and renovate the Talbot Center's program and office space. The 38,483 square foot project (32,206 square feet of new construction) opened in the summer of 2003. Twelve of the units are 200 square foot single-room transitional units and thirty-eight are permanent affordable units. The permanent units range from 320 square feet to 600 square feet and include 16 studio apartments and 22 one-bedrooms. All units are "clean and sober" with alcohol and drug use strictly prohibited.

Project owner, AHA, is committed to providing housing "for people to live with dignity," and saw the opportunity to create healthy, efficient and sustainable indoor environments as a natural extension of their mission. The City of Seattle's Office of Housing has prioritized green building and considers Traugott Terrace a model for sustainable affordable housing development. Beacon Development Group served as the development manager for AHA. The Seattle-based nonprofit architectural group Environmental Works was selected as designer/architect and the RAFN Company was the general contractor. Both RAFN and Environmental Works had experience with green projects.

The $6.4 million project (approximately $4.06 million construction costs, $2.34 million soft costs) attracted $4.92 million from its Low-Income Housing Tax Credit syndicator, Homestead Capital. The Seattle Office of Housing provided a first mortgage of $760,817 through a program funded with local property taxes, and the Washington State Housing Trust Fund provided a second mortgage of $750,000. The City of Seattle's LEED Incentive Program and funds from Environmental Works' Sustaining Affordable Communities initiative (a total of $35,000 in grants) subsidized the soft costs associated with the LEED certification process and the Seattle City Light Built Smart program provided $36,119 in rebates for electric efficiency upgrades.

Green Design & Construction

The innovative green features and added design time incorporated at Traugott Terrace added $296,839 to the cost of the project, or $7.71 per square foot. This amount represents 4.7% of the combined total design and construction costs. Broken down further, additional design costs were $35,000, $0.91 per square foot, and the green construction premium was $261,839, $6.97 per square foot. It should be noted that $71,119 of these additional costs were covered by rebate, incentive and grant monies secured specifically to cover green features and practices.

Overall and itemized cost figures were developed from a variety of sources, including Final Cost Certification documents prepared for the Washington Housing Finance Commission, LEED documentation prepared by Environmental Works and the general contractor and personal communication with the staff of Beacon Development and Environmental Works. Table 2 breaks out the additional green features and costs. [1]

Table 1 - Net Cost of Greening

	Cost	Cost/square foot	% of Total Dev. Costs
Green Design	$417,000	$10.84	6.53%
Traditional Design	$382,000	$9.93	
Green Design Premium	$35,000	$0.91	
Green Construction	$4,066,000	$105.66	63.68%
Traditional Construction	$3,804,161	$98.69	
Green Construction Premium	$261,839	$6.97	
Net cost of greening	$296,839	$7.71	4.65%

Table 2 - Green Premium (Savings) by Category

Features Category	Traditional Cost	Green Cost	Green Premium
Design Process	$382,000	$417,000	$35,000
Sustainable Sites	$0	$0	$0
Water efficiency	$0	$0	$0
Energy and atmosphere	$116,449	$255,018	$138,569
Materials and resources	$407,183	$457,183	$50,000
Indoor environmental quality	$47,801	$121,071	$73,270
Total	$953,433	$1,250,272	$296,839

Green Features

Project partners AHA, Beacon Development and Environmental Works, envisioned Traugott Terrace as a sustainable project from the beginning. The original design complied with Seattle's progressive energy and building codes as well as Seattle City Light's "Built Smart" standards which emphasize energy efficiency, recycling and indoor air quality.[2] However, when the team decided to pursue the LEED rating, many additional green features were added. The traditional and green alternatives represent the cost differences between the original design (traditional) and the LEED certified project that was built (green).

While finalizing the original design, the project partners saw an opportunity to access city funding for LEED buildings. They organized a goal-setting workshop and included the Seattle Office of Housing and Seattle City Light (the municipal electric utility), using the session to generate strategies for cost-effective greening and eventual LEED certification. Although the LEED standards are targeted primarily at commercial and office development, the project team recognized that they could apply the process to greening a multi-unit residential project like Traugott Terrace.

Environmental Works divided potential green elements and materials into two categories: those with little or no additional first cost, and those expected to bring a significant increase in construction costs. Alternates were specified for the latter, more expensive, group in the event that construction bids came in over budget. Fortunately, bids were surprisingly low, approximately $208,000 under what was expected, and all green elements were retained in the design. In fact, designers were able to add additional features including linoleum flooring, more durable windows and a gearless traction elevator.

While the design team used an integrated approach, funding sources required that the general contractor be selected with the traditional post-design, low-bid process. Aside from complying with construction document specifications, there were no unique requirements to qualify potential contractors. The fact that the selected contractor, RAFN Company, had previous green building experience may have been a coincidence or, more likely, may have given RAFN, who had a familiarity with green features, the confidence to bid low.

Upgrading the project to LEED standards added $35,000 to the design costs, which paid for research on green materials and methods, additional planning and documentation, energy modeling, and the goal setting workshop. The additional design costs were paid for by grants from Seattle City Light's LEED Incentive program and Environmental Works' Sustaining Affordable Communities program funded by the Russell Family Foundation. Without these grants, the project would not have pursued LEED certification.

Sustainable Sites

Built above an existing building in the heart of an urban neighborhood, Traugott Terrace models a sustainable, infill site. Residents have easy access to the Matt Talbot Center below and are nearby other services, including shopping and employment opportunities. Numerous transit routes serve the area and bicycle parking was included in the project. In keeping with city zoning, no vehicle parking spaces were developed for residents. While no specific green vs. traditional costs have been broken out for site selection, the urban infill location and the city's parking guidelines are significant aspects of the project's green building goals.

Water Efficiency

Traugott Terrace units are equipped with low-flow fixtures including 1.5 gal./min. faucets and showerheads. Common laundry areas feature efficient front-loading washing machines which use only 15 gallons per load (50-60% less than typical top-loading models) and also reduce water heating requirements.

Energy and Atmosphere

Building smaller than average living units (200 square foot transitional rooms and 320-600 square foot studio and one-bedrooms) in a common building created efficiencies for space conditioning. The L-shaped design and southern orientation of the building maximize daylighting at no cost.

Vinyl framed windows with low-E glazing contribute to thermal efficiency. A "Solarban" treatment on the windows limits excessive heat gain from direct sunlight. The original building design specified similarly efficient windows, but available funding allowed the installation of more durable Euroline windows at an additional cost of $75,269. Although this is a significant price increase, the developer expects partial payback through reduced maintenance and replacement costs.

The building envelope is insulated with recycled-content, formaldehyde-free fiberglass batts in the walls and ceiling and expanded polystyrene styrofoam (EPS) foam at the foundation. Comprehensive air sealing eliminates drafts at window and door openings, wall penetrations, outlets, and electrical boxes. With ratings of R-21 for walls, R-49 for the roof and R-30 floors, Traugott Terrace meets or exceeds Built Smart standards. These features were included in the original building design so no additional cost was incurred. In fact, the Seattle City Light Built Smart program provided rebate monies totaling $36,119 for the efficient thermal shell features, lighting and the gearless, traction elevator.

A light-colored, reflective Energy Star rated roof coating was applied over the standard membrane roof to reduce solar absorption and cooling loads as well as the urban heat-island effect. Additional costs for the roof coating alone have not been broken out here, but were included in a package of LEED–related upgrades which totaled $25,000.[3]

Space heating in residential units is handled by inexpensive electric radiators, but a natural gas-fired boiler provides hydronic heating for all common areas and hot water for the entire complex. A heat recovery ventilator, included for an additional cost of $6,300, supplements the boiler and maintains indoor air quality in common spaces, offices, and corridors.

The project installed a Kone Monospace gearless traction elevator, faster and up to 70% more energy-efficient than hydraulic-type elevators. The premium for the elevator upgrade was $57,000, but a Built Smart rebate covered $8,875 of this additional cost.

The project used T-8 compact fluorescent lighting fixtures throughout (with T-8 fixtures in the offices and the meeting room), and daylight and occupancy sensors in common areas switch off the lights when they are not needed. Exterior lighting was designed to minimize light pollution. As with insulation, efficient lighting was included in the original design and was funded in part by energy-efficiency rebates from the Built Smart program.

Appliances were selected for energy and resource efficiency, including Energy Star refrigerators, gas-fired dryers, and the front loading washers described above.

Materials and Resources

Along with environmental qualities, affordability, availability and durability were key considerations in selecting materials for Traugott Terrace. Sustainably harvested, locally sourced lumber certified by the Forest Stewardship Council (FSC) was used for framing and sheathing. FSC lumber added $25,000 to costs, less than 10% of total lumber costs.

Concrete containing 30% fly ash and locally-produced drywall with 12% recycled-content was specified for no additional cost. A durable, locally-manufactured steel siding was used on the building exterior and 25% recycled–content carpet was installed in the residential units. Cost premiums for the siding and carpet have not been itemized here, but were, like the reflective roof coating, included in the package of upgrades which totaled $25,000.[4]

The Matt Talbott Center was renovated while Traugott Terrace was being built above, and various items including doors, light fixtures and wooden beams were salvaged and reused in the new development or donated to a local materials exchange program. This reuse paid for itself.

The contractor, RAFN Company, developed a recycling and waste management plan that recycled 87% of construction waste, primarily wood, drywall and concrete. All recyclable materials were dropped in one commingled dumpster for later sorting at an off-site facility, lowering dumpster rental costs. RAFN employees received appropriate training in implementing the recycling plan and a recycling coordinator was designated. All subcontractors were obligated to comply with the plan.

Indoor Environmental Quality

Traugott Terrace's most significant indoor air quality upgrade was the specification of natural linoleum tile flooring for all but the bedrooms of residential units. Linoleum represented a $73,270 or 220% markup over vinyl or carpet and was included along with the Euroline windows and gearless, traction elevator as additional funding became available. Carpeting was also minimized through the use of linoleum in all corridors and common rooms and stained concrete floors in the lobby.

To reduce harmful off-gassing, all paints, sealants and adhesives are low-VOC content and most are water-based. Any additional cost for these products is included in the $25,000 package of LEED-related upgrades.

Operable windows and heating controls, while typical for housing, are nonetheless important in allowing residents to individually control conditions in their units, and earn LEED "controllability of systems" points. Bathroom and kitchen range hood fans, as well as laundry rooms and trash/janitorial closets are all vented to the exterior. The heat recovery ventilator provides fresh air to common areas while increasing heating efficiency.

The contractor followed an Indoor Air Quality Management Plan to ensure that the building ventilation system was not contaminated during construction. This included not operating the system and sealing return openings during construction, then cleaning or replacing all coils, filters and fans prior to occupancy.

Operating Savings: Green versus Traditional

Although the project team's commitment to sustainability goes well beyond a desire to realize financial benefits, Traugott Terrace should yield significant operating savings over time for both the owner and tenants. The owner pays for all water and water heating, common area heating and lighting, the elevator, and building maintenance, while tenants are billed individually for electricity use, which includes heating for each unit.

The team performed comprehensive energy modeling using the eQuest software package to provide an estimate of monthly electricity and gas use for the project as designed, and for a comparable project built to the ASHRAE 90.1 energy standards. Separate analyses were performed to compare water consumption and elevator electricity use to traditional alternatives. Actual electricity usage data for January 2004 through December 2004 was available and used in the research team's analysis. This data showed that the building was performing at close to the predicted levels (Traugott was using 5% more electricity than predicted by the energy model). A full year of operating data was not available for water and gas usage, and we relied on the modeled results to predict usage. The results are summarized in Table 3.[5] Traugott Terrace should save 30% in combined utility costs compared to a traditionally constructed building. This amounts to a total annual savings of $21,511.

Much of the utility savings can be attributed to the following features:

- A majority of the projected annual utility savings are the result of reduced water heating loads due to the efficiency of the gas-fired boiler and reduced demands of low-flow water fixtures and appliances
- Thermal shell features account for significant savings
- The heat recovery ventilator and common area efficiency measures save the next largest portion.
- Reduced water consumption accounts for just over 10% of the savings.
- The remainder of the savings come from efficient lighting and the gearless traction elevator.

Actual Operating Data

As discussed above, the project team supplied electricity usage information for the period from January 2004 through December 2004. That showed the building operating at close to predicted levels for electricity use (a 5% increase in electricity use as compared to the model and 27% savings in comparison to a conventional building). However, they did not supply a full year of gas or water usage information.

The Traugott development team provided three months of water, gas, and electricity operating data for the first three months that the building was fully occupied, from November 2003 through January 2004. During this time, water use was 63% greater than projected and gas consumption was 71% greater. If this pattern held for a full year, it would add $5,328 to the expected utility costs in Table 3, effectively wiping out any operating savings from water and gas usage. Higher water use is likely the result of greater daytime occupancy by tenants who are more often unemployed than tenants in a more typical multi-family building (from which the base case assumptions for water usage are derived). Greater gas use can be partially accounted for due to this higher water use. Other possible explanations for the gas use discrepancy include the hydronic combined space and water heater not operating as designed, occupants using more hot water than expected, efficiency problems with the common area heat recovery ventilator and modeling errors. With building systems in operation for such a short time and the project

Table 3 - Operating Costs

	Electricity		Gas		Water		Total
	kWh	Cost	Therms	Cost	Gallons	Cost	Cost
Trad./ASHRAE 90.1	360,026	$23,358	58,386	$47,288	618,228	$6,592	$77,238
Traugott Terrace*	264,096	$17,686	41,924	$33,988	380,156	$4,053	$55,727
Savings	95,930	$5,672	16,462	$13,300	238,072	$2,539	$21,511
Savings – pct.	27%		28%		39%		30%

* Note - The electricity usage and cost numbers above are actual operating numbers for calendar year 2004. The water and gas numbers are estimates from development team models.

team's commitment to identifying and solving any operational problems, the original modeling results remain the most reliable basis for calculating future operating costs. We have used the modeled numbers for estimated gas and water use in the net present value calculations that follow.

Net Present Value Summary[6,7]

The changes made by the project team create long-term value, but only a portion of that value accrues to the owner. The remainder of the benefit is realized by residents who did not have to invest in the green building approach. In order to clearly show this, we have broken down the costs and benefits labeling which accrue to the owner and which accrue to the residents. This also provides a clearer picture of the overall benefit of green building for this project because it shows whether or not these changes are financially viable for both the project owner and the project residents. In calculating these life-cycle costs and benefits, we have assumed that residents receive the savings related to electricity use in the unit,[8] which includes unit heating and cooling, and that all other costs and benefits are borne by the project owner.

Overall, the green building features of Traugott Terrace have a value of $321,234 for the building owner and $1,211 per unit, over the assumed thirty-year lifespan of the project. Tables 4 through 7 summarize these results, first for the project residents and then for AHA.

The energy features, which cost the residents nothing, have a value of over just $1,000 per unit over a 30-year time period. All the savings that accrue to residents come in the form of decreased expenses for electric heating and cooling, and other electricity use in the unit. They do not have to pay any additional interest for the added first cost of the green features, nor are they responsible for the replacement or maintenance of green features.

The story for AHA is somewhat different. They bear all the costs for improved utility performance, lower maintenance, etc. but they also get most of the benefit. In the end, the changes made by the project team have a total value of $321,234 over a 30-year time period.

This value arises from over $48,000 in additional interest payments that the project makes due to the increased first cost that results from the choice to build green. However, this interest cost is more than made up for by the $412,000 total value that comes from the reduced operating expenses due to energy, water, and resource efficiency measures. In the end, the green building decisions made at Traugott Terrace should generate significant value for the project owner and residents alike. Finally, it should be noted that this analysis does not account for any improvements in occupant health or well-being due to improved indoor air quality or related features.

Table 4 - Resident NPV by Feature

	Green savings (cost)
Additional Interest	$0
Energy - Electricity	$1,211

Table 5 - Resident NPV by Category

	Green Savings (cost)
Additional Interest	$0
Operating Costs	$1,211
Replacement Costs	$0
All Other Green Features	$0

Table 6 - Owner NPV by Feature

	Green savings (cost)
Additional Interest	$(48,557)
Energy - Electricity	$96,012
Energy - Gas	$250,334
Water Efficiency	$63,361
Elevator - Gearless Traction	$2,892
Flooring	$(20,201)
Siding	$37,393
Recycled Carpet	$0
Recycled Drywall	$0
Fly Ash Concrete	$0
All Other Green Features	$(60,000)
Total	$321,234

Table 7 - Owner NPV by Category

	Green Savings (cost)
Additional Interest	$(48,557)
Operating Costs	$412,599
Replacement Costs	$17,193
All Other Green Features	$(60,000)
Total	$321,234

References and Acknowledgements

- Sandra Mallory of Environmental Works and Karen Brawley of Beacon Development provided most of the data and documentation used in developing the case study, including overall project budgets and financing information, details on cost of individual features relative to traditional alternatives, energy modeling data and actual utility billing figures.
- Two RAFN employees John Schroeder and Ann Schuessler were also helpful.
- Other helpful sources included:

A paper on Traugott Terrace, "Sustaining Affordable Communities," authored by Ms. Mallory and Bill Singer of Environmental Works for the American Solar Energy Society,

An online case study on the Homes Across America website (http://www.homes-across-america.org)

Project Cost Certification documents obtained from the Washington Housing Finance Commission.

Environmental Works Website (Community Design Center/Architecture and Planning): http://www.eworks.org

(Endnotes)

[1] Note: Cost figures for each category only include incremental costs for a green material or method. Actual total costs were higher. Features included in calculations:
Design Costs – Research on green materials, planning, LEED documentation, energy modeling, design/development team workshop
Water Efficiency – Low-flow fixtures, laundry machines
Energy and Atmosphere – Windows, elevator, insulation, heat recovery ventilator
Materials and Resources – FSC lumber, carpet, drywall, concrete, steel siding, roof coating, paints, sealants, adhesives, construction air quality and waste management
Indoor Environmental Quality – Linoleum flooring

[2] See http://www.cityofseattle.net/light/conserve/resident/cv5_bs.htm

[3] The upgrades included the roof coating, low VOC pains sealants and adhesives, and the contractor's costs for LEED oversight and documentation.

[4] See note above.

[5] Table 3 shows electricity, gas, and water usage. The electricity usage numbers are actual expenditures and usage levels for calendar year 2004. Gas and water data for a full year was not available and the numbers shown are from the energy and water modeling that was done by the development team.

[6] In completing this analysis the following assumptions were made:

- The project received $70,240 worth of rebates
- Researcher provided lifespan differentials for linoleum (40 yrs) vs. vinyl (15 yrs), Steel siding (100 yrs) vs. Wood Clapboard (15 yrs), Recycled Carpet (10 yrs) vs. Virgin Carpet (10 yrs), Recycled Drywall (30 yrs) vs. Virgin Drywall (30 yrs), Fly-ash concrete (100 yrs) vs. Regular concrete (100 yrs).
- Developer modeled operating cost assumptions for electricity, gas, water, and elevator maintenance. We had access to limited actual operating data. The actual operating numbers showed slightly lower than expected electricity use (-4.6%), substantially higher gas use (+159.1%), and substantially higher water use (+62.4%).

[7] The life-cycle cost comparison is not actually directly between Traugott Terrace as built and Traugott Terrace as originally designed (before the decision to pursue LEED certification). The life-cycle cost analysis uses first costs as compared to the original building design and operating costs as compared to a building designed to meet the ASHRAE 90.1 standard.

[8] In order to allocate energy costs between residential units and common areas, we have utilized the breakdown from actual operating data, which indicated, based on the readings from the "House Meter" from January through June of 2004, that the common spaces it Traugott Terrace were utilizing 46% of the electricity in the development.

WOODLAWN DEVELOPMENT ASSOCIATES

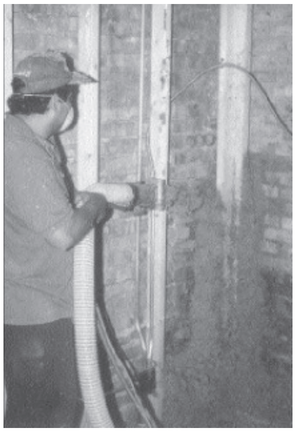
CHICAGO, IL

Project Information

Number of Units	10
Unit Type	Multi-Family, Attached
Construction	Renovation
Target Occupant	Low-Income Families
Developer	Woodlawn Development Associates
Contractor	South Chicago Workforce
Architect	Sam Marts and Associates
Total Square Footage	11,694
Total Development Cost	$1,103,133
Average Cost per Unit	$110,313
Average Cost per Foot	$94
Incremental Cost to Build Green	$55,351
Greening as % of Total Dev. Costs	5.02%
Green Building Focus	Materials & Energy Efficiency
Financing Sources	LaSalle National Bank, Illinois Housing Development Authority, DOH - Joint Lender's Program, Woodlawn Development Associates, Illinois Department of Commerce and Community Affairs, Federal Home Loan Bank

"We are dedicated to building environmentally and economically sound buildings so they remain affordable to people in the long term."

Pat Wilcoxen
woodlawn development associates



Overview

The Southern Side of Chicago has a rich past highlighted by its tradition in art, music, and architecture. That past belies its recent history, a time marked by economic and social hardship that has endured since the middle of the 20th century. South Side neighborhoods have the lowest median incomes in the city, and the area is perennially challenged by poverty. The community-based non-profit, Woodlawn Development Associates (WDA), has grown up in this neighborhood, offering services that include outreach, community organizing and events, community gardening, housing development, economic development and the Woodlawn Community School.

Since 1994, a three-story masonry building in the WDA service area had been vacant. In February of 2000, WDA renovated that building to create an affordable and energy-efficient co-housing development. The project was intended to serve as a model for affordable, urban, sustainable development. Not only did it effectively re-use an existing building, but the project team's focus on green materials and energy efficiency helped the Woodlawn building stand apart from many similar projects in the area. The 11,694 square foot building contains 10 rental apartments with 7,997 square feet of livable space. All 10 units were made available for low income renters.

Many of the sustainable elements of the project were made possible by a grant from the Illinois Department of Commerce and Community Affairs (DCCA), under the Illinois Energy Efficient Affordable Housing program. DCCA provides energy grants to nonprofit housing developers to install energy-efficient products in their developments. Funding also came from more traditional sources, the largest source being the Illinois Housing Development Authority.

Green Design & Construction

Construction accounted for 75% of the total development costs, by far the single largest share. Acquisition and project soft costs both accounted for 11% of total development costs, while the consultant fee was 1% total project costs. The developer collected no fee for this project, and total construction costs include the $29,720 cost of the photovoltaic (PV) panels. The costs are broken down in Table 1.

The choice to build green added a little over 5% to project development costs ($4.74 per square foot). All of this increase was borne in construction cost as shown in Table 2. In addition, over 50% of the green premium for the project came from the cost of the PV panels, which were paid for with support from DCCA. The team installed a 2.4kW photovoltaic system on the roof of the building, and it powers the fluorescent lighting used in all common areas and the laundry machines. A small energy surplus is sold back to the building's electricity provider.

Table 1: Total Development Costs

Activity	Dollar Amount
Property acquisition	$113,265
Final construction cost	$827,220
Architecture and engineering	$0
Environmental assessment and testing	$0
Development consultant(s)	$15,000
Legal	$0
Lender fees and costs	$0
Construction and pre-development loan interest	$0
Project management and overhead	$0
Other Soft Costs	$122,648
Developer fee/profit	$0
Capitalized Replacement Reserves	$25,000
Capitalized Operating Reserves	$0
Total	$1,103,133

Table 2: Net Cost of Greening

	Cost	Cost/square foot	% of Total Dev. Costs
Green Design	$40,000	$5.00	3.63%
Traditional Design	$40,000	$5.00	
Green Design Premium	$0	$0	
Green Construction	$827,220	$70.74	74.99%
Traditional Construction	$771,869	$66.00	
Green Construction Premium	$55,351	$4.74	
Net cost of greening	$55,351	$4.74	5.02%

The most remarkable aspect of this development is the degree of energy efficiency achieved. Because of Chicago's intense climate, the architect focused sustainability planning on energy efficiency measures, employing an approach that is easily replicable. That approach included more insulation, better windows, weather-stripping, airlock entry-ways, high efficiency furnaces and appliances, energy efficient water heaters, and energy efficient lighting. For water efficiency, water-conserving showerheads were installed in each unit. The project team found that inclusion of other green materials such as recycled tile, recycled carpets, and non-off-gassing products was more difficult due to the research time necessary to specify appropriate products and to product availability. None the less, many of these materials were included in the final design. The developer's commitment to energy efficiency and to greener material choices can be seen in Table 3.

Green Features

According to the energy consultant on the project, Paul Knight, Chicago area multifamily rehab projects have included energy-efficient building practices for more than ten years; largely due to DCCA's funding efforts. In this time, area designers and developers have learned a great deal and there is general acceptance of these practices among major players in the building process – including financiers and code officials. Green building practices have proven valuable for residents in project after project, providing much needed housing that is affordable to tenants and developers alike. The Woodlawn project was intended to push area learning about green building by demonstrating the use of PV in affordable housing. Knight hopes that in another 10 years, energy-generation technologies like PV will be widespread in affordable

Table 3: Green Premium (Savings) by Category

Features Category	Traditional Cost	Green Cost	Green Premium
Design Process	$40,000	$40,000	$0
Sustainable sites	$113,265	$113,265	$0
Water efficiency	no data	no data	$0
Energy and atmosphere	no data	no data	$30,925
Materials and resources	no data	no data	$19,152
Indoor environmental quality	no data	no data	$5,274
Total			$55,351

multi-family rehab in the Chicago area. The full range of project features is discussed below.

Sustainable Sites

The project redeveloped an existing building in a dense urban area. This represents a significant commitment to sustainable building by helping to focus development to an urban neighborhood with existing services.

Water Efficiency

Low-flow fixtures were used in bathrooms and kitchens, to reduce the amount of water usage in the units. No other significant water efficiency measures were utilized.

Energy and Atmosphere

The project focused on energy and atmosphere, and included a number of green materials and methods to improve building performance.

Insulation

2x4 oriented strand board (OSB) wood studs were used to frame the inside faces of exterior walls. A 1-inch gap was left between the framing and the exterior wall itself, leaving 4 ½ inches of wall cavity for insulation. Spray rock wool insulation was installed in the wall cavity, providing a total R-value of 18.6 (R-value of 4.13 per inch). In addition, holding the framing away from the wall allowed installers to create a thermal break by spraying rock wool between the studs and the masonry wall. Rock wool was also sprayed onto the exposed brick in the ceiling cavities between the first, second, and third floors. Additionally, the attic crawlspace was insulated to R-43 with rock wool insulation.

Windows

The project team replaced all the windows in the building using double-glazed, low-e single-hung windows by Quaker (Weather Tite series 4050). They selected aluminum windows with a thermal break and an R-value of 2.88.

Air Sealing

For the systems to function properly, it was important that there was minimal air leakage from the building. To measure air leakage, a blower door test was conducted for the entire building after rehab work was completed. The blower door was installed in an exterior door opening. Unit doors to the common area were opened and the basement door was closed. Air leakage was less than 1 $inch^2$ /100 ft^2 of envelope area and 0.17 CFM_{50}/ft^2 of envelope area.

In typical masonry buildings, a major air bypass occurs where the floor joists tie into the masonry at the building perimeter and at interior masonry bearing walls. This bypass results from the typical construction methods for masonry buildings, where floor and ceiling joists were set in the masonry. With joists secure, the subfloor would not be installed tightly to the masonry, and the gap between the subfloor and the masonry would be covered by the lath and plaster. Furring strips from 1 to 2 inches were then fastened to the masonry. Rather than being cut, the furring strips would often extend down beyond the floor plane and above the ceiling plane. When the plaster and lath was installed to the furring strips, it would leave a continuous air space along the wall between the basement and attic crawlspace. Convective air currents from the basement to the attic crawlspace could be established in this space. To prevent convective currents within the wall, this air space was sealed at Woodlawn. When the joint was exposed during plaster and lath removal, workers installed expanding foam between the subfloor and the masonry wall to seal the joint.

The second air sealing measure employed was the airtight drywall approach (ADA). By installing drywall from subfloor to subfloor, rather than from subfloor to ceiling, as is typically done, a continuous air barrier is formed. This necessitates notching the drywall to fit around the ceiling joists where they are perpendicular to the wall or connecting to the bottom of the joists, without notching, where they are parallel to the wall. To further prevent heat loss, they caulked the joint between the top of the drywall and the framing and the joint at the base between the drywall and subfloor. On the top floor, they installed drywall in the typical fashion-- to the bottom of the ceiling joists--because the top floor ceiling drywall serves as the air barrier.

Any other penetrations through the drywall were sealed to maintain the integrity of the ADA. This included joints between junction boxes and drywall, joints around plumbing penetrations, and joints between window frames and drywall returns.

Mechanical Systems
The central-heating system consisted of two gas-powered Weil-McLain GV-4 warm water boilers. Each boiler has an input rating of 105,000 BTU's and a seasonal efficiency of 87.3%. Domestic water heating is provided by two gas-powered, 60-gallon A.O. Smith Cyclone water heaters. Each water heater has an input of 125,000 BTU's and a seasonal efficiency of 94%. It is also important to note that each individual unit has its own thermostat. This allows residents to control the temperature of their units individually as opposed to a central control which can often lead to some residents being over-heated and others being under-heated. This, in turn, often results in such inefficient practices as a resident being forced to open a window in the dead of winter.

Lighting
Fluorescent lights were installed in all common areas. Twenty-four fluorescent fixtures (27W each, total 648W) in the hallways and the stairwell remain on 24 hours a day. Seven exterior 27W fixtures (189 watts) remain on at night. The 2.4 kW PV system installed on the roof powers the lighting load as well as other loads on the common area (such as emergency exit lighting, laundry lights, and basement lights).

Appliances
The project included Energy Star rated refrigerators. Both Magic Chef 18.6 cubic feet and 15 cubic feet models were used. The 18.6 cubic foot model is rated at 485 kWh usage per year, while the 15 cubic foot model is rated at 437 kWh usage per year.

Reflective Roof Coating
The Woodlawn building's roof had a low-pitch, therefore re-roofing was done with modified bitumen. To help reduce the interior temperature of the top floor units during the summer, a reflective roof coating (#608 Aluminum Roof Coating) was applied over the roof. For the coating to adhere, the roof surface has to be extremely clean, and it took about one day to apply the reflective coating.

Photovoltaic System
As previously discussed, DCCA provided funds for the installation of a 2.4 kW PV system on the roof. The system provides power for common area lighting and the laundry. The total installed cost is estimated to be $29,720, or $12.38 per watt.

The PV system consists of four modules. Each module has eight 75W Siemens Solar SP75 panels that measure 21 inches x 48 inches and weigh 16 lbs. The panel arrays are mounted on a steel rack that is tied to the roof rafters.

An inverter (model SW by Trace engineering) in the basement electrical room converts generated power from DC to AC. A 2" diameter conduit was installed between the roof and the electrical room where a 1" or 1 ½" diameter would have been sufficient. However, the team did not know the wire size until they closed in the building, and they chose an oversized conduit to ensure adequate space for the wires.

To minimize cost and maintenance, the team did not include battery storage. Generated electricity is fed directly into the common-area circuitry in place of power from the electric utility. At certain times, excess power feeds back into the system, and is sold to the electric utility. The system is maintenance-free except for occasional cleaning of the PV panels.

Materials and Resources

Though more difficult to accomplish, another area of focus was on materials and resources. DCCA provided additional funds to replace typically used building products with resource-efficient products.[1] The goal was to identify resource-efficient building products that might be suitable for an affordable housing rehab. Recommendations were determined based on incremental costs of products, product availability, and the general contractor's experience. Several suitable products that the team had intended to use were not incorporated into the rehab, including ACQ treated lumber[2], cork tile and wheatboard for a variety of reasons. Intended to be used for structural framing on the back porches, the ACQ treated lumber would have required an extra trip that the subcontractor was reluctant to make. Cork tile was planned for the kitchen floors, but the existing floors were in good shape. The team chose to patch and refinish the kitchen floors instead of replacing them. Wheatboard was planned as the substrate for the kitchen countertops and interior window sills. However, the general contractor was unable to persuade his vendor, Home Depot, to have their subcontractor use wheatboard as a countertop substrate. Medex, a formaldehyde free particle board, was used instead.

Framing

Frameworks 2x4 engineered wood studs[3] were used to frame the interior of the masonry walls. The studs look like OSB and may be ordered to any length. Unlike conventional studs, each FrameWorks stud is straight, with no twisting or warping, and they can be ordered through any lumber supply house. The project used studs of 9 ft 8 inches, and top/bottom plate members of 24 feet. The OSB studs are denser than a conventional southern pine stud, but this was not a problem, since the sub-contractors were using power saws and pneumatic nail guns. The team investigated finger-jointed studs, but found that they were not available locally.

Rock Wool Insulation

Rock wool is made by heating rocks like basalt and diabase, then spinning the rocks into fibers to form insulation. The end-product is non-combustible, non-corrosive, and will not absorb moisture. For open-cavity installation, rock wool is mixed with a dry adhesive and water when installed with a pneumatic hose. Immediately after installation, a stud scrubber shaves off the excess insulation, which is then transported back to the hopper for installation. The insulation dried within seven to ten days at the Woodlawn building, and was installed in November when there was no heat. Once installed, rock wool has an R-value of 4.13 per inch and a density of 4.0 lbs per cubic foot. The total R-value of the installed insulation is 18.6, while the masonry wall alone is 2.4. Through redevelopment, the project team improved the thermal efficiency of the exterior walls by a factor of almost 8.

Drywall

The team used FibeRock drywall, made from recycled newsprint and gypsum, in the building hallways. Roughly 20% denser than conventional drywall, FibeRock should hold up well in the common areas of buildings like Woodlawn and other high-traffic areas. To save costs, FibeRock was used only on the lower half of the wall (where abuse would be heaviest) and conventional drywall was used for the upper four feet of wall area.

Because it has no paper face, FibeRock does not blister or bubble when it gets wet. But, it does have tapered edges and can be scored and finished like drywall. After finishing and painting, the joint between the FibeRock and conventional drywall is imperceptible. The team could obtain Fiberock quite easily.

Ceramic Tile

Instead of conventional ceramic-tile floors in the bathroom and entryway, the team installed TerraTraffic tile, a product of Terra-Green Ceramics. They used the same tile to finish the shower walls in three of the bathrooms. Available in nominal sizes of 4x4, 4x8, 8x6, and 8x8, Terra Traffic is 3/8" thick and contains 70% recycled glass. Prices ranged from $4.35 per square foot to $8.70 per square foot depending on color.

Carpet and Carpet Padding

Image stability carpeting made by Mohawk was used in project bedrooms. This carpet is made from polyethylene terephthalate (PET) plastic. Recycled two-liter soft drink bottles serve as the primary source of the plastic used in this carpeting. Underneath the carpet, the team placed a recycled felt pad made from waste fibers without chemical additives; the pad was held in place with tack strips instead of glue.

Baseboard

The original rehab work specified an inexpensive, vinyl baseboard. The team investigated plastic lumber as a replacement, but could not find it in a baseboard profile. Instead, they turned to finger-jointed baseboard and shoe molding. This created additional labor costs for painting, which typically results in most affordable housing projects not using this product, though its use is widespread in the rest of the residential building sector.

Plastic Lumber

Trex, a wood/plastic composite made from reclaimed hardwood sawdust and polyethylene, was used in the rear porch decking and the handicap ramp. The product is cut and fastened just like wood. Because plastic lumber is non-structural, the porches' structural framing, stringers, and treads are made of conventional pressure-treated lumber.

Medium-Density Fiberboard

Medium-density fiberboard (MDF) is made from softwood dust or chips that would otherwise be burned or sent to a landfill. While it is a good use of a material waste, most MDF products use urea-formaldehyde glue as a binder. Urea-formaldehyde off-gasses and can create an indoor air quality problem. However, Medex is an exterior grade, formaldehyde-free product that can be used in areas with moisture. At Woodlawn, Medex was used on interior windowsills, the staircase and entryway baseboard, and the kitchen countertop substrate.

Indoor Environmental Quality

Caulks
AFM Safecoat was used to caulk all joints, cracks, and penetrations in the building. This nontoxic, water-based interior caulk was designed for general air sealing. It comes in 5-gallon buckets and 1-quart containers, and must be loaded into bulk caulk guns. The Safecoat caulk was used to:

- seal the drywall to the framing members (top and bottom plates, corner studs, rough-opening members)
- caulk the joint between the base of the drywall and the subfloor
- caulk the drywall returns to the window frames
- caulk the window stools to the drywall
- caulk the junction boxes to the drywall
- caulk around plumbing penetrations that pass through the drywall

Low-VOC Primer
The project team used Glidden's Primecoat 2000 to prime the walls and ceilings. With no organic solvents and no volatile organic compounds (VOCs), this latex primer is applied in the same manner as any primer, it dries quickly, and it provides a uniform finish. The primer emitted no odor when drying, and there was no problem in obtaining it. The team had originally hoped to use a low VOC paint as well, but in an oversight, the general contractors used a regular latex paint. The dilemma points to the importance of project oversight when specifying green materials which may differ from more traditionally used industry standards.

Wood Floor Finish
Because the hardwood floors in the kitchens and living areas were in such good shape, the project team decided to patch and refinish them instead of replacing them with cork tiles. Hydroline, a water-based urethane floor finish, was used to seal the floors rather than polyurethane. Hydroline dries faster than polyurethane; so much faster that two coats can be applied in a single day, but the coats are not as thick and a third coat is necessary.

Innovation in the Design Process

The project was innovative in several ways. First, it continued the DCCA-funded tradition of energy-efficient rehabs of multi-family buildings in Chicago, pushing forward the collective knowledge of building industry actors involved in this type of redevelopment. In addition, it included energy generation technology with the PV installation that provides power to the common areas of the building.

As part of the ongoing learning about green rehab, Paul Knight has been able to reflect on the material and method choices made in the Woodlawn project. In retrospect, he feels that the project would have been less expensive and not significantly less sustainable if the OSB wood studs and the Terra-Traffic tiles had not been used. Each added over $3,000 in incremental cost and did not, in Knight's estimation, add appreciably to the green-ness of the building.

Operating Savings: Green versus Traditional

Since the completion of the project, ComEd (Woodlawn's energy provider) has kept track of the extra energy the photovoltaic panels have fed back to the grid. For the year between July of 2003 and July of 2004, the PVs produced and extra 1,081 kWh that were sold to ComEd at $.06981 per kWh. This earned the building $75.47. However, the vast majority of the power generated by the PV array is used directly on-site. Unfortunately, we have no good data on the exact level of energy supplied by the PV to the building.[4]

Operating costs were available for the boilers that provide the heat in the building. The efficiency of heating a building is measured in British thermal units (BTUs) per heating degree day per square foot. An average building uses 12 btu's per heating degree day per square foot. The Woodlawn apartment only uses 4.6. This represents more than a 50% reduction in heating costs for the units. Table 4 shows this data. It also indicates that we have no reliable data to measure most of the energy efficiency benefits from the changes made at Woodlawn. This lack of data keeps us from performing a full life-cycle analysis of the overall costs and benefits of these changes.

Table 4: Operating Costs

Operating Cost Category	Green	Traditional	Minimum savings
Annual cost of gas for heating	$243 per unit	$486-$729 per unit	$243 per unit
Annual cost of gas for water heating	No data	No data	No data
Residential electric costs	No data	No data	No data
Common area electric costs	No data	No data	No data
Water costs	No data	No data	No data

Net Present Value Summary

As described earlier in this report, for each case we have estimated the financial impact of green building decisions over an expected thirty-year building lifespan. In the case of Woodlawn, this is made more difficult because we have so little reliable operating data to measure benefits, particularly energy efficiency benefits. However, we have carried out a partial life-cycle analysis. In doing this, we have made several key assumptions:

- The annual cost for gas water heating, residential electric use, common area electric use not supplied by PV, and water costs for both residents and WDA is the same for both the green building that was built and a hypothetical conventional building. This assumption is almost certainly wrong, and almost certainly reduces the life-cycle value of green building for both owners and residents. Each of these green upgrades create expected life-cycle benefits, and there is fairly good evidence that many of them have improved building performance in other places. But our lack of data about this particular building prevented the research team from being able to construct any reliable estimate for expected cost savings due to these changes.
- We have assumed that the PV panels supply six times more power to the common area electric system than they sell back to the power plant. The research team constructed this estimate based on gross approximations of energy loads and expected usage. While a more sophisticated method could likely be developed for this estimation, we feel the current method is more realistic than the assumption that the PV system supplies no power at all.

Table 5: Assumptions for Life-cycle Analysis

Green Feature List	Green expected life (yrs)	Conv. Life (yrs)
Tile vs Vinyl Flooring	over 30	10
Fiberock vs regular drywall	over 30	over 30
High grade vs Low-grade carpet	15	10
Trex decking vs Wood	over 30	15
Engineered studs vs Regular	25	25
Finger-jointed baseboards vs Regular	25	25

- We have made assumptions about the expected life of certain materials and features installed in the building, in order to calculate replacement cost differentials. Those assumptions are displayed in table 5.

The changes made by the project are intended to create long-term value, but only a portion of that value accrues to the owner. The remainder of the benefit is realized by residents who did not have to invest in the green building approach. In order to clearly show this, we have broken down the costs and benefits tracing which accrue to the owner and which accrue to the residents. This also provides a clearer picture of the overall benefit of green building for this project, because it shows whether or not these changes make financial sense for both the project owner and the project residents. In calculating these life-cycle costs and benefits, we have assumed that residents receive the savings related to heating and cooling the unit,[5] and that all other costs and benefits are borne by the project owner.

Overall, the green building features of the Woodlawn building have a cost of $49,154 for the building owner and a benefit of $6,064 per unit (a total of $60,640) for the residents, generated primarily through the gas heating and cooling load reductions which cost the them nothing. Tables 6-9 summarize these results, first for the project residents and then for WDA.

All the tracked savings that accrue to residents come in the form of decreased expenses for unit heating and cooling. We expect that residents also recognize benefits from reduced electrical loads, better indoor air quality, water efficient fixtures, and the efficient gas water heater. They do not have to pay any additional interest for the added first cost of these green features, nor are they responsible for the replacement or maintenance of those features.

The story for WDA is somewhat different. WDA bears all the costs for improved utility performance, lower maintenance, etc. and they get very little of the benefit (at least of the benefit that we can measure with our data). In the end, the changes made by the project team cost WDA over $49,154 over a 30-year time period.

This cost arises from over $8,500 in additional interest payments, a life-cycle loss of nearly $8,400 on energy efficiency features, and a life-cycle loss of over $32,000 on material choices. In the end, the green building decisions made at the Woodlawn Building generate significant value for the residents and significant costs for the project owner. On balance, the investment in green by WDA represents a transfer of value from WDA (and project funders) to project residents. The residents gain more than $60,540 over the building lifespan for investments that cost WDA $49,154 over that same span. This represents a total life-cycle benefit of just over $11,000, and we have not included any benefit from many of the energy and water-efficiency changes that were made. In effect, the choice to build green represents a significant cost to WDA, but that cost is balanced by a larger benefit accruing to residents.

Table 6: Resident NPV by feature

	Green savings (cost)
Additional Interest	$0
Energy Efficiency	$6,064
Total	$6,064
Note: Total is per unit	

Table 7: Resident NPV by Category

	Green savings (cost)
Additional Interest	$0
Energy Efficiency	$6,064
Total	$6,064
Note: Total is per unit	

Table 8: Owner NPV by Feature

	Green savings (cost)
Additional Interest	($8,515)
Energy Generation	($16,536)
Energy Efficiency	$8,140
Flooring - Tile	($3,680)
Drywall	($729)
Flooring - Carpet	($2,874)
Baseboards and Wood Studs	($19,686)
All Other Green Features	($5,274)
Total	($49,154)

Table 9: Owner NPV by Category

	Green Savings (cost)
Additional Interest	($8,515)
Operating Costs	($8,397)
Replacement Costs	($32,243)
Total	($49,154)

References and Acknowledgements

- Pat Wilcoxen, Housing Chair of Woodlawn Development Associates, provided a majority of the information on this project.
- Paul Knight, of Domus Plus, who was the energy consultant on the project, also provided valuable insights, and much of the information included in this write-up is taken from an article which he wrote (see below).
- David Sullivan, of South Chicago Workforce, also provided information for this case study.
- Other sources include:

Knight, Paul. Green Products Brighten Multi-Family Development. Home Energy Magazine Online, Nov/Dec 2000. Available at:
http://hem.dis.anl.gov/eehem/00/001114.html

(Endnotes)

[1] The project team defined resource-efficient products as those that use primary resources in an efficient manner, use recycled and secondary resources, and contribute to a healthy indoor environment.

[2] ACQ treated lumber (Alkaline Copper Quaternary) is a widely used alternative to CCA treated lumber (Chromated Copper Arsenate) which was phased out via EPA regulation beginning in 2000 due to the health threats posed by the arsenic treated compounds.

[3] Made by Trus Joist MacMillan.

[4] We have estimated that the building uses six times more energy than it sells back to the utility for the purposes of our life-cycle analysis. While this is a better estimate than assuming that the building uses no energy (the tacit assumption if we don't include some energy use in the analysis) it is not based on reliable operating data.

[5] We only have data on residential heating use. To allocate costs to residents and the owner, we have assumed that residential space uses three times as much heating as common area (only parts of the common area are heated) and calculated the owner costs based on how much of the building square footage is residential units and how much is ingress, egress, and common space.

WHAT DID WE LEARN?

GENERAL FINDINGS

CHALLENGES LIMITING OUR FINDINGS

SUGGESTIONS FOR FURTHER RESEARCH

RECOMMENDATIONS ON DATA AND INFORMATION GATHERING

RECOMMENDATIONS FOR PROJECT DEVELOPMENT AND POLICY

FINDINGS

What Did We Learn?

This chapter presents the general conclusions from our report followed by a discussion of several specific issues, including:

- Limitations to the findings and how to improve data gathering;
- Suggestions and recommendations for further research; and
- Recommendations for changes to policy and financing systems to support green affordable housing.

General Findings

Green affordable housing makes financial sense over the long-term. The current system to assess financial viability of green affordable housing, however, places too much weight on initial capital costs. A life-cycle costing approach that more deliberately considers both capital and operating costs over the expected life of a building provides a better understanding of the true value of such investments. Using the life-cycle approach, fourteen of our sixteen cases show project benefits outweighing project costs over a thirty-year building life,[1] with a mean NPV benefit of over $15,000 per unit. This overarching finding has several components that merit individual discussion including:

- Green affordable housing projects have a small first-cost premium over conventional projects.
- Green building benefits are real: green buildings are operating at lower cost to owners and users than conventional buildings.
- Costs and benefits of greening affordable housing are distributed unevenly. Project residents and homeowners (in homeownership projects) almost always experience a net benefit over a project's life.[2] Building owners and developers receive a net benefit in a majority of the cases.
- The current system for financing affordable housing makes green buildings difficult to develop because of its emphasis on initial development costs rather than on life-cycle costs.
- There are other advantages to green affordable housing – improved health and quality of life for residents – that are not considered in standard financial analysis.

These findings are discussed in more detail below.

Small Premium

Our research indicates that there is generally a small development cost premium for greening affordable housing projects. Total development costs for green projects ranged from 18% below[3] to more than 8% above conventional project costs, as shown in Table 1. The mean premium was 2.4% of total development costs and the median was 2.9%.[4] We also broke this premium down into several parts and found that most if not all of the premium pays for increased construction costs, as shown in Table 2. Even when projects used an integrated design process and hired the project team earlier in the development process than usual, most projects reported no increased design costs. When design cost increases were reported, they were generally modest, also shown in Table 2.

Interestingly, many of the projects we studied received significant design and technical support from third-party groups with expertise in green building. The nature of this support varied from state-sponsored programs to fund and test green building practices, to local sustainability advocacy groups that could identify appropriate green building standards and material suppliers, to technical assistance providers who helped with project planning and development. There was also significant variation as to whether or not this third-party support was paid for directly by the project. In several cases, this support was funded independently and helped limit overall project costs. Beyond this, the significant presence of third-party organizations points to the impact that these actors can have on supporting green projects. While our evidence for this is anecdotal, organizations that provide green building advocacy, technical assistance, and funding are helping to promote construction of projects that would not otherwise be green.

Green Building Benefits Are Real

To the extent that green buildings costs more initially, developers and financiers of such buildings take on some added risk. They are paying more up-front for a building under the assumption that it should cost less to operate. This problem is compounded in the value-constrained world of affordable housing (see section on *Why Affordable Housing* in the

Table 1: Total Development Cost (TDC) Premiums for Greening

	First Cost Premium	Premium without Photovoltaics
20th Street	3.17%	3.17%
Arroyo Chico	0.74%	0.74%
Betty Ann	1.92%	1.92%
Brick Capital	1.64%	1.64%
CAST	0.62%	0.62%
Colorado Court	9.09%	4.68%
Erie Ellington	-18.33%	-18.33%
Emeryville	2.95%	2.95%
Johnson Creek	7.25%	7.25%
Linden	0.18%	0.18%
Melrose	2.51%	2.51%
New Homes	8.15%	4.14%
Positive Match	2.93%	2.93%
Riverwalk	6.24%	6.24%
Traugott	4.67%	4.67%
Woodlawn	5.02%	2.32%
Mean	2.42%	1.73%
Median	2.94%	2.72%

Table 2: Design and Construction Cost Increases for Greening

	Design Premium	Construction Premium
20th Street	0.00%	17.15%
Arroyo Chico	0.00%	0.97%
Betty Ann	9.64%	2.56%
Brick Capital	0.00%	1.76%
CAST	0.00%	2.12%
Colorado Court	0.00%	11.41%
Erie Ellington	0.00%	-25.00%
Emeryville	0.00%	4.51%
Johnson Creek	0.00%	38.94%
Linden	0.00%	0.30%
Melrose	0.00%	3.27%
New Homes	0.00%	4.40%
Positive Match	0.00%	4.40%
Riverwalk	1.22%	8.19%
Traugott	7.28%	6.59%
Woodlawn	0.00%	3.10%
Mean	1.13%	5.29%
Median	0.00%	3.83%

Introduction), where funders use first-cost controls as a screen for allocating scarce dollars. As a general rule, money flows to affordable housing projects that build the most units at the lowest first cost. In this light, greening advocates must show funders that green buildings will result in operating and replacement savings that pay for the increased first cost over time. In order to make an investment in a green project and take on this added risk, investors must be convinced that the operating savings are actually achieved in green buildings.

As documented in the case studies, the benefits of green affordable housing are real and, in some cases, substantial. In all our cases except one,[5] we see decreased utility and/or water usage as a result of green changes made to the project. In many cases, decreased operating expenditures alone more than pay for the incremental initial investment in green in present value terms over a thirty-year building life. While none of the projects we studied have been in operation long enough to have actual replacement cost data for materials or equipment that are expected to be longer-lived, many of the materials for which we show replacement cost savings have warranties that cover all damage and replacement expenditures up to the end of their expected life. To the extent that these warranties are honored, the estimated replacement cost savings should be realized.

Our findings also reinforced the idea that building commissioning[6] and system testing is essential for ensuring optimal performance. Through this research process and through the consulting work that research team members have done, we have seen instances where systems were improperly installed or did not function properly, and the dramatic impacts that such problems had on building performance and operating costs. Commissioning helps a building owner or manager test for and fix problems before building occupancy. This often reduces call-backs and saves time and money.

In addition, we have found that while operating benefits are real, pre-construction models vary widely in how well they predict future energy usage. Sometimes, the pre-construction model predicted larger energy savings than those actually realized, and in other cases models under-predicted the savings. Though this underscores the importance of building commissioning, we recognize that it does not make it easier for an affordable housing developer to find the money to pay for such testing. How to pay for building commissioning is addressed below in our policy and financing recommendations.

Who You Are Matters: The Uneven Distribution of Costs and Benefits

From the combined perspective of residents and developers, green building benefits exceed costs in fourteen of the sixteen case studies (indicated by a positive NPV in Table 3). The two other cases had special circumstances that accounted for net additional costs. Positive MATCH in San Francisco, California is special needs housing for immune-deficient mothers and their children that invested in indoor air quality and health-related improvements. In the case of Brick Capital in Sanford and Broadway, North Carolina, the developer reported skewed results based on variation in home design and resident income.[7]

However, these benefits and costs do not accrue equally to all parties. Residents and homeowners[8] generally pay for little or none of the first-cost increases and receive most of the benefits from reduced energy and water use. Developers generally pay for most if not all of the first-cost increases but receive minimal energy and water use benefits (usually those associated with common areas and in rental projects where owners pay some portion of the utilities). Replacement cost benefits accrue to the long-term owner of a project – often the developer in a rental project and the homeowner in an ownership project.[9] To analyze the impact of greening on developers versus residents/homeowners, we have broken down our net present value analysis to present the various costs and benefits for each party.

For residents and homeowners, the benefits of greening outweigh the costs in all but one of our case studies. The mean NPV benefit to residents is over $12,000 per unit. This comes as little surprise. They receive a majority of the benefits (reduced energy and water costs when residents pay for utilities, plus replacement cost savings for homeowners) and pay for few of the initial costs of greening. However, developers of these projects are mission-driven to provide safe and affordable housing to people who would otherwise be unable to afford it. Our case studies show that residents who

Table 3: Net Present Value Results per Unit

	# Units	Resident/ Homeowner NPV	Rebates/Grants for Greening	Developer/Owner NPV After Rebates	Combined NPV
20th Street	34	$6,460	$1,100	-$507	$5,954
Arroyo Chico	17	$7,820	$0	$0	$7,820
Betty Ann	76	$6,919	$592	$789	$7,709
Brick Capital	5	-$140	$0	$0	-$140
CAST	42	$1,962	$1,382	$1,027	$2,990
Colorado Court	44	$0	$12,626	$5,673	$5,673
Erie Ellington	50	$23,451	$1,326	$34,764	$58,215
Emeryville	3	$11,506	$7,202	$0	$11,506
Johnson Creek	15	$9,953	$1,013	-$1,842	$8,110
Linden	42	$59,861	$1,200	$8,031	$67,892
Melrose	90	$36,721	$0	-$306	$36,415
New Homes	25	$13,702	$10,640	-$4,012	$9,690
Positive Match	7	$1,497	$0	-$9,730	-$8,233
Riverwalk	52	$15,213	$3,692	$3,904	$19,117
Traugott	50	$1,211	$1,405	$7,829	$9,040
Woodlawn	10	$6,064	$2,900	-$2,015	$4,049
Mean		$12,637	$2,817	$2,725	$15,363
Median		$7,370	$1,263	$0	$7,965
Benefits outweigh costs		14		7	14
Costs outweigh benefits		1		6	2
Benefits equal costs		1		3	0

live in green affordable housing benefit from an inherently more affordable home, not to mention one that provides improved health and better quality of life.[10]

The story for the developer/owner is more varied. They generally pay for all the up-front costs of greening, but do not usually receive a proportionate share of the benefits. Often the up-front costs of greening are reduced through grants and rebates, but this generally only covers a portion of the incremental costs. In the end, about half of the developers in our cases receive benefits from greening that exceed their costs (see Table 3 for more information).

Financing Green Projects

Green affordable housing is more difficult to develop under the current financing system because it often requires slightly higher up-front costs, and initial capital costs (e.g., per unit cost caps) are the critical factor considered by funding sources. This is the case even when long-term benefits exceed costs in net present value terms. There are currently few, if any, financing products that can defray higher up-front costs in affordable housing based on recouping those costs with operating benefits down the line. The financing picture is further complicated by the fact that up-front development costs are borne by the developer, while much of the benefits in terms of reduced operating costs are enjoyed by residents/homeowners. Thus, to receive these financial benefits, a developer would need to retain a long-term ownership interest. Any financing products that redistribute the benefits to change the outcome for the developer may appear to take money out of the residents' pockets. Some consider this as antithetical to the mission of CBO-developed affordable housing while others view it as achieving a balance between serving individual clients and financially sustaining a critical, but fragile, part of the affordable housing delivery system. These are important policy issues for financiers interested in green affordable housing development. Presently, however, there is little evidence that a debate about these issues is underway.

Additional Benefits

This report has not incorporated the monetary value of quality of life impacts into our analysis, even though they may be among the most significant long-term benefits of green building.[11] For example, the assessment of costs and benefits does not directly account for resident health, aesthetic appeal, or quality of life.[12] Though these are among the most compelling reasons for CBOs to build green affordable housing, methods for translating improved health or quality of life into monetary terms (e.g., cost estimates due to changes in productivity and absenteeism) are difficult to apply to the residential sector.[13] Even without accounting for such benefits, our research indicates that green affordable housing can create long-term value for the owner/developer and is almost always more affordable for the residents.

Challenges Limiting Our Findings

Our initial research indicated that there were a sufficient number of green affordable housing developments built nationally to inform general conclusions about the costs and benefits of greening affordable housing. This report began with a set of 59 identified developments that were both green and affordable. What quickly became evident was that many of the projects did not meet our basic criteria, including minimum number of affordable units, to be included in our analysis (outlined in Methodology section). The number of cases was further diminished by the fact that many of them relied on sweat equity (volunteer labor) or some other type of construction support that could not accurately be quantified, and would skew the green premium calculations. Still other cases were dropped due to a lack of operating data.[14] The 16 cases presented in this report are thoroughly researched and analyzed and provide the best data available to address some of the important questions related to the costs and benefits of greening affordable housing.

Other challenges are discussed in more detail below.

High Rates of Staff Turn-Over
High turn-over in CBOs was particularly difficult because knowledge about the nuances of the projects was not readily available, and the research team had to track down people who had more accurate and current information. In addition, staff turn-over means that valuable lessons learned in the greening process are lost to the CBO unless particular care has been taken to log these lessons into some form of institutional memory.

No Central Repository for All of the Data
By their very nature, affordable housing projects include many more players than traditional market-rate development projects. In addition to a traditional development team which includes the developer's staff, legal counsel, development consultants, and design professionals, an affordable project generally has a patchwork of financing professionals involved. In part because of the large team, it was rare that a single individual or organization had all the information about a project. Beyond this, different reporting requirements and underwriting criteria for each of the funding sources led to data being housed at different organizations.

Developing a Baseline
Another challenge arose from the method we used to make comparisons. In order to calculate a green premium, we needed a cost estimate for a similar conventional project as a basis for comparison. The majority of the projects calculated total development costs for a *green* project and not for a comparable *conventional* project. This necessitated a methodology for assigning comparable total development cost numbers for a conventional project,[15] something we ultimately vetted with the CBOs' project staff. When project were unable to identify a conventional project cost, we used other resources, most notably RS Means Construction Cost Guides.[16]

Lack of Adequate Operating Information
The biggest challenge to the net present value analysis was the gaps in long-term operating information. Many cases had very short operating histories, but even those that were completed several years ago often had limited data on operations. Moreover, many of the developments are ownership projects and utility payment information is private and not readily accessible to developers or CBOs. In other cases where the developer/owner paid the utility expenses, the mechanisms to track those numbers were not in place. In green developments where special attention was paid to reducing energy expenditures through energy efficient systems, it was interesting to find that many programs that subsidized these upgrades did not require multi-year tracking.[17]

Data Consistency
Three main challenges arose in comparing the 16 cases. First, there were regional differences in the data. Second, there were four different building types: multi-family, single-family, duplex, triplex. Third, the data came in many different forms, requiring standardization.

The fact that this report includes cases from all across the U.S. raised the issue of how, for example, to compare a project in Washington state to one in Massachusetts. In addition to having to develop a method to compare green to conventional, we also had to identify the best resources for regional pricing, so that green premiums were accurately calculated and easily compared. The different building types also posed a difficulty, which ultimately cannot be reconciled. That is, one cannot meaningfully compare a multi-family rental building to a single family, detached homeownership development. The problem not only lies in building type, but in the size of the data set as well. Sixteen cases do not provide a large enough data set to tease out the differences in green premiums between building types. And finally, because of the many organizations and individuals involved in collecting disparate pieces of data, there was no uniform typology or terminology for the data that could be easily culled from the completed surveys and analyzed. This required careful interpretation of the data we received from the project teams so that it was correctly considered in our analysis.

Suggestions for Further Research

Over the course of completing this report, and in beginning to apply the findings to the project team's ongoing work assisting community-based development organizations in greening their projects, we have identified a number of questions that merit further research, including:

Does use of an integrated design process reduce permitting time and cost overruns?
Anecdotally, there is evidence that an integrated design process – involving a broad team from the outset, systematically considering green options, and establishing project targets and goals – reduces permitting time because the development team proactively addresses issues of concern to permitting agencies, such as siting, stormwater management, energy use, and

construction techniques and materials.

There is also evidence that the integrated design process reduces cost overruns because the relationships among various building systems and components are more thoroughly considered than they might otherwise be and the design is vetted by the full project team before construction. In contrast, greening often calls for new techniques and technologies, and touches on issues such as increased site density and reduced parking. A study of the impacts of integrated design on permitting time, change orders, and cost overruns would provide developers and financiers a better understanding of this critical aspect of the green building process.

Does building commissioning reduce developer call backs and does it improve the effectiveness of HVAC and other systems? Can the value of commissioning be monetized? Most of the projects studied here did not have funding for full-fledged commissioning. Several of the case study projects experienced some difficulty with HVAC systems or did not meet the projections from energy models. A thorough evaluation of the cost/benefit of commissioning would be valuable, as would an examination of how to incorporate commissioning into the affordable housing development and financing process.

How can we measure the non-economic benefits that are apparent in green projects, such as improved comfort, better indoor air quality and enhanced resident health? Assuming positive value, is there a way to use this value to advance projects? Thorough qualitative surveys with community members, residents, and management companies could result in more insight on these issues. Also involving public health researchers to put a monetary value on reduced asthma and respiratory incidences could result in preliminary quantification of the benefits of at least the improved indoor air quality components of projects.

What financing tools can be used to address the different cash-flow needs of green projects? Although it does not necessarily increase total development costs, the integrated design process results in front loading many of the design costs, as members of the project team are participating in design meetings before they would normally be involved in a conventionally designed project. With this report in-hand (as well as other data documenting the life-cycle benefits of greening), it would be useful to engage financial institutions that support affordable housing in an exploratory dialogue about new financing approaches and tools to address the different cash-flow needs of green projects.

Can the affordable housing finance system provide the flexibility to meet these needs? Can reduced interest rates, subsidized debt or other non-traditional means be made available to green projects to cover the cost of any construction premium? Is there a place for use of non-traditional financing tools, such as leases, to account for the reduced long-term costs from advanced HVAC or renewable energy systems? Again, effectively addressing these questions will require engaging affordable housing financiers. For example, expanding the use of green design criteria in assessing LIHTC applications could advantage green projects. These are also questions the research team is in the process of addressing in our companion report on green affordable housing finance.

Can the operating subsidy contracts utilized in affordable housing be aligned with a life-cycle costing approach? Many affordable housing projects benefit from operating subsidy contracts that cover a portion of operating expenses and debt service.[18] In such cases, there are no apparent incentives for owners or tenants to improve the efficiency and lower the operating costs through green practices. This is a fertile area for investigation with HUD and other parties that fund such contracts, perhaps focusing on the utility allowance mechanism.

How valid are the energy models that are used to predict energy savings? There is a wide variance in the accuracy of pre-construction energy modeling. To reduce this variance, data from a longitudinal study of energy efficient homes would be invaluable in testing the validity of the energy models used. This would also test the effectiveness of the combination of tight building envelopes, improved insulation and windows, ventilation and high-efficiency heating systems that are used in most of the projects studied in this report.[19]

How valid are the manufacturer's claims of long term maintenance savings? Do premium windows, roofs, siding and flooring, for example, perform as claimed and actually reduce maintenance and replacement costs? These queries could be answered by more systematic tracking of replacement information. This requires diligent data collection on the part of developers and building management teams, as green affordable housing projects constructed over the last decade begin to require significant component or system replacements.

How should affordable housing developers prioritize greening strategies when faced with budget constraints? Which greening strategies are the most cost effective? Part of the answer to these questions can be in a better general understanding of how to implement greening opportunities (e.g., using integrated design and hiring experienced green design professionals), so a broad educational strategy is essential. There are a number of tools to systematically evaluate greening options according to cost-effectiveness and green benefit. One of the current challenges is that most developers don't know where to begin to organize the volumes of data that are out there on greening.[20] One possible solution is for a national consortium of green affordable housing stakeholders to ensure that tools and data are kept up to date and made widely available.

Recommendations on Data and Information Gathering

The following recommendations are aimed at facilitating the development and broad dissemination of reliable information on the life-cycle costs and benefits of greening affordable housing. Such information will help address the largely unchallenged assumption held by CBOs, financial institutions, and others that green costs more and is therefore problematic for affordable housing. Recommendations include:

- Staff training on the importance of institutional memory;
- Developing a common understanding of why the data is important and where it is housed;
- Making the connection between data and its impact on future funding support; and
- Collecting operating and maintenance data in the long-run.

Institutional Memory

Given the high staff turnover rate in much of the CBO affordable housing development world, the lessons learned by CBOs who complete green affordable housing projects are at risk of being lost. Unless there is a mechanism in place to institutionalize these lessons throughout the organizations involved, they will not be incorporated into future projects . One effective strategy is to formally share green project results with Boards of Directors, outlining the greening strategies and documenting their benefits. The next step is to work with the Boards to make sure that greening goals are incorporated into future development projects and possibly the overall missions of relevant organizations. This may require more in-depth conversation and training with Boards to make sure that they feel comfortable embracing a green approach to project development.

Staff training goes hand-in-hand with the Board training concept, where staff experienced in green building become the "resident experts" and are understood to be the in-house resources for questions pertaining to the greening process. To support long-term capacity for greening projects and avoid loss of knowledge in the event of staff turnover, guidance documents, including internal design guidelines, and a resource library could also be created and maintained and actively promoted in staff trainings.

We also recommend that CBOs explore the applicability of production networks to their work, in order to reduce the likelihood that lessons learned will be lost. Specialization and collaboration among CBOs, and creating tighter relationships with the "supply chain" of architects, builders, financial institutions and development consultants, is another effective way to retain, develop and expand the knowledge needed to cost-effectively build green projects.[21]

Importance of Data Collection

When it comes to making the case for green affordable housing, the main challenges has been the perception that green costs more. The second challenge is the lack of adequate data to counter this perception. It is essential that all involved in a project – from project managers to funders to designers – understand why the information should be carefully tracked. It is equally important for all parties team members involved to agree on data development and consolidation procedures and, ultimately, where the data will be housed.

A central repository for project data is critical. Ideally, the data would reside with the developer/owner, who would provide team members with a clear protocol for tracking and reporting project cost data. This procedure should be implemented as the project moves along the development process, not in hindsight. Much of the cost data should be available from information already collected by project stakeholders – banks, city/state/federal government subsidy providers, the CBO, etc. The data collection survey tool that we created for this report (see Appendix 2) is one useful way to organize the information, though the structure may differ from existing reporting requirements and the level of detail may be difficult to achieve. Having a standardized method of collecting data will improve understanding of the economics of green affordable housing as well as facilitate cross-project comparisons, which facilitates both internal and external research.

Future Funding Support
Rigorous reporting on the outcomes of green affordable housing projects, including detailed information about green premiums as well as operational savings, will help address the uncertainty about the value of greening often expressed by the finance community. As financiers gain confidence in the long-term value of green projects, it is likely that they will adjust their financing structures to reflect the realization of this value.

Operations and Maintenance Information
To accurately assess how operating savings relate to initial costs and to understand and document life-cycle costs and benefits, it is important to track operating and maintenance costs on an ongoing basis. In fact, it can be argued that it is a better indicator of the quality of the asset than the initial cost. To be most reliable and meaningful, operating and maintenance cost data should be collected on an ongoing basis over the long term. Most of the savings associated with building operations will not be realized in the first one or two years. Similarly, replacement cost savings due to installation of more durable materials and equipment will not be realized until the useful life of conventional materials and equipment has been reached.

Recommendations for Project Development and Policy

This section discusses several recommendations for how policymakers and development practitioners can adjust their practice to more effectively facilitate green affordable housing development.

Recommendations for Project Developers

Developers Should Focus on Assembling an Effective Team, Integrated Design, Standards, and Life-Cycle Costing
Based on the findings in this report, the research team has concluded that assembling an effective team, engaging in an integrated design process, establishing goals based on existing green building standards, and conducting life-cycle cost analysis are essential for effectively developing green affordable housing. Neglecting any of them will reduce the chances of a successful project.

Team selection is perhaps the most important consideration in determining whether a project is cost-effectively greened. The developer should prepare appropriately detailed bidding documents with green specifications and provide additional education and oversight of contractors who may be unfamiliar with green building techniques. The more experienced and more motivated each member of the team is, the higher the likelihood of success in greening the project.

Once selected, the developer must assure that the selected team employs an integrated design process in which all key members are involved in the design process from the outset. This point increasingly recognized: "Dozens of successful projects now attest to the fact that integrated design is an effective approach – perhaps the only effective approach – for creating comprehensive green buildings on a reasonable budget."[22] Because the process uses a whole-building approach, the relationship among building components and systems is well understood, thereby allowing improvements and savings to be realized that are not usually possible in a sequentially designed project. The integrated design process also helps to establish successful working relationships among team members. Moreover, there is anecdotal evidence that an integrated design process reduces permitting time and change orders.

Developers of green affordable housing projects should become more aware of the emerging local and national standards for greening housing. We recommend that at the conceptual design stage, the development team set its project goals in relation to an established standard. There is no reason to reinvent the wheel. The existing standards provide effective models for greening housing, and many have been tested and put in to practice by local builders and developers. In addition to a number of local and state standards, the USGBC is nearing completion of its pilot LEED for Homes (LEED-H) standard, with input from local and national stakeholder groups. Second, these standards will help match the scope of greening to the purpose of the project. In this report, for example, the Positive MATCH case study demonstrates how the green features considered for multi-unit housing designed for a medically vulnerable population will differ from features considered for first time home-buyer single family housing. Whatever the standard used, meeting an established benchmark can be used as a marketing tool and may allow a green project to be sold or rented more quickly than a comparable conventional project.

A project developed as described above, and one that has clear documentation of both the initial capital costs as well as expected operating costs is in the best position to benefit from financial incentive programs for green buildings. The case studies in this report demonstrate the breadth of incentives and subsidies available for green projects from utilities, Energy Star, low-income energy assistance, renewable energy, and other programs. Note that applying early will increase the likelihood of receiving maximum rebates. We recommend that project teams analyze their project for the life-cycle costs of at least energy, water, and maintenance issues to determine the net present value of green features. This analysis should be presented to local financiers to explore finance methods that account for the value of lower operating costs resulting from green features.

Recommendations for Policy Makers

Funding Innovation

The evidence presented in the case studies demonstrates that properly designed and sized systems, energy and water efficiency, and reduction in long-term maintenance costs are achievable for no or modest increases in total development costs. These advances are important and should be immediately adopted in all affordable housing developments. However, to achieve higher levels of greening (e.g., on-site generation of energy, complete use of non-toxic materials and sustainably harvested wood) would likely increase first costs and require additional financing. To meet such needs, all levels of government, financial institutions, utilities, and private foundations must increase the funding available for innovative greening. This will spur innovation, permit the assessment of the costs of innovative features on a production level, and develop methods and techniques that can be transferred to the production of market rate housing. This in turn should have significant demand/supply side effects, ultimately affecting pricing.

All Jurisdictions Should Adopt Minimum Standards for Greening Affordable Housing

Many of the successful projects profiled in this report took advantage of green housing standards to help set their parameters for greening. We believe that a minimum standard for greening that goes beyond current building codes should be adopted by all local jurisdictions.[23] This change would institutionalize many of the features profiled in the case studies, and could be accomplished without significant impact on project budgets. It would spur the development of the green building industry, make it easier to build green housing, and ensure that all projects incorporate basic green features. Such standards could be adopted from other localities, states, or national institutions such as USGBC, which as indicated above, is in the process of finalizing a pilot LEED for Homes.

Regional Green Building Expertise

The case studies reveal the value of non-profit and government green building assistance providers. The range of services provided by these entities includes contractor training, technical assistance on greening, assistance with specifications and contracts, matching green project teams to developers, assistance with maximizing rebates and grants, and consulting on integrated design. These entities have clearly made a difference in advancing the cause of green building, and deserve to have funding continued and increased.

Financing Changes

The case studies documented in this report provide convincing evidence that many green features can be cost-effectively included in affordable housing. Even when this requires a premium on first costs, the data indicate that the future savings in energy, water and maintenance costs usually make this a sound investment. Of course, green features have a greater impact than just on the costs of a project. The off-site environmental impacts of green features, such as sustainably harvested lumber or reduced greenhouse gas emissions, cannot be easily measured and are tangential to project costs. The effect of improvements in indoor air quality on occupant health and comfort are difficult to measure and quantify in dollar terms. Moreover, energy efficiency can be a hedge against rising future costs of energy. And the value of neighborhood cohesion and sense of community that results from density, transit-oriented development, mixed-use neighborhoods and brownfields redevelopment is simply not reflected in financial analyses of projects.

The application processes for subsidies for affordable housing, including grants, tax credit financing and debt financing, should at least require attention to energy and water efficiency, occupant health and long-term maintenance. We suggest that projects that do not meet these minimum standards be sent back to the project team with the charge of addressing these issues.

Higher Standards for Energy Efficiency Should Be Mandatory

The energy efficiency standards of most state building codes do not require housing to be built to Energy Star standards.[24] Given that the majority of the cases profiled in this report exceeded the Energy Star threshold, there do not appear to be significant cost or technical barriers to reaching a Home Energy Rating System (HERS) score above 86 (the minimum Energy Star rating) in affordable housing. A requirement to meet these standards would clearly reduce the operating costs of affordable housing, and would decrease fossil fuel use. States should also ensure that local building officials are trained and motivated to enforce these standards.

(Endnotes)

[1] These figures include rebates and grants made specifically for greening. The number falls to twelve of sixteen before rebates, but these other two projects (New Homes for South Chicago and Colorado Court) had photovoltaic systems that the project developers would not have included had they not received specific subsidies for greening. Without these photovoltaic systems, both projects would have obtained life-cycle benefits from greening that outweighed their life-cycle costs.

[2] Exceptions to this are noted in the case studies.

[3] One green project, Erie Ellington, was built at a significant cost reduction and several others had an almost negligible premium

[4] For the three projects with photovoltaic systems, the cost premium drops significantly when these systems are excluded from the cost analysis.

[5] The one project where residents fare worse in green buildings is Brick Capital. In this case, the project developer believes that anomalies in design (several green buildings in the operating sample have hard to heat and cool vaulted ceilings that the conventional buildings do not have) and resident income (the residents living in the green homes have much higher disposable incomes and larger energy loads from additional appliances and electronic equipment than residents living in the conventional homes) have accounted for the variation in the operating expenses and not the energy efficiency of the buildings in question.

[6] Building commissioning is the systematic testing of the systems and components installed in the building to ensure that they are performing properly. This is particularly important for advanced HVAC systems and for other unfamiliar materials or components.

[7] For a more complete discussion of these cases, please turn to the Case Study section.

[8] Only homeowners in affordable housing projects would avoid paying the first cost increases, and this is due to the price-constrained nature of affordable housing. In a market project, the developer wouldn't build a green project unless he or she believed that any incremental costs due to greening would be recouped from eventual buyers through higher sales prices.

[9] Note that longer-lived, more durable buildings may have a perverse impact on the level of tax credits available for rehabilitation. For example, when affordable housing developers/owners apply for the 4% rehab credit to maintain an expiring use affordable building as affordable, the value of this credit is calculated based on the value of rehabilitation needed. Since a longer lasting building will need less rehab, a longer-lived building will not receive the same level of 4% rehab credit as a more conventional one. We have not directly accounted for this in our analysis.

[10] Note that submetering of utilities (electricity, gas, water and sewer) and passing on such costs to tenants is one way owners of rental housing try to minimize their exposure to the risk of rising utility costs. By sending a direct price signal to residents, it promotes maximum resource conservation, thereby minimizing operating costs.

[11] For example, asthma incidents for children that live at Erie Ellington in Boston, Massachusetts are down according to a survey of residents.

[12] While better quality green buildings should have lower vacancy rates, higher rents (though not in affordable housing where rent is controlled), and lower lease-up or sales times (higher absorption rates), they do not become more valuable directly because the children living in them have fewer asthma incidents. Despite the market's failure to reflect health and quality of life benefits, it does not negate the importance of reducing asthma incidence in children through green design and construction methods.

[13] See *The Costs and Financial Benefits of Green Buildings, A Report to the California Sustainable Building Task Force*, Greg Kats, Capital E, (October 2003), which did quantify the productivity and health benefits of green buildings in the institutional and commercial sectors. This study recognized that over the life of a building employee costs overwhelm building costs, perhaps by a factor of ten. Many studies have been published in recent years on the relationship between building performance and worker productivity and health. The Rocky Mountain Institute (www.rmi.org) has been at the forefront of this field. To date, however, very little has been done on quantifying similar benefits for homeowners/residents.

[14] See *Lack of adequate operating information tracking* section.

[15] See Methodology section of this report for more information on comparable numbers used in our analysis.

[16] Use of RS Means is noted in each case, and cost estimates were always shown to project team members to ensure reasonableness.
[17] The cases presented in this report did not face these challenges to the extent presented here. By and large, the cases in the report had some good actual or modeled operating data. However a number of projects that were initially considered appropriate for this study were ultimately not included because such data was unavailable.
[18] All of the projects in the present study were recently constructed or renovated and therefore unlikely to be beneficiaries of operating subsidy contracts. There are, however, hundreds of thousands of existing affordable housing units throughout the country that are subsidized through this mechanism. Many of these are aging projects that will have an opportunity for greening through refinancing and capital improvements in the near future.
[19] Our research team was surprised that a study like this does not already exist, but in conversations with HUD and Energy Star, they are aware of no such information, and we have been unable to identify anything in the literature.
[20] We are aware of a few incipient efforts in this regard, including one by GreenBlue of Charlottesville, VA and another by First Community Housing of San Jose, CA.
[21] Note that this may be problematic as many of the secondary funding programs (like HOME) have procurement requirements that restrict a developer's ability to always utilize the same project team.
[22] Nadav Malin, "Integrated Design", *Environmental Building News,* v. 13, no. 11, November 2004, p. 1.
[23] Ideally, a state-level or national standard would be the most efficient way to promote greening. However, the process of adopting such standards at these levels can be complicated and lengthy.
[24] Some states, including California, have already adopted energy codes that go well beyond the Energy Star standard.

ORIGINAL CASE STUDY LIST

SURVEY INSTRUMENT

A NOTE ON PRESENT VALUE AND DISCOUNT RATE

DESCRIPTION OF RESEARCH TEAM

APPENDICES

APPENDIX 1
ORIGINAL CASE STUDY LIST

List of Green Affordable Housing Projects Considered for Case Studies

Completed Cases	Location
20th Street Apartments	Santa Monica, CA
Arroyo Chico	Santa Fe, NM
Betty Ann Gardens	San Jose, CA
Brick Capital Community Development Corporation	Sanford & Broadway, NC
Colorado Court	Santa Monica, CA
Columbia Terrace (CAST)	Cambridge, MA
Emeryville Resourceful Building	Emeryville, CA
Erie Ellington	Boston, MA
Johnson Creek Commons	Portland, OR
Linden Street	Somerville, MA
Melrose Commons II	Bronx, New York
New Homes for South Chicago III	Chicago, IL
Positive Match	San Francisco, CA
Riverwalk Point	Spokane, WA
Traugott Terrace	Seattle, WA
Woodlawn Development Associates	Chicago, IL

Survey sent but not completed	
1400 on 5th	New York, NY
Burnham Building	Irvington, NY
Churchill Homes	Holyoke, MA
Denver Dry Goods	Denver, CO
Gateway Crossing	Hagerstown, MD
Gold Dust Apartments	Missoula, MT
Museum Place Lofts	Portland, OR
Nueva Vista Family Housing	Santa Cruz, CA
Portland Place	Minneapolis, MN
Portsmouth Metropolitan Housing Authority	Portsmouth, OH
REECH, LLC	Charlotte, NC
Rural Development, Inc. Pilot Homes	Franklin County, MA
Upham's Corner Marketplace Redevelopment	Dorchester, MA
Vistas at Kensington Park (Carl Franklin Homes)	Dallas, TX
Wilson Community Improvement Association	Wilson, NC
Winchester Greens	Richmond, VA

Removed from consideration by screen	Location
33 Everett Street	Allston, MA
81 Hano Street	Allston, MA
Auburn Court I	Cambridge, MA
Bernal Gateway Apartments	San Francisco, CA
Buckman Heights	Portland, OR
Cambridge Cohousing	Cambridge, MA
Casa Verde Homes	Austin, TX
Casas de Don Juan	Santa Fe, NM
Cherrie Turner Towers	Canton, OH
Egleston Crossing	Roxbury/Jamaica Plain, MA
Esperanza del Sol	Dallas, TX
GreenHOME	Washington, DC
High Prairie Apartments	Chicago, IL
Homestead Apartments Phase II Building A	Homestead, PA
Hometown Neighborhood Development	Chicago, IL
Jackson Street Village	St. Paul, MN
Maverick Gardens	East Boston, MA
Mechanicsville/College Homes	Knoxville, TN
Metro Denver Habitat for Humanity Green Program	Denver, CO
Morville House	Boston, MA
Murphy Ranch	San Jose, CA
Newbury Street homes	Lawrence, MA
Northside Stawbale Project	Missoula, MT
Paseo Studios	San Jose, CA
Reviviendo Family Housing	Lawrence, MA
Takoma Village Cohousing	Washington, DC
The Solaire at 20 River Terrace, Battery Park City	New York, NY

APPENDIX 2
SURVEY INSTRUMENT

Survey Instructions

Green Affordable Housing Survey — Green CDCs Initiative

	General Instructions
Overview	This survey is intended to help document the costs and benefits of greening your project. The survey has three sections: Project Information, Capital Costs and Operating Savings, and Project Financing. The survey can be completed and sent back to us (address below), or it can be completed through a telephone interview with someone from the Green CDCs Initiative.
Section 1	The first section asks for general background information about the project.
Section 2	In the second section, we are interested in learning about several cost aspects of the project. First, we would like to know what the overall construction costs were for your project, and what the construction costs for a comparable, traditionally designed and built project would be. This will demonstrate the incremental costs of greening for the entire project. Next, we would like to gather information on the Capital Costs for the project's green features. We have organized this section of the survey into six categories of green features: Sustainable Sites, Water Conservation, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, or Innovation and Design. We also wish to understand the Operating Savings that the project has achieved or projects to achieve as a result of specific green features. In the Operating Savings section please provide any quantitative or qualitative information you have about the savings resulting from the greening of the project. Operating savings can be achieved by lowering utility costs, operations and maintenance costs, labor costs, materials costs, and/or through savings from reduced replacement costs due to improved material durability.
Section 3	The final section asks for information about the financing used in the project. This section has basic questions about financing sources and amounts as well as questions about the impact of greening efforts on financing sources.
Notes	We anticipate that one person may not have all the information necessary to complete this survey. We request that you contact others who may have additional information about the project so that we can have the most complete description of the project and its associated costs and benefits. Project documentation is requested in the Section 1: Project Information worksheet in Parts D and E. Please send this documentation and any other documentation to: **(Researcher Name), (Researcher Address). You can also reach me by phone at (researcher phone #).** Additionally, please feel free to add any relevant information, either by adding lines to the appropriate section of the existing survey or as a separate attachment. Many thanks for your participation in this project. Please do not hesitate to contact us with any questions.

Section 1: Project Information

Section 1: Project Information

Please fill in the following information about the project

A. Background Information

Project Name		Construction Completion Date	
		Occupancy Date	
Project Address (city, state, zip code)		New construction or Rehab?	
		Basement? (Y or N)	
Sponsor or Developer		Number of Units	
Dev. Consultant (if used)		Number of Bedrooms	

Survey respondent: Name		Number of Affordable Housing units (restricted to families with 80% median income or less)	
Address			
Phone Number		Number of other income restricted units	
Email Address		Number of market-rate units	
Contractor name		Note: if fewer than 20% of the project's units are affordable housing units, please do not proceed with the survey, and contact us to discuss the project.	
Architect name			

B. Housing description

Housing Type	Number of units
Family Rental	
Conventional Elderly Rental	
Rental, Special Populations (including assisted living)	
Co-op	
Owner Occupied: Fee Simple	
Owner Occupied: Condominium	
Other	
TOTAL UNITS	0

Unit Type (across entire project)	Number of units
Single Family, Detached	
Single Family, Attached	
Duplex	
Multifamily	
Townhouse	
TOTAL UNITS	0

Section 1: continued

C. Gross square feet of project

	Square Feet	Notes
Residential units		
Commercial space		
Community space (for residents or community at large)		
Common area, circulation, maintenance, systems		
Other (describe in notes section)		
TOTAL	0	

D. Actual Project Development Costs

Please provide a copy of a **project cost certification (summary) for a public lender or regulatory agency**. **Alternately, provide** a summary of **final construction proceeds requisition** or **drawdown request** (showing cumulative draws).

If such documents are unavailable, please provide the following information.

Activity	Dollar Amount
Property acquisition	
Final construction cost (include all approved and likely-to-be-approved change orders)	
Architecture and engineering	
Environmental assessment and testing	
Development consultant(s)	
Legal	
Lender fees and costs	
Construction and pre-development loan interest	
Sponsor/Developer project management and overhead	
Other Soft Costs	
Developer fee/profit	
Capitalized Replacement Reserves	
Capitalized Operating Reserves	
TOTAL	**$0**

Section 1, continued

E. Operating History

For rental projects, for every 12-month operating period since project completion and 95 percent occupancy, please provide at least **ONE** of the following *(indicate which is being provided)*:

	Provided (Y/N)
Month 12 Budget to Actuals Operating Report (with year-to-date figures) as prepared by property manager	
Operating Expense Information as included in Project Audit	
Annual Operating Report Submitted to Lender or Regulatory Agency	
If home ownership project, is there an outside agency that tracks the operating history that has this data?	Name:

Section 2: Capital Costs and Operating Savings

Section 2: Capital Costs and Operating Savings

In this section, please first record the Overall Project Costs and then record the Capital Costs for the project's green features. Features are listed in one of six categories: Sustainable Sites, Water Conservation, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, or Innovation and Design. Finally, record any Operating Savings resulting from the green features.

A. Overall Project Costs (excluding site acquisition and preparation)

Please provide the cost of the design of any features for the project that required additional design and engineering. Next, provide the construction costs (excluding site acquisition and preparation and the design costs) for the project and the construction costs for a comparable, traditionally designed and built project.

	Cost	Cost/square foot
Green Design		
Traditional Design		
Green Construction		
Traditional Construction		
Net Cost of Greening	$0	$0

B. Capital Costs (excluding site acquisition and remediation)

Please provide the cost for incorporating green features in the project (design, engineering, construction, excluding site acquisition), and the costs for a comparable, traditionally designed and built project. Project features are listed in one of six categories: Sustainable Sites, Water Conservation, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, or Innovation and Design.

		Traditional Capital Cost	Green Capital Cost
Sustainable Sites			
	(e.g., Building orientation; Brownfield; Infill)		
Water Efficiency			
	(e.g., Low-flow fixtures/appliances; Low-water landscaping)		
Energy and Atmosphere			
	(e.g., Efficient HVAC systems & appliances; Envelope improvements beyond code)		
Materials and Resources			
	(e.g., Non-toxic materials, paints, and finishes; Certified wood)		
Indoor Environmental Quality			
	(e.g., Ventilation & moisture control; Non-toxic materials)		
Innovation and Design	(Note: List only those green features and design processes that have not been accounted for in the other categories)		
Total		$0	$0

Section 2: continued

C. Operating Savings

Are there any performance or operating cost analyses the developer/sponsor has done with respect to green features? If yes, please specify below (type of analysis, for whom, etc), and provide a copy of the analysis.

If available, please provide the Operating Savings that the project has achieved or projects to achieve as a result of greening the project. Operating savings can be achieved from utility costs, operations and maintenance costs, labor costs, materials costs, and/or savings from reduced replacement costs due to improved material durability.

Operating Cost Category	Traditional Operation (units)	Traditional Operation ($/yr)	Green Operation (units)	Green Operation ($/yr)	Operating Savings ($/yr)
Electricity (kwh)					
Gas (Therms)					
Oil (gallons)					
Water (gallons)					
Maintenance					
Other (incl. replacements)					

Section 3: Project Financing

Section 3: Project Financing

Please provide the following information about the financing used in the project. If the project had additional financing mechanisms that do not fall into one of the categories listed below, please describe them on an additional line or a separate sheet.

A. Pre-Development and Construction

	Source (name of institution)	**Amount**	**Type (loan, equity, grant)**	**Terms, if loan**	**Was source aware of sponsor/developer's plans to include green features? (Y/N)**
Predevelopment: funds used before start of construction	Sponsor/Developer				
TOTAL		$0			
Construction Period	Sponsor/Developer				
TOTAL		$0			

Section 3: continued

B. Home Mortgages

Please complete this section for any "For Sale" project, with owner-occupied units

				Mortgage(s) associated with a Green Lending Program?	
	Lender	**Number of mortgages**	**Value of mortgages**	**Y/N**	**If yes, type of program**
Developer-arranged mortgage financing					
Other mortgage financing (that developer is aware of)					

Section 3: continued

C. Permanent Funders

i. Name of institution or organization	ii. Amount of funding	iii. Type of funder (from key below)	iv. Type of funding (from key below)	v. Disclosure of green features by developer to funder (from key below)	vi. Funder's response to green features (from key below)	vii. Did green features affect the terms of the funding? If yes, how?	viii. Post construction monitoring of green features? (from key below)
TOTAL	$0						

Key:

iii. Type of funder	iv. Type of funding	v. Disclosure by developer to funder	vi. Funder response	viii. Funder monitoring
A. Bank	A. Senior mortgage	A. All green features were explicitly highlighted in presentations	A. Funding was made specifically for green development	A. None
B. Syndicator	B. Subordinate mortgage/amortizing		B. Funder was enthusiastic/positive about green features	B. First operating year
C. Government Agency	C. Investor equity	B. Some but not all green features were explicitly highlighted	C. Funder was neutral about green features	C. First 2 operating years
D. Quasi-public agency	D. Government grant			
E. Non-profit loan fund, financial intermediary/CDFI	E. Equity-like, e.g., deferred payment mortgage	C. Green features were referenced in application materials, but not highlighted	D. Funder was skeptical/negative about green features	D. Continuous following project completion
F. Foundation	F. Unsecured loan			
G. Other grant-maker	G. Grant (non-government)	D. No specific references to green materials in presentations or application materials	E. Funder was negative about green features and subjected project to unusual review	E. Occasional or episodic
H. Developer/sponsor	H. Developer's equity			

APPENDIX 3
A NOTE ON PRESENT VALUE AND DISCOUNT RATE

What is the time value of money, and how do you calculate it?

People often talk about the time value of money. In simplest terms, this concept can be summarized by the idea that one dollar today is worth more than one dollar tomorrow. You could do a lot of things with your dollar today. You could invest it and make more money, you could buy a candy bar, you could put it in an old sock and bury it in the yard. In order to give up the right to having that dollar today (and all the things you could do with it presently) then you will need more than $1 tomorrow. The nature of time-dependent assets rests in this idea. One dollar today and one dollar tomorrow are not equal. But it's not clear how unequal they are. We need a way of comparing different values at different times so that we can judge which is better and how much better it is. To clarify this idea, think about two examples.

1) You pay $100 today. Then you receive $25 per year for each of the next 5 years.
2) You pay $100 today. Then you receive $60 per year for each of the next 2 years.

If we look just at total dollars, then in investment 1, you pay $100 and you receive $125 in return. In investment 2, you pay $100 and you receive $120 in return. However, in investment 1, you have to wait 5 years to get all your money. In investment 2, you only have to wait 2 years. So which one is better? First let's think through the situation. In both investments, you give up $100 in the beginning, and then the clock starts running. At the end of year 1, you have $25 from investment 1 and $60 from investment 2. You can do something with that money. Spend it, invest it, bury it in the old sock. The next year, you get another $25 from investment 1 and another $60 from investment 2. At this point, its preferable to have the $120 from investment 2 versus the $50 from investment 1, but investment 1 is not done paying you. You continue to get $25 per year for the next 3 years. What's this worth?

Let's assume that you had a third option. You could have invested your $100 in a bank account that paid you 5% annual interest. We'll come back to this assumption in a little bit, but for now, we can assume that the 5% annual interest that you could have earned by putting your money in a bank account serves as the discount rate for evaluating future cash flows. The discount rate is the interest rate used to determine the value, in current dollars, of a future stream of cash flows.

$$PV = \sum FV_t / (1+d)^t$$

Where PV is the present value of an asset in today's dollars, FV_t is the future value of a given cash flow, d is the discount rate, and t is the time period in which the cash flow occurs.

It's easier to see this if we go through the example. Let's start with investment 1. At time 0, we spend $100, since outflows are negative, we'll record this as -$100 or ($100). Putting this in the PV formula yields the following for that single cash flow:

$PV_0 = -100/(1+.05)^0 = -100$

This result makes sense. We're paying the $100 right now. So when we discount the value back to right now, we should get -$100. At the end of year 1, we'll receive $25. Putting this in the formula, we get:

$PV_1 = 25/(1 + .05)^1 = \$23.81$

For year 2, we get:

$PV_2 = 25/(1+.05)^2 = \$22.68$

For the last three years, we get:

$PV_3 = \$21.60$
$PV_4 = \$20.57$
$PV_5 = \$19.59$

Let's ignore the cost of the investment momentarily and look just at the present value of the future cash flows. Summing PV_1 to PV_5 together will give us the present value of the full investment. It should equal $108.24. In effect, if the discount rate associated with this investment is really 5%, then you are receiving a series of cash flows worth $108.24 for $100. This sounds like a good deal. But is it the best deal available to you? Let's look at the second potential investment. How would we calculate the value of the future cash flows associated with it?

$PV_1 = 60/(1+.05)^1 = 57.14$

$\underline{PV_2 = 60/(1+.05)^2 = 54.42}$

$PV_1 + PV_2 = 111.56$

So investment 2 has a value of $111.56 and only costs $100. Both of these sound like pretty good deals, but which is the better one? If given a choice, what would you do? What should you be willing to pay for investment 2? (Answer: $111.56) Investment 1? (Answer: $108.24)

Discount rate and risk

We said a minute ago that we would return to a discussion of discount rate, and the assumption that it was 5% - the hypothetical return you could have earned by putting your money in a savings account. The value of the investments discussed above was based largely on the measure for discount rate. How do we know that we have the right one?

We can also think of the discount rate as a measure of the return you need in order to be indifferent between making a given investment and keeping your money. To understand this definition of discount rate, we need an understanding of risk.

Risk is the expected variation in future cash flows.

Often risk is understood as the possibility that you'll lose your money. This is not exactly right. Risk is related to one's ability to predict an investment's future value. Risky investments have a high probability of being worth a lot more or a lot less than one expects, i.e. they are volatile. Less risky investments are more predictable. Government bonds carry a fairly low cash flow risk (i.e. one can predict with a high degree of accuracy what the future cash flows from a government bond will be). Stocks are much more risky, particularly stocks for a start-up company (i.e. it is hard to tell what future cash flows will be). One of the reasons that stocks earn a higher expected return than government bonds is that there is more risk (less predictability) in stocks. Risk can be broken into two components: the risk-free rate which is a market level characteristic not specific to any investment and the risk-premium which is a specific characteristic of a given investment. Those components are described in more detail below.

The risk-free rate accounts purely for the time value of money. This is the discount rate that would be associated with a riskless asset. In other words, if I could perfectly predict (with no uncertainty) the future cash flows of a given asset, then I would still discount those cash flows at this rate, because the rate accounts for the time cost of making this investment. I am giving up the use of the invested funds for a given time in order to get those future cash flows.

The risk premium accounts for the volatility inherent in any investment that one might make. The risk premium would include but not be limited to a measure of how unpredictable future cash flows will be and the probability of default on the payment of those cash flows.

Discount rate may also be thought of as the risk-free rate + risk premium for a given asset. The risk-free rate describes the cost of money in a given time period (measure related to the general financial market). The risk premium describes the additional risk associated with the particular investment in question.

With this idea in mind, consider a choice between 2 assets. They both require initial investments of $100, and they both have expected returns of $60 per year for each of the next 2 years. But one is guaranteed to return that $60. The other has a 50% chance of returning $60 each year, a 25% chance of returning $40 each year, and a 25% chance of returning $80 each year. Which investment do you want and why? Answer: Investment 1 because it has lower risk (i.e. variation in expected cash flows).

References Used

Geltner, David and Norman G. Miller. Commercial Real Estate Analysis and Investments. South-Western Publishing: Mason, Ohio. 2001.

Fisher, Lynn. "Mortgages." Class notes prepared in 2003.

Hammond, John S. III. "Introduction to Accumulated Value, Present Value and Internal Rate of Return." Harvard Business School Case # 9-173-003. 1972. Revised June 1, 1975.

APPENDIX 4
DESCRIPTION OF RESEARCH TEAM

Description of Research Team

The Green CDCs Initiative

The Green CDCs Initiative is a first-of-its-kind model for improving urban environmental conditions and expanding environmental constituencies through sustainable approaches to community development. It was launched in 2001 to engage and support Massachusetts community development corporations (CDCs) and other non-profit developers in the planning and implementation of green development. The Initiative views these community developers as key players in sustainable development because of their unique development capacity as well as their commitment to social equity, community economic development, public health, and civic engagement for low-income and minority populations. The convergence of their missions and the Initiative's environmental protection goals offers the promise of better development projects - projects that reduce consumption of natural resources and dependence on fossil fuels, last longer and are cheaper to operate and maintain, are more aesthetically pleasing, and generate greater public support - as well as better environmental and public health outcomes. New Ecology's partners in the Green CDCs Initiative include the Tellus Institute, Massachusetts Association of CDCs (MACDC), and the Boston office of the Local Initiatives Support Corporation (LISC).

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Will Bradshaw is currently a doctoral student in the Department of Urban Studies and Planning (DUSP) at MIT. He is also currently enrolled in DUSP's Masters in City Planning Program and the Masters of Science in Real Estate Development Program at the Center for Real Estate at MIT. He received his undergraduate from Davidson College. His interests focus on the intersection of green building, community development, and economic development. Prior to enrolling at MIT, he was the Organizational Director of the Davidson Housing Coalition, a small non-profit affordable housing developer based in Davidson, North Carolina.

Edward F. Connelly is the President of New Ecology, Inc. (NEI). For the past decade Ed has worked to integrate environmental stewardship and development. He founded and ran CleanScape, Inc., a triple bottom line social venture that provides recycling and landscaping services to corporate and institutional clients, and creates living wage jobs for residents of the Providence RI Enterprise Community. He is the former Acting Executive Director of the Rhode Island Resource Recovery Corporation, a $34 million, quasi-public solid waste management corporation, where he was instrumental in developing innovative programs to double the collection and processing of recyclable materials without increasing the costs. Mr. Connelly also served as the assistant town administrator for Sharon, Massachusetts. He holds a bachelor's degree from the University of Chicago and a JD from Boston College Law School.

Madeline Fraser Cook, the Vice President of New Ecology, is an urban planner with a strong commitment to community-based economic development. Fluent in Spanish, Ms. Fraser Cook has worked on housing and economic development projects with low-income Latino communities from North Carolina to Massachusetts. Ms. Fraser Cook has a keen understanding and enthusiasm for economic development, affordable housing, and community organizing. She understands the importance of sustainable development for creating and maintaining vibrant urban centers. She is an experienced technical assistance provider on green building and sustainable neighborhood planning, microenterprise development, real estate market analyses, and community organizing. As a HUD Community Development Fellow at M.I.T.'s Department of Urban Studies and Planning (DUSP), she worked extensively with Massachusetts community development corporations. Ms. Fraser Cook received her Masters of City Planning from DUSP and she holds undergraduate degrees in Economics and Political Sciences from Swarthmore College.

James Goldstein is a Senior Fellow at Tellus Institute where he directs the Sustainable Communities Program. His research centers on the development of analytic methods and stakeholder processes in support of community-based initiatives to integrate environmental protection, economic development, and social well-being. He has over twenty years of experience in the assessment of environmental problems and policies, with a particular emphasis on pollution prevention, solid waste management, green planning, and watershed protection. The current focus of his work is the incorporation of a global perspective in designing local and regional sustainability efforts. Current projects include promoting green development among community development corporations with a particular focus on affordable housing, developing long-range sustainability scenarios for the Boston metropolitan area, and designing training programs to help state agencies and post-secondary educational institutions become more sustainable. He presents widely on a range of environmental and sustainability issues.

Justin Pauly is currently a researcher at New Ecology. He holds a Masters Degree in City Planning from the Department of Urban Studies and Planning at the Massachusetts Institute of Technology. He is interested in the design and development of sustainable models of housing with a particular focus on how those models can be applied to agricultural regions in the western United States. Before journeying east, Mr. Pauly spent several years with Siegel and Strain Architects in Emeryville, CA, where he worked on a number of projects utilizing green building techniques. Prior to joining Siegel & Strain, Mr. Pauly received his BA in Architecture from the University of California at Berkeley.

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